ACTIONS FOR SURVIVAL

Saving Lives in the Immediate Hours After Release of Radioactive or Other Toxic Agents

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DEDICATIONS

In appreciation of their long service in initiating and supporting civilian defense programs that would save lives in the event of nuclear attacks, I dedicate this book to two devoted scientists with whom I had the pleasure of working when I was employed as a physicist at the Federal Civil Defense Administration in the 1956 to 1957 period:

Jack Greene and Marlow J. Stangler.

Jack Greene was a physicist who, through continued initiatives, began the nation's civil defense radiological program in the early 1950s, recognizing the factors that would help save lives and improve our nation's will to survive after an unexpected nuclear attack. Jack was dedicated to this program, and eloquent in explaining its scope and requirements. He worked for many years to sustain the program, and continued his interests until his passing. I dedicated the text of the 2004 Health Physics Society Summer School text, "Public Protection from Nuclear, Chemical, and Biological Terrorism," to Jack, and his picture is included in that dedication.

I first met Marlow Stangler at a 1956 Headquarters meeting of the Federal Civil Defense Administration in Battle Creek, Michigan; he was involved in educating and indoctrinating radiological defense personnel entering into the FCDA civil defense training programs. The meeting was led by Jack Greene and initiated my admiration of his dedication, professional manner, and communication skills. Sometime after the meeting, I was diverted for two months from my duties as Region II Radiological Defense Officer of helping seven states and the District of Columbia with their instrument requests and responder training, in order to assist Marlow Stangler in preparing for and conducting field monitoring training at the 1957 atomic tests in Nevada, Operation Plumbob. Marlow and I trained firemen and policemen from around the nation in the radiation fields from actual fallout from some of the nuclear detonations. I found Marlow in his early years already a dedicated professional, a competent and pleasant colleague. Although I left the FCDA in 1957 to join the Atomic Energy Commission, where Jack had originally helped institute the AEC Civil Effects Test Research program at the atomic test sites, I continued to support the radiological defense program and continued my association with Marlow Stangler. Marlow stayed with the program for over fifty years, through many reorganizations within the FCDA and Department of Defense, and the Federal Emergency Management Agency, until FEMA unfortunately ended the program of support to the States in the mid 1990s, and most States ended their programs — presumably a benefit of the so-called "peace dividend" of the breakup of the Soviet Union.

Since September 11, 2001, the nation has been trying to rebuild its radiological defense, but most of the original information, program data, and taxpayer-bought radiation instruments of FCDA have been lost, or not remembered and used by the newer generations. Marlow has been at my side in many efforts to restore the knowledge and goals of optimum protection of the public in the event of a radiological attack. I am grateful for his continued advice, cooperation in writing chapters and presentations, and long-term friendship. He is the epitome of the unsung hero of dedicated professional government servants, who unfortunately are rarely recognized for their behind-the-scenes efforts on behalf of the United States citizen.

With sadness, as I complete this book, I must also dedicate this book to Dr. Marcel M. Barbier, who passed away on February 7, 2008 at 83 following a traffic accident. He was a nuclear physicist with doctorates in electrical engineering from the Swiss Federal Institute of Technology in Zurich in 1950, and in physics from the Sorbonne in 1954. After working on nuclear research in Geneva from 1954 to 1973, he moved to Herndon, Virginia, where he worked for consulting firms and then for many years offered expert consultation including contributions to the

design of shelters. He contributed generously to efforts for public protection, including some references in this book, and was an example of someone in the private sector who devoted himself to these issues throughout his later years. His vast expertise as a physicist and engineer will be missed.

Watching the ceremonies of March 7, 2008 on C-SPAN, of the fifth anniversary of the establishment of the Department of Homeland Security (DHS), inspired one more necessary dedication. Because I have at times in this book made a few critically different recommendations from those that might have been made, or perhaps not have been made, by the Department, I do not want to give the impression that I do not appreciate the enormous amount of hard and good work that must have been done by the professional staff within DHS. The lack of a serious attack since 9/11 indicates that DHS employees have accomplished much to protect us in these dangerous times. Their assignments have not been easy. Having served in several Federal agencies, I know that there must be many unsung heroes among DHS staff whose work is not publicly disseminated. I dedicate this book also to those within DHS who have devoted themselves to our public and national protection.

For reasons given in Appendix I, I also dedicate this book to the late Dr. Payne S. Harris, physicist and physician. He has served, usually behind the scenes, as a physicist, physician, radiation biologist researcher, and practical field health physicist, on many radiation and nuclear projects related both to the USA nuclear weapons program as well as to projects beneficial to public interest in peaceful applications of nuclear energy and radioisotopes. His focus has always been on protection of workers and the public from unnecessary and harmful radiation. We became fast friends in the early part of this twenty-first century, and I have had the pleasure of recording many of his accomplishments in a video interview that I have deposited with the Health Physics Society History Committee. I just learned of his passing in reading the papers of Simon et al., now added to the references, while checking and updating the final manuscript of this book.

"A prudent man foresees the difficulties ahead and prepares for them; the simpleton goes blindly on and suffers the consequences." (Someone's interpretation of Proverbs 22:3)

ACKNOWLEDGEMENTS

I first want to thank Dr. Gordhan Patel for encouraging me and guiding me into writing this book according to its current scope. Dr. Patel is an outstanding chemist, who among his many patented chemical products has produced a sequentially improved set of "SIRAD" credit-card size, pocket dosimeters, available for purchase by responders or members of the public. My heroes also include Dr. Gordon Riel, who very early supported the development and testing of initial productions of Dr. Patel's dosimeters when he worked for the Department of Defense, and Todd Brethauer of the Technical Support Working Group in DoD, who selected the SIRAD series of dosimeters out of 60,000 submissions for funding the SIRAD dosimeter to its present quality. Another hero is Fay Crowe, who established a start-up company to market the SIRAD dosimeters for Dr. Patel, and who read through a very early draft of this book and has continued to encourage its completion; she has obtained the approval of many Federal and State agencies for the purchase of these dosimeters with Department of Homeland Security grant funds. The availability of these dosimeters has further inspired me to provide this book of information on what various ranges of radiation dose would mean in terms of risk or harm, and early protective actions that could be taken by members of the public if they understand risks and know simple actions for protection.

Stephen Jones, as indicated in Appendix I, has provided many comments and much inspiration throughout the final year of writing this book, and is one of my heroes for his many years of selfless devotion to civil defense preparations that would save many lives in the event of a radiological or nuclear attack.

I also express appreciation to others who have commented on drafts of this book. Particularly helpful were the detailed comments and suggestions of Dr. John Lanza, Professor Ronald L. Kathren, Dr. Niel Wald, John D. Hoyle, Dr. Judy Foulke, Dr. Stephen V. Musolino, Dr. Carl Paperiello, Shane Connor, K. Paul Steinmeyer, Dr. Bobby Scott, Lynn Bercot, Denise Donovan, and her husband Sean, who is a volunteer fireman. My dear wife Phyllis L. Brodsky, who published two books in 2008, has also provided suggestions that improved the book, and has been a continual supporter. Dr. Jane Orient, President of Doctors for Disaster Preparedness, who was introduced to me by Steve Jones within the past year, also invited me to give a talk about this book in July 2010 that inspired me to complete the book earlier than I might otherwise have done. Dr. Mondher Chehata and Jason Dunavant, scientists at Science Applications International Corporation, provided helpful comments and access to documents that provided fallout patterns.

The staff at Copy Central, my local copying and commercial art service, has also been so pleasant and devoted to my work. Linda Dearing, owner and manager, has put up with my many interruptions of her staff, and often pitches in to meet deadlines. Linda Kessinger has been outstanding in managing my priorities, producing Exhibits and manuscripts in publishable form, and generally fitting me into her busy schedules. Roy, Pat, Pat Quade, and Judy have also been wonderful to work with and devoted to services.

I thank my copyeditor, Sharyn Mathews, who produced my 1996 book on radiation risks and uranium toxicity. She always has done amazing copyediting, page makeup, computer graphics, and anything else needed to produce a perfect editorial product, and she was always a cheerful and helpful working partner in any writing project. I also want to thank Pat Quade, who skillfully put together the final copy after Sharyn no longer could provide her services.

I also very much appreciate the great work of Melody Ravert and Robin Surface for taking on the publication of this book, after Sharyn Matthews was not able to continue her good work. Perhaps it was fortunate that this book was delayed so that I could include at least some information that might help the Japanese. They are wished Godspeed and recovery from the disaster and its terrible effect on their health and economy.

Finally, I would like to thank our Creator. On the cover of this book, the beautiful sunset looking West from Ocean City, Maryland, is an example of the great art in nature. In addition, we have been admonished to turn swords into plowshares, through our abilities for logical deduction and loving thy neighbor, with which our genes have been endowed. The beautiful sunset on the cover is similar to the beauty of mushroom clouds that I have witnessed minutes after the detonation of hydrogen and atomic bombs. We must use our intelligence and caring, together with lessons of history, to bring together the nations and peoples of this earth in our quests for peace. This quest must include our efforts to eliminate the risks of nuclear war, retaining only the beauty of sunsets. Senators Nunn and Lugar are among my heroes, who should be acknowledged for their program that has turned so much plutonium from Soviet missiles into fuel for energy. This kind of turning swords into plowshares must continue.

FOREWORD

by Ronald L. Kathren

This is a multilevel book designed to serve a multilevel readership. On one level, it provides for the practicing professional the scientific bases underlying protection of the population following an act of nuclear terrorism. On another level it provides first responders with the necessary information to counter an act of nuclear terrorism and to carry out the mission that they are wont to do, protect and save the lives of innocent civilian members of the population. On yet another level it is a resource for elected officials and decision makers charged with the responsibility for protection of the civilian population. On its most important level, it makes available in plain language for all members of the general public the vital information needed necessary for survival following a nuclear terrorism event, providing simple common sense methods applicable to chemical and bioterrorism as well.

This book is not a dry textbook or simple recitation or cookbook of protective actions. Rather it sparkles with anecdotes and real life experiences and frustrations from the more than half century of professional practice and teaching by its author, an internationally known expert in the field of health physics, the science and art of protecting people and the environment from radiation hazards. Dr. Brodsky, it seems, has known just about everybody involved in radiation protection, and has a story to tell about many. These along with his narratives of his personal experiences with radiation and radiation safety, illustrated in some cases, are interspersed throughout the book and make for gripping reading. So too does his near legendary passionate concern for protection of the public from radiological disasters come through loud and clear as an underlying motif. For decades he has advocated radiological protective measures for the general public, persevering despite numerous frustrations in his effort to educate and gain the support of elected officials and other decision makers.

The genesis of this book can be traced back to the end of World War II, a war brought to a swift and sudden climax by a powerful new weapon, the atomic bomb. The bombings of Hiroshima and Nagasaki starkly demonstrated the destructive powers of this new weapon, which, in addition to the destruction wreaked by the blast and heat produced, left a lingering hazard in the form of exposure to ionizing radiation. Despite our rather blasé attitudes towards radiological protection of the public during the era of the Cold War, we were fortunate in that there was no need for protective measures. However, the destruction of the World Trade Towers on September 11, 2001, gave an awakening to the potential for nuclear and other forms of terrorism, and this book will hopefully demonstrate how we can protect ourselves and our families following terrorist acts.

Ronald L. Kathren, MS (Hygiene), CHP, DEE
Professor Emeritus of Pharmaceutical Science, Washington State University
Former President, Health Physics Society, Former President, American Academy of Health Physics

March 22, 2010

PREFACE

In order to reach as many citizens as possible with guidance for their safety, I am aiming the writing to serve the widest variety of backgrounds and interests. Therefore, at certain points in the text, I am advising persons of different interests that they may skip or skim certain chapters or sections of the book that do not meet their immediate needs or interests, or read them later as desired. Therefore, I have included some repetition of statements that I have thought were needed in certain chapters, in order to help in understanding introductory material that might have been skipped in previous chapters. I hope that I have limited the redundancies to a reasonable amount.

Why am I writing this book? One book, *Public Protection from Nuclear, Chemical, and Biological Terrorism*, was published for the Health Physics Society as a text for their 2004 Summer School, and this Summer School text (see References Section) covers even more information for protection in over 800 pages. The Summer School book was prepared with the input of more than forty experts whom I solicited from throughout the nation. However, the 2004 reference book included much more scientific and technical information for use by scientists or engineers, or other responders, who would be involved in recovery efforts many hours or days after an attack. It has been distributed to a limited number (hundreds) of scientists and professionals involved in preparing for attacks by weapons of mass destruction (WMD). However, much information needed by most responders as well as members of the public for their own immediate protection has apparently not trickled down to them, including the information and planning documents that have been produced by our government homeland security agencies and our expert professional organizations. Therefore, the present book extracts information for the public, as well as immediate information needed by technical personnel, from references to chapters in the 2004 book, from many other documents cited in the references, and from my own experiences with fallout from weapons tests and other experiences managing patients who were exposed to intakes of radioactive materials.

This book is needed and timely because we know from the news almost every day, and from some other books and literature, that a terrorist attack with weapons of mass human destruction could occur in the United States within the next few years. Experts say that this is so despite the billions our nation has spent on homeland security and on attempting to detect dangerous materials or people entering our borders. Terrorists could destroy the future not only for my children and grandchildren, but yours too. Therefore, I am focusing this book on information on protective actions that members of the public, including responders and emergency managers, need to know in order to avoid undue panic and save as many lives as possible in the event such terrorist attacks do occur.

Why do all members of the public need to know about protective actions? Knowledge of immediate actions to take in any emergency can save lives. Discussions with many persons tell me that most of the public and many responders are still in the dark about protection from weapons of mass human destruction. Our citizens must know how to save as many lives as possible after any attack and be resolved to survive in a free nation. In any fight, the fighter can only win if: 1) the fighter knows how to strike the blows; 2) the fighter knows how to block the

blows of his opponent, and 3) the fighter is prepared through preparation and strength to take as many blows as necessary to survive and win the fight. Our government, military, and in particular the Department of Homeland Security, have made progress on the first two abilities. However, while our military focuses mainly on delivering and dodging blows abroad, I believe that our military, our leading agencies, and all of the rest of us, have done all too little to prepare ourselves to receive the blows that are likely to come our way, on our own American territory, as did the attacks on 9/11.

I know that such preparation is possible with the right policy attitudes. When I was a physicist in the Federal Civil Defense Administration (FCDA) in 1956-57, our nation did face up to the possibilities of the most destructive attacks with nuclear weapons sent to us from the Soviet Union. Many millions were spent in the 1940s through 1960s by our government agencies and military organizations to perform research toward civil defense protections and continuity of government. Much of the research and preparations for national survival in this early period has been forgotten, particularly since its demise in the so-called "peace dividend" of the 1990s claimed by politicians after the collapse of the Soviet Union. As the Radiological Defense Officer of Region II in Olney, Maryland, 1956-57, my job was to visit with State and local emergency directors in seven Eastern States and the District of Columbia, and negotiate with them to receive Geiger counters and other radiation monitoring instruments that had already been manufactured in large quantities at minimal prices, and to provide training for their responders. All citizens were aware of the possible dangers, and we were well on our way to providing shelters for the public and educating them on survival actions. The President and the members of Congress had secret, heavily sheltered, evacuation sites, some of which I visited in secret when I was employed by the FCDA. Plans for continuity of government were well prepared in the event any of our leaders would be killed.

Still, nobody in the public seemed to panic about the possibility that such a multi-hydrogen-bomb attack could occur. In those days, before the Cuban affair in the early 1960s, there was no assurance that the Soviet Union could or would control its nuclear arsenal and not indeed initiate a nuclear attack upon the United States.

However, today, much of the earlier civil defense effort has been dissipated, and the research of the Civil Effects Test Group of AEC has been forgotten. One of the shelters for members of Congress that I visited with my wife a few years ago has been turned into a museum. The citizen shelters that were designated around the country are now mainly ignored by the public. With wishful thinking, too many, but not all, political leaders joined the bandwagon of advertising their presumed victory over the Soviet Union as a "peace dividend" and worked to end our radiological defense programs in the 1990s. Despite joint pleas to congress with my friend, Marlow Stangler, who for fifty years after I left FCDA continued instructing responders to perform in radiation fields, even the radiation instrument calibration program was ended, and the vast majority of States gave up their calibration sources. The Department of Homeland Security (DHS), with its new generation of emergency experts, has been attempting to prepare the general public appropriately, but has not brought to bear much of the actual experience with training needs for responders, or educational needs for the public, to adequately avoid unnecessary fears of small amounts of radiation exposure. Neither is the DHS adequately recommending or promoting the kinds of instruments and protection against the possible large exposures to a minority (but large numbers) of civilians in the event of an attack with a nuclear weapon or radioactivity dispersing device (RDD)(sometimes called a "radiological dispersal device" or "radiation dispersal device").

What caused this increasing apathy and opposition to civil defense efforts beginning in the late fifties? Probably some of it was due to good, outspoken, anti-war activists, who believed that our own preparations to save lives of citizens would somehow indicate to the peaceful Soviets that it was we who wished to start nuclear war and destroy them. This belief is somewhat akin to thinking that if we put smoke detectors in our homes, we will likely

want to set our homes on fire. Anyone who has studied or seen the effects of nuclear weapons knows that our nation would not initiate nuclear war, even if protections were established for survival of some of our population. Kruschev slammed his shoe on the table and said, "We will bury you!" His statement was unrelated to any of our civil defense research or preparations, which the Soviets had undertaken themselves.

Apathy about civil defense preparations began, I believe, with media presentations such as the widespread viewing of the 1950s movie, "On the Beach." This movie came out giving the public the misleading impression that in any nuclear attack everyone in the world would die from radiation exposure, and that protection measures were futile. Although widespread radioactive contamination would devastate life as we know it for the immediate generation, most persons would survive and live to old age. The misimpressions were reinforced by activists such as Dr. Ernest Sternglass, a colleague of mine at the University of Pittsburgh, whose (largely successful) misinformation activities I will address in Chapter 1.

With movies like "On the Beach," and such misinformation in the media, public apathy grew and through the years the civil defense program was kicked from one agency to another. I followed the civil defense, or domestic preparedness programs, through the years after my FCDA participation largely through contacts with my friend, Marlow Stangler, one of those to whom this book is dedicated. The last of the Federal radiological equipment program was finally destroyed in the mid-1990s as a presumed benefit of the end of the cold war. My visits with Marlow to Congressional offices did nothing to help stop this destruction. Little political or public thought was given to civil defense after that, until the September 11, 2001 attack.

I will give in the early chapters at least some concrete examples from my own experience, and make some additional remarks about the misinformation propagated in our media, which have contributed to our apathy about personal civil defense protections. After all, congressmen and administration officials come from all walks of life and all parts of our nation. They must have been influenced at least in part by what they were taught in school and what they read and heard in the media in the past fifty years or more. Nobody under retirement age today could have been subjected to the logic of the 1950s scientific information that initiated our early radiological defense program, worked and trained responders in actual nuclear weapons fallout, or evaluated and helped triage some of the few persons exposed to the inhalation of plutonium or other radioactive materials in the era when nuclear power was still expanding in the USA. That is another reason why I feel obliged to write this book.

I know that when people understand dangers and know actions to take to reduce them, they do not panic and can immediately take the proper actions for protection. I know this from my own experiences as a scientist who recovered neutron-measuring instruments in heavy fallout fields from nuclear weapons, from training police, firemen, and other responders in such fallout fields, and from evaluating and comforting patients exposed in production plants to intakes of plutonium and fission products. I also know this from other personal experiences as a young man and from my Army training as a combat platoon leader. All Americans must know this from observations of how our trained soldiers perform bravely under combat conditions, although I regret the overburden that is now being placed by us on so few of our young adults. (I think that many others should be drafted to serve at least at home in the National Guard or in other efforts against terrorism. Many younger citizens should be allowed to enjoy life experiences at least up to age 40 before being drafted for combat. Probably many more over 40 would be saved from heart attacks than would be killed in combat, if they were put into good physical shape by military training. I have personal reasons to believe that also.)

Moreover, as I have observed, many first responder courses today are emphasizing the measurement of very low levels of radiation intensity with extremely sensitive instruments, sometimes misnamed "pagers" because of their size. These pagers, which were really designed to detect clandestine nuclear materials, can measure radiation

exposure rates so low that they present little or no danger, and thus could induce unnecessary panic or fear if radiation risks vs. exposure levels are not understood. Unfortunately, many myths propagated (sometimes innocently) to the public about small amounts of radiation by the entertainment and news media over the past six decades could do much harm if not adequately dispelled. Most members of the public, including those currently employed in national policy making as well as those teaching responders, grew up with myths about radiation and its monstrous effects in entertainment media, violent video games, many books and comic books, and even the daily news. That is why some personal evidence of my own about media misinformation is presented.

This book will provide a necessary understanding of these issues, and will recommend not only protective measures, but also recommend urgently the provision to the public of appropriate, light, pocket-sized radiation exposure indicators so that the majority of citizens who will not be exposed to dangerous levels of radiation will not panic. I know from my work in fallout fields in the 1950s, and from examining the distribution of fallout from many nuclear weapons in my more recent employment, that even in the worst cases of radioactive contamination, there are still very large areas where initial radiation measurements will set off a high click rate in Geiger counters but still not cause lethal or even harmful total exposures to persons taking proper precautions. Also, those few survivors of a radiological attack who might receive exposures needing further medical surveillance or care should know from their personal pocket dosimeter cards how and when to get such care, and/or provide for their own decontamination and immediate first aid.

In order to support my statements and also provide further information for those who would like to search deeper into these issues, I cite a number of references. Perhaps I should apologize for citing so many of my own publications. However, it is easier for me to find many of the important facts in my own writings; and in these writings I always tried to cite and give credit to other authors with whose work I have developed my own concepts and methods. The references in all of the cited publications can lead interested readers, especially those whose jobs require planning for homeland security, to many hundreds of other literature sources with which to dig deeper into these subjects.

Thus, this book is aimed at providing information to save many lives in case attacks do occur. Such scenarios are not fun to write or read about, but must be addressed in our current world situation. Each member of the public is his own "first responder" in the initial moments after an attack, and will need to understand and be prepared with ways to protect himself and his or her family within the critical first seconds and minutes after an attack. Otherwise, serious panic or wrong actions will occur, which could inundate medical facilities and also interfere with the later rescue and recovery efforts of responders. There are not enough responders in the nation, such as policemen, firemen, and medics, to be at everyone's side, or to advise everyone by radio, in the immediate hours after an attack.

After writing the above paragraphs, I arose early on July 7, 2008, and watched the Black Writers Conference on C-SPAN at 6-6:30 a.m. The questions from the audience, and the responses of the panelists, made me aware of the fact that there is a strong analogy between the Katrina aftermath failures voiced at the Writers Conference and my concerns about preparations of the public and government agencies at all levels for WMD attacks. Especially of note, the Poet Laureate of Louisiana, Marie Osbey, gave her impression of governments "…on vacation…" and that no individual strata of society by itself could have prepared for the events of Katrina. At one point, she blamed the flooding catastrophe on the failures of the Corps of Engineers, who had responsibility for planning, constructing, and maintaining the protective structures, having assured the population through many events that they were adequate. This is an illustration of how citizens must be prepared to protect themselves in any event. Even with the best efforts of government agencies, individual citizens cannot rely on government or any other

groups to make up for the lack of individual preparedness needed before or after catastrophic events. Government agencies and responders can only do so much, even with their most competent efforts and maximum resources. Only appropriate individual citizen preparations can provide most of the safety and survival actions needed in the immediate minutes and hours after a catastrophe of any kind.

Because much of this book is aimed at providing concepts and methods of protection for most citizens, who usually are not trained in the radiation sciences, the detailed data and methods provided for the scientific readers should not interrupt their reading necessary information for protection of themselves and their families. Thus, the important, simpler information for protection of all citizens is set apart by print in italic font, as is this paragraph.

Finally, a caveat: Although I have sought comments from many, the content of this book is my responsibility alone; nobody with whom I am affiliated has approved the final version of this book. Any mistakes, or statements that are disagreeable to any reader, are my fault alone. In many parts of the book, the mixture of units of radiation measurement and radioactivity is deliberate; I want the reader to have practice in remembering the different units because units are mixed on the various radiation instruments now available within the United States, and documents provided by the Federal government and other useful references will present quantitative information in different units. Simple definitions appear in Chapter 3, and more complete definitions and discussions of units in Appendix A.

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February 2011

CHAPTER 1

AN UNPLEASANT TRUTH

An Unpleasant World Situation

This section is not a pleasant one to write. It is distasteful to me to recollect my failed attempts to refute myths about radiation that were propagated in the media by certain former colleagues and others. It is also not pleasant to think about possible terrorist attacks that might harm my own and other persons' children. However, because almost everyone alive today has been subjected to a barrage of mostly inaccurate myths about nuclear radiation, in the media or even in school texts, and either in reference to nuclear power programs or civil defense efforts, I must present documentation of some personal experiences and information to assure the reader of the credibility of my statements and recommendations in this book. I must, therefore, document truths about radiation risks and some of my personal experiences that document the distortion of these truths and outright myths, as well as caution the reader about possibilities of terrorist uses of the so-called "weapons of mass destruction (WMD)."

As derived from my personal experiences and observations, the odds are very high that any reader opening this book has been subjected through various media more to misinformation rather than to true facts about radiation risks and how they have been controlled within our society. If we are to be prepared to minimize loss of life in the event of terrorist attacks involving radiation, or other toxic agents, we must understand how to judge the differences between non-harmful and non-lethal exposures and the high exposures that are dangerous to life and health.

In particular, the deliberate release by a terrorist of larger amounts of radioactive material within a large population area, will immediately confront members of the population with levels of radioactive fallout and exposure never before occurring in the United States. (This is true except in atomic test sites where all participants were appropriately trained, monitored and protected from exposures likely to cause health effects; again, as I can document from personal experience evaluating such exposures (including my own) this is also true despite claims that have reached the press.) When such a terrorist release is deliberately aimed at the general public, we can no longer depend on peacetime regulatory controls and programs that have maintained natural background levels for the public. We need to be able to discriminate between the vastly larger numbers of persons who will <u>not</u> receive exposures likely to cause harm and the others who might need medical attention. Undue panic over the lower levels of radiation that would not likely be of significant harm, but which can easily be detected to be well above background, can only result in unnecessary deaths and societal disarray in the event of releases of radioactive material to the environment.

Dr. Marcel Barbier (Barbier[1] 2001), in a panel discussion after 9/11 organized by the Baltimore-Washington Chapter of the Health Physics Society (BWCHPS 2001), presented an outline of the shelter and protective cautions instituted in other nations, precautions that have been neglected in the United States. He stressed, even then, that terrorists or rogue nations might well have or acquire nuclear weapons. He also quoted Edward Teller (H bomb developer), who visited Russia after the Soviet Union collapsed and was told by a high ranking officer that 8 nuclear rocket tips were already missing. Teller asked, "What about nuclear artillery shells?" and the officer answered, "On that we have absolutely no control." Barbier also pointed out that nuclear bombs can be introduced into the United States aboard ships and airliners that load many millions of containers or packages into trucks that reach all areas of the nation.

By now, everyone who listens to radio, watches TV, or reads newspapers and magazines must know it is an unpleasant truth that there are a growing number of terrorists throughout the world, in organizations or sleeper cells, who aim to destroy our nation and our lives unless we adhere to particularly extreme religious practices, are governed only by their strict religious laws, or are governed in other autocratic ways. ***Many of these terrorist groups have no "exit strategy";*** *they train generation after generation to commit suicidal acts according to their touted religious objectives (Wright 2006). We learn about these terrorists while at the same time hearing about the ease with which they might obtain so-called "dirty bombs" (which are not really dirty but contain dispersible radioactive material) and deliver them within our country (Ervin 2006; Kean and Hamilton 2006; Burchfield 2009, Ridge 2009).*

One morning (October 12, 2007), before beginning Chapter 2, I heard on CNN TV news that there are 101 countries who are attempting to develop nuclear weapons. One report indicated that we know such weapons, if developed by some of these countries, will be used on us. Osama bin Laden has advertised many times how he intends to obtain such weapons and use them to destroy America (Wright 2006). Illegal exports of critical materials and equipment to produce such weapons have already been uncovered, with little more than a "slap on the wrist" to the violators, who could usually give good reasons for their error; many items of modern technology already traded in our global economy can have dual or multiple uses. Margonelli (2007), in tracing the history of oil exploration and the current origins and production of oil and gas, provides insights regarding how the misdirection of oil profits in some nations dominated by tyrants are impoverishing populations and causing unemployment, providing breeding grounds for the recruitment of young terrorists who would be happy to detonate a nuclear or RDD weapon within the United States.

We already know from many news reports that North Korea has obtained nuclear weapons and their delivery systems despite the long negotiations and applied sanctions. We are also aware of the many times North Korea has attempted, perhaps with considerable success, to sell and transport these weapons to other nations who do not love us or any democratic societies. Parsi (2009) has suggested it is not likely that those in power in Iran will let any negotiations, threats, or stated agreements to stop their uranium enrichment toward nuclear weapons, despite the fondness of many of their fine citizens for the United States. John Bolton, a former United States Ambassador to the United Nations, has appeared several times in September 2010 on national television warning of the devotion of Iran's despotic leaders to the development of nuclear weapons, showing videos of the mountain sites in which these leaders are safeguarding their nuclear activities. The longer we wait, the more difficult it will be to stop them. Relying on our own abilities to destroy the good citizens of Iran as a counter to their leaders' hatemongering and death wishes for us, is not to me a moral policy. We must ensure the survival of our own families, and not plan to kill the many good and intelligent citizens of Iran, who themselves are severely limited in their freedoms and persecuted by their leaders. All of my graduate students who came from Iran have been fine and intelligent people.

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1 Dr. Marcel Barbier (Ph. D., Electrical Engineering, Swiss Federal Institute of Technology, Zurich; Ph. D., Physics, University of Paris), a particle and protection physicist with long-term experience in civil defense and shelter design)

Exhibit 1 shows a sample of news article warning about possible imminent dangers of a terrorist attack, including possibilities of a bomb containing radioactive material ("dirty" bomb). Exhibit 2 shows news articles about the possibilities for terrorists to obtain radioactive material or nuclear bombs. As time passes, the chance that terrorists will obtain and use such weapons against us only increases unless such weapons are destroyed in time, or terrorists are somehow prevented from obtaining them (Ferguson and Potter 2005).

The reasons for every citizen to prepare for possible attacks by terrorists with weapons of mass destruction may also be reinforced by examination of Jerry Strope's (Strope 2007) web site of the Strategic Defense Initiative, www.strategicdefense.org.[2] The January-February (2008) issue (ASDA 2008) of his concise newsletter includes the repeat of an article (Schultz et al. 2008) in the Wall Street Journal. The authors of this article, the noted previous high government officials George Schultz, William Perry, Henry Kissinger, and Sam Nunn, provide a summary of current dangers of nuclear proliferation and their efforts to reverse current trends. Just a few quotes from this article will further indicate the reasons for my continued concerns:

> "We face a very real possibility that the deadliest weapons ever invented could fall into dangerous hands."
>
> "With nuclear weapons more widely available, deterrence is decreasingly effective and increasingly hazardous."
>
> "These smaller and more portable nuclear weapons are, given their characteristics, inviting acquisition targets for terrorist groups."

We see and hear every day how we are working through the United Nations to get the leaders of Iran to stop their work toward development of a nuclear weapon. Did thirteen United Nations sanctions of Iraq convince Saddam Hussein to allow inspectors to determine the status of his weapons of mass destruction? Did negotiations prevent North Korea from obtaining nuclear weapons?

Should we not wonder whether any negotiations or sanctions will really be effective in stopping Iran's development of an atomic bomb? We have initiated discussions with representatives of Iran's leaders, but can we believe whatever they say or promise, when their President tries to refute truths that all of us know from our own family soldiers and survivors who witnessed the holocaust? Iran's nation is controlled by extremists whose religious beliefs, certainly not mainstream Muslim, determine them to destroy not only Israel, as proclaimed by their front man who is called President; we can see the hatred of America that they are instilling in many youth so that they can also destroy democracy throughout the world and eliminate all other religious beliefs and the freedoms we take for granted.

Our nuclear armaments will not protect us if we do not ensure the destruction of their nuclear capabilities. A retaliatory attack on the good Iranian people, many of whom I have known, would add just another global sin to any attack on us. I am afraid that the United States citizens in their anger would just set off nuclear attacks that would only kill the good populations of Islam, not the despots who are causing all the trouble. In order to avoid this, we need to prepare to survive any radiological or nuclear attack and remain level-headed enough to preserve our nation and take only appropriate retaliations, regardless of our degree of suffering. The President of Iran is trying to draw out discussions, while surreptitiously building nuclear capabilities, by claiming that it is fair for Iran

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2 Unfortunately, Jerry, one of the last remaining stalwarts of civil defense research and administration, passed away in October 2010 at age 92. Attempts are being made to keep active his website of articles on foreign affairs and national defense.

to have nuclear capabilities if the US has them and has used them. Nobody should be fooled by such arguments. We must remember that our use of nuclear weapons was only to save millions of lives, including many in the Japanese population who would have died in a continuing war. And then, we did not destroy Japan and Germany, but instead helped their populations to get back on their feet, keep their cultures, and develop nations that provide their citizens with more freedom, not less, and a better life.

It is the intentions of Iran versus the United States that must be seen as the difference that makes imperative the prevention of Iran's leaders' obtaining nuclear weapons. Israel cannot do it alone, as many have suggested. Also, it is erroneous to think that the world will be less favorable to us if we destroy Iran's nuclear facilities. Neither Syria nor the rest of the Arab world hated Israel any more (if it could) after Israel destroyed the Syrian nuclear facilities. Quietly, the rest of the Arab world, and everyone else, was thankful. They would also be quietly thankful to us if we prevented the despotic present rulers of Iran, who enslave their peoples, from obtaining nuclear weapons. If we do not prevent Iran or other unstable nations from obtaining nuclear weapons, as many think we cannot do, then our citizens must be prepared as described in this book to provide maximum immediate protections for themselves, and avoid destructive fear and panic. Both efforts, prevention of a nuclear Iran, and preparations for our own public protection, must be pursued at the same time in this troubled world.

October 20, 2007
The Washington Post

Homemade Bombs Pose Rising Threat, Say FBI, DHS

BOMBS, *From A1*

Los Angeles Police Department's bomb squad, which responds to about 1,000 calls a year, has 28 full-time explosives technicians and is about to move into a new, $8 million downtown headquarters. The squad has an explosives library, a research facility for testing, and access to an explosives range for training.

In contrast, the D.C. police bomb squad's 10 technicians handle about 700 calls a year but are housed in portable trailers, and must also perform crime patrols. Alone among the six U.S. metropolitan regions considered top terrorist targets, the Washington-area has not earned the top rating of DHS's three-level scoring system for bomb squads, although regional officials recently decided to spend $7 million in federal grants to buy equipment to lift that rating.

Experts and officials have struggled in reaching a consensus that the government should invest more in efforts to detect and disrupt bomb plots in advance, and not just buy equipment and training that could keep specific devices from exploding in metropolitan regions or reaching other targets.

January 4, 2010
The Washington Post

MONDAY, JANUARY 4, 2010

THREAT

From page A1

Mr. Abdulmutallab, who held a U.S. visa, has been linked to a branch of al Qaeda in Yemen. Last month, his father, a prominent retired banker, went to the U.S. Embassy to report that his son had expressed radical views and was worried about his plans. The embassy alerted Washington and the son's name was logged into a database of more than 500,000 people, but he was not put on the "no-fly" list of 4,000 people or another list of nearly 15,000 people who are stopped for additional screening when they try to board a plane.

January 6, 2010
The Washington Post

Obama: Security agencies failed

'THAT'S NOT ACCEPTABLE'

Bomb attempt was preventable, he says

BY KAREN DEYOUNG AND MICHAEL A. FLETCHER

President Obama said Tuesday that U.S. intelligence agencies could have prevented the attempt to bomb an airliner on Christmas Day, and used a grim and forceful White House statement to demand rapid improvements in efforts to protect Americans from attack.

"This was not a failure to collect intelligence," Obama said after meeting with senior national security and intelligence officials, "it was a failure to integrate and understand the intelligence that we already had. . . . That's not acceptable, and I will not tolerate it."

Exhibit 1: Prevention

EXHIBIT 1 — News Articles Showing Continued Vulnerability to Explosive Devices, Including Those Containing Radioactive Material.

January 25, 2010
The Washington Post

Officials fear lethal use for faux Botox labs

Black-market factories could produce deadly form of toxin for sale to terrorists

BY JOBY WARRICK

In early 2006, a mysterious cosmetics trader named Rakhman began showing up at salons in St. Petersburg, Russia, hawking a popular anti-aging drug at suspiciously low prices. He flashed a briefcase filled with vials and promised he could deliver more — "as many as you want," he told buyers — from a supplier somewhere in Chechnya.

Rakhman's "Botox" was found to be a potent clone of the real thing, but investigators soon turned to a far bigger worry: The prospect of an illegal factory in Chechnya churning out raw botulinum toxin, the key ingredient in the beauty drug and one of world's deadliest poisons. A speck of toxin smaller than a grain of sand can kill a 150-pound adult.

No Chechen factory has yet been found, but a search for the maker of the highly lethal toxin in Rakhman's vials continues across a widening swath of Eastern Europe, the Middle East and Asia. U.S. officials and security experts say they know the lab exists, and probably dozens of other such labs, judging from the surging black market for the drug.

Al-Qaeda is known to have sought botulinum toxin. The Lebanese Hezbollah movement, which the U.S. has designated a terrorist organization, and other groups have bought and sold counterfeit drugs to raise cash. Now, with the emergence of a global black market for fake Botox, terrorism experts see an opportunity for a deadly convergence.

"It is the only profit-making venture for terrorists that can also potentially yield a weapon of mass destruction," said

BOTOX CONTINUED ON A4

November 29, 2009
The Washington Post

PAKISTAN

Zardari cedes control of nuclear arsenal

Pakistan's president relinquished command of the country's nuclear arsenal Saturday to the prime minister, a political ally, as he faces growing pressure to resign.

President Asif Ali Zardari's office said the decision to transfer control of the National Command Authority to Prime Minister Yousaf Raza Gillani was a step toward ceding sweeping presidential powers that had been adopted by Zardari's predecessor, Pervez Musharraf. The authority comprises a group of top military and political leaders who would make any decision to deploy nuclear weapons.

February 7, 2010
The Washington Post

Gates skeptical of Iran's claims about nuclear deal

BY CRAIG WHITLOCK

ANKARA, TURKEY — Defense Secretary Robert M. Gates on Saturday played down assertions by Iran that it is ready to reach a deal on its nuclear program, saying Tehran's overall response to overtures from the Obama administration has been "quite disappointing."

On Friday, in a speech at a security conference in Munich, Irani-

MONDAY, FEBRUARY 8, 2010 The Washington Post

Iran set to produce more potent uranium

Ahmadinejad's order could spell trouble for nuclear deal with West

BY THOMAS ERDBRINK AND CRAIG WHITLOCK

TEHRAN — Iranian President Mahmoud Ahmadinejad on Sunday ordered the production of higher-enriched uranium — significantly beyond the levels of its regular nuclear fuel — prompting the United States to renew threats of carefully targeted sanctions.

Exhibit 2: Materials

EXHIBIT 2 — Articles Indicating Potentials for Terrorists to Obtain Radioactive or Nuclear Material.

This is a very small sample of many articles seen by the public.

We also know that many of these nations whose citizens are calling for our destruction are governed and brainwashed by dictators who hate our democratic governments and ways of living; examples of democratic government observed at close range or internet by their citizens would threaten their reign as dictators. Some of these dictators, if replaced by truly elected leaders, would lose their rights to enjoy as many wives and concubines as they wish to force into their harems, would lose their rights to siphon off much of the wealth of their nations for their families, and would lose the ability to pass on their powers and riches to their offspring and other relatives. We can understand why these dictators would prefer that we and other democratic governments cease to exist, and thus spread hate propaganda against us in their self-controlled media.

Of course, some of these dictators have now realized they must moderate their support for some of the extreme clerics or jihadists. They themselves have been subject to assassination attempts, and some assassinations, when they have not conformed to the extremes of some of the clerics. Also, rivalries for power have also resulted in assassinations. Osama bin Laden was estranged from his own family and banned from Saudi Arabia after he called the Saudi King a heretic, qualifying him for assassination. He declared war on the United States in 1996, when at the time he actually had only a few dozen of his own followers. (Wright 2006)

We also know that some of the nations that would support terrorists either already have nuclear bombs, or might be expected to have them within the next few years. Inspectors of the International Atomic Energy Agency (IAEA) tell us that this is possible, either from their own observations or from the fact that they have been prohibited from making some of their desired inspections. Recent intelligence reports that other nations are far away from obtaining nuclear bombs are based on uncertain information given to inspectors by belligerent nations that are intent on, and expert in, deception about their hidden nuclear programs. Strope (2007) reports that the recent National Intelligence Estimate (NIE), which indicated that Iran had ceased development of nuclear weapons in 2003, only says, "We judge with **high confidence** that in the fall 2003 Tehran halted its nuclear weapons program." What was not clear in the unclassified summary of the NIE was that the NIE estimate was not a determination based on certainty. The covert program may well have been halted in 2003 after Iran saw the invasion of Iraq as evidence of international resolve to halt terrorism. However, uranium enrichment has continued, with the possibility that it could continue all the way to enrichment to bomb-grade material. Strope's report indicates that only a tiny circle within Iran's regime possesses certain knowledge of Iran's current nuclear weapons program. In the meantime, Ahmedinejad has announced in February 2010 that Iran is now a nuclear nation.

Also, in regard to North Korea's agreement to dismantle the nuclear reactor that produced material for its first nuclear bomb and to end its uranium enrichment program, as of early January 2008 the documents requested by President Bush to ascertain that the agreements of North Korea to end its nuclear weapons program were neither complete nor accurate. North Korea signed an agreement in 2005 to end its nuclear weapons program at the six-nation talks in the summer of 2005, but walked out of the next meeting in which schedules were to be planned to implement the agreement, when conflicts about the scheduling reached an impasse. No further meetings were scheduled in 2006, and in October 9, 2006, North Korea conducted its test of a 1 kiloton nuclear bomb. Although some called this a "fizzle" compared to the bombs that devastated Hiroshima and Nagasaki, a 1 kiloton bomb could result in a serious loss of life if detonated in a population center by a terrorist (Auxier 2004), and could disrupt economic and human activities in such a center for a long period of time. The US and other countries condemned the test and the UN Security Council passed Resolution 1718 on October 14, 2006, requiring North Korea to refrain from further nuclear or missile tests, to rejoin the Nuclear Non-Proliferation Treaty, and to abandon its WMD and missile programs. After some further impasse, North Korea agreed on February 13, 2007 to begin implementing the denuclearization agreement of 2005. IAEA inspections in July 2007 verified the shutdown of the Yongbyon reactor facilities. The disabling of these facilities has not yet been completed. While Back Jong-chun, a key South Korean official, said he expected North Korea to easily meet its pledge to disable the reactor by the end

of 2007, this has not occurred and the complete abandonment of North Korea's nuclear weapons program has not occurred (Strope 2007). In fact, we now know that North Korea has continued development of nuclear weapons, has detonated some in nuclear tests, and continues to develop missiles for their delivery.

Before his visit to Iraq after the fall of Saddam Hussein, I talked with Dr. David Kay, the scientist appointed by President George W. Bush to lead the mission to find the WMDs that Dr. Kay had assumed were likely hidden by Saddam Hussein from his previous inspections. I visited with Dr. Kay when he was employed in McLean, Virginia, by the same company where I was employed. I was impressed by his scientific achievements and his down-to-earth honesty. His opinions about the expertise of Saddam's scientists in hiding such WMD weaponry were widely reported in print media before his team's latter inspections after the fall of Saddam. This fact can be checked. His honest statements about not finding the WMDs after Saddam's fall from power do not erase the facts about his earlier opinions; they also indicate that President Bush would not have appointed someone like Dr. Kay if he had wanted to bias the findings.

Anyone who cares to examine Dr. Kay's reports will find that he did not assert that the President was attempting any deception; only that the inspections did not reveal the evidence of WMDs. Dr. Kay did not assert that these weapons had not existed, or were not planned by Saddam. Do we really know that such WMD were not passed over the border to some other nation supporting terrorism? Have there been effective inspections in such border nations? Is there really any doubt that some of these dictators would slip nuclear bombs into terrorist cells that could not be identified with the origin of these bombs? Many others have asked these questions. Some of these dictators have assisted Al Qaeda and their allies in attempts to take over other Middle East nations, ultimately construct a fundamentalist Caliphate covering the Middle East and Asia, and then again further attack Europe and America (Lewis 2003; Wright 2006; McConnell 2008). I would not want to risk the error of assuming that these bombs will not fall into the wrong hands and not be used on us.

Because we are a free nation, we will never, even with our best efforts, be able to ensure that a terrorist with a weapon of mass destruction (WMD) could not enter our country; we can never guarantee against such an attack (Ridge 2009). In order to guarantee minimum, rather than maximum, killing in the event of an attack with WMD, it is to that end this book is dedicated.

Guaranteeing minimum effect of a WMD attack requires that we face up to this possibility and prepare ourselves as we attempted to do in the days of the cold war and the civil defense programs related to possibilities of hydrogen bomb attacks. However, going back to such thoughts does not make for happy moments, and I believe that many of us would rather believe that somehow WMD attacks on us will never really occur. In my own case, I am by nature just another happy American, usually focusing on the good life in my retirement years, preferring to play tennis and enjoy happy occasions with my wife and family. Writing this book has not been a joyful experience, and has required overcoming mountains of procrastination.

However, thinking back to my many opportunities has made me obliged to share experiences that might save life in the event of an attack. My experiences include: recovering instruments in high intensities of radioactive fallout as a scientist on the early hydrogen bomb tests; training responders in fallout fields at nuclear tests in Nevada as a physicist and Radiological Defense Officer with the Federal Civil Defense Administration in 1956-57; managing and evaluating patients accidentally exposed in the growing nuclear industry of the 1960s to inhalation of plutonium, americium, and fission products as Technical Director of the Radiation Medicine Unit at University of Pittsburgh Medical Center; and in other positions involving radiation emergency response leading up to being the first chairman of homeland security for the Health Physics Society after September 11, 2001. These experiences have informed me about the dangers of exposures to radioactive material at high levels and how to reduce them. The ways of estimating and minimizing radiation risks under accidental or attack conditions are probably more

real to me and are more often among my conscious concerns. My experiences and my current discussions with responders and the public also tell me, unfortunately, that responders and the public are still largely uninformed today about radiation matters and ways for their own protection and avoidance of panic.

Although most of the thrust of this book is in regard to protection against radioactivity dispersing weapons, there is also material in Chapters 6 and 7 regarding information about chemical and biological weapons. We have known of the existence of these weapons, and the possibilities of their finding their ways into terrorist organizations or the hands of disturbed individuals from the use of anthrax in the attacks against Congress, and the subway use of botulinum toxin in Japan by the Aum Shinriko cult. Unfortunately, in the past few years, as a result of the popularity of Botox for the treatment of skin aging and other medical problems, with the toxin used in very dilute concentrations, the availability of underground and widely available sources of the potent form of Clostridium Botulinum (CB) bacteria has increased. Al Qaeda has been known to be trying to obtain CB, as well as other weapons of mass destruction. (Warrick 2010; Mowatt-Larsen and Townsend 2010)

However, the lethality of such agents, when present on human skin in the smallest amounts (smaller than a grain of sand in the case of CB toxin), allow little prospects of immediate personal protection in the case of their effective dispersion other than some of the same protections suggested for limiting exposure to radioactive fallout — seeking immediate shelter before exposure, holding breath or covering face if exposure is expected, and immediately seeking indoor shelter. Yet, some further discussion of chemical and biological agents, and references to further information, will be provided in later chapters.

How I Know the Public is Poorly Informed on Life-Saving Actions after Terrorist Attacks

The remaining sections of this first chapter are not particularly necessary for learning in later chapters the actions that might need to be taken to save life in the event of terrorist attacks. Therefore, they may be skimmed or skipped. The rest of this chapter provides anecdotes and evidence to show, from my own experience as well as from experiences of other colleagues, how the vast majority of the American public has been misled about phenomena involving radiation for decades. In this way, I show my realization that this book has to overcome much misinformation and belief before the facts and recommended protective actions presented would be accepted by many. This material will be of interest to many of my colleagues and others who deal with policies regarding informing the public and preparing for homeland security.

I thus provide documentation about my factual information and some suggestions to colleagues about some communication principles I have learned in presenting radiation information to the public, from my personal experiences as well as from some of the references I cite in the text. I do know that members of the American public are intelligent enough to understand the basic information in this book, and can hope this book will have life-saving impacts in the event of any WMD attack.

My efforts, and those of my best-informed colleagues, to educate the public through the media, professional activities, other writings, and meetings with top government officials, have not borne sufficiently widespread fruit at the public and personal levels. This is not because the citizens are not intelligent, but because adequate and true explanations have not been generally provided to those outside the community of radiation and nuclear scientists. All members of the public need to face the facts about present dangers, and understand what can be done to save lives in the event of terrorist attacks. Life is precious and nobody should die because of ignorance of simple facts and preparations that could save many lives. Some of these preparations could save life in the event of natural disasters. Moreover, if people know the actions they can take after the moment of attack, they will take the proper actions and not panic. They will also retain a resolve to survive and fight back as a nation.

I need here to support with some documented facts and personal experiences about how the public has been misinformed on radiation and nuclear issues. I must also provide evidence of how other honest and outstanding

scientists I know have attempted with futility to provide truths, in an environment where so much misleading information about radiation has reached the public by a media courted by aggressive but misguided scientists; the credentials and accomplishments of such scientists will be found to be absent from professional literature on radiation risks and effects, or will be found to be rejected by many other authors. My statements will be documented for the reader. One of my exhibits will show irrefutable evidence of a personal experience with such misinformation.

CASE 1: A congressional hearing in 1978 about a report on claimed radiation risks, in which the TV journalists covered only the witness claiming findings of harmful occupational exposure, and censored out all of the evidence that I, a former co-investigator of that witness, and other competent scientists presented that refuted the false claims:

On January 9, 1978, I was seated waiting to testify before the House Subcommittee on Health and the Environment (Brodsky 1978b), and watching my former boss Dr. Thomas F. Mancuso, testify about his claimed findings of radiation-caused cancers among workers at the Hanford site at Richland, Washington. I was going to testify against Dr. Mancuso's claims of such findings, only because I knew his methods of analysis, obviously selected by Dr. Alice Stewart, to be defective and his claims to be absurd. It was not pleasant for me to prepare for my testimony, because Dr. Mancuso and I had worked well together for over eight years; I had believed that he was a careful and honest investigator, and we had become good friends.

I had been a co-investigator from the beginning of the Atomic Energy Commission (AEC) Health and Safety Study with Dr. Mancuso and Dr. Barkev S. Sanders when I was on the faculty of the Graduate School of Public Health, University of Pittsburgh, 1964 through 1971, and adjunct faculty through 1972. I had written my part and edited the final version of Dr. Mancuso's first research proposal to the AEC, and with major contributions by Dr. Sanders and input of Dr. Mancuso, all the other proposals and project reports up until the time I left the project. I left the University of Pittsburgh in 1971, having by then taken a position as radiation therapy physicist at Mercy Hospital, Pittsburgh, and Adjunct Research Professor at Duquesne University School of Pharmacy. However, I continued to work with Drs. Mancuso and Sanders in 1971-72 on my own time, without additional salary, until we provided our report to the AEC on the methodology we had developed and some preliminary results (Mancuso et al. 1971), and presented them at a midyear meeting of the Health Physics Society (Mancuso et al. 1972). The methodology had been finalized for an extensive "retrospective-prospective" analysis of large populations of atomic energy workers over the many years since the advent of the Manhattan District during World War II. By the time I left the project in 1972, I had expected that the developed project methodology would be stable and result in a continued unbiased study of AEC worker populations for many years.

A few years before my Congressional testimony, I had been shocked by a presentation by Dr. Mancuso with Dr. Alice Stewart, at a midyear meeting of the Health Physics Society in Buffalo in the latter 1970s. Mancuso and Stewart presented a limited and improperly analyzed case-control study of the Hanford population, claiming to have found radiation-caused cancers in the Hanford worker population. At this Buffalo meeting, the Mancuso-Stewart presentation was followed by a talk by Dr. Sidney Marks, a physician with a background in statistics, together with statistician Dr. Ethel S. Gilbert, who was already, and has continued to the present time, to be one of the foremost statisticians involved in radiation epidemiology. Marks and Gilbert refuted the so-called findings of radiation-caused cancers at Hanford by Mancuso and Stewart. Yet, I was deeply disturbed to find that Dr. Mancuso had, without really understanding statistical methods in human research (which he had admitted to me when I tried to explain the "t test" on an airplane trip), had fired Dr. Sanders several years after I had left the project, and had discarded all of the careful methods and procedures that Dr. Sanders and I had set up for the project, in over eight years of effort on my part and more than 11 years for Dr. Sanders.

I would not have been shocked at all if Dr. Mancuso had found positive evidence of radiation-caused cancers using proper analytical methods; our original intent and all procedures that the Mancuso-Sanders-Brodsky team had developed were focused on finding truths about occupational exposures, including some statistical tests of possible confounding effects of chemical exposures — positive or negative (Mancuso et al. 1971, 1972). A few years after I had left the project, Dr. Sanders was fired and replaced by Dr. Stewart after Dr. Sanders provided a detailed report to Dr. Mancuso in which he concluded there was no evidence of radiation-caused cancers in the Hanford worker population.

Several years after Drs. Mancuso, Sanders and I had reported our preliminary analysis using a limited control population taken from persons listed as siblings on Personnel Security Questionnaires (but not comparing, of course, each employee vs. his own sib, who would be of different age and sometimes different sex) (Mancuso et al. 1972), Dr. Sanders prepared his own report using much more extensive control populations matched by many personal characteristics as well as years of healthy employment. Dr. Sanders discussed hundreds of comparisons in his report and concluded no radiation-caused cancers could be observed statistically in the Hanford population. When I was on the project with him earlier, I had examined his contributions in detail in the process of editing them, and had checked by my own statistical methods the overall conclusions of Dr. Sanders' analyses (Brodsky 1979b). I knew his work to be very careful and unbiased. Dr. Sanders had also developed some unique methodologies of his own for collection and analysis of morbidity as well as mortality data. He had retired from many years as a statistician at the Social Security Administration, and was particularly helpful in obtaining, according to confidentiality requirements, worker records of service as well as other data used in examining morbidity as well as mortality.

I was extremely disappointed to find that Dr. Mancuso had fired Dr. Sanders after his findings, discarded our carefully developed methodology, and adopted Dr. Stewart's improper methods. I felt obligated to set the record straight before congress, preparing testimony on my own time without feeling it proper to request concurrence of superiors at the Nuclear Regulatory Commission; my knowledge of this matter preceded my joining the NRC and was independent of my work there.

Toward the end of Dr. Mancuso's testimony, the committee chairman asked him, "Who is this Dr. Brodsky who is following you with his testimony?" Dr. Mancuso replied something like, "He is a competent health physicist who was an investigator with me for many years." I thought to myself, "What would he have said if he knew how I was going to testify?"

I noticed to my chagrin that after Dr. Mancuso concluded his testimony, again having used the improper statistical methods of Dr. Stewart to claim findings of radiation-caused cancers, that the TV camera men disassembled all camera lights and left the hearings, not interested in covering or reporting my testimony, nor any other testimonies of the number of scientists who would, after me, refute the claims of Dr. Mancuso. I had planned to present my testimony with some degree of justified drama, hoping that both the congressmen and the media would sense my serious concern about Dr. Mancuso's methods and claims.

Although I was scheduled to testify immediately after Dr. Mancuso, an epidemiology professor from the University of Pittsburgh, whom I knew, interjected that he had to catch a plane and insisted that he testify next. So he was called up before me.

When I was called to testify, the House committee members, particularly the chairman, asked me many questions about the Mancuso testimony, and I had adequate time to answer and present my views, in addition to my written testimony (Brodsky 1978b). One statement I emphatically made was to raise my voice, point over to Dr. Mancuso, and point out the lack of any attention to the chemical exposure data we had collected during my work on the project. I said something like, "Neither did Dr. Mancuso in his present analysis with Dr. Stewart evaluate whether chemical agents of exposure had any effect, positive or negative, on the employees." Then, shaking my finger I turned toward Dr. Mancuso and said something like, "And it was Dr. Mancuso who taught me the

necessity of considering chemical exposures in these studies." Even this little bit of drama I offered still did not attract any media attention, even though it did arouse the congressional investigators and led to a later invitation to testify before a Senate committee (Brodsky 1979a). The TV cameras did not re-appear, nor did they appear for the subsequent testimonies of scientists like Dr. James Liverman and others who refuted the testimony of Drs. Mancuso and Stewart. This is just one example of how you, who are all members of the public, have received mostly negatively biased or incorrect information about radiation effects from the TV news media.

My dramatic and forceful answers seemed to impress the congressmen. I had been concerned that perhaps they might accuse me of contempt of congress, but they did not. They were a group who, themselves, obviously liked to show a dramatic concern for constituents in front of the TV cameras.

Nevertheless, although I felt that my testimony was taken seriously by the committee, I already knew that without the cameras, the public would not hear my views on the evening news. The chairman completed the questions to me by asking a question about another aspect of the hearings. He asked me if I thought that a cluster of six leukemias in an area where fallout had deposited from one of the nuclear tests was "statistically significant." I told him that, as a scientist, I would need to examine all the data on the study before offering an opinion. However, he would not let me off the stand with such an answer, so you can read in my testimony that I eventually threw him a bone and replied something like this, "If all other possibilities have been examined objectively, I suppose that it is statistically significant."

(Little did I know that this hearing in 1978 was to be the basis for a long-term reconstruction of doses to "atomic veterans," the Nuclear Test Personnel Review (NTPR) project, on which I would be employed in the 1997-2006 period of my life at Science Applications International Corporation (SAIC). It completed the circle of experiences in my career when I found that the NTPR files at SAIC not only contained the records of my participation and doses received at the first two hydrogen bomb test in the Pacific, Operations IVY and CASTLE, but also a copy of the originally classified report of CASTLE that included my fission track measurements of spectra and doses versus distances from the ground zeroes of the two hydrogen bombs, with a few words and sentences blanked out in the unclassified copy (Hanscome et al. 1955). The important methods and results were still intact. Although I had been able to publish my methods of neutron spectral measurements with fission threshold detectors (Brodsky et al. 1956, 1958), these publications did not include the classified results of neutron spectra and dose versus distance. After not seeing my classified report since I wrote my section in 1954, I was then in the early 2000s able to check the fact that my neutron doses versus distance were consistent with those that have been summarized in Auxier (2004). I believed at the time of my participation in CASTLE that my project was designed to confirm approximately the measurements being undertaken at CASTLE by the Oak Ridge team, P.N. Hensley and his co-workers, allied with Auxier, who were often our companions in the Pacific Proving Grounds.)

After the hearing session was over, a young reporter approached me who represented the famous columnist Jack Anderson, whose columns appeared in newspapers all over the nation in those days. With pad and pencil in hand, he asked me about my testimony and I explained the basis on which I had rejected Dr. Mancuso's claims. I thought that, "Now, at least the newspapers will report some truths, or at least someone's opinion from the other side of the issue." I thought at least they would want to cover the opinions of someone with a doctorate in statistics and the rank of full professor, who had been Mancuso's co-investigator for over eight years. But no. Jack Anderson's column came out the next day reporting about Mancuso's "findings" of radiation-caused cancers at Hanford. His column mentioned nothing about my testimony, nor about any of the testimonies of all the scientists following me who rejected Mancuso's " findings."

Many years later, at a dinner meeting sponsored by the University President for former colleagues and graduates of the University of Pittsburgh, Jack Anderson was to be the speaker. I chose a table up close to the speaker's podium. Fortunately, although only a few questions were invited, I was called on first. I reminded him of my experience and asked how he assures himself that he is receiving and reports objective views of facts and opinions obtained from his young reporters. He just gave a brief elusive answer about depending on them, and turned his

head away. So, I had the limited satisfactions of finally confronting him, and letting the audience of dignitaries learn of my chagrin about news media bias. There remained still no chance to properly inform the general public. So much for depending on TV news for truths about matters of radiation exposure. Except when full hearings are covered on C-Span today, one can still not depend on objective TV news coverage of radiation issues. Practically all present reporters must have been brought up in an environment of radiation myths and falsehoods.

As Dr. Mancuso's co-investigator, radiation exposure data expert, and writer of his research proposals and reports for eight years, I had been very concerned about the use of proper epidemiologic and statistical methods in the collection and analysis of all aspects of project data. I had been finishing my doctorate in biostatistics and radiation health when I was first employed by Dr. Mancuso in 1964, and continued with him as part of my assignments after my graduation and promotion in 1966 to Associate Professor in the Department of Radiation Health, where Dr. Niel Wald was Chairman. I therefore examined the range of statistical methods used in epidemiologic research in the early years of the project, and decided that an overall chi-square test of the significance of the many t-tests on hundreds of subgroups needed to be made to check the final conclusions of Dr. Sanders' indefatigable examination of two-by-two tables of subgroup comparisons.

For those who have studied some elementary statistics, I offer the interesting outcome of a comparison of results between methods of Dr. Sanders and me in the first trial analysis. Before our first report at a scientific meeting (Mancuso et al. 1971, 1972), I wrote down a formula summing the squares of a statistic expected to follow the t distribution, and thus become represented by a "chi-square" distribution of a variable n degrees of freedom for testing the totality of two-by-two table comparisons. I had an independent programmer write and run the code for this chi-square test of the overall significance of all of Dr. Sanders' two-by-two tests. The tests were run on the same populations used by Dr. Sanders, in order to determine whether any final conclusions of Dr. Sanders, positive or negative, could be accounted for in the random ways that diseases among individuals, other than the ones under examination, occur and mask statistical appearances of selected diseases in populations of given size and composition. For those who know some elementary statistics, a chi-square test is made up of the sum of the squared t statistics that follow the "Student t" distribution (Brodsky 1982c, 1982f). The numbers of degrees of freedom were so large, in the hundreds, that I could not use the chi-square tables, but instead had the programmer program the functions for the chi-square distributions that accompanied the tables (Brodsky 1982f). When Dr. Sanders compared Hanford workers to matched controls, including matching by years of recorded healthy employment, made up from the entire population of workers obtained from the PSQ forms, he found that the Hanford employees had significantly better health outcomes than the controls. This could have erroneously indicated that Hanford employees exposed to radiation were healthier, if Dr. Sanders had wished to report his results that way.

However, cleverly, and showing the extreme caution that he exhibited in all of his work, Dr. Sanders then examined his statistics intensively when only the Hanford workers who had one or more sibs who grew to maturity were matched, including with similar years of healthy employment, in each subgroup to controls from the PSQ forms (who were brothers and sisters and obviously came from families capable of producing two or more healthy offspring). This ensured that members of both the exposed and control populations came from families that bore two or more healthy sibs, each of whom lived to be employed in adult life. Dr. Sanders then found, after examining, counting, and testing all of his many subgroups, that there was not an overall difference in mortality between the two populations of employed persons, those known to be employed in work involving radiation and those not known to be exposed to radiation in their workplaces.

I had the computer scientist run his algorithm of my chi-square formula on the same populations, and found that the chi-square statistic of hundreds of degrees of freedom (the many subgroup comparisons of Dr. Sanders) very dramatically changed to a value far below any reasonable level of significance. (Brodsky 1979b). Thus, my

overall single calculation confirmed Dr. Sanders' overall conclusion from his very intensive examination of all subgroups. This is how I knew that Dr. Sanders' work was not only brilliant but also accurate and honest.

I point this out because it could be valuable in other human follow up studies to realize that it could be important to include the number of sibs reaching healthy adulthood as another human variable in health follow up studies, where an inherited genetic strength passed on in families, as well as their family size preference, requires consideration. Although these findings were reported in the progress reports and at the Hanford symposium, and were later published as peer-reviewed papers in Health Physics, I have not seen any recognition of the phenomenon found by Dr. Sanders in further literature.

Now, the above results do not mean that some tests that might have indicated significant differences in individual subgroups would not be worth some investigation. In any study, both the results of the overall health of study and control populations must be carefully examined, as well as the respective results of subgroups that might have received higher or different work-environment exposures, to avoid the "dilution" effects in the overall examination of differences between large populations. However, even the preliminary analysis with the limited population obtained from the PSQs indicated that there were certainly few, if any, radiation-caused health effects in the Hanford worker population. The management of Hanford, particularly under the control of the eminent medical physicist Herbert Parker, was known to be especially attentive to worker safety. Radiation exposures under Parker's management were maintained as much below recommended or regulatory limits as possible, even in the early years, 1943-1945, of the Manhattan District projects.

Partly because I had already seen that the public would not know of Dr. Sanders's results, nor those of others who refuted Dr. Mancuso, and partly because I thought Dr. Sanders' latter results and my earlier results and methods could be useful to other investigators, I prepared my work for journal publication and urged Dr. Sanders to summarize his work for publication also. For several years after he was discharged by Dr. Mancuso, Dr. Sanders attempted to expose Mancuso's findings and some of his other activities as fraudulent. I cannot know whether Dr. Mancuso's motives were questionable. No one can read another person's mind. I believe that Dr. Mancuso was a person of ethical intentions, who did not understand proper use of statistical methods of research. However, Dr. Sanders had finally washed his hands of the whole matter and moved from Chevy Chase, Maryland, to California, where he went into the real estate business and had a fifth successful career. (He lived an active life in California with his wife, from about age 75 to age 99; I hope to write more about my amazing friend in a later book.) I convinced him to prepare a publication, but he lost interest in answering questions from peer reviewers. So, I convinced my friend, Professor Ronald L. Kathren, who had published many books and papers, to help Dr. Sanders revise and re-submit his paper for publication. Our papers were published in Health Physics, following a publication by Mancuso (Mancuso et al. 1977; Sanders 1971, 1978; Brodsky 1979b). My own paper includes, in addition to my recommended chi-square check and findings confirming those of Sanders, about twenty-five other published reports refuting the so-called "findings" of Mancuso and Stewart. (These references in my paper, and later refutations of Mancuso's "findings," still seem to have gone unnoticed by the public.)

I do not know whether any other epidemiologic studies have considered the specific findings and methods of Dr. Sanders and me. The only value of these publications might be just some degree of relief of conscience. Most senior epidemiologists already have their own methods of testing and computer algorithms in place, and do not have time to examine unconventional approaches in detail. Also, there is some reluctance among some investigators to find, and report, negative outcomes of large, difficult studies, particularly when tests between some subgroups, or only for specific codes of cancer, can be touted to possibly represent significant findings. I have reviewed the matter of the Mancuso-Sanders personal and scientific differences in more detail on pages 148 to 152 in my radiation risk book (Brodsky 1996); I also discuss some other questions about certain radioepidemiological

studies on other pages, in order to reveal additional problems with assertions by Mancuso and others, as well as to present some particular issues about such studies that I think are important.

Apparently, my testimony before the House committee was observed by some Senate staff, because I was then invited to testify before Senator Hart's Environmental and Public Works Committee. I was actually quizzed by a young and very gracious Senator Domenici, when Senator Hart needed to be absent from the hearing (Brodsky 1978b; this date precedes the date of reference of the House hearings because the transcripts were published sooner). (Senator Domenici has published an excellent and well-documented book on the necessary solutions to the energy and global warming crises (Domenici 2004).) In these hearings, I was placed at the table between the Director, Office of Research, Nuclear Regulatory Commission (NRC), Robert B. Minogue, who was several levels above me in the NRC, and to my right the professor of epidemiology who had testified before me at the House hearings. I testified as a private citizen on the basis of my previous experience on the University of Pittsburgh faculty. We were each asked to submit our written testimonies but limit our verbal presentations to five minutes each. There were no TV cameras at this hearing. Minogue asserted that his agency should not be responsible for conducting health studies. The professor argued that health studies should only be carried out by university professors, independent of government. My arguments were that I had been part of a university study that used up about six million dollars and then still resulted in a waste product, under the direction of my physician friend, Tom Mancuso.

I suggested that the NRC should maintain some responsibility for supporting epidemiologic followup of the health of its licensee employees. I suggested that a more objective and successful study of almost the entire population of radiation workers (and similarly for other toxic exposures recorded in industry) should be conducted by a highly competent group of statistical, epidemiological, medical, and health and safety scientists, employed long-term by a government agency, with oversight from a committee made up of independent professors from ten top schools of public health as well as laypersons in workers' communities. I also suggested that the data collection aspects of the studies might well be supported by the existing budgets of industrial hygiene, health physics, and safety management operations in each of the facilities where environmental exposure was possible. We had found early in the Mancuso study that, with appropriate collection and computer recording of exposure data, the same data system used for daily management of safety programs could also be made available for health studies, perhaps with some calculations to estimate exposures more unbiasedly for the health studies rather than just on the high side as for safety operations.

I also made it clear to Senator Domenici my disagreement with the physician epidemiologist, who was sitting to my right that I knew that placing the direction of such studies in a university-based physician could not guarantee proper and unbiased analysis. I have since that time been of the opinion that health studies are too important to be entrusted to physicians alone, unless they also have eminent reputations as mathematical statisticians (some do). After the best coding of causes of death that can be done, the bottom line of health studies deals with the quantitative evaluation and comparison of numerical data, usually stored in large banks of computer memory. Only trained biostatisticians, or other scientists also capable in biostatistical analysis, unencumbered by allegiances to industrial or governmental organizations with an axe to grind, and guaranteed salaries dependent only on their reputations among peers for competent, honest research accomplishments, should be directing the ultimate methods of data collection, analysis, and writing of final reports and publications.

I do not know if my testimonies had any public benefit at all. However, much of the current work on radiation epidemiology is being carried out by an outstanding group of scientists at the National Cancer Institute; many of these scientists having acquired an outstanding reputation lasting many years.

CASE 2: A misleading print news article using my name, distributed after Three Mile Island throughout the nation:

Exhibit 3 of Dr. Ernest J. Sternglass' article grossly exaggerating exposures after the Three Mile Island accident is also characteristic of his statements attempting to convince the public of the futility of preparing for nuclear attacks. He has been very successful in his efforts, perhaps due to the lack of trained scientists employed by the news media, as well as their reluctance to consult the relevant learned societies before publishing scientific scare stories about radiation.

Sternglass has long been one of the most well-known scientists who have appeared in many media, attacking early civil defense efforts to save life, as well as grossly exaggerating the dangers of nuclear power plants. He has also argued in the early years of the civil defense program against preparations to protect against radioactive fallout. My first encounter with him occurred when I questioned his assertions after he attacked the government programs of providing fallout shelters on a panel discussion in the early 1960s. However, I still later recommended to my supervisor, Dr. Niel Wald, that Sternglass be appointed a Professor in our radiation health program within the Graduate School of Public Health at the University of Pittsburgh, after noting his accomplishments in physics and his ideas for reducing patient exposure from x rays. After he became a faculty colleague, I invited him to lecture on the history of physics in some of my courses, and encouraged a group of faculty members to help him obtain support for his research. I also invited him to present some lectures on his early concerns about radioactive fallout, when the fallout over Troy, New York, had indeed seemed to possibly be in the range that might produce thyroid symptoms. However, after being his friend and colleague for a number of years, I realized that it was not possible to bring his studies and claims into the realm of careful scientific investigation when it came to the subject of radiation risks. He would repeatedly come to me with careless "back of the envelope calculations," and run to the press with his so-called unfounded "findings."

Exhibit 3 is a copy I found recently in my files of a news article in which Sternglass claimed that the Nuclear Regulatory Commission (NRC) was playing down effects of the radioactive releases from the Three Mile Island (TMI) nuclear reactor accident. In Exhibit 3, the headline asserts that the government, the NRC, is lying, not telling the truth. My own name, misused by Sternglass to misinterpret my own data and support his contention, can be seen in two of the paragraphs in this article. In this article, he calls me an "expert," which gives me some direct evidence of his lack of scientific ethics and credibility. Yes, I am an expert — on the lack of credibility of Sternglass' exaggerated claims in regard to radiation effects or nuclear power. When I was his colleague at the University of Pittsburgh, Sternglass used to show me many of his "findings" from back-of-the-envelope calculations. I saw repeatedly how Sternglass selected his facts, or manufactured them from half-truths, to prove what he wanted to prove.

I give here one indisputable example. Sternglass mentioned my name in other news articles after the Three Mile Island accident; these articles were similar to that in Exhibit 3. These articles sometimes appeared on front pages all over the United States, and contained the same false references to my own analyses. He did not consult me beforehand, but evidently used for his own reference (not mentioned in the news articles) a paper I had published and given to him in 1965 that calculated effects of a ***full*** *fission product release from the fuel elements in the reactor (Brodsky 1965b). Even preliminary data after the accident indicated that less than one-millionth of the relatively volatile radioactive iodines were released to the environment and far less than one millionth for other radiotoxic nuclides, except the rare-gas xenon isotopes that passed by with the wind (Brodsky 1982e). Very little of rare-gas isotopes are absorbed in the body, and estimates of doses from the passing cloud, although calculated to maximize dose, gave the highest estimates of 100 mrem to anyone at the reactor site boundary, mostly from the external gamma radiation directed from the cloud plume toward ground as it passed by.*

Because I could not get the news media to refute Sternglass' false statements and news reports using my name after Three Mile Island, I published my refutation as part of an article that was already in press (Brodsky 1980a). However,

few members of the public read the Health Physics journal (certainly less than membership of the Health Physics Society; i.e., 6,000/200,000,000 = 0.00003 , or 0.003%, of the US population at that time). Therefore, was not my right of free speech denied in these modern times of news dissemination? Some of my friends around the nation who have read various versions of the article in Exhibit 3 might still think that I was supporting Sternglass' false assertions about the effects of the Three Mile Island accident.

Anyone can obtain the article (Brodsky 1965b) that I had given to Sternglass, and confirm what I am writing here. The article has since been checked and updated in a more recent paper, in which long-term stochastic effects of the estimated 25-rem-equivalent inhaled amount are also examined (Brodsky et al. 2001). In my 1965 article, I presented the effects of full release of many of the most biologically harmful radioactive nuclides, to allow estimates of the effects of a real accident by a later multiplication of each amount of radioactive atom in the nuclear fuel by the fraction actually released. I published my 1965 article to avoid any dangerous underestimation of effects of fission product releases from nuclear accidents; I believed the article necessary to correct what I had thought were underestimates of the radiation effects of such a release in an earlier article by Cowan and Kuper (1958). Thus, a reading of my 1965 paper will show that **I am one of the good guys**, trying to protect the public in the event of a nuclear accident that might release radioactive material to the environment.

Case 3: Another very good guy.

Scientist and esteemed professor of physics Dr. Bernard L. Cohen is now Professor Emeritus, University of Pittsburgh. Among Cohen's books, two have provided to the public in interesting detail the benefits and low risks of uses of radiation and nuclear power as designed and controlled in the United States, as well as the distortions that reach the public about radiation dangers (Cohen 1983, 1992). Although familiar with his many basic contributions to nuclear physics beforehand, I came to know him well when he headed the nuclear physics program at the University of Pittsburgh in the 1960s, particularly after he asked me in 1969 to present a seminar to his students on the uses of physics in radiation protection practice. After the Three Mile Island accident in 1979, I was visiting Pittsburgh one day, already having moved to the DC area as a scientist with the Nuclear Regulatory Commission (NRC). At NRC, I had been asked on occasion to examine Bernie Cohen's analyses of plutonium and other hazards of radiation, and already knew that his work was reliable and honest. When I saw him on a street corner in Pittsburgh, near the University, I had already seen Ernie Sternglass on TV with his false information to the public, in addition to seeing the false articles such as those of Exhibit 3. Knowing that Bernie had previously been able to get some attention from news media, I asked him, "Bernie, how come you did not go to the TV media and refute some of Ernie's lies about the doses from Three Mile Island?" Bernie lamented, "Allen, I gave 83 talks around the country to small audiences, on my own money, but I cannot hope to refute Ernie when he gets audiences of many millions on the news media. I tried to contact the TV stations, but they ignored me."

So, here is one brilliant scientist, who when told of the hazards of nuclear power, decided in the late 1960s to investigate the matters for himself. Despite his many books and papers, his message has still not reached the huge audience that Sternglass and his books have received. Cohen published in one of his chapters (Cohen 1983) a research of records of New York Times articles, showing the tremendous bias and distortions of radiation issues in the print news media, compared to other types of more serious accidents frequently reported to the public. Still, with the limited distribution of his amazing books, only about less than 0.03% of the public have received his messages of truth. Thus, Bernie Cohen's freedom of speech has been denied many times over that of mine, considering his gigantic and continued efforts. That is another reason why, knowing his indefatigable and ingenious efforts, I feel obliged to inform the public of my own experiences in kind.

NRC covers up radiation effects

by Ernest Sternglass

(© 1979 Pacific News Service)

The Harrisburg nuclear power plant accident may have exposed about a million people to up to 130 times more radi ation than the government has reported. And the effects will be far more serious and long-1asting than the Nuclear Regulatory Commission (NRC) has so far acknowledged.

The NRC reported only the external gamma radiation doses received from passing clouds of radioactive gases. It failed to calculate the total and most damaging dose received by organs and bones from inhalation of fission gases. NRC's claim that pure xenon and some traces of iodine 131 were the only radioactive gases released is also misleading and unproven.

The government did not measure the precise composition of the radioactive steam that escaped into the atmosphere at the start of the. Harrisburg disaster.

But there is every reason to believe that the escaped steam contained many radioactive chemicals normally produced by fission. The NRC's Dr. Allen Brodsky, an expert in the field, lists 21 such elements.

Gases inhaled from clouds of radio active steam produce a dose about 130 times greater than that from external gamma radiation, according to Brodsky. He bases this calculation on data from earlier nuclear accidents and during nuclear bomb tests carried out in the '50s and '60s.

The NRC says that maximum accumulated doses were 80 millirems in the week following the Harrisburg accident, but true maximum doses to the lung may have been as much as 10,000 millirems. Doses to bones from elements ineluding Strontium 89 and 90, which are decay products of the rare gas krypton, are about 30 times greater than what is absorbed by external gamma radiation.

Strontium 90 was not only released during the accident, but is also emitted during normal operations of nuclear power plants, as are cesium 137, berium 140 and larger amounts of xenon and other, chemically inert gases. Official publications of the NRC list these elements among annual radioactive releases into air and water.

Krypton and xenon are the most common radioactive fission products. The NRC has told the public the emissions contained mostly these inert gases which do not necessarily produce the greatest biological damage. However, official statements have generally failed to point out that these elements decay into more hazardous materials, including cesium, berium and strontium.

Strontium 90 has been regarded by the scientific community as the most toxic of all fission products of nuclear testing. It collects in the bones and can cause cancer and leukemia. It has a half-life of about 30 years and, like other radioactive isotopes produced in the fission process, lingers and builds up in soil. It may present a hazard in food grown near Three Mile Island.

In the past few months, however, the NRC has issued new regulations that will no longer make it necessary routinely to report the level of strontium 90 in local soil and milk

Failure to consider strontium 90 and other decay products emitted during the Harrisbuig accident is a coverup of the damage done. It is further evidence that the NRC is primarily concerned with protecting the nuclear industry.

The health hazard has also been discounted by other federal officials. Last week, Joseph A. Califäno Jr., Secretary of Health, Education and Welfare, told the Senate health subcommittee that leaked radiation was not expected to cause a single cancer death among the people living within 50 miles of the plant.

Yet even using only the external do ages that the NRC has reported—2 millirems to a population of about a million within 50 miles of the plant—between 0 and 50 cancer deaths can be expected, according to Dr. Karl Z. Morgan, former director of the Oak Ridge National Laboratory's health civics division.

But if the unreported exposure from inhalation is also considered, 300 to 2,500 cancers may develop in the next 10 to 20 years. Other health effects can be expected to include genetic defects and physical and mental retardation among the newborn.

Officials have repeatedly compared radiation doses at Harrisburg to those received during dental x-rays. This is a completely deceptive attempt to minimize the exposure. A dental x-ray is confined to a couple of inches of relatively insensitive area. At Three Mile Island, the whole body is exposed. Furthermore, the dental x-ray is over in fraction of a second while the inhalation of strontium 90 will irradiate thc bone and marrow for many decades after the individual has been exposed. It will also affect an infant developing in the, mother's womb, possibly years later. This is not true of dental x-rays.

The Harrisburg health hazard is far from over. There will be continued emission of radioactive gases from the plant over many months and possibly years as radioactivity is removed from the plant

To protect the population, we should insist that all animals that produce food or milk be fed imported seed and hay until the full extent of the contamination is established. This should continue for some time while rain washes radioactive elements deeper into the soil and into rivers and ocean and diminishes the levels in grass that serves as local seed. ■

Ernest Sternglass is a professor of radiological physics at the University of Pittsburgh School of Medicine and the author of Low Level Radiation (Ballantine).

EXHIBIT 3 — One Example of Many News Articles That Misused My Name and Misrepresented My Findings, and Which Was Circulated Throughout the United States by Ernest Sternglass After the Three Mile Island Nuclear Power Plant Accident

This article was circulated by the Associated Press in 1979 soon after the accident. Note that mention of Sternglass' book, *Low Level Radiation*, at the end of the article has also given him much undeserved publicity; his articles and publications regarding radiation have been generally refuted by the scientific community and were disreputed in a statement by past presidents of the Health Physics Society (Moeller 2001).

An appearance of Dr. Ernest Sternglass on national TV news after the TMI accident

Sternglass appeared on national TV news at prime time, 11 p.m. Saturday night, several days after the initiation of the TMI meltdown. His hysterical warnings caused even many of the physicians and chairmen of departments in the Hershey Medical Center to evacuate with their families, even though no serious radioactive material had been emitted for days. The short appearance of Dr. Morton Heller, giving a more rational report on the accident, was put on the TV program only for a minute or so near the end of the news at 11:30. I had watched this news from the home of Kenneth L. Miller, a faculty member of Pennsylvania State University, who was responsible for managing any contaminated workers who might arrive at the University hospital from the accident. None arrived, and on Monday, Ken had me talk to the medical staff about the need to remain calm, and the likelihood that they would be safer just staying in the hospital. (I noted in the previous section how the TV media had ignored Professor Bernard Cohen's offers to inform the public.)

Thanks to misleading statements to the press like those of Sternglass, the TMI accident and the ensuing exaggerated press coverage in the late 1970s caused unreasoned fear of nuclear power, and a cessation of construction of new nuclear power plants in the United States (while at the same time France expanded to 80% nuclear power using some of our inventions). My publications in the References will show that I was an early advocate of environmental protection. My later paper confirming my 1965 estimates of effects of exposure to accidentally released fission products (Brodsky et al. 2001), checked my earlier 1965 hand calculations using more recent computerized data available from the national nuclear physics data center (as provided independently by my co-author Dr. Dudley Raine), and used updated literature on the biological effects of radiation.

Sternglass' headline was absurd and effectively as bad as a lie in itself, perhaps even worse because he supported it with scientific-sounding discourse. Whether Sternglass realized it or not, he was effectively the liar, not the government. After the TMI accident, measurements on air filters indicated that less than one millionth of the volatile radioactive iodine compounds were released (Brodsky 1982e). Yet, although I received seven copies of articles by Sternglass, similar to that in Exhibit 3, from friends and acquaintances around the nation, the press would not print my refutations, even though Sternglass had used my name and called me an expert. So, I explained in a submission to an article already in press, how wrong Dr. Sternglass was and how nobody in the public would likely have been harmed even if all elements in the nuclear fuel had been as volatile as iodine (Brodsky 1980).

Yet, over the years since then, Sternglass, and other eloquent but ill-informed scientists and physicians, have received the major portion of media attention. Only colleagues in the Health Physics Society and other professionals in fields of nuclear science and safety have had access to my 1965 and 1980 articles. This is probably because the media do not usually hire scientists to filter their writings, and are likely to pay most attention to those who make alarming, attention-getting, headline material for the news media. I would always defend the rights of media for freedom of the press and the protection of their sources. However, they nevertheless need to exert more responsibility to report the truth. Much more attention and oversight is needed to ensure responsible reporting in a democracy where facts influencing public opinion are important in voters' views on important public policies. But for the misinformation presented to the public about radiation issues, we might today be much better prepared for radiological attacks, and have had an expansion of safe nuclear power after Three Mile Island that incorporated the many lessons learned from that event. Such an expansion would have already reduced carbon dioxide emissions to a level per person of that achieved in France, and contributed a great decrease in the vast pollution from carbon burning (Cravens 2007). It would also have greatly reduced our dependence on foreign oil.

I cannot know exactly why Sternglass, after many discussions with me and refutations of his work by reputable scientists over the years (Stannard 1988, pages 1016 to 1025) (including a rebuke years ago by past Presidents of the Health Physics Society), continued to distort information about radiation exposures and effects. One cannot read another person's mind. I know him to be quite capable, and even brilliant, in his accomplishments in other

areas of physics. One of my doctoral students, Dr. Shlomo Yaniv, once said to me, "I do not argue with Sternglass; with him it is a fanatic religion to hate nuclear phenomena, and I do not argue religion with people." It is also difficult to understand the motives and beliefs of others of eloquent talent who have distorted facts about radiation that make it difficult to prepare the public for its own protection.

CASE 4: Unfair and inaccurate impressions created by TV programs purporting to present "both sides"

Even when the media try to be fair and present "both sides," they might not realize that the argument is still not fair when they put a seasoned myth deliverer against only one scientist from the other side who might not be experienced with media appearances to refute unexpected statements from his opponent. Moreover, the public likely sees the debate as an even one, one person on each side of the argument, not realizing that there are many more scientists expert in the subject matter who would refute the myth propagator than there are who would support him. This fact can be verified by anyone who would take the time to examine the number of peer reviewed papers in the literature on one side and the other. Of course, most members of the public would not be able to review such literature, so scientific truth is at a big disadvantage when the media do not realize such facts. The media really need scientific review boards to assist them, overseeing scientific articles written by appropriate science journalists. (Of course, we might never see such a system in our time.)

One TV experience of my own can illustrate this problem. I appeared on a popular Miami TV program on prime time one Saturday evening not long after the Three Mile Island accident, having been asked by the show producers to present opposing views to those of Dr. George Wald (not a relative of, and not to be mistaken for, my former department chairman, Dr. Niel Wald). Dr. George Wald was a Harvard Professor and winner of the Nobel Prize for having discovered the importance of carotene in the biochemical processes of vision. Not having been on a TV interview for over 17 years, I had no idea how to approach my participation. I had brought with me a copy of Dr. Petr Beckmann's book (Beckmann 1976) on *The Health Hazards of Not Going Nuclear* to show to the audience. (Dr. Beckmann had asked me to substitute for him on this show so he could grade final exams.) I also had asked about 10 persons in the Miami area, all new acquaintances except for a male and a female cousin who were brother and sister, to see the program and critique my performance. As I remember, the name of the TV program was something like, "To the Point." One of the co-stars and producers was in support of nuclear power, the other was opposed. I was to back up somehow the pro-nuclear woman; Dr. Wald was to be the anti-nuclear-power scientist. (I did not ask my supervisors at NRC to approve my TV appearance; I appeared on my own time. I felt it important that someone should stand up against exaggerations of risks that could preclude even the most beneficial and safe uses of nuclear technology.)

When I arrived at the studio, I was invited to wait in a conference room with Dr. George Wald for the program to begin. Dr. Wald was wearing college-student attire, even with his grey hair, and had been touring the nation giving many speeches at colleges about the supposed dangers of nuclear power. My co-star, a charming woman co-producer and opposing voice to her anti-nuclear co-producer, simply greeted me, showed me to my chair to wait in the conference room, and left the room; I did not receive any instructions or guidelines, except that she said to speak up so I could be heard. My wife had previously told me, before I had left home, not to be emotional or loud, so that I could appear "professional." Dr. George Wald and I had a friendly chat for about 20 minutes until we were escorted into the studio minutes before the program.

Soon after the program began, I realized that there were many ways in which I could be interrupted while trying to make a point: interruptions from either of the co-stars of the program; advertisements that would come on at unpredictable moments; telephone calls that would come in with questions from local TV viewers; and a continued flow of anti-nuclear myths from Dr. Wald. Dr. Wald had what seemed to be an infinite number of sound-bite myths that flowed easily from his polished tongue. Not only was he presented as a Nobel Prize winner

from Harvard, while I was introduced as just another scientist from the government; he had just come back from a nation-wide speaking tour while his research laboratory was under reconstruction.

After realizing that I was making no contribution to the program at all in the first ten minutes, and realizing that I could not logically refute Dr. George Wald's sound-bite myths in unpredictable short bursts of time, I decided to discard my quiet manner and tried some more aggressive and emotional, but measured, responses to Dr. Wald. Still, by the end of the program I felt that I had earned at best a C- for my performance, if not lower. The program directors thanked me, and I went on my way to rest for the night at my hotel.

The next day I called eight of the people whom I had asked to watch the program. They had about an even view of who was more believable, Dr. Wald or I. It seemed that the views of each were rather in line with their opinions before the show. Then, before returning home to Maryland, I visited my two cousins. Maury Rayman, my cousin the trial lawyer and politician told me, "You did great when you finally spoke up!" Later, when I visited his sister Sylvia, she said, "You were fine until you showed too much emotion." I told her that her brother Maury had thought I did well when I spoke up with some emotion. Her response was something like, "Oh, he's just a big-mouthed trial lawyer." Thus, in the views of those I had planted to watch me, I came out about even. No progress was made in the direction of truth by my appearance. Does this earn me a C? Is it fair to put an inexperienced presenter, introduced as a scientist from the government, against a professor with a Nobel Prize?

Some Lessons Learned from TV Appearances

A lesson learned from my few TV experiences was better amplified and explained when I took the courses from Ray Johnson in the early 1980s. The lesson is that different individuals have different preferences for communication — receiving and interpreting information. I took Ray's Myers-Briggs Type Indicator tests with classes of other health physicists, and results showed not only the variations of communication style between those of us in the class, but also the sharp differences between the range of styles of health physicists (or scientists) as a group and the styles of members of the general public. Even individual members of the general public will differ from each other. Johnson continued these courses over many years, and his results have been published for use in public communication of radiation issues in his four chapters (Johnson 2004a, 2004b, 2004c, 2004d).

For readers who might want to become more active in volunteer or professional efforts to support homeland security, there are additional lessons about ways to interact with the media and audiences in the excellent chapter by Karam et al. (2004). Before going into many useful suggestions, obtained from a number of media performers, their chapter lists the following brief suggestions that can be remembered (I have changed a few words to make the points broader):

- **Summarize:** Summarize your main points and relevance in 30 seconds or less.
- **Headlines:** Picture your words as a headline in tomorrow's newspaper.
- **Address:** Address the reporter (or audience) as you would a smart interested teenager.
- **Release:** Release control of the story once the reporter has it.
- **Point:** Think of your main point ahead of time and repeat it often in the interview.

Note that the boldface words begin with letters that spell "sharp." The advice is to be sharp.

From the above TV experience, and other presentations to public audiences, I would add the following suggestions to the sharp points:

- **Study:** Study your audience or interviewer while you talk by noting eye movements and body language. Estimate their communication styles having studied Johnson's chapters.
- **Head:** Keep your head up, maintain good posture, and look at the audience. I had to laugh at myself in viewing the tape of the Miami program. Much of the time, the lights shined from my bald-looking head right into the camera.
- **Act Out:** Do not shout like some famous dictators. But show some emotion and caring about audience concerns. The public audience sees properly measured emotions as caring; inanimate scientists appear to many to be "cold fish." However, balance your acting out with quiet listening to concerns and questions to bring out those concerns, as discussed in Johnson's chapters.
- **Reply:** Reply to statements that you believe erroneous. If time is likely to be short, simply say, "That is absolutely wrong," or "Given time, I could prove otherwise." Make your points with an air of conviction and authority.
- **Posture:** Posture yourself as being also a member of the public, with family and friends you care about, exposed to the same environmental pollutants as everyone else, but also make known your expertise by referring to a research experience or qualification that supports each point. I realized only after the Miami TV show, that I was introduced only as a scientist from the government, while Dr. Wald was introduced as a Harvard professor and Nobel Prize winner. Who must have then seemed more credible?

Lessons Learned About Changing Views by Giving Public Talks

Soon after that TV appearance, I was a participant in a panel discussion presented to over 200 members of the League of Women Voters in Cleveland. I had presented my assigned talk on how comprehensively nuclear reactors were examined for safety before they were licensed. I had been assigned to give this talk by a Nuclear Regulatory Commission Office Director, Robert B. Minogue, when he was unable to appear himself, even though I was not involved directly with reactor licensing. I presented the slides that had been given to me, discussing the stages of review that the NRC conducted before licensing a reactor. Then, the other presenters, including anti-nuclear-reactor speakers, presented their talks. The anti-nuclear speakers included a tall, thin man who was a high school science teacher; he was joined by another presenter who was a young woman recently graduated from college. One of the speakers was Dr. David Waite, whom I knew as an active member of the Health Physics Society and who would later become its President. David was the one who talked about the safety aspects of nuclear waste disposal. The anti-nuclear speakers brought out the usual barrage of myths exaggerating nuclear power and radiation risks.

During the question session after our presentations, I was handed a card from the audience with a question about nuclear waste disposal. Although I am not exactly an expert on that subject, having long believed that many other competent engineers were dealing with that issue, I had some replies to make to the question. However, from my experience with the Miami TV show, I had prepared to give a better picture of my qualifications and had planted a few extra slides at the end of my prepared talk. I said, with a tone of conviction and wide eyes with a sincere look, something like the following to the audience before responding to the question on the card handed to me:

"Before answering this question, I would like to add something that was left out in the qualifications that I gave to our host and panel chairperson. In addition to my present position as a scientist with the Nuclear Regulatory

Commission, and my previous tenures on the faculties of the University of Pittsburgh and Duquesne University, I have some important additional qualifications. I am a citizen on this same planet with a family and young children whom I love. Please show the next slide in my tray. This slide shows a picture of me kissing the forehead of my dear, white-haired mother, who taught me to be honest and protect the family name in everything I do. She loves me and I love her. Next slide please. This slide shows my three beautiful children. I love them as much as you in the audience love your children. They breathe the same air, drink the same water, and eat food sold in this country like everyone else. I am just as concerned about the environment as any of our speakers or anyone else." I then gave a short answer to the waste disposal question.

That statement of mine seemed to have a profound effect on the young lady who had been an anti-nuclear speaker. At the end of the evening, she came up to me with a changed demeanor and said, "You are the first real human being I have met who has come from Washington." I talked with her and invited her to visit me at the Nuclear Regulatory Commission, where I could show her some of the documents and evaluations that we perform before licensing nuclear power plants or uses of radioactive materials. She said she would try to visit me. However, while waiting for our hostess to take us for a late snack, I overheard her partner, the older and taller teacher, castigate her for speaking to me. Shades of KGB!! This shows some of the fanaticism among those who might be followers of the likes of Sternglass, as well as the potential to change minds when showing caring and humanity with a touch of sincere emotion.

Lessons Learned from Participating in the Book, "Nuclear Power: Both Sides"

Another personal example might be cogent here of the imbalance of written presentations, between the few self-proclaimed radiation experts and the many scientists whose peer-reviewed publications about radiation biology and risk would, if available to the public, weigh against exaggerated myths of low level radiation. Dr. Bernard L. Cohen and I were invited to contribute chapters in a book to be edited and produced by a known "anti-nuclear activist" (ANA), Dr. Michio Kaku. Dr. Kaku, a theoretical physicist, also enlisted a young journalist named Jennifer Trainer to help with the solicitation and editing of many of the chapters. Dr. Cohen and I first considered refusing to participate, because we knew that if half the chapters were by ANAs, and the other half by reputable scientists in the field of radiobiology and radiation protection, the book would still be strongly biased by the equal weight given to myths and truths, resulting in half-truths or worse, which would further confuse and exasperate the public. However, we decided to accept the offers and contribute chapters, rather than allow the chances that even a worse bias might prevail. (Brodsky 1982; Cohen 1982.)

My chapter was supposed to refute some of the claims of my former mentor and supporter, Dr. Karl Z. Morgan, a pioneer in the field of health physics for whom I had created a Distinguished Service Award that I presented to him when I was an HPS chapter President in Pittsurgh. Dr. Morgan later in life reversed himself and joined the ANAs, for reasons I can only conjecture about but cannot be deciphered here. As it turned out, the editing of Jennifer Trainer made my chapter somewhat less effective than I had hoped. However, to make a long story short, Jennifer Trainer, who had been anti-nuclear-power before I had worked with her, admitted to me at the end of our writing project that she had been converted by the information I had given her. This is another experience that tells me it is sometimes possible to change the beliefs of persons who have open minds and are willing to receive additional, documentable, truths.

More recently, the book by Gwyneth Cravens (Cravens 2007), a journalist and publisher of several novels prior to her interest in the subject of nuclear power, is another example of a person who, after initial opposition to nuclear power, changed her mind after examining the facts with the help of a friend's husband. She describes how Dr. D. Richard (Rip) Anderson, an engineer and scientist expert in a broad variety of nuclear and environmental issues, graciously listened to her concerns about nuclear power and then eventually led her through visits and

literature covering the entire uranium fuel cycle. From an opponent who was an activist against construction of nuclear power plants, she became an advocate for nuclear power, detailing in her book the exaggerations of radiation risks, and the quantitative evidence of the need for nuclear power as the best choice for protecting our environment and avoiding human contributions to global warming.

This shows that, although it is difficult to change views of someone who has long been indoctrinated in one direction, a change can be accomplished if empathy, truth, and reason are patiently administered, as Rip Anderson applied in his gracious guidance of Gwyneth Cravens (Cravens 2007, page 15). Rip helped her discover truths on her own. The chapters by Ray Johnson, mentioned above, are helpful in guiding us on the ways to achieve such change in personal beliefs, if and when it is at all possible.

It is Possible to Dispute False Myths Face to Face with a Jury, but This Does Little to Inform the Vast Majority of the Public

Another experience indicates the possible success of simple logic in convincing members of the public to accept truths about radiation and reject misinformation propagated, consciously or not, by eloquent doctors such as Alice Stewart. The experience was my testimony for the Department of Justice in the Dennis vs. General Electric case (Brodsky 1984b). I was contacted by Donald E. Jose, JD, of the Department of Justice one day while working on regulatory guides for radiation safety at the NRC. He had heard of my testimony before Congress refuting Alice Stewart's testimony as presented by Dr. Mancuso, and asked if I would be a witness in a trial in which someone was suing an AEC contractor for work-related radiation doses that were supposed to have caused Mr. Dennis's "Waldenstrom's Macroglobulinemia." I said I would be glad to help if I could serve any cause of truth and justice, as long as my management at the NRC approved.

I had previously served as an expert witness on behalf of two workers who had truly been injured severely by high doses of radiation on the job, but this was the first time I had been asked to defend the employer. In the previous two cases, in which limbs had been amputated, I had the necessary dose data, and was able to give my opinions about the manufacturers' and users' liabilities for not providing what I believed should have been adequate radiation warning systems independent of operating circuits of the equipment.

In the first case the data I used for testimony was my own, obtained from my measurements with multiple dosimeters placed on a phantom to mock up the exposure situation at the Van de Graaff accelerator involved. This first accident is described in Brodsky and Wald (2004). With dose measurements at various positions of a phantom set up to receive exposures as did the worker with the highest dose, I was able to prove that the particle accelerator ("atom smasher") caused the tissue damage within a certain time period. This deposited testimony would have refuted important opposition arguments. The case was settled in the plaintiffs' favor for about 1.5 million late-1960 dollars.)

In the second (Dennis) case, I was given exposure data from the Idaho National Laboratory (which I trusted from knowing the competence of the Idaho people involved, including Dr. G. Victor Beard who was the early director of their health protection laboratory). In fact, neither Mr. Dennis' attorneys nor his witnesses questioned the dose of about 2.5 rem recorded by the Idaho national laboratory. Mr. Dennis' attorneys had Dr. Alice Stewart argue that this 2.5 rem dose caused his macroglobulinemia, "more probably than not." My simple presentation to the jury to show the false logic of Dr. Stewart's testimony is summarized in Appendix A to Brodsky (1996a).

My management at the Nuclear Regulatory Commission approved my participation in the Dennis case as requested by the Department of Justice, and allowed me to be absent from my NRC office for the time it would take to work on the case with Mr. Jose. Of course, they did not give any of my assigned work to anyone else or change my deadlines, and the extra work provided no additional monetary compensation. Nevertheless, as a

scientist and good person I should always be willing to work day and night to stand up for truth. Right? Well, yes, and it did give me satisfaction to see that a jury could judge truth from fiction when they had the chance to hear truth simply presented.

When I began working with Mr. Jose, I became exceptionally impressed with his work ethic as well as his intellect. One of the first tasks he gave me was to fill a large suitcase with books on physics and radiation measurements that would help him understand the exposure issues, and the issues of probability of causation of cancers by radiation, and bring it to him at his hotel room in Baltimore. Although Mr. Jose lived in the DC area, he worked 7 days a week in Baltimore in preparation for the case, which was to be tried in a Baltimore, Maryland, court room. He sometimes had me tutor him in his hotel room on some of the science involved.

My first approach to my own testimony, which was only part of the testimonies to be presented by many of Mr. Jose's witnesses, was to use the formulations and tables of data from the National Institutes of Health report on probabilities of causation by radiation. This report was not published until 1985, but I was able to obtain a draft copy. The report listed tables of what the scientists at NIH had wanted to call "Assigned Share," but an act by Congress (which followed the House hearings I describe below) had required them to be named "Probability of Causation (PC)." The values calculated were not probabilities of an event happening after an initial exposure; they were what are called "Bayesian" estimates of the likelihood that someone already having disease or having died might be judged "more likely than not" to have the disease caused by radiation than by some other factor, if the radiation exposure level had reached some listed value. The values were calculated for an average individual of given age-at-exposure and age-at-death, for females and males, and for smokers and non-smokers, for a range of cancer types. Of course, other specific histories of lifestyle or toxic agent exposure could not be included for individuals, or for any group of individuals exposed to agents, because there was insufficient data.

(Later, in Brodsky (1996a), I included a simple summary of the 1985 NIH PC methods using an article by Wagner et al. (1989) with curves replacing the enormous compilation of NIH tables, to provide an easier understanding of the methods and easier calculation of estimates of PC by health scientists or administrators. Since then, in the early 2000s, the NIH team has been reconstituted, has revised its methods of estimation, and has published on a publicly available website a method to obtain computerized estimates of PC directly on one's computer. I made some predictions of how the values of PC might change with newer estimates of risk from the Hiroshima-Nagasaki studies, but have not checked my predictions.)

When I proposed to Mr. Jose to use the NIH PC tables in my testimony, he immediately rejected my proposal to use the NIH tables and insisted on presenting arguments in plain language. He had already read about the tables and knew that additional data on the work history, exposures, and lifestyle of the particular exposed individual, Mr. Dennis, should be used in this case. He asked me to prepare my testimony without reference to the NIH tables. That is what I did. I wrote a draft by hand of my testimony, beginning with a recapitulation, step by step, with simplified arithmetic illustrations, of the testimony that I knew from her depositions that Dr. Alice Stewart would make in her testimony on behalf of Mr. Dennis' case. After I wrote the detailed review of her testimony, including simple arithmetic facts that could be understood by any person in a jury, I then proceeded to show by further simple arithmetic operations, that she could not, for a dose of 2.5 rem, state that "…it was more probable than not…" that Mr. Dennis' disease was caused by the radiation he received performing the final dismantling of the structure that had supported the reactor that blew up in the SL-1 accident. (See the description of Ed Vallario's attempt to rescue one of the victims in the next chapter.)

When I showed Mr. Jose the hand-written testimony I had prepared, he said it was fine as is and that copies would be handed to the jury members before my testimony for them to examine as I explained Dr. Alice Stewart's fallacious logic. I also gave Mr. Jose some hand calculations of how I could also refute testimonies of Dr. Ernest

Sternglass and Dr. Karl Z. Morgan, but he did not propose to hand those out, as I remember. (The final result of my testimony against Dr. Stewart's eloquent testimony but flawed logic is published in my radiation risk book (Brodsky 1996a) as Appendix A, "Example of Testimony Refuting Erroneous Use of Doubling Dose Concept in Determining Probability of Causation of Cancer." It is published there to warn readers about other illogical statements of radiation risks, and how one might easily refute such false logic.)

When I sat on the witness stand in court, after hours of testimony by Drs. Stewart, Sternglass, and Morgan, Mr. Jose first asked me questions about my qualifications as a witness, skillfully putting me at ease. He then, in carefully measured steps, asked me questions about my testimonies against those of Dr. Stewart, and then my testimonies against those of Drs. Sternglass and Morgan, which were easily refuted from my own knowledge and calculations. I will not dwell on how I dealt with my old friends Sternglass and Morgan; it was short and easy. At the end of my testimony against Dr. Stewart's, I cancelled factors in the simple arithmetic related to Dr. Stewart's testimony, demonstrating simply that Mr. Dennis at the time his disease appeared had received at least 11 rem from natural background radiation. Even without presentation of his history of smoking and exposure to asbestos and other agents, wasn't it evident that nature — its radiation alone — would be more likely responsible for his disease than the exposure of 2.5 rem near the SL-1 structure, which was within accepted limits of NCRP and ICRP for workers. Actually, Dr. Waldenstrom himself, by televised testimony from Europe, had provided his opinion to the jury that he did not believe that the disease bearing his name could have been caused by the radiation received by Mr. Dennis.

When Mr. Jose stated that his questioning of me was over, after my sitting just about an hour on the witness stand, I found myself feeling somewhat disappointed. I was hoping he would continue. I had more to present, and found a sort of satisfaction being able to look straight into the eyes of a jury full of laypeople and destroy so vigorously in one hour the testimony of three pseudo-scientists who, on the subject of radiation effects, had so often misled the public on national media. I had learned, from much experience and that of some eminent colleagues, that I could not hope to have opportunities to adequately refute exaggerated, alarmist, presentations about radiation effects in front of a news television camera, or before a group of reporters. Adequate opportunities for such news media refutations would not exist.

After Mr. Jose was finished, I then expected to be on the stand to answer hours of questions from the opposing attorneys. However, the first simple question from an opposing attorney was something like, "You are biased against Dr. Ernest Sternglass, aren't you?" I replied with something like, "I am always biased against someone who does not tell the truth, or who presents false information knowing it is false." At that point, the opposing attorney rested his case. I supposed he wanted to get me off the witness stand. I was again disappointed that I could not point out further falsehoods and absurdities presented by the opposing witnesses.

As I stepped down from the witness stand and proceeded to a seat in the observer section, I was pulled aside by a health physicist from Idaho who was to be a later witness. He said something like, "I am a people watcher, and I think you were a convincing witness to the jury." I already had that impression from the way the jury members looked at me when I talked, and also from the way the opposing attorney rushed to get me off the stand. As I walked farther, another of the Justice attorneys I had met told me I did a good job. Well, maybe I did, but I had a jury audience who had been carefully selected to be open-minded, and without an anti-radiation industry bias.

NOTE: In my first testimony, I was on the side of workers who were truly injured by radiation. In the second case above, I sided with those who were unjustifiably accused of injuring someone by exaggerated effects of a low dose of radiation when other factors were likely causing the disease. Two other cases I have since been involved in were split between a real radiation injury and a wrongful claim of radiation effects. In all four cases, I was on the winning side. So, am I still one of the good guys?

Lessons learned from these testimonies:

- The general public is intelligent and can understand quantitative arguments about radiation exposures and risks if they are presented in commonly used language and by simple arithmetic examples.
- There were no news media reports about my testimony, so again it was not possible to reach more than a jury full of people with logic that would have destroyed the credibility of three of the most famous "anti-nuclear scientists" who had attained public fame (and I had known all of these three personally and professionally). How fortunate our society would be if they had been only "anti-nuclear-weapons scientists." Although some public scrutiny is necessary to ensure independent audits of information provided by special groups in government or industry (and I have been personally involved in responding to public comments in my government regulatory work), and some of it by environmental groups has helped improve safety requirements, on the whole the domination of media information by pseudo-scientists who more quickly can provide careless analyses has more negatively than positively affected the health and welfare interests of the public.

It seems that there is a high correlation in certain individuals between the activation of a gene to distort radiation phenomena for the purpose of preventing the use of nuclear energy, and the activation of a nearby gene for the purpose of preventing sensible and simple civil defense measures to protect the public from unnecessary loss of life in the event of WMD attacks. I feel that this question could be the subject of many good doctoral dissertations in social consequences of neural and behavioral genetics.

Further remarks about my qualifications and supporting information

Many of you who have read up to this point have also been intellectual victims of Sternglass, whose name I use to represent those like him I have known of similar persuasion. While not widely publicized in the news media, I do have qualifications and documentation to back up my statements in this book. As a result of my efforts to protect workers and the public from harmful exposures to radiation, including my contributions to Federal regulations and standards in positions at the Atomic Energy Commission and Nuclear Regulatory Commission, I was presented with a Distinguished Graduate Award in 2005 by the Graduate School of Public Health, University of Pittsburgh. I have also received other awards from my kind colleagues for research, teaching, and writing that contributed to understanding safety requirements for the applications of radioactive materials.

Sternglass, on the other hand, has written many other articles and books that have been published and received much wider distributions in the media. I could provide volumes from reports I have written over the years, in addition to examples in Brodsky (1996a), to provide the public with refutations of all of Sternglass' contentions, and those of the few but famous others who have also distorted facts about radiation in widely distributed books as well as through the news media. Other extremely competent scientists and authors whom I have known (Beckmann 1976; Lapp 1979; Willis 1982; Cohen 1983, 1992; Lenihan 1993; Rockwell 2003; Domenici 2004; Walker 2004; Waltar 1995,2004; NAS 2006; Mossman 2007) have published books that can be read to understand the wrongful exaggerations of Sternglass and a few others (e.g., Sternglass 1972; Goffman 1982, Caldicott 2006). However, the books and writings of those competent scientists who rebut Sternglass and others have also received only limited distribution. There needs to be some better way of educating the media as to whom they provide audience.

Sternglass et al. have almost monopolized the media with misinformation and exaggerations about effects of low-level radiation. If the competent scientists who have published on this subject had received as wide a distribution of their works as Sternglass et al., this chapter could have been much shorter. However, for the reasons I give here, I feel obliged to share a sample of my own views and evidence accumulated over my lifetime. Yet,

instead of reprinting volumes of my rebuttals, only a few brief examples of my own experiences with media bias are presented here. Few in the public would be entertained by such volumes. The hard evidence of Exhibit 3, and a few more remarks that follow, must suffice to keep this book at an affordable size.

Further references to my experience with media bias are in my publications, and in my testimonies before Congress. Some of them are in my book on radiation risks and uranium toxicity (Brodsky 1996a). Even more comprehensive in presenting media distortions about exposure matters are the studies of media reports, and the facts presented in the books by Professor Bernard L. Cohen (Cohen, 1983,1992).

Also, for those wanting to delve further into how Al Qaeda and like terrorist organizations developed their philosophies and capabilities in recent decades, a number of well-documented books have appeared that would confirm my concerns as stated above (e.g., Wright 2007). Books showing how even the vast attempts at stopping terrorists or bombs at our borders cannot be absolutely effective have also appeared. (Ervin 2006; Ridge and Bloom 2009)

Thus, we must face the media problems of our era, and move on to better ways to reach the public.

A comprehensive text on communicating risks and safety issues to various audiences is Lundgren and McMakin (2004). This text includes references to concepts and publications of many of the other authorities currently involved in risk communication research.

ADDENDUM, BREAKING NEWS: Reports of Higher Diagnostic Medical Doses from CT Scans on the News Media on December 15, 2009 Further Exaggerate the Already Exaggerated Fears of Radiation, and In Applications That Would Be Beneficial to Patients

After attending the Beebe Symposium of the National Academy of Sciences on December 9, 2009 (NAS 2009), at which the increased radiation exposures of the United States population from diagnostic CT scans, other x ray procedures, and nuclear medicine, was discussed (NCRP 2009), I was astounded to hear on the news this morning (December 15) the scare reports to the public about the thousands of deaths presumed due to late cancers resulting from these medical procedures. The scary reports on TV news of December 15 probably originated from the release of perhaps the latest paper on estimated late cancer risks of medical procedures, as determined by a rather competent and well-known group of medical researchers (Berrington de Gonza´ lez 2009).

However, although the purpose of such late cancer risk estimates is to provide incentives to improve medical procedures to reduce such risks, the authors recognize in their article that these risks are small for an individual in comparison with the diagnostic value of reducing cancer and other risks. Nevertheless, even if the late cancers were estimated with confirmed low-level radiation risks, such reports should not be used to scare the public away from needed examinations, certainly not without concurrent information on the numbers of lives saved by these procedures from the early discovery of cancers. Even Dr. Sanjay Gupta, who is an excellent and trusted medical reporter as well as surgeon, was presenting numbers he was given of tens of thousands of late cancer deaths in various groups; he did acknowledge that benefits were received from using CT equipment, and that the estimated deaths are calculated from assumed risk factors that might not apply to the patient populations (see Chapter 4 on risk factors when the entire body is exposed). It is not Dr. Gupta's fault that the report is slanted toward exaggerated risks; he must use information given to him by whatever presumed experts provided him with the information.

At the NAS Symposium, it was acknowledged by prominent medical professionals that most CT scans are delivered for good medical reasons, and that they are much safer for patients than the surgical procedures that were formerly needed to find possible cancers and other pathology within the body. However, many of the speakers did bring out the need to limit unnecessary degrees of radiation exposure by encouraging, or requiring, equipment manufacturers to meet consistent standards, and to build in devices to alert equipment users to the amounts of exposure being given to the patient. Wagner (2009), a professor of medical physics, showed slides indicating how serious skin burns and other pathology could be avoided by simple quality assurance observations by the medical physicist, who should check each scanning procedure. For example, he described a case where a patient receiving a scan by an oblique passage through his chest received a serious burned area on the back of his upper arm; this burn could have been avoided by simply moving the arm out of the x ray field. All that this would have required was an awareness that in the particular oblique geometry, his arm was much closer to the x ray source than otherwise.

Thus, it is important that education be further improved for physicians, technicians, and other health professionals involved in radiology, in all medical schools and hospitals. This is a subject of importance for the radiology profession, and possibly for some initiatives in Federal regulation (Suleiman 2009). Too much regulation of medical practice has long been avoided to appropriately limit government interference with the presumed better balancing of benefit versus risk by the patient's own physician.

On the other hand, in regard to the levels of radiation dose used in therapy, there is a need for urgent action, and perhaps stronger regulation, to prevent the terrible suffering that can result from mistakes that cause extreme harm to the patient (Bogdanich 2010). There has always been a continuing need for vigilance and improvements in quality assurance when exposing patients to levels of radiation that, if misdirected or improperly administered, could cause more harm than good. Methods for annual staffing analysis for medical physics and radiation safety have been suggested from my own earlier experiences in medical institutions (Brodsky 1991). The Bogdanich

article indicates that the introduction of such analyses in every hospital and medical institution that exposes patients to potentially harmful levels of radiation is still sorely needed. Perhaps this provision should be a part of hospital accreditation requirements, if not regulations.

In the 1990s, I was called with three other professors of medical physics to audit for the Nuclear Regulatory Commission (after I had retired from the NRC) the radiotherapy program of the Yale University Medical Center. They had been cited for four misadministrations of radiation from NRC-licensed radiation sources within the previous two years. Among our recommendations, I insisted that we include in our report the need to have at least three independent persons check the planning of all procedures that could deliver harmful amounts of radiation to the wrong tissues; the recommendations of our auditing group were accepted by Yale and some important changes were made in their procedures and staffing as a result of these recommendations.

NRC regulations and inspections have already resulted in a very low incidence of mistakes in the medical use of licensed radioactive materials. However, not federally licensed in the way licensed radioactive materials are, the now prevalent linear accelerators with field-shaping and attenuating blocks that are controlled by computer programs require more attention to providing adequate staff to properly check all procedures and settings. Also, the delivered doses should be checked after each treatment.

Although such misadministrations are relatively rare, they should be zero or close to it with modern knowledge of technology, adequate hospital staffing of radiology and oncology departments and their independent Radiation Safety staffs, and widespread use of the educational programs already provided by the Radiology Professions (e.g., Frush 2009; Goske et al. 2008). Nevertheless, the misadministations in therapy, as well as injuries from the use of diagnostic radiation, have been rare. They still do not justify the public media scare about the estimated numbers of late cancers. Although reported as in the tens of thousands in the December 15 media, the late cancers are probably overestimated and in any case would be a very small percentage of the millions of persons aided by such examinations. The number of CT scans and nuclear medicine procedures performed in the United States during 2006 (the last year for which data was obtained) was estimated at 67 million and 18 million, respectively (NCRP 2009). So, in addition to the likelihood that the media reported estimates of tens of thousands of late cancers are overestimates, they would also be such a small percentage of the persons examined that they could not be observed in any epidemiological study of feasible cost and effort. Furthermore, it is likely that many more lives are saved among the many millions of persons examined, due to the early discovery of real cancers and other life-threatening pathologies. Members of the public should not be frightened away from receiving such radiological examinations when ordered by their physicians.

At previous preliminary presentations of the rise in population exposure from medical examinations (Mehadavappa 2007), epidemiologists indicated that studies of the efficacy of such examinations (lives saved) were just begun and would take many years to yield results. I arose to caution that the increased radiation exposure on a population basis should not be advertised to the public as implying cancer deaths calculated by uncertain risk factors until accompanied by information on the lives saved by such examinations. The important goal is to maximize the "benefit/risk" ratio; that is, a maximum number of lives should be saved by any procedure while minimizing risks, and the lives saved should far exceed any harm that might occur from mistakes or misadministrations. After the 2007 preliminary reports, no media scares were noticed. However, now that the final report has been published (NCRP 2009), a few medical scientists have inappropriately calculated later cancers and advertised their results to the media. This should not have been done without concurrently telling the public of the great benefits of the increased use of more modern technology in medicine.

It is unfortunate that it will take so long to obtain the benefit information on numbers of lives saved. The benefit information is inevitably delayed due to: the lack of current medical records electronically available between all institutions; necessary conformance with privacy requirements; and the sometimes long lag time that often occurs between the discovery of malignancy or other pathology with a CT scan, x ray, or nuclear medicine

procedure, and the final outcomes of treatments. All of these factors, and more, make the epidemiology of both the life-saving effects of these treatments as well as the side effects difficult to study. They require long time periods of study and large study populations (Pearce 2009). Yet, as acknowledged by physicians and medical scientists at the NAS meeting, personal observations and case studies make it obvious that the performance of these diagnostic examinations certainly provide benefits far exceeding the risks.

Dr. Wagner, who has previously published recommendations on the radiological examination of children and pregnant women (Wagner et al. 1985), agreed with me at the NAS Symposium that the participants should at least be cautioned to not advertise the additional CT exposures to the public as if they were only harmful, without at least providing the opinion, prominent among the radiologists, that the benefits of CT scanning outweighed the risks.

Most members of the public are unfamiliar with long-term or short-term effects of radiation, and will not calculate the small percentage of those examined who have been predicted to succumb to late cancers. They will mainly see that such cancers are estimated to be in the thousands; they will not know that these late cancer estimates have been made by risk factors that have been recommended as not applicable for multiplication by population size at the radiation levels low (less than 10 rem) compared to those at which a small percentage of cancers were seen in the Hiroshima-Nagasaki populations (Health Physics Society 2004; NCRP 1995).

Today's reports, the way they are often given in the media, will surely frighten many persons who need CT, x-ray, and nuclear medicine examinations from getting them. Also, insurance companies will use the publicized information, as well as the recently promoted recommendations about not providing routine breast examinations to women under 50, to reject payments for preventive medicine procedures that could save many lives.

Conclusion: Many more persons might now die from lack of examinations than would ever succumb to late cancers, as a result of the exaggerated fears of low-level radiation, or high levels used properly for effective therapy. What is needed from the media are more balanced reports of serious overexposures such as that of Bogdanich (2010), which at the same time inform the public that the frequency of such overexposures is very small and should not prevent them from receiving the best therapy that might cure their diseases. Patients might just begin to insist that each treatment dose be checked by three independent team members, and also be checked by an independent dose measurement of the entrance dose and field. Chapter 8 presents an inexpensive color-changing dosimeter that could be shown to a patient after each treatment to assure the patient of proper quality control, without significant cost or loss of time to the medical staff.

CHAPTER 2

WHY PREPARE YOURSELF FOR PERSONAL AND FAMILY PROTECTION

There Are Good Reasons for Preparation

The preceding chapter gives some insights regarding the reasons most members of the public are still not adequately prepared or informed to provide their own protections. This chapter will provide motivations for reversing this situation. Those who are already motivated may skip this chapter, at least in the first reading.

It is important to reverse the myth that there is no effective protection at all from any amount of exposure to radiation. Ever since the 1950s movie, "On the Beach," this myth has been reinforced by misinformation presented from grade school on up by the misinformed scientists who have courted the media and our educational institutions. This prevalent myth discourages personal efforts of members of the public in the US to provide protection for their families. I have heard many say that if a nuclear attack comes, they do not want to live. Yet, consider the New Orleans Katrina disaster, and note how so many still wanted to survive even though many died. Pre-hurricane measures by members of the public themselves, which could have included the sheltering measures that we recommended when I served in the FCDA, would have saved many lives, as is now being learned in many hearings.

My own belief and philosophy is: "If the death of one person is tragic, then the death of a million persons is one million times as tragic." This book is not about preventing terrorist attacks. Much is being done by the Department of Homeland Security and other Federal and local governments in regard to detection and prevention. Some of the technologies for detecting and interdicting nuclear materials are described in chapters of Brodsky et al. (2004) that I solicited from scientists and engineers involved in their development. However, as I have noted in Chapter 1 of this book, with reference to some expert opinion, there are no absolute methods of ensuring the prevention of serious attacks with weapons of mass destruction. We must prepare to save as many lives as possible in the event attacks occur. I know that much more could be done beforehand to save lives after an attack, and for much less funding than is spent on other homeland security programs.

The citizen is truly the "first responder" who can take appropriate actions in minutes to avoid panic and human tragedy. The "Golden Minute" was coined by me, in analogy with the "Golden Hour," which was coined by my

co-editor and author, the nuclear physicist and emergency physician Dr. Ronald E. Goans, in the referenced 2004 book (Goans 2004). There will not be enough responders, police, fire, or paramedic teams to help most citizens in these critical early times after an incident. Also, some of these teams are being trained improperly in ways that would cause them to panic at insignificant radiation levels, insignificant compared to the much higher risks they would usually take to save human lives. The average citizen needs adequate information, in addition to some simple inexpensive radiation measuring devices (see Chapter 8), to be able to take proper actions immediately on his own and for his family (within the "Golden Minute"). If, despite the proper actions, some citizens are injured or exposed to harmful levels of radiation, personal radiation monitors must be available so that these citizens can call for help and be reached, to the extent possible, by medical emergency personnel within the "Golden Hour"

Despite the many billions of dollars spent to reorganize many agencies of the Federal government into or in coordination with a Department of Homeland Security, and the many more billions that have been contracted to private industry to develop devices or instruments to detect or interdict dangerous persons or materials that might enter our nation, I find that the vast majority of the public remains uninformed of even the simplest steps that can be taken to minimize their chances of harm from an attack that could spread radioactive material over large areas of the nation. The programs and devices for detection of dangerous materials and the surveillance of dangerous persons are all to the good. However, we all know from daily news reports, magazine articles, and available books, that no methods of detection can with certainty prevent attacks on American soil (Ervin 2006; Ridge 2009). Therefore, each American must prepare himself, on his own initiative, with minimum knowledge and supplies to take the best actions for survival in the event of an attack. As indicated in the Preface, the main aim of this book is to provide guidance to the public for such preparations. As suggested elsewhere in this book, a person prepared to take the best actions for protection will take them, and will not panic. Remember how panic alone at the Haaj in Mecca killed many persons, as did panic in many other disasters. Panic leads to irrational actions that can be avoided by knowledge of the best emergency protective measures.

Even in the morning of October 12, 2007, before beginning this chapter, I heard on CNN TV news that there are 101 countries that are attempting to develop nuclear weapons. One report indicated that we know such weapons developed by some of these countries will be used on us, if developed. Illegal exports of critical materials and equipment to produce such weapons have already been uncovered, with little more than a "slap on the wrist" to the violators, who could usually give good reasons for their error; many items of modern technology can have dual or multiple uses. Therefore, we must raise to a high priority our efforts to be personally prepared to act rationally in the event of a nuclear weapon attack, as well as a "dirty bomb" attack.

There is Available Information for Protection Based on Real Experience and Research

To indicate that there is much authoritative information for WMD protection already published, I here point out some features of the Health Physics Society Summer School book (Brodsky et al. 2004). This book has over 800 pages of comprehensive information for the public, responders, and emergency managers, for preparations and protective actions for saving life after an attack with weapons of mass human destruction. It also references many other government and organization materials and web sites, and abstracts many of their recommendations up to 2004. The chapters in this book were written by me and over 35 other authors who are outstanding experts in their subjects. These chapters also contain valuable information for professional scientists or planners; however, most of the written material can be understood without a scientific or mathematical background. Much practical information is given to encourage early actions to save life. However, my own chapters are best known to my memory and contain broad information that will illustrate the extent of available concepts, data, and information. In order to avoid taking too much time and too many pages, I will lean heavily on my own chapters to provide simple protective actions for members of the general public.

Although I was told, when appointed in 2001 as the first chair of homeland security of the Health Physics Society, that I should not include nuclear weapons in my scope of subjects, I knew that such weapons were still going to be available and should be included in our training and in the text. I asked Dr. John Auxier to provide some basic information on nuclear weapons (Auxier 2004). Dr. Auxier was an early scientist leading the Hiroshima-Nagasaki dosimetry studies, and is an expert on nuclear weapons and their effects. Some of my own earlier experience and training in civil defense is in my discussions in Chapter 13 of Brodsky et al. 2004. This chapter also references other authors in the same book who deal with dirty bombs as well as nuclear weapons. However, my Chapter 13 alone is 63 pages, so only some condensed information essential for most members of the public is presented in this current book. For those who will be training responders and wish to add material on preparations for nuclear weapons attacks, I have included in Appendix B the material (Brodsky 2004b) that I developed and used to train responders in the 1950s eight-hour courses (which also included practice using radiation instruments); Appendix B is only 15 pages. Appendix C of this current book reprints material similar to what I have had published in my own local newspapers to inform my neighbors on actions they can take to minimize radiation exposure and unnecessary fears; such brief material should be revised and circulated to suit the conditions of the locality in which each person resides. Another version of this material is in Brodsky (2004c).

Another version of the information to be circulated to the public was written by a subcommittee that I established when I chaired the Ad Hoc Committee on Homeland Security of the Health Physics Society in 2001-2003; this subcommittee was co-chaired by Dr. Audeen Fentiman, Chairman, Department of Nuclear Engineering, Ohio State University, and Dr. P. Andrew Karam, a foremost member of the Health Physics Society. However, I am not aware that their document has been adequately circulated in the press, although Dr. Karam has continued to be very active in responding to public questions on the Health Physics Society's question and answer website. At my request, Dr. Karam also provided the excellent final appendix to the 2004 Summer School book (Karam et al. 2004). As mentioned earlier, this appendix deals with ways to inform the public, and includes a journalist, Thomas Rickey, as a co-author.

It seems to be getting very late in this terrorist war for most members of the public to still be in the dark regarding information for self-protection and survival. While scientists in general have been taking courses in communication, and preparing themselves in the ways suggested by Dr. Karam, it does not help the matter if the vast majority of competent scientists do not get most of the opportunities to appear on the public media. That is why I am now writing this book to communicate directly to the public, as well as share my experiences with my co-professionals. I find that members of the public, and even responders who have received some present training, are not as informed as the teams we trained in the 1950s programs of the Federal Civil Defense Administration during the cold war with the Soviet Union. The 2006 book, "Open Target," by Clark Kent Ervin, the former Inspector General of the Department of Homeland Security, makes clear that there are potentially many ways in which terrorists can defeat our imperfect barriers to attack us with weapons of mass destruction and murder. Another 2006 book, "Without Precedent," by Governor Thomas Kean and Congressman Lee Hamilton, co-chairs of the "Nine-Eleven Commission" (Kean and Hamilton 2006), confirms the continuing vulnerabilities of America laid out by Ervin. Governor Ridge, former Secretary of Homeland Security still has similar concerns (Ridge 2009).

How I know that Fear-Induced Panic Can Be Prevented by Prior Preparations

As indicated before, many of my professional colleagues have talked and written about the "fear factor" associated with the spread of detectable radioactive material in the public environment. That is why I have written this book to replace unreasoned fear with public knowledge, understanding, and a resolve to minimize harm in the event of a radiological attack, and a resolve to replace fear with a determination to withstand any assault and to resist terrorism and continue as a free nation.

Articles and books about how to deal with the fear factor, although possibly helpful in comforting some who might be reached hours or days after an attack, will not help us prevent panic and destruction of hospitals and other important facilities if the general public is still fearful of even the lowest amounts of detectable radiation. Small, but not likely harmful, levels of radiation could be detectable by the sensitive radiation monitors (unfortunately called "pagers") already distributed to responders around the nation. These smaller levels of radiation could be deposited over hundreds of square miles after a dirty bomb or nuclear bomb attack, whereas the lethal area could be confined to only a few square miles, as shown by the fallout patterns presented later in this book. Even the exposure to lethal levels could be reduced by some of the actions described in this book.

However, without public understanding and preparation, hundreds of thousands of persons in the vicinity of a large population center could panic in the early minutes or hours after a radiological attack. There would certainly not be enough psychologists or psychiatrists at their beck and call to pacify them or control them. Nor would there be sufficient responders available to inform them and prevent their panic. Each person must therefore be his own "first responder," and have knowledge of immediate protective actions and personal dosimeters to indicate radiation exposure.

Of course, Osama bin Laden, his partner and mastermind, the great surgeon Dr. Ayman Zawahiri, and the cells of followers and believers that they have now spread throughout the world in the past ten years, are well aware of our psychological and infra-structural weaknesses. They and similarly empathetic groups have long-term goals of eventually destroying democracy and freedom as we know it, and replacing it with a form of religious law that would be anathema to the vast majority of peace-loving Muslims in the world (Lewis 2003), as well as those of all other religious or non-religious persuasions. No peace deal in the Middle East that creates or sustains democracies will change their goals; rather the opposite would occur, as we may witness from the recent murder of the courageous Benazir Bhutto. Although I have read many other books and articles that verify his information, I refer any reader who doubts my statements in this paragraph to the most comprehensive treatise of Lawrence Wright (Wright 2007).

As also indicated earlier, if information about doses and associated risks are familiar to an individual, if radiation instruments and/or dosimeters are immediately available to assess the radiation environment, and if actions are available for reducing risk are well ingrained in consciousness, **a person will take proper actions to reduce risk and not panic at and after the moment of attack**. *This has been my experience. The person will also know how to reduce the fear and panic of other persons in the vicinity by directing them to take useful actions to make them feel they are doing something positive to reduce risk.*

This has been my experience with radiation accident cases, as discussed in Chapter 20 (Brodsky and Wald 2004); in the very first case of a worker who had inhaled plutonium sent to our counting and chemistry laboratory, I describe how it was necessary to give those around me something useful to do (actions) to reduce their anxieties and get them out of the way of effective responses to the exposed individual.

*This experience of mine is consistent with the list of actions given by Norwood (2007), a psychiatrist and Senior Policy Analyst in the Office of the Assistant Secretary for Preparedness and Response with the Department of Health and Human Services. I was delighted that, in her presentation, she pointed to a list on her slide 33, "Principles of Emergency Risk Communication," adapted from a 2002 report by the distinguished communicator Dr. Peter Sandman, and emphasized among the principles the advice, "***Give people things to do***." I believe this is the most important early action that one can take to help avoid panic; that is, if one is prepared with the knowledge of appropriate actions, has the proper equipment to rapidly assess the situation and take immediate action, and can provide direction to others with consideration for the psychological and cultural state of the individuals concerned (HHS 2004), then panic in the face of even great danger will be reduced and loss of life will be minimized.*

*Therefore, in the words of Peter Sandman as seen on Norwood's slides, one of the main purposes of this book has been to "***Give people things to do***." There is copious material (e.g., HHS 2004; Johnson 2004a, 2004b; Barnes 2004) on the problems of stress, anxiety, and panic among those exposed to terror; the references given here should suffice, but those*

*interested in these psychological phenomena may consult further the hundreds of other articles to which the bibliographies of these references lead. This information is important to those responding to care for, or counsel, victims who have already succumbed to terror. I hope in this book to provide, to as many citizens as possible, some adequate understanding and knowledge of appropriate actions ("**things to do**") in the immediate aftermath of an attack, so that they will not panic in the first place, and will in many cases save their lives and the lives of others. The acceptance by the public of the right "**things to do**" depends on their trust of the information and actions presented to them, as presented in the summary list of the chapter by Barnes (2004). That is why I have preceded later chapters on "things to do" with Chapter 4, whichexplains differences in levels of risk, and how to assess them.*

The need for this public understanding and preparation for action is urgent. This has already been recognized in Congressional hearings. However, perhaps because politicians do not dare by themselves to further alert the public to personal dangers for the fear of them being called "fear mongers," the public was told after 9/11 to just go back to normal life and not worry. "The government will reorganize and take care of you" might well have been the national motto. Thus, as opposed to the situation in World War II, the vast majority of the public has not taken the simplest measures to prepare for their own protection and survival. Part of this is due to the misinformation about civil defense in the media in the years after WWII, as discussed earlier, and the feeling that nuclear deterrence would keep us safe. The public must be informed for their own protection, as well as protected by increased surveillance and the presence of most of our National Guard as well as trained responders in our own communities. **Our nation will not continue to exist if its citizenry is in complete panic and disarray from exaggerated fears after an attack, without an understanding of the things they can do for their own protection, the things they must NOT do in panic to destroy our medical institutions and infrastructure, and the resolve to carry on and fight back as a nation.**

*We might take notice of the preparations in Israel, where all citizens have designated shelters nearby and know the **things to do** when sirens scream. The entire public participates in annual "resilience training." (Adini-Weisel 2010) Even when suicide bombers have killed and destroyed, the members of the public have not panicked; they have reacted rapidly for rescue and recovery and have resolved to continue as a nation. On a recent visit with my wife, our guide said it was safe to visit places in the Galilee. The day after the visits, we read in the papers that a rocket from Hezbollah had landed in the area after we had passed through. In Israel today, an occasional rocket is not apparently considered a danger. However, they did keep us away from the Southern half of the nation, where rockets from Hamas arrive regularly. Also, we did observe the bomb shelters that are required to be near every home.*

Of course, it is not possible to remove all fears just by education, instruction, and preparedness; I am only stating that I know these fears can be contained and not end up in panic for those who immediately know "**things to do.**" **In this way, we defeat some of the purpose of the terrorist to terrorize us**. Perhaps in order to be clear that I am not suggesting that it is possible to alleviate all fears from the public consciousness by prior instruction and counseling, I should mention some personal experiences as well as the training received by our troops.

*When I was eighteen years old, I had a summer job as an operator at the benzene and pyridine plants of Bethlehem Steel Company in Baltimore. I was not particularly brave; although I had been in a few fights as a kid, I was scared of anyone who threatened me. One day, passing by a large tank of benzene, I noticed one gauge at the top of the tank indicating that pressure was rising rapidly. I knew where the valve was that relieved the pressure. I knew the "**thing to do**." Without anyone telling me, within seconds, and without any thought, I climbed the ladder to the valve and released the pressure. I did not run away from the tank. In the following minutes, I wondered how I was able to take this action. Now I know that I knew ahead of time that "it was the thing to do." This is only one personal experience that tells me the importance of every citizen knowing "things to do" in the immediate seconds and minutes after a terrorist attack.*

Another experience can be understood by everyone: When World War II ended, I had just finished high school and was still too young to be drafted. I felt sort of guilty when some of my cousins came back from having served

in battle. I enlisted in ROTC at Hopkins and was commissioned as a 2nd Lt in the Corps of Engineers, Army of the United States, at the same time I received a degree in chemical engineering in 1949. During the summer of the following year, when I was completing a one year Fellowship in Radiological Physics at Oak Ridge National Laboratory, the Korean War began. I had hoped to soon become engaged, plan a wedding, and start a new life. I was not happy about the likelihood of going to war. I was afraid, but I continued to remain in the active reserve and attend training sessions. These training sessions included knowing "**things to do**" even when you are scared. The nuclear navy has also developed these training concepts to perfection, because the lives of an entire crew can depend upon the rapid and proper actions of each sailor aboard (Rockwell 2003; Karam 2002).

In order to know more "things to do," I was consulting some of my fellow students at Oak Ridge, eight out of eleven of whom had actually served valiantly in World War II. Fortunately, through a series of unexpected events, which might be detailed in a later book, I received a position at the Naval Research Laboratory before being called to duty. They applied for several delays, and when I was called to active duty, I was sent to be a physicist on the first H-bomb tests, for which the Army needed scientists. Thus, instead of being hit by bullets in Korea (like some of my fellow graduates had been), I was hit only by about tens of trillions of gamma-ray bullets (photons), each knocking out electrons that broke up thousands more atoms in my body. So, I, and some of my family, are lucky to be here over 56 years later.

Thus, I experienced the kind of combat and construction training that troops receive today, although I was diverted from needing to use it. But, I think most of us who watch some of the current troop action in Iraq or Afghanistan have seen how our well-trained and committed troops act quickly on the things they are trained to do, despite their fears and wishes to be home. More information, education, and training needs to be given to our entire population, in order to stand up to and survive the stated short- and long-term plans of al Qaeda and their allies (Wright 2007).

One more experience might be pertinent, particularly to scientists and emergency personnel who will be among responders that will within minutes or hours arrive to assist in casualty reduction and damage control. As described in Brodsky and Wald (2004) the first patient sent to Dr. Wald with plutonium in his lungs arrived at Presbyterian-University Hospital on a night when I had not yet set up the equipment to measure his intake. Fortunately, I had already purchased the necessary alpha and x-ray detectors with the few hundred dollars left in my budget. I had not yet set up nor calibrated the equipment, nor had I previously managed such an accident case at a major hospital.

Although my equipment was there but not ready, I knew that I was prepared with the knowledge that would guide me on the "**things to do**." I, thus, suggested to Dr. Wald that we try to manage, and treat as necessary, the patient at our hospital, rather than send him to the other side of the country, far away from his family, as some previously experienced experts had advised us to do. Dr. Wald, a physician who is and was expert in radiation treatments, had assigned to me, his physicist, the tasks of managing the contaminated patient for measuring his intakes by body counting and biological sample analysis, and remaining with the patient to explain to him the aspects of his exposure and the likelihood that he would remain healthy when we discharged him to go home.

As it turned out, we were able to assemble our equipment and assess the individual's internal burden of plutonium in time for Dr. Wald to administer the calcium diethylltriaminepentaaceticacid (DTPA) (zinc DTPA was used later) that would remove some of the inhaled plutonium from his body and reduce his internal radiation exposure. In the process of managing the situation, one of the things that I found I had to do was to tell others "**things to do**." Graduate students and others naturally wanted to help, but no organization, task assignments, or written operating procedures had yet been documented. Someone had already changed the settings on the multi-channel analyzer that I had set to measure the pertinent L x rays from plutonium. I needed to take charge and get some of the people out of the way, so I could do my own "**things to do**."

Details of this event, and others, can be read in Brodsky and Wald (2004), or in the Chapter 20 available on www.medicalphysics.com for a free sample viewing. I just want to point out that I learned from this event that the most important factors in managing the radiation exposure of someone and preventing panic are: 1) a mind prepared with **understanding and facts about things to do** (I had by then taught radiation dosimetry to many graduate students); and 2) the **appropriate equipment** to measure the more likely types of radiation involved. There is no time to read procedure manuals, or to go to libraries, in the seconds or minutes when it is necessary to take care of a patient and make him feel confident that you are both competent and caring. Any information needed in these immediate moments must be either at hand or in the head. I also learned from this event, as well as the others described in our chapter and more, that any citizen can understand the phenomena of radiation exposure and risk if these matters are explained calmly and in simple everyday language, and they can have their fears alleviated to the point that they remain calm and cooperative, even when their possible exposures might turn out to be relatively high.

In analogy to these experiences with patients exposed to inhalation of radioactive materials, responders and members of the public must: 1) understand the situation and the things to do for their protection, and 2) have appropriate dosimeters or equipment to immediately and continually determine their exposures.

Good Fighters Must Be Able to Take a Punch, Not Just Deliver a Punch and Block a Punch

We thus need to learn how to receive a punch, if we are to survive. Good boxers must know how to "take" a punch when it lands on its target, as well as how to deliver a punch and to guard their chins and abdomens. My main contribution will be to show how to take a punch; that is, how to quickly assess situations and provide available protections from radiation exposure for ourselves and families. With this knowledge, our nation will not panic in the event of an attack, but will take the proper actions and survive. Much of the protective actions and concepts to be presented will be extracted and simplified from the book for scientists, responders, and managers involved in homeland security, "Public Protection from Nuclear, Chemical, and Biological Terrorism," (Brodsky et al. 2004). This book can be obtained from the publisher's web site www.medicalphysics.org. Additional information can be obtained from the websites of government agencies and other organizations, as given in Appendix D.

Even most of our first responders, who were properly trained in the old civil defense days when I was involved in nuclear tests and training responders, are now lectured in ways that could cause them to fear small intensities of radiation that would not pose even the routine risks that they face in everyday life. Even more important, as indicated before, each member of the public would need to be his own "first responder" in the early minutes after attack; there could never be enough police, firemen, or medical emergency teams available to be at the side of every person at the early crucial moments of life and death decisions.

Although much information was published in the early days of civil defense that is still appropriate for responders and the public, most of it is now forgotten or available only to the few involved in civil defense over the years. The Department of Homeland Security has already provided much new instruction for the current training of responders and hospital personnel, but some perspectives based on real experience are missing in this information, and much of the good information has not reached the general public. My examination of books in public libraries shows me that most available books are those propagating harmful myths that would inordinately magnify insignificant risks and cause panic even in areas of very low radiation intensity (e.g., Gofman 1982; Caldicott 2006). I have also been told by friends with children in high school, about texts and information given to our children that exaggerate radiation effects and the imagined dangers of actually very beneficial uses of radioactive materials in our Society (Waltar 2004). Thus, we need to overcome the belief, propagated in our society over generations, that any amount of radiation exposure is dangerous. This will require some understanding of the origin and nature of our currently available scientific information on radiation risks, which are summarized in Chapter 4.

Because so many of the myths about radiation have been ingrained in the public mind for decades, I have felt an obligation to support my statements with documentation that can be examined in order to authenticate my credibility. In public presentations, some scientists in their zeal over their myths have often demeaned the competent scientists as having bias because they worked for some "establishment" or other. Thus, I need to state up front that I have not held stock in nuclear companies, and my career has not been dependent upon nuclear power, nor on nuclear weapons. I was assigned in the Army to work on the first two H-Bomb tests (1952-1954) as a physicist measuring nuclear radiation signals, but at the time I had been a volunteer combat platoon leader in the Army reserve. Admittedly, I could have rejected the assignments to work on the H-Bomb experiments, and insisted on being sent to Korea as a combat platoon leader, for which I had been prepared. As a combat platoon leader, I probably would have been hit by only a few bullets that would have killed me, rather than the tens of trillions of gamma rays that hit my body; that happened when I jumped off a helicopter onto a highly contaminated island to recover my neutron spectrometers after the 1954 H-Bomb detonations. (This scenario is described in Chapter 6.) Yet here I am, 56 years later and still playing tennis. Therefore, I must deal with the fact that radiation risk depends on the amount of exposure in a complex, but well-researched way. I will do this in Chapter 4.

Because it is possible that terrorists might use chemical and biological weapons individually or in combination with weapons that disperse radioactive materials, it would be best for citizens to be informed and be prepared with survival actions for all of them at the same time. Some elementary information about chemical and biological weapons protection is given in Chapter 7. However, a detailed description of the characteristics of chemical and biological weapons would be even more complex than the information needed for protection against radioactivity. One chapter (King 2004) in Brodsky et al. (2004) was solicited from one of the authors of a book that deals with all three weapons of mass human destruction. His chapter is a condensation of the information in Byrnes et al. (2003). These sources may be consulted for additional information on chemical and biological agents. Some information that can be protective for the general public will be included in context with recommendations for radiation protection. However, if dangerous chemical agents should get on the skin, the most urgent action is to wash them off immediately; even so, some of these agents can be lethal in small quantities. Complete shelter or appropriate evacuation ahead of time, or as rapidly as possible once a chemical or biological agent is known to be released, might be the only protective measure against such agents.

Individuals exposed to biological weapons might not show symptoms for days. There was an article in the July 31, 2006, issue of The Washington Post, by Joby Warrick. This article makes it clear that the secrets of biology that allow genetic engineering of new and harmful organisms, some that produce lethal chemical toxins, are now on the internet. The government is spending large amounts to attempt to counteract these agents, and the situation is fluid. Such issues must be dealt with by the general public health community.

There is one chapter in Brodsky et al. (2004) that deals with chemical and biological agents, in addition to the chapter by David King. I solicited that chapter from the Research Director of the Armed Forces Radiobiology Research Institute, Dr. Terry C. Pelmar. She told me that the interactions of the three types of agents on humans is not completely known, but provided a concise chapter and talk on the subject (Pelmar 2004). The information in this chapter should satisfy the desired knowledge of the vast majority of the public.

Some of the recommended protective measures against radiation will also provide some protection against chemical and biological agents — particularly decontamination. Moreover, chemical and biological agents are not likely to be as widely dispersed and detectable as small amounts of radioactive materials, which would be easily detectable by Geiger counters or more sensitive instruments at levels far below those that would be harmful. (Of course, political leaders are careful to avoid panic, considering the possible economic consequences to the nation. On the other hand, public health authorities at State and local levels will be the best source of information about "things to do.") Some simple actions for protection in case of an attack with these agents are included in Chapter 7.

CHAPTER 3

A FEW NEW WORDS TO REMEMBER

As we have seen from the above discussion, some special words are needed to discuss radiation doses and risks — words that are not used in everyday conversations among our general public. Many of you have been exposed to some of these words in high school science courses, and those words will be familiar. However, some additional words might not have been used in school, so to make it easier to remember the little bit of basic information needed to protect yourself and your family from radiation and "radiation panic," some definitions and concepts are presented in this section. Do not worry. You do not need to be a nuclear scientist to know the simple facts and understand the simplified concepts that are sufficient for personal protection and survival.

NOTE: Word definitions in this book are not taken exactly from official sources, but are put into language that the author believes better for understanding by most readers. Also, various units are used throughout the book, without consistency in either historic or current international usage, nor especially within any standard set of units. I do this because the reader, in examining various documents related to radiation protection, current or past, might run into any set of units that an author in any era might be constrained or prefer for convenience to use. Do not despair. Most lives will be saved if only the definitions and concepts of the roentgen (R), rad, and rem, or the corresponding current System Internationale (SI) units of Gray (Gy) corresponding to the rad, and the Sievert (Sv) corresponding to the rem, are learned. As shown elsewhere in this book, the units of radioactivity are less important for immediate actions for survival, because the likelihood from harm due to the intake of radioactive materials for those who survive blast and heat effects, is very low. *Therefore, the citizen in immediate moments after an attack need not quantitate amounts of radioactive material. Learn mainly the words in the final summary of this chapter. Also, as recommended in the document prepared by the Executive Office of the President (EOP 2010), in the moments after an attack, it is best to simplify the estimation of immediate exposure or dose from external gamma radiation to assume that 1 R of exposure, read on some instrument, is the same as 1 rad absorbed dose or 1 rem biological dose, or 100 Gy or 100 Sv.* The rem or the Sv is also not used consistently to describe local or effective whole body doses even in the international standards. Therefore, in some places in the book, the doses in rem or Sv, or their subquantities, might be prefaced by words like "organ dose" or "effective dose" to indicate whether the dose is just related to a local organ dose, or to an estimated equivalent whole body dose of x or gamma radiation that would give the same overall cancer risk from any type of cancer. These latter complications do not need to be of concern

to the average reader, but this book is also written to provide information for scientists or responders concerned with assistance to the public and later triage and health evaluations.

Appendix A presents in more detail definitions and concepts that will help those who want to delve beyond knowing just the immediate actions for the general public. Some readers might want to involve themselves as volunteers or employees in organizations planning responders to help the public beyond the immediate minutes or hours after an attack. Some readers might be scientists or engineers who just need some additional information in order to be able to join efforts of community or national recovery.

Only a few simplified definitions of terms needed for immediate understanding and actions on the part of most citizens are presented below in this chapter. These definitions are not presented in alphabetic order, but rather in order of higher to lower importance for members of the general public to commit to memory.

Just a few new or recalled words (and concepts) for discussing quantities of radiation and risk

Exposure — *Exposure refers to the amount of radiation incident, or passing through, an area in which a person might be present. An amount of exposure may be measured in a narrow beam of gamma rays that impinge on only a small part of the body, or in a broad beam that impinges on the entire body. The latter exposure is called a "whole body" exposure. A given exposure to the whole body would of course be much more serious than an exposure of, say, just a finger. When the amount of the body is not mentioned, it is usually assumed that the entire body received the average exposure stated.*

For example, if a person reads a radiation instrument at about waist high in air, and says that someone received 3 R per hour (3 R/hr) at that position, then he means that if the person stayed there for one hour at the same intensity reading, the person would receive an exposure of 3 R. Just like for speed, the rate in miles per hour, multiplied by the number of hours driving at that speed, gives the distance driven in miles. When I try to maintain a speed of about 60 miles per hour on a trip, I note that in one hour I have traveled about 60 miles. Sometimes persons monitoring radiation fall into the unfortunate habit of saying the reading is "3 R" when they mean 3 R/hr. The unit of time is important, because in discussing rescue work, we will often need to think in times of minutes or seconds, to work fast and greatly reduce exposure. The unit of exposure most likely to be used in our country is the roentgen, abbreviated R. The newer SI unit of exposure, defined and discussed in Appendix A, is not generally used in measurements associated with homeland security in the United States.

Roentgen (R) — *One R of exposure means that, at the point where it is measured, the exposure to x or gamma rays has created, in each cubic centimeter of air exposed, 1 electrostatic unit of charge (1 e.s.u. of negative electrons are removed from atoms in air leaving 1 e.s.u. of positive charges called ions).* Physicists very early in the 1900s learned to collect the negative electrons on a positively charged plate or wire and the positively charged ions on the negative plate of a pair of plates with a voltage maintained between them, some of the earliest ways of measuring radiation used such "ion chambers" or Geiger counters (see definitions below) and the most basic radiation measurements are made even today using these principles.

An abbreviated way of remembering the concept of 1 R is to remember 1 R yields 1 e.s.u per cc of air.

Remember, simply**: *1 R = 1 e.s.u. of electronic charges knocked out of atoms in 1 cc of air.***

You can imagine a concentration of billions of "broken up" atoms in a little box of air where the exposure is measured.

Milliroentgen (mR) — *When instruments read in mR on a scale, it means it is reading* ***one-thousandth*** *(1/1,000 or 0.001) of an R.* Many instruments used after an attack will have scales in mR exposure (such as a pocket chamber measuring total exposure as it accumulates), or scales reading in mR/hour (such as a Geiger counter attached to a box that has a scale labeled in "mR/hour" or "mR/h."

Dose — *The word "dose" in this book will usually refer to a radiation dose, but some discussions of chemical or biological dose will be in units other than those for radiation dose given below. Radiation doses are measured or calculated as the* ***energy absorbed per unit mass of material****, tissue or otherwise.* For exposure of people, the main thing to remember is that radiation incident on the body results in energy absorbed from the radiation, which for simplicity is assumed to be related to risk. For gamma radiation coming from radioactive material dispersed after a terrorist attack, we usually assume that a measurement in R is close to the dose; this gives us a safety factor in making quick decisions, because the gamma radiation dose, for a certain exposure, decreases through the body as the radiation loses gradually loses its energy. We may safely relate exposures in R, and doses in rad, or rem (defined in Appendix A in more detail) interchangeably to the Exhibits of risk versus dose in Chapter 4, for purposes of early emergency actions. Radiation doses will sometimes be given in units of rad or rem, with the corresponding international (SI) units Gy or Sv in parentheses.

Effective Dose — *The sum of absorbed doses in each organ or part of the body, after multiplying each dose by a tissue weighting factor (ICRP 1980) that is estimated to make that organ dose equivalent in risk to a whole body dose of the same amount.* Thus, when an effective dose is given for non-uniform irradiation, or for internal depositions that give different effective doses to each organ, it has been obtained by summing the partial effective doses to each organ. In this way, the indicated effective dose is about equivalent in cancer risk to a uniform external irradiation of the entire body at that dose.

Rad — ***An absorption of 100 ergs of energy per gram****, at the point(s) under consideration, from the exposure to any kind of ionizing radiation — alpha, beta, or gamma . A dose of 6,000 rad from a narrow beam aimed at a tumor would be damaging mainly to the tumor and some surrounding tissue. Many cancer patients exposed to such a dose aimed mainly at a tumor, as accumulated over about six weeks, go home with hope of a longer life. A dose within one day of 6,000 rad average over the entire body would be lethal within a couple of days*. Therefore, it is important to know something about the duration and extent of body exposure. For quick decisions and actions after a terrorist attack, an instrument reading a certain exposure rate in R/hour could be assumed to mean that someone in that vicinity is receiving a whole body exposure of 1 R/hour, and a dose rate of 1 rad/hour to the whole body. This assumption would at least high-side, and not underestimate, the exact dose.

An SI unit for dose, used generally in other countries, and often in the USA, is the Gray (Gy), which is defined in Appendix A. I give my own opinions in Appendix A regarding why the SI units should not be preferred for use in radiation protection in the United States, but not everyone agrees with me (no surprise). Thus, we must know that

1 Gy = 100 rad

If an instrument reads in Gy, multiply by 100 to realize the dose in rad, if comparing against risks listed against such units. It could be lethal not to recognize an instrument reading that is in Gy and interpret it in rad.

Rem — *As discussed in Appendix A, the rem is a unit to take into account that heavier particles such as alpha particles, protons, and neutrons (which knock some protons out of molecules as they pass through tissue) often produce more biological effects per unit rad dose than x, gamma, or beta rays.* For our purposes of understanding rapid actions to take after a radiological attack, we can assume that radiation doses in rem are the same as in rad. It is unlikely that persons surviving any attack will be exposed to neutron radiation. Alpha particles are only harmful if the radioactive atoms that emit them, such as plutonium, americium, or radium isotopes, are taken into the body by breathing them or eating them. Exposures to inhaled alpha-emitting materials are discussed in Chapter 4.

As for rad, there is an SI unit of biological dose, the Sievert (Sv): Also remember that

1 Sv = 100 rem.

It could be dangerous to mistake a reading in Sv as a reading in rem, just as indicated above for the Gy.

Prefixes for subunits of exposure or dose — You might hear responders talking about microR, or other multiples of the R, or in the same way of the rad or rem. A microR, oftern abbreviated with the Greek letter mu as a prefix, μR, means one-millionth of an R, or 0.000001 R, a very small exposure indeed. Therefore, to convert a reading in microR to R, move the number 6 decimal places to the right, as above. I will not bother you with all the prefixes we scientists use in measuring and reporting radiation quantities. This chapter is aimed at keeping the words as few as possible, so you remember what they mean if the time comes to use them.

Geiger counter (or Geiger-Mueller (GM) counter — a radiation detector that detects and estimates the intensity or flow rate through space of ionizing radiation such as beta or gamma radiation. It is designed with a fine wire "anode" that is placed at a high positive voltage, typically about 1,000 volts or more, with respect to a negative or ground voltage voltage of zero at the wall surrounding the wire, which is insulated from the wall. With a thick wall of metal (perhaps only in millimeters) beta radiation can not be detected, so the counter can detect only gamma radiation. Although most gamma rays of interest can penetrate the wall, enough gamma photons interact with the wall and release electrons into the chamber to produce an electrical pulse. These electrons are fast enough, so that they knock out electrons from atoms of the gas (or air) in the chamber with such energy that, under the high attractive positive voltage at the anode wire, they cause a huge avalanche of electrons that saturate the anode with a pulse of current, which is registered by an appropriate electronic circuit that then restores the proper voltage to the anode to allow recording a following pulse. Restoration of voltage can occur within a millisecond interval so that thousands of pulses per minute can be recorded by a GM counter. The amplification in a geiger counter avalanche is such that about 100 billion electrons arrive at the anode for a pulse initiated by only one electron knocked into the gas by a gamma ray (science standards now recommend no capitalization of the word Geiger, even though it was a scientist's name). If a very thin window is cut into the wall of the chamber and sealed with a thin plastic membrane protected by a screen, so that the gas in the chamber can not escape or be infiltrated, then when the detector is placed near a surface contaminated with a beta emitter, the betas (fast electrons) can then immediately be detected very sensitively by the counter. The counter is connected to an electronic circuit and meter that indicates the number of counts per unit time, which, if no betas are entering the chamber, sometimes is roughly indicated on a scale to indicate the exposure rate of gamma radiation in mR per hour, for a certain range of gamma energy and within certain limits of accuracy. The range of gamma radiation for which exposure is roughly indicated within a certain accuracy is specified in the information provided with the instrument. Sometimes, the count-rate is also connected to an integrating circuit that can accumulate the counts as well as the indication of total exposure. Therefore, a Geiger or GM counter is most suitable under peacetime conditions for making surveys of laboratories or industries where one wants sensitive detectors, because workers might be exposed to gamma or beta radiation over a lifetime on the job or many years of work.

(Note: The definitions and descriptions of radiation detecting and measuring instruments in this book have been simplified so that the reader interested in the scientific bases of these devices can have at least some concise idea of how they work. (More detailed descriptions and concepts may be found in the textbooks by Cember (Cember and Johnson (2008), Evans (1955), and Turner (1995), listed in the References section. The chapter by Johnson (2004d) describes all types of radiation instruments as they might be used by emergency responders.)

Ion chamber (or ionization chamber) instruments — These chambers are much less sensitive than the geiger counters and are used to measure radiation intensities in the thousands of mR per hour, or R per hour. These are usually larger chambers but with much lower voltage on the anodes, perhaps a few hundred volts or less. In these chambers, there is no large amplification of the number of electrons reaching the anode. Only the electrons

produced from the knocked out electrons from the wall or in the gas are collected by the anode and feed into the reading circuits. Limiting readings to count the pulses by circuit or gas design is usually not employed. Often, Geiger counters are too sensitive for use in emergencies where it is necessary to assess whether higher intensities or exposures might be accumulated within the minutes or hours of exposure before adequate shelter or evacuation can be effected. In emergencies, it is necessary to have available the much less sensitive ionization chamber survey instruments, in which levels of radiation just below or approaching those likely to give health effects might provide appropriate warnings of the limits of stay time. When I was called one night in about 1960 to survey a leaking nuclear fuel cask in the Baltimore train yard, my GM counter battery turned out to be dead, but I was glad anyway to have a higher-range ion chamber survey meter called a "Cutie Pie," as named in the early atomic energy lingo. I was able to not only monitor any gamma radiation that might occur, but also with the thin window of the chamber open, I was able to calculate as I drove to the train yard the fact that I would be able to estimate radioactive iodine concentrations in air from the chamber ionizations of the betas from the iodine isotopes with the window of the chamber open. Iodine nuclides, being the most volatile and likely to escape from the fuel elements, could help me estimate the limiting exposures that I might find. This ensured me that I could properly manage the situation with any radiation risks to persons or the environment that I might find on arrival. I had calculated that I could have detected a concentration equal to one thousand times the routine maximum permitted beta concentration in time to order evacuation of personnel in one minute, if necessary. Fortunately, when I arrived at the leaking cask, I found no readings from beta particle concentrations in air, and any gamma exposure rates were not dangerous to the workers in the area. (More detailed descriptions and concepts may be found in the textbooks by Cember (Cember and Johnson (2008), Evans (1955), and Turner (1995), listed in the References section. The chapter by Johnson (2004d) describes all types of radiation instruments as they might be used by emergency responders.)

Proportional counters — These are somewhat similar in principle to GM detectors, except that they are operated at lower voltages (for a given chamber geometry) so that the number of electrons reaching the wire anode is proportional to the initial ionization produced in the chamber, and not always 100 billion. In this way, heavily ionizing particles such as alpha particles can be discriminated electronically from beta radiation, when surfaces or clothing are monitored. (More detailed descriptions and concepts may be found in the textbooks by Cember (Cember and Johnson (2008), Evans (1955), and Turner (1995), listed in the References section. The chapter by Johnson (2004d) describes all types of radiation instruments as they might be used by emergency responders.)

Scintillation detectors — These are solid or liquid detectors that provide light scintillations when activated by ionizing radiation absorbed within them. Light flashes are then sent as pulses through a circuit that provides counts per minute. As a result of their greater mass, they can interact more often with gamma rays (or neutrons for hydrogen-rich scintillators) and thus be even more sensitive than GM counters, and can with appropriate circuitry tell something about the unit photon or neutron energies encountered. Usually, they would be more expensive than other detectors and not as suitable for the higher exposure rates encountered in early phases of emergencies. Thus, no further description of these types of instruments is within the scope of this book. (More detailed descriptions and concepts may be found in the textbooks by Cember (Cember and Johnson (2008), Evans (1955), and Turner (1995), listed in the References section. The chapter by Johnson (2004d) describes all types of radiation instruments as they might be used by emergency responders.)

Other Solid state detectors — These are detectors that are more often needed to more accurately assess the energies or energy spectra of ionizing types of radiation. They would be used by specialists who know their characteristics and uses after a nuclear or radiological emergency. Many designs are used. Thus, no further descriptions of these detectors are appropriate here. A good summary for the interested reader is that by Johnson (2004d).

Nuclear disintegrations (or transformations) — The nucleus of an atom that is unstable, and thus radioactive, emits either alpha rays (mainly the heaviest elements), beta rays, and/or gamma rays when the atom changes to a more stable atomic configuration (i.e., when it disintegrates, or in later terminology transforms to another chemical atom). For a given initial amount of a particular type of radioactive atom, one that transforms by nuclear disintegrations, the radioactivity (rate of transformations) is reduced over time according to its particular characteristic "half-life." The half-life of such transformations ranges from microseconds (for precursor fission products) to billions of years (as for thorium-232 or uranium-238). The longer the half-life of the radionuclide (the time for half of the radioactive atoms to decay), the more mass that accompanies a given quantity of radioactivity. At some point, e.g., natural uranium with most atoms as uranium-238, so much material would need to be inhaled to produce a serious internal radiation dose to any organ that the chemical toxicity risk exceeds the radiation risk. Therefore, regulatory intake limits for natural or depleted uranium by inhalation or ingestion are limited by the amount determined from research or patient examinations that would begin to cause kidney defects.

NOTE: The following definitions related to radioactivity are not as important for every member of the public to memorize in order to know immediate actions for protection. As described elsewhere, based on my experience and research, the amount of radioactivity inhaled or ingested after a release of radioactivity is not likely to be a serious risk to the vast majority of persons. In any case, scientists or trained technicians who will determine any intakes of radioactivity will necessarily be able to arrive and make their determinations only hours or days after the immediate protective actions are taken.

Radioactivity — *The process of atoms transforming, by nuclear transformations, and emitting nuclear radiation. The rate of transformations is also sometimes called "radioactivity," or by scientists involved in rate measurements and talking between themselves, just "activity." The most used units of measurement, or discussion, are the Curie, the Becquerel, or just the number of atoms transforming per second, or the transformations (disintegrations) per minute, usually abbreviated as dpm. The rate per minute (dpm) is more often used, because one minute is a more convenient time for measurement. The unit definitions to remember, then, are:*

- *Curie (Ci) — A rate of disintegration equal to 3.7 x 10^{10} disintegrating atoms per second (dps), which is 37 billion dps. Most often used is the prefix* **μ***; a* **μ***Ci is 37,000 dps, which is the same as 0.000001 Ci.*
- *Becquerel (Bq) — A rate of 1 dps, introduced with the other SI units. 1* **μ***Ci = 37,000 Bq.*
- *dpm — disintegrations per minute.*
- *tpm — transformations per minute, which means the same as dpm.*

MeV — *Millions of electron volts. An electron-volt (eV) is the amount of kinetic energy that an electron, or something having the same amount of negative electric charge as an electron, gains as it falls through an electric potential of one volt*. This is a small unit of energy suitable for expressing the energies of radiation particles or waves that are emitted during nuclear transformations. An eV is only 1.6 trillionths of an erg (i.e., 1.6 x 10^{-12} ergs), for those interested in studying more of the science of radioactivity. A kilo-electron volt (keV) is 1,000 eV, and an MeV is one million eV.

Alpha particle — *Basically, a* ***helium-4 atom stripped of two outer electrons****, as it is emitted from a heavy radioactive atom yearning for a more stable state.* Therefore, it is a helium nucleus, two protons attached to two neutrons by nuclear forces, but with two positive charges as a result of the empty shells of two electrons as it is ejected from a heavier nucleus. Alpha particles are often ejected having discrete kinetic energies of about 4 MeV or more. Because they are much heavier than electrons, this amount of kinetic energy is represented by much slower velocities than for the beta rays (particles) emitted from most fission products. Therefore, the positively charged alpha particles moving slowly through matter have more time to lose energy as they pass close to electrons and thus have much shorter paths through material. Alpha particles cannot, in fact, pass through the dead outer layers of skin, and thus are not a hazard unless a large amount of alpha-emitting atoms are taken into the body.

Beta particles — *Beta particles are electrons ejected from the nuclei of radioactive atoms that desire to change a neutron into a positively charged proton to obtain better nuclear stability. Most of the products of nuclear fission, the breakup of uranium or plutonium atoms when a bomb explodes, or when nuclear reactor fuel fissions and produces energy, eject (emit) beta particles with a range of energy from a maximum energy down to zero. Some radioactive atoms emit beta particles of enough energy that they can travel one meter or more in air before all lose their energy. Therefore, if there is fallout on the ground where you walk, the part of your feet and ankles that are uncovered will receive a greater dose from beta particles than your waist or neck. Many of the beta particles emitted from fission products will not reach as far as the upper body. Also, as beta particles impact on the skin, they are absorbed within about one centimeter, or one-half inch. Thus, they can produce skin burns that are perhaps deeper than those caused by ultraviolet from the sun, but they cannot cause deep organ doses, unless the beta-emitting atoms are taken into the body.*

For readers who are scientists interested in preparing to evaluate skin doses after an attack, the doses to skin from the particular radioactive materials on the skin that are most likely to be used in a dirty bomb, or might be prominent in fission products, are given in Table A.10.8 of Appendix A.10 of the 2004 HPS text, including a simple rule of thumb for converting Geiger counter measurements to skin dose (Brodsky 2004d,e). Easily used algorithms are also available for calculating beta ray doses, and beta ray instrument responses, for beta spectra reaching out to various distances (Brodsky 2004e,g,h). Methods of determining beta doses from various nuclides on the ground, at various times after explosion, are given in Barss and Weitz (2006). The information in these references is not needed for most citizens desiring immediate personal protection, as long as they are sure to wash if exposure is expected.

Gamma rays — *Gamma rays are electromagnetic radiation emitted usually after beta decay of a radioactive nuclide. They are sometimes even referred to as gamma particles or photons. These gamma particles are wavelets, called photons, which have no mass. They travel at the speed of light in vacuum, c = 30 billion centimeters per second (which is 186,000 miles per second). However, as Dr. Arthur Compton showed, and won the Nobel Prize for, the interactions of gamma photons with electrons can sometimes be exactly like the classical mechanical collisions of one billiard ball with others, when the momentum of the photon is taken to be its energy divided by c.* Further discussion of this is beyond the scope of this book. I just want to indicate that, in public discussions, I think it could be useful to simply say that **gamma rays knock out electrons from atoms when they get close enough**, as they pass through tissue. Thus, some gammas that do not get close enough can pass through the entire body without delivering any dose.

Summary of Words to Remember for Immediate Protection

Only a few concepts and words need to be remembered to make the right decisions for protecting you and your family in the early moments after an attack. Exhibit 4 shows the penetrating ability of alpha, beta, and gamma rays. In addition, in order to understand exposures or doses given to you (or read from your own personal dosimeters, to relate them to the degree of risk as discussed in the next chapter, and to take any necessary immediate precautions to increase shielding or distance from radioactive fallout, remember the following definitions:

1 roentgen, written 1 R = 1 e.s.u. of charge knocked out per cc of air — unit of exposure. Note: This unit applies only to the measurement of gamma or x rays in air.

1 milliroentgen, written 1 mR = 0.001 R, which is one thousandth of an R

1 rad = 1 erg per gram dissipated in the material. If a finger were held in air at the point where 1 R is measured by an instrument, the dose to the soft tissues of the finger would be about 0.87 rad. The average dose within the body would be less than one rad, how much less depending on the energy, or energies, of the incident gamma rays.

1 rem = 1 rad x (quality factor). The quality factor for gamma and beta rays of most interest here is 1. So in the aftermath of radioactive fallout, you may assume that a dose reported in rem is the same dose in rad.

R, rad, or rem, as measured from a personal dosimeter or calculated from R/hr, rad/hr, or rem/hr over a certain amount of time, may be assumed to be the same in estimating risk, danger, or safety, when compared under emergency conditions with risk factors given in the next chapter. That is because more accurate information is not needed for emergency actions. The measurements obtained are usually on the high side as read on available instruments or dosimeters, and the variations in biological sensitivity of a given person from day to day, and between persons, can vary by a factor of two or three (Mettler et al. 2007). This is why instruments for health protection are best designed to read on the high side, in any circumstances where they might not be accurate.

CAUTION: If you read an instrument or personal dosimeter yourself, or someone gives you a number from a measurement, make sure you know whether the reading is a rate — R/hour, rad/hour, or rem/hour, or a total exposure in R, or total dose in rad, or in rem received over a certain amount of time. Also, be prepared to divide rem/hour by 60 to get rem/minute, or by 3600 to get rem/second. Many life saving actions can be taken within minutes or seconds, followed by running back into safe shelter locations, or being evacuated by helicopter.

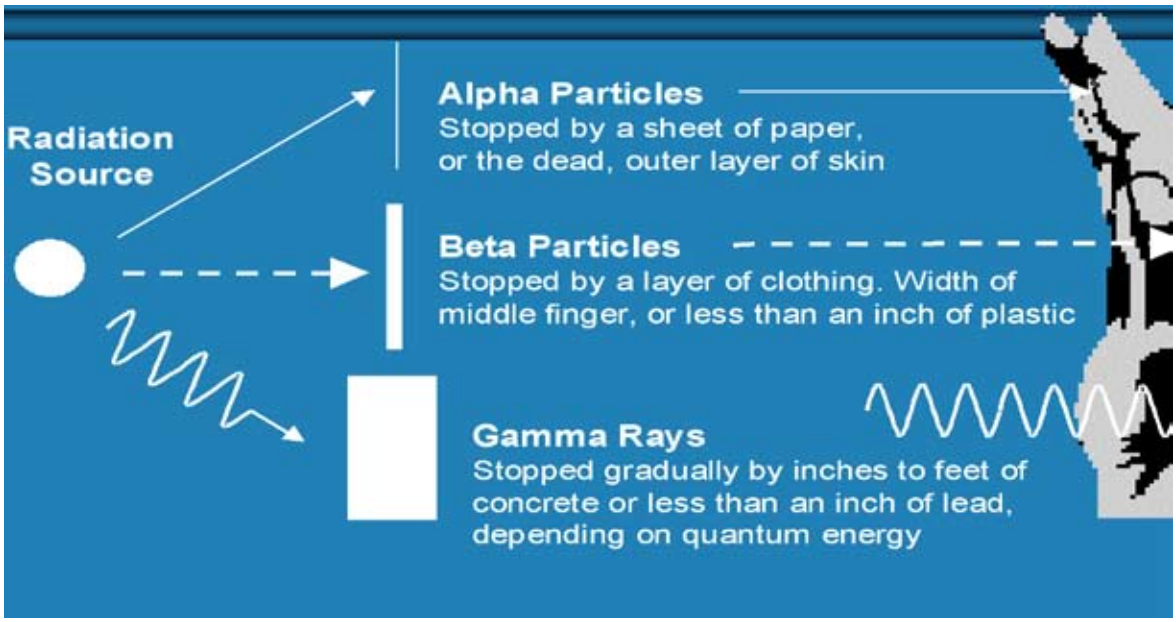


EXHIBIT 4. A Visual Picture of the Degree of Penetration of Alpha, Beta, and Gamma Rays

CHAPTER 4

SOME BASIC INFORMATION ABOUT RADIATION HEALTH EFFECTS AND RISKS

This chapter summarizes information on radiation effects and risks, and reference documents, for the reader to know at what radiation dose levels risks to health become significant. The word ***"risk"*** *as used here refers to the* ***chance*** *of something happening, not necessarily to a level of danger. To the public, the word "risk" is often used to denote danger.*

The reader who does not have time, or need, to dwell on the details in this chapter may do well to read just the highlighted material, or perhaps the Summary of Things to Remember About Radiation Risks*, at the end of this chapter****.*** *Much of the detail is for health physicists or others who might be involved in advising response organizations, or in training responders at various levels. In this chapter, I refer to and use only data and research conclusions of those whom I know to be respected and eminent scientists in their fields of study.*

Radiation Doses Already Received by the Public

Exhibit 5 shows the wide range of doses that may be encountered in normal life. This dose table could be updated by several other versions recently published, but here the general range is of interest. It must be noted that in Exhibit 5 the therapy, heart catheterizing, and barium enema doses are received only over limited parts of the body, whereas the other doses are assumed to be averaged over the entire body. A preliminary report of the NCRP (Mahesh 2007) indicated that since the 1980s, the use of computerized tomography scans using x rays or radioactive isotopes increased almost a factor of ten due to the need to diagnose serious diseases as early as possible, resulting in about a doubling of the average radiation dose to members of the public from medical x rays to an average of about 300 mrem per person per year in the USA. The data have been confirmed and the NCRP report has been issued (NCRP 2009). The report gives estimated doses; hopefully, the benefits of this additional radiation will be covered in a later report of the NCRP.

The therapy doses (up to 6,000,000 mrem) listed in Exhibit 5 would be lethal within a short time to anyone receiving such a dose over more than a small tumor target in a short period of time. In this chapter, some essential information is presented to provide guidance on how much radiation causes how much risk or harm, if any.

Typical Radiation Doses

Annual dose from living near a nuclear power plant < 1 millirem

Flight from Los Angeles to London	5 mrem
Annual public dose limit	100 mrem
Annual natural background	300 mrem
Fetal dose limit	500 mrem
Barium enema (limited part of body)	870 mrem
Annual radiation worker dose limit	5,000 mrem
Heart catheterization (skin dose)	45,000 mrem
Life saving actions guidance (NCRP-116)	50,000 mrem
Mild acute radiation syndrome (if whole body dose)	200,000 mrem
LD 50/60 for human (bone marrow dose) (whole body dose)	350,000 mrem
Radiation therapy (localized & fractionated)	6,000,000 mrem

EXHIBIT 5 — Some typical doses of radiation received in normal life, as compared to the usual regulatory peacetime limit to any member of the public of 100 mrem to the whole body, and compared to additional doses other than medical doses, which are deemed to be balanced by medical benefits.

The large radiation dose indicated for therapy is, of course, administered only to a small amount of tissue, which is the cancerous target tissue of interest. Such a dose would result in immediate death if delivered to a substantial part of the body. In fact, a few accidental misadministrations of such doses to the wrong tissues have resulted in deaths to patients. It can be seen from this exhibit that discussions of radiation dose can range over many orders of numerical magnitude; the range is even larger than indicated here. Note: These doses as expressed in mrem might need to be changed if a mixed neutron and gamma field is involved. However, this particular accident scenario is not pertinent to this book.

Exhibit 6 below provides another list of exposures to give perspectives about the exposures and doses to be discussed in this book.

	Dose in rem	Whole Body or Local
Some Commonly Encountered Radiation Doses:		
One transcontinental airline flight	0.003	WB
Standing beside a diagnostic nuclear medicine patient for one hour	0.0001-.008	WB
Living in a brick house for one year, add to your natural background exposure		
One diagnostic nuclear medicine study	0.01-2.2	WB
One chest radiograph	0.03-0.05	L
Natural background in the United States at sea level for one year	0.08-0.15	WB
Natural background for Denver for one year	0.12	WB
One abdominal radiograph	0.5-1	WB
Annual occupational dose to a nuclear medicine Technician	0.3-1	WB
One CT series of the brain or trunk	2	L
Recommended Maximum Permissible Doses:		
Regulatory does limit for one year for individuals not exposed occupationally (the public)	0.1	WB
Recommended maximum permissible radiation worker Dose for one year	5	WB
Recommended limit for special dose (sometimes 25 rem in emergency)	10	WB
Maximum permissible dose for one year to hands of occupationally exposed individuals	75	L
Potential Biological Effects from Radiation Doses:		
Dose of average age to cause 1% chance of cancer death	20	WB
Temporary change in blood count	25	WB
Cataract formation (eye exposure only)	600-1500	L
Permanent sterilization in men (acute dose)	100-300	L
Permanent sterilization in women (acute dose)	250-800	L
Lethal single exposure (acute dose)	150+	WB
Therapeutic dose for malignancy (over 6 weeks)	6,000	L

EXHIBIT 6 — Additional Exposures Received by the Public, in Comparison to High Doses in Radiation Therapy or Those Causing Serious Effects.

Adapted from McElroy and Brodsky (1985) with changes. WB stands for "whole body" irradiation, while L means only part of the body, or a specific tumor or organ under treatment is in the radiation beam.

Is Any Amount of Radiation Dangerous?

*Some scientists and physicians eminent in the investigation of biological effects of radiation in animals and in humans have not been the most careful in expressing the range of risks to the public — possibly because they are not astute in the language of probability, or chance. They have repeatedly made the statement that, "**Any** radiation is **dangerous**." This sentence itself is dangerous, because it causes undue fear in the public mind of many of the known beneficial uses of radioactive materials that are essential to health and welfare (Waltar 2004). Some of these beneficial uses expose members of the public to negligible levels of radiation, if any at all. The word "dangerous" to a member of the public usually means that the threat of death from the exposure is imminent. This is obviously equivalent to a myth, because, as shown in the table of Exhibits 5 and 6, we are always exposed to some radiation. In fact, the average exposure to natural radiation can vary a factor of two or more, depending in whether you live at a high or low altitude, whether you are exposed to uranium-containing building materials in your home, or whether radon emanates from the soil beneath your home and is not vented away. There are even places in the world where people live and receive ten or more times the average background in the United States of about 300 mrem per year (Eisenbud and Gesell 1997). Even our bodies are exposed to radiation from naturally radioactive materials present in our bodies, such as potassium-40, which is not removable from the potassium needed in our bodies for us to live.*

Some personal perspectives about risks of high versus low levels of radiation

Soon after the Three Mile Island (TMI) accident, I was invited to participate in a panel organized by the Pennsylvania Medical Society in conjunction with the Commonwealth of Pennsylvania, to inform physicians and the public about radiation exposures resulting from the accident. While I was waiting for my turn to speak, I was astonished to hear Dr. Arthur C. Upton, M.D., Ph.D., say during his talk that, "Any radiation is dangerous." I knew him to be an outstanding physician and researcher in radiation bioeffects, and he later became Director of the National Cancer Institute. He must have meant that even very small amounts of radiation might have some very small chances of causing cancer. Unfortunately, I have heard Dr. Upton's statement repeated many times by others since the TMI accident.

*More recently, a number of otherwise competent scientists I know have made similar statements. In fact, in a recent booklet of the EPA (2007) on how to communicate radiation risks, on page 16 there is the statement that, "**No** amount of radiation is **safe**." This statement is equivalent, and just as misleading and dangerous as the statement that, "Any amount of radiation is dangerous." If these statements were true, there would be no human race. As shown before, we are all exposed to some level of radiation from natural background radiation and other sources. The human race has even evolved under exposures to natural radiation that were ten times higher many millions of years ago (Carbon 1997).*

What they are referring to is the linear, non-threshold (LNT) model, of radiation risk vs. dose that is used for conservatism in peacetime control of radiation exposure. Dr. Elaine Ron, one of the leading cancer epidemiologists at the National Cancer Institute, has reported that there is no evidence of non-linearity in the dose range below 15 rad from studies of the Hiroshima-Nagasaki (HN) population exposed to prompt radiation in Japan (Ron 2007). Although this conclusion is based on only 84 "excess" cancers assumed to be (but actually not) statistically significant and attributable (only with great uncertainty) to radiation out of a total of about 14,000 cancer cases due to all causes in the below 10 rad range in the HN study population of more than 100,000 persons, these are the primary data on which ICRP, NCRP, and radiation safety regulatory bodies assume that radiation risks increase from zero linearly as dose increases, ignoring other evidence that doses within a certain low range can also have beneficial effects (hormetic effects) that completely overcome net risks.

In my own publications, I have used the LNT model for my own recommendations for peacetime ease of management of radiation protection programs, and to avoid the unnecessary spread of radioactive contamination that could affect other peacetime applications. However, we must not induce unfounded fears in the public mind

and cause undue panic in emergency situations where radioactive materials are deliberately released by terrorists, and where doses are below (or even somewhat above) the "accepted" 25 rem for responders in life-saving situations, or where doses to members of the public are below levels likely to cause harm. There are so many greater risks from panic and improper behavior. We must not ignore the extremely low chances of health effects at low exposure levels that even the LNT model predicts. Moreover, we should remember that for such doses received over a longer period, perhaps many days, there are biological repair processes. Also, there is evidence that doses lower than about 10 to 20 rem can have beneficial (hormetic) effects through stimulation of the immune system, and through increasing resistance to higher subsequent doses (Luckey 1991; Lenihan 1993; UNSCEAR 1994; Brodsky 1996a; Rockwell 2003; Scott et al. 2008).

We know from experience that, even with the LNT model, as the dose goes down, the risk can be made to go down to negligible levels — risks far lower than those accepted by even the most cautious members of the public in their daily lives. This is true even if we ignore the evidence for hormetic effects of low levels of radiation (Brodsky 1996a; Lenihan 1993, especially pages 18-33). I can conclude only that those persons of scientific backgrounds who have stated that, "Any radiation is dangerous," have not realized the inappropriate fears that this statement would invoke, often tending to preclude the beneficial health and economic applications of nuclear energy and byproduct sources (Waltar 2004; Rockwell 2003). Such fears have also prevented us from an adequate civil or homeland defense to reduce unnecessary exposures in the event of terrorist attacks or accidents releasing radioactive materials. I do not think that Dr. Upton would make such a statement today (Mettler and Upton 1995).

High enough exposures to radiation would, of course, be dangerous. Above some level, where the mean whole body dose in a short time is above about 10-20 rem, as exposure (or dose) goes up, risk can go up. This is true for the LNT model or other proposed models of risk versus dose. Organizations that recommend safety guidance for radiation protection, and government agencies at present, assume for simplification of radiation protection practices that even very low exposures entail some (very low) risks. Nevertheless, even with the conservative LNT assumption, recommended and regulatory limits of exposure to workers have always been based on keeping risks down to the same risk levels, or below, of accidental injury or illness exhibited in the safest industries and work situations (Brodsky 1996). Limits of public exposure have always been kept at least one-tenth or below those of workers.

We discuss and deal with an enormous range of amounts of radiation exposure; Exhibits 5 and 6 give only a small sample. The word "dangerous" conveys to members of the public that they are being exposed to enough exposure to be an immediate risk to life, requiring immediate escape or protective action. The word "any" conveys that even extremely low doses are "dangerous." If any radiation dose was dangerous, none of us would ever exist. As noted earlier, there have been even greater exposures of the human race to natural background radiation in earlier millennia of human existence. Even without assuming hormesis, my experience in research and regulatory agencies confirms that all beneficial technologies involving radiation exposure can be, and have been, conducted with a safety record much better than for many other human activities (Waltar 2004); this is true despite other impressions often given to the public in the news and popular literature.

Just let me give you a few scientific facts for example, using some of the special words defined in Chapter 3 and Appendix A. Even just for the natural potassium within each of our bodies for proper heart activity, a small percentage (about 0.0118 percent) of the atoms is the radioactive potassium-40 (Eisenbud and Gesell 1997). Potassium-40 is abbreviated K-40 by scientists. This small amount of natural K-40 among the natural stable K-39 in our bodies is "radioactive"; that is, the K-40 atoms slowly transform into stable calcium-40 atoms. K-40 and K-39 atoms are so similar chemically that there is no way we can get rid of the K-40 in our bodies. The transformation of K-40 is so slow that it takes 1.28 billion years (International Commission on Radiological Protection (ICRP) 1983) for half of a bunch of K-40 atoms to change to stable calcium-40 (Ca-40); yet there are so many billions

of trillions of K-40 atoms in our bodies (mainly among about 140 grams of potassium in muscle tissue) that each of us has about 3700 K-40 atoms disintegrating each second. Each transformation emits beta and x radiations that are not very penetrating but contribute to about half of our self-exposure from within our bodies. (Our total self-exposure to internal naturally occurring nuclides gives us an annual dose of about 39 millirem (mrem).) In addition, about 10.7 percent of the transformations of K-40 also emit a high-energy gamma ray of 1.46 MeV energy; this gamma ray can penetrate through tissue, and only a fraction of its energy, on the average, is absorbed within our own bodies.

Therefore, when I hug my wife, I am bombarding her with some hundreds of high-energy gamma rays each second — those gamma rays that are emitted in her direction and are not absorbed in my body. However, when I hug her, she is doing about the same thing to me. Anyway, the enormous benefit of her healthy hugs is trillions of times greater than any insignificant risk I might receive from the small exposure or dose of absorbing hundreds of gamma rays each second. I hope that my wife feels the same way. I hope that this incontrovertible fact will help indicate how absurd it is to say that, "Any radiation is dangerous."

When I was on the faculty of the University of Pittsburgh, I also served in 1964-1970 as Technical Director of Radiation Medicine at the Presbyterian-University Hospital. At this hospital, I designed with my colleagues Dr. F.J. Bradley and Dr. Niel Wald, and set up, a large shielded counting room and radiochemical laboratory for measuring amounts of radioactive material in patients and workers from the nuclear industry. To calibrate my measurements, I actually used the amount of K-40 in my own body to adjust and calibrate a large scintillation counter for detecting gamma radiation "fingerprints" from radioactive materials in the bodies of workers exposed to inadvertent inhalation of radioactive materials. I also filled a human-like plastic phantom with water and added the 140 milligrams of potassium to provide another check on the gamma ray counts. Because at the time I was about the size of an average man, my gamma ray counts and the shapes of my 1.46 MeV energy fingerprints matched those of the phantom exactly. Thus, I also effectively measured the K-40 in my own body in this way, in comparison to the phantom. This is one way in which muscle to fat ratios are measured in humans. The gamma ray counters that I used were within a large room with walls made of pre-atomic-bomb steel about 6 inches thick, so that other background gamma radiation interference with our counts was about a factor of 50 lower than the average background exposure you receive from gamma radiation every day. Many thousands of gamma ray counts were detected from my body every minute by the large scintillating crystal about two feet above my body when I reclined in a specially-selected, low-activity, lawn-type chair within the steel room. I often used 40-minute counts of my body reclining in the lawn chair as a check on system stability. (This was a good way to work when I was tired.)

In addition to the exposure from K-40 within our bodies, there are varying amounts of K-40 in rocks and soil in our environment; gamma rays from the ubiquitous K-40 in our environment contribute radiation exposure from sources external to our bodies. There are also many other naturally occurring radioactive nuclides (radioactive atoms) in our environment. Of about 340 natural types of atoms, about 70 are radioactive (Eisenbud and Gesell 1997, page 134). By just living, we receive certain "background" exposures from these natural radionuclides. The comparison in Exhibit 5 of annual exposures received from various sources is extended by comparison with other doses received in short but accepted medical diagnostic x-ray procedures (Domenici 2005, page 189)

Some personal perspectives on hormetic effects of radiation

Many scientists now believe also in the hormetic (beneficial) effects of low level radiation (levels, for example, that might reach up to 20,000 mrem, or more, received over many months). A number of ecological studies of human populations exposed to very high natural background levels of radiation, due to unusually large amounts of uranium and thorium (and their radioactive decay products, radium and other gamma emitters) in the soil where

they live, have indicated the existence of such hormetic effects (Eisenbud and Gesell 1997). I have observed some suggestive evidence of such effects myself, and have also reviewed those applicable to mammals in the thousands of references cited by Luckey (1991) (Brodsky 1996a). Rockwell (2003) reviews this subject in terms that readers can understand. Feinendegen et al. (2010) and other current papers in the Dose-Response journal provide more recent scientific evidence of hormetic effects at low doses of radiation.

These hormetic effects of low-level radiation are believed to be similar to those of known medicines and vitamins. For example, swallowing one aspirin each day may be helpful; swallowing an entire bottle all at once is lethal.

Essential nutrients such as the small amount of selenium in some vitamins are lethal in much larger quantities. When I was working on the first hydrogen bomb project at Eniwetok, an Army doctor gave me a prescription for Selsun, which contains a 1% selenium suspension as sulfide, to control dandruff (when I had hair). Some years later, Selsun was placed on the market with no prescription required, but with some warnings to avoid getting it into the eyes or the body. My daily vitamin pill now contains 20 micrograms of selenium (29% of the estimated daily requirement). The amount of selenium that is in the 2 milliliters of shampoo with about 1% selenium in suspension that I now use every other day (without much hair) is therefore about 20,000 micrograms, which is assumed to be harmful if entering my body. With the precautions given on the bottle, however, it is thus assumed that only a healthy amount would enter through my skin (perhaps less than one part in a thousand).

In order to provide a comparison for this book, I looked up the toxicity of selenium in (Rockwell 2003, page 159). He points out that the minimum intake recommended for health is about one ten-thousandth of a gram, which is 100 micrograms. The 29% on my bottle is equivalent to the fraction 0.29. The 20 micrograms divided by 0.29 gives a daily requirement on my bottle of 20/0.29 = about 70 micrograms, which is close to the 100 cited by Rockwell. He also observes that three to five times the daily requirement would be considered an upper "safe" limit, and that a similar sort of curve would be observed for radiation. I assume he means "safe limit" is a level above which some small portion of a well-constructed population study would begin to show some additional fraction of exposed persons who have suffered harmful effects.

Another striking example of hormesis is the fact that an amount of Botulinum Toxin Type A smaller than a grain of sand will kill an adult if placed on the skin, yet very diluted concentrations of the same toxin in Botox has been used for beneficial medical treatments such as removal of wrinkles in aged skin, and alleviation of muscle spasms and migraine headaches. (Warrick 2010)

Observed effects of low-level ionizing radiation exposure that might be considered examples of hormesis are evidenced in the many experiments that have shown that an earlier low-level exposure can reduce the effects of a much higher later exposure (Brooks et al. 2009). This phenomenon is known as an "adaptive response" and has been recognized and reviewed in reports of expert international and national organizations. A somewhat analogous effect of an early series of low sun exposures protecting against serious sunburns from later exposures of much greater degree is familiar to anyone who has sunbathed. The adaptive effects of ionizing radiation (i.e., gamma and beta radiation) are similar to the adaptation to sun exposure (the ultraviolet portion). There are many variations of radiation effects depending on rate of exposure, age at exposure, and many other factors too numerous to discuss here (Brodsky 1996). In a following section of this chapter, some simple risk numbers are provided for long-term (stochastic) effects to ensure that these effects are not underestimated. These risk factors will tend to exaggerate radiation effects, but will provide simple guidelines for use in rapid response to unexpected exposures. While the factors would usually exaggerate long-term effects, they would still avoid for the vast majority of exposed persons after terrorist attack, the fear and panic that current lack of information, and misinformation, would entail.

Effects of External Gamma Radiation: Knowing When Radiation Levels Are High Enough to Cause Significant Harm (for "External Radiation," Radiation Received from Radiation Sources Outside the Body)

It is important to know when your radiation dose might be approaching a level that could result in significant short-term or long-term chances of harmful biological effects. It is important to know this because a small proportion of persons exposed to radioactive material released in an attack should be able to seek any available medical care in case life is at stake. It is also important for persons to know their exposures so that, if personal dosimeters (see recommendations in Chapter 8) or estimated cumulative exposures from rate meters (such as Geiger counters) do not indicate serious doses will be received, then the vast majority of the population will not panic and would not take actions that would be more harmful than the small radiation exposures received. One of my worst fears is that hordes of unnecessarily panicked citizens could inundate and destroy the capabilities of hospitals or physicians' offices that would already be overloaded trying to help those really in need).

The following Exhibit 7 should be studied by all responders and posted to provide familiarity with the higher levels of dose that begin to threaten life. (The more simplified summary of effects in Exhibit 8 should be ***memorized*** *by all responders, who might be asked to volunteer to conduct life-saving work in areas of high radiation intensity.) Worthy of special note is that survival ranges from 0 to 50% for the dose range of 200 to 400 rad (2 to 4 Gy). I had previously quoted the 50% lethal dose to be at a midline dose of about 250 rad, which would sometimes be related to an exposure of about 400 R at the entrance to the trunk of the body, in a field of high-energy gamma radiation, similar to fallout from nuclear weapons or some of the higher gamma emitters in the references mentioned. Exhibit 7 is taken from a group of authors who have examined some of the radiation sickness and lethality cases of responders to the Soviet disaster at Chernobyl, who were also exposed to heat, high beta exposures, and other trauma.* On the other hand, they might have added significant information to the rare cases of total body exposure to humans exposed in radiation accidents, in which radiation dose measurements were available. *Exhibit 9 summarizes briefly some recommended dose limits of Federal agencies; the use of these dose limits by practicing professionals requires a reading of the Federal guidance, but the visual picture here suffices for the general public.*

The reader must remember that the doses presented in Exhibits 7 and 8 are assumed to have been received over the entire body of persons within a matter of hours or less. Rockwell (2003, page 154) references the statement of Dr. Lauriston S. Taylor, the radiation physicist who in 1929 established the predecessor organization of the National Council of Radiation Protection (NCRP) and led it for many decades: "…if people are exposed to 350 to 400 rem in a short burst, about half of them would die within 30 days… the same dose administered uniformly over a year's time could pass unnoticed by most exposed persons." Rockwell also explains, "This should not surprise us; we know that a large bottle of pills, such as aspirin, taken one a day might be beneficial, whereas gulping them all down at once could kill us."

I quote from Rockwell here because I know of his scientific rationality and credibility. I also knew Dr. Taylor for many years, having already admired his great stature so much that, in 1957 in my youth, I was overjoyed when he accepted my invitation to be the speaker at the first meeting of the Baltimore-Washington Chapter of the Health Physics Society. The statements above are also consistent with the information in Exhibit 7 and that which I examined in writing my book on radiation risks and uranium toxicity (Brodsky 1996a).

In order to be conservative, I would assume from Exhibit 7 that above about 200 rad there could be considerable likelihood of lethality without the immediate availability of the special care of radiation medicine experts. In the one case of external radiation described in Brodsky and Wald (2004), it seems to me that without the bone marrow transplant and special care recommended by Dr. Wald to a worker for whom I mocked up and measured a 600 rad mean bone marrow dose, the victim would surely have died. His rapid fall in lymphocyte counts over the following

days indicated his course toward lethality. I would not bet on survival of anyone exposed to more than 250 to 300 rad mean whole body dose. Therefore, as in many current reports, I would recommend maintaining doses of emergency workers under the 25 rem limit that has appeared in many past reports, and some current ones, for ordinary emergency response activities. For saving life, some of the current EPA recommendations do recognize that informed persons, particularly older ones like me, might be allowed to receive short-term-rescue doses up to 100 rad (or rem) or more for important lifesaving activities.

On the other hand, although no genetic effects were found in the Hiroshima-Nagasaki population (the "Life Span Study (LSS)"), as reported in a report of the United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR 2006)(Kodama 2007), a greater sensitivity of the embryo to teratogenic effects (malformations and decreased intelligence) has been found in the LSS population. As confirmed by animal experiments, such effects are confined mainly to radiation exposure of the pregnant woman during the period of organogenesis, about 18 to 40 days after conception (Brent 2007). **Brent points out that the threshold of 20 rad (0.2 Gy) for birth defects still provides a safety margin for current uses of CT and other scanning in most diagnostic radiological studies.** At the same time, it is important for diagnostic medical personnel to be cognizant of the safe levels of exposure when balancing benefits of procedures versus risks to patients in their periods of gestation. On the other hand, Dr. Brent, an international medical authority on effects of radiation on the fetus and on the growth of children, provides examples of the **many tragedies resulting from unnecessary abortion recommendations of physicians** unfamiliar with radiation effects, as well as his own experiences with the many lives saved of those who have consulted him before undertaking pregnancy terminations recommended by others (Brent 2007).

Goans (2004, page 378), a physicist and physician, suggests from a plot of dose vs. time to emesis that the **median dose for a time to nausea of less than 4 hours is 3.6 Gy (360 rad)**, and that patients with emesis less than 4 hours be triaged for special professional medical care, while those with nausea onset after 4 hours be sent home initially or instructed to receive delayed medical attention. The authors of the table in Exhibit 7 have apparently taken the range of minimum onset times and associated them with the dose ranges indicated. This table then suggests that at 2 Gy (200 rad), some persons might need special care and have some probability of dying. The triage criteria used by physicians involved would, of course, depend on the availability of this special care that is recommended. If many people are exposed to doses greater than 200 rad, the special care suggested would probably not be readily available, under present circumstances. **Thus, responders as well as the public would be well advised to stay far below 200 rad, if at all possible. Of course, I would take more than that to save members of my family.**

A more recent paper (Azizova et al. 2008) presents a review, by an international group of physicians and scientists, of the prodromal symptoms and blood analyses of workers exposed in accidents at the Russian Mayak Production Association. This production facility was built under extreme political pressures, without the degree of worker protections built into such facilities in the USA by that time. In the period 1948 to 1958, fifty-nine workers developed an acute radiation syndrome as a result of nineteen accidents. The findings of this detailed analysis of more cases than occurred in the USA appears consistent with the data in Exhibit 7 and with the prodromal syndrome vs. dose information in Goans (2004). The data analysis of Azizova's group indicates a range of times to vomiting (emesis), excluding those obviously responding to shock as well as radiation that is consistent with that in Exhibit 7 and in the corresponding data plot of Goans (2004). Both sets of data indicate that if vomiting due to radiation sickness does not occur within two hours, a lethal dose has not been received. Any slight differences in the Russian data and previous data published would affect only the judgments of medical doctors in regard to managing the treatment of patients exposed to high doses of radiation many hours or days after exposure.

Exhibits 8 and 9 provide brief summaries of some doses to remember, and their implications.

	Degree of severity and corresponding dose range				
Symptoms Listed Below	**Mild (1-2 Gy)***	**Moderate (2-4 Gy)**	**Severe (4-6 Gy)**	**Very severe (6-8 Gy)**	**Always lethal (8 Gy +)**
Vomiting onset % Incidence	2 hours after dose 10-50%	1 to 2 hours after dose 70 to 90%	Earlier than 1 hour after dose 100%	Earlier than 30 min. after dose 100%	Earlier than 10 min. after dose 100%
Diarrhea Onset % Incidence	None —— ——	None —— ——	Mild 3 to 8 hours Less than 10%	Heavy 1 to 3 hours More than 10%	Heavy Within 1 hour Almost 100%
Headache Onset % Incidence	Slight —— ——	Mild —— ——	Moderate 4 to 24 hours 50 %	Severe 3 to 4 hours 80 %	Severe 1 to 2 hours 80 to 90%
Consciousness Onset % Incidence	Unaffected —— ——	Unaffected —— ——	Unaffected —— ——	May be altered —— ——	Unconsciousness for secs. or mins. Seconds/mins. 100% @> 5 Gy
Lethality	0%	0 to 50% Onset 6 to 8 weeks	20 to 70% Onset in 4 to 8 weeks	50 to 100% Onset in 1 to 2 weeks	100% Lethal in 1 to 2 weeks
Medical Care Needed	Outpatient observation	Observe in general, treat in special hospital, if needed	Treat in special hospital	Treat in special hospital	Palliative treatment only**

* 1 Gy = 100 rad

** With appropriate supportive therapy, individuals might survive for 6 to 12 months with whole body doses as high as 12 Gy.

EXHIBIT 7 — Symptoms and survival for high dose ranges above 100 rad (1 Gy = 100 rad)

This table was selected and edited from data in Tables 1 and 3 of Mettler et al. (2007), who cite the origin of the data as IAEA 1998. Note: The doses given are assumed to be distributed over the entire body.

ACUTE RADIATION EXPOSURE

0-25 rads: No observable effect

25-100 rads Slight blood changes

100-200 rads Significant reduction in blood platelets and white blood cells (temporary)

200-500 rads: Severe blood damage, nausea, hair loss, hemorrhage, death in many cases

>600 rads: Death in less than two months for over 80%

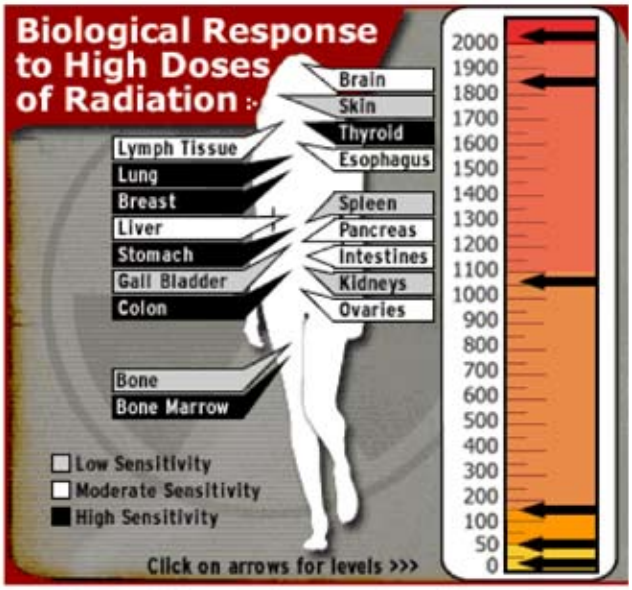


EXHIBIT 8 — Brief Depiction of Effects of High Levels of Radiation.

Adapted from a slide provided by Dr. Gordhan Patel.

ACCEPTABLE RADIATION EXPOSURES

- **NRC Guidelines for Radiation workers**
  - **— 5 rads:** Yearly limit (averaging 2 over 10 years)
  - **— 25 rads:** Lifetime limit
- **EPA Guidelines for Emergency workers (once-in-a-lifetime event)**
  - **— 25 rads:** For voluntary maximum radiation dose to emergency workers for non-lifesaving work during a reactor emergency.
  - **— 75 rads:** For maximum radiation dose to emergency workers volunteering for lifesaving work.

NRC: US Nuclear Regulatory Commission
EPA: US Environmental Protection Agency

Exhibit 9 — A Brief Summary of a Few Simple Guide Limits of Federal Agencies, Easy to Remember.

Adapted from a slide provided by Dr. Gordhan Patel.

Salter et al. (2004) have developed a sophisticated biodosimetry tool that takes into account both clinical tests as well as physical symptoms to provide triage information on responders who have been exposed to high amounts of radiation. However, such tools are likely to be useful only to those medical or responder personnel specially trained to use them. The Armed Forces Radiobiological Institute, by courtesy of Drs. Terry Pelmar and William Blakely, have provided their "Medical Effects of Ionizing Radiation," as Appendix A.2 in Brodsky et al. (2004). This chapter provides additional information useful to medical personnel involved in managing persons exposed to high levels of radiation, with somewhat different range values than appear in Exhibit 7, some additional detail, and further advice on the management of persons exhibiting an acute radiation syndrome (ARS). However, considering the uncertainties in this information, the AFRRI table is consistent with the data in Exhibit 7. The AFRRI table also gives information up to doses of 3,000 rad, which deals with gastrointestinal and neurological syndromes that lead to certain death. This is not information likely to be needed by the general public.

A number of chapters in Brodsky et al. (2004) also provide much more detailed information on the triage and management of highly exposed individuals, as well as websites and other sources of recommendations and information. However, more detail is unnecessary and beyond the scope of this book. Those medical personnel who would provide the special care indicated are already familiar with the appropriate reference data. Unfortunately, medical personnel so specially trained might be in very short supply after a major radiological attack, certainly in the early hours after detonation. Therefore, it is important that every citizen know at least the most elementary actions to take for personal dose reduction and possible avoidance of harm. (See the Health Physics Society position paper, "Guidance for Protective Actions Following a Radiological Terrorist Event" and the accompanying background document, "Background Information on Protective Actions Following a Radiological Terrorist Event," either available from the Health Physics Society (2007) or as reprinted in Appendix A.1, pages 610-626 of Brodsky et al. (2004), with references to a number of standards of expert government and independent groups regarding emergency protection from high levels of radiation.)

Perhaps the most important information to be retained from Exhibit 7 by most citizens for their own protection is the line on percent (%) mortality. *Other illness is correlated with the same dose ranges. It is best, if at all possible, to keep yourself and your family below, or well below, 25 R (or 25 rem). For the vast majority, or perhaps everyone who survives a "dirty bomb" that disperses radioactivity, this will easily be achieved, as long as survivors do not panic about small levels of radiation and evacuate toward the very limited sites of higher levels.*

The above paragraph leads us to the need for some adequately brief information for emergency evaluation of the potential long-term effects of lower levels of radiation — levels well below those where acute lethality or illness is likely in the immediate years ahead.

Likelihood of Long-Term Effects of Lower Levels of External Radiation
Effects on Infants and Children

For the range to be considered "low-level radiation," I choose a level below 25 rem for the general public, modified perhaps by a limit of 10 rem for pregnant women.

Effects on the embryo and fetus:

Malformations: Hall (2007), an eminent biophysicist with two doctoral degrees and professor at Columbia University, points out that "moderate doses" of radiation effects on the embryo and fetus "…can produce catastrophic effects on the developing embryo and fetus." His definition of "moderate" will be put into perspective in the paragraphs below.

The effects discussed by Hall, which depend on the stage of gestation, the dose, and the dose rate, were: growth retardation, congenital malformations, and embryonic, fetal, or neonatal death. In an earlier book, Hall (1984) points out that the most sensitive period of gestation is that of organogenesis, when the organs of the body — e.g., the eyes, brain, arms, and legs — are formed. He estimates then that the organogenesis period occurs between the 9th day to the 6th week. This period, in which malformations are likely to occur is consistent with his more recent estimates of the period of organogenesis, obtained by comparing human effects with early effects of the megamouse experiments of the Russells (Hall 2006, 2007). However, the malformation effects demonstrated by Dr. Hall are observed in mice at a dose of x rays of 200 R (which would approximate an average soft tissue dose of close to 200 rad in such a small animal). I would not consider this a "moderate" dose level. At such doses or even somewhat lower, during the period of organogenesis, radiation can affect the organs that are developing at the moment of exposure. The effects can be similar to those seen after administration of the drug thalidomide, given to pregnant women to suppress morning sickness, resulting in babies born with stunted arms and legs. This drug has been banned for some time now, but had been administered to someone in my own family. I worried for years whether the effect might be passed on to a grandchild, but fortunately this did not occur. Rubella, usually not a serious infectious disease, can also induce gross abnormalities in a fetus. (Hall 1984.)

Dr. Brent, perhaps the most eminent physician involved for over fifty years in radiation research on the fetus, finds that genetic malformations are confined mainly to radiation exposure of the pregnant woman during the period of organogenesis, about 18 to 40 days after conception (Brent 2007). A Health Physics Society position paper (available by entering the society name on the web) suggests that above 10 rem some congenital ("teratogenic") effects may occur in the fetus. ***However, below 20 rem, as mentioned previously, Dr. Brent points out that it would be unfortunate to think that such an exposure would produce effects serious enough to require termination of pregnancy in humans. Dr. Brent has saved many thousands of lives for pregnant women who were fortunate enough to consult him before electing an abortion after receiving an x ray or other diagnostic exposure (Brent 2007).***

Dr. Kenneth Mossman, a noted professor of radiation biology who initiated my appointment to the Georgetown University faculty in 1987, has contributed the opinion that, at doses less than 10 rad, which are encountered in almost all diagnostic medical x ray and nuclear medicine procedures, the risks of developmental anomalies are insignificant (Mossman 2007a). This opinion is consistent with that of Dr. Brent. Mossman discusses radiation risks, and his philosophy for limiting them and explaining them, in considerable detail in his recent book (Mossman 2007b).

Yet, within the medical profession, there is still a need for further educational efforts and professional enforcement of radiation protection standards for the patient, to avoid even the rare or occasional overexposure of patients of all ages in procedures that use more radiation than necessary for the diagnostic or therapeutic procedure, and in harmful amounts. This has been made clear by the participants in the Beebe Symposium of the National Academy of Sciences (NAS), which also included some suggestions that certain regulatory provisions be enacted by the Food and Drug Administration if voluntary standards and efforts are not successful (NAS 2009).

Growth and mental retardation: Hall (2007) summarizes the effects of growth retardation observed in 80% of the 1,613 children exposed in utero at Hiroshima, and followed up to age 17 years. Comparisons were made of those exposed in utero within 1500 meters of the bomb hypocenter (point of detonation), and those exposed who were in the vicinity of Hiroshima but were more than 3,000 meters from the hypocenter. The average dose differential of about 25 rad (actually likely to be somewhat less) appeared to result in a shorter height of 2.25 cm by age 17, a slightly lighter weight by 3.0 kg, and a smaller head diameter by 1.1 cm. The incidence of severe mental retardation as a function of dose at 8 to 15 weeks after conception, indicated a risk coefficient of 0.4 per 100 rad (0.4 per Gy), but it was consistent with a threshold of 20 rad (0.2 Gy). This would mean that severe mental retardation would occur in about 40% of those born who were exposed to 100 rad if they were in their mother's

womb when she was exposed to the instant radiation from the bomb; however, it would be unlikely that those receiving less than 20 rad would be born significantly retarded.

Neonatal and prenatal death: Neonatal deaths (of those born alive) would occur mainly if the 100 rad of radiation was received by the mother in the 12th to 17th day post conception; the number of such deaths would be about 80% of the frequency of malformations, as judged from the figure presented (Hall 2006, 2007). Hall's figure indicates that fetal deaths in the womb would be about 80% for 100 rad received within the first 3 days, decreasing to less than about 10% for irradiation after 25 days. These are approximate values read from the curves presented by Hall.

Brent (Brent 2007) decribes the chances of prenatal death in another way. He defines a "no adverse effect level (NOAEL)" below which there are not likely to be any harmful effects. He indicates that the no-effect level of radiation for embryonic death is lowest during the preimplantation, preorganogenesis stages, and is about 10 to 20 rad at 0 to 14 days postconception in the human. The no-effect level increases further to about 30 to 40 rad during organogenesis and is similar to the mother's risk in late gestation. ***From both Hall's and Brent's assessments, it is clear that doses should be maintained below 20 rad to the fetus in the early part of pregnancy to avoid any chances of prenatal death.***

Cancer: In a talk (Ron 2007), Dr. Elaine Ron summarized a wealth of studies of radiation carcinogenesis (the search for radiation as a cause of cancer). I use her presentations here because she is one of the leading epidemiologists of the National Cancer Institute, whom I have known to be reliable in the presentation of data from radiation followup studies. She described the results of many types of studies, but only a bottom line useful for a member of the general public can be given here. The studies summarized show that the probability of cancer occurring after radiation exposure depends on many factors, including age of exposure, age at cancer occurrence, radiation dose, dose rate, and times over which dose is received.

Reading only a few representative points from several curves she presented, I find that the Excess Absolute Risk (EAR) of having cancer occur at age 50 was: about 20 per person-year after exposure "at risk" per gray dose of radiation (PYGr units) for those Japanese who were exposed at age 20 to 39 at the time of bombing (ATB); 45 PYGr for those having cancer at age 50 but having been 10 to 19 years old when they were exposed by the bomb; and about 60 PYGr for those having cancer at age 50 when they were exposed at age 0 to 9 years of age. Considering other data on cancer incidence of those exposed in utero, the sensitivity to cancer in the 0 to 9 year age group is seen to be about three times the cancer incidence of those exposed when they are in the adult age group of 20 to 39 years of age. This is partly due to the fact that infants and small children have many more "years at risk" to obtain cancer, and partly because they are believed to be more sensitive to cancer induction at these early ages. (The PYGr unit itself need not be of concern here, where I am interested in relative risks of infants and children relative to risks of exposure to adults. The PYGr values result from adding, for all individuals in the study population, the arithmetic product of the (time-in-years-since exposure) times (the estimated dose in gray (Gy) received at the time of the bomb).)

The curves of EAR for each age group rise curvilinear upward with attained age in Dr. Ron's slide. However, except for those over age 40 at the time of exposure, the factor of three is representative and conservative at any attained age when cancer appears. Data for those attaining cancers at age 50 when exposed at age 40 were too sparse and insignificant, because someone who was 40 at the time of bombing would have been 50 only ten years after the bomb exposure. The Atomic Bomb Casualty Commission, which performed such studies, was organized several years after the bombing, and did not collect complete data before that time (Schull 1995, 2007). In about 1949, a team of scientists arrived to see if the ABCC project should be terminated, since no effects had been seen

by that time; however, General MacArthur insisted the ABCC project be continued, and thus saved the research that has given us most of our knowledge of radiation effects on humans (Schull 2007).

Most solid cancers that occurred after exposure to the bomb radiation were later shown to have a latent period of about 20 years before they appeared; to me, this suggests that most of these cancers were initiated in a two-sequential-stage manner, where the first mutant change in a cell caused by radiation needed to be followed in a certain sequence by a second specific change induced by another radiation or carcinogen exposure at a later time. This is only my conjecture, but seems to be a reasonable way of understanding and remembering this phenomenon. The only support that I can claim for this theory is that presented in my development of a two-stage sequential model of carcinogenesis, based on some early experimental animal evidence I had observed (Brodsky 1978a, 1979c, 1984a). Leukemia, however, rose to a peak in about 5 years and has since almost disappeared as caused by radiation (Brodsky 1996a). It is now known that the incidence of leukemia is secondary (small) compared to the incidence of other cancers caused by radiation.

Because the curves of excess relative risk (ERR) decrease with attained age at first observation of cancer, in Dr. Ron's twenty-seventh slide, it is clear that the predominant cancers that occur at older ages are due not to the radiation received from the bomb, but to natural causes. Thus, the additional solid tumors to be expected in future years should not change current risk estimates significantly. Yet, it is important that the ABCC/RERF studies be supported and continued until all lifespans of the Japanese victims have been completed. It is not likely that any future study will again be organized and followed for so many years in such a careful manner. In fact, we all hope that no such radiation exposures from future atomic bombs will occur.

Getting back to quantifying cancer risks for the young, it is often assumed that children are more susceptible to internal radiation (radiation received from radioactive materials taken into the body either accidentally or for medial diagnosis) as well as external radiation. Estimated dose conversion factors for internal exposure and limits for intake of radioactive materials assume that, for most radionuclides, internal doses to the internal body organs of infants would be within two to three times as effective in producing cancer as in adults; sometimes the estimated effective doses are as much as ten times greater (Eckerman 2004). The dose conversion factors used to calculate "equivalent" internal doses include factors called "tissue weighting factors" to take into account that absorbed doses in different organs have produced somewhat different chances of cancer (Brodsky 1996a). I have known Dr. Eckerman for many years as a leading scientist in developing criteria for estimating effective doses to internal organs, and calculating limits of intake of the hundreds of types of radioactive material that might be available for human exposure. He has led the internal dose committees of the ICRP and NCRP since the loss of Dr. Walter S. Snyder in the late 1970s. The effective doses per unit intake, and other conversion factors, listed by him in the 2004 reference are those currently accepted internationally.

*I will now **assume**, for levels of exposure that might produce harmful effects, that the main long-term chance of **cancers among fetuses, infants, and children below about ten years old, are ten times the chances of cancer per unit exposure estimated for adults**. The chance of cancer in exposed adults is, in absolute value, taken as 5 chances in 10,000 per rad of exposures of dying from cancer if exposed to long-term low-level radiation exposure rates, beginning at an average age in about the mid-30s. This average over the US population includes the risks to children and infants, and is a broad number for the entire population. (The development of this risk estimate, from many calculations to correct for various demographic factors, was described in an appendix of ICRP Report 60 (ICRP 1990), written by the eminent radiation biophysicist, Dr. Warren Sinclair, who followed Dr. Taylor as head of the NCRP. I have summarized for radiation protection administrators (Brodsky 1996a), Dr. Warren Sinclair's detailed description of the derivation of risk factors in ICRP (1990). These risk estimates have essentially remained unchanged since 1990 (ICRP 2006).)*

Using a factor of ten for conservatism, this would mean that a dose of 1 rem (1,000 millirem) to an infant or child would result in a chance of ultimate death from cancer (before other deaths) of 5 chances in 1,000, or

0.5%. The normal mortality rate from cancer for all ages is about 14%, but it varies with age. The risk is higher for children, levels off until mid-life, and then increases rapidly with age in the later years. The average normal mortality rate of 14% from cancer was calculated from total cancer deaths in 2008, as reported in Wright (2008). Cancer death rates rise rapidly at later ages; 76% of all cancer deaths occur after age 55 (Wright 2008, pages 388-389). The simple risk factors used in this chapter for average population cancer death risks from radiation are estimated for the average age in the United States population, as converted mostly from the Japanese survivor data adjusting for demographic and other factors (Brodsky 1996; NAS 2006).

Deaths from leukemia, which are much less frequent than deaths from solid cancers, are much lower in frequency and are taken into account in this number. Deaths or ill effects from genetic effects in babies born to persons exposed to radiation are also now known to be so small as to be non-observable in the Japanese LSS population, but are estimated by the ICRP from animal data (Brodsky 1996a). All of the above causes of death, plus the effective healthy life lost by those who develop cancer but survive, are estimated by the ICRP to be equivalent to a risk of death of 8 chances in 10,000 for members of the general US population (Brodsky 1996). Using this estimate, the risk of death to an infant or child under 10 years of age would be equivalent to 8 chances in 1,000.

The risk factor of 5 cancer deaths per 10,000 per person per rem exposure includes what is called a "dose and dose-rate effectiveness factor (DDREF)," which reduces the risk from instantaneous exposure such as that from the prompt bomb radiation by a conservative factor of two when exposure is extended over time, as for a working population. Therefore, I recommend, to use a single risk factor for emergencies, removing the DDREF, raising the risk factor another factor of ten, and using an additional 60 % safety factor for all children (including those more susceptible (NAS 2009), to obtain a risk of possible lethal effects during a lifetime to about 16 chances in 1,000 per rad, when dealing with early exposure to radiation from an RDD or nuclear bomb. Using this risk estimate, a fetus or child in the 0 to 10 range age would have an additional chance of 1.6% of dying from cancer if exposed to 1 rad or rem (1,000 millirad or millirem) of prompt gamma radiation, added to the child's normal chance of more than 14% of dying from cancer from other causes.

Conclusion: The assumption of a 1.6% chance of cancer death equivalent per rad added to a normal chance of more than 14% of eventually dying of cancer during the cnild's lifetime, should be a reasonably conservative estimate of maximum cancer risks to those under age 10. Actually, below 5 or 10 rad, we do not know that any estimated cancer risk to children of this age group might not actually be overcome by hormetic benefits; however, we take the precaution to keep children well below these dose levels when possible. However, children should not be exposed in emergencies to the levels allowed for adults in Exhibit 9, but should be kept well below those levels when possible.

Those readers who are professionally involved in the management of homeland security or emergency response programs, or others interested in more of the details of radiation risk but not routinely involved in radiation protection science or activities, may consult my book (Brodsky 1996a) for simple definitions of EER, EAR, and the various input parameters used by the ICRP and other expert groups to convert data on the LSS Japanese population to risk factors pertinent to US populations, and to recommend limits of exposure. My book also contains the references to many more detailed studies of the expert agencies who have extracted data from the vast radiobiological literature for use in setting radiation protection standards. Those wanting authoritative information and more detail on risks of radiation to unborn children or infants should consult the article by Brent (2007).

Very Important: **Those concerned about possibilities of malformation or other effects to fetuses exposed to radiation should consult the article by Brent (2007), or ask their questions on the Health Physics Society website listed in Mossman (2000, 2007b).**

The book by Wagner et al. (1985, pages 120-123) might also be of interest to those wanting to examine sources and effects of diagnostic radiation exposures in more detail; although published in 1985, Wagner et al. refer to Dr. Brent's earlier publications and they are relatively consistent with the article by Brent in 2007 in rejecting some earlier recommendations for considering abortions at doses as low as 1 rem to the fetus.) Dr. Brent has also been involved in providing hundreds of answers on the Health Physics Society website www.hps.org that have prevented unnecessary or unwise abortions. In his own consultations with patients, he has prevented unwise decisions that had been prompted by others who were not expert in radiation effects. In his article he shows a picture of a mother, her daughter, and a beautiful granddaughter whom she enjoys in her later years. If this woman had not consulted Dr. Brent and had listened to an original recommendation, she would be left alone without family and would not be smiling as she was in the picture (Figure 17 in Brent 2007). Also, Dr. Brent discusses the estimated hundred thousand abortions in parts of Europe after the Chernobyl disaster, where the doses were well within the lower range where he would have advised against abortion. Dr. Brent documents his statements with much of his own research as well as current literature of other investigators.

Also, note that my conservative estimate of 1.6% cancers at 1 rem (1,000 millirem) is given for purposes of instilling all available caution and giving priority to earliest protection of the young and unborn in the event of expected radiation exposure. It should not be multiplied by 20 to suggest that a 32% chance of eventual cancer counters Dr. Brent's advice against abortion at this level. The risk factor at 1 rad has been obtained from an assumed linear model fit to all of the LSS population data. It should be noted that in Dr. Ron's twenty-fifth slide, only 159 cancers attributed to radiation occurred in the dose range below 20 rad, in over 50 years of study of the Japanese population of 105,427 persons (population given in Ron's slide 20) exposed to atomic bomb radiation. Moreover, chances of cancer over the long term do not detract from the many advantages of a healthy child living most of its lifetime without disease, even if my estimates here were real rather than conservative. There are also many ways to reduce the chances of cancer during this healthy life, e.g., by avoiding smoking, by proper eating and exercise habits, and by avoiding exposure to other carcinogens. These other factors might tend to potentiate the risks from the initial radiation exposure.

Radiation Risk Estimates for Low-Level Exposure of the General Population

This section reviews risk estimates of low-level radiation for persons above about 10 years of age. Risks for infants and children were summarized in the previous section.

Examining the review of Auxier (2004), it is clear that most people exposed closer than about 500 meters (a little more than 500 yards) to the detonation of a nuclear device of 1 kT or more (except as in Japan for a few lucky souls who were in floors deep below strong buildings) will die from blast or heat radiation burns, and those farther than 500 meters would be exposed mostly to the fallout radiation on the ground, which would deliver doses over a period of many hours. For dirty bombs containing radioactive materials, those exposed to the fallout to any serious degree would most likely receive their doses over a period of many hours or days. Thus, I will here use risk factors derived by the ICRP (ICRP 1990) for long-term exposure, rather than from the initial radiation from nuclear bomb bursts. If one desires to consider exposures to have occurred within a few hours or less, then these risk factors may be multiplied by a factor of two.

Because the long-term risk factors have been derived for the most part from the Hiroshima-Nagasaki population exposed to prompt radiation, I will compare here some information from Auxier's chapter (2004) with that recently presented by Ron (2007). Auxier, who led the teams that performed the earliest dose estimates to the Japanese victims, points out that the number of persons killed in Hiroshima was about 60,000 and the number killed in Nagasaki was 20,000, but exact numbers are not known because populations were somewhat larger than in peacetime. The number of registered survivors is 80,000. There were 4,000 "high-dose" survivors who had received

more than 0.5 Sv (50 rem); of these there were about 300 cancer deaths attributed to the prompt radiation from the bombs. Auxier attributes his summary data to an article by Pierce et al. (1996), who has long been eminent in analyzing the survivor statistics. There were few who died from radiation sickness, because most of those who received the highest doses also received other, usually fatal, effects from blast, thermal effects, or fire, if they were close enough to the explosions to receive high doses of prompt radiation.

The talk by Ron (2007) provides a relatively recent update on the data from the A-Bomb Life Span Studies (LSS). Some of the information presented by Dr. Ron was a preview of that published in the journal, Radiation Research, authored by Preston, Ron, Tokuaoka, Funamoto, Nishi, Soda, and Mabuchi, and covers solid cancer incidence observed over the period 1958-1998. Various parts of her presentation indicate that: the LSS cohort was composed of survivors within 2.5 km of the bombings, survivors within 2.5-10 km of the bombings, and those "Not in City (NIC)," comprising a study population of 120,321; some of this LSS population was far enough from the bomb detonations that radiation exposure was negligible and they could essentially comprise "controls" of zero exposure; among those exposed to more than 0.005 Gy (0.5 rem or 500 mrem), 17, 448 cases of solid cancer (non-leukemia) have been observed, of which 853 cases above that expected from controls (about 5 percent) have been attributed to radiation exposure.

These results are essentially consistent with those given by Auxier (2004), because the study was extended until 1998, past the 1990 data cited by Auxier. Also, the 853 cases of cancer occurring would imply that perhaps only one-half or less of these resulted in death, as a result of effective cancer therapy. Thus, if 400 cases of these cancer cases died, this might be an expected increase above the 300 cited by Auxier on the basis of the study of Pierce et al. (1996), over the time since the completion of each of these studies. The difference in the start date of observation, 1958 for Ron as opposed to 1950 for Peirce, is indicated by the fact that Ron, in her discussions of the advantages and disadvantages of the LSS study population, mentions the fact that the information of solid cancers is inadequate in the 1945-1958 period, and the information on leukemia was not complete in the 1945-1950 period.

We may recall here the quotation of Rockwell (2003) of Dr. Lauriston Taylor's statement: "…if people are exposed to 350 to 400 rem in a short burst, about half of them would die within 30 days. 'By contrast, he writes,' he writes, 'the same dose administered uniformly over a year's time could pass unnoticed by most exposed persons.'" Dr. Taylor has authored many publications on the history and development of radiation protection standards, from the times, and earlier, that 15 rem per year was considered the acceptable annual dose to workers until many decades later when he retired as President of the NCRP and the worker dose limit was 5 rem per year, which could theoretically become **250 rem** over a 50-year assumed working life. Two of his major books have detailed the notes from meetings and background information on standards development from the year 1928 that he attended the first international meeting forming the precedent organization of the ICRP, returning the following year to form the precedent organization of NCRP (Taylor 1971, 1982).

The limit still remains 5 rem in any one year, according to current US regulations Title 10, Code of Federal Regulations, Part 20, with the admonition to limit the average exposure over ten years to 2 rem per year, or 20 rem in ten years (ICRP 1995; NAS 2006). At the same time, regulations over the years, have limited public exposure, which would include exposure to the young less than 18 years of age, to one-tenth or less of that allowed for workers. Many of the NCRP reports over the decades have, in their prefaces, indicated Dr. Taylor's belief that no human evidence of harm caused the lowering of accepted limits of exposure, only the realization that some lowering and conservatism had appeared feasible without undue economic harm.

My own examinations of the history of radiation protection and exposures received by workers and the public over the years of my career attest to the efforts of private and government standards organizations to maintain dose to workers and the public "as low as **reasonably** achievable (ALARA)," which has resulted in lifetime exposures of almost all workers and members of the public that are far below the limits that might be allowed by national

regulations. My own continuing studies of worker exposure (e.g., Brodsky et al. 1976; Brodsky et al. 1995) verify this fact; my use of the lognormal descriptions of dose distribution, or modified truncated versions, have been adopted in some of the reports of the United Nations Scientific Committee for Atomic Radiation (UNSCEAR) for data presentations in some of the reports of dose distributions in nations throughout the world. In the same way, exposures during emergency situations should also be ALARA, and kept at least below 25 rem when possible, except that **the word "reasonable" must be kept in mind**. In an emergency situation, involving life and death decisions, **it might not be "reasonable" for you to leave a loved one dying in the street just because you reached a dose level of 25 rem or rad on your dosimeter** (see the table of effects of high dose levels in a preceding subsection of this chapter).

For an extensive review of the experimental animal and human followup studies conducted from the World War II Manhattan Project until the late 1980s, the interested reader is referred to the enormous compilation of Professor J. Newell Stannard (Stannard 1988), who was a leading researcher and mentor of many of the eminent doctoral graduates of the University of Rochester School of Medicine. Professor Stannard was President of the Health Physics Society when I was Chairman of the Standards Committee; he helped me then, and even in his late eighties, to prepare standards for the accurate assessment of radioactive materials within the human body. I can personally attest to the authoritative nature of his research and his book reviewing the work of thousands of other radiation research scientists.

A review of the biological effects of radiation on humans and the ways expert organizations have developed quantitative estimates of radiation risks and standards for protective measures, may be found in my 1996 book (Brodsky 1996). A more recent update of risks has now been published by the National Academy of Sciences (NAS 2006). The risk estimates and conclusions in my book have not changed substantially to the present for our purposes. Updated data examined by the expert committee on biological effects of ionizing radiation of the National Academy of Sciences still leads to an estimate of about 5 chances in 10,000 of a person (averaged over sex, age and other characteristics) in the United States population dying from cancer for per rad dose (neglecting hormetic effects below about 20 rad), and a chance of equivalent harm and loss of life from all causes of about 8 chances in 10,000 per rad. Some smaller risks from genetic effects and other health effects have been updated (ICRP 2006), but not enough to change the above-mentioned probabilities. However, it is unlikely that most persons informed by this book will receive from a dirty bomb anywhere near as much as 1 rad (which is 1,000 millirad from gamma radiation, or 1,000 millirem from any radiation), especially if they take the simple precautions presented in Chapter 6.

For simplicity in management and additional conservatism, as mentioned below, risk estimates used for government regulatory purposes in the United States continue to be based by advisory groups on the assumption that the relative risk of solid cancers depends linearly on dose down to zero dose. Regulatory philosophy to date includes the belief, from much experience, that regulatory limits and standards based on this linearity assumption do not unreasonably reduce the human benefits of the applications of radiation sources and nuclear power. However, many scientists believe that our extreme assumptions about effects of low level radiation, ignoring hormesis, adds to the exaggeration of radiation risks in the public mind.

The Health Physics Society has issued a position statement against using low doses to make estimates of cancer deaths in large populations. Thus, there is considerable controversy about the linearity assumptions, about the need to consider possibilities of hormesis at low levels, and about how the regulatory requirement to keep radiation doses "as low as reasonably achievable (ALARA)" is applied in practice (USNRC 2006; Rockwell 2003; Mossman 2007b; Scott et al. 2008). There is not any controversy, however, among the vast majority of informed scientists who would agree that risks are certainly not greater than those used by regulatory agencies based on the linearity assumption.

Summary of Risk Factors for Long-Term Effects of Gamma or X Radiation

Recommended risk factors for rapid, conservative, overestimates of long-term risks in emergencies:

The risk factor to remember, then, is the one mentioned in above. There are at most (neglecting hormesis) ***5 chances in 10,000 that a person of average age will die prematurely from cancer rather than another disease, if the person receives a dose over a long term of 1 rad (1,000 mrad, or 1,000 mrem for gamma and beta radiation).*** *There are about 8 chances in 10,000 that a person exposed to 1 rad or 1 rem would succumb to the equivalent loss of healthy life from cancer and all other estimated effects (ICRP 1990). A 1 R exposure, as mentioned before, may be assumed to deliver a dose of 1 rad or 1 rem from x or gamma radiation; this assumption will provide a factor of safety in the dose estimation.*

For children, or fetuses in utero, as indicated in the previous subsection, the risk of life lost should be considered to be about 16 per 1,000 per rad or rem, or 1.6 percent, for protection purposes in the event of emergencies or attacks. *On the other hand, if the exposure of a fetus exceeds a few rad, this should not be considered a serious indication for termination of pregnancy; an* ***expert*** *physician should be consulted in this regard.*

These risk factors neglect the likelihood that hormetic effects might counter, in overall effects, the risks of cancer below doses of about 10 rad. Thus, they are conservative in the interest of safety, but can be lived with for simplicity as long as there is no panic at these low doses under attack conditions.

Important cautionary statements and perspectives that must be kept in mind:

Note Again: *It is important to remember a minimum of word definitions in order to make quick decisions in an emergency.* Definitions are explained in more detail in Appendix A, and the more important ones related to amounts of radiation have been reviewed again more briefly in Chapter 3. It is important to remember the short-hand prefixes that might be attached to the conventional or SI units that might be read on some meter or dosimeter, or on the types of affordable and wearable personal dosimeters described in Chapter 8.

For example, suppose that a child is exposed in utero for as much as 10 hours before rescue or sheltering at 10 mR per hour, a level readable on about the middle of the highest range of a civil defense Geiger counter. (This is a level that would for an audible instrument yield thousands of beeps per minute. It is also a level that is sometimes unfortunately recommended as a level to rope off for responders and the public, to which I have objected (Brodsky 2005).) The child would receive in this ten hours a dose of somewhat less that 100 mrad, which is 0.1 rad. A dose of 0.1 rad to a fetus, only under the extreme assumption of the LNT model being valid down to zero dose and my conservative safety factors above, would mean a chance of only 1.6 in 1,000 of the child having any effect at all from this dose, in perspective with the much higher 15 percent chance of dying from other causes of cancer alone. The normal rate of malformations alone, without any radiation exposure, is in the greater range of 300 to 600 per 10,000 births (Brent 2007). Dr. Brent points out how absurd it would be to suggest that all fetuses be aborted because of this natural incidence of malformations. There would be no more children born in the world. Note also the admonition of Dr. Brent in a previous subsection that no reasonable fear of birth defects or cancer should be expected at a dose as high as 20 rad (20,000 mrad), and that **no** "therapeutic" abortions should be considered below 20 rad, which is 200 times the 0.1 rad that would be received in 10 hours at an exposure rate of 10 mR per hour.

Ways to understand chance (probability): *For comparison with chances of long-term radiation effects, we may consider that the number of persons likely to be killed in an auto accident in their lifetime (not including the severely injured) are about 1 in 100. Comparing this chance to the above numbers, this would read: 100/10,000 over a lifetime, which is 10^{-2}, or 0.01 expressed another way, or also expressed as one-hundredth of a chance of being killed in an auto accident. In the first draft of this book, I did not bother to find the exact chance of being killed in an auto accident in recent*

years. (In talking to the public, I like to use numbers that are easy to remember and use in quick calculations.) I assumed that a person lived an average life on the road of about 60 years, and there were about 50,000 auto deaths per year, this means there are about 3,000,000 (or 3 million) auto deaths over a life span in the US population. If we take in round numbers that the US population is about 300,000,000 (300 million), and we divide 3 million/300 million, we get a 1 chance in 100, about the same as the extra chance of dying of radiation-caused cancer if an adult of average age would receive an extra 20 rem of radiation above background, according to the LNT model discussed above. Although some of my colleagues have argued otherwise, I think that any person who studied math in school can understand this concept of chance. If we apply the same chance for each person of dying in an auto accident to the population of 300,000,000 by multiplying by 0.01, we get back the original number of auto deaths in an average life time span of 3,000,000 persons dying of a car accident in 60 years. Rockwell (2003), using somewhat fewer highway deaths of drivers, shows another way to obtain such an estimate with simple arithmetic, coming up with a risk slightly lower than that above, but on the same order of magnitude.

In preparing the final draft of this book, I checked accident and population numbers. The 2008 average life expectancy of males and females at birth was about 78 years as of 2004 statistics (J W Wright 2008, page 395). The traffic death rate in 1993 (Carpenter and Provorse 1996, page 15) was 16.29 per 100,000 per year (Wright 2008, page 422). The United States population in 2007 was estimated to be 306,000,000 (Wright 2008, page 484). Using these numbers for an overall risk calculation, the risk of being killed in an auto accident during one's lifetime would be 16.29 x (306,000,000/100,000) = 49,874 deaths per year (somewhat lower today Wright 2008)). The lifetime death rate per person would then be 49,874 x 78/306,000,000 = 0.0127, close to what would be obtained by using all of the older data from Carpenter and Provorse (1996). This is the same as a 1.27% chance of dying in an auto accident after you are born, aside from other causes of death. This number is greater than the rough number calculated above partly due to an increased age assumption. The number will fluctuate each year depending on auto safety measures and population statistics. It is difficult to get all exact number from one book. However, only the order of magnitude is of interest here. The radiation risk estimates at these levels of risk have even more uncertainty.

Bottom line: Any adult worried about long-term effects after getting even as much as 25 rad (25,000 millirad) during an emergency for saving life, should never get into an automobile in peacetime.

Perhaps of more interest than the probability of dying during a lifetime is the combined statistic that predicts the amount of healthy lifetime lived (or lost) (Mossman 2007b). Exhibit 10, as adapted from Cohen (1992), shows Cohen's estimates of "loss of life expectancy (LLE)" in days of life lost due to deaths from cancer, cancer illness, or other relevant illness for many sources of public radiation exposure, compared to the respective losses of life from many other activities or common agents of risk. Although Cohen has published many articles rejecting the LNT theory at low radiation levels, he has conservatively used the LNT theory in constructing this table, so the table does not underestimate LLE. I have checked Cohen's formulas for calculating LLE in the process of reviewing this subject in Brodsky (1996), and can attest to the correctness of his formulae. It should be noted that the public perceptions of the risks of radiation have been, for many, opposite in order to the sequence of risks shown in Exhibit 10. Cohen (1992, e.g., page 192, and 1984) has performed research into the files of news media to show the reasons for public misperceptions about radiation and the radioactive materials associated with nuclear power. He also speaks from much personal experience. His findings about media effects are supported by those of many others who are professionally involved in public communication research (e.g., Johnson 2004a, 2004b). My personal experiences with media contacts, as presented in Chapter 1, further support the observations of Cohen.

In order to help overcome these public misperceptions, an excellent article that contains many good points, including some by journalists, to help scientists familiar with radiation risks to communicate them to members of the public or media, appears at the end of the HPS summer school text (Karam et al. 2004).

ACTIVITY OR RISK	LLE (days)
Living in poverty	3,500
Being Male (versus female)	2,800
Cigarettes (male	2,300
Heart Disease[a]	2,100
Being unmarried	2,000
Working as a coal miner	1,100
Cancer[a]	980
30 lbs. overweight	900
Grade school dropout	800
Suboptimal medical care[a]	550
Stroke[a]	520
15 lbs. overweight	450
All accidents[a]	400
Vietnam army service	400
Living in Southeast (SC, MS, GA, LA, AL)	350
Mining construction (accidents only)	320
Alcohol[a]	230
Motor Vehicle Accidents	180
Pneumonia, influenza[a]	130
Drug abuse[a]	100
Suicide[a]	95
Homicide[a]	90

ACTIVITY OR RISK	LLE (days)
Air Pollution[a]	80
Occupational accidents	74
AIDS[a]	70
Small cars (*versus* midsize)	60
Married to smoker	50
Drowning[a]	40
Speed Limit: 65 *vs.* 55 miles/hour	40
Falls[a]	39
Poisoning/suffocation/asphyxiation[a]	37
Radon in homes[a]	35
Fire, burns[a]	27
Coffee, 2.5 cups/day	26
Radiation worker, age 18-65	25
Firearms[a]	11
Birth Control pills	5
Peanut Butter (1 tablespoon/day)	1.1
Hurricanes, tornadoes[a]	1
Airline crashes[a]	1
Dam failures[a]	1
Living near nuclear plant	0.4
All electricity, nuclear (NRC)[a]	0.04

* Adapted from Cohen (1990), page 128

[a] Averages over total U.S. population; other LLEs are averaged only over the indicated populations at risk.

EXHIBIT 10 — Comparison of loss of life expectancy (LLE) from many causes and activities of daily life, including some from exposure to small amounts of radiation from the nuclear industry

Compiled from Cohen 1992 (2nd printing of his 1990 book), as adapted in Brodsky (1996a, page 180). See also Cohen (1991). The LLEs from radiation exposure were calculated by Cohen under the conservative assumption of a linear, no-threshold (LNT), dependence of risk on dose, although he himself often rejects the LNT dependence at low doses from his own research. These estimates also do not take into account that at low doses, hormetic effects have been suggested by many environmental studies; if these hormetic effects become proven and accepted by a majority of the scientific community, then the LLEs shown for radiation workers and environmental exposures to the public may actually become zeros, or even extensions of life. (Is that why I am living so long after my exposures at the nuclear test sites?) Note: As shown in the second footnote to the table, some LLEs of interest are averaged only over the populations involved in the habit or practice, rather being averaged and diluted by the entire US population.

Effects of Internal Radiation: Knowing When Radiation Levels Are High Enough to Cause Significant Harm (for "Internal Radiation Exposure," Radiation Received from Radioactive Material That Has Been Taken Into the Body)

Doses and Risks from Beta and Beta-Gamma Emitters Taken Into the Body

The estimation or measurement of internal doses and risks from beta and beta-gamma emitting radioactive materials that have entered the body is much more complex and difficult to describe, even though external radiation risks are more complex than presented here. In addition to the dependence of gamma or beta radiation entering the body from the outside on many factors, including depth to the point of interest, the different types of physical and biological interactions involved, and the type of measurement or calculation, emergency assessment of external doses can be accomplished without underestimating doses or risks by the use of instruments or personally-worn dosimeters placed outside the body. These instruments or dosimeters can be readily examined or retrieved for early assessment of dose, using safe assumptions related to conditions of exposure. *Because persons exposed to internally deposited nuclides are not likely to allow their bodies to be cut up for radiochemical or other analyses, internally deposited radionuclides need to be quantitatively estimated over time from measurements of small tissue samples or excretions; the measurements then need to be interpreted over time with complex mathematical models by scientists expert in their use and having the proper software available.*

Even a cursory review of the research results on risks of many internal radionuclides that emit gamma and beta radiation, exposing different organs according to their varied chemical compositions and tissue affinities, would make this book impractical. Those with some science interests who would like to review the wealth of experiments conducted to evaluate effects of internally deposited radionuclides may consult the comprehensive review of research results from the days of World War II (Manhattan District) until the late 1980s (Stannard 1988), by which time the bulk of knowledge of internal emitters has been obtained. (When I was employed in the Biology and Medicine Division of the Atomic Energy Commission in 1957-59, the annual budget for such radiobiological research was about 80 million dollars per year; this would amount to an equivalent of about one billion dollars per year in today's dollars. One can imagine the amount of research that has gone into providing us with information that allows the establishment of standards and limits of exposure to inhalation or ingestion of radioactive materials.)

Probably the best introduction to how the radiobiological data is used over the years in estimating internal doses can be obtained in Cember and Johnson (2008), with included example calculations. A concise summary of how internal as well as external dose limits and regulatory standards have been historically developed over the years, with explanations of the equations involved, is presented in Brodsky (1996a). Cember and Johnson (2008, pp. 344-421,) bring this review up to date by summarizing the latest, but very complex, methods of the International Commission on Radiological Protection on estimating internal dose.

In any case, experience shows that doses from internal emitters can best be determined by radiobioassay and whole body counting, only to within a factor of two or three, after many days or years of bioassay and in vivo counting measurements (Brodsky and Wald 2004; Raabe (1994). Other biodosimetric determinations of dose (Simon et al. 2010) from samples of human tissues, blood, teeth, or hair would also require many hours or days, would only be able to determine doses in the range where biological effects could become significant, and could only be made by specialists on a limited number of persons in a limited number of research laboratories.

However, do not despair. Here also, we can utilize rules of thumb and certain field measurements to at least limit the order of magnitude of emergency intakes, doses, and risks. Such rules of thumb and simple emergency measurements for early triage and avoidance of panic in the vast majority of those exposed are described in the next chapter. When the latest methods for estimating internal doses from beta and beta-gamma emitters is needed, use has been made

of the dose conversion factors in Eckerman (2004). Otherwise, simpler methods and concepts have been used to derive rules of thumb for use in emergency triage from biological and physical data relevant to humans. This information is presented in Chapter 5, along with some limited examples of information on doses from specific radionuclides and their risks.

Doses and Risks from Plutonium and Other Alpha-Emitting Nuclides Taken Into the Body

While we will rely on simple rules of thumb, or the dose-conversion factors of Eckerman, for estimating doses and risks from internal beta-gamma emitters, effects of plutonium and alpha emitters are somewhat updated in this subsection because there has been widespread fear of plutonium, and because some significant new information has been obtained on plutonium relevant to internal alpha emitters.

A personal experience involved a patient who entered the Radiation Medicine Department in May, 1967, at age 31, with 2 microcuries total americium-241 in his body (see Brodsky and Wald 2004). This person was still alive at age 72, but passed away at this age on March 7, 2009, since the first draft of this book was distributed for comment. In a telephone call to his daughter following his death, I was informed that he died after suffering pancreatic cancer. Thus, he lived an additional 42 years without liver or bone cancer, while accumulating an estimated dose to total bone mass of about 1,000 rad. As given in the chapter (Brodsky and Wald 2004), a quality factor of 20 was used to obtain an estimated dose equivalent of 20,000 rem to bone; the calculation also used the much faster removal rate of 20 years (Rosen et al. 1980) observed for this patient, rather than the 100 years in ICRP (1979). For most of the years after cessation of treatments with DTPA, removal from the total body was close to exponential in time; the liver doses were lower than those to bone and were also assumed to be exponentially removed in equilibrium with feedback from bone to blood. It is true that this was only one person, but many billions of cells in his body were exposed to alpha bombardment over the years. Note consistency with the following findings.

Americium-241 compounds, and plutonium nuclides in physico-chemical forms more transportable from the lung, deliver their greatest doses to bone and liver. For workers exposed to the more high-fired plutonium oxides, higher doses to the lung occur (Wilson et al. 2010). The lack of finding bone or liver cancers in the americium case with an initial 2 microcurie burden is consistent with the lack of any cancers being correlated with bone or liver for alpha doses up to thousands of rad, as received from the amounts of alpha emitters remaining over time in the bodies of human cases of the Uranium and Transplutonium Registry (Fallahian 2008).

An extensive analysis by prominent scientists has compared animal data with human data for risk modeling of a sample of 17,740 of the Mayak Production Association (MPA) workers of the Soviet Union (Wilson et al. 2010). Although a sample of 214 of these workers (compared with only 139 matched controls) were found with relative risks of **lung** cancer above that of controls at doses in ranges as low as 10 rad (200 rem) and below, only 26 liver cancers occurred among the workers with only 15 as differing significantly from 14 controls (95 percent confidence intervals) above the 100 to 300 rad dose interval (2,000 to 3,000 rem), and only 3 **bone** cancers all above the 1,000 rad (20,000 rem) level differed from the relative risk from 15 controls. The latter finding is statistically consistent with our observations on the americium case with 2 microcuries initially in his body.

Although Wilson et al. (2010) list 111 MPA workers in the 0 to 0.1 Gy (0 to 10 rad) lung dose group whose 95 percent confidence interval in relative risk lies above 1, it is doubtful that any of these lung cancers were actually due to plutonium inhalation. Among the literature reviewed in Brodsky (1996, pages 112-117) on effects of inhalation, the conclusions of Raabe and Parks (1993) provide an estimate of the threshold for lung cancer derived from extending data from non-transportable plutonium oxide exposure of dogs to humans by normalization of times to life span. The threshold for lung cancer in the dogs occurred at 1 Gy (100 rad or 2,000 rem). (In a more

recent paper, in which he examines internal exposures to alpha and beta emitters fitted to three-dimensional models of time to tumor, dose rate, and incidence or lethality, Raabe (2010) finds an apparent threshold for lung cancer in dogs of only 0.5 Gy (1,000 rem) when plutonium is administered by inhalation in dispersible nitrate form, but that the threshold is higher for more insoluble forms (likely to be encountered after an explosion).) However, Fisher and Weller (2010) have found suggestions of possible homeostasis at lung doses of 2 to 70 rad (40 to 1400 rem when multiplied by the tissue weighting factor for alpha radiation), and a possible threshold of 15 to 40 (300 to 800 rem), in beagles exposed to inhalation of plutonium oxide ($^{239}PuO_2$).

When extrapolated to humans, it was estimated that the threshold would be equivalent to receiving 220 rem to the lung per year over the years after a single inhalation. Fallahian (2008) found no association between radiation exposures from transuranium elements and lung or other organs, from pathological and radiological examination of the tissues of 319 deceased nuclear workers who had donated their bodies to the Transuranium Registry; these workers included those exposed to the greatest releases of plutonium and americium in the workplace since the beginning days of nuclear developments. Fallahians's results with a Registry population of 319 former workers is consistent with the earlier finding of Gold and Kathren (1998) with 260 former plutonium workers. Fallahian did, however, find cancers associated with exposures to benzene or toluene, cigarette smoking, chlorinated solvents, and the duration of these exposures.

Exhibit 22 of the next chapter, using the inhalation conversion factors of Eckerman (2004), indicate that an inhalation of 0.06 **μ**Ci would deliver at most an effective dose (equivalent to a whole body dose) of 25 rem. The maximum organ dose for that intake would be about 500 rem, spread out over a number of years (Exhibit 22). If it is assumed that about 50 percent or more of the intake remained in lung, it could be detected by measuring the L x rays from plutonium (or like alpha emitters) at the 0.03 **μ**Ci level or above (see Chapter 5). For a much higher intake, extremely unlikely from a WMD, the patient would need to be referred for special treatment or lung lavage (Stannard 1988, pp. 1682-1685). However, such a procedure might not be medically advisable for many patients, and in any case the very few so exposed would need to be referred to special medical centers. If particles containing the plutonium have been phagocytized and concentrated in lymph nodes, investigations have shown that no cancers will likely be observed even with very large concentrations of alpha-emitters in the lymph nodes (e.g., Stannard 1980; Gold and Kathren 1998; Fallahian 2008).

The number of humans exposed to inhalation of plutonium oxide is not large, fortunately. However, animal experiments have also confirmed that 0.03 **μ**Ci remaining in the lung would not likely result in long-term or short-term health effects. As summarized in Stannard (1988, page 572), W.J. Bair in 1970 estimated from dog experiments that less than 0.5 nCi per gram of lung is unlikely to produce either pulmonary insufficiency or lung tumors. If we scale this concentration to the 1,000 gram nominal mass of the human lung, we get the value of 0.5 **μ**Ci for the human lung.

FOR SCIENTISTS ONLY, OTHERS MAY SKIP FROM HERE TO "SUMMARY OF THINGS TO REMEMBER…" AT END OF CHAPTER

Some Important Statistical Traps to Avoid in Interpreting or Reviewing Epidemiological Data on Radiation Risks

This hopefully brief subsection covers: 1) limitations of all large epidemiological studies that do not apply, before wording their interpretations, an overall test, such as chi-square, to determine whether the many tests of differences between subgroups of those exposed and the matched controls actually contain individually significant differences, while at the same time guarding against "dilution" effects (Brodsky 1979); 2) the need to understand

the fact, and the importance of explaining it properly in scientific and public literature, that, no matter how large or careful a study, one can never prove statistically that an administered pharmaceutical, or agent of exposure under study, will have an absolutely zero chance of harmful "side effects" of any particular kind; and 3) the need for epidemiologists to avoid improper normalization of risk estimates derived from dose-response data. (Brodsky 1996)

The estimates of radiation effects and risks in this chapter have been derived from publications of scientists and physicians whom I have known, either personally or by long acquaintance with their publications, to be eminent and credible among their peers. These eminent scientists usually shy away from publicity and are not often represented adequately in the news or literature reaching the general public, as is documented with some of my experiences in the first chapter. Nevertheless, while these eminent scientists can almost always be relied upon to properly set up their studies and fairly present their data and methods of analysis, there have been on a few occasions some problems that I have had with the ways their data have been used and the words used in their interpretations of results. Therefore, I will try to summarize what I think are some important suggestions below without adding too many burdensome pages.

Chi-square tests to determine the significance of a pattern of "significances" in t tests of subgroups

As discussed in the section in Chapter 1 on my experiences with congressional testimony against the Mancuso claims of finding radiation-caused cancers at Hanford, my concern regarding the misinterpretation of statistical fluctuations due to sampling uncertainties in small population subgroups led me to have programmers set up overall chi-square tests of the many two-by-two tables examined by Dr. Sanders (Mancuso et al. 1971, 1972; Sanders (1978). Anyone who has studied the elementary testing procedures of statistical analysis knows that the "Student t" statistic, used when testing the difference between two means, if squared and added for all the subgroups tested, will follow the mathematical formulation of a chi-square statistic with a parameter representing the "degrees of freedom" (equal to the number of independent two-by-two subgroups tested by a t test). In our large epidemiological study of radiation workers that began in 1964, the "AEC Health and Safety Study" (one of the shorter titles given to our reports), Dr. Sanders performed hundreds of detailed examinations of differences between worker population subgroups and their controls (matched, e.g., by age group at employment, sex, work histories, radiation exposures, and years of employment). I concluded that an overall test of significance was necessary before any firm conclusions could be reached about subgroup comparisons, or before any dose-response examinations could be appropriate. The chi-square test, a result of the addition of squared t statistics, actually tests whether there is any overall statistical significance in a large study, without bias regarding whether any observed differences in health effects are negative or positive. This does not mean that examination of subgroups is not therefore worthwhile, even if the chi-square test shows no overall health significance (see later); the subgroups should still be examined for clues to pursue in further investigation.

As indicated in Chapter 1, I had the programmers include a statistic that I wrote down to represent the t statistic into the analysis of project data (Mancuso et al. 1972; Brodsky 1978b, 1979a, 1979b). Because the tables of chi-square values did not extend to the hundreds of degrees of freedom that I needed, I gave the programmers the mathematical formulas to program the chi-square distribution for testing against "critical" values, for arbitrary numbers n of subgroups compared, that would indicate whether the overall differences between exposed and control populations would be less than 1% (0.01 probability), or 5% (0.05 probability) due to real differences in health effects rather than due to the random way diseases occur among groups of individuals in a population. (These random differences can be due, for example, to unobservable differences in how many persons in a particular

subgroup were subjected to someone with tuberculosis coughing while in their vicinity during the time period of the study subgroup.) Because I found this type of test very enlightening in examining Dr. Sanders' work, I later published the curves and formulas for the chi-square distribution in my chapter on statistical tables most useful in radiation measurements or radiation biology (Brodsky 1982f, Figure 6.5-1, page 424 and page 455).

An amazing thing happened when the chi-square test was applied to a large, but preliminary, study with an initial control population. When Dr. Sanders cleverly changed comparisons from Hanford workers vs. matched populations from sibs to Hanford workers with one or more sibs living into matched healthy years of employment vs. sibs (who by definition have one or more sibs), the chi-square test that had indicated a significance of findings of a population difference in the former comparison then changed dramatically to indicate insignificant differences, i.e., a high probability that the two populations showed the same overall health status. This was just what Dr. Sanders had concluded independently from his examination of all of the two-by-two table statistics. This idea of Dr. Sanders should be considered as another way of improving the matching between exposed and control populations in any study of disease etiology. The chi-square test that I used, as well as my own commentary refuting the later claims of Mancuso (Mancuso et al. 1977) and listing a couple dozen references to other refutations, was published in Brodsky (1979b). Sanders' analysis that refuted Mancuso's claims of radiation caused cancers was published as Sanders (1978). My earlier analysis, in which I presented the overall chi-square test in our first presentation of the 1964-72 AEC Health and Safety Study methods, was published in more detail in Mancuso et al. (1972).

Now, I must again caution that the examination of individual subgroups is not to be avoided in any case. We need to squeeze out any indications of correlations available in examining these expensive and difficult human followup studies of diseases and their causes. An examination of the chi-square test would show that the overall chi-square test could well indicate no overall differences in a large population study, while for a few subgroups there might be a very strong indication of a serious agent effect in the circumstances and exposures of those subgroups. We cannot afford to miss these indications. These few subcategories that show significance in a two-by-two test might yet be strong indications of subcategories to look at more carefully, even though the overall difference between the entire exposed and control populations was not significant. Also, an investigation in depth of such subcategories that "hint" at providing evidence of some unknown causative factors would then be much cheaper and easier in which to dig for more information on the possible agents of exposure involved, and other factors affecting these segments of the population that affect health. My recommendations in our various project reports included a recommendation that we should not spend money doing dose-response analyses until we ascertained that not only was there significance in the overall chi-square test, but that there were also indications that certain subgroups should be examined more carefully for possibilities that important evidence was within those subgroups. Then, as I recommended, subgroups indicating effects could be tested with dose-response methods and evaluated appropriately, including with greater investigation into all of the other agents of exposure and lifestyle variables that might be important for those subgroups.

Statistical procedures estimate probabilities and, moreover, provide probabilities for investigators to use in prioritizing further studies or experimental designs. This is the value of the proper use of statistical methods of analysis in health studies. No single statistical analysis of even carefully designed prospective cohort studies can be taken as proof of causation of a disease by any agent or pharmaceutical. Repeated studies in different populations must be attempted in order to "weed out" possible exposures or factors that might not be recorded or known, but which might confound the analysis of effects of the agent(s) of interest. Also, repeated studies are necessary to observe the same correlations between disease and the occurrence of exposures to an agent in time and place, in order to converge toward any conclusions of causation in the field of epidemiology. That is so, in part, because human studies cannot be controlled to the same degree as animal experiments. Most societies today would not allow humans to be put into cages for life, and made to eat the same specific diets day after day.

Now, I must admit that, after my 1979 paper was published, there was a serious letter in the journal Health Physics that claimed that the entire presentation of my 1979 paper was not valid because the mathematical form of the t statistic that I had written down for the programmers was not the one that would be derived from first principles, the statistic I later presented in Brodsky (1982c). However, I had to reply to the comments of these two presumably well-educated Ph.D. mathematical statisticians. I admitted that I should have derived my t statistics from first principles (as I lectured my graduate students to do). However, I tested the fit of the *ad hoc* individual t statistics (which I had hastily given to the programmer) to the mathematical form of the t distribution after the chi-square test came to the point of complete insignificance (Brodsky 1980c). My ad hoc invented t statistic fit the exact formulas beautifully. This showed that my check of Dr. Sanders' brilliant analyses was still valid anyway, and I further chastised these mathematical statisticians for not understanding or realizing this outcome, and that many other important and still valid points were made in my 1979 paper. I also pointed out to these statisticians that other eminent statisticians, including those who peer-reviewed my paper before it was published, also did not notice that my t statistic looked a little bit sick, or at least they decided not to make me cry over it. When one attempts to publish anything, one must be prepared to occasionally fight back, sometimes against giants.

No study of pharmaceuticals or agents can prove absolutely zero adverse effects over time

This is a fact of probability and statistics that can, and must, be understood not only by scientists and epidemiologists, but also by lawyers who litigate unreasonable, costly and detrimental lawsuits against pharmaceutical manufacturers or industrial companies that produce beneficial, but under some conditions toxic, products. Frivolous lawsuits that give inordinate riches to a few can destroy companies that employ many, and take away health benefits from others who need them. I know that lawyers are smart enough to understand the underlying mathematical and statistical concepts explained here. Donald E. Jose, LLD, then at the Department of Justice, used an entire suitcase of physics books that I had brought to him, in preparation for the Dennis vs. GE trial mentioned in Chapter 1.

The formulation of an equation for calculating defined detection limits of radioactivity in biological and environmental samples has been found to be useful in explaining the need to measure standard samples and background activities to technicians in the nuclear industry (Brodsky 1986; Brodsky and Gallaghar 1991). Thus, I think that a simple illustration using detection limit statistics will help to understand why, even with a perfectly designed study and increasingly large exposed and control populations, there is always a lower limit of detection no matter how large the sample or how long it is counted. The same is true for human studies; there can always be some lower limit below which one cannot say the number of persons affected will be zero. However, one can from statistical considerations specify a lower limit that is so low it is obvious that the pharmaceutical has far greater likelihood of saving lives than adversely affecting health.

The statistical derivation of the "Decision Level (DL)" and "Minimum Detectable Amount (MDA)" concepts are presented in the above references and will not be repeated here. In examining the formulations in the literature, I decided that the numerator of the formula, MDA = (4.65 Sb + 3)/kT required an exact 3 in the numerator to give the often-used 0.05 (5%) chance of not detecting the presence of radioactivity even when the background count in T minutes, Sb, is zero. The 3 comes about because in the Poisson process formula, the probability of observing zero is 0.05 when the expected number to be observed is 3; i.e., exp(-3) = 0, where exp(-3) means raising the base e of natural logarithms to the negative third power. Those needing and desiring understanding of this must consult a text on statistics. In this formula, for example, Sb might be the total number of background counts obtained in

time T minutes, and the value of k might be the calibration constant obtained from counting a known amount of radioactivity in counts per minute per microcurie. (Brodsky 1982c, 1982d; Brodsky and Gallaghar 1991)

Thus, in the case of sample counting, kT would be the counts per microcurie for a given counting set up over a given amount of counting time. In the extreme case of a human study to see if a new disease exists with new defined symptoms, not known to be caused by any agent, is searched for in a particular population exposed to a new agent X, the product kT would be cases per amount of population studied over the study period. Then, with these assumptions, one can only say with 95% assurance that if 100,000 persons had been examined in a study, there is 95% assurance that the incidence of the disease is less than 3 per 100,000. If 10,000 persons had been studied, one can only say that the incidence of the disease is less than 3 per 10,000, and so on. One can never say, even if no significant additional cases happen to be observed in a particular study, that another study would still show zero cases. Thus, an "upper bound" of the likely cases can be established from a good study, but one can never prove the incidence of a disease will be zero. Of course, because the types of cancers caused by radiation are also caused by other agents or natural causes, the "background" of cases in any epidemiological study of radiation effects is very high, so that the upper limits of risk at the 95% uncertainty level about zero for any real study would be higher than the 3 per 10,000, in the study of 10,000 example above.

However, it is known from the extending of life through applications of medicine that certain health benefits exist from the research and discovery of pharmaceuticals. When the health and life saving benefits of a new drug have already been established to be much greater than the estimated upper limits of risk of adverse effects, then it would certainly not be beneficial to public health and welfare to prevent the use of such a drug because it might have occasional adverse effects. That is why frivolous lawsuits by persons who have had adverse effects that are honestly explained in the drug package inserts must be limited, or not be judged in such a way that they deplete the jobs or resources that provide for others to have adequate health care. Our society needs to understand these issues in its own self-defense, and provide a national plan for health care that helps everyone in need without destroying the very health resources that have extended life in our society. This is one area in which we need to realize that our society needs to pool its resources together through efficient government health programs, and limit destructive law suits against legitimate industries. The Food and Drug Administration has the difficult, but important, task of deciding from the research performed whether a drug is likely to save many more lives than produce adverse effects in a population of sick people who need it. This matter needs to be explained better by pharmaceutical companies and the FDA, and understood by all the public, particularly those who litigate and those who legislate.

A related principle for unbiased reporting of health studies is that **no research papers presenting dose-response data should present points at zero on the dose axis without also showing the upper limits of the risks (upper portions of the "error bars" at defined probability levels) associated with these observed risk levels.** Sometimes these error bars should be shown in the region of negative risk, or improved health, if that is what the data show.

The above discussion of not being able to prove zero effect reminds me of an example application of this concept, which I found important in a later discussion with Dr. Robley D. Evans, when the Mancuso-Sanders-Brodsky team visited him at MIT during the initial stages of the AEC Health and Safety Study. Our visit with him was aimed at obtaining his recommendations about looking for bone sarcomas from some of the bone-seeking radionuclides processed in the atomic energy industry. It is one of the few times I have been able to suggest a useful change in presentation of scientific data to so elevated a scientific hero of mine. At the lower levels of radium measured in bone at which no bone cancers were observed, Dr. Evans had been plotting points at zero on the x (dose or radium quantity) axis of his graphs of frequency of bone sarcomas among the women who painted luminescent instrument dials for World War I aircraft. I mentioned to him that, to avoid criticisms from statisticians, he should instead indicate a 95% range of uncertainty with a line going down to zero on the x

axis, but ending at an upper limit calculated at least from the concepts above and the number of persons in that particular radium content group. He apparently adopted my suggestion in his later papers. See Figure 2-21a, page 114 in Brodsky (1996), which is plotted from Evans et al. (1972). I remind other epidemiologists of this need, although I think that any of them well schooled in statistics already understand this issue.

I would here like to pay tribute to the memory of Robley Evans. I first came to know him well when I served on the Health Physics Society Board of Directors with him in the 1967-1968 term, and again when he was active as President of the Society in 1972-1973. He was famous among all students of nuclear physics for his outstanding textbook on nuclear physics (Evans 1955), but was also known to all of us in the radiobiology or health physics professions as the physicist who made the original measurements of radium in the dial painters, and thereafter led a long-term epidemiological study of their bone diseases while also continuing as a professor of nuclear physics at MIT. He also became President of the Radiation Research Society.

He established the maximum allowable amount of radium in the human body in 1941, setting the limit, using a safety factor, of one-tenth the level that was found to produce bone sarcomas in any of the radium dial painters. His input on this subject was requested by the military for use in limiting exposure to radium-illuminated aircraft instruments in World War II. His recommended limit of one-tenth of a microgram of radium in the body of an average adult still represents the level of dose to total bone to which other bone dose estimates are benchmarked in physiological models for estimating radionuclide intake limits. Limits were calculated using the doses to total bone from the amounts of radium that are less than one-tenth those that caused bone sarcoma in humans, as measured by Evans and later by others (ICRP 1960). Then, these levels were adjusted for radionuclides other than radium, like plutonium and americium isotopes, using relative effectiveness of these nuclides compared to radium for cancer induction in animals. Although later recommendations of ICRP have used models that assume most plutonium or americium accumulates in a much smaller mass of bone (near endosteal and periosteal surfaces), the requirement that calculations of limiting intakes agree with human and animal observations of cancer risk have evidently resulted in the use of lower tissue weighting factors so that limits on intake by air or water are about the same as those calculated in ICRP (1960) for "low solubility" plutonium (Brodsky 1992).

I was extremely honored to receive the Robley D. Evans Medal from the Health Physics Society in 2001, and now feel obliged to continue contributing what I can in his memory. I once asked Robley Evans' wife at a reception, "How did he manage to write such an extensive textbook on nuclear physics while meeting his research, teaching, and epidemiological obligations?" She told me, "He gets up to work on his writing at 4 a.m. and writes for about two hours before going to work at MIT." Robley Evans also provided voluntary services to many national committees. He was a tall, handsome, charismatic, and strong man, with a kind, gracious manner. His historic contributions, and many honors, have been reviewed in numerous publications, including in Stannard (1980).

For any scientist who may be able to obtain a copy of Evans' book from someone through the internet, the chapter on statistics of counting systems alone would be worth the cost. His chapters from pages 746 to 819 provide a concise coverage of the vast majority of concepts needed in radiation measurements; many of these concepts are also applicable to other random processes. Copies of older books can often be obtained for bargain prices from internet sources.

The need to avoid inappropriate normalizations of radiation risk data in dose-response analysis or presentation

I have hesitated to give an example of this inappropriate procedure, because I found it in a paper originating from what is usually the most reputable of sources; and these sources have now corrected the procedure. However, it would be difficult to explain my point without this example, which I discovered in an important paper from the

Radiation Effects Research Foundation (RERF) studies (Shimizu et al. 1988) only because I took the trouble to add in each line of a table both the number of observed cases of cancer and the expected number of cases in each dose range within each time period. The number of expected cases in each time period, totaled over all dose ranges, was found to be normalized and made equal to the number of observed cases (a whole number) in each time period. The numbers of expected cases should not be so normalized, because forcing the total number of expected cases to be equal to the number of observed cases in a particular time period, or any subcategory, would obviously preclude a greater, or less, number of total cancers in one population rather than the other. Also, it can be seen in Shimizu's tables, that such a normalization procedure could greatly distort the shape of any dose vs. relative risk curve that might be obtained in any subcategory, as well as the total population altogether. This obviously makes any further analyses invalid.

Expected numbers of cases should be calculated independently for each population or subpopulation from natural cancer data for a population of similar factors of age, sex, and other characteristics used for matching controls and the "exposed" population. Thus, the relative risks of radiation exposure in the different categories, as reported in this paper, could not be valid. Fortunately, the RERF investigators must have discovered this error, which has not occurred in following analyses (Ron et al. 1994, 1995a, 1995b). A more detailed examination of this problem may be obtained from the particular tables abstracted from Shimizu with my discussion of them on pages 87-92 of Brodsky (1996a).

Summary of Things to Remember About Radiation Risks

The foregoing details about radiation risks in this chapter are too much to remember in an emergency; they have been presented to justify, to skeptics or scientists (always skeptical), the following conclusions that taken by themselves would save the vast majority of lives that would otherwise be sacrificed to panic:

- *Maintaining external exposures to gamma radiation less than 25 R for responders will ensure that they will not likely face serious health effects performing life-saving rescues;*
- *However, as much as possible, families should strive to 5 R or less to maintain average body doses below levels that would significantly reduce chances for long-term effects, even in children;*
- *No family should consider aborting a fetus that has received even up to 20 R or more, especially without consulting medical researchers who are expert in radiation biology;*
- *Controlling internal exposures is certainly accomplished by limiting external exposures, except for the very unusual circumstances of persons exposed in the passing radioactive cloud from a detonation. The only case known to the author of such exposures that have yielded health effects is that referenced to the formerly classified Soviet report in this chapter. Other internal exposure assessments have been calculated using resuspension assumptions from field measurements; these, for the many thousands of workers exposed to fallout after atomic tests, have shown internal exposures to be very low compared to external exposures. Some examples of monitoring measurements that can be made are given in the next chapter.*
- *Despite many scare stories about plutonium, no individual is likely to receive a serious plutonium exposure from radioactivity dispersing devices (RDDs) or nuclear bombs. The threshold for cancer induction due to long-term exposure of tissues and organs to internally deposited plutonium (americium, other alpha emitters, etc.) is at least 100 rad (2,000 rem) to any organ. (A recent paper by Raabe (2010) supports this conclusion, but indicates that, for the most potent beta-emitting carcinogen yttrium-90, the threshold would be about 0.5 Gy (50 rad) for lung carcinoma, but higher for other beta emitters, including strontium-90 in equilibrium with its yttrium*

daughter.) Radiobiologically, plutonium is a negligible fraction of the radionuclides released in an atomic bomb explosion; its effects would be swamped by those of the much larger quantities of fission products.

- *The maximum estimated chance of dying from long-term cancer for gamma exposures is 5 chances in 10,000 per rem*[3†]*, and this risk factor should be used to calculate cancer risk on the high side only for doses 10 rem or above.*[4*] *For the whole body exposed acutely to 10 rem, the risk of cancer for the average age person thus becomes about a maximum of 50 in 10,000, which is 0.005, which is 0.5 percent or half of one percent, added to a prevalent cancer death risk from natural and other causes that is at least 30 times greater. Thus, in any case, everyone should take precautions to have possible cancers diagnosed early. Furthermore, the chances of solid cancers from such exposure, which are the most prevalent, begin to show up only after about 20 years of latent period, possibly because radiation is usually only a co-carcinogen in combination with other exposures or mutations. Therefore, if I should expect to receive 100 rem for ten rescues at age 81, I would gladly volunteer to save ten lives; my chances of additional cancers would be such that I could postpone worrying about them until age 100. See the cartoon in the next chapter about my rescuing my neutron spectrometers in a field of 30,000 mR per hour. I would certainly be willing to do this to rescue you and at least nine others from a field of high gamma intensity. There are likely many fit responders over 60 years of age who would also be willing to participate in such rescues after reading this chapter, or being subjected to proper training.*
- *Last but not least, the inexpensive, well-tested credit card monitor, described as SIRAD in Chapter 8, could provide the exposure information needed to take appropriate actions, if worn in a pocket either by responders or members of the public. The insert with this monitor describes simply its use, and knowledge leads to doing the right things, not panic or unfortunate actions.*

3 † The Department of Homeland Security (DHS 2008b) suggests 6 chances in 10,000 instead of 5, but such a difference is not significant for rapid assessments in the early moments after an attack.

4 * Scanning journals in the evening after writing this page (1/24/10), I found reference to a recent report reviewing the radiation biology literature (Brooks et al. 2009). Written by highly respected and trusted authors it concludes that, in over 230 studies and reviews in current literature, there is no evidence of human cancer in persons exposed to less than 10 rem.

CHAPTER 5

BASIC INFORMATION ABOUT WMD THAT CAN SAVE YOUR LIFE

This chapter gives some information that will help in understanding the matters of radiation and radioactive fallout, to aid in rapid decision-making on the part of the public, or emergency responders, after a radiological or other WMD attack. ***Those not interested*** *in the math or technical material do not need to absorb it.* ***Just skim it or skip it*** *and go on to the simple things to do for your protection. However, some technical information is useful for those interested in planning protection or recovery operations after the immediate actions to save life.*

First, I will list a few facts to remember, starting with **what you do not know in advance of a terrorist attack.**

What you do not know in advance of an attack

Fallout patterns cannot be predicted in advance, wind conditions can change from moment to moment, and you do not know from which direction the wind might be coming

Exhibit 11 shows the famous fallout pattern of the BRAVO Shot hydrogen bomb of Operation CASTLE, March 1, 1954, where the expected wind was supposed to go to the West and then shifted to the East. The fallout deposited on the surprised and unprepared natives of Rongelap Atoll, 90 to 110 nautical miles (about 104 to 126 miles) away from ground zero. Some natives received almost lethal doses of external radiation (some estimates were about 180 rem), and a number who were outside not knowing that the white stuff falling was radioactive received up to about 6,000 rem skin doses on spotty places on uncovered parts of their bodies. It is noteworthy that although some of them were eating in open vessels, the internal doses were much lower than the external. (Later, when on the University of Pittsburgh faculty, I had a consulting job to estimate the skin exposures from some of my own experience with fallout on the islands. I estimated the dose to a lesion on the ear of one of the natives as 6,000 rad. A physician then told me that my estimate was consistent with his prognosis from the degree of tissue damage.)

When the fallout hit the ship that I was on, the ship crew knew how to measure radiation; we were sent below decks, the ventilation system was turned off and we were crammed together in high temperature and humidity — not a very happy bunch of campers. The decks were washed with hoses set up for such conditions. Thus, simply knowing enough to "get out of the rain," so to speak, can lower doses to safe levels. I had worn a pocket chamber and noticed that after the

ship was cleared for us to exit to the deck or our quarters, my pocket chamber read only 100 mR (0.1 R). I was not only below deck while the fallout was depositing and being washed away; I was also shielded by the large crowd surrounding me. This experience provides a lesson for action in the event of a terrorist attack. For example, if you are in a department store when you expect radioactive fallout might be blowing your way, go to the basement level, look at the tables with bargains to occupy yourself, and alert others to gather around each other in large crowds. Ask the store manager to quickly close all doors and windows and turn off any ventilation system drawing air from outside.

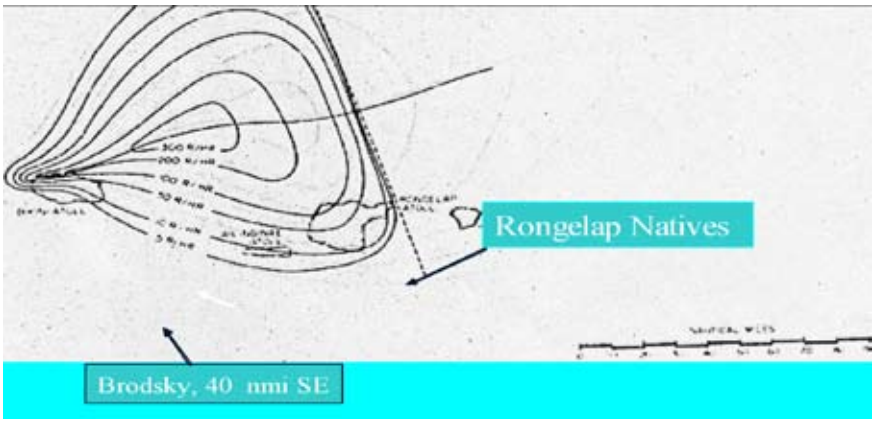
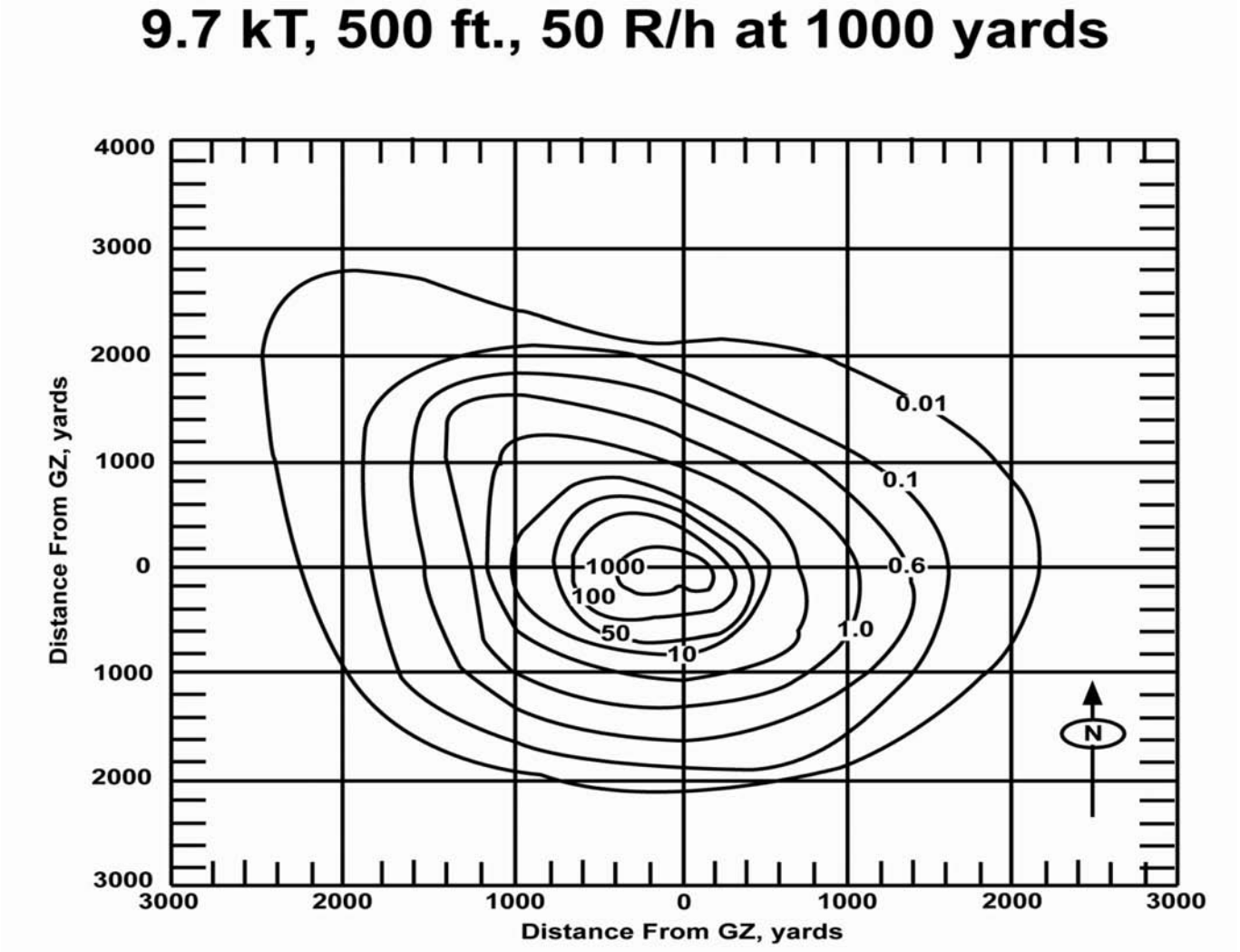


EXHIBIT 11 — The fallout pattern in 1954 from the BRAVO 15 megaton ground burst at OPERATION CASTLE (Hawthorne 1979a), showing where I was on the USS ESTES and where the natives were.

Personnel on the USS ESTES (including the author) would have received several rem (Thomas et al. 1984) if remaining on deck and if the ship were not washed down; instead, personnel below deck received only about 0.1 rem or less. On the other hand, natives on Rongelap Atoll, as has been reported in the media, received up to almost 200 rem external radiation, and up to about 6,000 rad on skin surfaces, because they had no knowledge of the nature of the fallout and continued to remain outdoors and cook in open ovens.

Exhibit 12 shows the radiation dose-rate pattern from a 9.7 kiloton detonation at 500 feet, as it might appear after detonation on the roof of a tall skyscraper. This pattern is almost circular, quite different from most of the ragged shapes of fallout deposition patterns (Hawthorne 1979a, 1979b).



9.7 kT, 500 ft., 50 R/h t 1,000 yards

EXHIBIT 12 — A fallout pattern from a 9.7 KT weapon detonated at 500 feet at Operation Plumbob in 1957 (Hawthorne 1979b)

This detonation at a height of 500 feet in a downtown building might be considered a plausible scenario for a terrorist desiring maximum blast effect. (The arrangement and strength of surrounding buildings would naturally change the above pattern.) We can see that the 50 R/hour contour extends to about 1,000 yards. Thus, for example, beyond 1,000 yards, a rescue taking 6 minutes would result in a dose of about 5 rem or less to a responder. With appropriate monitoring instruments and quick arithmetic, a responder could save a life in such a field, or a member of the public could leave shelter for six minutes to gather food.

Exhibit 13 shows idealized fallout patterns if the wind stayed in exactly the same direction for a number of hours. However, everyone knows that such an idealized wind pattern does not exist. Patterns such as these have been useful only to emergency planners in estimating the possible areas of damage and harm from various attack scenarios. Everyone who has been outdoors knows, especially when playing sports like football or tennis, that winds vary every moment in direction and intensity.

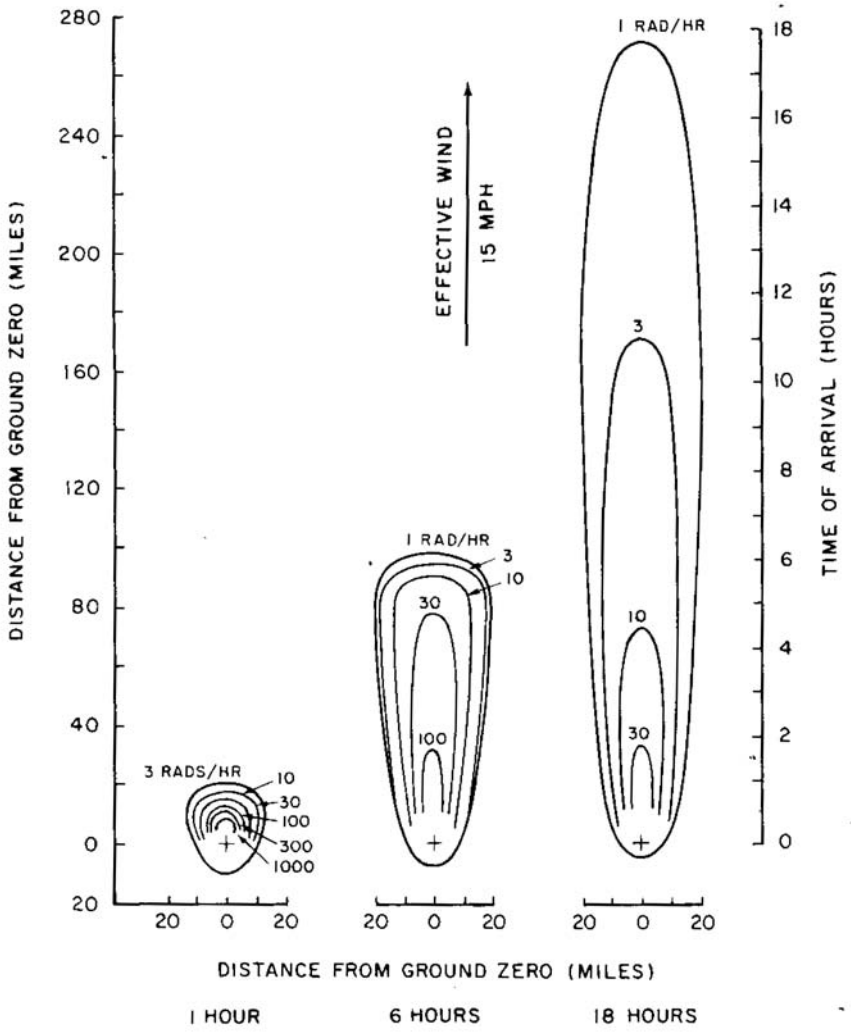


EXHIBIT 13 — Idealized fallout patterns for a 15 mile per hour wind, for a 2 megaton hydrogen bomb with 50% fission yield.

From Glasstone and Dolan (1977, page 425). The distances on the left ordinate are in miles, and the times on the right ordinate are the times the fallout arrives at the corresponding distances. The exposure rates are those after all fallout has deposited.

Exhibit 14 below presents cloud distances and widths, and the narrower widths near the origin at ground zero, as scaled according to the W = kilotons of TNT equivalent of a nuclear detonation in the kiloton range. The subtitle gives an explanation of its use. Of course, the W values for a dirty bomb would be extremely small. A kiloton of TNT would be 1,000 tons, or 2 million pounds. No person would carry such a bomb on his back. A truck might be packed on the order of a few thousand pounds of TNT. In any case, the values obtained from the table below are used only to give an idea of the amount of distance or area that might be covered by fallout to give different levels of radiation intensity. Any real patterns will be in ragged shapes, according to wind patterns and their frequent variations at ground level and throughout the altitudes from which particles fall to the ground at different distances. Additional perturbations from idealized patterns would occur where winds would be interrupted by buildings. Thus, the ideal patterns that have been shown in news media or TV presentations, with ideal shapes like those in the patterns above, are not realistic, but only for indicating approximate amounts of area that would be contaminated.

Reference Dose Rate at 1 Hour (rad/hr)	Downwind Distance (statute miles)	Maximum Width (statute miles)	Ground Zero Width (statute miles)
3,000	$0.95\ W^{0.45}$	$0.0076\ W^{0.86}$	$0.026\ W^{0.58}$
1,000	$1.8\ W^{0.45}$	$0.036\ W^{0.76}$	$0.060\ W^{0.57}$
300	$4.5\ W^{0.45}$	$0.13\ W^{0.66}$	$0.20\ W^{0.48}$
100	$8.9\ W^{0.45}$	$0.38\ W^{0.60}$	$0.39\ W^{0.47}$
30	$16\ W^{0.45}$	$0.76\ W^{0.56}$	$0.53\ W^{0.41}$
10	$24\ W^{0.45}$	$1.40\ W^{0.53}$	$0.68\ W^{0.41}$
3	$30\ W^{0.45}$	$2.20\ W^{0.50}$	$0.89\ W^{0.41}$
1	$40\ W^{0.45}$	$3.30\ W^{0.48}$	$1.50\ W^{0.41}$

EXHIBIT 14 — Table of scaling relationships for unit-time reference dose rate (RDR) contours for a contact surface burst with a yield of W kilotons and a 15 mile per hour wind.

As an example of use of this table, take the simplest case of a W = 1 kiloton burst. Then W to any power is still = 1. So, in the bottom line of the table, we see that an exposure rate of 1 R per hour would occur at 1 hour reference time at 40 miles downwind in the center of an ideal, one directional wind, if all fallout had been deposited. But for a 15 mile per hour wind, it would take almost 3 hours to reach 40 miles. Thus, the reference radiation intensity must be understood. For those who would like to do calculations on a scientific electronic calculator, using the $R\ t^{-1.2}$ decay law discussed in Appendix B, after all fallout has been deposited at 40 miles, the exposure rate at ground level would reach a peak at about 4 hours of about 1 R/hr x $(4)^{-1.2}$ = 0.189 R/hr, or about 190 mR/hour. A sensitive Geiger counter might click like mad at such an exposure rate (the CD V-700 instrument discussed later would read almost half scale on the highest scale and click at a rate of about 12,000 counts per minute). However, at an exposure rate of 190 mR per hour, a person could leave shelter at that distance for an entire hour to collect food and water for the family, and still receive a whole body dose less than 190 millirad. Such a dose would likely be less than the individual would get living in natural background for one year, and more years of living would certainly be available. Just remove your booties (or plastic foot covers) before coming back into the house, and you will have little to worry about. But you can see how someone might panic at such a seemingly high count rate of clicks, unless they knew the risk and action information in this book. So, you are therefore lucky you bought this book and will not panic when you need to help your family.

Exhibit 15 shows the pattern of only one of hundreds of above ground nuclear tests in Nevada that spread measurable radioactive material well beyond the test site into other states. It is clear from the curves of different levels of intensity in mR/hour that a far greater area, in the hundreds of square miles, can be contaminated to 10 mR/hour or greater, whereas, levels in the 100 R/hour (100,000 mR/hour) range where exposures could be lethal in little more than one hour cover only relatively small areas.

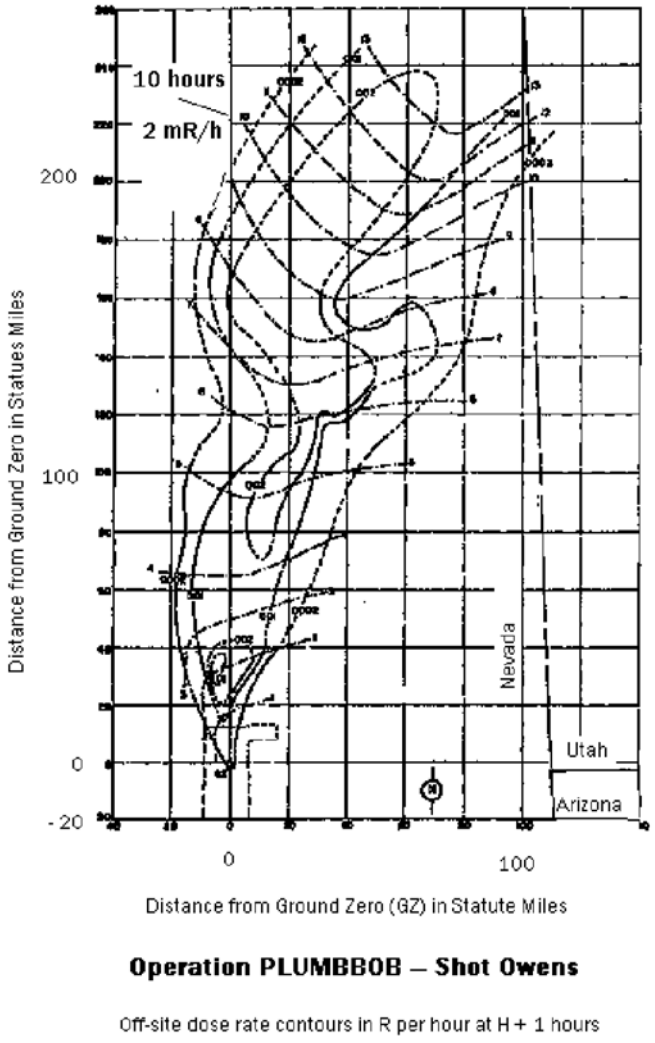


EXHIBIT 15 — Fallout Pattern and Times of Deposition from 9.7 Kiloton A-Bomb.

This pattern shows the extent of the off-site fallout from a 9.7 kT weapon, detonated at Operation PLUMBOB at the Nevada Test Site in 1957. The 2 mR/hour pattern extended out to 200 miles, arriving some 10 to 12 hours after the blast. However, this type of fallout pattern presents exposure rate contours at H+1 hour, as if all the fallout had at the indicated distance at the time indicated by the time of arrival curves that cross the exposure rate curves. This is done so that exposure rates at times after fallout arrival may easily be calculated using the Way-Wigner formula (discussed in text for the mathematically inclined) For example, using the 0.002 R per hour (= 2 mR/hour) rate indicated at the intersection of 0.002 and 10 hours at the left-most dotted curve, the actual exposure rate after all fallout has deposited at 10 hours at that location would be $0.002\ (10)^{-1.2} = 0.000126$ R per hour, which is about 0.13 mR per hour. Although very low, this exposure rate is about six or more times higher than natural background radiation, and will give a visible and audible indication on any Geiger counter instrument, especially those expensive "pagers" with which many responders are being trained. Many responders trained today would be unduly alarmed at such indications of radiation intensity and would not be able to perform. I do not recommend for responders the types of rate meters or dosimeters that alarm and frighten responders and the public in the mR/hour, or mR exposure, regions. In civil defense lectures, we found it quite reasonable to teach the reading of meters and simple arithmetic calculations. There are obviously hundreds of square miles of area contaminated up to 100 mR/hour or less, in which responders can enter without fear to save life and property. The limit for acute exposure of responders, which was accepted by the Division of Biology and Medicine, AEC, for use in Operation IVY when I was there in 1952, was 25 R. This level of exposure is still often suggested as a limit for emergency workers, unless special circumstances might make higher doses acceptable to informed individuals for important lifesaving actions. The 25 R exposure is not expected to show appreciable acute effects or illness. Similar orders of magnitude exposure or dose have been more recently recommended as acceptable to save life after an attack. (See text.)

Many additional requirements were imposed on nuclear power plants for emergency drills, including possible evacuations, after the Three Mile Island accident of 1979. Thus, within the Nuclear Regulatory Commission (NRC) and the licensed nuclear reactor facilities around the nation, many individual health physicists, engineers, and other employees were assigned emergency response planning and participation duties. This produced many new emergency planning and response experts, or persons whose main duties were involved around postulated "worst case" nuclear accident scenarios. Therefore, many of these reactor emergency experts naturally brought their methods and experiences into their planning activities when they joined efforts regarding responses to terrorist attacks.

With nuclear power plants, we know where the presumed source of released radioactive material will come from. The worst accident in the history of nuclear power operations in the United States occurred at the Three Mile Island plant in Pennsylvania at 4 a.m., Wednesday, March 28, 1979 (Willis 1982). As seen in the Three Mile Island accident, which occurred on a Thursday, there was much time for evacuation away from the plant well before any radioactive material was released. In fact, when called into a meeting at the Nuclear Regulatory Commission (NRC) where I worked at the time, I advised that all persons in the vicinity should stay in their homes, or on their jobs, rather than evacuate into the open where they could be exposed to the small amounts of radioactivity that could possibly be released. With the unpopulated zones required around the reactor, I did not believe it likely that serious releases would occur that would harm the population. However, my advice was not accepted and others warned the public to evacuate. After the meeting, my advice at the NRC was not called upon further.

However, the Saturday after the initiation of the emergency, I felt the need to offer my services as a physicist who had managed and evaluated in a hospital many persons highly contaminated with radioactive material (Brodsky and Wald 2004). So, during a visit to Pittsburgh to attend a retirement dinner for my wife's former principal, I called my friend and former student Ken Miller to see if he could use some help in case contaminated and injured persons were to arrive at the Hershey Medical Center of Pennsylvania State University. Ken was head of health physics at the university, and had established safe procedures and facilities at the hospital for managing radioactive patients (Miller and Weidner 1982). Already a respected faculty member, Ken was responsible, under contract with management of TMI, to receive, monitor, and appropriately decontaminate as necessary any persons who might be referred to the medical center. When I called, Ken advised that he might well be able to use some additional assistance. Thus, I excused myself from the retirement dinner, and headed down the Pennsylvania Turnpike from Pittsburgh to Hershey, Pennsylvania. On the way, I heard over the radio that there was still danger of a major explosion and release of radioactivity from the plant. Thinking that I did not want to be embarrassed as a health physicist going into a high radiation area without at least a pocket dosimeter, I stopped at a State Police barracks and borrowed a 500 R (500,000 mR) pocket chamber. (Before FEMA recommended, and some Senators urged, the decimation of the radiological defense instrument program, such dosimeters were in the possession of police and firemen throughout the nation.) With the dosimeter in my pocket, I continued down the turnpike feeling I would not enter any area of danger without knowing the extent of the radiation I was receiving.

When I arrived at my friend Ken Miller's home Saturday evening to see if I could be of assistance, I found that the Geiger counter on Ken's coffee table still read only natural background radiation intensities. Yet, advice from some officials, and exaggerations of the release that evening by Dr. Sternglass on TV news (as well as in newspapers; see Exhibit 3 and Sternglass' misuse of my name as a seeming confirmation) caused even some physicians who headed departments to leave the area with their families, suspending some care for their patients. I was invited by Professor Kenneth Miller to explain the situation to the medical staff on Monday, to calm fears. The releases from the plant, through filter banks in the auxiliary building, were mainly the rare gas nuclides that are not taken up by the body in significant concentrations. Sternglass' contentions about the public exposures were absolutely false, although they reached most of the public.

As Willis (1982) concluded, "The radiation doses from the accident to the people in the area were less than the doses from nature to these same people in the same period of time." The information that I obtained from my own examination

of the data verified his conclusion (Brodsky 1980a; 1982e). One of the many lessons that Willis lists for reducing the chances for such nuclear reactor accidents also includes the lesson that, "1. The safety systems can protect the public even after gross failures and maloperations."

Now, do not assume that I am opposed to any plans for evacuation mandated by the Nuclear Regulatory Commission (NRC), as long as conditions are appropriate and the evacuation instructions do not give the impression that great danger from these plants is likely. NRC has been extremely conservative in order to decrease any chances of public harm effectively to zero. Evacuation plans should not be unduly restrictive to the point that they prevent the building of safe sources of power needed for public benefit. Although there have been no other reactor accidents like that at TMI in more than thousands of reactor-years of operation in the United States, it is prudent to have appropriate evacuation plans in the event a particular accident might possibly result in a release. Such plans can be inexpensive and flexible according to conditions, because the source of release is known, and time would be available for an orderly evacuation. However, there should be much less concern about such an event than there should be about accidents at chemical plants, gasoline refineries, or even tank trucks on the highway.

There has been concern expressed in the media about the possibility of a terrorist attack upon a nuclear power plant, usually by persons who have some expert knowledge of nuclear matters, but who might not know of the observational and natural evidence about limits on the release fractions that can enter the biosphere and humans. I have tried to excite some interest in this matter in some of my papers (Brodsky 1980a; 1980b). It should be well known that an airplane could not penetrate through the containment building of a nuclear power plant and all the other barriers to cause a release of fission products to the environment, unless the plane contained a nuclear bomb. In that case, there would be more to be concerned about than the reactor radioactivity. Effects of a nuclear bomb are summarized in the chapter by Auxier (2004), and in an appendix at the end of Chapter 13 (Brodsky et al. 2004). Estimates of the effects of the radioactive material from the reactor fission products, added to the radioactivity created in the nuclear bomb burst, can be made from information in the appendices of Brodsky et al. (2004), particularly Appendix A.10 (Brodsky 2004d).

An attendee of the 2004 HPS summer school asked, after an excellent summary by Michael Slobodien of the multiple barriers against fission product release built into nuclear power plants (Slobodien 2004), "What if an aircraft plunged into the spent fuel pond?" I asked for the microphone and referred the questioner to the section in Chapter 13 of the HPS Summer School text, where I had summarized the extremely small fraction of radioactive material released from two fuel elements subjected to the highest possible temperatures that could occur in an aircraft crash. One 5,000 curie fuel element was placed above a pond of jet fuel, and after experiments to find the highest temperature, the pond was set on fire and allowed to burn out. In the second phase, a 10,000 curie fuel element was surrounded by a simulated aircraft frame, placed upright in a cylindrical furnace containing magnesia, also surrounded with other flammable materials, and ignited with an oxygen-fed fire. In the second experiment, the entire fuel element was melted into a puddle in the Idaho desert in less than two minutes; it had reached a temperature of about 5,000 degrees Fahrenheit. In both cases, although radioactivity could be detected in the air by sensitive detectors up to about a mile away, there was insufficient radioactivity to cause serious harm to anyone beyond about 50 feet. Rabbits exposed from 100 to 1,000 feet from the first experiment showed no significant activity in the lungs or on the fur of the head. More of the important details are summarized in the Chapter 13. The complete report of the experiments is in the government report (Brodsky and Beard 1960).

Alvarez (2004) describes dirty bomb experiments, also conducted in the Idaho desert. These experiments show how difficult it would be to penetrate fuel casks containing nuclear fuel elements and disperse significant amounts of radioactivity. The chapter also discusses possibilities of detecting the radionuclides that are likely to be placed within dirty bombs, to prevent such devices from being smuggled through borders.

Because I love my children, I have long ago told them that if a nuclear or dirty bomb attack is expected and they find themselves near a commercial nuclear power plant, they should run toward the plant and stay within the reactor

containment building, not run away from the plant. Anyone who knows how nuclear power plants are constructed, tested, and secured today in the United States will understand why I advised my children in that way (see Carbon 1997).

However, I say again that it might well be appropriate to have evacuation plans for nuclear reactor plants, as long as the plans are not so elaborate as to deplete significant financial resources. On the other hand, the much more likely protective measure for a terrorist attack, where the moment of detonation would not be known, would be to stay indoors and shelter in place, as a "default" response. Citizens should seriously examine the advanced training and reasoning of local government or industrial officials if they are planning evacuations, and the circumstances that would activate an evacuation. The information presented above shows why staying indoors and sheltering in place are much more likely to be the most protective immediate responses of members of the public in the event of a terrorist attack.

Conclusions: Only in the case of a release of radioactive material from a nuclear power plant would the location of the source, and lots of time, likely be available for ordering an appropriate evacuation. However, for the reasons given above, I think that no sane, self-respecting terrorist would actually plan to attack a nuclear power plant — either from without or within. Terrorists have many easier ways to kill lots of people in the United States. In addition, terrorists attacking nuclear power plants should have no chance of creating fear or terror in anyone who reads this book. Therefore, it is not likely that the location of release of radioactivity from a dirty bomb or nuclear device will be known beforehand, or in the seconds, minutes, or even hours when personal protective actions must be taken.

You do not know whether the terrorist has planned a second bomb (or third…) at your designated evacuation location. It might not be wise to concentrate populations into large above-ground shelters.

In addition to not knowing where an initial terrorist attack with a weapon of mass destruction might occur, releasing radioactive or other toxic or infectious materials, one never knows whether additional attacks are planned at publicly known evacuation routes and receiving locations. On the evacuation routes, traffic jams might cause a high density of innocent persons to be available for the kill. The same could be true of the receiving or sheltering locations, which, after the decimation of our civil defense program, are not likely to have provisions for protection against infiltration of dangerous concentrations of material, or shielding from gamma radiation; these receiving locations — such as the stadiums used after Katrina — provide an attractive target of concentrated humanity for terrorists interested in killing many people at once.

Also, there would be no information on immediate wind conditions to direct a rapid evacuation into safe directions before the evacuees could reach any reasonably safer shelter than the home, school, office building, or department store where most of them were located in the first place.

It should be obvious, then, that evacuations, particularly from large cities, should be recommended only under very special circumstances, and if there is any absence of knowledge about the safety of evacuation, persons should shelter "in place" or inside the nearest available structure and stay there.

Exhibit 16 shows a picture of the traffic on the DC beltway one day when I was trying to get to work in the morning rush. Evacuation of everyone from a city in a short time would be impossible and could be disastrous.



EXHIBIT 16 — The Futility of Evacuating a Large City at Moment's Notice.

This picture was taken from my driver's side window as I drove to work in McLean, Virginia one morning on the Washington, DC, beltway. Imagine the stationary targets of auto-borne people if asked to evacuate immediately before an expected attack at unknown time, not to mention the panic, heart attacks, and other tragedies.

You do not know the size of the detonation beforehand

If you are alive and not injured after a bomb blast, you still do not know the distance it has occurred from your location. A nuclear bomb would likely light up the entire sky for many miles away, but for how many miles would depend on its TNT energy equivalent. Some facts about the velocity of blast waves and protection against blast and heat will still be presented later in this book. For example, it can be important to know that, after a short distance from ground zero, the blast wave travels in air near sea level at the speed of sound, which is about 360 meters per second; this speed decreases with altitude initially. This means it takes about 4.5 seconds to travel one mile at sea level. Rounding this out for easy memory and adequate precision in emergencies, we can remember that the blast wave takes about 5 seconds per mile to reach us at any blast survivor's distance. This tells you that after a flash of light, there could be at least seconds to duck within a closed room or within some close shelter before impact occurs. Also, the light flash of a nuclear bomb will likely remain for several seconds, during which searing heat could cause skin burns. Directly transmitted ultraviolet rays travel close to the speed of light in air (essentially instantaneously along with the bright visible light). Dashing behind shadowing materials could save much harm from severe burns. See Appendix B and the chapter by Auxier (2004) for information on the effects of nuclear weapons of various sizes. Appendix C provides brief summaries of immediate life-saving actions.

Some basic facts to remember for saving life

Planning assumptions

Based on some of the information presented above, it should appear that there is still general validity to the basic Federal Civil Defense Administration (FCDA) planning assumptions of the 1950s, as presented at the end of Appendix B:

l) The enemy will attempt to contaminate a vast area of our country with deadly radioactivity.

2) Many bombs will be dropped (or detonated), causing an overlap of fallout patterns, perhaps at different times.

3) It may be unwise for a person outside of the blast area to try to escape the fallout area, since he increases the hazard by exposing himself in an open country during the most dangerous hours. Also, when escaping upwind of one fallout pattern, he may be running head-on into a pattern from another city (detonation).

As indicated by the words in parentheses, the wording of these planning assumptions should be changed somewhat in dealing with dirty bombs or improvised nuclear explosive devices (INEDs) rather than just hydrogen bombs, but

multiple detonations are not only possible, but likely. Remember some of the attacks in Iraq. Therefore, similar planning assumptions might still be valid in the 21st century.

Some simple facts about blast protection

Some simple knowledge about blast waves from explosions could save many lives in the event of an attack, and saving lives is what this book is about. Once ingrained in the mind, some simple but important facts will remain available to a person in an emergency, without further thought, concern, or fear. For example, we all remember that if we are caught in a fire, we must stay low to avoid suffocation by carbon monoxide until we exit the building. We all remember the number 911, I think.

For one thing, particularly in the case of large explosions, particular nuclear bombs, improvised or otherwise, it is important to know that the blast wave in air will travel at a slower speed (and take about 5 seconds to travel one mile) than the blast wave in the ground (which takes only 1 second per mile); at close distances in a trench or underground, this initial blast wave would be felt as the first rumble. For a nuclear explosion in about the kiloton range of the bombs dropped on Hiroshima and Nagasaki, for example, a person with improvised shelter or basement below ground, might possibly survive the blast even as close as one mile from ground zero if the person knows some simple facts. (See table in Appendix B.) Also, even if a person is within a mile of an atomic bomb the size of those detonated over Japan, ducking for cover within a strong building and away from windows can greatly improve chances for survival. Some Japanese in well protected locations did survive at closer distances than would be indicated for total destruction. Knowing to move rapidly when an extremely bright and blinding level of light occurs, one can find some protective cover within seconds. An interesting story follows.

BLAST PROTECTION SCENARIO: A civilian huddled in a trench within a couple of miles from a nuclear bomb detonation

Theodore (Ted) Rockwell, Rickover's Technical Director in designing and building the first nuclear submarine and first civilian nuclear power plant, provides in one of his books the following dramatic example of this phenomenon (Rockwell 2003).

After receiving his bachelor and master degrees in chemical engineering at Princeton, Ted was employed in the very secret Manhattan Project at Oak Ridge in 1943 and found himself working on chemical and electromagnetic processes to provide the uranium-235 for the atomic bomb to be delivered on Hiroshima (but he was not aware of the ultimate use of the material until after the bomb was delivered). Ted's performance in the Manhattan District at Oak Ridge, for the next few years impressed Rickover so much that Ted was coaxed by Rickover to join the nuclear power development program and became a major player in Rickover's arduous quest to develop nuclear energy for national security and energy. After Ted was on his team for several years, then-captain Rickover, the legendary father of the nuclear navy, decided he would like Ted to experience a nuclear test explosion; Ted would not have such an opportunity in the nuclear power programs. I could never tell the story as well as Ted, but will abstract just enough to illustrate some points in a memorable way. (You must read his fantastic book (Rockwell 2003).)

Rickover calls Ted into his office and asks, "Ever see an atomic bomb go off, Rockwell?"

"No sir," Rockwell replies. "You want to?" Rickover asks. "Well, yeah. Sure," Rockwell replies.

At that point, the conversation was over, as Ted knew. Rickover returned to his work. Rickover was hardworking and thrifty with time, and not one to be patient with small talk. Not knowing whether Rickover would send him to an atomic test or not, Ted left the office. He later found himself with orders dispatching him on March 20, 1953, to a hot tent at Camp Desert Rock, Nevada, to get ready to experience first-hand the detonation of an atomic bomb at Yucca Flats.

(This is just a sample, from the beginnings of Ted's 2003 book, of his many stories of fascinating adventures working for Rickover, which tell much about management aspects, scientific and engineering aspects, and human aspects, of some of our most important defense projects.)

On the day of the shot, he found himself cowering in a trench with about six other civilian observers and a regiment of thousands of soldiers in full battle gear, preparing to participate in mock battle exercises in the presence of variable radiation fields. The battle plan simulated a hostile attack on Las Vegas. Many of the soldiers were veterans of major battles of World War II; they had trained and fought in the gear, including the gas masks, they wore. No protective clothing was provided for the civilian observers. The trench was only four thousand yards (a little less than three miles) from the largest nuclear bomb ever detonated in the continental United States. Ted thought to himself, "Four thousand yards! I thought the observers were always several miles away — in concrete bunkers!"

Ted, who was used to cramming activity into every minute, describes in his book many other thoughts and feelings after being aroused from sleep by reveille at 5:10 a.m., only to wait after breakfast for hours before being taken to the trench. He stood for an hour and a half in the cold, dark, slit trench, before hearing the announcement: a one-ton TNT-equivalent World War II blockbuster demonstration shot would be first detonated at the same distance from the trench for comparison with the explosion of the atomic bomb. Ted felt his heart thump in his chest. Then, after the one-ton bomb had been detonated, the announcer informed participants that the atomic bomb to be detonated next would be, "an estimated thirty-five thousand times as powerful as the one you have just witnessed." (That is, 35,000 tons, 35 kilotons (kT), 70,000,000 pounds of TNT!) This would be about TWICE the power of the bomb that destroyed Hiroshima.

Ted began to think that the announcer, "…can afford to sound calm, I thought. He's at the observation post, ten miles away. Did the clowns who calculated I'd be safe really know what they were doing? I don't see any of them here. They can't even be sure how big a bang this will be. This is really just an experiment. I'm somebody's guinea pig. Did I really volunteer for this job?" (Some of these thoughts remind me of my own, when I waited on March 1, 1952 on the deck of a Navy ship at about 50 miles from the ground zero on an Eniwetok island, for the detonation of the world's first hydrogen bomb "device," which was expected to release explosive power equivalent to about 15 megatons (15 MT, or 15 million tons, or 30 billion pounds, or 30,000,000,000 pounds of TNT!!). There were then rumors that the hydrogen in all of the air's humidity would become involved, the entire sky would be on fire, and we would all die. However, although not completely sure, I really did not believe we were in danger. I knew some of the scientists involved in the bomb design, and knew they were extremely competent and not crazy. More about my hydrogen bomb experiences is presented later.)

Ted, with his thoughts, did not even hear the countdown reach zero. He was shivering in the cold, crouched on his knees in the trench, with his face buried between his thighs, when all of a sudden an "unearthly white light began to intensify." The shadowless light seemed to come from everywhere. The color was the whitest light he had ever seen and it grew, first in silence. (At the hydrogen bomb tests, we were all warned to keep our eyes completely covered for at least 10 seconds; I suppose Ted was instructed to do the same.) Ted further describes the light and the experience in his book.

All the participants had been warned that, "…to expose yourself during this shot may be fatal. Keep your head down until the audible blast has passed." The intense light remained in silence in the early seconds. Then, Ted describes that he became a terrified participant as the solid earth beneath him and the walls of his trench turned to jelly. This was the arrival of the ground shock wave. According to instructions, Ted kept his head down, and so did the soldiers in the trench, until the boom and pressure of the shock wave traveling through the air reached the trench. (I assume that it took a bit less than 9 seconds; the shock wave takes a bit less than three seconds to travel the first mile, during which the shock wave initially travels faster than the speed of sound, 1,100 feet per second.)

After the shock wave passed, the soldiers stood up and left the trench to participate in the military exercises and observations. Ted then stood up and began to observe the effects of an atomic detonation. The rest of Ted's observations are left for the reader to glean from Ted's interesting and informative book.

Lessons to be remembered: If a large explosion lights the sky around you, hurry to improve your sheltering in some place where you can be surrounded by strong structures or solid materials. Go to an inside room with no, or minimum windows, if you are at home; or a hallway if you are in a strong office building. Sit, or lie down, duck under a strong table if available, cover your face and head with your arms and keep your eyes closed for at least ten seconds. At least get away from glass windows and do not go back to them to see what happened. This might save your life. See the further immediate actions in Appendix C.

Wright (2006, pages 270-271) describes the plans and events that led to al Qaeda's attack on the American embassy in Nairobi, Kenya, in August 1998. This was al Qaeda's first documented terrorist attack, despite bin Laden's earlier claims of successful involvement in suicide attacks. As planned, one of the two attackers, who were riding in the truck carrying two thousand pounds of TNT and other explosive ingredients, jumped out of the truck to kill the guard and raise a gate allowing the truck to get closer to the embassy. But he had left his gun in the truck and could not get the gate raised. However, as planned, he threw and detonated a stun grenade in the courtyard, before his companion set off the huge explosion in the truck. The grenade detonation was used to draw attention to persons in the embassy. Dr. Ayman Zawahiri, Osama bin Laden's partner in al Qaeda, had learned from his bombing of the Egyptian embassy in Islamabad three years before (and before he had actually joined al Qaeda with his followers), that an initial explosion brought people to the windows to see what had happened. Many were then decapitated when the real bomb went off. Despite the fact that the truck did not get as close to the embassy as planned, the toll after the truck bomb destroyed the embassy and some nearby buildings included 213 dead, 4,500 injured, and more than 150 persons blinded by the flying glass.

Lesson to remember: *Do not go near any windows, even after you think that the first blast wave has passed by.*

Some simple facts about sheltering from radiation exposure

- *If a building, house, subway levels below ground, designated or prepared shelters, or tunnels, are nearby, it is best to enter them as quickly as possible and remain in shelter until other information or assistance is available. Have your cell telephone on, and your portable radio, if they are available and work.*
- *Approximate reductions in gamma ray exposure for fallout from nuclear detonations are shown in Exhibit 17 for a variety of shielding situations above and below ground. Although Exhibit 17 shows a factor of 2 to 10 protection for a basement without a shielded roof beneath (or on) the first floor above, additional protection can be obtained by sitting on a pillow on the basement floor in a corner of the basement close to the highest adjacent ground level. Some official advice about remaining in the center of the home might be confusing; it applies only if there is no basement or other prepared shelter, and the family must seek the least area of radiation inside the home, which would be in a centralized room with no windows. Further information is given in Chapter 7.*

Soon after the September 11, 2001 attack, I wanted to know if my wife, Phyllis, had the basic knowledge for protection in case of a radiological attack. I was working away from home during the week, and I knew that very little knowledge about radiation protection likely remained among local responders from the old civil defense days. I asked her, "What would you do if you heard on the news, or from local authorities, that an RDD or nuclear bomb had just been exploded somewhere near Washington, DC?" She said, "I don't know." I said, "Knowing that a wind speed of about 10 miles per hour would suggest that as much as 15 hours might pass before the radioactive cloud might drop fallout in our area near Ocean City, Maryland, you would have plenty of time to prepare for protection. Pack your car trunk with food

and water, and any other needs, and call my cousins Arnold and Margie. Ask them if you can come over for a week or more to enjoy their company. They live about twelve floors above ground in an apartment in the Golden Sands, right at the beach. In about the center of their apartment, you would be shielded by many layers of concrete from the floors below, and many layers above from any radioactive material on the roof. Also, some of the heavier chemical agents, if also dispersed, tend to remain near the ground. Any chemical or biological agents would also tend to have been widely diluted and dispersed by the ocean and other prevailing winds. You would be entirely safe to remain in the apartment until local authorities have obtained information about the safety of leaving or evacuating." This scenario serves to illustrate how a little bit of knowledge, such as that in Exhibit 17 can be helpful to someone to take proper actions and not panic in the event of a radiological emergency (in this case, with adequate time, evacuation to a safer location). Otherwise, even a relatively low reading on a Geiger counter when the fallout arrives might result in panic.

- *Although Exhibit 17 shows only a reduction of a factor of two or less in an above-ground home, earlier civil defense research at atomic tests resulted in published designs of shelters, including those above ground, which provided additional shielding. Exhibit 18 shows an above ground shelter that I had built in the late 1950s behind my first family home, which did not have a basement. Thus, I designed an above ground shelter behind my backyard patio that included walls and a ceiling thick enough to reduce even the highest gamma intensities from a hydrogen bomb to less than one-five-thousandth of that outdoors in a wide area of fallout. My older son, Richard, who was about eight years old at the time, is shown in the Exhibit to provide a visual indication of dimensions.*
- *The shelter was built with inner and outer walls of hollow concrete block, tied together with multiple steel rods for blast strength. A one-foot gap between the inner and outer walls all around the spacious sheltered room was then filled with sand and compacted for additional gamma ray shielding. The hollow concrete blocks tied together through the sand were then filled solid with concrete. A steel-reinforced roof of about two feet thickness was constructed to shield the inside from gamma rays coming from fallout on the roof. A thick iron door was later to be installed for blast resistance, with the intention of stacking sandbags behind the door for gamma shielding of this limited area of the wall. The shelter was designed to withstand a 30 psi peak blast pressure at about 5 miles, which would protect my family from about a 20 megaton hydrogen bomb dropped in downtown Baltimore. The cost of this shelter plus some patio and walkway area was about $5,000 in 1959 dollars. Although I needed to borrow the money, I felt the cost was worthwhile to protect my family, and was prudent for someone who had recommended home shelters when employed by FCDA. More will be said about shelters later.*

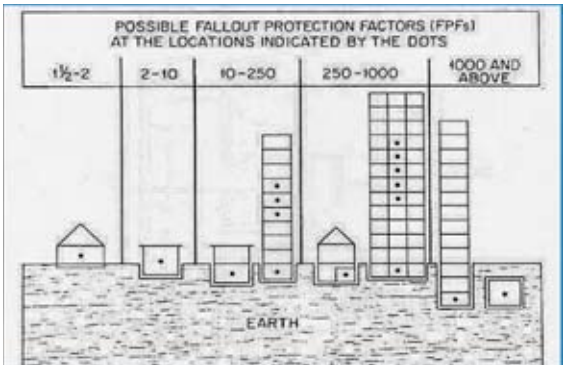


EXHIBIT 17 — Approximate Shielding Protection Factors in Different Locations Provided by the Federal Emergency Management Agency (FEMA).



EXHIBIT 18 — Shelter Built Above Ground at My Home in Baltimore County in Late 1950s to Protect My Family.

The shelter is shown after the walls were completed and faced with a more attractive brick. More concrete was yet to be poured onto the roof, so the iron rods spaced about 18 inches apart are showing. My son, Richard, is shown standing on the platform. Although some say most people cannot afford such a shelter, after two more years of graduate school and much debt, I borrowed $5,000 dollars to add this above-ground shelter beside a deck behind my $12,000 home. I drew up plans and hired a contractor, adapting a design from an FCDA publication that specified a reinforced concrete roof and two concrete block walls tied together by rods, through about one foot of sand between the block walls for additional gamma shielding. Bricks were added on the outside for appearance as well as additional shielding. This shelter was designed to withstand about 30 psi blast pressure, which would be about the blast at 5 miles from a 15 megaton hydrogen bomb. The building of such shelters, if promoted by our society as required in 1950 in Switzerland and other places, could have been subsidized initially by government for a much reduced price, with a possible return to the treasury of the general taxpayer contribution from a portion of the builders' profits. This could also be done today, with leadership from someone in high places in the government or the building industry. If homes had this kind of shelter, there would be many lives saved in the event of hurricanes and other natural disasters, even if a dirty bomb or nuclear attack never occurred. Such a national project today could reinvigorate the building industry, and put many artisans back to work.

- Today, with most all homes constructed already without shelters, it is unlikely that I can convince most readers to spend the money needed to convert an area of the home to an adequate shelter. As discussed later, in the United States, as opposed to some other nations, a shelter requirement for every home was not adopted for safety requirements. If it had been, many lives could have been saved during hurricanes or other natural disasters over the years, even if some believed that nuclear or dirty bomb attacks on the United States would never occur. However, it could be helpful to know the following rule of thumb:

  About 300 pounds of material behind each square foot of wall will reduce gamma exposure rates from fission products produced in nuclear detonations by a factor of more than 1,000. This reduction would be sufficient for protection over a number of weeks from the most intense fallout fields possible, even from a hydrogen bomb. Exhibit 19 provides a simple table giving the number of inches to attenuate fission product gamma radiation to one-fifth the unshielded intensity. The subtitle of the table shows how to estimate reductions for additional thicknesses. For the various radionuclides most likely to be used in a dirty bomb, the attenuation factor given for a fission product mixture of radionuclides would also likely serve for the single gamma energies of the dirty bomb nuclides (Brodsky 2004 i, d, a).

  Water shielding could be available in an indoor hot tub, jacuzzi, stacked cans of drinking water, or other improvised containment. Also, human tissue is about as attenuating as water. About 11 inches of water can attenuate a broad beam of gamma radiation from fission products down to one-fifth intensity. A crowd of shoppers in the bargain basement of a department store could crowd around together, groups taking turns within the crowd. Younger adults and children should remain in the middle of the crowd. There are many ways to improvise shielding, knowing data such as that in Exhibit 19.

Material	Density (pounds/cubic foot)	Thickness for 1/5th Reduction (inches)
Wood (birch, oak, maple, etc.)	40	17.5
Paper (compacted in books)	56	12
Water, or human tissue	62.4	11
Earth (loose)	75	9.3
Sand (dry)	100	7.0
Brick (common)	110	6.4
Concrete block (solid)	140	5.0

EXHIBIT 19 — Table of approximate densities, and thicknesses to reduce radiation intensities to one fifth, for available shielding materials.

If a given one-fifth thickness of concrete of 5 inches reduces the radiation to 1/5, then an additional one-fifth thickness giving a shield of 10 inches will reduce it to about 1/5x5 = 1/25, and another added thickness to give a shield of 15 inches reduces it to 1/5x25 = 1/125, and another thickness to 20 inches reduces it to 1/5x125 = 1/625 = 0.0016. After several attenuations, the energy spectrum of the photons in the gamma radiation beam remains about the same, and the multiplication of attenuations as above can be used for simple approximations. Therefore, if the fallout intensity close-in to the detonation of a 1 kiloton nuclear IND is as high as about 50 R/hour outside on the ground (Auxier 2004), then within a surrounding shield of 20 inches of concrete block, the intensity would be reduced to 0.0016 x 50 = 0.08 R/hour, or 80 mR/hour. Neglecting decay of the radioactivity, staying in such an intensity for 3 days (72 hours) would result in an exposure of 72 x 0.08 = about 6 R. Even at this high intensity location, with such shielding surrounding a person, no acute radiation effects, and little likelihood of long-term effects, would ensue.

Sheltering is advised in a Position Statement of the Health Physics Society (HPS 2004, page 2): "Sheltering should be directed if the projected effective dose (see Recommendation 5) is, or has the potential to be, greater than 10 mSv (1 rem)." However, it is unlikely that in the minutes or even hours after an attack, most persons will receive the necessary assessments or advice to make such judgments, unless they have their own personal dosimeters, perhaps other appropriate instrument, and some simple understanding of some essential facts. There are certainly not enough health physicists in the nation, or even responders, who will be available to talk with most citizens, or governments to give timely advice in the early hours, when essential protective actions must be taken by each person. More information and suggestions for radiation instruments and dosimeters to be included in emergency kits will be given in further chapters. Chapter 7 will provide more information on the construction of shelters for those interested in providing the best protection for their families at home, ahead of time. Chapter 8 provides information for the purchase of an inexpensive, light, credit-card-size, colorimetric personal radiation monitor, in a paper envelope with a simple sheet of instructions and information on at what doses significant health effects might begin to appear. This monitor (often called "dosimeter") takes little space in a pocket or purse, and meets the needs specified in the above HPS Position Statement. Some smaller and even cheaper "RADStickers, which can be stuck on wallets or purses, are also discussed in Appendix I.

Some Facts about the Inhalation or Intake of Radioactive Material

Inhalation of Fission Products Released in a Plume (or Mushroom Cloud) From a Nuclear Bomb or Radioactivity Dispersal Device (RDD)

*From calculations I have made of the internal radiation doses received from breathing mixed fission products in passing clouds of debris following an explosion or accidental release, a rule of thumb was obtained: within about a factor of about two, a **300 microcurie inhalation** of such fission products would result in a combination of internal organ doses, and a small external dose in the passing cloud, which would be about as harmful in acute effects as a **25 rem dose from external gamma radiation**, averaged over the body (Brodsky 1965b). (The 300 microcurie intake is equivalent to the intake of a person breathing at about a walking level, 17 liters per minute, for an air exposure of 1 curie-second per cubic meter. This means an exposure to 1 curie of activity per cubic meter for one second, or 0.1 curie per cubic meter for 10 seconds, and so on.) The 300 microcuries inhaled, equivalent to an aerosol exposure of 1 Ci-second per cubic meter of air, was derived to approximate an "acceptable emergency dose" (AED), using the same terminology as Cowan and Kuper (1958). However, my estimates were intended to provide a safer standard, for exposure to inhalation of mixed fission products from bomb detonations or reactor releases less than about 30 days since the incident. More recently, a formerly secret Soviet report was declassified that presents data on humans exposed to released gross fission products from an underground detonation that tends to verify my rule of thumb (Brodsky and Reeves 2009). Thus, the rule of thumb that about 300 microcuries inhaled is likely to be closer in combined effects, both short and long-term (Brodsky et al. 2001), to a whole body exposure of 25 R, and other estimates in my papers would also be much safer to use in an emergency than the earlier estimates of Cowan and Kuper.*

I made these estimates using judgments of the biological interactions of damage to the different internal organs exposed to the intakes of representative mixtures of fission products from detonation of nuclear bombs vs. time after detonation, and for various mixtures of fission products from different reactor operating times and times after removal of the reactor fuel or reactor shutdown. In the more recent paper (Brodsky et al. 2001), I re-examined my 1965 calculations with two co-authors, and confirmed the estimated bomb and reactor inventories with the latest nuclear data. For this latter publication, I also calculated the probabilities of long-term cancer deaths from such intakes, using the LNT model, and was surprised that estimates would also agree, within a factor of two, of such cancer deaths made from the more recent estimates using ICRP-60 organ cancer weighting factors. Some of the results of these two papers are summarized in my chapters in Brodsky et al. (2004).

Exhibit 20 shows a plot of the final results of estimated quantities of radioactivity inhaled that would produce acute and chronic effects approximately equivalent to a 25 R external exposure. It is noted that a horizontal line through 1 shows that the rule of thumb that 1 Ci-sec per cubic meter (an intake of 300 microcuries) holds within about a factor of 2 (0.5 to 2) within about 30 days of the release of total fission products present, either for a nuclear bomb or reactor fuel of various times of reactor operation.

Exhibit 21 provides estimates of filtering efficiencies of material held over the mouth while breathing through the mouth during cloud passage. Exhibit 22 provides estimates of amounts of single nuclides breathed in from exploding RDDs that would compare to the 1 Ci-sec per cubic meter exposure to mixed fission products less than 30 days since release.

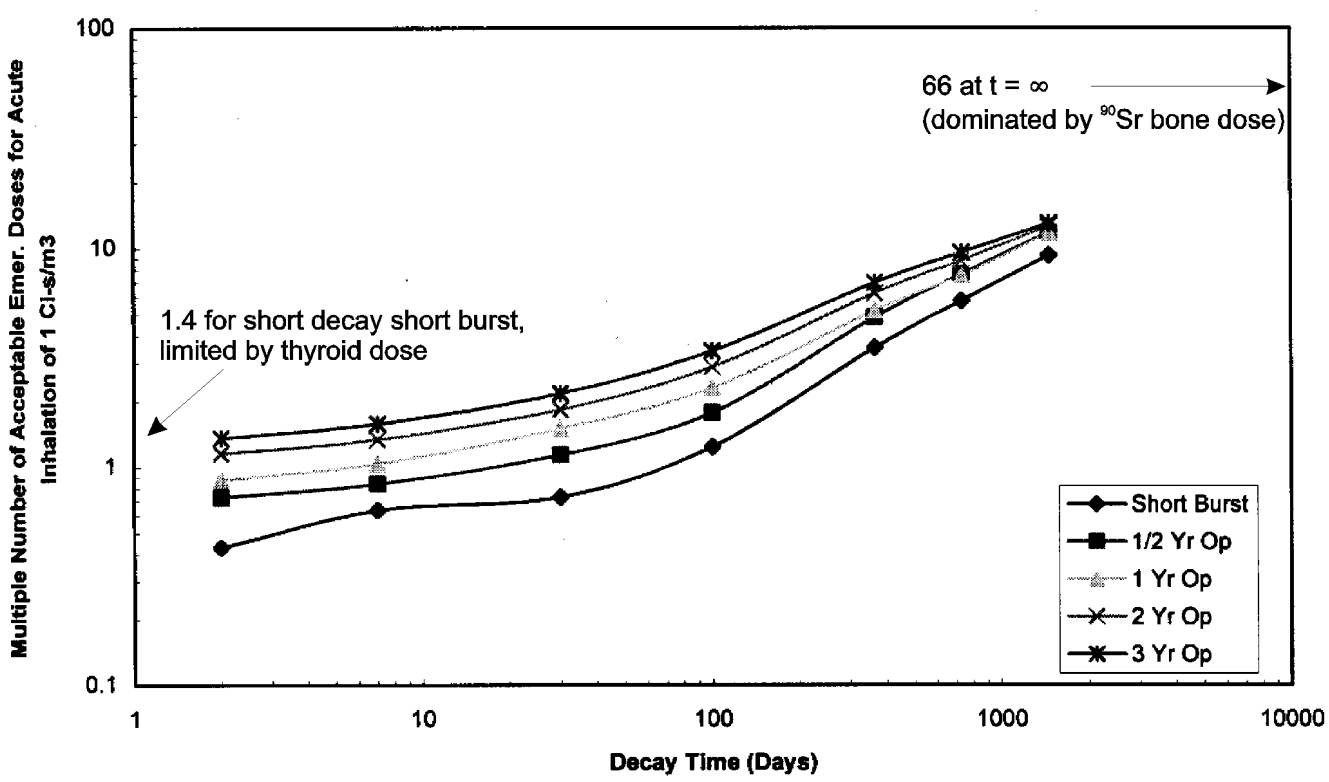


EXHIBIT 20 — Multiple number of AEDs ("acceptable emergency doses" estimated equivalent in risk to an external exposure to 25 rad of gamma radiation) for exposure to 1 curie-second per cubic meter (an inhalation of about 300 microcuries) in a cloud of fission products.

These curves have been derived for a short burst as in an atomic bomb cloud, or for several reactor operating times, and vs. time since last fission, as derived in Brodsky (1965b), checked and updated in Brodsky et al. (2001), and included in Brodsky (2004d). It is noted that a horizontal line through 1 Ci-s per m^3 on the ordinate scale is within about a factor of two of the equivalent of a 25 rad external exposure, up until about 30 days after release of the complete fission product mixture, for release of both bomb fallout as well as from gross fission product mixtures from nuclear reactor operations.

I published the original paper because the earlier paper (Cowan and Kuper 1958) made estimates of "acceptable emergency doses" for exposure to inhalation in passing clouds that I believed would cause serious harm or death, rather than being acceptable. Dr. Fred Cowan, an early President of the Health Physics Society, whom I admired,

had told me that I should not submit my 1965 paper for publication, because his group at Brookhaven National Laboratory was going to re-do their estimates and publish them. I felt, however, that I should have my own independent estimates published anyway. I am glad that I did. Dr. Cowan never did complete and publish any revisions, to my knowledge.

I do not fault Cowan and Kuper for their courageous attempt to provide emergency guidance on intakes; they needed to work with less complete radiobiological data, human and animal, than I had available in the 1960s. Their main analyses must have been done in the 1956-57 era, because their conclusions were published in one of the earliest reports of the possible effects of what were called "maximum credible accidents," in the beginning days of licensing nuclear power plants (Beck et al. 1957). (This 1957 report was an early attempt to define the worst accidents that could occur, as an exercise that could reveal the many needed safeguards to be required in licensed nuclear power plants to prevent such "maximum credible accidents.") In 1955-57, only the rare leukemias had statistically appeared in the Hiroshima-Nagasaki populations, and no solid tumors were yet observed (United Nations 1962,1977). Also, there was little information on effects of inhalation of fission products in humans, and many of the animal experiments designed to examine effects of different radionuclides deposited in different organs were still underway (Stannard 1988). Even the physiologic transfer and tissue concentration data used in the 1959-60 International Commission of Radiological Protection/National Council of Radiation Protection report on maximum permissible concentrations for worker exposure were not yet complete and published (ICRP 1960). So, Cowan and Kuper had little data on effects of radiation on humans with which to work.

I recommended, when employed by the NRC, that experiments on animals exposed to inhalation of various mixtures of fission products be carried out to test or confirm my estimates from conservatively calculated doses to individual organs. Such experiments have not been done. This is partly because it is so difficult to accurately expose animals to the inhalation of respirable aerosols containing even one or two nuclides at a time and determine the spectrum of internal organ doses (Stannard 1980). Of course, it would not be acceptable to conduct such experiments on humans. So, I believed that my estimates, not always recognized or understood, were likely the best data around for judging possible effects of internal doses from breathing in a passing cloud containing fission products. The declassified Russian data on human exposures to inhalation in a plume of fission products appears to confirm the validity of my rules of thumb, and the Acceptable Emergency Doses (AEDs) in Exhibit 20, that are estimated to produce signs and symptoms, and health effects, similar to a whole body exposure of 25 R (Brodsky 1965b; Brodsky et al. 2001; Brodsky and Reeves 2009).

A summary of the human data confirming the estimates of effects from inhaling about 300 microcuries of fission products up to 30 days since release.

I will now summarize some of the information in the article on this subject in HEALTH PHYSICS (Brodsky and Reeves 2009). Some of the details about the human exposures are abstracted here from the declassified report for the interested reader.

On March 4, 2008, I received an e-mail from Glen Reeves, M.D., forwarding preliminary copies, approved for publication, but not yet printed, of two papers translated from Russian; these papers review previously classified radiation exposure and clinical data on humans and animals exposed to gross fission products released from Soviet nuclear tests. One paper (Gusev et al. 2008) included effects of exposure on persons exposed in May 1974 to inhalation of fission products and a limited external dose from a radioactive plume emitted from an underground nuclear test. The report by Gusev et al. provided the first information I had seen on humans exposed to mixed fission product plumes emitted from either nuclear explosions or reactor accidents in which internal and external radiation exposures were determined for human subjects, as well as their clinical signs and symptoms as related to degrees of expression of the radiation syndrome. Many of the symptoms of Exhibit 7 for persons receiving up

to several gray (Gy) of radiation, and associated blood element changes, were observed in this group, although no deaths were reported.

In the May 1974 exposure, fission products from a 150 kiloton Soviet bomb, detonated at 450 meters below ground level, were vented in a low-level passing cloud that exposed human subjects (I presume unintentionally). A group of 162 individuals located at 9 to 10 kilometers from the explosion epicenter received a range of exposures that resulted in radiation sickness among many of them. Those in the center of the cloud numbered 127; another 35 others were about 2.5 kilometers off to the side. They were divided into three groups for study; their doses, signs, and symptoms are presented in the report (Gusev et al. 2008). The short-term exposures of these test participants to this low-lying radioactive cloud resulted in external gamma irradiation of from 170 to 260 mGy (17.0 to 26.0 rad), and internal contamination from 10-20 minute-old radioactive fission products in the 296 to 740 MBq (8 to 20 mCi) range. Some data on the radionuclide composition is given in the report (Gusev et al. 2008).

Clinical manifestations varied, but were accompanied by symptoms of the acute radiation syndrome, including for many subjects hematological changes and central nervous system damage. The authors of the report concluded that, from their literature review, the appearance of an obvious initial reaction in a majority (80%) of those in the center of the cloud (127 persons) would indicate that the integrated biological effect of the combined radiation corresponded to an external radiation dose equivalent of about 1.00 Gy (100 rad).

The report also recognized that, for these individuals exposed in a passing cloud of fresh fission products, the internal dose was a significant contributor to the clinical effects, exceeding the effects of the external doses of up to 26 rad in their overall synergy.

The external doses of 17 to 20 rad, concurrent with inhaled fission product activity in the 8 to 20 mCi range, which resulted in the symptoms of the Soviet participants, may be compared with the external exposure and intake of about 300 microcuries (0.3 mCi or 11 megabecquerels (11MBq) that results from my rule of thumb that an "Acceptable Emergency Dose (AED" to a fission product cloud of less than 30 days since release, for a biological insult estimated to be roughly equivalent to that of a 25 R of external exposure, is about 1 Ci-sec per cubic meter (Brodsky 1965; Brodsky et al. 2001). The external exposure from 1 Ci-sec per cubic meter in my papers is only 0.28 R, but it must be recognized from the paper by Gusev et al. that much of the external dose of these Soviet participants was received by remaining for a short time in the deposited fallout as well as in the passing cloud. However, the up to 26 rad of external radiation received by the participants did not account for their signs of radiation sickness. Thus, it might be assumed that the up to 20 mCi deposited in their bodies must have produced, by the combined internal organ exposures, the equivalent in harm of at least an external dose of about 75 rad.

My estimate of an AED intake of 0.3 mCi as equivalent to 25 R (perhaps 20 rad deep dose) externally received, would mean that the up to 20 mCi intake of the Soviet participants would result in an equivalent dose of up to about (20/0.3) x 20 = about 1,300 rad equivalent combined internal dose (e.g., 1,300 rem effective dose), making the up to 26 rad external dose relatively insignificant. (I used 20 rad here assuming an external exposure of 25 R to gross fission product gamma radiation would result in an average absorbed body dose of about 20 rad.) This internal dose would be spread over time in different ways for different internal organs and could be expected to result in some of the radiation sickness observed; there were no other animal or human experiments with which to judge these effects exactly at the times I made the estimates in my earlier papers.

More details and conclusions from the Gusev et al. (2008) report are summarized and discussed in Brodsky and Reeves (2009).

Conclusion: It seems, therefore, that my selection of parameters and acceptable organ doses in combination, to be equivalent to a 25 R external exposure (combined with the small 0.28 R external exposure) in the passing cloud for an intake of 1 Ci-sec per cubic meter, were adequately on the safe side for use in emergency assessments or

triage. On the other hand, the AED intakes recommended in the paper by Cowan and Kuper (1958) would be about an order of magnitude higher than mine, which would put them in the lethal range, rather than the 25 rem equivalent range that they intended. In consideration of the effects on the Soviet participants who had up to 20 mCi deposited internally, perhaps the NCRP should take another look at the adoption of the Cowan and Kuper recommendations in NCRP Report 29 (NCRP 1962).

Bottom Line*: A serious internal dose** *from breathing concentrations of radioactive material in air, or ingesting them in food if reasonable caution is taken to wash food and use mostly sealed containers, is* ***very unlikely for the vast majority of persons who will find themselves in measurable concentrations of fallout! *The internal dose from intakes of radioactive material will be negligible compared to external exposures,* ***unless*** *you are caught outside exactly in the path of a passing cloud containing radioactivity, as were the Soviet subjects. If you are caught outdoors in the passing cloud of fumes or smoke from a bomb, or are caught in the mushroom cloud from a nuclear bomb (at a high elevation on a mountain top), which is unlikely and almost impossible if you go indoors soon enough,* ***only then*** *could your internal dose be high compared to the external dose. This is confirmed by my examination of dose reconstructions of my own and my colleagues of hundreds of cases of participants in the nuclear tests in Nevada and in the Pacific.*

If indoors, the smaller micron or submicron size particles that would produce most internal dose if inhaled would pass with the wind around the home or structure you are in, without the time that would be required for indoor concentrations to approach equilibrium with those in the passing cloud. A cloud or puff of smoke from an explosion will ordinarily pass by within a minute or two, not long enough for the radioactive concentration to equilibrate into the structure, particularly if windows and doors are closed, and absolutely if openings are sealed shut and intake ventilation is shut down. *Therefore,* ***DO NOT*** *go to a hospital or medical clinic to check if you are radioactive, unless you are seriously injured. Just dust off and wash off and check yourself with any radiation instruments available, or with your SIRAD card (see Chapter 8). The color-changing SIRAD dose indicator will likely begin to change color if there has been an amount of contamination on you that likely would be harmful. This is so because contamination in contact with your clothes or body would give beta radiation surface dose rates to skin or the SIRAD card that would be many times the prevailing external dose rates from gamma radiation (see Exhibit 23).*

Even the Marshallese islanders, who were outside in the fallout from the BRAVO Shot H-Bomb of Operation CASTLE in 1954 and did receive serious skin burns from the fallout, did not die from those injuries, and would not have received them if they had been indoors. After the BRAVO and ROMEO H bombs of 1954, I was dropped off onto an island where the external exposure rate was 30,000 mR per hour, ran and picked up my neutron spectrometers, jumped back onto a helicopter after about 5 minutes, found 10,000 mR per hour on my booties that picked up radioactive contamination from the island, and de-robed and showered over 20 minutes later on an aircraft carrier deck. My external exposure average over the body was less than 3 rem, no significant contamination remained on the exposed parts of my skin, and no significant internal dose was received from any radioactive materials resuspended by the winds. I am still healthy 56 years later.

So, again, ***PLEASE, do not run to a hospital, inundate the staff, and destroy limited medical resources in order to check or remove contamination. Wash and dust off or remove clothing wherever you are!*** *Do it immediately if you suspect you have been contaminated; do not wait for any responders in the early minutes, or even hours, after an attack.* ***I am 99.9% sure you will be safe****; consider my own experiences and evaluations of hundreds of other cases. Hospitals are prepared in the early days after an attack* ***only*** *to decontaminate as necessary those unfortunate individuals who are* seriously injured by the *bomb blast, removing perhaps some radioactive contamination on their clothing or bodies before or as they are being treated (Bushberg and Miller 2004). The ordinary precautions used in hospitals (surgical masks, cleanliness, etc.) are sufficient to protect medical staff against all of the patients who might arrive with some radioactive contamination, and they are prepared to clean skin and debride wounds in the same ways that they would for any other contamination or medical procedure. This statement is confirmed by my own personal experience.*

Something for those who want to know some of the math, or scientists working on emergency response: Converting the 300 microcurie value given above to atoms decaying per minute, we multiply 300 times the easily remembered number of 2.22 million disintegrations per minute per microcurie, to get:

300 x 2,220,000 = 667,000,000 dis. per min. — a large number!!

Many scientists who have been experienced in managing radiation protection programs under peacetime conditions will not believe immediately that this can be considered an "acceptable emergency dose" for internal radiation exposure. That is because peacetime standards are based on inhalation of concentrations for a lifetime — 40 hours per week for an assumed 50 years for workers, continuously for members of the public. Most radiation experts under retirement age who are now involved in emergency planning have not experienced emergency levels in short-term exposures, either from major accidents in plants processing large amounts of radioactive material for the growing nuclear industry in the 1970s or earlier, or from weapons test fallout from above-ground testing, which was banned in 1963.

For example, take the concentration of a relatively insoluble compound of cerium-141, a typical fission product of biological significance, which may according to regulations be inhaled by a worker for a lifetime of work: 2 x 10^{-7} microcuries per cubic centimeter of air breathed during work (Brodsky 1992, page 136). Cerium-141 (symbolized Ce-141) has a half-life of 32 days. The amount of Ce-141 inhaled in a short period of time to give 15 rem to the organ receiving the maximum dose is about 706 microcuries, from the same referenced table. (Note that in comparison of the 300 microcuries approximating an AED for mixed fission products, the 706 microcuries gives a **maximum** organ dose, whereas the 300 microcuries for fission products is estimated to give an **equivalent dose** of Cerium-141, equivalent in inducing about the level of acute and long-term biological changes from the combined exposure of all body organs, as would be induced by a 25 rem mean whole body dose from external gamma radiation.) Also, Ce-141 is seen in the referenced table to be a nuclide having about the same radiotoxicity as a fission product mixture just released from a nuclear explosion, in terms of the approximate maximum internal organ dose received. This reference also shows that the permissible concentration of Ce-141 over time has not changed significantly between international recommendations.

The amount of air breathed in the workplace during an assumed 50-year career in the same job would be about 9.6 cubic meters per day, or 9.6 x 10^{6} cc/day, times 365 days per years, times 50 years, which is:

9.6 x 10^{6} x 365 x 50 = 1.75 x 10^{11} cubic centimeters of air breathed in 50 years

This is also a big number! Multiplying the amount of air breathed by the maximum permissible concentration for the work area, the number of microcuries that could be breathed in 50 years (if any worker should stay so long on a job in such a constant concentration) would be:

1.75 x 10^{11} cubic centimeters x 2 x 10^{-7} microcuries/cc = 35,000 microcuries.

Compared to this number, an intake of 706 microcuries in one or two minutes to give 15 rem does not sound like so much. Thus, we need in an emergency to place numbers in perspective, and not cause panic because we measure radioactivity intakes that seem very high compared to those we would allow on a daily basis in peacetime activities in order to control long-term worker, or public, exposures.

I am not suggesting that anyone should go out of the way to inhale such an amount of radioactive material. We should minimize such exposures when we can. However, in a terrorist attack deliberately designed to release radioactive material to the environment, we will not have a choice to maintain radioactive contamination to the extremely low levels we require in peacetime. I just want to provide a perspective so that **nobody will panic** if an intake is well below, say, six hundred million disintegrations per minute, which is 10 million Bequerels, or about 300 microcuries, in round numbers. But, how would you know how much was inhaled?

Protection against inhalation if outdoors

If someone wore a four-folded (sixteen cloth layered) handkerchief held over the mouth while breathing through the mouth in a radioactive atmosphere, no more than about 6 percent of the radioactivity would get through the handkerchief and deposit in the deep lungs. Exhibit 21 presents some filtration efficiencies of readily available materials for a 2.1 micron mass median diameter aerosol, with 95% of the particles between 1.0 and 5.0 microns (an aerosol size about that which would be absorbed in the deep lung and result in the highest effective internal dose). These data are summarized from measurements of Phillips et al. (1958), as abstracted in Brodsky (2004d, page 765):

Man's cotton handkerchief, 16 layers (four folds)	94.2 %
Toilet paper (3 layers)	91.4 %
Man's cotton handkerchief, 8 layers	88.9 %
Man's cotton handkerchief, crumpled	88.1 %
Bath towel, 2 layers	85.1 %

EXHIBIT 21 — Percentages of airborne radioactive material of most harmful particle size that might be filtered out when breathing in by mouth through commonly available materials, as measured by Phillips et al. (1958).

Obviously, the percentages would differ from those above for different materials and different aerosol compositions. However, the potential to markedly reduce intakes by such quick action is evident. Also, it is relatively easy for a person with healthy lungs to take deep breaths through the mouth while the mouth is covered by these materials. Try it. Usually a single cloud of material from a detonation would pass by at the most concentrated regions of the cloud within a few minutes, during which a person could often find indoor shelter from such a cloud.

Checking for internal contamination

If you have already purchased a calibrated, sensitive, radiation instrument with a Geiger counter as a probe, you may best check yourself and others in your family or group for contamination, rather than wait for some other scientist or responder, who might not come by to help for hours or days. If you do purchase a radiation instrument, the instructions that come with it will likely be sufficient for you to understand its use, but it would be better yet to seek some training (see, e.g., the Health Physics Society website). If you do not have such a counter, you might, when it is safe to travel, go to the radiation safety office of a university, research laboratory, industrial laboratory, or other site that uses radioactive material in research or commerce. Know in advance where they are. Particularly know your civil defense, emergency operations, public health, and homeland security agencies in your local community or county, and where they have prepared facilities for checking you and possibly helping with decontamination. In any case, unless special facilities are known to be set up at a local hospital or medical center and you are advised to go there, **do not inundate ordinary hospital facilities** with requests for decontamination, unless you are seriously injured. You can simply wash in the normal ways, and know from the information in this book that you will most likely be all right.

In general, before using a Geiger counter or other radiation instrument, protect it with Saran wrap, a thin plastic bag, or some other clear and removable material that can removed if the instrument might possibly touch a contaminated surface.

Checking a handkerchief or mask: After the radioactive cloud has passed, the beta count rate on the surface of the handkerchief can be checked with the open window about equal to or larger than the mouth breathing area. Many such Geiger counters might be off scale and not be able to read more than about 150,000 counts per minute. In such a case, a less sensitive instrument would be needed or a known amount of attenuation would need to be used. However, for an appropriate measuring instrument, such high readings would need to be confirmed by scientists specializing in such measurements. Such a high reading would be unlikely for the vast majority of those exposed to a dirty or nuclear bomb. The vast majority of the public could be screened and released from concern by readings obtained on Geiger counters with sufficiently thin windows.

CAUTION: A CD V-700 instrument, the one distributed in large quantities beginning in the 1950s, which are still often available, has a Geiger counter probe with an open window that will admit high-energy betas but not low-energy betas and alpha particles. Moreover, the open window of most of these older instruments with cylindrical Geiger tubes will detect beta emission from nuclear bomb fission products, but not from some of the other single nuclides that might be used in "dirty bombs." The window thickness ranges from about 50 to 100 mg/cm^2 (which would correspond to a thickness of range of 0.05 to 0.1 cm in water, human soft tissue, or any other material with density closed to 1 gram per cc). The full scale reading on the highest scale of the CD V-700 is labeled 50 mR/hr, corresponding to a count-rate of only 30,000 counts per minute, when the scale values are multiplied by 100 for the switch turned to the highest scale. The CD V-700 open window thus has a glass wall thickness that will block out many of the lower energy betas associated with nuclides other than some of those in a fission product mixture from a nuclear bomb.

Therefore, a modern instrument with a thin window of thickness less than about 2 mg/cm^2 that will let both lower energy beta particles, and some alpha particles when held very close to a contaminated surface, penetrate into the Geiger tube would be best for contamination monitoring. Also, even with the thinner windows, the open window should be held close to the surface being monitored to prevent too much air absorption. The 0.006 **μ**Ci technetium-99 source that came with my SE2 instrument (SE International, Inc., listed in Appendix F) gave a reading of about 1400 counts per minute, and about 0.5 mR/hour (not an actual gamma exposure rate reading) when switched to the scale that would be used to measure gamma intensity, when held about 2 millimeters from the surface of the counter window. The beta emission of technetium-99 occurs for 100% of the transformations (ICRP 1983). Therefore, the beta emission rate of the 0.006 **μ**Ci check source is about 0.006 x 2.22 x 10^6 = 13,320 betas per minute. The efficiency of detecting this source, of narrow diameter compared to the open window, is 1400/13320 = 0.105, which is 10.5%. When a light cardboard file folder (front and back) was placed between the technetium source and the thin window of the counter, almost no counts were obtained. Therefore, for a beta emitter of low energy (technetium-99 emits beta rays of only 0.101 average, and about 0.27 MeV maximum, energy) it is important to have a window thickness known to admit the beta rays from the nuclides of interest.

If we assume that the efficiency of a contamination counter is only 10 percent when the window of the counter is placed about 2 millimeters from a handkerchief contaminated with 300 **μ**Ci of fission products, the beta particles entering the counter would yield about 300 **μ**Ci x 2.2 x 10^6 (assumed emissions per minute per **μ**Ci) x 0.1 = 66,000,000 (66 million) beta particles counts per minute. If anywhere near this number of betas would enter a Geiger tube per minute, it would likely overload the counter to where the readings would not be reliable.

Thus, in general, for rapid assessment by any member of the public using an available instrument, let us for example place the **decision level** to receive further examination for internal contamination at the much lower value of **30,000 counts per minute** on the handkerchief or mask used to prevent inhalation, as a very safe **rule of thumb**. Below 30,000 counts per minute on a handkerchief or mask worn by someone during cloud passage, it would be certain that even those in the vicinity without a mask would not have been seriously exposed. Even for the most radiotoxic alpha emitters such as plutonium-239 and americium-241, nasal swabs that were analyzed

in our radiochemistry laboratory to contain up to **100,000 alpha counts per minute** (sometimes more) were obtained from patients who survived their accidental exposures for many years (Brodsky and Wald 2004). They could wait until much later for confirmation of their actual intakes.

Conclusions: *Any on-scale reading of **less than 30,000 counts per minute** of beta, or alpha, radioactivity from a handkerchief, or a nasal smear, with a Geiger counter having a thin open window of about 2 mg/cm^2 **should not cause concern about internal exposures**. Simple cleaning of nostrils and washing the body with soap and water, taking care not to inhale while swabbing the nose or removing contaminated clothing, will ensure that **significant internal exposure will not occur. Of course, any contaminated Q tips or clothing should be placed in bags and saved at a distance where persons will not receive measurable exposure rates.** In any case, there will be no reasons to panic.*

NOTE: Information in this book provides only the simplest, but most urgently needed, procedures for triage of populations of many persons exposed to the possible intake of measurable amounts of radiation, so that in the first hours after an attack the many exposed persons who will NOT be seriously affected can be triaged and comforted for release. Detailed scientific and medical procedures for more accurately assessing actual radiation doses in the more advanced practice of radiation medicine and health physics will not be available for many days after an attack and not for many persons. It is important to very early determine the masses who will not need to be held for treatment by later specialists.

NCRP (2009b) has recently published an excellent document for specialists in radiation medicine and radiation health physics that updates the data, information, and methods for assessing and removing both external and internal contamination for the very small percentage of persons who will need followup to reduce exposures. Although the copious information in the NCRP document is for use of the scientists and physicians expert in this subject, some readers of this book might benefit from this resource.

Radionuclide	Inhalation for Max. Organ Dose of 25 rem (ICRP-II methods) (μCi)	Inhalation to Give Effective Dose of 25 rem (Eckerman 2004, except for mixed fission products) (μCi)
Mixed fission products	Variable as mix changes	About 300 for long-term effects*
Cobalt-60	37	200
Strontium-Ytrium-90	1.1	40
Iodine-125	11	500
Iodine-131	20	350
Cesium-Barium-137	50	180
Tantalum-182	84	700
Iridium-192	120	1,040
Gold-198	890	6,800
Radium-226 + daughters	0.025	0.7
Polonium-210	0.84	1.6
Plutonium-238	0.12	0.061
Plutonium-239	0.003	0.057
Americium-241	0.013	0.069

*As estimated from Brodsky et al. (2001). The remaining values in this column have been translated from SI units from Eckerman (2004). These values are lower (less intake here is estimated to result in 25 rem equivalent dose) than in a draft report of the NCRP, on the web for comment but not for reference, March 9, 2008.

EXHIBIT 22 — Table of activities to deliver 25 rem to the maximum dosed organ by conservative ICRP-II calculations, and the activities to deliver 25 rem effective doses by recent ICRP calculations.

The third column values have been weighted to be equivalent in long-term cancer risks to a 25 rem external gamma dose. Caution: The values in each column of the table have been selected for the physico-chemical form of the nuclide that would give the highest respective dose. More careful evaluations of actual dose would need to be made for each person over a longer period of time than that for urgent emergency actions by the individual. That is why maximum doses have been used to perform triage judgments that would be on the "safe" side. Also, it should be noted that the activities in the third column are not quite in relative order to those in the second column; this is due to the fact that the activities in the third column are calculated from doses that use different weighting factors to multiply specific organ doses for each nuclide, as appropriate to estimating effective doses that are related to **long-term** effects. **NOTE**: The next Exhibit 23 shows that alpha-beta-gamma emitting radium and daughters, and all of the beta-emitting nuclides except strontium-90, can be detected at a level of about 100 microcuries in the lung, in the presence of natural background radiation (but not in heavily fallout contaminated areas) with an ordinary Geiger counter survey meter placed within about 10 cm of the chest soon after inhalation. Inhalation of strontium-90 or the alpha-emitting plutonium or americium nuclides could be detected at any harmful levels from nose swabs held near the "open window" of an alpha-beta detecting probe, as indicated previously.

Measurements of Gamma Radiation for Rapid Triage of Possibly Contaminated Persons

If a handkerchief or mask has not been used during suspected inhalation of radioactive material, and perhaps in any case to confirm absence of any serious internal exposure, Exhibits 22 and 23 show another way to assess the approximate level of internal exposure of a person exposed to a cloud of radioactive material; this is accomplished by measuring the gamma or x-ray exposure rate near the chest, in mR per hour. For just a rough measurement but sensitive indication, place a sensitive Geiger counter (Johnson 2004d) close to the chest after removal of any

possibly contaminated clothing and washing of skin, perhaps within 20 cm (one-fifth of one meter) from the approximate center of each lung within the body at the level of a person's chest. (More accurate field measurements require corrections for thickness of the chest wall and many other calibration considerations, which have been derived by some health physicists for emergency use. However, health physicists or other scientists with this capability are rare among the population and would not likely be available in the immediate post-attack period when responders or citizens will need to use the simpler recommendations in this book.)

More accurate measurements can also be made after several days by scientists having the proper equipment in specialized laboratories or medical centers, as in the cases discussed in Brodsky and Wald (2004) and references of that chapter. However, these specialized centers are even rarer than the proximities of health physicists who can make more accurate field measurements. For the necessary early evaluations to ensure most citizens they are not at risk, or selecting those individuals who should be followed further later when appropriate facilities are available, only conservative procedures for such assurance are suggested here. The suggestions in this book are intended mainly for the rapid triage of the vast majority of individuals who might be concerned but who will not be at significant risk.

Any portable Geiger counters, proportional counters, or other instruments used to make field measurements should be covered with Saran wrap or a plastic bag to avoid contaminating the instrument. Exhibit 23 provides some data on exposure rates at one meter from typical single sources, and approximately from early fission product mixtures, that might reside in the lung a few minutes after inhalation. Readings at 20 cm would be about 25 times (5-squared times) those at one meter. Readings at 10 cm would be about 100 times those at 1 meter; however, this estimate is not accurate because at close distances the spread of contamination throughout the lung no longer approximates a "point source." However, these rules of thumb must suffice in the immediate emergency period when specialists with special instruments will not be available.

If any gamma radiation can be detected at one meter, then the external gamma exposure rates are calculated as if the radioactive material is distributed through the lungs as "point sources," such that differences in distance within the lung are deemed to be small compared to the distance between points of the material within the lung and a measuring device at one meter. That is, the sizes of the lung and the thyroid are relatively small enough compared to one meter, so that the exposure rates in the table for one meter can be used to estimate intakes for emergency purposes. Exhibit 23 also provides data on the skin dose rates from contamination of selected nuclides; persons exposed in the open to passing clouds of radioactive material would most likely also have measurable contamination levels on their open skin surfaces.

Radionuclide	**Half-life**	**Point source exposure rate (gamma or x ray) (mR per hour per mCi at one meter)**	**Skin dose rate (rad per hour, per microcurie per square centimeter)**
Mixed fission products	**Variable, 0.1 in 7xtime**	**About 0.33 early on**	**Use 9 for safety [d]**
Cobalt-60	5.26 years (1,900 days)	1.3	4.24
Strontium-Ytrium-90	29.12 years (10,100 days)	0.0015 [a]	15.8
Iodine-125	60.25 days	1.3 (less air absorb'n)	Negligible
Iodine-131	8.08 days	0.25 [b]	1.54
Cesium-Barium-137	30.0 years (11,000 days)	0.32	7.18
Tantalum-182	115 days	0.78	5.53 [c]
Iridium-192	74.2 days	0.40	5.89 [c]
Gold-198	2.7 days	0.24	13.0 [c]
Radium-126 + daughters	1,602 years (590,000 days)	1.0	0.095 [c]
Plutonium-238	87.74 years (33,000 days)	Low x rays[e]	0 (mainly alpha emitter)
Plutonium-239	24,065 years (1.9 x 10^6 da.)	Low x rays[e]	0 (mainly alpha emitter)

[a]This approximate value for strontium-90 in equilibrium with its daughter is calculated under assumptions of x-ray production by the beta rays as discussed in Brodsky (2004i, pages 680-681). It is dependent on the material surrounding the nuclide. The exposure rate from the pure beta emitter phosphorus-32 would be of the same order of magnitude.

[b]From Table 1 in Brodsky (1992). Isotopes iodine-133 and 135 in an effluent often contribute additional emissions.

[c]Obtained from the iridium-192 value by multiplying it by the ratio of the respective nuclide beta-and-electron equilibrium dose constant to that of iridium-192, as given in Weber et al. (1989). Additional skin beta exposure from radium could be added for whatever daughters are in equilibrium, but radium is not deemed a likely candidate for dirty bombs, and moreover the volatile daughters are likely to separate from the radium if it is involved in a detonation.

[d]See Barss and Weitz (2006) for detailed information on calculating beta doses to skin from material on the ground. Barss (2000) provides information on skin beta doses vs. time for a variety of mixed fission products as determined from a number of nuclear detonations.

[e]These plutonium nuclides are often in mixtures that contain some of the gamma emission of americium-241 and beta emitter of other isotopes. The chapter by Brodsky and Wald (2004) gives scenarios of workers exposed to various mixtures in which the ratios of isotopes needed to be determined in order to better assess internal doses.

EXHIBIT 23 — Table of point source exposure rates at one meter and skin doses per unit skin concentration for some nuclides likely to be used in RDDs.

The radiation intensities measured at one meter (about arm's length) from material inhaled into the lung, within a few hours of inhalation, will be less than the point source measurements given in the above table, mainly because of the attenuation by interactions of some of the gamma or x radiation with tissues of the lung and chest before the gammas can escape. However, as mentioned above, scientists who could more accurately assess lung depositions would be available only hours or days after the initial emergency period. However, great accuracy is not really called for in emergency situations, where fast answers regarding whether someone is in danger, or not, or required. Few people will by chance be near the borderline during any realistic triage. Many will need to be rapidly monitored.

In checking for internal lung radioactivity, it would be best to measure the gamma radiation coming from the person's chest at arm's length, facing both the back and the front, then taking an average. If one measurement is much higher than the other, check for surface skin contamination that must be washed off, and try again. If skin contamination is not indicated, by close measurements of beta activity with an open window counter, for example, or by similar readings from front and back when measuring gamma radiation only, then it would be sufficiently conservative to multiply the exposure rate in mR per hour at one meter by 2, and then compare the number with the point source exposure rates in **Exhibit 23** to assess whether the activity in the lung is much less, or close to or greater than, the number in **Exhibit 22** that might indicate a significant internal radiation dose. If no indication of internal body contamination is indicated by the one meter measurement, then a measurement close to the chest (or within 2 centimeters) should be made. If it is confirmed by Geiger counter open window readings around the body, or absorption tests with millimeter slabs of paper, that external skin contamination is not affecting the readings, and the closer measurement still reveals **less than about 0.2 mR per hour above background**, then the person may be comforted by saying that **no serious internal exposure is likely**.

If there is time and a one-liter (or one quart) plastic milk bottle and a small but measurable sample of contamination is available, measurements at one meter with the bare contamination sample (perhaps some dust or salt), and the sample dissolved or dispersed within a water-filled bottle, can provide a reasonable correction for lung attenuation of the gamma radiation from most of the likely nuclides to be use in terrorist attacks.

The following example should make the use of Exhibits 22 and 23 clearer.

Inhalation of Iodine-131: Let's assume that nobody with a gamma spectrometer is available soon after an exposure incident to identify the radionuclide involved (very likely).

First, suppose after removing any clothing found to be contaminated, and washing off any skin contamination, a reading close to the chest at about 20 cm from the average point in the thyroid is assumed to be about 0.1 mR per hour above background inside an area shielded from external radiation to read about 0.03 mR per hour background. The total reading would hover about 0.13 mR per hour in the area shielded from outside fallout radiation. The thyroid is a tiny organ near the front of the neck that would have absorbed much of the inhaled iodine by several hours after exposure, but would not attenuate the gamma radiation very much. From Exhibit 23, we find that I-131 gamma emissions at one meter (100 cm) would give an exposure rate of 0.25 mR/hour per millicurie (mCi). Thus, at 20 cm from the thyroid (about two-thirds of a foot), without any tissue attenuation, the exposure rate for 1 mCi would be (100 cm/20 cm)(100 cm/20 cm) x 0.25 = 6.25 mR per hour per mCi. Therefore, a reading of 0.1 mR per hour above background at 20 cm would mean the estimated thyroid content would be (0.1/6.25) = 0.016 mCi. From Exhibit 22, an intake of 0.02 mCi would give a dose of about 25 rem to the average male thyroid. Also, inhalation of 350 μCi (0.35 mCi), for which perhaps 70 μCi would on the average remain in the thyroid after several hours (ICRP 1960), would give an effective dose of 25 rem. Therefore, a measurement of 0.1 mR/hour at 20 cm would indicate that 0.016 mCi was deposited in the thyroid (taken a few hours after exposure), giving an **effective** dose of (0.016/0.07)(25) = 5.7 rem. Although, according to Exhibit 22 the **absorbed** dose to the thyroid itself from inhalation of 0.016 mCi would be about 20 rem, this is still far below the doses given for thyroid ablation or cancer therapy. Thus, it can be seen that external monitoring of the thyroid is sensitive enough to detect any doses that would result in significant harm. (Over 700 concerned persons from the public were examined in a sensitive whole body counter after the Three Mile Island Accident and none had any measurable amount of iodine or any other radioactive material in the body.) (In diagnosing persons in nuclear medicine departments of a hospital, a more accurate assessment of thyroid intake of iodine-131 would be made with special calibrations with known quantities of iodine in a plastic phantom that mimics the size of the thyroid and surrounding neck tissues.)

Note: This discussion of iodine-131 has been kept simple. In short times after an emission from fission products, the isotopes iodine-133 and 135 will also contribute some internal doses. However, in the context of immediate actions after an attack, these contributions would be minor in the required overall assessments to avoid panic. References on the Windscale accident and others will reveal the contributions of these additional isotopes.

Protection with potassium iodide (KI): Large quantities of KI pills have been stored both for nuclear power accidents (which are unlikely to occur) and for homeland security. However, they have not been distributed or purchased by the public in large quantities. Although it is unlikely they would be needed, they must be taken at the earliest times after inhalation of radioactive iodine to be effective, at least before three hours post intake. It is unlikely that it would be wise to race to a drugstore to obtain some in the event of such an exposure. Some years ago, Dr. Rosalyn Yalow, the nuclear physicist who was awarded the Nobel Prize in Medicine for developing radioimmunoassays for disease diagnosis or medical research, requested that I help her organize a seminar to discuss the distribution of KI to the public. At the seminar, she gave reasons why she opposed KI distribution, fearing some risks of improper and ineffective uses. Dr. John Auxier, a prominent scientist and Chair of Homeland Security for the HPS in 2004, studied the questions and concluded that efforts to distribute KI to the public were unnecessary and ineffective, considering the improbability of serious exposures to radioactive iodines compared to other risks of terrorist attacks that require attention. Yet, some at the Nuclear Regulatory Commission have advocated its distribution, and that has occurred. *So, the need for the pills is still somewhat controversial. Yet, if you would feel better about taking some action to reduce possible radioactive iodine exposure, you can obtain KI in the proper dose packages from Shane Connor at Connor (2006, 2008).*

Use of tincture of iodine solutions: Kenneth L. Miller, Professor and Radiation Safety Office at Pennsylvania State Medical Center in Hershey, has informed me of some experiments he performed that indicate application of tincture of iodine (betadine) to the skin could be just about as effective as the KI pill, if applied soon after exposure. Miller et al. (1989) found that the availability of tincture of iodine solutions, used for decreasing the radioactive iodine entering the thyroid, may be used instead of potassium iodide (KI) pills for minimizing the amount of radioactive iodines entering the thyroid if applied to skin. After appropriate animal experiments, they painted iodine solutions onto the skin of human volunteers. Painted on the forearm, 4 mL of 2% tincture of iodine resulted in blood serum levels of iodine of 13.8 μg/dl (micrograms per deciliter). This was greater than the 10 μg/dl that is considered a blocking dose to prevent further iodine entering the thyroid. The same 4 mL of solution applied to the abdomen blocked only 35.8% of the uptake, but 8 mL blocked 81.7%. *Thus, it might be well for anyone concerned about iodine uptakes after a terrorist attack to stock some tincture of iodine in the home or shelter.*

The Difficulty of Detecting Strontium-90 in the Lung by External Counting

In Exhibit 23, the estimated exposure rate for 1 mCi of strontium-90 is 0.0015 mR/hour at one meter, from the x radiation (bremmstrahlung) emitted by this pure beta emitter (with no gamma emission). Exhibit 22 indicates that inhalation of 0.04 mCi (with about 0.02 remaining in lung the first day) would if transported to vital organs give over time an effective internal dose equivalent in cancer risk to 25 rem. If a portable detector were held at an average distance of about 10 cm from the material in the lung, then the 0.02 mCi remaining in the lung would yield an exposure rate of only about 0.003 mR/hour; this would be below the average natural background and not likely detected. Even the placement of a field survey meter against the chest would not likely detect this lung burden under field conditions, except perhaps for some large area, thin, sodium iodide detectors. Thus, if strontium-90 intakes are expected to be significant, setups with large area sodium iodide detectors in shielded areas would be needed. However, as indicated above, nasal smears or measurements of items placed over the face during exposure would easily detect any exposures that would yield harmful internal doses.

Analysis and Interpretation of Plutonium and Other Alpha Emitters Taken into the Body

It might not be possible to estimate internally-deposited, alpha-emitting nuclides accurately by rapid survey methods available to most responders, and rarely available to members of the public. Thus, early triage using external gamma or beta counting portable instruments, or simple detection by color changes of the SIRAD dosimeter discussed in Chapter 8, would not be applicable to detection of some internal alpha emitters in amounts of interest to assessing long-term health effects. That is why emphasis in this book has been devoted to inform citizens, from experience, that it is very unlikely that harmful amounts of such alpha-emitting material will enter the body, if even the simple actions of washing and shelter presented in Chapter 6 are not taken immediately after an explosion.

However, after the initial hours and days, many citizens might want to have measurements made for assurance of long-term health, as they were after the Three Mile Island nuclear accident. Because a terrorist attack with an RDD or nuclear weapon would likely deposit fallout over large areas and populations where the radioactivity would be detectable, much more rapid and simple methods of analysis might need to be available for much larger numbers of persons. Even the emergency analytical laboratories and procedures available in the nuclear energy installations or other institutions processing or working with radioactive materials are limited in availability to the rare accident cases that might now occur involving workers on staff or within geographic proximity. The analytical laboratories that do offer services for radiobioassay of human tissue or excretion samples are not adequate in number or capability to process rapidly the samples demanded by a large population, nor is there a planned expansion for such homeland security purposes.

The radiochemists, physicists, or other scientists and engineers involved in laboratory or medical institution measurements of radioactivity in, on, or from samples of humans exposed to radioactive materials are already expert and well prepared with their procedures and equipment. They do not need further information in this book to determine accurately the external or internal quantities of radioactive material deposited, nor to evaluate the radiation doses delivered to human tissue from their measurements. However, such accurate determinations can take many days or months, and would be available only after the immediate response period, and only for the most seriously exposed individuals. Also, the analytical capacities of these laboratories would allow the analyses of only a small proportion of requests or demands if there is undue fear among the public of intakes of radioactive material.

Nevertheless, some limited information and references are given here, as well as in later sections, to possibly assist a much larger group of persons, such as science teachers or nuclear medicine technicians, to establish at least limited capabilities to confirm that the larger intakes of alpha emitting radionuclides that might cause health effects has not occurred.

In Vivo Counting of Internal Alpha Emitters That Also Emit X or Gamma Radiation

Some alpha-emitting radionuclides that might be of concern, such as Americium-241 and Radium-226, also emit gamma rays that are easily detected by some portable instruments, as described above. These radionuclides can also be measured more precisely with fixed and more sensitive radiation detectors, such as sodium-iodide crystals and other solid-state detectors, shielded from background radiation and calibrated beforehand. The plutonium, americium, and other alpha-emitting transplutonium nuclides also emit low-energy x rays when they fall to ground states after alpha emission. High school laboratories and many other industrial, academic, and medical institutions often maintain radiation measuring equipment, and it is necessary only to maintain arrangements with such places in order to monitor and triage a much larger number of persons. However, these laboratories must make special preparations beforehand.

Exhibit 22 shows that an inhalation of about 0.05 to 0.06 microcuries, where perhaps half remains in lung after exhalation, would not likely result in long-term health effects from any cancers, nor would it likely deliver a dose above threshold for acute lethality considering the column in the exhibit indicating maximum organ doses. In addition to the literature cited in Chapter 4, Scott and Peterson (2003) have suggested that the median lethality dose that could cause bone cancer from intakes of weapons grade plutonium would be 19 Gy (1,900 rad or 22,800 rem), using their suggested relative biological effectiveness (RBE) factor of 12).

Weapons grade plutonium may be detected at levels of 0.02 microcuries in single 20-minute counts with a 2-inch-diameter by 1 mm sodium iodide detector held against the chest; americium-241 may be detected at a level of about 0.003 microcuries (Brodsky and Wald 2004). Sedlet (1965), one of the earliest pioneers in radiochemical bioassay, suggested that emergency measurements with thin sodium iodide crystals could detect the then-recommended Maximum Permissible Body Burden (MPBB) of 0.04 microcuries (ICRP 1960) of plutonium-239 in the lung; but it could not be detected after it was transported into bone and other organs. An MPBB amount of plutonium, in the assumed "insoluble" form likely to result from an explosion, was calculated to deliver a dose rate to total bone of about 30 rem per year if solubilized in the lung, transferred to the systemic circulation, and deposited in bone. The rate of removal from the lung was nominally taken as 120 days biological half-life (ICRP 1960), but later taken as an average of 500 days for low transportable plutonium. The uptake in real human cases varies greatly, as observed in the accident cases measured over the years. (The more recent complex ICRP models (summarized in Cember and Johnson 2008) for deposition and translocation to various organs are not deemed necessary for the types of emergency estimates appropriate in the context of this book. In any case, the dose conversion factors of Eckerman (2004) have been used when necessary to check whether calculations by ICRP (1960) methods can be depended to be on the side of safety.)

The detection of plutonium-239 results from the emission of a group of L x rays around the low energy of 17 KeV; other isotopes of plutonium may also be detected by looking at the 17 KeV spectrum. Of course, these measurements were done in a "whole body" counting facility in which external gamma radiation backgrounds were about one-fiftieth of average background levels outdoors (Brodsky and Wald 2004). Nevertheless, shielded mock-up arrangements could allow these low levels of detection to be approached under emergency conditions. The 60-KeV gamma ray from americium-241 would appear prominent in most human background spectra, as would the 17-KeV group from plutonium or americium. Other solid-state detectors that show photon peaks more sharply than sodium iodide scintillations would further improve plutonium detection (Johnson 2004d).

In evaluating lung concentrations from human accident patients, we found that multiple measurements over the chest with the 2-inch diameter, 1 mm thick, sodium iodide crystals were more informative than measurements with larger detectors; the local measurements allowed spot location of residual surface contamination on the chest skin, while detection capabilities for alpha emitters in the lung could be even lower than those quoted above for single counts by cumulating both the total number of counts and the low background counts (Brodsky and Wald 2004).

Such thin sodium iodide detectors could be set up in many laboratories of schools, laboratories in universities, nuclear medicine departments, or any other place where radioactive materials are routinely counted for research, medical, or teaching purposes. Those science teachers or others with the basic knowledge to set up in vivo counting capabilities throughout the United States would have enough science background to understand basic references and instructions. Crapo (2004) offers a very brief introduction to this subject with references that can provide further assistance. Raabe (1994) provides a comprehensive reference, which is still valuable. A number of examples of the followup of persons who have taken into their bodies various forms of plutonium and americium are presented in Brodsky and Wald (2004). The quantitative information in such examples, and from other measured intakes reported in the literature, can be helpful in obtaining, by comparison of the various sample measurements,

an early evaluation for triage of persons exposed to these alpha-emitting nuclides after a terrorist attack or nuclear accident.

Those who set up laboratory facilities for more sensitively detecting alpha emitters that have low or no gamma or x ray emissions will still need some portable instruments, such as portable scintillation counter survey meters, to initially assess persons before they are allowed to enter a laboratory for lower level measurements, and to see if they first need further external washing or decontamination. Johnson (2004) provides a comprehensive chapter on this subject.

With the availability of this information, and further examples of possible exposures later in this book, there is no point in packing further scientific information or instruction on in vivo measurements here. As they say, "A word to the wise is sufficient." To my thinking, anyone who has studied science or engineering, and can prepare to provide quantitative information useful in preventing panic and saving lives, is wise, and can follow the references given.

In Vitro Bioassay (Measurements of samples taken from individuals and processed radiochemically to determine concentrations that are then used to assess radiation doses to internal organs and tissues of the body).

Sedlet (1965) has suggested that rapid chemical methods (1 to 2 hours) are probably limited to blood samples of 10 to 15 milliliters (mL) and urine samples of 100 mL. Fecal samples, which can be valuable in estimating total intakes of radionuclides, would take perhaps at least six additional hours, and urine samples taken at 24 hours would require two to three additional hours. Further, although such laboratory analyses might be available in peacetime for a few individuals accidentally exposed to intakes of radioactive material, laboratories capable of such analyses would not be able to serve large populations after a terrorist attack. Samples of radioactivity concentration well above those routinely analyzed in occupational surveillance and protection programs can sometimes overload even the best laboratories to the extent of delaying emergency assessment of exposed workers (Brodsky and Wald 2004).

Sun (1997), using data from a paper by Owais et al. (1995), has derived blood retention functions that fit fairly well up to about 10 days with retention data from two volunteer individuals injected with plutonium-247 (half-life 45.3 days, giving a much lower long-term dose than plutonium-239). Sun suggests that blood sampling can be more sensitive to plutonium uptake detection than urine sampling and more efficient under emergency conditions because: only about 20 to 60 mL is needed, compared to a 24-hour cumulated urine sample of 100 mL; drawing blood of 500 mL from donors is accepted and would likely be accepted by most of the public under emergency conditions; since blood samples are stored in small glass vials rather than plastic bottles, no acid preservation is needed; sampling, handling, and transporting blood samples to laboratories is easier, with less cost and risk of contaminating the sample. Altogether, collecting and analyzing a small blood sample is relatively safe and fast (except perhaps for a small risk of needle infection).

Sun suggests that fission track analysis (induction of fission product tracks in emulsions or track-etched solids by bombardment in nuclear reactors with neutrons) (Moorthy et al. 1988) could provide ultra-low detection of plutonium in blood at 1microbequerel levels (on the order of one ten-billionth of a microcurie or less). Efficient statistical methods have been developed for evaluating such data on the basis of their uncertainty distributions (Klemm et al. 2003). Electromagnetic separation methods have also been developed within the past decade that can achieve such ultra-low detection levels. However, such methods take considerable time and are not likely to be available for analysis of samples from large populations within a reasonable time.

Simpler chemical methods developed in a number of laboratories should suffice to rapidly detect plutonium or americium in blood samples at levels that would be practicable for triage of the few persons that might require further examination after a terrorist attack. In order to conservatively estimate bone doses in developing permissible intake limits, ICRP-II (1960) relied on earlier human data from a relatively few accident cases as well as animal data to suggest that as much as **0.25** of a micron-sized dispersed aerosol of plutonium oxide would be transported to blood after inhalation. Assuming inhalation of the 0.06 microcurie amount estimated in Exhibit 22 to give an equivalent to **25 rem** effective dose, delivered externally, this amount of inhalation would result in a concentration of about **100 alpha disintegrations per minute** (dpm)(or transformations per minute (tpm) **in 20 mL of a typical blood** volume of 5,200 mL of blood in an adult (ICRP 1975).

Alpha proportional counters (Johnson 2004d; Cember 2001), if made available in laboratories throughout the nation, could easily detect and measure alpha transformation rates of 100 dpm from blood samples within minutes; even portable alpha-counting survey meters might detect harmful amounts with thin-enough counter windows. The blood samples would need to be evaporated onto planchets after removing the bulk of organic material, so that low self-absorption of the alphas would occur and about 50 percent detection efficiency could be obtained. Sedlet (1965) suggests that blood samples can be most rapidly analyzed after precipitation or solvent extraction, having first removed organic matter by oxidizing the sample with nitric acid and hydrogen peroxide. More sophisticated methods are available in the subsequent literature, but would require chemists experienced in these procedures. A rapid procedure is available for electrodeposition of plutonium and other fissionable elements from pure solutions onto platinum as adherent, uniform films useful for alpha counting (Brodsky et al. 1958). This procedure used ammonium acetate as an electrolyte and resulted in uniform, hard deposits of about 200 micrograms per square centimeter on platinum. At 0.0617 curies per gram specific activity for the plutonium-239 isotope, a 200 μg cm^{-2} deposit would represent about 12.3 μCi cm^{-2} deposit, much too high for counting; however, this indicates that very thin deposits with negligible alpha particle absorption should be possible by this electrodeposition method. This procedure could be used to prepare calibration sources, but would not likely work on blood samples unless all interfering compounds were first removed.

In the event that **none, rather than 0.25**, of the amount of plutonium inhaled is transported to blood within 24 hours, then early detection would need to rely on external counting. Thin solid-state detectors could easily detect high surface contamination, and then determine x ray emissions from plutonium in the lung after decontamination. As indicated in the previous subsection, it was found that in an area of very low background, it was possible, by placing a thin sodium iodide detector against areas of the chest and back for repeated 10-minute counts, to detect only 0.02 μCi of weapons grade plutonium in the lung (Brodsky and Wald 2004). *A lung content of as much as 0.06 microcuries of plutonium oxide would be unlikely at distances of most survivors from the source of release. In any case, as discussed in Chapter 4, a lung or lymph node content of 0.06* μ*Ci would be unlikely to present any short or long term risks.*

Decontamination of Plutonium or Americium from Human Skin

As already indicated, simple washing of beta-gamma emitting radioactive materials from clothing or skin can be easily accomplished by washing with soap or ordinary detergents, taking care to not damage or penetrate the skin.

One accident patient arrived at our hospital in January 1966 after a glovebox explosion singed his eyebrows and produced minor first degree facial burns (Brodsky and Wald, page 337). His face, hair and chest were contaminated with oxides of plutonium and americium at levels up to hundreds of thousands of counts per minute measured with portable detectors at the workplace. Nose swipes read up to 100,000 alpha counts per minute. At the plant, the worker's clothing was removed before showering, and this contaminated parts of his body that had been spared

of contamination by his clothing (showing the need to remove contaminated clothing carefully). After arriving at our hospital, the worker was required to shower again and put on clean coveralls before being allowed to enter the operational area enclosing the whole body counter. At this point, all external alpha contamination was removed except for one spot reading 1,200 counts per minute on the right chest. His nasal contamination was reduced by irrigation with water to 1,000 alpha counts per smear. These final levels, achieved with normal showering and washing, posed no risk to the patient or to our staff.

In another incident later in 1966 involving a glovebox explosion, the worker was this time covered with nitrates of plutonium and americium (Brodsky and Wald 2004, pages 343-344). After the worker had been decontaminated at the site, portable proportional counters at our hospital still detected up to **one millon counts per minute on his skin**, as high as could be read. Removable contamination was all over his body. Smears of removable contamination of about 100 cm^2 areas of skin read up to 10,000 counts per minute in a gas proportional counter at about 50 percent geometry. These measurements were made after the patient was decontaminated at the work site, further decontaminated at a local hospital, and then brought to our hospital.

We thus needed to find better ways to decontaminate his skin from these nitrate depositions. Further decontamination with Phisohex and other agents still did not remove the contamination, even after a number of hours. Our faculty colleague, Dr. Jack Schubert, who at Argonne National Laboratory was likely among the first to develop bioassay procedures and publish them after World War II, prepared a special chelating solution that was formulated to remove the plutonium and americium without damaging skin. The use of this solution in removing these fissionable alpha-emitting elements was remarkable, reducing the contamination very sharply. The formulation, included in Brodsky and Wald (2004), is given below:

Schubert's Solution for Decontaminating Plutonium and Americium from Skin*

Tartaric Acid	3.0 g L^{-1}	0.2 M
Citric Acid	4.2	0.2 M
Disodium EDTA or DTPA	8.0	0.2 M
Calcium Chloride	2.2	0.3 M

* All reagents were adjusted to pH = 7 with concentrated NaOH.

An Absolutely Absurd Upper Limit of the Fraction of Radioactive Material Released from a Dirty Bomb That Could Be Inhaled at Various Distances Downwind

In the early days at the AEC, when I was asked to evaluate environmental exposures from radioactive materials released from various production facilities, I did not have experienced meteorologists at my beck and call. Thus, I adopted the Sutton diffusion equation, a mathematical model of diffusion of a released puff of gas or inhalable aerosol based on expanding normal distributions of concentration with time and distance, for my initial assessments of risk to the public under extreme emergency assumptions. This was the model used by the larger AEC staff of engineers who were in the 1950s already examining possible nuclear reactor accidents at that time. It is a model that would still give inhalation results on the high side at present.

For simplicity in examining most situations, I assumed inversion weather conditions that would give the highest doses, and calculated them for someone standing at ground level at the center of a cloud that continues to follow a steady wind in a constant direction. I assumed a wind speed of only 1 meter per second (about 2.2 miles per hour) for my calculation and the other parameters shown in the graph of Exhibit 24. Now, anyone who has played tennis or any other sport outdoors, or who has driven a car across a bridge, knows for certain that no wind blows steadily in the same direction for more than a few seconds. Also, nobody who has watched weather reports believes it very likely that the wind would blow often at only 1 meter per second (about 2.2 miles per hour).

However, for want of any other model, I plotted the graphs shown in Exhibit 24 and used them to decide whether a particular release would be a significant hazard, even under extreme assumptions about possible releases. I found that for almost all situations, because of the wide range of radioactivity amounts involved in work with licensed materials, and the wide range of the radiotoxicities of even the same amounts for different radioactive nuclides used (Brodsky 1965b), the graph would tell me whether I needed any further investigation of this matter, and the conclusion was almost always that I did not. (The range of radiotoxicities alone of the various short and long half-life nuclides in use was about 1 to one thousand-billion-billion, as I used to show students, because of the ranges of physical and biological factors involved in the equations providing the calculations of regulatory limits of intake.)

Therefore, with these limited disavows about the extreme overestimations of the graphed quantities, I provide them in Exhibit 24 for whatever comfort the curves may provide to someone who might expect to have been exposed to a cloud of radioactive material released from a dirty bomb.

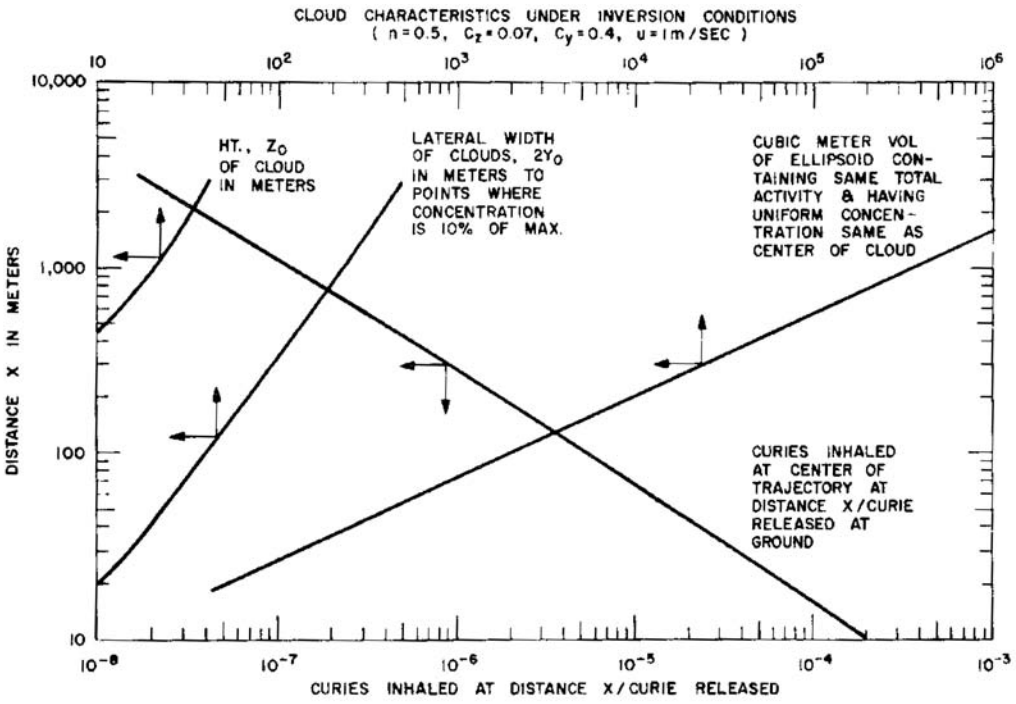


FIG. 2. Cloud characteristics under inversion conditions.

EXHIBIT 24 — Fractional amount of activity inhaled per amount released vs. distance, and cloud dimensions, under severe inversion conditions and only 1 meter per second wind speed (adapted from Brodsky (1965b), as re-published in Brodsky et al. (2004)).

In reading the decreasing straight line on this graph, it is seen that at most 5 millionths (5×10^{-6}) of an amount released can be breathed in by a person totally within the center of the cloud at 100 meters (a little over 100 yards) as it passes by; less than 2 millionths at 200 meters; about one ten-millionth at 800 meters (half a mile); and about five one-hundred-millionths at one mile (1,610 meters). NOTE: The fractional amounts inhaled are based on the assumption that the aerosols involved are small particles in the respiratory range (less than 10 microns). The sizes, chemical and radionuclide composition, and distribution of radioactivity within particles is dependent on many factors such as height of burst, ground composition, and fractionation of the mix as particles travel and descend downwind (Crocker et al. 1966).

Estimation of Maximum Fractions of Bomb-Released Radioactive Materials Inhaled at Various Distances (Scoping Data)

With the use of Exhibit 24, it is thus seen that if the entire amount of a 6,000 curie cobalt-60 source could be aerosolized in a "dirty bomb" explosion, at most 600 microcuries (μCi) could be inhaled by a person at one-half mile away in the center of the puff passing by. By Eckerman's conversions (Eckerman 2004), this would produce an effective dose of about 75 rem, mostly from internal organ doses. As explained in the text, such an exposure is practically impossible, the meteorological calculations being extreme. Also, Alvarez (2004) has described experiments indicating how difficult it would be to explode this material in a bomb so that it would disperse in respirable size particles. Still, such an inhalation would not be lethal to the individual, not immediately and very unlikely in the long term. A person seeing such a cloud could protect against inhalation with a handkerchief. The lateral width of the cloud at one-half mile is seen to be about 100 meters down to 10% concentration. The longitudinal extent of diffusion would be expected to be about the same. Thus, the cloud, even at only 1 meter per second (60 meters per minute), would pass by within about two minutes, a time not too long for difficulty in breathing through a handkerchief.

If one kilogram of plutonium-239 were released in an RDD attack, the likely maximum amount inhaled at about 1 mile, under the most severe meteorologic conditions of concentration at the center of the downwind cloud, would be about 2×10^{-8} (two hundred-millionths) (see Exhibit 24). With a specific activity of the pure nuclide of only about 0.062 curies per gram, the total activity of one kilogram (1,000 grams) would be about 62 curies. Therefore, the maximum amount of activity inhaled at one mile from the one kilogram released would amount to less than one microcurie inhaled, which would be less than that inhaled by the patient who lived to age 72 without indications of bone or liver cancer. Also, any effects of such an inhalation would likely not appear for years. Thus, no intelligent terrorist would plan to use plutonium-239 in an RDD when it would be much more effective if used to make a nuclear bomb. In regard to americium-241, the amounts on thousands of smoke detectors would need to be used to achieve an effective RDD, and for similar reasons of no likely ill effects within years, would not likely to be used in an RDD.

In regard to plutonium or other alpha emitters as contaminants after a nuclear detonation, they would be insignificant compared to the beta and gamma emitting fission products after detonation of either a uranium or plutonium bomb (Brodsky 1965b; Brodsky et al. 2001).

In the case of strontium-90, the doses to lungs or the most concentrating organs would be less than one percent of the doses, per curie inhaled, from inhalation of plutonium or americium (Brodsky 1965c). The specific activity of strontium-90 is 144 curies per gram. Therefore, the doses to lung and to bone from inhaling a given mass of strontium-90 could be on the order of magnitude of those from plutonium or americium. *It is possible that enough strontium-90 could be obtained by a terrorist to make an RDD that could give long-term doses that would cause health effects, but the effects would not occur for years and the effects are unlikely to occur in a significant portion of the population, considering the extreme meteorological conditions assumed for the plutonium calculation. Therefore, I do not think it likely that strontium-90 would be an effective weapon, particularly if persons and agencies involved in homeland security could adequately inform the public to reduce fears.* If such an RDD should release enough strontium-90 to cause long-term health effects, the amounts in exposed persons' lungs could be detected for triage considering the data in Exhibits 22 and 23. An amount in the lungs at early times could be detected as x radiation (bremsstrahlung) with thin-window scintillation counters repeatedly at various points on the chest.

Conclusion: *Because internal exposures to either the alpha-emitting or beta-emitting bone seekers are not likely to be easily observed or as effective, it seems more likely that terrorists would use high-energy gamma emitters such as cobalt-60, cesium-137, or iridium-192 in an RDD. (See Exhibits 1 and 2.)*

Decontamination of Skin Exposed to Beta-Gamma Surface Contamination

If anyone is caught outdoors in such a radioactive atmosphere, they should immediately dust off and then wash off with ordinary soap and water any likely contamination on the skin or in the nostrils. A rough rule of thumb is that, if a radioactive cloud deposits 1 microcurie per square centimeter of skin (more than about 2 million disintegrations per minute of a beta emitter per square centimeter; most fission products and likely nuclides to be in dirty bombs can be assumed to emit about 1 beta particle per disintegration, for our rule of thumb here), the dose to skin before the contamination is washed off could be up to 10 rem per hour (Brodsky 2004d, pages 475-477). Such a dose rate to skin could, if continued for more than 24 hours or more, possibly cause serious burns or permanent damage. *However, if ordinary washing is repeated and checked with radiation instrument measurements, it is reasonable to expect that the contamination could removed, for the most part, in less than one hour.*

Particular attention in washing must be given to more secluded parts of the body and the hair. In no case, however, should decontamination or washing be so abrasive that it causes breaks in skin. Normal washing or scrubbing with soap and/or mild detergent should suffice for the early hours until responders with instruments arrive for more detailed monitoring. Those who have not been in the path of the passing cloud (or plume), or have been able to go indoors before it arrived and passed, need not be concerned about serious health effects in any case. If further assurance is needed, the carrying or wearing of a personal monitor, such as those described in Chapter 8, should ease concerns; if there is no color change in the first hours after fallout has arrived, then even if the monitor is shielded from beta radiation, the lack of serious gamma exposure would indicate that any internal exposure is also insignificant. This would be especially true for anyone indoors when the radioactive cloud passes or fallout descends.

How to Estimate Radiation Exposures Received from Nuclear Bomb Fallout over Time, Using Operation CASTLE Experience as an Example

As indicated in Exhibits 35a-c, I received 2.5 R when recovering my neutron spectrometers from a contaminated island 3 days after the Operation Castle second hydrogen bomb detonation. I was on the island for about 5 minutes. I am assuming that the reading of my film badge at waist level was due in most part to my exposure on the island. My exposure at waist level, and thus the indications of average whole body dose, would have been only a small fraction of the exposure level near my booties, as a result of the distance from my booties to my waist. For example, according to the inverse square law, if my booties read about 10,000 mR/hour at 3 inches, and my badge was at waist level at about 36 inches, then assuming an approximate small source at the booties, my exposure rate at waist level during the 20-minute helicopter ride would have been about (3/36) = 1/144 = 0.0069 of the 10,000 mR per hour, or about 69 mR per hour. Therefore, for about 20 minutes, the exposure rate to the badge from my booties would have been only about 23 mR = 0.023 R. This is very small compared to the 2.5 R badge reading. Of course, there must have been other contamination on the deck of the helicopter, and on the booties of my friend Don Willett and my other booty. However, we can see the contribution to whole body exposure from deck or booty contamination would still have been a small portion of that registered by my film badge at waist level.

Now, we can calculate what my total exposure would have been if I had stayed on, or lived on, the island for longer times. These calculations will show how similar calculations can be made for various intensities and exposure times to fission product fallout from nuclear detonations. I will assume here that my exposures were all due to fission products from the bomb, although at the close distances where I picked up my detectors, it is possible that a considerable amount of the gamma intensity still came from induced radioactive material produced in the soil elements by the absorption of prompt fast neutrons that emanated from the hydrogen bombs. In any case, assuming that all of the ground fallout activity was from fission product fallout rather than direct, prompt, neutron activation, would give a conservative, high-sided estimate of exposure. The activation products would

decay more rapidly than the fission products. Anyhow, anyone close enough to a hydrogen bomb detonation to receive a serious exposure from prompt neutrons, or their activation products, would probably be vaporized and need not worry about fission product exposures. On the other hand, someone exposed at, say, 5,000 meters (a little more than 3 miles) could probably survive inside a shelter and still be exposed to about 0.8 to 8 rem of fast neutrons, plus some prompt gamma radiation, as estimated from Figure 6.8 in Auxier (2004). In any case, exposures to neutrons could only be estimated by persons in the general population from a personal dosimeter worn on the body that had been calibrated for neutron exposure beforehand, or by a later assessment of scientists who specialize in such measurements. More than 99 percent of the surviving population would not likely be exposed to serious prompt neutron doses.

Therefore, to calculate estimated exposures from fission product gamma radiation, we use the simple equation given in Appendix B that E = 5 I T, where E is the exposure in R if the person were to remain in the area with the same amount of shielding for an infinite time (many weeks), I is the intensity in R per hour measured with a survey meter, or estimated from the rate of change of a dosimeter reading, by the dosimeter wearer at a time T in hours after the detonation, a time when all fallout at that distance has deposited on the ground. The time of detonation will be known to anyone within one hundred miles of a nuclear detonation from the extremely bright flash of light, even many minutes before any blast wave is felt for those many miles away.

Knowing that all of the fallout had occurred before I arrived on the island three days after the ROMEO Shot, the exposure I would have received if I had stayed on the island and lived there for many weeks would have been: E(infinity, T = 80) = 5 x 30 x 80 = 12,000 R. This would surely have killed me, even though the dose was spread out over time. I am assuming 80 hours here by assuming that I arrived on the island in the afternoon of the third day after detonation, which was early in the morning, i.e. T = 72 + 8.

If I had stayed on the island only one day before being rescued, I would estimate my dose by subtracting the two long-term doses (to infinite time), as calculated for two times T, 80 and 80+24 hours after the detonation. Although the simple formula 5 IT is obtained from the mathematical integration of the Way-Wigner $t^{-1.2}$ law described in Appendix A, the intensity at the end of my stay at 80+24 hours would either need to be measured again, or calculated with a scientific calculator from the $t^{-1.2}$ approximation, or simplifications of it. Using this power function law to obtain the exposure rate at 80+24 hours (since I am no longer on the island to make a measurement), the exposure rate I2 must be calculated by back calculating the power function to unit time (1 hour) and then calculating forward to 80+24. This is done as follows:

Exposure at unit time (1 hour) = $30\ (80)^{1.2}$ = 30 (192.1) = 5763 R per hour at 1 hour (index exposure rate only; the fallout would not have all come down by 1 hour); the exposure rate at 80+24 hours is then calculated from this index exposure rate as $5763\ (80+24)^{-1.2}$ = **21.9 R per hour at 24 hours** after I arrived in the 30 R per hour field; then, the exposure received during my 24-hour stay on the island would have been 5 (30)(80) — 5 (21.9)(104) = 12,000 — 11,388 = **612 R**. As indicated in the Chapter on radiation risks (Exhibit 7), a dose of 612 R would likely have killed me if I stayed on the island without any protection, and without heroic medical efforts afterward (see Chapter 4).

An alternative formula for estimating the dose received in a given time interval is also derivable from the Way-Wigner power approximation to fission product decay:

$$\mathbf{E = 5\ I_1(T_A^{-0.2} - T_B^{-0.2}),}$$

where here I_1 is the (back calculated from some measurement) intensity in R/hour at 1 hour that would have existed at the location if all of the fallout had deposited by the time personal exposure was initiated (a power function of this type requires working back to unit time, in the units used, since setting times to 0 in inverse time

functions leads to infinity); T_B is the time the person leaves the area (quickly); and T_A is the time the person arrives in the area (quickly). Checking the above answer:

$$\mathbf{E = 5\ (5763)\ [(80)^{-0.2} — (104)^{-0.2}] = 613\ R,}$$

which is acceptably close to the total exposure found above, using a scientific calculator.

Using the nominal factor of 0.7 (Brodsky 2004d) to estimate the mean body dose in rad or gray (Gy) from the exposure R, the dose in rad would have been 0.7 x 612 = about 430 rad, or 4.3 Gy. Exhibit 7 indicates that, although the dose would have been spread over 24 hours, I might have had (without specialized medical care that would not likely be immediately available) only about a 30% chance of survival at that dose (or a 20 to 70% chance of dying in 4 to 8 weeks), but would likely have been nauseous within about one hour after receiving the dose, and would likely have had some of the other symptoms shown.

An approximation to the power function law is that 7 times the time since the detonation, the exposure rate is reduced to one-tenth. Thus, if the exposure rate was 30 R per hour at 80 hours, it would be only 3 R per hour at 560 hours (about 3 and a third weeks). An even easier way of estimating future exposures would be the simple 1/T rule, which would give a high-sided (more conservative estimate of future exposure rates from fission product fallout); for example, if I wanted to use this rule instead of the power function and scientific calculator, I would obtain the exposure rate at 80+24 hours by multiplying 30(80/104), to get **23 R per hour at 104 hours**. This is **not too different than the 21.9 R per hour** calculated above using the power function. Of course, phenomena such as weathering and washing contamination into the soil or sewerage streams have not been taken into account. Also, rain can also bring down an additional amount of fallout, so if it is raining, one better find appropriate shelter after a release of radioactive material into the atmosphere. These types of calculations can only provide an approximate estimate of any radiation situation. In a city with complex structures, fallout gamma intensities will also be reduced by other phenomena. It is best to assume the worst, and to have one's own measuring equipment or personal dosimeters available, as discussed in Chapter 8.

How to Estimate Radiation Exposures over Time After the Release of Radioactive Material from an RDD

For one of the long half-life nuclides, such as 5.26 year half-life cobalt-60, 30-year half-life cesium-barium-137, 74-day half-life iridium-192, or other long half-life gamma emitters, it is best to assume in the early hours or days after fallout has arrived that the exposure rate will stay about constant. Ignore possibilities of weathering and other reductions. Just multiply exposure rate in R per hour by the number of hours you are in a given shelter or non-shelter situation, and you can estimate the total exposure. Multiply that by the 0.7 factor to obtain mean body dose in rad or gray, and you will have a safe-side estimate of your total exposure.

For radionuclides that reduce significantly in the time you are in the area, multiply the exposure rate at the beginning of exposure by the mean life (average life) of the atoms to obtain the exposure for a long (infinite) stay time. The average life is τ = half-life/ln2 = half-life/0.693. For example, if you measured an exposure rate of 1 R per hour (1,000 mR/hour) when 74-day iridium-192 has deposited in your area, then the total dose if you stayed for many months would be 1 x 74/natural log of 2 = 1 x 24 x 74/0.693 = 2,563 R. This would likely be lethal, even though spread over months. Therefore, finding shelter is necessary until evacuation could be provided.

If you stayed in the iridium-192 gamma field for 1 week (7 days), the 1R/hr intensity would have been reduced 1 exp (-0.693x7/74) = 0.936 R/hr (converting time on island into days, the same unit used here for half-life). Your total exposure if evacuated within 7 days (quickly) would be obtained by subtracting the two exposures to infinity: 2563 — 2398 = 165 R; you would likely feel nausea within an hour but might not die if you were healthy,

particularly if you mocked up some shelter, as described below. This is the way intensities decay exponentially for single radioactive nuclides. Combinations of more than one radionuclide at a time, or in sequential explosions, would be more complex. The reader is referred to the texts by Cember or Turner in the References for any more detailed discussion of radioactive decay, or to my summary chapter (Brodsky 1982d).

Estimating the Maximum Likely Level of Ground Contamination and Corresponding Exposure Rates vs. Distance from Detonation

Exhibit 25 below may be used to provide an estimate of the scope of maximum ground-level fallout concentrations, using the same meteorological model as used to estimate amounts inhaled versus distance.

The model used for this exhibit assumes the same severe inversion conditions, a very low wind speed of 1 meter per second, and a representative fallout particle deposition velocity of 2 millimeters per second. This deposition velocity ensures that the particles will be carried far downwind and yet deposit to give an expected maximum gamma intensity at ground level. It also provides a long time period for descent of fallout, which would result in high-sided calculations of intake for anyone caught outdoors during the fallout deposition. It is unlikely, however, in any given situation that meteorological conditions will be close to those assumed here; the assumed conditions here are made only to provide a likely conservative estimate of possible external doses.

Caution: *The function in Exhibit 25 is not applicable if there is rain or other precipitation, which can cause much higher levels of ground contamination when such precipitation washes radioactive particles out of a passing cloud at ground level or any height above. One must know that it is best to stay out of the rain.*

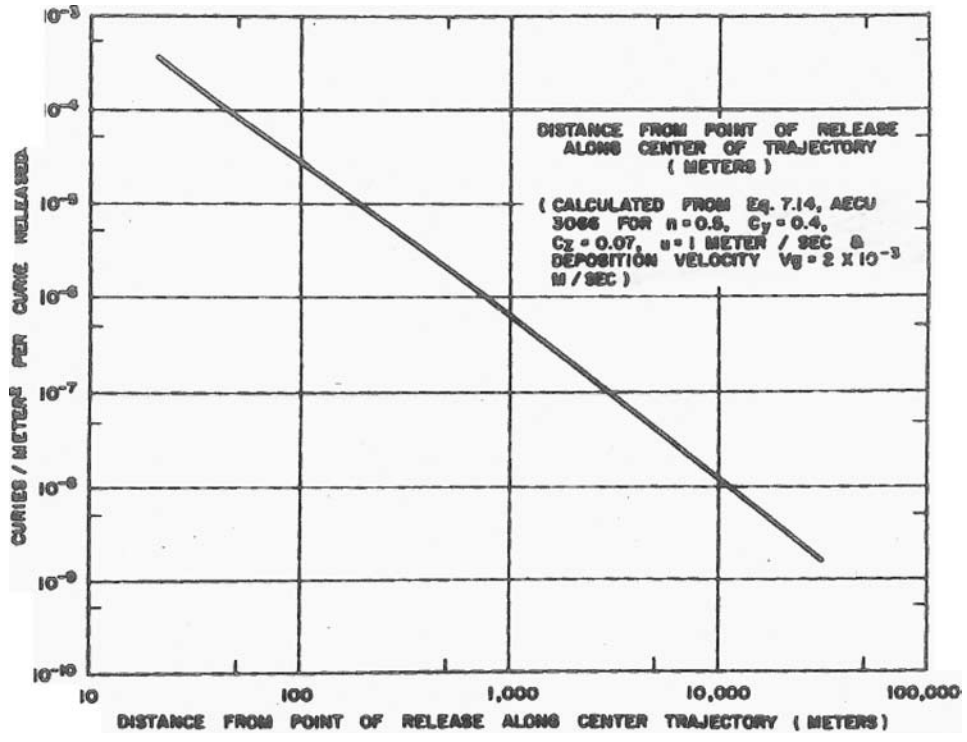


EXHIBIT 25 — Activity in curies deposited per square meter per curie released at ground level, versus centerline distance, under inversion conditions at 1 meter per second wind speed and a particle deposition velocity of 2 millimeters per second (from Brodsky 1965c, as plotted in Brodsky 2004d).

Exhibit 25 is based on the release of fine, respirable particles, with a deposition velocity chosen to provide both a significant direct inhalation problem downwind as well as a significant resuspension factor at distances within a few miles of an RDD or IND. Much wider parameters are possible than those indicated in Exhibit 25 (Crocker et al. 1966). To demonstrate the use of Exhibit 25, consider for example that a 6,000-curie cesium-137 source was vaporized and dispersed by an RDD. Then, at about 750 meters (about one-half mile away) the deposition would be one-millionth of a curie per square meter (1 **μCi m^{-2}**) **per curie released**. Thus, for release of 6,000 curies (Ci) the ground contamination would be 6,000 **μCi m^{-2}** at about one-half mile. A deposition of **1 μCi m^{-2} of fission products gives an exposure rate of 10.6 microroentgens per hour** (μR/hr) at three feet above ground for a wide area of contamination (Brodsky and Beard 1960, page 78). Assuming that the 0.67 MeV gamma ray from cesium in equilibrium with barium-137 closely simulates fallout from a nuclear bomb within 30 days, the exposure rate about one-half mile from an RDD releasing **6,000 curies of cesium-barium-137** would likely be no more than about 60 mR per hour (60 mR h^{-1}). Note that this is only a rough estimate at a particular distance along the centerline of the plume, without taking into account factors such as ground roughness and limited extent of the field. A more exact calculation, which of course might not be worthwhile for such rough scaling estimates, can be made with algorithms in Brodsky (2004f).

*If 6,000 curies of **cobalt-60** (about the amount found in a therapy source) were released, a deposition of 6,000 μCi m^{-2} would yield a likely maximum exposure rate of about 400 mR/hour at one-half mile, considering that the gamma energy emission from cobalt-60 is about four times higher than from cesium-barium-137, per unit activity. Also, its mass-energy absorption coefficient is about the same.*

A responder in an open field at 400 mR h^{-1} could stay there for about 63 hours before receiving 25 R.

Of course, such estimates are useful for planning purposes only. It is necessary for each responder to have his own personal monitor to check exposure rates or dose rates during his rescue activities, and to have an aerial survey or some information on exposure rates available immediately at a command center to plan his activities. This poses the need to urgently build such field monitoring systems, which have so far been mostly neglected.

Note for health physicists or other scientists and engineers involved in planning or response

The heading for Table B.6, page 15, in Brodsky and Beard (1960) should be mR/hr, not MR/hr (1,000 R/hr). Otherwise, **pages 52-96 of Appendix B of that report provide many rules of thumb that should still be useful for rapid estimates of exposures and their immediate practical emergency limits during responses to terrorist attacks as well as to accidents releasing radioactive materials to the environment**. Amounts of radioactive material released from any explosion will depend on bomb design. The dose estimates in Brodsky and Beard are based on ICRP (1960), and the rules of thumb are based on the indicated references to data collected during the copious studies of fallout effects in the era of nuclear tests in Nevada and the Marshall Islands. As always, all calculations should be checked by at least one independent method.

Estimating Skin Doses and Effects from Ground Contamination Resuspended in Air

A resuspension factor of **10^{-6} m^{-1}** has been recommended for estimation of airborne exposures above ground contaminated with radioactive material, and for persons engaged in normal activities, based on determinations on flat surfaces both indoors and outdoors (Brodsky 1965c, 1980a,b); I have found this same resuspension factor used by others in later documents assessing human exposures. This resuspension factor, in these units, means that we assume that if the concentration of radioactive material on the ground is 1 microcurie per square meter, then normal wind and human activity would produce an air concentration of one-millionth of a microcurie per cubic meter of air, at about waist height above ground. As mentioned elsewhere, a colleague (Dr. Payne Harris) informed me, and I later found this in a report of weapons projects in the Nevada Test Site, that he was able to obtain a

resuspension factor of several times 10^{-4} m^{-1} by driving a military vehicle with an air sampler in the back in violent circles in the sandy desert of the Nevada Test Site.

I will use a resuspension factor of 10^{-5} m^{-1} in this example for conservatism. In the Nuclear Test Program Review calculations, we used data on the actual decay rates of the fission product mixture on the ground as estimated from radiochemical measurements of cloud samples over time, changes in resuspension factors as ground concentrations were depleted by weathering into soil or blowing away with the wind, and many more specific data items folded into complex mathematical algorithms. Here, I will just make a rough estimate of skin contamination produced by wind blowing over a contaminated surface with the assumption that all radioactivity impinging on a person's skin will stick there and not be removed while the individual is outdoors. This will illustrate the considerations involved.

Assumptions: A gusty wind of about 20 meters per second; a person's bare chest always facing toward the wind when outdoors for 15 minutes gathering food from the emergency kit in the trunk of his car; all of the contamination directed toward him sticking to his skin and building up during the 15 minutes. With these assumptions, the following calculation will be clear to those familiar with following scientific units.

For a concentration of 1 **μ**Ci per m^2 and a resuspension factor of 10^{-5} m^{-1}, the air concentration will be 10^{-5} **μ**Ci m^{-3} (10^{-5} **μ**Ci per m^3). With a wind of 20 meters per second blowing this concentration onto the skin, the skin concentration will build up at a rate of 10^{-5} **μ**Ci m^{-3} x 20 m/sec = 20 x 10^{-5} **μ**Ci m^{-2}/sec. This would be 20 x 10^{-9} **μ**Ci cm^{-2}/sec. (There are 10^{-4} m^2/cm^2.) In 15 minutes = 900 seconds, the activity on the face of the individual's skin would build up to 1.8 x 10^{-5} **μ**Ci cm^{-2}. From Exhibit 23, the highest dose rates to skin from any nuclides likely to be confronted are 9 rad/hr per **μ**Ci cm^{-2} from bomb fission products or about 16 from strontium-90 (not likely in my opinion).

Therefore, the individual out in a field of 1 **μ**Ci per m^2 would build up a skin dose rate from bomb fission products no more than about 1.6 x 10^{-4} rad/hour, or 0.00016 rad/hour, or 0.16 mrad/hour, a negligible risk level. The contaminated individual could wait 1,000 hours at this dose rate before washing his skin and still not expect any skin damage.

This dose rate would then be due to a contamination level in disintegrations per minute of

2.22 x 10^6 dpm/**μ**Ci x 1 **μ**Ci per m^2 = 2.22 million dpm per square meter, which is 222 dpm per square centimeter, or 22,200 dpm per 100 square centimeters, the latter a unit often used in peacetime to assess contamination levels. Thus, health physicists or other scientists accustomed to working only with peacetime standards should practice conversion to emergency standards in the event of terrorist attacks. It would be impossible to maintain peacetime standards under widespread contamination, and from these calculations one should be able to see there is no need for panic at contamination levels of the above amount.

In the Windscale incident, mentioned elsewhere, a ground deposition of 1 **μ***Ci per* m^2 *of iodine-131 was estimated to result in a dose of 20 rad to an infant thyroid of 1.5 grams, for an infant drinking milk from cows grazing on that pasture. Thus, any milk not bottled prior to an attack would not likely be used before decay of iodine-131 and likely could be checked if needed many days later. However, the dose level indicated would not be likely to cause serious thyroid disease at this level. Also, since iodine doses are predominant for about 100 days after mixed fission product releases descend onto the ground (Lacy and Stangler 1962), it is apparent that a 1* **μ***Ci per* m^2 *level of ground contamination based on skin doses should not cause great harm.*

Estimating Inhaled Intakes from Resuspended Ground Contamination

Using the 1 **μ**Ci per m^2 ground level and 10^{-5} **μ**Ci m^{-3} resulting air concentration for a resuspension factor of 10^{-5} m^{-1}, the rate of inhalation for an adult breathing at a normal light activity rate of about 20 liters per minute (L min^{-1}) would be: 10^{-5} **μ**Ci m^{-3} x 20 L min^{-1} x (1/1,000) m^3/L = 2 x 10^{-7} **μ**Ci per minute inhaled, which in

one hour would result in the inhalation of only 0.000012 μCi, which is more than three orders of magnitude below even the "maximum permissible body burden (MPBB) for plutonium-239, which would deliver a dose rate of about 30 rem per year averaged over total bone mass. Any organ doses from beta-gamma emitting fission products or radionuclides used in RDDs would be thousands of times lower than those of plutonium-239 at these contamination levels. Evidently, as found in the Nuclear Test Personnel Review (NTPR) of persons exposed to fallout at test sites, the inhalation of resuspended contamination is not likely to be a serious problem in the context of the immediate aftermath of a terrorist attack.

Estimating Inhaled or Ingested Intakes from Descending Fallout

Such estimates would depend greatly on the concentration of the radioactive material in air that is descending, the deposition velocities of the different radionuclides, the fractionation out of the mix at that time, circumstances, location, and other factors. Suffice it to say that most persons will not be eating outdoors, as did the Rongelap natives during the CASTLE shot fallout. Even in that case, the external doses were much greater than the internal doses from ingestion of fallout in food or the inhalation from the descending fallout, which did produce serious beta burns on skin, as indicated elsewhere in this book. Many assessments of internal dose from descending fallout were made while I was employed for over 8 years at the NTPR, and I did not observe serious doses occurring from descending fallout, even though we calculated doses for military personnel eating sandwiches outdoors during the descending fallout.

Anyone at all aware that a detonation might be spreading radioactive contamination to the environment would not likely stop to picnic and eat outdoors.

Emergency Ground Contamination Limits

Some suggested limits or action values for ground concentration of plutonium (of 140,000 dpm per microgram) derived mostly from observations and tests during the era of nuclear testing in the 1960s (Meyer 1958 in Brodsky and Beard 1960) are: **35 micrograms** per square meter in controlled areas, and 3500 micrograms per square meter as primary danger zones. The 35 μg per m^2 would yield radioactivity levels of 35 x 140,000 = 4,900,000 dpm per square meter, or about 500 dpm per square cm, or 50,000 alpha dpm per 100 square cm. Kathren (1968), examining the literature and making his own assessments, suggests using "Interim Maximum Permissible Surface Contamination Levels for Environmental PuO_2" of: an average of 1000 dpm per 100 square cm for urban, suburban, and recreations areas; 10,000 for rural truck farming, annual food crops, grazing land, milkshed, etc.; rural deep root perennials of 100,000 dpm per 100 square cm; and 1,000,000 dpm per square cm for remote areas.

Considering that the relative radiotoxicity of inhaled gross fission products is about 10,000 times lower than that for plutonium (Brodsky 1965b,c), this makes beta-gamma surface contamination limits more dependent on the external gamma radiation levels than on the possibility of inhaling dangerous quantities.

Therefore, the suggested limits of ground contamination of Kathren for plutonium above should suffice in any case for the early days after an attack when contamination composition has not yet been identified.

A Visual Instruction: Demonstrating Monitoring Beta and Gamma Radiation from Contamination with a Geiger Counter

Exhibits 26 to 29 show a series of slides in which I have often demonstrated how my hand can absorb most beta radiation from the uranium in one of the old Fiestaware type dishes that used uranium-oxide glaze for the attractive red colorings. The first two slides show how most of the beta radiation from the uranium is stopped in my hand, when I exposed my hand to a fluence of beta particles that measured about 16,000 counts (beeps) per

minute. Exhibits 28 and 29 show a simple calculation of my long-term risk of getting cancer from a one-minute exposure of this type, using the linear risk factors discussed in Chapter 4. While the beta radiation from the uranium glaze gives a high count rate, the amount of x or gamma radiation coming from the natural uranium on the plate, which has not been fissioned in a reactor, gives insignificant counts as can be seen, because most of the x or gamma radiation would pass through the detector without interacting with the gas in the counter. The result of this demonstration and calculation is that, even under the linear hypothesis, the chances of getting cancer in my hand from such a one-minute exposure would be less than 3 chances in one trillion. This would be so even if I should live another forty years to the age of 120. Such a low probability should be considered as evidence that even this amount of exposure to my hand is safe. Yet, I would not want to receive a dose to my hand that was one hundred billion times higher.

This illustrates my concern that many responders are being trained to be concerned about sensitive Geiger counter readings that represent only a few times the exposure rate from natural background radiation. Much of the concern about such low levels of radiation is absolutely absurd, considering the dangers that emergency responders such as police and firemen confront every day. Emergency responders should use Geiger counters only to detect possible sources introduced illegally or harmfully into society. They should be equipped with much higher-range ion chamber instruments, such as the ion chamber instrument I used to measure the 30,000 mR per hour field into which I entered in 1954 for about five minutes to collect my neutron spectrometers, following two hydrogen bomb detonations above the 10-15 megaton range. They should also all be equipped with the types of credit card size pocket dosimeters, and pocket ionization chambers, presented in Chapter 8, in order to be able to visually assess the amounts of radiation exposure accumulated during rescue or recovery operations.

However, the type of Geiger counter, with provision for opening a thin window to the internal Geiger chamber, is needed to monitor radioactive contamination of low intensities, which could still be of concern if found in food and water, or remaining on skin for lengthy amounts of time. Such uses are presented in the next section. Johnson (2004d) provides descriptions and procedures for use of portable radiation monitoring equipment.

EXHIBIT 26 — Checking a uranium-glazed plate with a Geiger counter*

16,090 cpm at about 2 inches



This Geiger counter has its approximately 20 square centimeter "window" (on other side, not seen in picture) open to admit beta rays. The small number in the upper left corner (difficult to see in this picture) indicates that the reading of 16.09 should be multiplied by 1,000, giving about 16,000 beta rays (mostly) entering the Geiger counter per minute. (If the GM counter switch had been turned to the exposure rate scale, which would be used to estimate external gamma exposure rates, the scale reading would have read about 5 mR per hour; however, mainly beta radiation is activating the counter in this picture, so the exposure rate reading would not be meaningful, although approximating the level of beta dose rate in mrad per hour to skin from the plate) This kind of Geiger counter can be used to check a sample of food to see if it is fit to eat for a short 10-day period. (See text and Brodsky and Stangler (2004).) *The GM counter instrument is the "Radiation Alert — Inspector" marketed by SE International, Incorporated, P. O. Box 39, Summertown, TN 38483-0039. This instrument was provided for my demonstrations by courtesy of Beth Cramer of SE International (beth@seintl.com). This instrument will be designated briefly by "Inspector" in the rest of this book.

Exhibit 27 — Placing my hand between the plate and the Geiger counter.

Only 547 cpm with hand in place



Absorption of the beta rays in my hand is indicated by a reduction of 16,000 to about 550 counts per minute. In demonstrations I usually explain how most of these betas are stopped in my hand, and ask, "Is it true that any radiation is dangerous?" and, "Am I a fool or crazy?" I also invite others to see if they can feel the radiation. See the next Exhibits for easy arithmetical calculations that show the maximum risk is negligible, even if hormesis is ignored.

Quick Beta Dose Estimation

Assume betas enter 20 square centimeters of your hand, and penetrate to 0.5 cm.

What is the beta dose rate to your hand?

Surface beta dose rate to my hand:

Rad/min=c/min [2MeV/(g/cm^2) x 1.6 x 10^{-6} erg/MeV]/[20 cm^2 x 100 erg/g-rad] = 1.65 x 10^{-9} x [c/m]

My hand dose in 1 min = 1.65 x 10^{-9} x16,500 cpm = 2.7 x 10^{-5} rad

EXHIBIT 28 — Simple estimate of the dose to my hand when holding it near the plate for one minute.

The next exhibit shows the maximum cancer risk using the linear, no-threshold, hypothesis, even for this seemingly large number of beta rays going through an approximately 20 square centimeter area of my hand (about the area of the Geiger counter window).

A Risk Estimate for Hand Irradiation

Using whole body gamma risk factor maximizes risk (hands and skin of hands have lower risk of cancer death than whole body or organ exposure).

Assume risk proportional to mass of tissue exposed
Thus, risk of 1 minute hand exposure is:

- Less than 2.7×10^{-5} rad x 5×10^{-4} rad^{-1} $lifetime^{-1}$ x 10/70,000
- Which = 2×10^{-12}, or about 2 chances in one trillion

(neglecting hormesis and assuming liner response)

- Calculate auto accidents and compare with 1 chance in 100 of getting killed in a car accident (in an average lifetime)

EXHIBIT 29 — Estimating the risk to my hand.

This calculation shows that the risk of cancer would be less than 2 chances in one trillion for the demonstrations shown above, even if cell repair processes and hormetic benefits of low exposures are ignored. (Here, the mass of tissue in my hand that is exposed in assumed to be 0.5 x 20 = 10 cc, or about less than 10 grams, compared to an average 70,000 gram mass for the whole body of an average man.) Compare such a risk with the discussions of risk, and automobile risks in the USA. The risk of dying in an auto accident is 50,000 deaths per year, times an average of about 70 years of auto transportation per lifetime, divided by the US population rounded to 300 million. The risk of dying in an auto accident is therefore about 50,000 x 70/300,000,000 = 0.012, a little over one chance in one hundred. (The actual number can be checked in a recent almanac.) The seemingly large count rate results from the great sensitivity of the Geiger counter, and in this case **does not** imply a significant chance of harm. So, members of the public must be educated to understand amounts of radiation dose, the parts of the body exposed, and not panic at insignificant levels of exposure. It is not true that "Any radiation is dangerous."

Checking Food and Water for Possible Emergency Use over a Ten-Day Period

Publications of various agencies recommending limits of contamination in food and water, for peacetime or emergency application, are not new. Expert groups have deliberated over these issues for decades, in and out of government. Some of the earliest recommendations suggest limits of food and water contamination for short-term use, in recognition of the fact that unexpected incidents that contaminate large areas might require permitting the intake of higher levels of contamination than routinely allowed. Higher intakes for short periods can still be established that limit internal radiation exposures to levels that are not expected to result in serious risks of harm to populations that would otherwise sustain greater harm from lack of nutrition.

Water in closed containers before the attack and in protected indoor pantries or food lockers would be safe to drink. Water piped without disruption from even a fallout-contaminated public water supply would be filtered sufficiently so that its consumption would not likely pose a serious risk. However, contamination levels should be checked as indicated below, if possible. Radioiodine concentration in the thyroid would be the limiting consideration for the first 100 days after a nuclear bomb attack. (Lacy and Stangler 1962.)

Foods in closed containers, or having skins that can be washed, are almost certainly safe to eat, at least for the limited period of time you will need to stay at home or in a shelter. If the outdoor radiation level is not too high, someone could leave for a matter of minutes or even an hour, depending on the radiation level, to obtain food from another home or local store, even if an adequate supply has not been stored beforehand. Exhibit 30 shows a demonstration that I presented in

1957, when working for the FCDA, to a group of emergency directors and state officials. I had painted the outside of a banana with a low concentration of uranium on the outside skin. I then displayed the reading and clicks on a CD V700 Geiger counter to prove that the outside skin was contaminated. Then, I peeled down the skin and took off a bite-sized piece and ate it. I then fed a piece to the local civil defense director, and someone took a picture. I did not know about the picture until the civil defense agency sent their newsletter to me, and there it was on the front page, with the title I have given to the exhibit. This kind of demonstration can help alleviate unreasoned fear of starvation after a radiological attack.



EXHIBIT 30 — Top Banana Eats Hot Banana.

After coating the skin of a banana with a solution of uranium as uranyl nitrate (available in any chemical store at that time in one pound bottles), I then demonstrated to the audience in the mayor's conference room in a New Jersey town that a Geiger counter clicked away when placed near the outside of the skin of the banana. I then held the banana in a napkin, took a bite from the end, and then offered the civil defense director a bite, as shown here. Someone took this picture at the time, and I first saw it in a newsletter article sent to me by the director later. Of course, the amount of uranium contamination that was on the banana skin was an insignificant risk, much less even than the uranium in the glazed plate of Exhibits 26 and 27. The demonstration was intended to indicate how food contained in contaminated containers or skins was safe to eat if the containers, or skins, were washed and carefully opened.

The limits of radioactive material in food and water that may be ingested for ten days with little risk in an emergency are presented in Exhibit 31, taken from the chapter by Brodsky and Stangler (2004); the derivation of the suggested limits and the references used are in the chapter. In the early days of the civil defense program (1950s), the FCDA contracted with a group of professors to provide recommendations on limits of ingestion of food contaminated with fission products from the fallout deposited from nuclear bomb attacks (FCDA 1955). Because, since 9/11/01 Federal agencies involved in homeland security have not provided analogous limits of radionuclides likely to be dispersed from "dirty bombs," which might be considered acceptable for 10-day consumption under emergency conditions, Exhibit 31 is provided here.

It is useful to note that after the overheating of the graphite reactor at Windscale, England, and the release of an estimated 20,000 Ci of I-131, Scott Russell (as reported in Brodsky and Beard 1960, page 56) derived an emergency level of 0.39 μCi per liter of milk based on ingestion by infants. An emergency committee, in the absence of ICRP recommendations at that time, established a limit of 0.1 μCi/L based on a dose of 20 rad to an infant thyroid of 1.5 g. It is noted that multiplying the iodine-131 concentration in Exhibit 31 by 1,000 is necessary to convert it to 2 μCi/L, units that are comparable to the Windscale criteria. Thus, the 0.1 μCi/L level suggested long ago for application to the Windscale incident shows that the British provided a safety factor of 20 for infants, similar to the safety factor for infants I have suggested in Chapter 4 of this book.

It was found that the deposition of 1 μCi per square meter of grassland resulted in this level of 0.1 μCi/L in milk. This amount of iodine on grassland over a large area would result in an exposure level of about 3 μR/hour near ground level. Such levels are detectable above background with a NaI detector biased at 50 keV in a low flying aircraft (Brodsky and Beard 1960).

Federal agencies have provided limits for use of food following the Chernobyl disaster, which contaminated large areas of Eastern Europe and Scandinavia, but they are for longer term use or ingestion. Some of the Federal and expert agency recommendations of limits for food and water for longer term use have been summarized in Brodsky and Stangler (2004). However, it is likely to be many days before the numerous requests for food or water monitoring could be met from currently available expert government or private laboratories.

In the meantime, before government or other laboratory assistance might be available, it is useful for members of the public, or their more immediately available emergency responders, to at least have some approximate methods for determining whether food supplies that have been open to the environment might be acceptable for short-term use. Starvation or malnutrition, which could occur if local food supplies are not replenished and are assumed out of fear to be inedible after a large area attack, can also be harmful to health or lethal. In most cases, any food that has been sealed in cans or plastic, or fruit that can be washed and peeled, can be safely eaten, but there might be some food stored in open places, within stores or homes, that might be suspected to be contaminated. Although it might be difficult to obtain the uranium nitrate that was used to make comparison samples, as recommended by the FCDA, some paragraphs after the following exhibit provide simple methods of testing food and water with an ordinary Geiger counter open window. Companies that sell such Geiger counter instruments are listed in Appendix F, or can be searched on the internet.

Nuclide Mix	Activity ($\mu Ci\ cm^{-3}$)	Activity ($Bq\ g^{-1}$)	Effective Dose† After 10 Days (Sv)
Gross fission product beta activity (< 30 days decay after burst) (FCDA 1955)	0.09	3,000	0.043 (using Ce-141 as surrogate)
Gross alpha activity from nuclear burst (any period after burst) (FCDA 1955) (Not likely to be detected as important in early fallout material.)	0.005	180	0.9 (Pu-239 as surrogate, but delivered over 50 years)
Phosphorus-32	0.015	500	0.024
Cobalt-60	0.03	1,000	0.068
Strontium-Ytrium-90	0.0003	10	0.0056
Mo-99-Tc-99m	0.08	2500	0.03
Iodine-125	0.03	1,000	0.13
Iodine-131	0.002	60	0.026
Cesium-137-Barium-137m	0.012	400	0.104
Iridium-192	0.03	1,000	0.028
Polonium-210	0.0006	20	0.48
Radium-226 plus daughters	0.000012	0.4	0.0022
Plutonium-238/239	0.003	100	0.50
Americium-241	0.003	100	0.40
Curium-244	0.003	100	0.24
Uranium (natural or depleted)	0.03	1,000	0.9
Thorium (natural)	0.0015	50	0.23

EXHIBIT 31 — Emergency levels of radioactivity in water and food for 10-day consumption*

*The values for mixed fission products and gross alpha activity after a burst are taken from FCDA (1955). The values for the nuclides deemed in ANS (2003) and Alvarez (2004), plus two additional nuclides that are in widespread use in nuclear medicine, have been obtained by taking the ratios of MPC for water of the nuclides divided by the MPC for Ce-141 of 0.003 $\mu Ci\ cm^{-3}$ as multipliers of the values for gross beta activity in FCDA (1955). These ratios are approximately the same as obtained from the tables of Eckerman (2004).

†The effective dose is the sum of the products of committed dose equivalent over 50 years multiplied by the tissue weighting factors of ICRP 60, as calculated by Eckerman (2004) for single nuclides, except for I-125, where the main dose is to thyroid and the committed dose from NCRP Report No. 70 (NCRP 1982) is multiplied by the weighting factor 0.05 as used for thyroid in ICRP Report 61 (ICRP 1991).

NOTE: The values in the above table may be divided by 3 for 30-day consumption, but should not be used for longer periods of consumption. Values should be reduced for children less than 5 years age and reduced to one-twentieth for infants or pregnant women. (see appendix by Eckerman (2004).

Exhibit 32 presents limits for longer-term consumption recommended by the International Atomic Energy Agency (IAEA 1996), as published in NCRP Report 138 (NCRP 2001). For infants and small children a 70 year exposure is assumed, and for adults a 50-year exposure is assumed in the calculations of Eckerman (2004). Fifty years is 365 x 50 = 18,250 days, or 1,825 times longer than the 10-day period assumed in Exhibit 31. It is noted that for the gross fission product mixture, the 10-day concentration in Exhibit 31 is of the same order of magnitude as 2,000 times the comparable nuclides in Exhibit 32. For all other nuclides except the alpha emitters, the concentrations in Exhibit 31 are less than the proportionate 2,000 times the values in Exhibit 32. It might be reasonable and consistent to lower the concentrations for alpha emitters in Exhibit 31 by a factor of 50, so that none of the effective doses exceed 1 rem. However, I do not believe the values in Exhibit 31 for alpha emitters would generally be too high for a population facing much greater threats after a terrorist attack (see results of americium-241 case below). A particular consideration for very long half-life alpha emitters, especially natural uranium or thorium, is that the specific activity is so low that it is unlikely that enough mass could be deposited per unit area that the activity concentrations in food after an airborne release could reach anywhere near the respective levels in Exhibit 31.

The chapter (Brodsky and Stangler 2004) also compares with the above tables the "derived investigation levels (DILs)" of the Food and Drug Administration (FDA) for domestic or imported food at which consideration should be given to possible restriction of use (FDA 1998). The FDA report presenting this table includes an extensive discussion of considerations, and invites comments. The report also reviews efforts at obtaining an international consensus on such DIL levels. FDA uses DILs to help determine whether domestic food in interstate commerce or food offered for import into the United States presents a safety concern. FDA determines whether foods contain unsafe levels of radionuclides on a case-by-case basis, considering the totality of the circumstances and the extent to which those circumstances depart from the assumptions that underlie the derivation of DILs. The DILs adopted in the draft report (FDA 1998) were not binding on FDA, the regulated industry, or the courts.

Radionuclides	Foods Destined for General Consumption Bq g^{-1} (µCi cm^{-3})	Milk, Infant Foods, and Drinking Water Bq g^{-1} (µCi cm^{-3})
Cs-134, Cs-137, Ru-103, Ru-106, Sr-89	1 (0.00003)	1 (0.00003)
I-131`		0.1 (0.000003)
Sr-90	0.1 (0.000003)	
Am-241, Pu-238, Pu-239	0.001 (0.00000003)	0.001 (0.00000003)

EXHIBIT 32 — Generic action levels for foodstuffs (adapted from IAEA, 1996, as in NCRP (2001).

The activity concentration units have been changed here to Bq g^{-1} from the units in NCRP (2001). It can be seen that these concentrations, aimed for prolonged acceptable use of the food or water, are far below the values in Exhibit 31 for 10-day consumption (but, as mentioned in the text, are consistent with the range of values in Exhibit 31 if multiplied by the ratio of time periods of ingestion). If the lower concentrations of the IAEA and ICRP were enforced to prevent interim 10-day use of some food sources during the emergency period, such enforcement could possibly cause serious malnutrition or starvation if food supply chains are disrupted for weeks.

Simple test methods for food and water using a Geiger counter instrument and home supplies:

Early pre-1960 limits of radioactive contamination in food and water for 10- and 30-day consumption

Early civil defense recommendations of fission product and alpha emitter contamination limits for food and water for 10- or 30-day use have been summarized in the appendix of rules of thumb in Brodsky and Beard (1960, pages 72-74). These contamination limits were proposed in a number of references, but only a sample is needed here. Exhibit 33 presents these limits in terms of alpha and beta radioactivity concentrations.

For the most part, the ICRP-II (ICRP 1960) levels of intake of water, 2,200 milliliters of water per day, were assumed in the early calculations, with a similar equivalent intake of food. One easy method for rapid checking of food or water was to compare the beta count rate above an ointment tin full of the food or water sample with the count-rate above a sample concentration of natural uranium (the safer kind) mixed with plastic in another ointment tin. The preparation of the uranium sample (which I tested out for myself when working for the Federal Civil Defense Administration (FCDA)) was as follows:

Use of a uranium comparison standard for checking food and water

In the 1950s, at the request of the Atomic Energy Commission (AEC), Instrument Branch, the University of Rochester Atomic Energy Project (where resided some of the top professors on uranium toxicology, associated with Professor J. Newell Stannard (Stannard 1988)) developed a suitable emergency comparison standard for use with an ordinary Geiger counter (Hursh et al. 1951; FCDA 1952; 1955;1959). (I worked at times with two of the authors, professors Hursh and Dahl, as well as Stannard; I can attest to their expertise.)

The amount of uranyl acetate necessary to give a response to a Geiger counter equal to that given by mixed fission products from a nuclear detonation was experimentally determined at the 10-day acceptable risk concentration. As indicated by Cowan and Kuper (1958, page 79), this standard should also be applicable to measurements of most nuclear reactor fission products; the doses due to longer-lived fission products, such as strontium-90 would, for "…a reactor operating time of 180 days with a decay time of 24 hours not likely to be more than a factor of two greater than the strontium-89 dose upon which the comparison standard is conservatively based." In fact, considering that up to fifty percent of the most radiotoxic sizes of aerosols inhaled passes through the digestive tract, the relative contributions of nuclides in the fission product mix to the effective dose from ingested reactor fission products, even as calculated using current ICRP standards (Brodsky 2004, pages 747-753), should be such that it would be safe, using a factor of safety of two, to use the uranyl acetate standard for released fission products from up to three years of operation and less than 30 days since the release. **Nobody should starve!**

Making the uranium comparison standard for checking food and water

The beta comparison is prepared in the lid of a 4-ounce ointment tin (7.9 cm diameter by 2.3 cm height), as a base to hold the sample. Each standard is prepared by mixing 3.14 grams of finely divided (60 mesh) uranyl acetate ($UO_2(C_2H_3O_2)_2\tau\ 2H_2O$) in 5.0 grams of liquid casting plastic. Other uranium compounds such as oxides and salts can be employed in amounts proportional to the concentration of uranium desired. The amount of uranium required can usually be obtained in one pound bottles from chemical supply houses. Both the plastic and catalyst, used to hasten its setting, can be obtained in small quantities from hobby shops. If necessary, asphalt can even be used.

When thoroughly mixed with a glass stirrer, add 6 to 8 drops of the catalyst and stir the mixture for 5 minutes. After swabbing the inside surfaces of the ointment tin with a solvent to remove any greasy film, then weigh 8.14 grams of the mixture of uranium acetate and plastic into the lid of the standard 4-ounce tin. (About 9 grams would be about one-third of an ounce, which could be estimated by weighing on a kitchen or postal scale.) Next, heat the

lid at low heat on a flat surface of the stove until the material in the tin begins to harden, then remove. Overheating will cause the plastic to separate from the lid. (As bad as I am in the kitchen, if I can make one, anyone can.)

Comparisons between the uranium check standard and food and water samples can be made by filling the ointment tin with a sample to within the same distance from the top as the uranium standard in the lid. For fresh fission products from a nuclear detonation, food and water samples that give fewer counts per minute, or lower readings, with the open window of a thin-window Geiger counter placed against the tops of the lids, can be ingested for 10 days, starting within the first 30 days after the detonation (explosion). For fission product samples released from a nuclear reactor accident (which will never be a problem with USA reactors, in my opinion — see the true results of the TMI meltdown, as described in Chapter 1 and the evidence in (Brodsky 1980a)), a sample reading less than the check standard could be ingested for 10 days starting within a few days after the accident. **(Don't laugh! Food deliveries might well be delayed for a good while if there is a serious terrorist attack on the USA.)**

For using the sample to test for alpha contamination (not likely to be serious), a flat, thin-window, Geiger counter may be placed against the top of each ointment lid. The suggested acceptable level for these alpha emitters in food and water for 10-day consumption is 11,000 transformations per minute per cc (see below). In order to measure this rate, an alpha source calibration would be needed with the standard and a given detector with a thin open window of less than 2 milligrams per square centimeter (check with the instrument supplier).

The following Exhibit 33 provides recommendations in terms of radioactivity concentrations for 10- or 30-day ingestion of food or water from (Beacham et al. 1956; Hursh et al. 1951; FCDA 1952; 1955; 1959):

Consumption Period	Microcuries per cubic centimeter (cc)	Disintegrations (Transformations) per minute per cubic centimeter
Beta-gamma, 10 days	0.09	180,000
Beta-gamma, 30 days	0.03	60,000
Alpha, 10 days	0.005	11,000
Alpha, 30 days	0.0017	3,700

EXHIBIT 33 — Acceptable Radioactivity in Food and Water for Emergency Use, Early FCDA Values of Alpha and Beta Activity.

These concentrations were determined by balancing the risks of ingesting radioactivity against the risk of doing without food and water for a prolonged period of time. Where contaminated food is expendable, the food should not be used. (Beacham et al. 1956; Hursh et al. 1951.)

Conclusions about checking food and water

Comparing the above table with Exhibit 31, which includes specific radionuclides that might be used in "dirty bombs," it is clear that even for strontium-90, a rule of thumb, without further laboratory analysis, that 1,000 counts per minute on a thin window counter at 1 cm would be a safe limit when the nature of the radioactive contamination is not known. Some suggestions for similar monitoring of other radionuclides that might contaminate food or water, after a dirty bomb or spray release, are given in the next section. The best measurements for checking such contamination levels in food and water are, of course, those made by appropriate scientists in a qualified laboratory. However,

after an attack, such laboratories that exist would be swamped with work, even if a substantial number of citizens could arrange appropriate packaging and sending of such samples to a laboratory. Even then, a long time would probably elapse before a report could come from such a laboratory. You could get very hungry before then!! That is why I present this information. **You will more than likely be on your own for many days after an attack.**

Specific Information for Scientists Interested in Lots of Details

How I know it is safe to make this uranium check source (with the specific amount of uranium specified) on your kitchen table.

In order to show that mixing the uranium in my kitchen without a hood was safe, I first refer to an article that just arrived (Kathren and Burklin 2008). These authors, whom I know personally and from their previous work to be reliable, have again reviewed recent research reports on uranium toxicity, and suggest that ingestion of 5 grams of soluble uranium, or inhalation of 1 gram, is their best estimate of what would be lethal to 50% of healthy people. Less uranium stays in the body if eaten rather than inhaled, because uranium compounds that are soluble in tap water will become insoluble and precipitate in the gastrointestinal tract; then, much passes through without being absorbed in sensitive organs.

The limiting intake is used here for conservatism to assure no long or short-term effects would occur for anyone who might inhale uranium while preparing the food and water check source. The earlier ICRP estimates of safe intakes of air, food, and water are based on much earlier animal research as well as more recent experience with a few cases of human accidental intakes in the uranium milling industry. Using the maximum permissible "safe" body burden of about 0.015 grams from ICRP-II (ICRP 1960), and the fraction of that, 0.065, which would be in the kidney, we would calculate about 900 micrograms in the kidney for a maximum safe amount for long-term exposure. For a 300 gram kidney, this would be about 3 micrograms per gram of kidney. This is a long-standing standard limiting concentration that was confirmed in consultation with some of the best radiation toxicologists, when I chaired the American National Standards Institute (ANSI) Working Group that developed the uranium bioassay standard (ANSI 1996). This standard specifies criteria for quality assurance and interpretation of bioassay samples in determining uranium exposures to workers in the nuclear industries.

Despite a few published articles recommending stricter concentration limits for uranium, others, and most recently Kathren and Burklin (2008), provide information that indicates that the older ICRP-II standards give even higher exposure estimates than current ones, and they confirm my earlier conclusion from the literature that 3 micrograms per gram kidney is safe (Brodsky 1996a). My earlier conclusion, after looking at many other suggestions in the literature, actually agreed with the earliest conclusions of professors Stannard and Hursh (Stannard 1988). In addition, Kathren and Burklin provide more recent human evidence that, "There are no known long-term injuries that are (even) sublethal." In other words, if an intake of uranium does not kill you, you are not likely to have any other long-term effects; this is based partly on Kathren's own long-term studies of a worker who fell into a vat of uranium solution, and other human exposures.

Now, from personal experience with the accident cases I managed at the University of Pittsburgh as well as data in the literature, I concluded some time ago that a person working at arm's length with a toxic material would not likely inhale more than one-millionth of the material, certainly not more than about one hundred thousandth, if the total amount was suddenly dispersed by a mechanical accident or explosion (Brodsky 1980a). The 3.14 grams of uranyl acetate contains about 1.76 grams of natural uranium, about 99.3% of which is the isotope uranium-238 and the rest is uranium-235. The low amount of uranium-235 means that the greatest risk from higher intakes of natural uranium is from kidney toxicity, not radiation dose (Kathren and Burklin 2008; Brodsky 1996a). One hundred-thousandth times 1.76 grams gives no more than 17.6 micrograms (0.0000176 grams) inhaled, even

less ingested, even if the uranium blew up in one's face while the material was being prepared. Of course, nobody would be able to blow up the uranium compound used in this way, and anyone working in his kitchen would not want to spread any dust around anyway.

The 17.6 micrograms inhaled would be far less than the 900 that needs to remain in the body for a lifetime to equal the "safe" limit that was used to derived maximum permissible air concentrations, when I worked for the AEC on the original regulation 10 CFR Part 20, published in 1961. Current estimates, as indicated by Kathren and Burklin, indicate that these original worker standards were, and are, indeed safe. Furthermore, even if I had eaten the entire amount of uranyl acetate that I worked with in my kitchen, I would not have died, as indicated by the experience of the person who volunteered and ate 1 gram of uranyl nitrate, or the person who tried to commit suicide by eating 8.4 grams of uranium (Kathren and Burklin 2008). Anyhow, I do not recommend eating it; the latter person became very sick. **Other than eating it, you can handle it very safely and not worry about radiation exposure or toxicity. Moreover, natural uranium is not enriched enough in uranium-235 for anyone to make a bomb, not even enough to use in current power plants. No terrorist in a cave in his right mind would try to make something from this uranyl nitrate that would kill you.**

Another set of experiences that I had that tells me the amount of uranium to be deposited on a food and water check standard is safe for handling on a bench top or kitchen table stems from my work at the NRC on uranium bioassay guidance (USNRC 1988). I visited in the early 1980s one of the largest uranium mills with the best records of urine bioassay for uranium, and found that, although uranium could be detected in many workers, no worker had been exposed to a toxic amount or a radiation dose likely to cause harmful effects. I gave a report and paper on this matter at a conference on uranium sponsored by the NRC. My findings of the limited amount of exposure to uranium received in uranium mills, even by those exposed to the final dusty yellow cake deposited into barrels from conveyor belts, agrees with the observations of Cravens (2007) in her visits to a closed uranium mill. At that mill, one of the old timers who had worked there many years said, "They're monitored, and we all get regular physicals. We've got a lot of old-timers who've been here for decades. The majority of our workers have stayed in good health. Very few of us here now are young. But we're doing fine." (Cravens 2007, page 57.) This I found in a book by Cravens, who had originally been suspicious of safety programs in the nuclear industry.

Warning: My statement with regard to a specific amount of uranium does not apply in general to any amount of any radioactive material in any physical or chemical process. As indicated in my paper on how to design safe facilities, equipment, and procedures for working with the vast variety of radioactive materials (Brodsky 1965c), the relative radiotoxicity of compounds made from the hundreds of varieties of radionuclides varies by factors from one for the least toxic up to one hundred million for the most toxic forms alone. Thus, quantities handled as well as all of the various safety features or ways of containment and ventilation during handling need to be taken into account by professional scientists or engineers designing and planning operations with radioactive materials. Above a certain quantity that depends on the specific radionuclide, even a ventilated chemical hood is not sufficient and complete containment of the procedure or manipulation is required. Although I was never able, after several attempts, to convert my scheme for protection into a national standard, it was published in a number of handbooks and selected by my peers as an historic paper in the twenty-fifth anniversary issue of Health Physics (Brodsky 1980b). I since have found on many occasions that my scheme for selecting protection requirements continues to be valid; the latest re-publication is in the book by Miller (Brodsky 1992). (While completing this book, I was invited in 2010 to participate in a new Health Physics Society working group to prepare a national standard on this subject; I might yet be able to make up for some of my previous failures.) Further discussion of this important issue on peacetime uses of radioactive material is beyond the scope of this book.

A Note for the Public, and Also High Officials in Industry and Government

Thus, it would be safe for anyone to make one of these food and water check sources in one's home. It would be considered good practice to keep uranium dust off the table, and dispose all waste in a closed container. ***However, better yet, I would like see someone highly placed in industry and/or government, or both of them working together, to sponsor the manufacture of this cheap type of check source for food and water, and promote its distribution to the public as well as to responders, together with Geiger counters manufactured en mass, all over the nation. Taxpayers' or venture capitalists' costs could easily be retrieved by recovering a small and reasonable percentage of the price of each unit. There is a precedent for this.***

Some suggestions to laboratory scientists for possible check measurements on food and water without using the uranium check source

In the laboratory, a more accurate procedure can be developed than that suggested below. The numbers given in the suggested methods below can provide only an approximate validation of the procedure.

If we examine all of the beta-emitting nuclides in Exhibit 31, we see that, when a member of the public does not know what radionuclide might be involved, but has available a Geiger counter survey instrument with an available open window to emit beta particles, a safe rule of thumb may be used to tell when a sample of food or water is rather safe for 10-day consumption. To be on the safe side, from Exhibit 31 let us take only 0.01 μCi/mL as a limit, assuming iodine-131 or strontium-ytrium-90 are not present; if they might be suspected to be present, the detection level to be derived may be divided by 300 or 5, respectively. In any case, the level to be derived would not likely allow serious health effects from these two nuclides.

Examining other suggestions for providing emergency 10-day intake limits in food and water during the weapons-testing era of the 1950s and after the Windscale incident in Britain released 20,000 curies of iodine-131 to the environment (Brodsky and Beard 1960, pp.71-78), a few estimates may be helpful here. The 0.09 μCi/mL would give only 1 rad to the intestine if consumed for 10 days beginning at 1-hour post detonation; if ingested beginning at 24 hours, the intestinal dose would be about 15 rad. As mentioned above, the I-131 limit of intake from cows grazed on pastures after the Windscale incident was set at 0.1 μCi/L, which is 0.0001 μCi/mL, based on limiting the dose to an infant thyroid of 1.5 grams to 20 rad; however, this limit was set considering the time between release and the entire process of grazing, milking, bottling, and distribution of milk, during which time many of the shorter half-life fission products would have decayed. Further, the ingestion of the milk in this case was not to be limited to 10 days. The pastures from which milk containing 0.1 μCi/L was obtained had a measured exposure rate of 0.003 mR/hour soon after the release, and a contamination level of 1 $\mu Ci/m^2$, which could be detected above normal background with a sodium iodide detector biased at 50 KeV. The highest amount of iodine-131 found in a local inhabitant after the release was 0.28 μCi. This experience might provide some indication of the limited effect on health of an RDD releasing radioiodine.

Also, although it is indicated above that the 0.01 concentration might be divided by 5 for strontium-90, it must be recognized that the strontium beta activity would be less than 0.01 percent of the beta activity from a nuclear detonation, even after 2 days decay of the shorter lived nuclides (Brodsky 2004d, page 751).

Another useful piece of information from a table provided by the British is that the gamma intensity near a 2-4 gallon can of water contaminated with fresh fission products from a nuclear bomb, and still suitable for 10-day ingestion, would be 25 mR/hour; in a lake 2 feet deep near the shore, the gamma intensity would be 50 mR/hour for the same concentration. Thus, the 0.01 μCi/mL level should be rather safe for 10-day ingestion. However, many of today's experts who are accustomed to peacetime limits might not trust these emergency limits. Therefore, this is a subject perhaps worthy of another look, by Federal authorities writing guidance under consultation with the leading scientists on internal dosimetry; that is how it was done by FCDA in the 1950s to provide practicable

criteria for surviving nuclear attacks. As explained in Chapter 4, emergency dose calculations using ICRP (1960) data and methods should not really change much over the years insofar as the earlier dose calculations are still conservative in the interest of safety (ICRP 1960, 1980, 1991a, 1991b, 1994, 2006).

Now, using the 0.01 μCi/mL for this example: Take a large bottle lid, or ointment tin, turn it upside down, and tape with layers of adhesive tape a rectangle 2 cm wide by 4 cm long on the surface. Using a Geiger counter with open window about the size of the circular opening on the Inspector instrument shown in Exhibits 26 and 27, provide a 2 cm by 4 cm shield of one-sixteenth inch iron strips taped to the open window to define the area of the counter accepting incoming beta particles.

Spread about 1 cc of the food to be tested as evenly as possible over the 2 cm by 4 cm area on the lid; this should provide a thickness of food of only about 1.6 millimeters, which would not appreciably attenuate the beta particles. If the concentration of radioactive material in the food is 0.01 μCi/mL, then the area concentration will be (0.01 μCi/8 square cm) = 0.00125 μCi/square cm (0.00125 μCi/cm^2).

The beta count-rate for a 2 cm by 4 cm flat source at 1 cm from a Geiger counter open window of 2 cm by 4 cm, using the MATHCAD^r algorithm in Brodsky (2004g), would be about 2.5 x 10^6 counts per minute on an open window counter shielded by the 2 cm by 4 cm template, for an area concentration of 1 μCi/cm^2 at 1 cm. Thus, a food concentration of 0.01 μCi/mL spread out on the bottle lid as above, giving an area concentration of 0.00125 μCi/cm^2 would give a count rate of about 0.00125 x 2,500,000 = 3,125, or about 3,000 counts per minute. This would easily be detectable with such an instrument. Even the strontium-90 limits would be detectable with a somewhat larger and thicker spread of food, if the natural background of the instrument was in the range of about 35 counts per minute; of course, this would require that the counting be done in an area shielded from any additional fallout radiation.

In order to make an approximate check of the above result, I exposed a 0.006 μCi technetium-99 check source that came with my Inspector Geiger counter at 1 cm from the open window, which was shielded by the thick portions of two butcher knives of steel to make an approximately 2 cm by 4 cm entrance window to the Geiger tube. I measured the circular area of the source of technetium-99 to be about 2 cm diameter. (The manufacturer specifies for the circular open window of my Inspector instrument an effective diameter of 45 mm (1.75 inches) considering blocking by the copper screen, which protects the thin window part of the Geiger tube that is made of a thin slice of mica only 1.4 to 2 mg/cm^2 thick, so some alpha particles can also be detected by the counter). The area of the source is about π $(2)^2/4$ = 3.14 cm^2. Three readings of the Geiger counter, over the center of the source and with the two edges of the source below the edges of the circular counter window gave readings of 800, 650, and 600 counts per minute, approximately corrected for background. The average of 683 counts per minute for 0.006 μCi/3.14 cm^2 = 0.00191 μCi/cm^2 would be expected to give about (8/3.14) x 683 = 1,740 counts/min if the technetium-99 activity had been spread over 2 cm by 4 cm. Multiplying by the ratio of activity concentration in the paragraph above divided by the activity concentration in the last sentence, the count rate for 0.00125 μCi/cm^2 of technetium-99 in a food sample spread as described above would be (0.00125/0.00191) x 1,740 = only **about 1,140 counts per minute, rather than 3,000**. This is not a bad check, because the technetium-99 beta rays are of fairly low energy, averaging 0.1 MeV, so that some of them have been blocked by the protective screen over the Geiger counter open window, and some of the lower energy beta rays of the spectrum are probably absorbed in the air and the thin window of the Geiger tube.

These estimates show the need for more precise laboratory measurements to correct for some of these factors, for a given setup for checking food and water contamination. Yet, the scoping experiment described above indicates that detection by field instruments of even low energy beta emitters in food for immediate emergency consumption is feasible.

For scientists who might want to provide better calibrations the following data is provided from ICRP (1983); numbers have been rounded off and less significant beta or electrons have been omitted for this purpose. In the above table of radioactive beta-emitting isotopes possibly available for dirty bombs, the nuclides P-32, Co-60, Sr-Y-90, Mo-99-Tc-99m, I-125, I-131, Cs-137-Ba-137m, and Ir-192 have main beta emissions of energy and frequency, respectively (ICRP 1983): 0.695 MeV average E, about 100% for P-32; 0.096 MeV avg. E, almost 100% for Co-60; 0.196 MeV avg. E, 100% from Sr-90, and 0.935 MeV avg., 100% from its 64 hour half-life daughter Y-90, which may be assumed to be present in equilibrium with the Sr-90; 0.443 MeV avg. 82% and 0.133 MeV avg. 16.6% from 66 h Mo-99, and about 10% conversion electrons in the range of 0.12 to 0.14 MeV maximum energy from its 6.02 h half-life daughter Tc-99m; I-125 emits no beta particles but has a series of 0.027 to 0.031 X-rays that would be highly absorbed and emit electrons from the Geiger tube walls and gas, and a series of low-energy electrons; I-131 has an average energy 0.192 MeV beta emission for 89.4% of its beta transitions and others making an assumption of 1 beta per decay reasonable for a practical calculation; Cs-137 has a beta of 0.1734 MeV avg. E 94.6% of its transitions and another of 0.425 MeV avg. E 5.4% of its transitions, and its daughter Ba-137m (2.552 minute half-life) has a series of conversion electrons over 9% of its transitions that are of maximum energy 0.62 MeV or higher: and Ir-192 has two energetic betas, one averaging 0.1611 MeV at 41.5% of disintegrations, the other averaging 0.2089 MeV at 48.1% of the disintegrations, with many other conversion electrons that would provide for easy detection.

By contrast, the technetium-99 check source of 0.006 μCi that I used in the above home test has an average beta emission of 0.1013 MeV in 100% of its transitions. Except for I-125, all of the other beta emitters eject betas in spectra that are about the same or greater in energy than the technetium-99 source. (NOTE: The Tc-99 check source is a long half-life nuclide (213,000 years to decrease to one-half its radioactivity); this is NOT the Tc-99m indicated above that is the daughter of Mo-99 and used in the majority of nuclear medicine studies for its short 6.02 hour half-life. This short half-life provides optimum imaging of body organs using the 0.14 MeV gamma ray from Tc-99m, with a minimum dose to tissue as a result of its rapid decay to low levels.) **Therefore, if a Geiger counter measures less than about 1,000 counts per minute (above background) at 1 cm from a food sample, with a geometric positioning of food sample and detector as indicated above, the food sample is likely to be safe for 10-day consumption.**

In regard to alpha emitters, the lowest (most conservative) levels recommended in food and water for 10-day consumption was 0.0002 μCi/mL (440 dpm/mL) as safe, and 0.005 μCi/mL (11,000 dpm/mL) as acceptable risk (Brodsky and Beard 1960, page 73). **It is comforting that the latter value is the same as that for gross alpha activity from a nuclear burst, and not much higher than the values for plutonium-239 and americium-241 in Exhibit 31**. Although development of a rule of thumb for measuring alpha activity in water would be easier for water since water can just be evaporated, a field measurement in food samples would be more difficult without carefully ashing the sample because of self-absorption of alphas by the sample. Some Geiger counters have windows thin enough even for alpha particles to penetrate into the chamber. However, for alpha particles, penetration is very dependent upon the thickness of the window into the Geiger tube. It would be best to check food samples by placing the open window of a suitable alpha detection probe very close to the sample to be checked, perhaps about 1 millimeter away. In order to protect the detecting tube from becoming contaminated, in case there is significant radioactivity in the sample, it would be best to cover the detector with a thin plastic such as Saran wrap.

In my judgment, it is unlikely that the alpha emitters listed above, or any other, would be likely to contaminate a food or water supply significantly as a result of the explosion of a dirty bomb or nuclear bomb. The alpha emitters have longer half-lives and thus more mass of the nuclide is required to obtain the same amount of radioactivity. My examination of inhalation doses from fission product releases from nuclear bombs or reactors shows that the

amount of alpha-emitter activity such as plutonium or uranium would be a relatively small contribution to the dose to anyone inhaling in a passing cloud (Brodsky 1965b; Brodsky et al. 2001).

Also, another experience tells me that americium or plutonium released in oxide forms from a bomb explosion would not be a practicable weapon for a terrorist. A worker inhaled americium-241 while working with multiple curie levels (totaling about 3 curies) at arms' length for 2.5 years before the exposure was discovered by an AEC inspector who asked for better urine analysis. All of the material was in powdery form before being compressed into pellets. The resulting total body deposition was determined to be about 2 μCi (Brodsky and Wald 2004). (Unfortunately, he did not work with these quantities in a sealed glove box, as recommended in the tables of Brodsky (1965c)).

This case was mentioned in reference to biological effects of alpha emitters in Chapter 4. The worker was evaluated and treated with the chelating agent DTPA at the University of Pittsburgh, Presbyterian-University Hospital. I first measured his body radioactivity as about 2 μCi when he arrived at the hospital in May 1967. My radioactivity measurements on this patient were checked independently at Argonne National Laboratory, where the precise initial amount was determined. Americium-241 is about as radiotoxic as plutonium-239 in animals. The 2 μCi was about 70 times the maximum permissible amount at that time for an average man; it was estimated to deliver 70 times the amount that would deliver about 30 rem per year averaged over compact bone. This dose rate was thus 2,100 rem to bone per year, according to ICRP-II methods (ICRP 1960) used at that time. We initially expected that the worker might receive up to about 100,000 rem to bone during his lifetime. (Later determinations of the amounts remaining in bone and actual retention functions (Rosen et al. 1980) indicated a lifetime dose of 20,000 rem to bone.) Therefore, Dr. Niel Wald treated the patient with infusions of DTPA to remove as much of the americium as possible over a number of years. Although the treatments removed only about half of the americium, the patient lived to age 72, passing away from a cancer not believed to be related to his alpha exposures. Although this is only one case, many billions of cells were exposed to alpha bombardment, and the outcome is consistent with the findings of Fallahian (2008).

This experience with the americium patient indicates to me that nobody at any distance of many yards from an explosion spreading americium-241 could receive a significant internal dose from that nuclide. The worker handled americium-241 in quantities millions of times the amount of americium-241 contained in one smoke detector, and the material was in powdery oxide form before being compressed into smoke detector pellets. I do not think any terrorist in his right mind (and they are not insane, just fanatic), would attempt to make a dirty bomb out of the americium-241 in smoke detectors. There are many easier ways to kill and terrorize people than trying to dissolve millions of smoke detector americium-241 pellets, in very refractory form, and place the total activity into a dirty bomb.

Therefore, it is practically impossible that americium contained in an RDD could be dispersed in such quantities that serious intakes would be received by members of the public, either by inhalation or ingestion. Only the deliberate placement of a lethal amount in someone's food or drink, such as in the Po-210 poisoning of former Russian KGB agent Litvinenko, is likely to produce serious health effects from alpha emitters. Such material is likely to be in the hands of a terrorist only if provided by someone close to a nation's protected chemical operations in a nuclear materials recovery operation. Still, members of the public might well demand examination for intakes of plutonium, americium, or other alpha emitters, after an RDD attack.

Scientists or engineers among you might want to make check sources, and calibrations of sensitive detectors, for monitoring radioactive material in food or water. Otherwise, perhaps the best way to obtain proper calibrations in preparation for response or recovery is to take your instrument to the Nuclear Medicine Department of a hospital, a Radiation Safety Office of a nearby university research program, or one of the commercial laboratories listed in Health Physics Society (2007), and obtain calibrations for the nuclides of interest. The use of the rough rule of thumb provided earlier should prevent panic and provide some assurance of the safety of short-term use

of foods or water when necessary. It can be seen that the alpha-emitting nuclides in the paragraph above are all detectable with the proper instruments, if deposited in thin enough layers.

For those scientists or engineers interested in becoming involved in more of the technical aspects of protection of food and water from contamination by radioactive, chemical, or biological agents of terrorism, a good 221-page book, still useful today is that of Beacham et al. (1961). This book also explains the nature of nuclear, chemical, and biological agents of war in clear, accurate, ways. It is one of the old references, of which there are many, still in my library. It is impossible in this book to extract all of the important and useful information provided in the many books and public information documents published in the original civil defense programs. I am aiming to provide mainly information needed by the general public and responders in the early moments and days after a radiological attack.

Additional Experience That Tells Me That Intakes of Plutonium or Uranium (and Other Alpha Emitters) Are Not Significant When Exposed to Fallout from a Nuclear Bomb

One of my assignments from Dr. Klemm when I worked in the Nuclear Test Personnel Review (NTPR) program was to take the lead in the statistical analysis of very low level measurements of plutonium in the urines of veterans who had been exposed to fallout at nuclear tests. Samples of urine from one hundred veterans were collected in the latter 1990s and sent to Brookhaven National Laboratory for plutonium determinations by fission track analysis. The data were checked and provided to me on spreadsheets. Some of the statistical methods derived have been reported in Klemm et al. (2003).

As a former veteran exposed to fallout at both the Pacific and Nevada test sites, and also having entered without respiratory protection an experimental area at the Nevada Test Site heavily contaminated with plutonium in 1953, I also contributed a urine sample that was included in the spreadsheet data, but with a code and not my name. Neither I nor any of the other veterans except one (as mentioned above) had a measurable amount of plutonium in his urine. This one veteran who did exhibit plutonium in urine was a physicist and physician expert in radiation biology; he believed that ocean currents would have adequately diluted the fission product concentrations in the hours before entered the water. He deliberately swam in the lagoon the day after the first H-bomb detonation (the MIKE Shot of 1952 at Eniwetok), and also experimented with resuspension of plutonium at the Nevada Test Site plutonium-covered area by driving a vehicle at high speeds in circles to see how much plutonium he could resuspend in air. (I recall that he obtained a resuspension factor of several times 10^{-4} per meter.) This one veteran who showed plutonium in his urine received a bone dose, as calculated by extrapolation of intake retention functions and ICRP dose calculation methods, that was much lower than that of the americium case mentioned above who received an estimated 20,000 rem. In fact, the bone dose of this one veteran was still within acceptable lifetime exposure levels. The last time I heard from him, several years ago, he was still an active octogenarian. None of the others of the 100 veterans, including me, received a significant dose from intakes of plutonium.

This result confirms my conclusions from examining the abundance of plutonium in fission products from nuclear bombs, and the likelihood of significant intakes relative to the other radioactive nuclides in the fallout (Brodsky 1965b; Brodsky et al. 2001).

I would also conclude that there is no danger from intake of plutonium or other alpha emitters from nuclear bomb fallout through cuts or wounds in contaminated skin, as long as care is taken to wash the skin in directions away from the wound. This conclusion is based on the experience of managing another americium case in which a worker's hand was cut off in a glove box accident, and the surrounding skin was contaminated with thousands of times the permissible amounts of americium or plutonium in the body. The hand was re-joined and then removed several days later, and eventually no detectable americium remained in the body after all scabs were removed from the remaining wound (Brodsky et al. 1972). The results of this case are also among those reviewed in Brodsky and Wald (2004).

Some Pleas to Policy Makers

(Now Skip to Protection from Biological and Chemical Agents, if the following paragraphs do not apply to you; I want to call them to the attention of certain leaders.)

A hearing was held in Congress at which a congressman expressed his chagrin that some of our nation's best government laboratories were being underfunded and essentially dismantled in terms of loss of the best radiochemists. I am particularly concerned about the loss of capabilities at the Idaho and New York laboratories, where I have known and followed their work since the 1950s. These laboratories, in addition to measuring human and environmental samples with methods they have developed through the years, also have served the entire industrial and governmental laboratory community by providing quality assurance samples and determinations. This is a true function of government, because an individual private company cannot be expected to provide such a service to all other private companies objectively, including some with whom they compete. Yet, I know that private enterprise of this type needs and wants to have this base of standard quality assurance service for their own benefit and profit, and to be sure that no fly-by-night company can undercut them with unsafe or unreliable measurements to make profits in the short run. I hope my message gets to the right people; I cannot cover the issue with any completeness, for it would take another book. I have long known the capabilities of these chemists in these laboratories, having joined them at their scientific meetings, and having worked on the writing of national standard criteria for their radiochemical analyses. I see the diminution of these laboratory capabilities as a loss of important national resources for both peacetime industrial needs as well as requirements after a radiological attack. In order to support the congressman, I visited with the cognizant staff member, Douglas S. Pasternak, Subcommittee on Investigations and Oversight, Committee on Science and Technology, U.S. House of Representatives, telephone 202-225-6375, doug.pasternak@mail.house.gov. Anyone who appreciates this issue and can help stem the tide against such destruction of national resources, and influence proper funding and support, is urged to contact the House subcommittee.

While I am at it, I must point to another national resource that, in my opinion, is not receiving adequate but deserved attention and support. (Information about this capability may be obtained at jason.d.dunavant@saic.com.) That is the Nuclear Test Personnel Review (NTPR) team I worked with from 1997 to 2006, a small group of extremely competent and dedicated scientists who have evaluated external and internal radiation exposures of "atomic veterans," persons in the active military service who were exposed to radiation in connection with their duties (scientific, administrative, technical, clerical, security or many other) at nuclear test sites in Nevada and in the Pacific Proving Grounds. This team has now been reduced to only two full-time scientists: Dr. Mondher Chehata, team leader, and Jason D. Dunavant, a scientist and certified health physicist. It deserves to be expanded and used to estimate individual and population doses in the event of a nuclear or radiological attack.

This group worked diligently and honestly in analyzing the received radiation exposures as part of the Nuclear Test Personnel Review program, which has been variously organized in Department of Defense agencies and most recently in the Defense Threat Reduction Agency (DTRA). Personnel have worked within both government agencies and through private contractors. The aim of the work was to determine whether a veteran's radiation exposure was sufficient to possibly award the veteran compensation on the basis of radiation dose calculations that were high-sided, as were the estimates of probability of causation, in order to give veterans the "benefit of the doubt" regarding whether their exposures received on military duty caused the claimed diseases.

This group that I worked with was with the Science Applications International Corporation (SAIC), which was a subcontractor to a contractor with DTRA who searched for and provided personal data from veterans' files. I realize now how fortunate I was to be hired by Dr. W. Jeffrey Klemm, SAIC Program Manager and SAIC executive, in the Fall of 1997. Jeff Klemm, who had been with the NTPR almost since the beginning and had

developed some of the basic physical models for estimating external and internal exposure, turned out to be a walking encyclopedia of information on the nature of exposures and the resources in the comprehensive library of reports and documents. These are the resources from which we extracted information on atmospheric tests all the way from ship locations vs. time to the fallout distribution patterns from every hydrogen and conventional nuclear bomb that had been detonated in the hundreds of US nuclear tests, from the one before Hiroshima and Nagasaki to the last one before the cessation of tests in 1963, as agreed between the US and the Soviet Union.

During my tour at SAIC, I evaluated the external and internal organ doses for about 100 veterans, in addition to checking results of many others and cross checking calculations and newer mathematical models, such as those for calculating skin doses from resuspended fallout, with my colleagues. Much of the newer modeling was in addition to using the already vast library resources of reports, data, and mathematical and computer methods, which had been collected since the 1978 Congressional hearings that had led to the development of the NTPR (see my testimony at these hearings (Brodsky 1979a)).

I am afraid, for my country, that these library and other resources will be lost if the group still with the NTPR is not recognized as a group to be permanently supported for future projects important to our nation. It is extremely unlikely that, if the present remaining personnel are lost to other jobs before others work with them, that the unique libraries and methods will not be available to important future programs. This is the kind of team that our political leaders should realize deserves the same stable and continuing support as, for example, the National Institutes of Health. In fact, as I will point out in the next paragraph, this team could be invaluable for a new radioepidemiologic study similar to those now being carried out by the National Cancer Institute.

I believe that some of the reasons for the decreasing support of this NTPR team have to do with some of the same type of prevalent misinformation about radiation risks that I have myself experienced, as presented in Chapter 1. I have belonged to some of the organizations of "atomic veterans," because of my service duties as discussed elsewhere in this book. I have noticed who their "scientific advisors" have been: my old colleague Dr. Ernest Sternglass (see Exhibit 3 and the professional chastisement of Sternglass by former Presidents of the Health Physics Society (Moeller 2001)) and others I have known who have distorted radiation effects and whipped up anger against not only government agencies involved in assigning veteran benefits, but also against this SAIC team in which I worked. I have sometimes dealt successfully with some of that anger, but only with a few veterans on a one-to-one basis. The vast majority of veterans and the public have obtained their views about this subject from the news media and the anti-nuclear bias of some advisors of their organizations. The political pressure exerted by these particular groups, in trying to obtain compensation regardless of the radiation dose received, has often distorted the dedication and expertise of the SAIC team, as well as exaggerated the likelihood of health effects induced by the lower levels of radiation exposure experienced by the vast majority of atomic veterans.

To make a long story short, I know that the accusations of these veterans' organizations, provoked by what I have defined as these ANA "pseudoscientists" based on just a bit of the evidence I have presented in Chapter 1, have influenced politicians to insist on committees that have reviewed the SAIC work. This is fine and appropriate, and the committees selected, particularly those of the National Academy of Sciences, have been comprised of scientists whom I know to be excellent in their fields. The problem is often that any different suggestion by these committees for the NTPR procedures has often been taken out of the context of the many complimentary statements about the NTPR work, and played up in the press. Then, some of our politicians or political appointees must answer to the ensuing anger of the veteran community, as well as the public. I will stop at this point, to just suggest a few reasons why it is urgent for someone in high places to realize the value of the SAIC staff and data I have now retired from:

- Although some of the competent staff brought to the NTPR by Dr. Jeff Klemm and others over the years have now retired, there is still a core of outstanding scientists who could be working at least part-time on

NTPR evaluations of veterans' doses, in addition to the two full-time staff mentioned above, Dr. Chehata and Jason Dunavant. Most of the original staff have already sought and obtained other employment. Time may be short for an adequate recognition and boost to this group. In addition to the few staff remaining with this project are those remaining in the area whom I knew as a core, and who could, if they had been retained, keep our national capability for estimating doses from dirty bomb or nuclear bomb fallout. To highlight their excellent work and capabilities, I want to name them here: Neil Barss (already employed elsewhere but in the area); Dan Martinez (no longer at SAIC, but in the area, practically a self-taught expert in using the most advanced computer algorithms to track a person through a varying radiation field and determine a dose; also one who as a Marine officer supervised part of the program in earlier years); Dr. Dudley A. Raine III (now employed elsewhere but in the area, a Ph.D. in nuclear engineering who knows all aspects of the NTPR, has developed and consolidated many of the computer algorithms and organized data needed in all of the internal doses calculations; Robert Schlegel (a fine nuclear engineer who has retired but might be available for additional work or consultation); Dr. Harvey Singer (now a professor teaching statistics at a local university); and John Stiver (M.S., CHP, who has also been employed elsewhere, an outstanding professional in the radiation sciences who has developed numerous algorithms useful in calculating radiation doses). I worked with these people and other associated scientists for over eight years, under the supervision of Dr. Klemm for about seven of those years, and need here to laud these colleagues for their dedicated performance. I can say that there was not one day that I did not come to work looking forward to being with this group. But it is not friendship that I am after; the friendships will remain in any case. I really am concerned with the loss to the nation of our ability to assess accurately the after-effects of a radiological terrorist attack.

- There are others that could be mentioned, but the above persons are examples of a core that could save the national ability to perform accurate estimates, with appropriate estimates of uncertainty, of any nationally important project that would require such dosimetric capabilities. These scientists who have worked in the NTPR, and the few that remain, could serve to train the additional number that would be needed to provide an expert group for determining individual and population doses more accurately after an attack, or an accident involving radiation. I specifically mention names here, to indicate that people who are scientists in our nation can be very important if not irreplaceable. Too often, we hear speeches about the need for more and better science education in the USA, while those speaking probably have little knowledge of the damage and discouragement that is often felt at the scientist's working level, in the USA today. I will now continue with just two examples of programs for which this group, whether remaining at SAIC or elsewhere, could be extremely valuable, in addition to the ways in which veteran doses may be obtained.

This group would be extremely **valuable for a system of dose and potential dose evaluation needed for lifesaving and recovery operations after a terrorist attack** that disperses radioactive material over large areas. In the 1950s, I and colleagues from various services in Region II of FCDA, just as those in other regions around the nation, met in command centers for regular exercises for recovery after nuclear attack. One of the tasks in these exercises was to plot out the expected fallout intensities over areas of hundreds of square miles, using expected wind patterns, which as usual could be very uncertain. Persons with radiation instruments would later need to confirm these patterns, with the expectations that many of these "monitors" or responders might themselves receive significant exposures.

Today, there are radiation monitoring instruments used, for example, in nuclear power plants, which have digital information on total doses and dose rates at all locations of interest. This information is transmitted instantly in real time to a control room, using GPS capabilities as well as computer analysis and monitor display

capabilities. In a similar way, the nation could and should provide for instant information of this type relayed to homeland security stations, where **the data could be used by methods constructed by the SAIC group to immediately provide digital and graphic intelligence data for use in early response and recovery operations following a terrorist radiological attack**. **This information should also be further supplemented by the actual radiation doses received by members of the public, who are wearing the inexpensive, light-weight, dosimeters presented in Chapter 8**.

One of the most difficult aspects of the studies of Hiroshima-Nagasaki victims was the repeated attempt at reconstruction of their doses, with attempts to estimate where each person was and how much shielding was involved. Such information, obtained from personal dosimeters, would be needed to avoid panic and treat the injured, as well as for any long-term examinations of the populations and individuals among them. Thus, the dosimeters described in Chapter 8 would here again be extremely valuable.

One more suggestion for Congressional and Administration leaders: In the early days of Atomic Energy Commission regulation, I needed to argue at times for safer standards and regulations for licensing the use of radioactive materials. In more recent times, I have been concerned with over-regulation or exaggerated requirements that prevent commercial success in the most beneficial and safe uses of radioactive material. I have seen cases where the Nuclear Regulatory Commission, where I was proud to work until retiring in 1986, has required considerable license fees to those requesting licenses for beneficial commercial uses of radioactive material. I have also seen some good industries put out of business by unreasonable expenditures or requirements for cleanup of miniscule, non-hazardous, amounts of relatively low toxicity radioactive contamination. In one case, this caused the closing of a small company that put about 50 poor people out of work (Brodsky 1996b). My book (Brodsky 1996a) also examined another case in regard to the possible need for another 100 million dollar expenditure to further clean the Watertown Arsenal in Massachusetts. My conclusion, mentioned in the Executive Summary, was that such an additional cleaning could not produce detectable or necessary results, and that if such a large sum of money was to be spent, it should be offered to the community to build a first-class cancer treatment center; such a center would surely save lives.

In his early book (Weisbrod 1961) and in many later publications, Weisbrod clearly points out that any nation, no matter how wealthy, really has what reduces to only two choices: to spend wisely, or unwisely, the amount of money allocated to public health. If spent unwisely, human life is harmed or lost more than helped.

Protection from Chemical and Biological Agents

Early protections available to the public are similar to those for avoiding exposure to radioactive materials dispersed to the environment in an attack: stay or get indoors, seal rooms from outdoor air, immediately protect the body from exposure anyway possible, breathe through immediately available cloth material (16 layers of handkerchief), wash off any suspected contamination; listen to the radio or TV to receive any instructions from local medical emergency response teams or organizations. Unfortunately, recent studies and reports indicate that our nation is still not well prepared to provide antidotes or antibiotics to the public on a large scale, if serious exposures have occurred.

As I suppose everyone knows from news reports over the years, there are a large variety of chemical and biological materials that, if spread successfully over large areas, or entered into the ventilation systems of buildings, can kill large numbers of people. Fortunately, although such agents have been manufactured in large quantity by certain nations, including the United States, these nations have not used them against other nations on a large scale, and there has even been significant destruction of such manufacturing and storage of these agents by nations. On the other hand, they have been used in well-known cases: e.g., mustard gas in World War I; the use by Saddam Hussein of mustard gas against Kurds; and the use of the chemical nerve agent sarin by the cult Aum Shinriko in

the March, 1995, Japanese subway attack that killed a dozen people and sickened thousands (Miller et al (2001). These agents are potentially available to non-national entities or "rogue" nations. Similarly, anthrax, botulinum toxin, and potent biological warfare agents, could be made in limited quantities by small groups and used to spread disease and death to many civilians. It is apparent that, if there are many terrorist cells, all of them acting together could produce much harm and induce much fear in even the strongest of nations. Al Qaeda has urged its followers to develop such weapons to kill Americans.

What should most citizens do to protect themselves in the event of the possible use of chemical and biological agents in the USA? Those who want to provide more effective protections than those that can be recommended in this book could urge their government representatives and military leaders to speed up research and development and launch greater efforts at mass production of vaccines and antidotes for some of the more likely agents, subsidizing their mass distribution to the public. Costs of such efforts should be small compared to current annual military expenditures. Everyone knows that only a small drop of some of the chemical agents on the skin can be lethal in a short time, while some of the biological agents might not show effects for hours or many days. Without greater investments of our society to provide immediate availability of protective medications, only actions to immediately reduce exposure to these agents, to the extent possible, are the available protective measures for members of the public.

The reasons for lack of sufficient priority to public protection from biological and chemical agents are, in some ways, similar to the reasons that our programs that were already in place for protection against radiological terrorism were decimated since the removal of the iron curtain. On a number of occasions, public health officials, some military leaders, and some in Congress and the White House, have attempted to put the US on a fast track for public protection against these agents, only to become frustrated in their efforts over time. Miller et al (2001, e.g., pages 151-164 and 188-195) trace some stories about how some top-level government officials, particularly Richard Danzig, who in 1993 was appointed Undersecretary of the Navy in the Clinton Administration and had served in a senior civilian post at the Pentagon in the Carter Administration, attempted to convince some military leaders to invest in production of vaccines against anthrax, only to be defeated by concerns about the safety of the vaccines available and the concern that allies would not be cooperative in fighting aside US troops who had been vaccinated. As usual, there were many reasons to give up on research that might save lives. Although we have all read reports in the news about national efforts after 9/11 to reactivate the vaccine issue after the deaths from anthrax contamination, this issue has apparently lost public and government attention in the last few years. At least, I have not heard much about it lately. Have you? I do not yet know any neighbors or friends who have been given the kinds of vaccine or antidote protection that can only come about from a national resolve to protect the public from chemical and biological agents. I have heard that a vaccine against botulinum is available, but it costs $500. Can we really give vaccines to three hundred million citizens, even if we could produce the amounts needed?

Dr. Terry Pelmar, Scientific Director of the Armed Forces Radiobiological Research Institute in Bethesda, Maryland, has provided a concise review of the possible synergistic (additive) effects of exposure to chemical or biological agents, and to radiation at the same time (Pelmar 2004). She also discusses possible effectiveness of vaccines. With limited data on humans of such joint exposures, she has been able to cite information that suggests that relatively large, but not lethal, exposures to radiation would compromise the immune system and make a person more susceptible to infectious agents. She also cites some human data on exposures to both nitrogen mustard and radiation in cancer therapy, which in some cases indicates a beneficial interaction between the two (presumably when aimed at the cancer cells), and in other cases a harmful interaction (additive effect). Her chapter makes it clear that much further research is necessary.

Therefore, this book summarizes only some simple measures that can be taken when exposure to chemical or biological agents is suspected. A review by Franz (2008) is included in Chapter 7. More detail may be found in the references

(Miller et al. 2001; Byrnes et al. 2003; King 2004). Also, while there is a potential for serious harm to our nation and its citizens from chemical and biological weapons, there is no point in describing the many agents and their effects in detail in this book. Those who want to scare themselves with the gory details can read Miller et al. (2001) or Byrnes et al. (2003), or even some of the scarier references in those books. In this book, it will be assumed that a citizen exposed to chemical or biological weapons, with or without concurrent exposure to radiation, must protect himself and family by some of the same actions as suggested for exposure to radioactive materials, if release of chemical or biological materials in the vicinity is at all suspected, perhaps by hearing some blast or observing some mist sprayed into the environment. Simple and rapid actions to be taken would be applicable regardless of the nature of the (usually unknown) agent.

Chemical agents at a dangerous level will be first detected by their effects on skin or the respiratory system. If shelter has not been reached in time, immediate decontamination should be attempted. Prior sheltering and/or appropriate protective clothing and respiratory masks would be necessary to prevent injury and death to populations exposed early in sufficient concentrations.

The first indication that biological agents have been used would be the appearance of victims (FDA 1955). The importance of reporting infectious diseases of concern (e.g., smallpox) immediately cannot be overemphasized. Following attack, all items must be considered contaminated and treated accordingly. The tasks of identifying agents and treating victims rests with public health and medical officials. Food and drug officials are responsible within their jurisdictions for seeing that products are handled in such a way that they are free of biological agents when they reach the consumer.

Protective actions against chemical and biological agents have been summarized from Byrnes et al. (2003) by King (2004), which will provide most of the actions for survival against such agents that are recommended in this book. Actions that might reduce exposure, if some warning is given of dangerous aerosols heading your way, would be: getting into shelters that will prevent exposure; shutting off ventilation and using duct tape to close off most openings to outdoors (yes, why not do anything that will save life); avoiding use of fireplaces or other heating or cooling systems that would draw air in from outdoors (but, perhaps using electric heaters or stoves that do not burn oxygen to warm air slowly within the room occupied in order to expand air volume, thereby promoting any air flow in a direction out from the room through any small cracks still open after room closure and taping.

CHAPTER 6

ACTIONS FOR THOSE WHO DO NOT WANT TO BOTHER WITH MUCH PREPARATION

I can understand how most of us do not want to think about terrorist attacks, or at least want to think they will not hit us where we work or live. I usually feel the same way, except that my previous experiences keep reminding me of the prudence, and my obligations, of preparing to save life just in case. Therefore, in this chapter, I will present only the easiest, cheapest, and simplest actions that are likely to save most lives, if not as many as the additional actions presented in Chapter 7.

Most of us, after so many years of hearing about attacks that have been prevented from occurring since September 11, 2001 (9/11) on our soil, have become rather complacent about preparing for such attacks. This is not just due to misinformation propagated to the public, as I have reviewed in the first chapter. Although I have had experience with nuclear weapons and fallout, training emergency personnel in fallout from atomic tests, and managing and evaluating workers who have inhaled plutonium and other radioactive atoms in accidents from a growing nuclear industry of the 1960s in areas surrounding Pittsburgh, I am still largely guilty today of inadequate personal preparations, except for a few instruments, food, and emergency items I keep in the trunk of my car. It is not pleasant to think of such matters when there are so many more pleasant activities in American life today. Also, I no longer have children living at home, although some come with grandchildren once in awhile. But then I think that we live in an area not likely to be attacked. (Am I sure?) Well, with the supplies in my car, and my variety of radiation instruments, maybe my family will be lucky and safe. Perhaps my writing this book will further assuage my guilt.

I present in this chapter mainly the recommendations provided by the Department of Homeland Security, regarding simple steps to keep in mind in order to prepare for optimum survival of a radiological attack, even if you do not want to, or cannot afford to, provide yourself and your family with additional protection.

However, first, before presenting the DHS recommendations, I want you to consider the following additional thoughts that have come to mind in my reading of the DHS recommendations:

- *Before taking off clothing and washing to remove radioactive (or other) contamination, be sure you are not outdoors in freezing weather.* ***It would not be better to die from frostbite or pneumonia*** *than to be exposed*

to a small dose of radiation. It is unlikely you will be contaminated enough or exposed enough to die from radiation before you can go indoors to a safer place, especially if you have ***not*** *been inside the passing cloud of smoke or debris from the explosion, or the mushroom cloud from a nuclear bomb. (See Chapters 4 and 5.)*

- *If you have a Geiger counter survey instrument with a thin entrance window that can be opened to let in beta and alpha, as well as gamma, radiation (but hopefully not over-sensitive), like the instrument shown in Exhibits 26 and 27, check skin and clothing with the open window within about a half inch of surfaces, for yourself and those in the vicinity. If you find* ***readings less than 30,000 counts per minute, be assured you can take your time to wash off and change clothing*** *without receiving anywhere near a lethal internal or external exposure. This is likely true even if you just hold your breath and lift off clothing over your head, rather than cut through it as advised by DHS. Of course, it would be best to dust off any particles that might contain radioactive material before lifting anything over your head and inhaling the dust. (See the experiences in Brodsky and Wald (2004). Also see Exhibits 26 to 29.) Again, the scientific basis for this statement has been presented earlier.*

- *When getting indoors and finding shelter in a room with fewest windows, as advised by DHS, and closing gaps or cracks through which radioactive, chemical, or biological agents can enter,* ***do not then freeze to death indoors if the temperature is lethal****. (YES, putting all the bad jokes aside that are usually aimed at any civil defense measures that might save life, why not follow the advice on using duct tape for protection against internal exposure when it is advised and might well save life!) While the DHS advice is to turn off all heating, air conditioning, and ventilating systems, know that* ***you can still turn on a small electric heater as needed to sustain life, as long as there is still an electric plug around****. If the air is heated very slowly, in fact, the air expands with rising temperature. Any air flow through leaks will then tend to be toward the outside of the room. However, this effect is limited. As DHS advises, if there is an allotment of only about ten square feet (a little more than 3 feet by 3 feet) per person in the room, the room may run out of air for breathing in about 5 hours. Some heating of the air will reduce this time. However, unless the bombing continues for that long, the puff of smoke or debris will have long passed by, and some openings can be made for fresh air. (Listen for information on your emergency radio.) As indicated by the parameters of Exhibit 24 in Chapter 5, a puff of smoke or debris from a bomb will usually pass by a certain point within a few minutes, and the indoor concentrations of toxic materials will not have much time to build up inside structures, except perhaps to a very small percentage of the outside concentration. That is why when outdoor air is deemed to be unhealthy, the weather channels usually recommend that susceptible people (all of us?) stay indoors. Thus, indoor air, which can sometimes be more polluted in some homes than outdoor air, is deemed safer than outdoor air when the outdoor air is seriously polluted.*

- ***Do not burn anything to produce heat****; it uses up air and might produce toxic gases in a closed area. Use only an electric heater, if available, or some chemical heating materials that are available in local stores. Keep heating rates low, to slowly heat and expand the air in the room. If at home, there should be time to run to other rooms to bring in coats and blankets. Huddling together with family members can also help.*

- *If you still suspect that some radioactive or toxic aerosols can creep both through the outside walls and into the safer room, and you know when a puff from the bomb is about to pass, you may breathe through a four-folded handkerchief in through the mouth and out through the nose, as suggested in Chapter 5, or through an inexpensive mask such as the "Industrial Grade" mask with an exhalation valve and two straps, as available in hardware stores.*

- *As indicated in the DHS recommendations, it is still safe to use electric fans inside your shelter as long as they do not tend to draw air in from outside. Some of the research conducted by Dr. Dade Moeller and his graduate students at Harvard showed that more circulation of room air tended to remove from the air the particles with*

radioactive daughter products of radon attached. These fine particles are of the type that can be most harmful when breathed. With fan circulation, they tend to migrate to walls of the room and stick there.

- *Last but not least,* ***at least purchase beforehand some inexpensive personal dosimeters like the color-changing dosimeters exhibited in Chapter 8. This could be the most important action of all****. These light credit-card-size dosimeters can be kept one at home, one in the car, and one in the office. Advantages of such dosimeters in assuring most persons of safe situations, or providing early indications of the need for more protection, are discussed in Chapter 8. They come with simple instructions and advice that can be read in minutes to allow ease of use and confidence in one's own self-monitoring. Most likely, as indicated in Chapter 5, if the color changing dosimeters do not register a significant dose, any internal dose or skin dose from contamination will not be serious. (Check my experiences in Chapter 5 or in Brodsky et al. (2004).) With a little more expenditure, if possible, the pocket dosimeters shown in Chapter 8 should also be purchased, with high enough scales so that you will not panic when it goes off scale at relatively non-harmful exposure levels. These pocket dosimeters also require a charger, to be re-charged if they leak charge over a period of time without any exposure to significant radiation above background. (However, I have been wearing a civil defense pocket ionization chamber ("pocket dosimeter"), CD V-742, with a full-scale reading of 200 R, and without it being re-charged for about 3 years, it still has drifted only down to a reading of 19R. This must be due to some charge leakage across the chamber insulation, because I could not have been exposed during these years to more than about 3 x 0.3 R from natural background sources. Yet, actually this is very good performance, which I am continuing to observe. Without re-charging the dosimeter, I just subtract the present reading from any additional readings I might get when I know I am exposed to additional radiation above natural background.)*

  For even more self-assurance of safety against radiation exposure, the availability of a Geiger counter survey meter, and a higher range ionization chamber instrument (or modern Geiger counter with high ranges), should also perhaps not be too expensive for most Americans if purchased by a group of individuals for the office or neighborhood. The survey meters would then allow checking for radioactive contamination to remove anxieties and panic of most citizens, or to indicate additional measures appropriate for decontamination.

Now that I have put in my two cents, I include below some of the good advice from DHS, with appreciation to DHS staff for its availability. I start first with a form, Exhibit 34, to record and appropriately distribute all of the information you and your family might need after an attack. Subsequent forms are also included from the DHS website for easy reference. These forms are copied here for your convenience and easy reference. There might be some redundancy in these forms, but repetition would be good for you in remembering some of the more important actions for survival.

Brief posters and cards that summarize the most important immediate actions for members of the public are included in Appendix C.



Ready

Prepare. Plan. Stay Informed.

Family Emergency Plan

Make sure your family has a plan in case of an emergency. Before an emergency happens, sit down together and decide how you will get in contact with each other, where you will go and what you will do in an emergency. Keep a copy of this plan in your emergency supply kit or another safe place where you can access it in the event of a disaster.

Out-of-Town Contact Name: Telephone Number:

Email:

Neighborhood Meeting Place: Telephone Number:

Regional Meeting Place: Telephone Number:

Evacuation Location: Telephone Number:

Fill out the following information for each family member and keep it up to date.

Name: Social Security Number:
Date of Birth: Important Medical Information:

Name: Social Security Number:
Date of Birth: Important Medical Information:

Name: Social Security Number:
Date of Birth: Important Medical Information:

Name: Social Security Number:
Date of Birth: Important Medical Information:

Name: Social Security Number:
Date of Birth: Important Medical Information:

Name: Social Security Number:
Date of Birth: Important Medical Information:

Write down where your family spends the most time: work, school and other places you frequent. Schools, daycare providers, workplaces and apartment buildings should all have site-specific emergency plans that you and your family need to know about.

Work Location One
Address:
Phone Number:
Evacuation Location:

School Location One
Address:
Phone Number:
Evacuation Location:

Work Location Two
Address:
Phone Number:
Evacuation Location:

School Location Two
Address:
Phone Number:
Evacuation Location:

Work Location Three
Address:
Phone Number:
Evacuation Location:

School Location Three
Address:
Phone Number:
Evacuation Location:

Other place you frequent
Address:
Phone Number:
Evacuation Location:

Other place you frequent
Address:
Phone Number:
Evacuation Location:

Important Information	Name	Telephone Number	Policy Number
Doctor(s):			
Other:			
Pharmacist:			
Medical Insurance:			
Homeowners/Rental Insurance:			
Veterinarian/Kennel (for pets):			

Dial 911 for Emergencies

EXHIBIT 34 — Family Information and Emergency Plan Form (DHS 2008)

Emergency Supply Kit Items Recommended by the Department of Homeland Security

When preparing for a possible emergency situation, it's best to think first about the basics of survival: fresh water, food, clean air and warmth.

- Water, one gallon of water per person per day for at least three days, for drinking and sanitation
- Food, at least a three-day supply of non-perishable food
- Battery-powered or hand crank radio and a NOAA Weather Radio with tone alert and extra batteries for both
- Flashlight and extra batteries
- First aid kit
- Whistle to signal for help
- Dust mask, to help filter contaminated air and plastic sheeting and duct tape to shelter-in-place
- Moist towelettes, garbage bags and plastic ties for personal sanitation
- Wrench or pliers to turn off utilities
- Can opener for food (if kit contains canned food)
- Local maps

Additional Items to Consider Adding to an Emergency Supply Kit:

- Prescription medications and glasses
- Infant formula and diapers
- Pet food and extra water for your pet
- Important family documents such as copies of insurance policies, identification and bank account records in a waterproof, portable container
- Cash or traveler's checks and change
- Emergency reference material such as a first aid book or information from www.ready.gov
- Sleeping bag or warm blanket for each person. Consider additional bedding if you live in a cold-weather climate.
- Complete change of clothing including a long sleeved shirt, long pants and sturdy shoes. Consider additional clothing if you live in a cold-weather climate.
- Household chlorine bleach and medicine dropper — When diluted nine parts water to one part bleach, bleach can be used as a disinfectant. Or in an emergency, you can use it to treat water by using 16 drops of regular household liquid bleach per gallon of water. Do not use scented, color safe or bleaches with added cleaners.
- Fire Extinguisher
- Matches in a waterproof container
- Feminine supplies and personal hygiene items
- Mess kits, paper cups, plates and plastic utensils, paper towels
- Paper and pencil
- Books, games, puzzles or other activities for children

My Note: Remember to add in at least a credit-card-size, color-changing, dosimeter of the type described in Chapter 8, or at least a RADSticker pasted on personal wallets.

Department of Homeland Security Actions for Protection against Radiological Attack (DHS 2008)

A radiation threat, commonly referred to as a "dirty bomb" or "radiological dispersion device (RDD)," is the use of common explosives to spread radioactive materials over a targeted area. It is not a nuclear blast. The force of the explosion and radioactive contamination will be more localized. While the blast will be immediately obvious, the presence of radiation will not be clearly defined until trained personnel with specialized equipment are on the scene.[53] As with any radiation, you want to try to **limit exposure.** It is important to avoid breathing radiological dust that may be released into the air.

If there is a radiation threat or "Dirty Bomb"

1. If you are outside and there is an explosion or authorities warn of a radiation release nearby, cover your nose and mouth and quickly go inside a building that has not been damaged. If you are already inside check to see if your building has been damaged. If your building is stable, stay where you are.

Close windows and doors; turn off air conditioners, heaters or other ventilation systems.

2. If you are inside and there is an explosion near where you are or you are warned of a radiation release inside, cover nose and mouth and go outside immediately. Look for a building or other shelter that has not been damaged and quickly get inside.

Once you are inside, close windows and doors; turn off air conditioners, heaters or other ventilation systems.

3. If you think you have been exposed to radiation, take off your clothes and wash as soon as possible.
4. Stay where you are, watch TV, listen to the radio, or check the Internet for official news as it becomes available.
5. Remember: To limit the amount of radiation you are exposed to, think about time, distance and shielding.
    - **Time:** Minimizing time spent exposed will also reduce your risk.
    - **Distance:** The farther away you are away from the blast and the fallout the lower your exposure.
    - **Shielding:** If you have a thick shield between yourself and the radioactive materials more of the radiation will be absorbed, and you will be exposed to less.

As with any emergency, local authorities may not be able to immediately provide information on what is happening and what you should do. However, you should watch TV, listen to the radio, or check the Internet often for official news and information as it becomes available.

For more general information from the Department of Homeland Security, see "Are you Ready?" from Federal Emergency Management Agency. Also, keep up-to-date on information provided by DHS by entering ready.gov in your search engine.

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53 I, the author, am not happy with this sentence. It illustrates the mindset of those in many important homeland security positions who do not realize the ready availability and life-saving value of the inexpensive and reliable SIRAD family of dosimeters discussed in Chapter 8, Appendix I, and elsewhere in this book.

Answers to Important Questions about Chemical, Biological, and Radiological Protection from DHS (DHS 2008)

Below are the answers to many frequently asked questions the Department of Homeland Security has received in response to information provided on Ready.gov. We hope you find the additional information below helpful. Please note that these questions are designed to supplement information on Ready.gov, so please be sure to consult that guidance first.

Most importantly, as you consider family preparedness, we urge you to remember that the best thing you and your family can do during an emergency is to listen to messages from your local emergency managers, broadcast on radio or television. They will tell you when to shelter-in-place and when to leave the area. They will provide you with the best ways to protect yourself and your family. With that information, and the preparedness information provided on Ready.gov, you will be better able to take appropriate action quickly and decisively.

What type of event would require sheltering-in-place?

- Emergency officials would likely advise individuals to shelter-in-place when the chemical is expected to dissipate in a short time period, there is not time to evacuate, or chemical fumes could quickly overtake you if you do not seek shelter immediately.

Can you really shelter-in-place?

- Studies have shown that taking steps to temporary seal off a room using common materials enhances the safety of a room against the impact of a chemical plume.
- The temporary shelter created by a shelter-in-place room definitely provides more protection than basic sheltering, i.e. going indoors, closing windows and doors and shutting off HVAC systems.

What room should you choose to shelter-in-place?

- You should take into account which room will be the quickest room to seal in order to prevent chemicals from entering the area.
- People often select a bathroom as they often are located in the interior of a home and tend to have few, if any windows. They also allow for the use of facilities while sheltering-in-place.
- Other rooms that may be appropriate include other interior rooms, rooms with one small window, or rooms with no exterior doors.

What room should we use if we don't have a room without windows?

- The best room is the room with the fewest windows and doors. Since each opening will require time to seal it off, minimizing the number that you will need to seal will shorten the time it takes to reduce airflow into the room.
- The room should be easy to get to and provide adequate space for family members.

Why does the government recommend duct tape and plastic sheeting?

- The items can be used to "shelter-in-place," creating a room with reduced air infiltration of chemical agents into an area.
- They are resistant to permeation from chemical agents.
- They provide the ability to rapidly exit from a temporary shelter-in-place once the plume has passed.
- The items are readily available for the general public.

Is there a particular type (brand) of duct tape that citizens should buy?

- DHS recommends using duct tape with a **minimum thickness of 10** mil (0.01 in).
- DHS does not recommend particular brands.

Can you use other types of tape?

- If you do not have duct tape, any tape that will help seal off a room and hold down the plastic sheeting can be used.

What is the most effective type of plastic sheeting?

- DHS recommends using plastic sheeting with a thickness of 4 to 6 mil (0.004 in. - 0.006 in.) or greater.
- For reference, commercially available sheeting is typically sold at 0.7, 1, 1.2, 1.5, 2, 2.5, 3, 4, 6 and 10 mil.

Can you use garbage bags instead of plastic sheeting?

- DHS does not recommend using plastic garbage bags instead of plastic sheeting as the thickness of the plastic is below the recommended 4 to 6 mil thickness.

Will shrink-wrap plastic used for weatherproofing work?

- DHS does not recommend using shrink-wrap plastic.
- The double-faced tape to secure the shrink-wrap in place has not been tested with chemical agents.
- Installing shrink-wrap plastic would take more time than using plastic sheeting and duct tape, due to the two steps required (adhesion to the frame using double sided tape and use of hair dryer to achieve a tight fit).

Do these precautions work? How safe will we be? How effective is taping and sealing a room?

- Studies have shown that using duct tape and plastic sheeting to shelter-in-place during a chemical or biological attack provides additional protection to people sheltering-in-place beyond that provided for by the structure of the house alone.

Is it 100% guaranteed to work?

- While it isn't considered guaranteed, studies have shown that using duct tape and plastic sheeting to shelter-in-place during a chemical or biological attack provides additional protection to people sheltering in place beyond that provided for by the structure of the house alone.

What is the science behind the recommendation to seal off rooms?

- Duct tape was tested as part of a study on chemical protective clothing materials.
- In this study, it was concluded that duct tape provided at least a temporary seal against permeation by stimulants of common chemical agents, including GB, VX, mustard and pesticides.
- Depending on the chemical agent, duct tape resisted permeation by a liquid agent for 3 hours to more than 24 hours.
- The study tested duct tape of 10 mil (0.01 in.) thickness.

- Plastic sheeting was tested as part of a test using live chemical warfare agents conducted at the Chemical Defense Establishment in Porton Down, England in 1970.
- Agents tested included H and VX. Varying thicknesses were tested, including 2.5 mil (0.0025 in.), 4 mil (0.004 in.), 10 mil (0.01 in.) and 20 mil (0.02 in.).

When should someone evacuate versus sheltering-in-place?

- Local officials are the best source of information when determining whether to evacuate or shelter-in-place.
- In the event of an emergency, individuals should listen to their radios and follow the directions of the emergency officials.
- In general, sheltering-in-place is appropriate when conditions require that you seek immediate protection in your home, place of employment, school or other location when disaster strikes.
- People should take steps to prepare in advance in case local officials direct you to evacuate. This includes having a disaster supply kit that is portable and can be taken with you.

What should be taped and sealed in the room I choose?

- Individuals should precut plastic to fit over the entire openings of windows and doors, including the frames. In addition, plastic should be cut to cover vents and ventilation fans.
- Cut the plastic a minimum of 6" wider than the opening. This will make it easier to put up the sheets if needed.

Do I need to disconnect water lines in order to tape over the opening?

- No, you do not need to disconnect water lines. However, you should make sure that the area where the pipe comes through the wall is properly sealed to eliminate airflow with an appropriate sealant such as caulk.

Do I need to tape over drains and faucets if I use my bathroom?

- You do not need to tape drains or faucet openings. However, you should seal around water pipes coming through the wall into the room. This can be done in advance with caulk or other appropriate material to eliminate any air leaks.

Should I cover the dryer vent to the outside?

- You should cover any opening from the room. This includes a dryer vent if there is a washer/dryer located in your shelter-in-place room.

How long can a family stay in a sealed room? Will we run out of air to breathe?

- DHS recommends that individuals allow ten square feet of floor space per person in order to provide sufficient air to prevent carbon dioxide build up for up to 5 hours assuming a normal breathing rate while resting.
- Many chemical releases would be diluted within a few hours, so the direction to shelter-in-place would likely be made for a short time period while a chemical cloud dissipates.

If we bring plants into our shelter-in-place room will we be able to stay in the room longer if needed?

- Bringing plants into the shelter-in-place room will not extend the time you can stay in the room.

Should I seal up the room ahead of time?

- DHS recommends that you precut plastic sheeting for any windows, doors, vents or openings and label them appropriately.
- The plastic should then be stored with duct tape and scissors in the designated shelter-in-place room so that it can be quickly accessed and installed.
- DHS does not recommend that you install the plastic sheeting in advance.
- You can, however, make sure that any areas that can be permanently sealed such as where pipes come out of the wall or where trim meets the floor and walls, are properly caulked. This will also help reduce heating and cooling costs so is a good idea overall.

Should I seal my whole house?

- No, you are better off moving quickly to a designated shelter-in-place room and seal the room to reduce air flow from the outside into the room.

Is using wet towels over your mouth or at the bottom of doors and windows effective?

- You should cover your mouth and nose while seeking shelter, but it should not be relied on as a safety measure in place of getting to shelter immediately. Covering your mouth does not prevent exposure to chemical vapors, however it is effective for smoke and for aerosols (such as would be released in the immediate area of a biological attack).
- In studies, using a dry folded handkerchief was the most effective filter for particulates or aerosols.
- Using wet material such as a towel or handkerchief actually reduced the effectiveness or filtering from vapors. In addition, wet materials are more difficult to breathe through.
- Placing a wet towel at the bottom of a door or window provides no protection against vapors entering a room.

Can you use fans in a room after you seal it off?

- The purpose of shutting off your home's furnace, air conditioning and fans is to reduce the airflow from the outside to the inside of your home.
- Operating a fan within a sealed room will not bring air inside and, as such, can be used. Take precautions though, so that the fan does not affect the seals that prevent air from entering the room.

Why do you shelter above ground for a chemical and biological attack vs. below ground for a radiological or nuclear attack? What floor of the house should the shelter-in-place room be located on?

- In a chemical attack, the contaminants are typically distributed in an aerosol that is heavier than air near the release of the chemical. As such, it will settle to the ground.
- However, as the vapor plume is carried down wind, the concern about settling in low-lying areas is reduced.

- With this in mind, the best room for sheltering-in-place is the room that is the most convenient for your family to quickly get to and seal that is large enough to provide appropriate air for several hours.
- With regards to a radiological or nuclear attack, the more shielding, distance and time you can take advantage of after such an attack, the less exposure you will face.
- The additional distance from the blast of a nuclear weapon provided by being below ground also offers an increased level of protection.

Can we shelter-in-place using a whole basement? Is the basement dangerous because the vapors will settle in low areas of the house?

- If your basement offers the easiest location to tape and seal all windows and doors, then it may be the best location for your family even though it is below ground.
- Since each opening will require time to seal it off, minimizing the number that you will need to seal will shorten the time it takes to reduce airflow into the room.
- The room should be easy to get to and provide adequate space for family members.

What should I do when the plume has passed by? How long will I need to stay/how long should I stay in the shelter-in-place room?

- You should remain in your sealed room until local authorities notify you that it is safe. Pay close attention to all official warnings and instructions to proceed.
- You should include a battery-powered radio with extra batteries in your emergency supply kit that you store in your shelter-in-place room for this purpose.

Will my house be contaminated with chemicals?

- If the plume passed over your house there is a potential for contamination, especially to fabrics, carpets, and other materials, although it is unlikely to pose a significant threat. Local officials will advise you if your house is safe and what actions to take after a chemical emergency.

Is it safe to touch objects in the house? Outside the house?

- Unless there was contamination by a liquid form of the chemical, objects in or out of the house should not pose a significant health risk, however one should take precaution and not touch or handle items or surfaces that were potentially exposed to the vapor cloud, especially outside the house.

Why do you recommend having three days worth of supplies if you'll only be sheltering for a short time?

- Disasters can sometimes make it unsafe for people to leave their residence for a period after the disaster hits.
- The need for long-term sheltering-in-place, e.g. having a three-day supply of food and water, is important for families preparing for emergencies where supplies to stores, electricity and water are disrupted.

What should I do if I'm outdoors when a chemical attack occurs?

- If the release is outdoors and you are near the contaminated area, seek shelter inside a building.

- If you are not in the contaminated area, move away from suspected areas of contamination and avoid moving downwind of the area of the attack.

What should I do if I'm not at home when a chemical attack occurs?

- If you are indoors and the release is outdoors, shelter-in-place in your location until notified by authorities that it is safe to leave the building.
- If you are indoors and the release is in your building - go outside if you can avoid passing through contaminated areas. Otherwise, go to your shelter-in-place location or move as far away from the contaminated area as possible.
- As in all emergencies, follow instructions from local emergency officials to determine when it is safe to evacuate.

What if I can't get to a shelter-in-place location that can be sealed?

- Move quickly to a small room with the least amount of windows and outdoor walls. Use any material in the area to block air from easily flowing into the room. This can include packing tape, rugs, plastic bags, newspaper or clothing. These are not the preferred materials for sealing a room, but would be better than no protective measures.

What should I do if I'm in my car when a chemical attack occurs?

- If you are in a car and are not in the immediate contaminated area, close windows, turn off vents and drive away from the area. Avoid going downwind of the area.
- If you are in the contaminated area, seek shelter immediately. If you cannot get into a building to shelter, stay in your car with the windows rolled up, engine off, and vents closed.

What should I do if I've been exposed to a chemical attack?

- Remove all clothing and other items in contact with the body. Cut contaminated clothing off that needs to be removed over the head to avoid contact with eyes, nose and mouth. If possible, put contaminated items in a plastic bag and seal.
- Wash hands thoroughly with soap and water.
- Remove contacts or glasses. Put glasses in a pan of household bleach to decontaminate. Flush eyes with lots of water.
- Gently wash face and hair with soap and water and thoroughly rinse with water.
- Decontaminate area of the body likely to have been contaminated. Blot - do not swab or scrape) with a cloth soaked in soapy water and rinse with clear water. Change into uncontaminated clothes.
- Listen to local authorities for specific instructions.
- If possible, proceed to a medical facility for screening.

How can I help those who have been exposed to a chemical attack?

- Help them through the steps outlined above, using extreme caution not to expose yourself to the chemical agent.

What does the government recommend as to the use of gas masks or protective hoods? Why doesn't DHS include information on gas masks and hoods as part of its recommendations?

- The use of gas masks and hoods by the public during a chemical threat is not recommended due to legitimate safety concerns.
- Improper use of masks and hoods as well as a false sense of security as to their effectiveness could pose a threat to public safety.
- For example, it is difficult to obtain a proper seal with the mask if you have facial hair such as a beard or long sideburns.
- Protective masks do not fit small children.

Note: Studies are ongoing and technology is evolving in the area of protective masks and hoods. We will continue to update the public as new products and information become available.

This completes the questions and answers obtained from the DHS website in February 2008.

Further comments to note (another two cents)

- In covering openings or windows with plastic, the DHS recommendations give evidence that at least a **10 mil thickness** is needed, and that garbage bags will not do. However, it is likely that garbage bags will be available in most locations, while other preparations might not have been made. I checked my own big, black, **garbage bags** at home (the ones my wife packs all the house trash and garbage in for me to take out) and found the box indicates a thickness of 1.1 mil (28 micrometers, reading 28 μm); the white, thinner, smaller-size, garbage bags that hold our daily garbage were 0.95 mil (24 μm). Two sides of the black bag together would be over 2 mil thick, and two sides of the white bag would be almost 2 mil. Therefore, if you are in a bathroom, for example, with only one window to the outside, you need only to tape five bags over the window with sufficient tape to seal all openings. Somewhat analogous to layers of clothing in the winter, the ten layers of plastic with some air between provide the additional protection of the air layers; chemically or biologically contaminated droplets would thus have much more surface area on which to be deposited rather than entering into your room. This would provide considerable protection against chemical or biological agents, as well as reduce any presumed concentrations of radioactive material to very safe levels.
- The bathroom of a home, or the restrooms of other buildings, might be a good choice for immediate temporary shelter, in those homes not damaged by any blast. In homes with a basement, the basement bathroom might be the best choice. In a home, the size of an average bathroom with tub would have ample square feet, and thus air, for 3 or 4 family members and usually no more than one window. Also, if power is still on, the tub could be cleaned and filled with water for any emergency needs, the sinks could be filled with water for washing off contamination, and the toilets could be used for disposal of paper and human wastes, at least on a temporary basis. Also, we keep soaps, towels, lotions, and some medical and first aid supplies in the bathrooms. Filling the tub with water, laying down mats or blankets, and having the family lie beside the tub for the immediate hours after an attack, with the youngest next to the tub of water, could also provide another factor of at least five protection of the youngest that almost certainly would reduce external radiation exposure to levels below those that would produce serious harm.
- If not at home, note and perhaps post as a reminder the exhibit in Chapter 5 showing the shielding obtainable above and below ground in various structures. Remember my advice to my wife to call our

cousins and invite herself to the middle floor of a high rise, where shielding of floors above and below would be protective from radiation, and one would be high enough above ground to probably avoid any chemical or biological exposure. Other actions will become common sense if just a few of the principles of protection are remembered.

- Listen to your emergency radio and TV stations, or obtain information in any way possible about conditions outdoors. However, interact with your county and local officials, and your emergency responders in advance, to be sure they are really familiar with not only instructions from the Federal agencies, but with the facts about radiation risks and levels of radiation likely to produce serious effects, as reviewed in Chapters 4 and 5.

Problems with some current responder training

My friend Marlow Stangler and I have attended some major county and local training sessions that used training materials provided by cognizant agencies. Marlow is the friend with whom I conducted two courses in 1957 at the Nevada Test Site, showing police, firemen, and other emergency officials how to monitor radiation in actual fallout from nuclear bomb tests. We showed them how to use not only Geiger counter instruments, but also the higher range instruments (based on ionization chambers) that would allow them to estimate exposure rates when they were up into the R per hour range or higher. In those days, we found all of these people capable of understanding the dependence of risk on the amount of exposure, and able to perform duties in radiation fields. Their general comments about the courses were favorable (Stangler and Brodsky 1958).

Now, in present "homeland security" courses for responders, after showing attendees the terrible effects of high exposures on the order of thousands of rad (millions of millirad), which have occurred in peacetime in the rare cases of radiation accidents, the trainers then spend most of the training time using so-called "pagers" that go up scale at only three times background or so (0.03 mR/hr). These are types of sensitive instruments that police or border security agents should be using **only for** detection of clandestine radioactive or nuclear material crossing our borders; responders should **NOT** be training to use them in recovery or life saving operations, and thus become frightened about insignificant radiation exposures. These responders are accustomed to face serious risks to save life in their daily work.

Perhaps the problem with current training is that those who have been employed by homeland security agencies today as experts in radiation protection have not had experience with the higher levels of radioactive contamination that might exist after the detonation of an RDD or nuclear bomb. Those of us who were able to experience the higher levels of radiation before above-ground tests were ended by international agreement in the early 1960s, and who trained responders in both low and high intensity radiation fields, found it necessary and easily accomplished to train responders to measure radiation at all levels and to rapidly assess their own exposures under emergency rescue conditions (Stangler and Brodsky 1957). Stangler (2004b) provides a review of past and present training programs. Stangler (2004a) reviews current responder and homeland security capabilities of the many government agencies now involved, and their coordination of activities.

In previous chapters I have reviewed my experience with the management of highly contaminated patients in a hospital environment, showing how it is possible to interact with such patients without being subject to significant personal contamination among hospital staff. Below, I will briefly describe my experiences with external radiation and contamination in fields of radiation in the early hours and days after detonation of nuclear bombs.

Personal Experiences with Higher-Level Fallout from Nuclear Bombs

Experience recovering my neutron detectors after a hydrogen bomb detonation: In my second tour at the Pacific Test Site, Operation CASTLE, I had my own project to provide a confirmation of other neutron spectral and dose measurements from hydrogen bomb devices, using fissionable elements faced against nuclear track-reading photographic emulsions (Hanscome et al. 1955; Brodsky et al. 1956). At the last moment, I finally developed an electrochemical procedure that provided me with hard adherent deposits of four fissionable elements plated on platinum discs (Brodsky et al. 1958), and proceeded to the Pacific Test Site a week after my boss's team had left, in time to place my detectors at varying distances from ground zero of the hydrogen bombs to be detonated.

After the detonation of the BRAVO device on March 1, and the ROMEO device on March 27, 1954, I was scheduled to be flown two days after the second detonation to pick up my fission track neutron spectrometers. However, radiation measurements from helicopters indicated that radiation intensities were still too high on day 2, so my recovery was delayed until day 3. As mentioned in Chapter 5, on day 3, I jumped off a helicopter into a radiation field one million times higher than three times background (30,000 mR/hr) in order to pick up my neutron spectrometers in the fallout fields remaining 3 days after the second H-bomb detonation and within about 0.8 to 2 miles of ground zero. (See Exhibits 35a-c.)

***This exposure rate in which I retrieved my detectors was one million times the rate of 3 times background that responders are today being trained to take seriously**.*

It took me about 5 minutes to run and pick up all of my detectors and jump back onto the helicopter when it arrived. After that, to check my contamination I picked up with my right hand my ion chamber survey meter (the one then called a "Cutie Pie," which had a cylindrical ion chamber in front of a case with its electronic circuit), hanging on to a pole with my other hand for dear life, since I was looking down into the Pacific through the unclosed hatch as the pilot banked around. The Cutie Pie was designed to measure gamma radiation up into the R per hour range. I found my booties to be reading about 10,000 mR/hr at a few inches during the entire 20 minutes it took to fly back to the aircraft carrier where I could disrobe and shower.[64]

My exposure on my belt-level film badge, which was evaluated later by the task force's radiation safety laboratory, had received only about 2.5 R (2,500 mR). Later evaluations by others at the Nuclear Test Personnel Review (NTPR), where I worked from 1997 to 2006 (see Chapter 5), showed I received up to perhaps 30 rem (30,000 mrem) to my lower legs. ***I am still here and healthy over 56 years later**. If requested as a member of a recovery team,* ***I would do the same thing ten or more times today to save the lives of others.*** *Even ten such 5-minute rescues would expose me to no more than a 25 rem effective whole body dose. I am sure that any fireman or responder would do the same, if not frightened by*

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64 At this point, I want to again remind the reader that I much prefer, especially for practical field use and emergency evaluations, using the conventional units described in Appendix A, rather than the so-called "Special SI Units" promulgated as recommendations of the International Commission on Radiological Units. Some military and professional organizations in the United States insist on adopting the newer SI units. In my teaching as well as practice, I have found that the newer special SI units are only an advantage in the practice of radiation therapy physics. In emergency work and health physics practice, there are dangers as well as inconveniences that lead to mistakes when using the ICRU special units. Although I have, unfortunately, not published the many problems with the SI units, I have included in Appendix E the slides of Anastas et al. (2003), which provide a number of illustrations of the absurdities of new SI units, recommended by the ICRU in the 1970s. The Nuclear Regulatory Commission, after thoroughly examining the issue, wisely decided (without my personal input) to remain with the older conventional units in its early 1990 regulations. For international communications, any data from United States activities that are recorded in the older conventional units can easily be converted to the newer SI units with the simple conversions shown in Appendix A. For only one example, gamma radiation begins to cause some health effects at a dose of 1 Sieverts = 100 rem. If a responder familiar with much of the available radiation measuring equipment mistakenly, under emergency conditions, interprets a reading of 6 — on an instrument to be read in the newer SI exposure units of coulombs per kilogram — incorrectly as only 6 R or 6 rem, he could exposure himself to a lethal dose of radiation (up to about 3,800 rem) during a rescue. If the instrument was supposed to be read in Sv and the reading was 25, an incorrect interpretation would allow a 2,500 rem lethal dose.

some of the limited information in some of the present homeland security courses. The public as well as responders should become familiar with the tables showing levels of radiation exposure or dose and degree of risk or health effects. Then, all should learn to think in terms of dose rates in R per minute, and R per second, not just in R per hour. Practice converting R per hour into R per minute and R per second to determine limits of time for important life-saving actions is required for rapid decisions and movement.



EXHIBIT 35A — Cartoon of Lt. Brodsky Retrieving His Neutron Spectrometers in 30,000 mR per Hour Field.

(Illustration by Jim Adcock, Adcock Studios, Snow Hill, Maryland)

Based on my later exposure readings, I estimate that I took about five minutes in this field on the island to pick up my multiple, fission-track, neutron spectrometers, place them in a bag, and carry them back to where the helicopter was to pick up me and my colleague, Don Willett. I had been dressed in cloth protective overalls that completely covered my body, except my face, to protect me from any airborne radioactive fallout (contamination) that might attach to my body. No mask was worn, but openings between my boots and pants, and gloves and sleeves, were taped, as well as other openings. My head was also covered. The spectrometers were in small brass cylinders that had been placed within steel blast bunkers at various distances of about 0.8 to 1.5 miles from ground zero of ROMEO Shot.



EXHIBIT 35B — Brodsky jumping back onto helicopter after about five minutes on the island.

(Illustration by Jim Adcock.)

My co-worker, physicist Don Willett, had already jumped onto the helicopter first after picking up his own neutron activation spectrometers. I, having been health physicist enforcing contamination control at Naval Research Laboratory in 1950-52, wanted to first sit on the helicopter floor, take off the cloth booties and leave them on the island, knowing they would be heavily contaminated by the sticky sand, but Willett had already contaminated the aircraft.

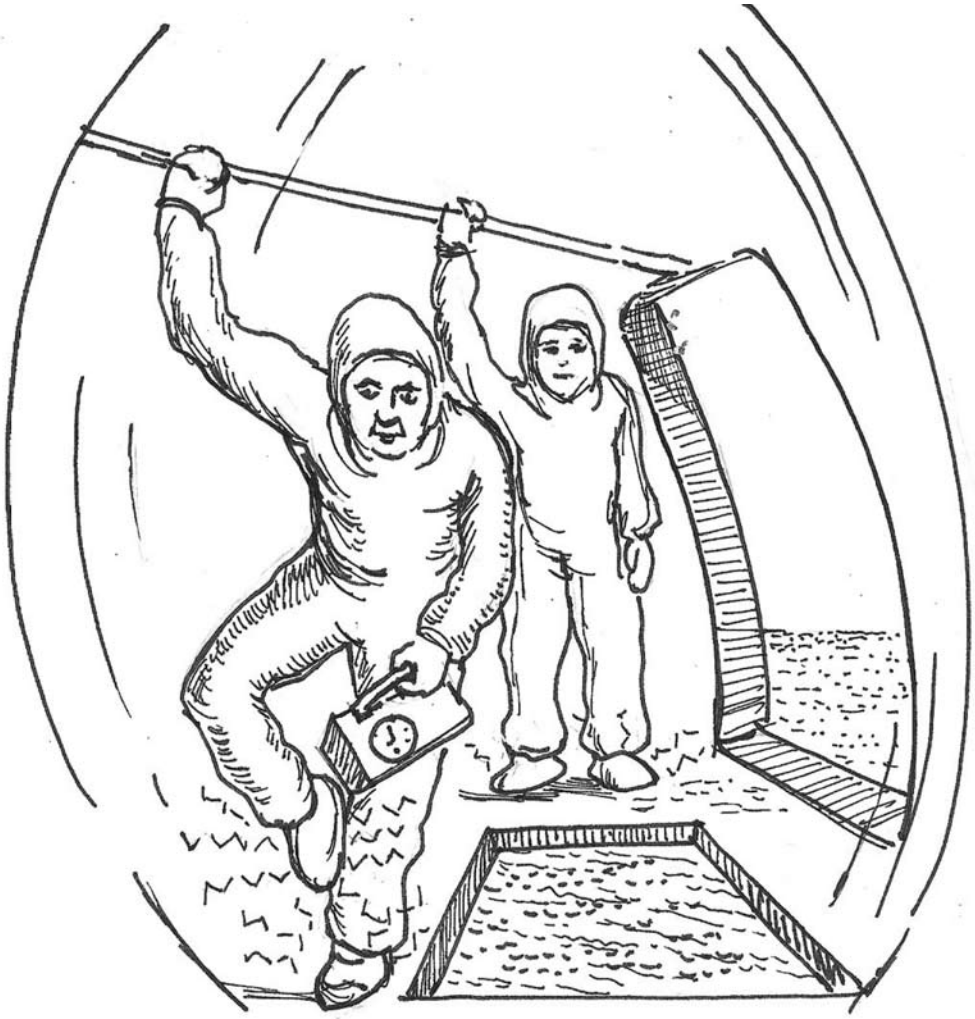


EXHIBIT 35C — Brodsky in helicopter on 20-minute ride back to aircraft carrier, holding on for dear life and reading 10,000 mR per hour at a few inches from booties.

(Illustration by Jim Adcock)

The trap door below me had not been shut and I was looking down into the Pacific. Therefore, I could not let go of the pole and take off my booties. By the time I got back to the aircraft carrier, disrobed, showered, and turned in my film badge, I had received about 2.5 R exposure at my waist level, and up to some tens of rad to my lower legs, as reported from the Task Force film badges and later assessed when I was employed in 1997 in the Nuclear Test Personnel Review program. If I had stayed on the island for one day, I would have received a lethal dose of gamma radiation.

Remarks about the accuracy of my film badge exposure readings: This story will be of particular interest to those who have used film badges for personal dose assessment. Some papers and books in the literature, and many verbal remarks I have heard, have unfairly assessed questions of accuracy of radiation exposure measurements with film badges. I also was skeptical about the 2.5 R reading of the military unit at CASTLE when they reported to me this reading. I had worn, throughout my over two months in the Pacific Test Site, a film badge for which I had previously developed calibrations when I was Head, Health Physics Unit, at the Naval Research Laboratory (NRL). My NRL badge was reported to read 7 R after I returned to NRL and it was processed and evaluated there. At that time, I tended to believe that I had received a whole body average exposure of 7 R (which would imply an average dose of about 5 rad or 5 rem to the body), and did not believe that the 2.5 R reading received from the military unit in the Pacific was correct. However, at that time, we were using the NRL badge in the Washington, DC, laboratories with a two-week turnover rate, and most badges were used under lower temperatures and humidities than were prevalent on the Pacific islands.

In 1961-62, my first graduate student, Ronald Kathren, prevailed upon me to help him set up an experiment for his M.Sc. project in which film packets were exposed to radium gamma rays under various temperature and humidity conditions, and for various exposure times. Publications based on these experiments, particularly Brodsky and Kathren (1963), Brodsky (1963), Kathren and Brodsky (1963), and other reports (Poston 2007), demonstrate the sources of error resulting from long wearing periods in high temperatures and humidities, in film badges unprotected from humidity except for the paper wrappers (similar to dental packets). The data showed that an increased fogging effect occurred after about 6 weeks in a high temperature, high humidity, environment, that overcame the fading effects in such environments. This explained the fact that the 7 R reading of my NRL badge, worn for over two months close to my body at high temperatures and humidities in the Pacific environment, was actually the one in error, and that the 2.5 R exposure reading of the military unit was more likely correct. This conclusion was also later further confirmed by evaluations of my colleagues on the Nuclear Test Personnel Review at Science Applications International Corporation, after 1997. The NTPR evaluations were based on recorded exposure rates documented in the NTPR library reports, which cover all of the nuclear test operations, and locations of personnel involved in the nuclear tests.

Protective Actions When Outdoors in Fields of Gamma Emitting Contamination

*As described in the section, **"How to estimate radiation exposures received from nuclear bomb fallout over time…,"** of Chapter 5, I received 2.5 R when recovering my neutron spectrometers from a contaminated island 3 days after the Operation Castle second hydrogen bomb detonation. I was on the island for about 5 minutes. I am assuming that the reading of my film badge at waist level was due in most part to my exposure on the island. As estimated in Chapter 5, the contamination on my booties could have contributed only about 23 mR to my average whole body exposure, but several tens of rad to my feet and lower legs. If I had stayed on the island for several days my total exposure would have been 100% lethal. Staying for one day would have given me over 400 rad, with possibly only a 30% chance of survival after severe radiation sickness.*

Of course, most citizens outdoors at the time of a detonation would have some kind of house or shelter that could be entered and closed, with quick actions to provide shielding, according to examples given in Chapter 7. The following describes a worst-case scenario based on my experience at Operation CASTLE, if no helicopters or other rescue equipment had been available to retrieve me from the island.

Knowing the simple information on shielding in this book, I could have remembered that about 7 inches of sand will decrease the gamma radiation intensity to one-fifth. Then, I would have scraped clean with my booty an area of contamination large enough to make a trench to lie in. Then, I would have cleaned my booties by scraping them against clean sand underneath the top layers. Then, I would have dug a trench deep enough to lie in or sit in within the cleaned

area. Then, I would have built a raised berm of sand around the trench to give me about a 14-inch thick berm, which would reduce direct gamma radiation to about (1/5)(1/5) = 1/25. This amount of sand, if surrounding me, would reduce the direct gamma exposure behind the berm to about 430/25 = about 17 rad, which would not make me ill if I lay down in the trench, or even sat up with my head below the berm level. Of course, there would be considerable gamma radiation scattered from the air above the trench that would come down toward the trench, but this would give an additional dose that would still not add up to be lethal. In any case, while lying down (which I find easy to do) and thinking about good things or writing poetry in my head, I could cover my chest and legs with sand and reduce the scattered gamma rays to lower levels. If I had a canteen of water, I could then wait for days to be rescued. Lots of people knew where I was.

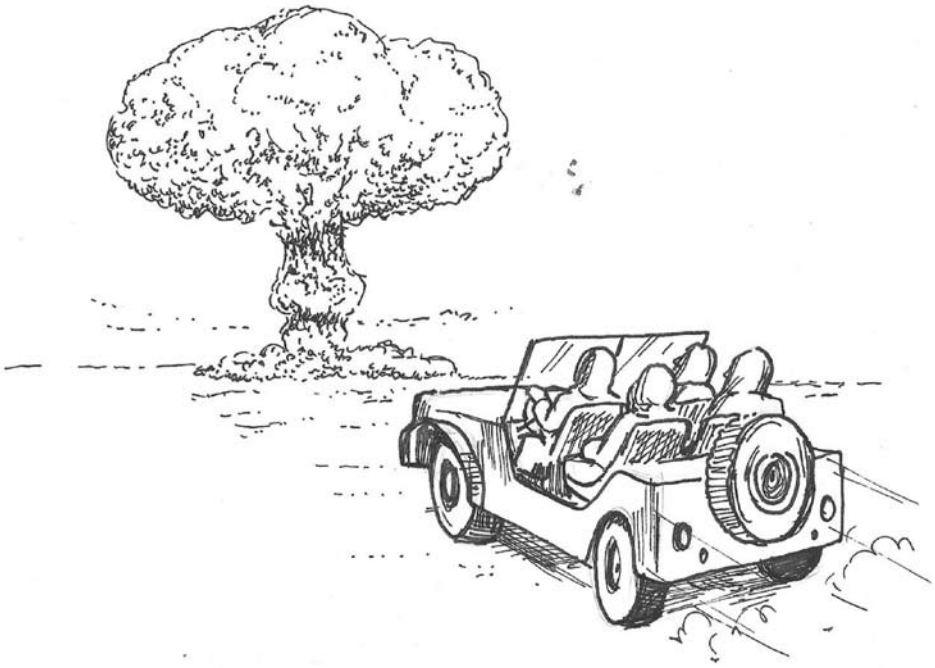
Or, if stuck on the island for a day, I could have immersed myself in the ocean near the island and enjoyed a swim for a good while, tiring myself so that I could run back to my trench for a good nap. After only a few hours following the nuclear detonation, the ocean water would be rather cleaned of radioactive contamination. As indicated elsewhere, I knew a major (Dr. Payne Harris again), who was a physicist and also a physician who had expertise in radiobiology as well as radiation physics; he swam for more than one-half hour in the lagoon near ground zero after the 1952 hydrogen detonation. He received some gamma and beta exposure from this swim, and his committed effective internal dose from participation in many nuclear test operations was less than about 10 rem. He lived to become an active octogenarian over 54 years later. Rapid methods for calculating gamma and beta doses from swimming in contaminated water are presented in Brodsky (2004d).

These rapid actions would also reduce the skin doses from beta radiation, if care is taken to be sure that the sand enveloping you is sufficiently clean of contamination, which will usually not penetrate to more than a couple of inches into the ground. Beta exposure to lower extremities when walking in fission product fields could be 10 to 30 times or more higher than the dose estimated from badges worn at the waste (see my booty experience and the reference Barss and Weitz (2006)). Remember that the Rongelap natives, who were outdoors as the fallout descended, had beta doses up to about 6,000 rad at places on uncovered skin, while their gamma doses were not quite up to that of a 200 R exposure. Skin doses of 200 rad could produce erythema (reddening) of skin within hours; skin doses of more than 1,200 rad would produce permanent skin damage (Jarrett et al. 2007; Strom 2003). It should be noted that the fallout that descended on the skin in the case of the Rongelap natives was in the form of large flakes, looking like snow, that remained on skin in non-uniform patterns. Thus, the 6,000 rad doses caused pain and permanent scarring in areas where particles remained for a length of time, but the damage was not lethal to the exposed individuals.

Conclusion: *So, with the information in this book, it is clear that the Rongelap natives who were exposed outdoors to the BRAVO Shot fallout on March 1-2, 1954, and who received almost lethal gamma doses and beta doses that caused serious burns, could have protected themselves with a recognition of the nature of the fallout, and some simple "things to do" for their protection. We Americans (and of course the natives) are lucky that the wind did not carry a little more fallout to these natives and kill them all (e.g., a movement of the wind pattern in Exhibit 11 a bit more to the East and Southeast). The same sort of simple actions described here could obviously save many lives after a terrorist attack involving nuclear weapons fallout.*

Experience Training Responders in Radioactive Fallout from Nuclear Detonations

Exhibits 36a-b illustrate another experience in which, during the FCDA training course for responders at the Nevada Test Site in 1957, I drove a jeep with police and firemen through ground zero after an atomic detonation, explaining how if they move rapidly in a high, but limited field of radiation, they can save life by knowing their exposure rates and limits to avoid their own health effects. In this exercise, the maximum exposure of any of the personnel in the jeep was only 0.5 R (500 mR)(Stangler and Brodsky 1958).



EXHIBITS 36A — Brodsky heading toward ground zero at Nevada Test Site in 1957 in jeep with responders in training.

(Illustration by Jim Adcock)

This exercise aimed to show how fast movement to save life can limit radiation exposures to safe levels. We wore both pocket chambers and film badges to measure our total cumulative exposures, and carried both low- and high-range survey meters to assess instantaneous changes in exposure rates. We were all suited up in protective coveralls, gloves and booties.

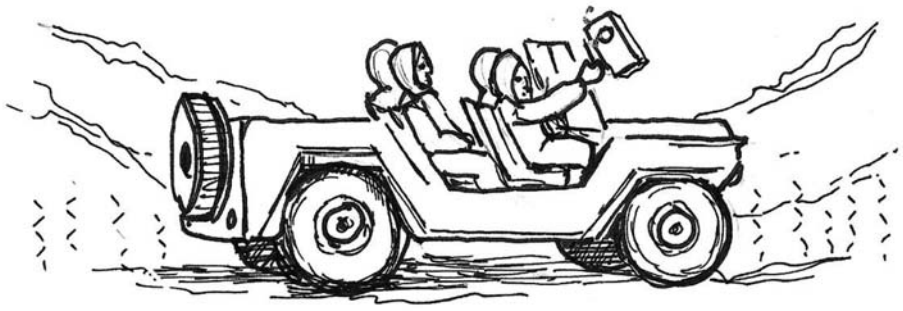


EXHIBIT 36B — Passing through and from ground zero with jeep full of responders.

(Illustration by Jim Adcock)

Areas near ground zero were in the R per hour range. Driving at about 30 miles per hour, the highest exposure received by any of us was only 0.5 R, which is received by many in the world by natural background radiation in one year. No significant radioactive contamination remained on us after the training session was over.

An important issue in training responders and educating the public: Dangers of setting control boundaries, cordoned-off areas, or signs limiting access, at low levels such as 2 or 10, or even 100 mR per hour

It can be extremely counterproductive and even dangerous to set boundaries or signs at the lowest levels as recommended in NCRP reports (NCRP 2001, 2005). In respect to the recommendations for a 10 mR per hour boundary, within which evacuation is recommended, the NCRP report recommendations are absurd, even though they are made by reasonable and expert scientists. These scientists have not experienced the significant levels of environmental contamination that could result from detonation of an RDD or nuclear bomb; nor have they dealt with the management of rescue operations under such conditions. Except for smaller amounts of contamination that might be released in inefficient RDD explosions, any fallout from nuclear bomb explosions could extend over hundreds of square miles, with perimeters at the 10 mR per hour level that could extend at least tens of miles around. (I believe that only "Improvised nuclear devices" (INDs), the smaller nuclear bombs, are considered in the NCRP reports.) There certainly would not be enough responders available to cordon off such areas, even if it were advisable under these kinds of emergency conditions. Responders would be busy with more important rescue activities. They are also accustomed to facing far greater dangers than fields of 10 or 100 mR per hour. Members of the public would be better advised to immediately find the best shelter, rather than evacuate such low-level radiation areas and possibly be outdoors when fallout arrives. Earlier chapters provide experiences that show why this is so.

These aspects of the NCRP recommendations, as opposed to the other valuable information in them, are unfortunate, because many government agencies respect NCRP recommendations and are promulgating them in their emergency preparations. I know many of the NCRP committee members who have prepared these recommendations and respect the entire group for their expert scientific and practical knowledge in matters of peacetime radiation protection. However, except for my former colleague and friend, Marlow Stangler, whose chapters I have referenced, I cannot find anyone still alive and active who has had experience with the higher levels of radiation that I worked in, trained in, and managed patients who were exposed in, in the earlier days of atmospheric nuclear tests and active reprocessing of nuclear fuels. Marlow has extensive experience, over a fifty-year span, with training responders who arrived in his courses without any knowledge of radiation or protection issues. He agrees totally with my views. Nobody under retirement age today was working until after the atmospheric tests were suspended in 1963. That is why I must undertake this unhappy task of contradicting my NCRP friends on this issue.

Many who have followed the development of NCRP and other expert group recommendations will remember how early NCRP committee members were cautious about using words like "limits" to describe levels at which certain administrative actions were recommended in peacetime management of radiation protection programs. They even changed wording to avoid use of the word "limit" when designating a recommended level of intake that should be routinely avoided by workers or members of the public who might be exposed over a lifetime. They knew that uninformed workers or members of the public would interpret higher exposure levels as "dangerous." The term "Maximum Permissible Concentration (MPCs)" in the early NCRP reports and in Federal regulations was changed to "Derived Air Concentrations (DACs)" to avoid the impression upon persons uninformed about the meanings of these terms to think they represent levels above which significant danger is encountered, which would not be so for a short-term or even an annual exposure. We should not make recommendations that will result in undue panic of persons who are in contaminated areas where they could stay for many hours without experiencing serious risks of short- or long-term effects. Note my experiences illustrated in Exhibits 35 and 36.

From the early exhibits of Chapter 5, we can see that the possible extent of areas that might receive such low exposure rates could encompass up to hundreds of square miles, and not even be amenable in radiological attack situations to be cordoned-off as boundaries. Radiological attacks might contaminate much wider areas than those

we might have expected under peacetime conditions, such as transportation accidents (which actually have not released hazardous amounts of radioactive materials at all in the USA). In the earlier civil defense programs, we taught responders to measure radiation intensity levels, with both low and high range instruments, all the way from background rates of 0.01 mR per hour to more than 500,000 mR per hour. They were also taught to use their own judgment of benefit versus risk when performing rescue or recovery operations, or at least the judgment of a specially trained person or leader on the team, knowing effects of certain levels of radiation (and the recommended emergency exposure of 25 R as a suggested level except for life saving). As pointed out earlier, their comments about the training at the Nevada Test Site were generally favorable (Stangler and Brodsky 1957).

One example of an unfortunate interpretation of NCRP 138 recommendations: One fire chief and official who put on excellent and highly-attended courses on chemical and biological protection several years ago, which I attended with Marlow, gave a fine talk until he said that considering the "ALARA" (as low as reasonably achievable) philosophy used by NCRP in peacetime management of radiation protection programs, he would reduce the boundary at which he would allow his firemen to enter an area from the 10 mR per hour level in NCRP 138 to 2 mR/hour. The 10 mR/hour is the first boundary to be recommended as a "green light" boundary in NCRP 138, and the later commentary (NCRP 2001, 2005). He said something like, "I will not expose my firemen to such dangerous radiation levels." I was disturbed at this point of his presentation, and I had to stand up and state something like, "At 10 mR/hour, I could spend 500 hours involved in rescue or any other work and still not exceed the regulatory limit of 5 rem in any one year, which was based on keeping radiation risks to the lowest level of any other occupation. I could continue to receive 5 rem per year each year for the rest of my working life."

Poston and Hamilton (2004) summarize the various recommendations of expert groups on emergency exposure, and the reasoning of their NCRP committee in recommending the 10 mR/hour demarcation (Dr. Poston was chair of the committee and Dr. Hamilton a member, both outstanding scientists and professors who provided to me chapters and presentations for the HPS Summer School (Brodsky et al. 2004). However, I knew that presenting specific boundaries or limits at low levels would tend to convince persons uninformed about radiation risks that any such boundary was a demarcation between a "safe" and "unsafe" area. In prefaces to earlier reports of the NCRP, the eminent Dr. Lauriston Taylor often emphasized that lowering the amount of exposure to a worker to 5 rem (5,000 rem) per year, as with previous lowering of standards, was not based on any evidence of harmful effects to the workers, but only on prudence of administration of radiation protection programs in peacetime. Some of the early changes in language of NCRP reports, such as changing "Maximum Permissible Concentrations (MPCs) for intake to the wording "Derived Air Concentrations" in later ICRP and NCRP reports were indeed a response to the recognition that these conservative intake numbers were being misunderstood as dividing lines between safe and dangerous concentrations.

My concerns about some of the NCRP recommendations, and others, since 9/11, have been expressed in Brodsky (2005), so I will not dwell on them further at this point. The NCRP 138 report has been prepared by outstanding scientists and professionals, and it has much of value for emergency managers needing to prepare for terrorist attack. However, I have had to disagree on their stating specific demarcations of exposure rates at low levels. The long-standing levels given in Chapter 4 and 5, and those summarized in Exhibit 8 and 9, together with some information in Exhibit 7 on the levels of exposure that might incur significant acute risks, are all that should be recommended to emergency planners and responders.

Since the civil defense programs in which Marlow worked up until about 1995 were decimated as a "peace dividend" after the Iron Curtain came down, probably few persons, if any, currently employed in Homeland Security remember the conclusions about training and instrumentation that were published using the millions of dollars spent earlier on Civil Effects research. Also, I do not know if anyone else is still around who managed and evaluated patients exposed to relatively high exposures and intakes of plutonium, americium, and fission products, in the growing nuclear industry of

the 1960s, as described by Brodsky and Wald (2004). That is another reason I have felt obliged to write this book. We cannot apply peacetime standards to emergencies requiring fast action to save life. We must realize that responders will need to work for short times in much higher exposure rates after terrorist radiological attacks than they would be allowed to work on a lifetime basis, in routine jobs involving radiation sources under controlled conditions.

Actually, Poston and Hamilton definitely indicate a realization of this fact in the various paragraphs of the NCRP 138 report; yet, their mere stating of this "green" level has resulted in an otherwise very intelligent and educated fire chief lowering even the 10 mR/hour level for his fire departments. Imagine how scared they would be to pick up people in a 30,000 mR/hour radiation field. Responders need to be able to think in terms of R per minute, or even R per second, under emergency conditions. Even at 3,600 R/hour, the likely highest radiation level in fallout from even a hydrogen bomb early after detonation, the rate is 3,600/3,600 second per hour = **1 R per second**. A fireman could pick up someone in ten seconds and lift him to a helicopter, or take him to a more shielded location within another five seconds, and receive only about 15 R, which is below the suggested 25 R limit for life saving, for informed personnel.

Additional emergency response recommendations are in the References, including books by Ansari (2010), Burchfield (2009), Brodsky et al. (2004), and Kearny (2001).

CHAPTER 7

ADDITIONAL PREPARATIONS BEFORE AN ATTACK THAT WOULD REDUCE RISKS

This chapter will provide information on preparations that can be taken to protect life before an attack. Some of this information was developed by the Federal Civil Defense Information, using research funding sometimes provided by the US Atomic Energy Commission, Division of Biology and Medicine. Unfortunately, the originally intended programs of FCDA were decimated by much of the myths about radiation and radiation protection. Examples have been given of these myths in Chapter 1; a review of facts about radiation effects has been presented in Chapter 4.

As a result of these myths that there is no defense against any levels of radiation from fallout, and also the desire to declare a "peace dividend" after the end of the Cold War, the thoroughly researched and long conducted radiological defense program that provided instruments and radiation calibration services to all of the States was ended by Congress and the administration in the mid-1990s, and most states abandoned their instrument programs. A program to provide discarded government and instrument programs to the States and localities in the 2000s, with some training, resulted in a variety of used instruments provided for responders. However, this program has been discontinued and no national calibration services have been provided for those instruments that are in the hands of responders. Most of the calibration sources and equipment distributed about the nation have been disassembled or destroyed, and the training provided in many cases does not provide proper perspectives to responders to help them distinguish relatively insignificant from more hazardous radiation intensities.

At this point, and in Chapter 8, I provide in this book information directly to citizens themselves to help them assess their own immediate risks and protection measures in the event of an attack involving radiation exposure. Now, I will recommend some preparations and purchases that can help the citizen who desires to prepare protections against exposures to WMD. After such preparations, having done the best to prepare for the worst, a person can then relax, knowing he has made preparations to protect his family and others with him.

For those who want to prepare for optimum protection to minimize risks, the following steps are outlined:

- **Review, post, and follow the recommendations already made in Chapter 6**. Particularly post and review: the Exhibits 7 and/or 8 on risk versus radiation dose; the recommended limits of dose when you judge it necessary to take immediate action to save life; the Exhibit 17 showing relative protection factors of ad hoc shelters available at home or in the community; and an appropriate summary of brief principles selected from Appendix C.

- **Provide radiation dosimeters and radiation monitoring equipment for yourself and fa**mily. In addition to the items in Chapter 6, contact the company in Chapter 8 and obtain for each person in your household an inexpensive credit-card size dosimeter, such as the SIRAD dosimeter shown in Chapter 8. (Actually, it would be best to have these dosimeters purchased by County or community leaders in bulk quantities of 1,000 or more, in order to obtain the best price (perhaps ten dollars or less for the more precise card size that has been tested by DHS, or as low as two dollars for the RADsticker (see Chapter 8 and Appendix I)**.)This dosimeter is perhaps one of the most important items to obtain**, in the sense that it is immediately available, and easily affordable, for a person to check his own status regarding radiation exposure. This lightweight dosimeter is compact and unobtrusive. It can be kept in a shirt pocket, in a wallet, or in a pocketbook without taking up significant space. In that way, it is not much noticed, but would be readily available for each person to assess his own exposure or lack of exposure to radiation. (I have three RADstickers pasted into my wallets, and usually have one or two card size SIRAD monitors in their envelopes in my shirt pocket.) In this way, anxiety can be relieved for the vast majority of the public, or appropriate actions can be taken for reducing exposure as recommended in Chapter 6 or in Appendix C (select a brief list to be posted for repeated review).
- In addition to the light-weight credit-card dosimeters, purchase, if you or a small group of neighbors can afford it, at least one **pocket ionization dosimeter**, self-reading, and a charger for the family or a group at work. To the extent affordable, also obtain a Geiger counter instrument for contamination control and low exposure rate monitoring, a higher range survey meter for use in planning retrieval of food or other supplies in short runs outside of shelter, and for checking for any contamination in foods that might have been exposed to contamination. There are also instruments for checking for toxic chemicals, but the selection and use of these is complex and perhaps the purview of an industrial hygiene specialist or a member of a HAZMAT team. Consulting your local fire department or HAZMAT team will provide additional guidance on chemical detection and protection. Some basic information on chemical and biological protection, and reference to sources of assistance, is included in the summer school text (Brodsky et al. 2004). Companies that sell radiation dosimeters or monitoring instruments, protective suits or masks, or other items for personal protection may be found today by simply entering the item desired into an internet search; the word "Fallout shelters" often provides access to companies involved with all of these types of supplies. Appendix F also provides a list of suppliers and their products and services.
- **Prepare the best shelter at home that you can afford and stock the shelter** with all of the items as recommended in Chapter 6, as provided mainly by the Department of Homeland Security web site. Some recommendations for preparing a shelter are given below. If you do not get around to preparing the shelter, at least stack enough solid concrete blocks in your basement or garage to provide the designed amount of shielding. See Exhibits 17 and 19 for shielding information.
- In addition to preparing protection in your household, also **prepare necessary emergency kits** for your car, your office, and for other places you often inhabit. Also, post the simple FEMA Exhibit 17 of Chapter 5 to review and keep in mind the ways additional shielding and indoor protection can be obtained if you are caught away from your main locations.

Obtaining additional information to fortify your understanding and preparations for reducing risks.

Many good fact sheets, reports, and books were published in the 1950s and 1960s to assist members of the public as well as civil defense and emergency response organizations in preparing to minimize loss of life in the

event of a nuclear attack. To list them all would take many pages; the reader can examine much of this literature by obtaining the civil defense references cited. This subject was taken seriously by Presidents Truman, Eisenhower, and Kennedy, and their administrations, in the era when it was clear that the Soviet Union had also developed nuclear weapons, including powerful hydrogen bombs and missiles for their delivery. I have drawn only a limited amount of information for this book from some of these references that are still in my library.

The citizen or emergency response official who wishes to examine in more depth the publications of the early civil defense program might obtain them from the Superintendent of Documents. I have also recently searched the web for "Fallout Shelters" and found and accessed one of the listed web sites to obtain the reference (Connor 2008); I telephoned Mr. Connor, and found he has collected an abundance of the early literature, has updated some of the information, and is another resource for both free and purchasable documents providing information on all aspects of survival preparation, as well as instruments, shelter designs, and supplies for stocking shelters in advance. After my discussion with Mr. Connor, I can recommend his site as a source of abundant and reliable information and supplies. The reference (Connor 2008) also provides a comprehensive list of supplies to consider purchasing at local stores if an attack is believed imminent. Connor recommends supplies for at least two weeks, and preferably two months, believing that local store supplies might well remain depleted for at least two months following a major attack. "Nuclear War Survival Skills," (Kearny 2001) is also available from Connor; it contains in depth information about surviving attacks from nuclear weapons.

In addition, assistance can be obtained from those companies in Appendix F that provide consultation, and from recent books* providing general information on preparations for protection against terrorist attacks (Ansari 2009; Burchfield 2009; NCRP 2001, 2005; Kearny 2001; Brodsky et al. 2004).

Need, Logic, and Designs for Preparing Shelters

Of course, the greatest need for protection is the nearby availability of appropriate shelters — at home, at shopping centers, at recreational facilities, at work, or wherever someone might be at the moment of hearing the explosion or seeing the light. Presidents Truman, Eisenhower, and Kennedy strongly supported protection for all citizens in the days when the Soviets achieved nuclear weapons and threatened our demise. One of the first assignments of President Kennedy to Secretary of Defense Robert McNamara was to give the American people the facts they needed to know about the dangers of a nuclear attack and what they could do to protect themselves. This resulted in a booklet of 47 pages that consolidated some of the vast amount of information published by the FCDA before transfer of the civil defense program to the Department of Defense (DOD) (DOD 1961).

However, while the initiatives of the early Presidents fueled the beginning of well-planned civil defense programs, including many research projects at nuclear test sites and elsewhere to determine design parameters for shelters, no mandate to construct such shelters was forthcoming — neither from the government nor the private sector. In the meantime, Switzerland, by popular vote in 1950, adopted laws that required every new building to have a shelter; otherwise no building permit was issued. Shelters were required to have dual use so that they would be maintained in livable condition. Existing buildings were retrofitted. The Swiss population is 95% sheltered. Similar programs were adopted in Sweden, Russia, China and Israel that were outlined in his presentation (Barbier 2001). A recent visit confirmed the availability of shelters in Israel.

While these other nations have recognized the need to ensure the survival of citizenry in this nuclear age, the myths discussed in Chapter 1 have eroded national attention to this matter. Instead, we continue to watch on TV news, as if it is part of our entertainment, repeated views of the deaths following natural disasters such as hurricanes and tornadoes. In the early weeks of February 2008, prior to my writing this chapter, we saw repeated reviews of the devastation of the latest tornadoes and the killing of fifty-four civilians throughout the nation. More recently, we have seen the destruction of homes and buildings from floods and earthquakes, and the many thousands of deaths, resulting from the lack of adequate

disaster planning and construction standards. Over the years, if the shelter program we recommended in FCDA in the early 1950s had been implemented with the priority it deserved, in every home as well as in public buildings, thousands of lives would already have been saved even without any attacks on our nation. Sometimes our attitudes make me wonder whether we have become more satiated by the entertainments focused on violence in our society than by our supposed convictions about the sanctity of human life.

I still hope that some leaders from the government and/or private contractor segments of our society will wake up our nation to the importance of protecting our civilian population and government centers at home. It would be a great boon to the construction industry if good blast and WMD shelters could be rapidly designed, provided in large quantities at low cost, and be required by building codes in every new construction and as retrofits in present homes and structures, as the Swiss have done. Then, each citizen would likely stock the shelter with appropriate supplies and have a much greater chance to avoid panic and have a much greater chance of survival. Such a building program would also be a better boon to our economy than the overbuilding of more homes and condominiums, which if re-started would soon again contribute to another recession. It is still not too late to advocate the building of home and public shelters, or at least to have materials available for the rapid construction of makeshift shelters.

On the evening of March 18, 2008, the Weather Channel continued a program about stories of damage, and lives lost and saved, during tornadoes in the USA. One striking fact pointed out was how a woman saved her life by entering a small room in the basement that was constructed with about 6-inch concrete walls as a tornado shelter, while the rest of the large 6,500 square foot home, made of today's building materials of wood and fabricated plasterboard was completed destroyed. A picture of this completely leveled home showing the one concrete room still standing made the point a visual remembrance. The TV presenter stated that such shelters could be built in any new home for only a 7 to 10 percent increase in home price. A program like this for shelters was something we tried to convince government leaders in the 1950s should be required throughout the nation in new construction, as it was in Switzerland and other nations. The program was provided with the research and suggested shelter designs, but it was left to the private sector to provide the initiatives. We all know the result and the many lives already lost to tornadoes and hurricanes. We also know how much less we are prepared to protect ourselves from terrorist or rogue nation attacks. I am still hoping some great leader will emerge who will realize that the urgent promulgation of such shelter construction would not only better prepare us for survival, but would be a way to rapidly stimulate the building industry and job market.

As indicated earlier, the amount of material generated in the civil defense research programs for the building of shelters could fill volumes. Only a minimally adequate amount of information is given here so the reader can begin to provide some protection without necessarily going to the vast literature or the hiring of a design expert. The references used here to extract the information below, which can be consulted further if the reader desires, are: (FCDA 1955a, 1955b; DOD 1959, 1961; Beacham et al. (FDA),1956; Strope et al. 1959; White et al. 1961; Breslin et al. 1963; Burson 1965a, 1965b; Barbier 2001; Brodsky and Beard 1960; Brodsky et al. 2004; O'Connor 2008.

Shelter designs that can be built by the handy homeowner: *A number of simple designs for makeshift shelters are presented in civil defense documents (e.g., DOD 1961a, 1961b). For someone who has made no plans at all, if some warning is available, a strong door placed at an angle against a basement wall in the corner, then topped with dirt or sand to a depth of about one foot (DOD 1961b), could provide a reduction of about one-twenty fifth to prevailing gamma exposure rates above ground. However, sitting in such a last-minute improvisation would be extremely uncomfortable for more than a couple of hours.*

A somewhat more comfortable shelter could be improvised from a strong table, either above ground or in a basement. Exhibit 37a presents a picture of the idea, with the homeowner stacking either books, papers or other solid materials on top of the table and about the sides. One foot of books, at a weight of paper of about 56 pounds per cubic foot, would offer a reduction of about one-fifth in the gamma intensity of most of the gammas encountered in nuclear weapons or

RDD fallout (about 0.08 to 1.25 MeV). Two feet of book thickness above and around the table would provide about one-twenty-fifth reduction, with an additional one-tenth reduction if the table is in a corner of the basement. Sitting rather than standing in the basement could reduce exposure rates about another one-fourth to one-fifth (Breslin et al. 1963).

If no basement is available, a similar stacking of books around a sofa moved to the center of a home and nearest a food pantry, could also reduce gamma intensities to about 1/25th of those outdoors, if the occupants are also protected by books above and on all sides facing ground that could be contaminated.

The illustration in Exhibit 37b assumes that the occupants on the sofa are facing out to a lake or river in which contamination has been washed away, or are facing a forest that has absorbed deposited fallout on its upper branches. These are some factors that can be considered ad hoc when the emergency has occurred.



EXHIBIT 37A — Improvising a shelter using a strong table, piled above and around with books, papers, or other more solid materials.



EXHIBIT 37B — Improvised shielding with bookshelves. Allen and family are shielded from any radiation coming from behind the books. This idea has helped Allen convince Phyllis that his large collection of old books, filling all walls of the garage and his study, still has some value.



EXHIBIT 37C — Last-minute shielding with books. Because Allen has not prepared at all to provide shelter beforehand (not since the early days of 1957-1960 when the concrete shelter was built, after which he moved), he might need to resort in a hurry to cover up.

A better shelter, which could be constructed within a matter of hours or days if concrete blocks, mortar, and some wood for framing the ceiling were already available, would be one as illustrated in Exhibits 38a-e, which could be constructed by a family team (DOD 1961). The cost for an 8 foot by 10 foot by 7 foot high basement shelter with four walls and a 16-inch thick ceiling, using solid concrete block of dimensions 8 inches by 4 inches by 16 inches that I priced in February 2008 at a retail cost of $2.28 per block, would cost about $3,000 for the block plus additional costs for mortar and wood. With two of the walls in a corner of the basement already provided below ground, the cost could be reduced to about $2,000 for the blocks and other materials. (In the original document of May 1959, the estimated cost of this shelter was only $150 to $200 in 1959 dollars, according to bids. It was also stated that this shelter would provide all of the protection needed from nuclear weapons fallout in most of the nation (DOD 1961); those were the days when we were trying to persuade government and the public to prepare adequate protection from a hydrogen bomb attack.)

Group Shelter Construction

There are many references of the early research related to gamma ray shielding and shelter design from the early test site studies, some of which have already been referenced. A major reference, however, is that of Strope et al. (1959), which can serve as a concise but detailed model for current construction and supply details of a shelter for 100 persons. Detailed cost estimates are included, which could be updated to current US dollars. It turns out that a 35 psi blast protected and fallout shelter for 100 persons would cost only about ten percent more than a minimal shelter that would protect against 10 psi. Strope's report includes design drawings for every aspect of the shelter, ventilation requirements, and all other power and supply requirements. Comparing floor space of the 100-person shelter with that of a 5-person family shelter, the report recommends 12 square feet per person for the group shelter and 13 for the family shelter. Air supply is 6.75 minimum and 16 maximum cubic feet per minute per person, except for the period when the ventilation system might be shut down to avoid intake of toxic agents (unless adequately filtered or provided with air tanks for the interim). Water supply is 0.7 to 1.1 gallons per day per person for the group shelter compared 0.5 gallons per day per person for the family shelter. **There are many more important specifications in Strope's excellent report. It should be used to develop an urgent national plan for the construction of shelters for our vulnerable populations. A nation without a civilian population prepared and resolved to survive a WMD attack rather than panic, is a nation defeated.**

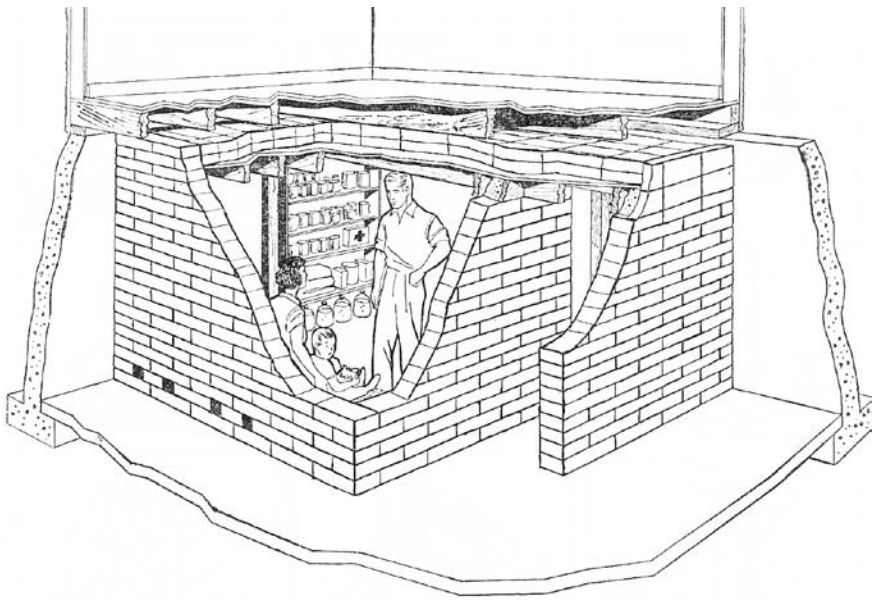


EXHIBIT 38A — Completed basement shelter that could be built by a family.

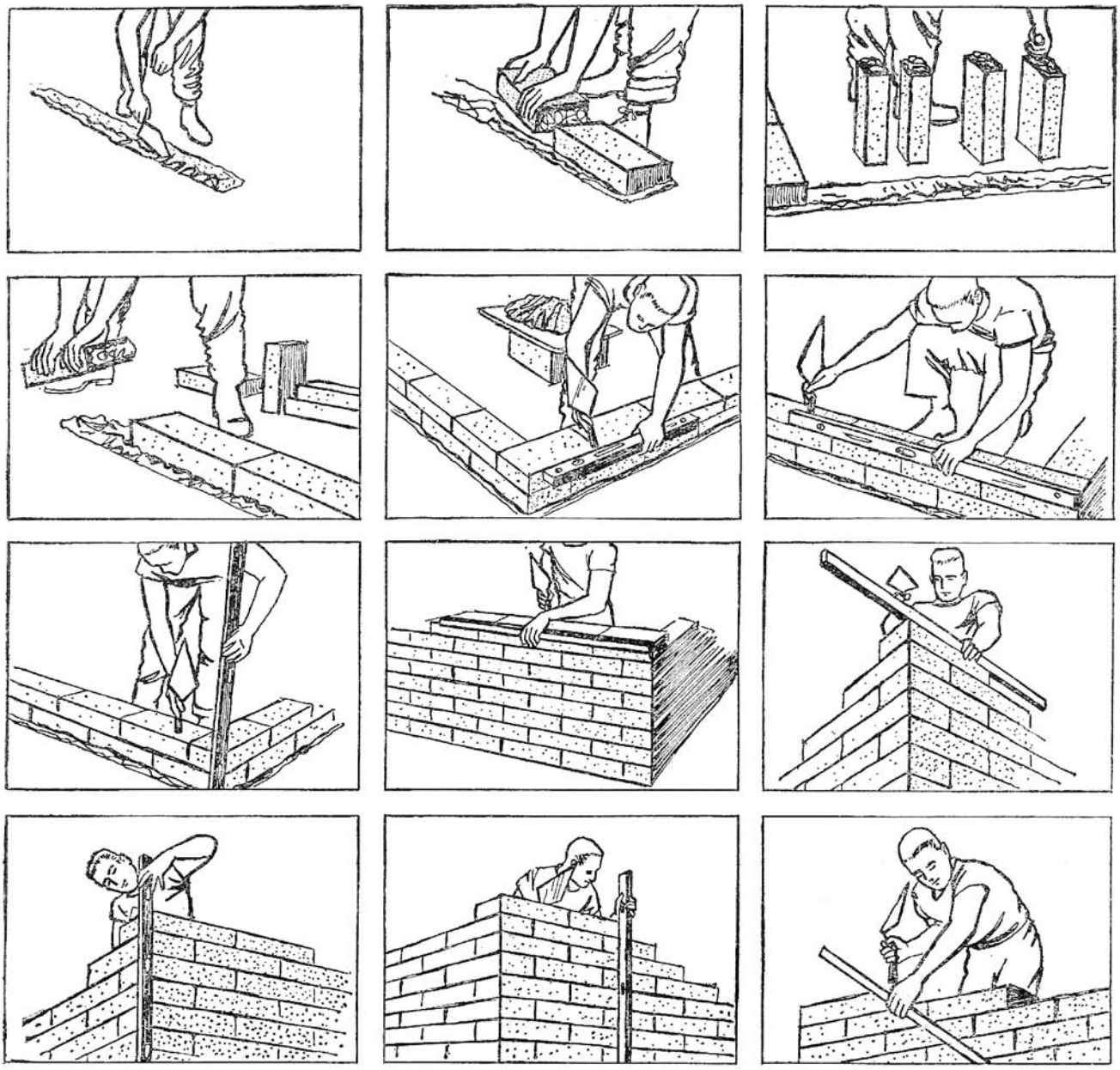


EXHIBIT 38B — Techniques for building a concrete block wall (from DOD 1961a).

The DOD (1961a) Figure subtitle suggests that more details can be obtained from such organizations as the National Concrete Masonry Association or the Portland Cement Association in Chicago, Illinois, or the Structural Clay Products Association in Washington, DC.

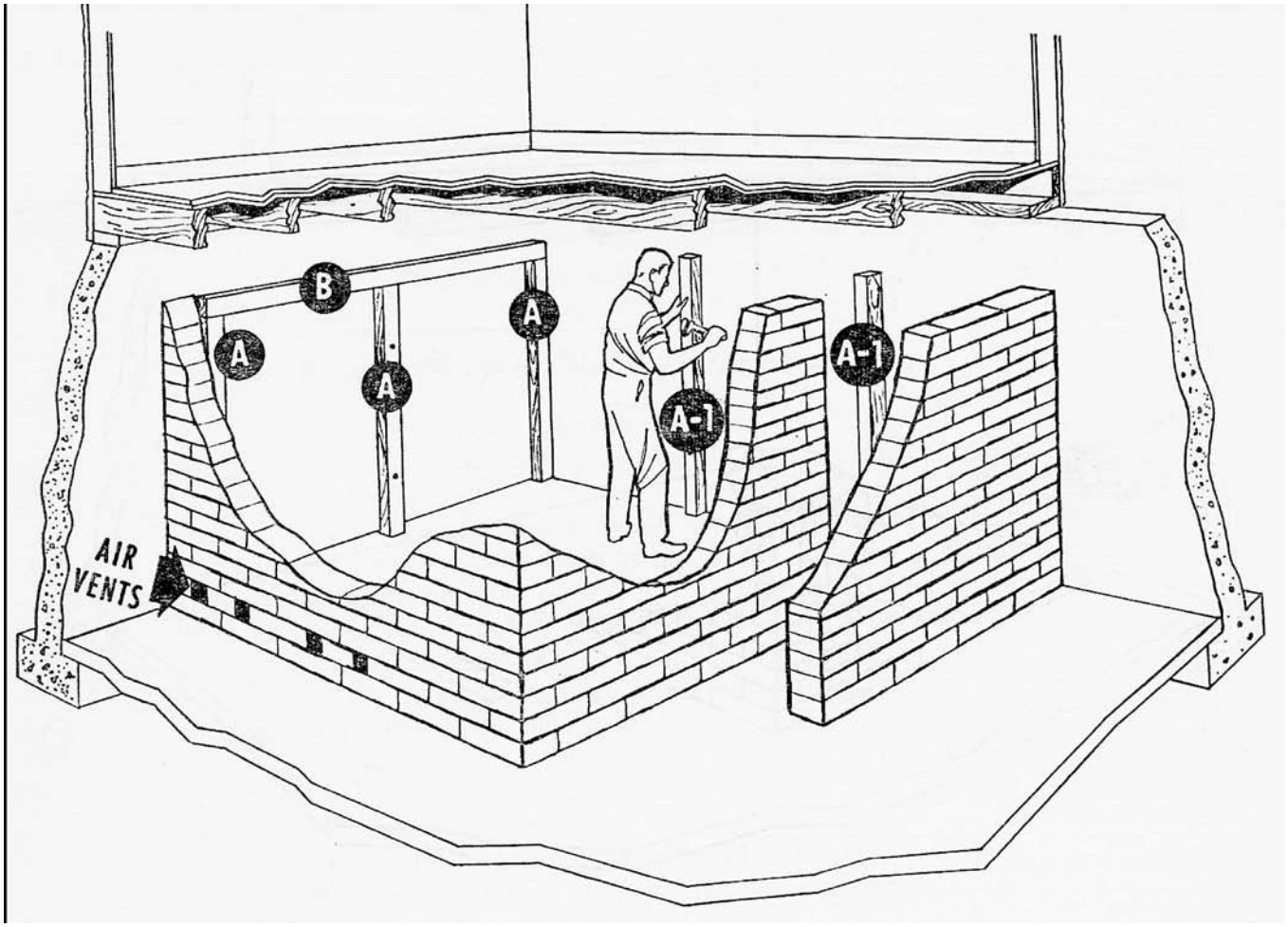
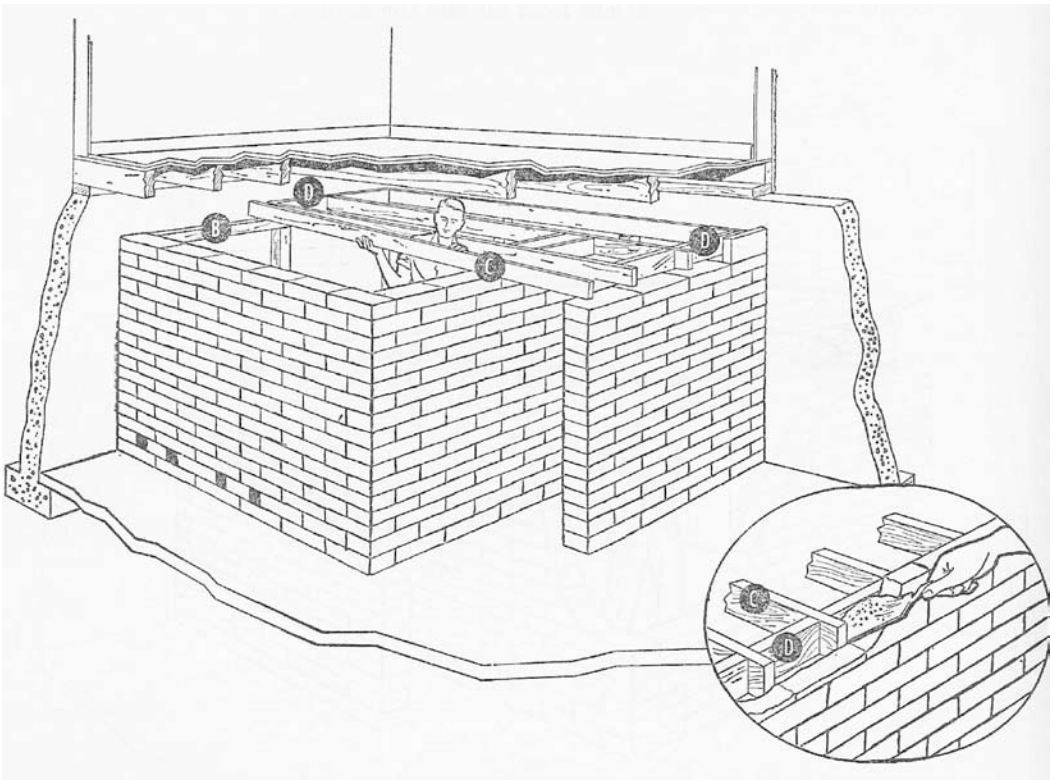


EXHIBIT 38C — Partially built basement shelter (DOD 1961a).

The wall protecting the shelter entrance from direct radiation should be the same height as the other walls. The posts that support the roof beams should be fixed to the basement walls with ½-inch anchor bolts. The height of the A-1 posts should equal the height of the A posts plus the thickness of beam B, which is against the rear wall nailed to one corner post to the other.



EXHIBITS 38D — Putting boards to support roof of shelter (DOD 1961a).

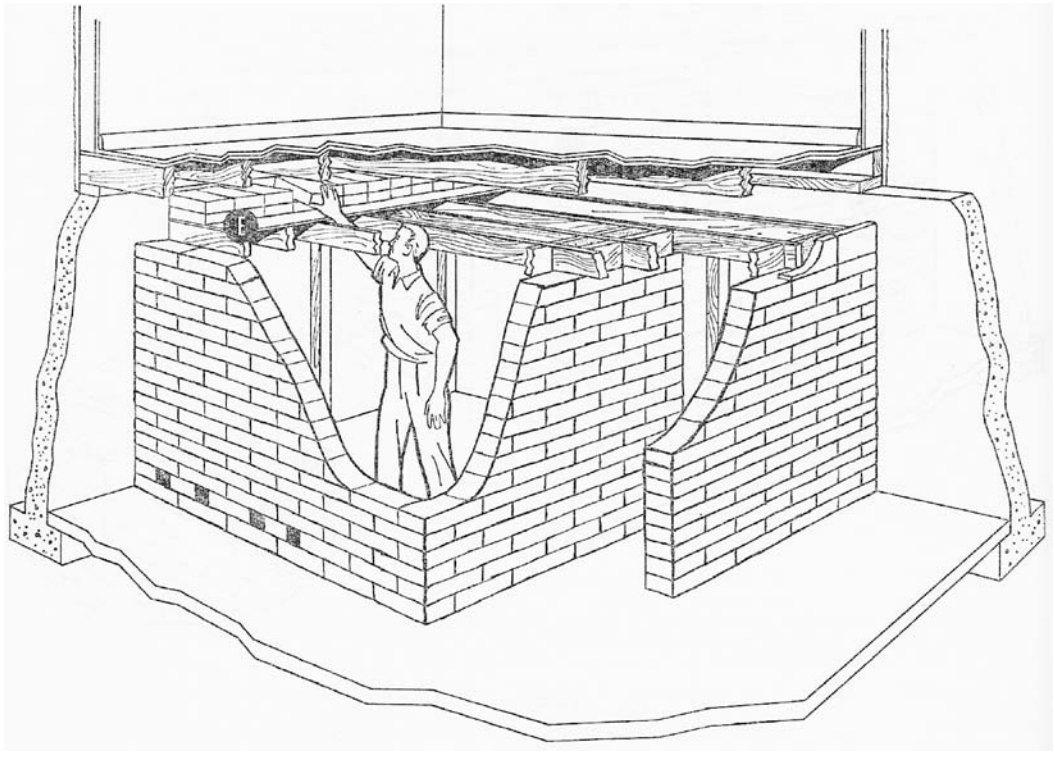


EXHIBIT 38E — Completing the basement shelter concrete block roof.

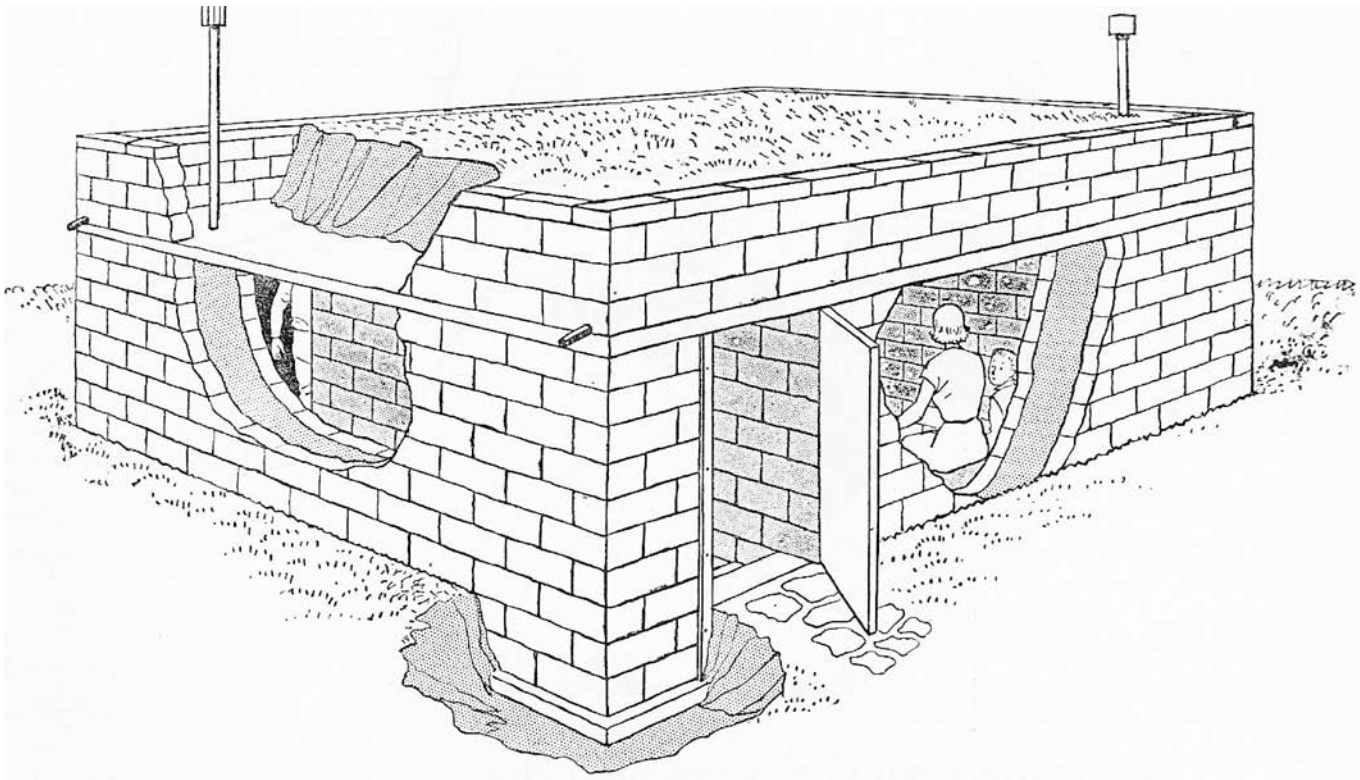


Figure 9.—Aboveground double-wall shelter

The materials for a double-wall shelter would cost about $700. Contractors' charges would be additional. The shelter would provide almost absolute fallout protection.

EXHIBIT 39 — View of a blast and fallout shelter constructed with two concrete block walls with sand in between for maximum radiation shield (DOD 1961a,b).

Note that the $700 cost is in 1960 dollars. This design would reduce external radiation intensities from fission product, or most RDD nuclide, gamma radiation by a factor of about 1/1,000 or better. With reinforcing rods, if placed as in my shelter shown in Exhibit 18, it would result in a shelter that could stand considerable blast or tornado overpressure. My own shelter design was taken from another document showing rod placements, and would withstand the pressure of about a 15 megaton hydrogen bomb at five miles. (Such a shelter could also save lives in the event of hurricanes or tornados.) The stronger type of shelter would need to be built by an experienced contractor. Although it cost me $5,000 in the late 1950s when I added it to my $12,000 home, it would likely cost in the many tens of thousands of dollars today, unless such protective shelters were designed, fabricated and subsidized en masse by the Department of Homeland Security **as a stimulant to the building industry.**

Preparing Protections against Chemical and Biological Agents

The participant in the 2001 panel discussion (BWCHPS 2001) whom I invited to present preparations for surviving terrorist attacks involving chemical and biological weapons was Dr. Kenneth L. Dretchen, Chairman, Department of Pharmacology and Office of Regulatory Affairs, Georgetown University, and consultant to the Surgeon General on biological and chemical agents. Dr. Dretchen summarized the likely biological and chemical agents that could be employed by terrorists, and the characteristics of distribution and the limitations in methods of protection. He emphasized that the main purpose of a terrorist is to terrorize the public; knowledge about biological and chemical agents is the primary need. He indicated that anthrax cannot be spread between people. Although serious harm had already been done in the then-current anthrax situation in Washington, DC, a perspective is that few have been killed compared to the number dead in the same period from automobile accidents. Smallpox is more serious since it can be spread by a suicidal terrorist who can enter populated areas and simply cough or sneeze. One hundred million doses of smallpox vaccine have been ordered by the government. A life can be saved if the vaccine is administered within 3 days. Other examples of antidotes and information the public should have to make rational decisions were presented. However, he advised against the current storing of antibiotics by members of the public. He also advised against the purchase of masks by individual members of the public, presumably because without proper selection and face fitting, and without likely advanced warning, such devices would not be effective.

However, I would encourage readers to learn all they can about possible instant protective measures and have included some references that will assist in selection of protective clothing and respiratory protection. The American Industrial Hygiene Association (AIHA) has issued a White Paper recommending standard setting for new classes of respiratory protective devices (Alves 2010). Any new developments in respiratory protection, and companies that manufacture protective devices, may be accessed through AIHA (www.aiha.org) and its journal. Of course, any new masks or respirators that would protect against the most toxic agents with filtration factors of 1,000 or more would likely cost in the hundreds of dollars. Even at 100 dollars, tens of billions of dollars would be needed to provide all citizens with such protective equipment. Yet, some persons living in most vulnerable places for attack might wish to provide masks for their immediate families. If only a few lives can be saved by such preparations, they are still worthwhile.

*Also, such preparations involve additional actions that can be taken (**things to do**) that would provide some additional comfort and help avoid panic. Some suggestions involving protection against chemical and biological agents, and references that provide much more detail, have been given in previous chapters. One of the most important actions the ordinary citizen can take is to be aware of any governmental or local health department preparations and programs, which might be able to provide available antidotes and immunizations soon after an attack.*

With these thoughts in mind, the following additional information, as abstracted from Franz (2008), is provided in this section for an elementary familiarity with the very complex issues of protection against the hundreds of possible chemical and biological weapons. It may be supplemented by information already cited in King (2004) and Byrnes et al. (2003). The format of Franz is retained below.

Countermeasures (Franz 2008)[76]

PHYSICAL PROTECTION

Most toxins are neither volatile nor dermally active. Therefore, an aggressor would most likely attempt to present them as respirable aerosols. Toxin aerosols should pose neither significant residual environmental threat,

76 Written by Franz as pertaining to soldiers, but providing a concise description of the nature of possible protections against biological and chemical agents.

nor remain on the skin or clothing. The typical toxin cloud would, depending on meteorologic conditions, either drift with the wind close to the ground or rise above the surface of the earth and be diluted in the atmosphere. There may, however, be residual contamination near the munition release point. Humans in the target area of a true aerosol would be exposed as the agent drifted through that area. The principal way humans are exposed to such a cloud is through breathing. Aerosol particles must be drawn into the lungs and retained to cause harm.

The protective mask, worn properly, is effective against toxin aerosols. Its efficacy is, however, dependent on two factors: 1) mask-to-face fit and 2) use during an attack. Proper fit is vital. Because of the extreme toxicity of some of the bacterial toxins, a relatively small leak could easily result in a significant exposure. Eyes should be protected when possible. Definitive studies have not been done to assess the effects of aerosolized toxins on the eyes. One would expect that, in general, ocular exposure to a toxin aerosol, unless the exposed individual is near the release point, would result in few systemic effects because of the low doses absorbed. Certain toxins have direct effects on the eyes, but these are generally not toxins we would expect to face as aerosols. Donning the protective mask prior to exposure would, of course, protect the eyes.

Because important threat biological warfare agents are not dermally active, special protective clothing, other than the mask, is less important in at toxin attack than a chemical attack. Presently available clothing should be effective against biological threats as we know them. Commanders should carefully consider the relative impact of thermal load and the minimal additional protection provided by protective clothing.

REAL-TIME DETECTION OF AN ATTACK

Because of the nature of the threat, soldiers may be dependent on a mechanical detection and warning system to notify them of impending or ongoing attack. Without timely warning, their most effective generic countermeasure, the protective mask, may be of limited value. There have been successful efforts in the past to develop real-time detectors of a chemical agent attack. It will be more difficult to develop such detectors for toxins for several reasons. As stated above, toxins must be presented as respirable aerosols, which act as a cloud, not as droplets (as the chemical agents) that fall to the ground and evaporate with time. The toxin cloud, typically delivered at night with a slight wind, would be expected to move across the battlefield until it either rises into the atmosphere to be diluted or settles, relatively harmlessly, to the ground. Unlike chemical agents, which might be detectable for hours, toxins might be detectable in the air at one location only for a few minutes. Definitive, specific toxin detectors would have to sample continuously or be turned on by a continuous sampler of some kind.

Furthermore, toxin detectors (assuming the present state of technology) would likely have to have the specificity of immunoassays to identify a toxin and differentiate it from other organic material in the air. Continuous monitoring by such equipment would be extremely costly, reagent intensive, and logistically very difficult to support because of reagent requirements. Identifying each toxin would require a different set of reagents if an immunoassay system were used. Analytical assays would necessarily be more complex and less likely to identify distinct toxins, but might detect that something unusual was present. Imagine the difficulty of developing a detection system based on molecular weight or other physical characteristics to differentiate among the seven botulinum toxins (molecular weight is the same for all of the botulinum toxins, while all seven require a different antibody for identification or therapy). Finally, to be effective, a detector would have to be located where it could "sniff" a toxin cloud in time to warn the appropriate population. This might be possible on a battlefield, but would be nearly impossible, except in selected facilities, in the case of a terrorist attack. It is possible that, if all the capabilities described were developed and available at the right place and time, an aerosol cloud of almost any of the toxins of concern could be detected and identified. Future advances in technology could well resolve our present technical difficulties.

DIAGNOSIS: General Considerations

Health-care providers often ask whether they will be able to tell the difference among cases of inhalation botulinum, staphylococcal enterotoxin intoxication, and chemical nerve agent poisoning Table 4 (Exhibit 40). describes these differences. In general, nerve agent poisoning has a rapid onset (minutes) and induces increased body secretions (saliva, airways secretions), pinpoint pupils and convulsions or muscle spasms. Botulinum intoxication has a slow onset (24-72 hours) and manifests as visual disturbance and muscle weakness, (often seen first as droopy eyelids). SEB poisoning has an intermediate (few hours) time of onset and is typically not lethal, but severely incapacitating. Chemical nerve agent poisoning is a violent illness resulting in respiratory failure because of muscle spasm, airway constriction and excessive fluid in the airways. Botulinum-intoxicated patients simply get very tired, very weak and, if they die, it is because the muscles of respiration fail. SEB-intoxicated patients become very sick, but typically survive.

TABLE 4: Differential Diagnosis of Chemical Nerve Agent, Botulinum toxin and Staphylococcal Enterotoxin B Intoxication.

	CHEMICAL NERVE AGENT	BOTULINUM TOXIN	STAPHYLOCOCCAL
Time to Symptoms	**Minutes**	**Hours (24-72)**	**Hours (1-6)**
Nervous	Convulsions, Muscle Twitching	Progressive Paralysis	Headache, Muscle Aches
Cardiovascular	Slow Heart Rate	Normal Rate	Normal or Rapid Heart Rate
Respiratory	Difficult Breathing, Airways Constriction	Normal, Then Progressive Paralysis	Nonproductive Cough, Severe Cases; Chest Pain/ difficult breathing
Gastrointestinal	Increased Motility, Pain, Diarrhea	Decreased Motility	Nausea, Vomiting and/or Diarrhea
Ocular	Small Pupils	Droopy Eyelids	May see “red eyes” (Conjunctival Injection)
Salivary	Profuse, Watery Saliva	Normal, but Swallowing Difficult	May be Slightly Increased Quantities of Saliva
Death	**Minutes**	**2-3 Days**	**Unlikely**
Response to Atropine/2PAM-Cl	Yes	No	Atrophine may Reduce Gastrointestinal Symptoms

EXHIBIT 40 — An Example of Symptoms Produced by One Chemical and Two Biological Agents (Franz 2008).

Health-care providers should consider toxins in the differential diagnosis, especially when multiple patients present with a similar clinical syndrome. Patients should be viewed epidemiologically and asked about where they were, who they were with, what they observed, how many other soldiers were and are involved, etc. Inhaled and retained doses of toxins will differ among soldiers exposed to the same aerosol cloud. Those who received the highest dose typically will show signs and symptoms first. Others will present somewhat later, while others in the same group may show no signs of intoxication. The distribution of severities within the group of soldiers may vary with type of exposure and type of toxin. For example, exposing a group of individuals to the staphylococcal enterotoxins would likely make a large percentage (80%) of them sick, but would result in few deaths. Exposing a group of soldiers to a cloud of botulinum toxin might kill half, make 20% very sick, and leave 30% unaffected.

One must consider the varying latent periods before onset of clinical signs. For patients exposed to toxins by aerosol, the latent or asymptomatic period varies from minutes (saxitoxin, microcystin) to hours (the staphylococcal enterotoxins), even to days (ricin, the botulinum toxins).

Save clinical and environmental samples for diagnosis. Both immunoassays and analytical tests are available for many of the toxins. Toxin samples taken directly from a weapon are often easier to test than biological samples because they do not contain body proteins and other interfering materials. The best early diagnostic sample for most toxins is a swab of the nasal mucosa. In general, the more toxic toxins are more difficult to detect in tissues and body fluids, because so little toxin needs to be present in the body to exert its effect. The capability exists however, to identify most of the important toxins in biological fluids or tissues, and many other toxins in environmental samples. Definitive laboratory diagnosis might take 48-72 hours; however, prototype field assays that can identify some toxins within 30 minutes have been developed recently. For individuals who survive an attack with toxins of lower toxicity, immunoassays that detect IgM or IgG (immunoglobulins produced by the body after exposure to a toxin) offer a means of diagnosis or confirmation or indirect identification of agent within 2-3 weeks after exposure.

APPROACHES TO PREVENTION AND TREATMENT

In developing medical countermeasures, each toxin must be considered individually. Some incapacitate so quickly that there would be little time for therapy after an attack. Others cause few or no clinical signs for many hours, but set off irreversible biochemical processes in minutes or a few hours which lead to severe debilitation or death several days later. Fortunately, some of the most potent bacterial protein toxins act slowly enough that, if they are identified, therapy is usually successful 12 to 24 hours after exposure.

It is always better to prevent casualties than to treat injured soldiers. For most of the significant threat toxins in military situations, vaccination is the most effective means of preventing casualties. Unlike the chemical warfare agents, many of the important threat toxins are highly immunogenic (exposing the body to small doses of the inactivated toxin causes the body to make antibodies that protect against subsequent actual toxin exposure). Immunized laboratory animals are totally protected from high-dose aerosols of these toxins. Immunization requires a knowledge of the threat, availability of a vaccine, and time. The time needed to allow the body to make its own protective antibodies to a toxin may range from a minimum of 4-6 weeks to 12-15 weeks or longer. Some vaccines currently in use require multiple injections, often weeks apart. The logistical burden of assuring that troops are given booster immunizations at the correct time could be overwhelming in a fast-moving build-up to hostilities.

It may be possible to reduce the time required for immunization. For example, antigens (materials that stimulate the body to develop antibodies) are being microencapsulated (entrapped in a synthetic polymer that breaks down, slowly releasing the material) to form timed-release vaccines that might provide the primary immunization, a boost two weeks later, and another boost 10 weeks after that-all with one injection. Another approach is being evaluated with current Medical Biological Defense Research Program vaccines. Soldiers could be given a priming dose and the first boost two weeks apart while in basic training. The response generated by the immune system's memory cells might last for many months or even years, although not all soldiers would develop fully protective immunity at that time after two immunizations. Shortly before the onset of hostilities, or when the soldier is assigned to a rapidly deployable unit, one boost could provide protective immunity quickly, and preclude the need for additional boosts after deployment. Preliminary data suggest that a boost up to 24 months (the greatest interval thus far tested) after two initial priming doses will be effective, even with moderately immunogenic vaccines such as the current botulinum toxoid. Studies are ongoing to determine the maximum reasonable interval between initial immunization series and the predeployment boost.

Passive antibody prophylaxis (where the soldier doesn't make his own antibodies, but is given antibody preparations produced in animals or other humans). This treatment is generally quite effective in protecting laboratory animals from toxin exposure. However, this option is of little real utility for large groups of people for several reasons. The protection provided by human antibody may last for only 1-2 months, and protection afforded by despeciated (animal antibodies altered chemically to reduce the likelihood of the human body identifying them as foreign protein) horse antibody may last for only a few weeks. Therefore, antibody prophylaxis would be practical only when the threat is clearly understood and imminent. Furthermore, it is unlikely that animal antibody would be used in an individual before intoxication because of the risk, albeit small, of an adverse reaction to foreign protein. The latter problem may be overcome within the next few years, as the production of human monoclonal antibodies (homogeneous populations of antibodies directed against one, very specific site on the toxin) or "humanization" of mouse monoclonal antibodies become practical. Unfortunately, single monoclonal antibodies are seldom as effective against toxins as polyclonal antibodies, such as those produced naturally in other humans or horses. However, combined antibody therapy, or "cocktails" of more than one monoclonal antibody, may overcome this problem in the future.

Pretreating soldiers with drugs is feasible, but little success has been achieved in the discovery or development of drugs that block the effects of toxins. Many toxins affect very basic mechanisms within body cells, tissues and organs; therefore, drugs that block these effects often have debilitating or toxic side effects. An exception is rifampin, the anti-tuberculosis drug, which protects laboratory animals exposed to the blue-green algal toxin, microcystin, and is safe for use in humans.

Pretreatment (treatment after exposure) with antibodies from human or animal sources is feasible for some of the 35 threat toxins. Passive immunotherapy (treatment with other than one's own antibodies) is very effective after exposure to botulinum toxin if treatment is begun soon enough, up to 24 hours after high-dose aerosol exposure to the toxin. The utility of antibody therapy drops sharply at or shortly after the onset of the first signs of disease. It appears that a significant amount of the toxin has, at that time, been taken up by areas of the body that cannot be reached by circulating antibodies. Even so, we have preliminary evidence that antibody therapy is at least partially effective after onset of signs of intoxication (36-48 hours after aerosol exposure) in monkeys exposed to botulinum toxin. The available antibody to botulinum toxin is produced in horses, and then despeciated to make a product with a reduced risk of adverse reaction that can be given to humans. Human monoclonal antibodies, or cocktails of two or more monoclonal antibodies, may be the next generation of antibody therapy. Passive antibody therapy such as that described here is more likely to be effective against neurotoxins like the botulinum toxins, which do not cause tissue damage, than against toxins that induce mediator release (the staphylococcal enterotoxins) or directly damage tissues (ricin).

Specific therapy with drugs (drugs that alter the action of the toxin or reverse its toxic effects directly) presently has little value because most of the toxins either physically damage cells and tissues very quickly (ricin), or affect such basic mechanisms within the cell (the neurotoxins) that drugs designed to reverse their effects are toxic themselves. Nevertheless, we have shown that rifampin stops the lethal intoxication by microcystin if given to laboratory animals therapeutically soon after toxin administration (within 15-30 min). Development of therapeutic drugs for toxins is presently aimed at several more general approaches. Where the mechanism of action of the toxin is understood and covalent (permanent) bonding of the toxin to cellular protein does not occur (example: ion-channel toxins), attempts are being made to discover drugs that compete or block the toxin from binding to its site of action. For toxins with enzymatic activities, such as ricin and the botulinum toxins, drugs that serve as alternate targets of such enzymatic action may be developed. For toxins such as botulinum, which block the release of a neural transmitter, attempts can be made to enhance the release of the needed transmitter by other means; the diaminopyridines are temporarily effective in reversing botulinum intoxication by this mechanism.

Finally, for toxins like staphylococcal enterotoxins and ricin, which induce the release of secondary mediators (actually, a natural part of the body's defense mechanism that overreacts), specific mediator blockers are being studied. It is likely that, in the next few years, drugs may find a place in the therapy of some intoxications as adjuncts to vaccination or passive antibody therapy, or they may be used to delay onset of toxic effects.

Other general supportive measures (Symptomatic Therapy) are likely to be effective in therapy of intoxication. Artificial ventilation could be life-saving in the case of neurotoxins, which block nerves that drive muscles of respiration (botulinum toxins and saxitoxin). Oxygen therapy, with or without artificial ventilation, may be beneficial for intoxication with toxins that directly damage the alveolar-capillary membrane (the site of movement of molecules between the inhaled air and the blood) of the lung. Vasoactive drugs (drugs that cause blood vessels to dilate or contract) and volume expanders could be used to treat the shock-like state that accompanies some intoxications. These measures could be used in conjunction with more specific therapies.

DECONTAMINATION: Is It Necessary?

Recall that a true respirable aerosol will leave less residue on clothing and environmental objects than would the larger particles produced by a chemical munition. This suggests that decontamination would be relatively unimportant after a toxin aerosol attack. Because we lack field experience, however, prudence dictates that soldiers decontaminate themselves after an attack. As a general rule, the decontamination procedure recommended for chemical warfare agents (Army FM 8-285) effectively destroys toxins. Exposure to 0.1% sodium hypochlorite solution (household bleach) for 10 minutes destroys most protein toxins. The trichothecene mycotoxins require more stringent measures to inactivate them, but even they can be removed from the skin (although not inactivated) simply by washing with soap and water. Soap and water, or even just water, can be very effective in removing most toxins from skin, clothing and equipment.

Again, because most toxins are not volatile or dermally active, decontamination is less critical than after a chemical attack.

Respirators (provided by K. Paul Steinmeyer, Radiation Safety Associates, Inc.)

The following brief information on respirators has been included, courtesy of K. Paul Steinmeyer, President of Radiation Safety Associates, Inc. His company has provided several types of courses to workers in the nuclear industries, including a course on respiratory protection since 1983, and has published my risk book (Brodsky 1996) and several of my articles. Thus, I know his material to be dependable and based on practical experience. Although, as I have discussed before, my experiences tell me that it is not likely that anyone inside or outside a shelter will take into the body a serious amount of radioactive material, unless actually in a passing cloud outdoors, it would still be useful to provide some degree of respiratory protection such as a small, inexpensive face mask. The same type of protection against radioactive particles will generally provide some degree of exposure reduction, although very limited, against chemical or biological agents. However, if chemical and biological agents are present in air in lethal concentrations, a face mask will not likely give enough protection. As indicated at the beginning of this chapter, contacts with the AIHA and its publications can provide information and access to better, but probably more expensive, means of respiratory protection and protective outfits. A sealed shelter is the best protection. Nevertheless, the following information could be of some help in reducing exposures to airborne materials.

Information on courses provided by Radiation Safety Associates is available on http://www.radpro.com or at 860-228-0487. Other companies that provide respiratory equipment and personal protective clothing and equipment are listed among the vendors in Appendix F.

Additional Information provided by K. Paul Steinmeyer:

Very small particles of radioactive fallout are likely to remain airborne for several days after a nuclear detonation. Also, in the weeks and months that follow, fine radioactive dust on the ground may again become airborne by the action of the wind, passing vehicles and other forces. During the first three days after such an attack, when the highest radiation doses from fallout are likely, any radioactive dust that infiltrates into your shelter and is inhaled will result in some internal radiation dose. It would be a good idea to limit this dose by using respirators for the first three days after an attack, even while you are indoors in your shelter. However, it would be unlikely that persons would be able to use a respirator for more than a few hours at a time. Fortunately, once in shelters, inhalation of toxic materials, particularly radioactive materials at dangerous levels, is unlikely for reasons given before.

The term "respirator" can mean anything from a self-contained breathing apparatus used by fire fighters, to a simple dust mask that can be purchased at a hardware or home store. You may have to find a safety equipment supplier to get the type of respirator suggested below (see Appendix F).

Adults

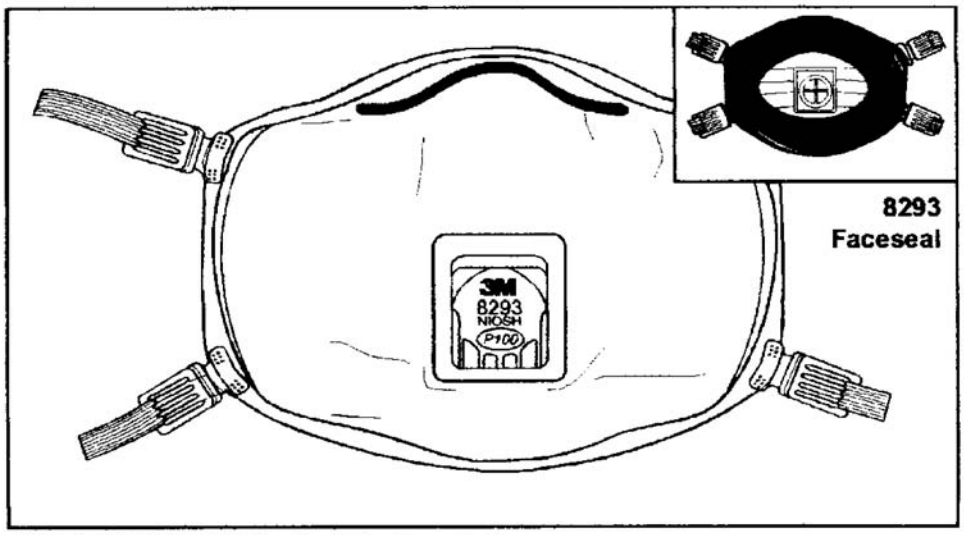
For reasonable protection from airborne radioactive fallout, a good quality half-mask should be adequate. Always use the following criteria to select which mask to purchase:

1. Choose a respirator approved by the National Institute for Occupational Safety and Health (NIOSH). The box or bag will contain the NIOSH logo and the logo of the Department of Health and Human Services (DHHS).
2. Select a respirator that is rated N-100, R-100 or P-100. The N, R and P have to do with how the respirator stands up to airborne oil vapors, which is not a consideration in this application. (N = non-oil resistant, R = oil resistant and P = oil proof.) The 100 indicates that these devices will remove almost 100% (actually 99.97%) of the airborne particles contained in the air that is breathed through them.
3. Finally, of the —100 respirators available, choose one that has foam rubber attached ALL AROUND the inner face-seal area*.

These respirators will have adjustable elastic head straps and a pinch-clamp to help it seal over the bridge of the nose. See Figure 1 below.

You will need more than one mask per person. A minimum of two per person per day is recommended. In a dusty environment, the filter will become more and more difficult to breathe through as it collects dust. Also, perspiration and moisture from exhaled air will cause it to eventually become damp and uncomfortable.

*For example, the 3M Model 8233 N-100 Particulate Respirator, or the 3M Model 8293 P-100 Particulate Respirator.



3M™ 8293 P100 Particulate Respirator.

FIGURE 1. A NIOSH-approved P-100 particulate respirator with adjustable straps and exhalation valve.

Respirator Fit

Respirators usually come in three sizes: small, medium and large. If possible, place one up to the face of each person who might need one, even if it is still inside a plastic bag. Select the one that appears to fit the best for each person. Men typically wear large or medium, women typically medium or small. Children would wear a small size.

Facial hair in the respirator seal area defeats the effectiveness of a respirator to a large extent. Men should shave prior to respirator use to ensure an adequate fit.

Don the respirator according to the instructions provided on the box or bag. The head straps should be snug but not overly tight. Since you will not be able to perform any type of a fit test, stand behind a person wearing a respirator and look at where the respirator seats on the wearer's face. Ensure that there are no open spaces between the respirator seal and the face of the wearer. If there are, try to readjust the respirator and straps until the best possible fit is obtained.

Each time a person changes respirators, put the used respirator in a 1-gallon self-sealing bag and mark the time, date and name of the person on the bag with a permanent magic marker. Store these as far away from where people are as possible (minimum of 10 feet). These respirators may be useful later if an assessment of airborne radioactive materials needs to be performed.

Makeshift Respirators

If respirators are not available, breathe through several layers of a cotton terrycloth towel or wash cloth, a man's cotton undershirt or similar types of materials. Almost anything is better than nothing. (See Exhibit 21.)

Children

Getting a child to wear a respirator for several days, or even many minutes, would likely be impossible. If you have reason to feel respiratory protection is needed, try to get the child to wear it as often as possible and for as long as possible. Alternately, try to get the child to wear a bandana over the nose and mouth, and play games of a western outlaw. Anything you can do to limit the amount of airborne radioactive dust a child breathes, in the event

you are caught in descending fallout or a passing cloud of radioactive material, the lower the internal radiation dose is going to be.

"Air Sampling"

If you have a thin-window radiation detector, you can use it to see if your respirators are actually filtering out airborne radioactive material. When you change respirators, keep the used one. Wait for FOUR HOURS after you take the respirator off, in order for natural background radon products to decay away. Turn the detector ON and put it in the CPM mode. With the detector held a minimum of several feet from any surface or person, read the BACKGROUND count rate. Then place the radiation detector about ½-inch away from the OUTSIDE of the respirator and read the count rate.

If the count rate increases noticeably, then there IS airborne particulate fallout in your shelter, and the respirator IS WORKING. Continue to use respirators.

If there is little or no difference between background and respirator, there is probably very little airborne fallout inside your shelter. Continue using respirators throughout the first three days. Fallout patterns can change quickly.

If you measure the mask soon after you take it off, you might see some detectable short-lived radon daughter products. While these are certainly radioactive, they are NOT due to fallout and shouldn't be of any concern. This radon daughter product activity will decrease by half every 25-30 minutes. It is the longer-lived materials from the explosion, like strontium, cerium and uranium that are of much more biological concern.

Trips Outside

If it becomes absolutely necessary to leave your shelter during the first three days after a nuclear attack, wear a respirator in addition to protective outer clothing. Remove the used respirator carefully when you re-enter your shelter. If you have a radiation detector use it to check the used respirator for radioactive contamination as described above. Put it into a plastic self-sealing bag, and label and store it as described above. If no detector is available, assume that the mask is contaminated and store it well away from other persons.

Other Reference Sources

For those who want to delve further into matters of protection against possible terrorist weapons of mass destruction, there is much additional background and many further recommendations that can be pursued in the copious documents published by the Federal Civil Defense Administration in the early years of research, as well as in later and more recent publications of the Federal Emergency Management Agency (FEMA) and the Department of Homeland Security. These references may be traced through the agencies mentioned or through internet resources. Many web sites pertinent to obtaining information relevant to personal protection have been listed in the Health Physics Society comprehensive text for the 2004 Summer School, Public Protection from Chemical, Biological, and Nuclear Terrorism (Brodsky et al. 2004), which is still available from the publisher indicated in the reference. This volume is over 800 pages, but a detailed table of contents and extensive index provides easy access to contents of immediate interest. (I receive no royalties for this book.) Additional books published since a draft of this book was distributed in 2008-2009 (Burchfield 2009; Ansari 2009) also provide suggestions for personal protection.

Vendors Who Can Provide Equipment, Supplies, and Advice on Protection Requirements

In order to provide a fair presentation of vendors who are available to provide protective requirements, Appendix F is a list provided by the Health Physics Society of the vendors who are Associate Members of the Society (HPS 2007). (This list has been updated to 2011 by a file courtesy of Richard Burk, Inc., Secretariat of the HPS.)

CHAPTER 8

THE IMPORTANCE OF PROVIDING AND WEARING SELF-INDICATING DOSE MONITORS (PERSONAL DOSIMETERS)

This chapter focuses only on a single important topic, because it involves the most important preparation for an individual: to be able to assess the presence and degree of radiation exposure ***immediately*** *after an attack, and select appropriate measures to reduce risks. The chapter describes the types of radiation dose measuring equipment that can be purchased or provided* ***before*** *any disaster or attack to help responders and members of the public be able to immediately determine their own exposures, by wearing and keeping simple, inexpensive dosimeters in their pockets or purses. The most important personal dosimeter recommended here is the Self-Indicating Radiation Alert Dosimeter (SIRAD) type mentioned earlier, because I have found no other type available that has all the advantages of the SIRAD, the very low price per dosimeter, and the possibility of production in very large quantities. The SIRAD has also received approval by Federal Agencies for distribution paid for by the Federal government under the Department of Homeland Security programs (Crowe 2009) (see Appendix G). Other instruments are also recommended, to provide instant readings of exposure rate; however, these instruments are generally more expensive and might require several persons or families to join together for their purchase. It is not expected under current budgetary constraints that wide distribution will occur of these radiation exposure rate meters to the general public, or to many responders, as they were in past civil defense program days.*

Lack of Recognition of the Immediate Importance of Personal Dosimeters Compared to Biomedical or Biodosimetric Methods Available Later for Limited Populations

Recent statements in the literature indicate that the availability of the important SIRAD dosimeters is not recognized in some important professional quarters. Personal monitors or dosimeters that can be worn by any responder or member of the public, and be easily understood and related to the levels of exposure that are, or are not, likely to cause serious injury, can provide much greater alleviation of panic and ensure proper personal actions. Such personal dosimeters will also provide for early triage of those requiring medical attention, and provide immediate relief for the vast majority outside the immediate lethal range of WMD. The vast majority of persons in fallout areas that would activate the sensitive Geiger counters now provided to responders would not

receive serious radiation exposures, especially if they rapidly sought shelter indoors with some shielding protection (Auxier 2004). Typical fallout patterns exhibited in Chapter 5 demonstrate that the fallout areas with detectable gamma and beta intensities, which might be of concern for a peacetime release, are more than ten times the areas near-in to a detonation where serious exposures could occur within the following days.

In discussing further development of methods for physician prognosis of local radiation injury through ultrasonic examination of surface tissues exposed in radiography accidents, Christensen et al. (2009), of the Department of Energy Radiation Emergency Center/Training Site (REAC/TS) state, "There has been no good and relatively inexpensive way to determine extent of injury early after exposure. One would like to know what the extent of injury is going to be before one can actually visually see it in order to begin appropriate therapy as early as possible." This statement is not true. It does not recognize the availability of physical dosimeters that radiography personnel are all wearing at least on the body, if not also one on the hand or finger, to give a continuing record of their exposures, and also any necessary alert to dangerously high accidental exposures. Moreover, the provision of an inexpensive SIRAD dosimeter on likely places of maximum exposure, either on medical staff or on patients, would provide **immediate** visual indications of any levels of dose that would produce serious harm. Any biodosimetric methods that might define such doses could only come hours or days later, and are currently available to only limited numbers of medical centers.

Roessler (2009), in reviewing the further development of methods of cytogenetic analysis of blood samples in the Cytogenetic Biodosimetry Laboratory (CBL) of the REAC/TS, states in the second paragraph that, "The main challenge is that the potentially exposed people…would not be wearing personal dosimeters. Since physical dosimetry measurements would not be available, responders would have to depend on biological dosimetry." I ask, **"Why not provide responders with the SIRAD-type dosimeters discussed earlier and described in this chapter!?**

All of the biodosimetry measurement approaches, including those well developed by Salter et al. (2004), will be of value once the very limited portion of the population that can benefit from medical treatments applicable to radiation injury are first identified by triage using their personal dosimeters. (Until the biodosimetric methods are very widely distributed with adequate training, the very few and specialized biodosimetry centers available may then provide further confirmation of radiation doses only for a small proportion of the population that might be able to benefit.

No biodosimetric methods can alleviate the fear and panic that could result in the immediate minutes or hours after an attack. Nor would they likely be available in the early minutes after an attack to the vast majority of the population exposed. The biodosimetric methods all require time for overt signs and symptoms, and tissue changes, to occur. The method of ultrasonic examination of local tissue injury under development by Goans (described in Christensen et al 2009) requires time for the injury to be expressed and the patient to report to a physician alert to such injuries. The cytogenetic determination of dose from rings and dicentrics in chromosomes requires time, after the injured patient is presented to an appropriate center, for lymphocytes to be sampled and cultured for 48 hours to reach mitosis (Roessler 2009). The use of time to emesis as an indicator of the amount of exposure (Goans 2004) would require at least an hour before symptoms appear in persons within the dose range where there is still opportunity for some medical intervention to save life, and even here there may be interferences that reduce chances for emesis to occur; if emesis does not occur, days might go by before symptoms again occur that indicate to the specially-trained physician that a life-threatening radiation injury has been received.

I am not one to oppose biomedical research, but promotion of such research should not ignore the practical needs and methods available immediately after radiation exposure. Also, I am not against the further development of biodosimetric methods for radiation injury prognosis, if they can be somewhat more rapidly indicative of radiation injury than methods already available, and particularly if they can be shared more easily between an

increased number of medical centers that might be confronted with the few seriously exposed persons from the occasional radiation accidents.

I know from personal experience the value of such methods, particularly in peacetime radiation accidents in which there are a limited number of persons exposed. In the 1967 Van de Graaff accelerator accident at Gulf Oil Corporation (Brodsky and Wald 2004), my supervisor and Department Chairman, Niel Wald, M.D., asked me to immediately set up a phantom and determine, with physical and chemical dosimeters, the effective dose to blood-forming organs from the distribution of dose throughout the body, as well as the higher doses to arms and legs in the beam of the one individual who was working on the target not knowing the accelerator was turned on. Dr. Wald was one of a limited number of medical authorities who knew the relationships between immediate physical measurements of dose and the later biomedical indications that could further enhance the planning of appropriate therapy.

While he advised on the hospital management of the individuals exposed, Dr. Wald performed his examination of blood count data over time and got the help of Dr. Michael Bender, a cytogenetic pioneer at Oak Ridge National Laboratory to determine the numbers of rings and dicentrics in lymphocytes as spread out at mitosis. He later reported that his estimates of effective doses to the blood forming organs, allowing effective treatment planning for the exposed individuals, confirmed the effective doses that I had obtained earlier with my several dosimetric measurements. The mean marrow doses, both by the physical and chemical dosimeters as well as the cytogenetic determinations, were 600 rad and 300 rad, respectively, for the two higher-exposed persons who both had film badge readings of 300 R on their waist-positioned film badges. In addition, for the highest-exposed individual, the doses that I determined to his arms and legs that were in the radiation beam were predictive of the ultimate need and preparation for quadruple amputation. The additional 300 rad effective blood-forming organ dose for the highest exposed individual, to make his total effective dose estimate to be 600 rad, was estimated from the 6,000 rad doses to his lower arms and hands, and the 2,000-3,000 rad doses to his lower legs and feet, as well as the fraction of leg and arm bone marrow included in the beam Thus, biodosimetry and physical dosimetry were in very good agreement with each other, and with the progression of symptoms and injuries as the two higher exposed employees were confined to germ-free hospital environments. However, the physical dosimetry estimates were possible to obtain much earlier than the biodosimetry estimates. This shows the need for persons or responders in the population receiving radioactive fallout from an attack to be wearing SIRAD dosimeters, or possible high range pocket chambers if available, and to constantly observe their exposures during hazardous operations.

Dr. Wald's contribution to the management of the highest-exposed patient, including advising the proper timing of a bone marrow transplant from an identical twin brother, could well have saved the individual's life despite the eventual need for quadruple amputation of his extremities. The bone marrow dose was in the range where death from damage to the blood-forming organs would have almost been certain without the transplant and the specially managed care. Dr. Wald has reported even further advances in his long development of methods of cytogenetic analysis of radiation injury (Wald and Kuniak 2004). These methods are similar to those reported by Roessler (2009). Dr. Wald was one of the pioneers in the clinical utilization of these cytogenetic methods, beginning his work in the late 1950s with experimental animals and historic human exposure data in Oak Ridge (Thoma and Wald 1958; Wald and Thoma 1961). His diligent work over the years was extremely valuable and probably life-saving in this Gulf Corporation incident.

I am aware of recent additional millions of dollars in grants to medical institutions for development of biodosimetric methods. These grants might be well supported. But those promoting such research should also be aware that a few million dollars could purchase enough SIRAD dosimeters to provide to hundreds of thousands of responders. The early readings of these dosimeters, together with GPS locators of the responders and immediate communications to command centers, would be helpful not only in allowing each responder to monitor his

individual dose, but also to provide very early intelligence on the degree and pattern of spread of fallout for use in recovery operations.

In the early days of civil defense, our plotting of fallout patterns in exercises at our command centers depended on the simulated and slow monitoring by responders spreading throughout areas where rescue operations were necessary, followed by telephone reports back to command centers. Of course, fallout patterns measured after monitoring will never agree well with those plotted beforehand for scoping purposes using predictions from weather patterns, as indicated earlier in Chapter 5.

Therefore, biomedical dosimetry should never be presented as a replacement or alternative to immediate dose observations provided by personally worn monitors that can be immediately interpreted in real time. At best, biomedical dosimetry can only be supplementary for a small proportion of those persons already screened by personal monitors to require biomedical screening in addition. Biomedical and physical dosimetry screening are not interchangeable; they are supplementary when indicated (Schauer et al. 2003).

Important Advantages of SIRAD Personal Dosimeters

The SIRAD dosimeters can actually fulfill the role of early prognostication to a sufficient degree so that the large number of persons who would ***not*** *require such medical screening, would not need to be examined in a hospital, and would not overload the very limited medical capabilities for biomedical examinations of samples.*

I have been attempting to alert persons in high places of government to recommend, at least to State governments, the ordering of SIRAD dosimeters for responders using at least a small portion of the Federal funds already allocated to States by the Department of Homeland Security. These dosimeters are inexpensive, light, and wearable, and require no maintenance or auxiliary reading equipment. I would also like to encourage someone influential in venture-capital circles to fund the mass production and distribution of such dosimeters to the public in stores throughout the nation. The ability of citizens to obtain immediate monitoring of their own radiation exposures, most of which would be well below levels producing serious consequences, would be crucial in avoiding unnecessary panic and the destructive inundation of our medical institutions. The availability of such dosimeters to all members of the public, as well as to emergency responders, would also provide incentives for the public to learn and understand facts about radiation and the wide differences in biological effects between radiation levels.

The basic information needed by the public for their own protection is kept simple on an insert included with the dosimeters. I know from my own experiences in civil defense training that all members of the public, whether educated in the sciences or not, have quite adequate knowledge and intelligence to understand the significance of radiation exposure readings and use them for their own protection or protection of others. All that is needed is communication in simple, everyday language.

Even with assumptions of risk extrapolated from high doses, there remains a wide range of lower doses where Geiger counters or other sensitive detectors may seem to show high readings, while the actual risks represented by these readings are very small, negligible, or even non-existent in the aftermath of a terrorist attack. The great majority of persons who survive blast effects will not receive lethal exposures from radioactive fallout after a terrorist event releasing radioactive materials (Brodsky et al. 2004). Therefore, it is important that members of the public have knowledge of the amounts of radioactivity and radiation exposure that are ***likely to be harmful, not likely to be harmful, and ways to immediately reduce potentials for exposure by their own actions*** *if they are receiving significant exposures. In order to be able to take appropriate actions for their own protection in the seconds, minutes, and hours before any emergency teams arrive, or emergency instructions can be formulated and broadcast, members of the public need to obtain and wear at all times simple personal exposure detecting devices.*

Because the wearing of such devices would be cumbersome if they were large or heavy, I recommend that the highest priority be given to obtaining very inexpensive and light, credit-card SIRAD dosimeters that can provide radiation dose information from a comparison of color changes (or degree of darkness) with the set of colors incorporated on the card. In addition, I would prefer to see some members of the public obtain pocket ionization chambers to provide more accurate estimates of exposure and backup for the card dosimeters. However, although pocket chambers were purchased for as little as $10 when purchased by the millions in the days of civil defense, these dosimeters would today be out of affordable range and not available in adequate quantity for most members of the public. I would not be recommending a specific commercial product in this book if I knew there was competitive product for the SIRAD dosimeters that would provide adequate warnings or assurances of low risk for the public. There is not such competition available. On the other hand, I do suggest that those who are able to afford them seek information from the vendors in Appendix F about additional instruments that would enable them to supplement and check immediate exposures and exposure rates.

An unfortunate recommendation of the otherwise excellent 2005 report of the NCRP (NCRP 2005) is that only alarming dosimeters should be given to the public. For the reasons I have given in Chapters 4 and 5 about the public intelligence and ability to understand simple information about exposures and risks, such alarming dosimeters would cause more public harm rather than less. Alarms could be set at such low levels that undue fear and panic could result. The military do not want such personal dosimeters that might reveal their presence at inopportune moments. Members of the public need an inexpensive and reliable pocket or handbag dosimeter that can be read at any moment and interpreted immediately by visual inspection. I have searched for years and find that the SIRAD dosimeters are the only ones that meet requirements of distribution to the majority of responders and the public.

The following Exhibit 41 displays views of several models of the "SIRAD" dosimeter developed by the chemist and manufacturer, Dr. Gordhan Patel, in his laboratories and shops — JP Laboratories, 120 Wood Avenue, Middlesex, New Jersey 08846 (Telephone Number (732) 469-6670; E-mail sirad@jplabs.com), as further described in Appendix G. The development and improvements over the years have been helped by contracts from military and government agencies, which have also involved limited sales and distribution. The Department of Homeland Security (DHS) tests showing the validity of exposure readings, and the adequate ruggedness and stability of these dosimeters under the ordinary range of environmental conditions faced by wearers (Klemic et al. 2007a; Klemic et al. 2007b), have been summarized by Brooke Buddemeier (Buddemeier 2007). He was one of my subcommittee chairs in the Homeland Security Committee of the Health Physics Society in 2002; he has become a leading consultant for DHS and other organizations involved in homeland security (Buddemeier 2004).

Dr. Patel is an outstanding chemist, who has produced among his many patented products this sequentially improved set of "SIRAD" credit-card size, pocket dosimeters, available for purchase by responders or members of the public. Many years earlier I had been given, by Dr. Gordon Riel, a fellow member of the Baltimore-Washington Chapter of the Health Physics Society, a sample of one of early models of the SIRAD dosimeter that was being developed under a Navy contract. I wore it for a number of years and marveled at its stability. It was not until the Fall of 2007 that I had the chance to visit Dr. Patel's factory and laboratory and examine his production methods. I was impressed with the diligence and scientific abilities of Dr. Patel in not only performing the research and development of his chemical dosimeters, but also his single-hand building of his own production and quality-control facilities and methods. He knows all aspects of his production processes, because he created them, and thus gives personal attention to his quality control procedures on a daily basis.

Since the 9/11 attack, I have believed that every citizen should be able to purchase an inexpensive dosimeter, complete with an insert of simple instructions and information such as that provided in the small envelope containing the SIRAD dosimeter. With this small dosimeter packet, all citizens could immediately assess their own exposures and understand whether the exposures are likely to be harmful. Then, the ***majority*** *of citizens who would not receive harmful levels of exposure would not panic and inundate hospitals or clinics. Those few citizens who do receive significant exposures,*

especially exposures that if further increased could be life threatening, would then, with the information in the SIRAD packet (and perhaps this book and other references), know what to do either to immediately take more shelter, or to seek medical assistance from physicians who are familiar with radiation effects and treatments.

I had originally hoped that members of the public would be able to purchase the types of pocket ionization chamber dosimeters (attachable to pockets like pens) that were bought for less than ten dollars apiece by civil defense agencies and distributed to responders throughout the nation when I worked for the Federal Civil Defense Administration. A limited number of these pocket ionization chambers might still be obtained by consulting vendors listed in Appendix F, or by searching for "radiation instruments" or "civil defense" in the internet. Connor (2009) has maintained a supply of some of the earliest and most rugged models, including those in the range up to hundreds of R. These pocket chambers need to be re-charged with a charger when they have drifted down scale over time, or when exposures are obtained and the chambers need to be re-zeroed. Thus, a charger must also be purchased with a set of pocket chambers, and pocket chambers should be selected that allow readings into the higher ranges where urgent protective actions or medical attention might be needed.

Although the credit-card size dosimeters do not seem as precisely readable as readings of the pocket chamber, this impression can be misleading. The SIRAD readings could still be more accurate because pocket ionization chambers incorporate more significant errors as gamma ray energies differ from the range for which they are calibrated. Also, the indications of color change on the SIRAD dosimeters are easier to read under emergency conditions and are adequate for the citizen to know when he is, or is not, approaching a level of radiation that could likely be of significant harm if not avoided. The credit-card dosimeter cannot be re-charged after a high exposure reading is received, but it can be stored in a shielded container to serve as an exposure record. Also, purchased in a quantity of 1,000 or more, it would cost only about ten dollars or less per dosimeter, so that several could be available for a family, and those otherwise saturated with color could be replaced by unexposed dosimeters. If production facilities are expanded, the SIRAD dosimeter could also be distributed to the public for a lower price affordable to practically all members of the public.

It is long overdue, in my opinion, for some persons in high places, both in government and in private venture-capital firms, to take note of the importance and urgency of supporting expansion to mass production and wide distribution of these types of chemical dosimeters to public marketing centers, for reducing death and panic in the event of a terrorist attack. A small investment, compared with the billions spent by the Department of Homeland Security on interdiction (which can never be perfect), would help establish production facilities that could mass produce dosimeters affordable to almost every citizen, possibly even with a major return of funds and profits to the treasury or the investors.

(Another effort to develop a colorimetric dosimeter. (Desrosiers 2007, 2008) has apparently been discontinued.)

I personally would like to see the SIRAD family of dosimeters available for purchase in every supermarket or major department store. I feel certain that such availability would be welcomed by the public, and would save many lives and much anxiety in the event of terrorist attacks that disperse radioactive materials. However, it is likely that this dosimeter, or personal exposure monitor, should first be accepted and obtained by responders and local responder organizations, because they would likely be the ones who would first educate the local public or answer questions about emergency preparations.

Other Possibly Useful Backup Dosimeters

An example of a "self-reading" pocket ionization chamber dosimeter is shown in Exhibit 42. The charger that is needed with these dosimeters is also shown in the Exhibit. The one shown is the one I have worn in addition to the SIRAD dosimeter in my pocket. It has a range of 0 to 200 Roentgens (R). I have another with a range up to 500 R. With the 200 R or 500 R chamber, I could tell, with references to the table of effects in Chapter 4, whether I might be receiving a serious dose of radiation, and be able to time any changes in dose to estimate

dose rates and determine how soon I must seek shelter. I feel that with my past experience and connections to responder organizations, I might be called upon to assist in responding to radiation incidents if they occur. These pocket dosimeters are of the types that were ordered and distributed by the Federal Civil Defense Administration (FCDA) when I was employed in the 1950s in Region II as a physicist and Radiological Defense Officer. They were manufactured to such strict specifications that the ones I have are still in excellent condition. Many of these dosimeters can still be found in responder organizations, and can be purchased from companies advertising on the web. Information on these dosimeters can be found by searching for "Radiation dosimeters" or "Fallout Shelters," or by going to the site KI4U of Connor (2008).

Connor's company also has salvaged many of the civil defense radiological equipment that was to be discarded by the States, and sells many types of dosimeters, radiation instruments, and authoritative literature relevant to sheltering and other personal protection. The self-reading pocket chambers are also heavier than the SIRAD card, so it is likely that the card would be more acceptable as well as more easily readable by most members of the public. Also, the pocket chambers can no longer be obtained for wide distribution, or at a price anywhere near as low as the SIRAD family of dosimeters.

Connor also sells a personal exposure rate meter, NukAlert, which is attached to a keychain and provides chirp sounds proportional to radiation intensity. The NukAlert dosimeter could be a useful backup to another dosimeter, but is much more expensive than the SIRAD dosimeter, and as I indicated above, the chirp sounds and alarm levels to be set could be a problem in many situations where the uninitiated could be unduly frightened.

Both the NukAlert, the Kearny Meter, and the document Nuclear War Survival Skills (Kearny 2001) have been rather successfully presented to many responders by Jones (2009), who has also been more recently very active in introducing the SIRAD card-size and the new small RadSticker. The Kearny Meter is an inexpensive ion chamber with provisions to examine the reduced repulsion of charged metal leaves as gamma rays or other radiations ionize the air in the chamber. All of these instruments and the NWSS document can be helpful in educating the public and students about radiation. The Kearny Meter is also available from Connor (2008), but also can be constructed with home materials using instructions obtainable from Connor.

Jones recommends the document NWSS, particularly in respect to the first 35 pages, as the best one for beginning public education about protection from nuclear attacks. Jones has also recommended that "The Kearny Fallout Meter, also available from Connor, is best used for educating students in the science of radiation measurement and protection, and would be a valuable addition to any school science classroom. Its field use is advisable only when no other instrument is available."

The list of vendors in Appendix F provides contact information on other companies that can provide additional types of instruments and protective equipment for those who are interested in a more sophisticated, albeit in some cases more expensive, level of preparation.

Note on interpretation of dosimeters: For a person in a fallout field where gamma radiation is coming from all directions on the ground, a pocket chamber or SIRAD reading in roentgens (R) or rad produces a reading on the safe (high) side whenever it is substantially in error at all. For most gamma ray energies likely to be encountered, the reading in R multiplied by 0.95 would give the absorbed dose in rad, and thus the same dose in rem from gamma radiation, for a small volume of tissue in free air near the vicinity of the chamber. However, because gamma rays coming into the body from the opposite side, or from the same side, on which the chamber is worn would be attenuated before reaching the internal tissues of the body, the mean dose to body tissue would be less than the contribution as indicated from unattenuated gammas. Studies of the average dose to the body from a surrounding field of incident gamma rays from nuclear bomb fallout indicate the effective body dose may be taken as approximately 0.7 of the reading in R or rad by a dosimeter worn on the chest. However, for lower energy gamma photons, such as the 60-keV gamma rays from americium-241, the attenuation would be greater and the

mean body dose would be much less than that indicated by a dosimeter worn on the body. **Therefore, the reading in R or rad on a pocket dosimeter would tend to always be on the safe side (high-sided) for fallout either from a nuclear device or RDD, so that the wearer would tend to seek even greater shielding protection.**

Exhibits 41 through 46 illustrate some of the concepts and concerns discussed in this chapter.

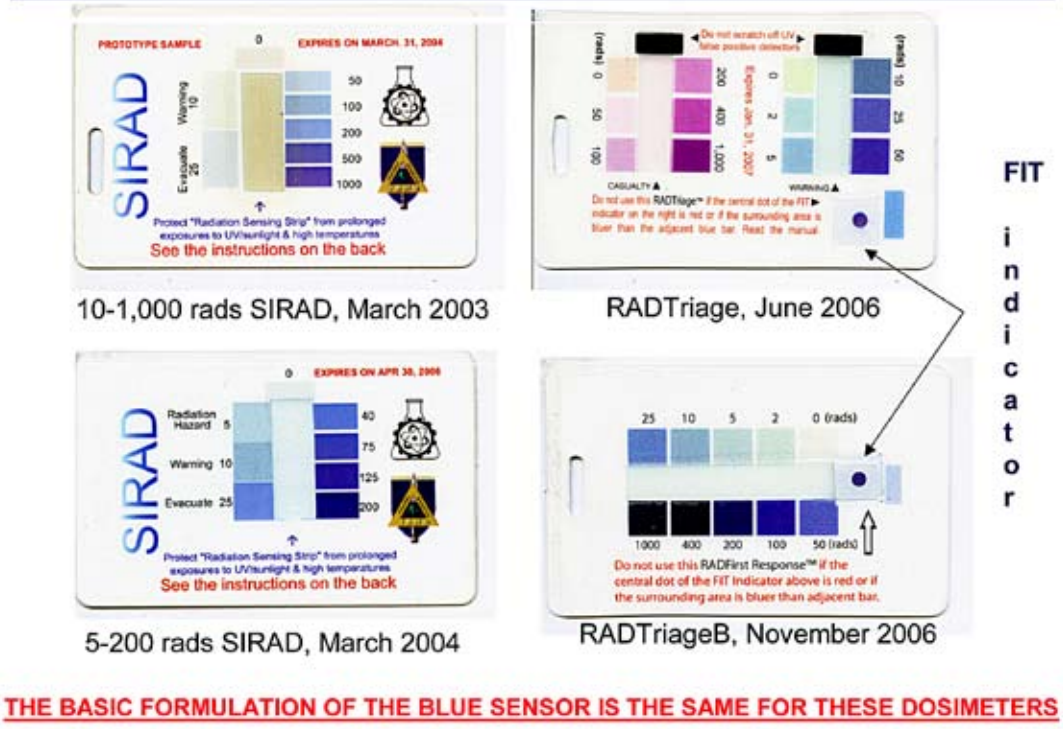


EXHIBIT 41 — The SIRAD group of light, credit-card-sized, pocket dosimeters. Reproduced by permission from a slide provided by Dr. Gordhan Patel.

The address for information on these inexpensive dosimeters, with included instructions for the general public, is: Dr. Gordhan Patel, JP Laboratories, Inc., 120 Wood Avenue, Middlesex, NJ 08846, telephone 732-469-6670, gnpatel@jplabs.com. **(See Appendix G for further specifications and purchase information. Other modifications and custom designs can also be made available.)**

Summary of Important Advantages of the SIRAD Family of Dosimeters

The advantages that make the SIRAD family the personal dosimeters of choice for responders and the public in the event of a nuclear or radioactivity dispersing device (RDD) attack are:

- It is dependable, quality-controlled, sufficiently accurate, and stable up to years of wear in varied climates, if properly protected and not abused.
- Its range of dose indication is appropriate for warning of serious doses but not so sensitive that it induces unnecessary panic. This range of dose is about the same as that for which the biomedical cytogenetic dosimetry is able to span (Roessler 2009), and is just as accurate.
- Built-in indicators are available to detect any misuse or inadvertent exposures to interfering ultraviolet or other sources that preclude detection of the fallout radiation.

- Materials of construction and wrapper are close enough to tissue equivalent that they indicate close to the actual radiation dose at the surface of the body where the dosimeter is worn, over a wide range of gamma ray energies (i.e., they are relatively "energy independent" in response to gamma exposure or absorbed dose at the skin surface).
- The dosimeters do not require any subsidiary and expensive readers but may be immediately examined visually, or over time periods of exposure.
- The dosimeters are not electronic, and so are not susceptible to interfering electric or magnetic fields, intense radio signals, or the electromagnetic pulse (EMP) that might destroy or annul other electronic dosimeters or communication equipment (Forstchen 2009).
- In the unusual event that a person has a large amount of beta-emitting contamination on or near the skin, the skin beta dose as well as the entrance gamma dose can be determined by the wearing of two dosimeters in a packet between which is sandwiched about 1 cm of paper or other low atomic number material close to that of tissue. Without such a sandwich, a single SIRAD dosimeter near the surface of the body will at least, if contaminated, overestimate gamma exposure and warn of possibly high skin doses.
- Because the sensitive colorimetric indicator and its surrounding materials of plastic and paper are of low atomic number material, in which the indicator approximates a Bragg-Gray cavity, the beta dose in rad would be about equal to the indicated reading on the dosimeter.
- Considering the same low atomic number of the materials, the hydrogenous plastic and paper surrounding the indicator could provide neutron detection for criticality accidents, with proper calibrations (OSU 2006).
- The SIRAD dosimeters can also be manufactured to be placed within security badges for persons working in nuclear plants or other facilities, and serve as emergency dosimeters where accidents that could involve life-threatening exposures might be possible.
- They may also be fabricated to be included in drivers' licenses for early intelligence on the exposure distributions of large populations, and for the assurance of wearers about their levels of exposure — usually well below levels of significant harm to health.
- They may be used as backup dosimeters to be worn by workers at NRC-licensed facilities to confirm that regulatory annual limits of exposure are not exceeded. Annual dose limits of 2 or 5 rem can easily be observed in the colorimetric sensors. Because they can be worn continuously when on the job, they can make up for any lost readings that might occur from inadvertent misuse or loss of the usual monthly or quarterly badges.
- The SIRAD dosimeters can also be fabricated into rings or smaller sizes that can monitor extremity exposures, such as we needed to estimate in the Gulf Corporation incident described above.
- The SIRAD dosimeters are inexpensive with no maintenance costs (they can be purchased for less than 10 dollars apiece depending on quantity, compared to many tens or hundreds of dollars today for other dosimeters with immediate readout).
- They are self-developing, easily read, and are dependable for years if not abused, without requiring batteries or any power source, and without requiring heavier and more expensive reading equipment that cannot be carried or worn on the body.
- They do not require individual dosimeter calibration or checking, as government testing has indicated, due to the outstanding consistency of manufacture, as developed and patented over the years by Dr. Patel.

- The color change is irreversible, permanent, and cumulative, so they can be saved if needed for any accident investigations.
- They can be fabricated for special purposes to have ranges less than 1 rad to above 1,000 rad.
- Their response over the range 1 to 1,000 rad to gamma, x ray, and beta radiation is independent of quantum energy from about 0.03 to 18 MeV, adequate for almost any routine or emergency monitoring of radiation. Thus, as indicated above, they are suited to be at least back-up monitors for routine or emergency exposures in medical institutions, nuclear power plants, or other facilities where high doses could be accidentally received.
- SIRAD dosimeters could be distributed to large populations of responders or members of the public, or posted on wooden poles, within current budgeted programs, so that with GPS identification of locations could serve the purposes of real-time intelligence of radioactivity dispersion and dose that could be relayed to homeland security command centers in the event of a radiological attack. This could be much faster and more accurate than the radiation isodose plotting that was required in the earlier days of civil defense operations, in which human monitors were needed to go into radiation fields and radio back their readings as they walked through designated areas. In the 1956-57 era, as Radiological Defense Officer at the Region II command center of the Federal Civil Defense Administration, I experienced difficulties and time lags in isodose plotting exercises, compared to what could be accomplished today with appropriately distributed SIRAD dosimeters and modern electronic data transmission.
- They can be stored in large quantities in hospitals throughout the nation, where they would be also be available for daily checks of patient doses from diagnostic and therapeutic x or gamma radiation, to avoid misadministrations that have on occasion produced serious bodily harm (NAS 2009). Despite some recent statements in articles on biodosimetry* (e.g., Roessler 2009; Christensen 2009), the SIRAD dosimeters **are available** and **suitable for patient checking**, either on the skin or behind the body in the beam, for daily checks on beam intensity at exposed parts of the body, or for accident dosimetry. Their use would also be very inexpensive, and the results would be immediately noticeable, in time to prevent further radiation treatments or diagnostic procedures that could harm the patient.

The above characteristics show that the SIRAD family of dosimeters is adaptable and dependable for many purposes of radiation protection and dose determination. Some of the advantages summarized above are my own and not so far claimed by the manufacturer, who would need to provide test information relevant to the respective claims. However, I am sure that any health physicist or other scientist familiar with the principles of radiation dosimetry could adapt the SIRAD dosimeter to provide any of the advantages listed above.

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* I must now confess my chonic chagrin about the use of the term "biodosimetry" to denote metric quantities of dose. Dose (rad or gray) is defined as an absorbed concentration of energy, even though it is sometimes multiplied by quality or weighting factors for convenient discussion of relative biological effects of different types of radiation on different organs or tissues. What is commonly referred to as biodosimetry by those involved in its research or applications should more properly be termed something like "radiobiologicmetricity," which is the determination or observation of a level of biological effect. The biological responses of tissues to doses of radiation can be defined at first only by examining particular responses (on a Y axis) as physical dose is increased (on an X axis). Only then, if some uniformly increasing function (not necessarily linear, which sometimes it is not) is found to represent a consistent correlation between the applied dose and the observed biological change or effect, can a biological effect be used to infer other future applied doses. Calling biological effects dosimetry only confuses persons about the Y and X axes. Although you can see, from my discussions of experiences with Dr. Wald using both physical and biological methods to infer doses in accident cases, that I appreciate the need for both determinations in high exposure cases. I wish that those who promote research and development of what they call "biodosimetry" would at least stop trying to indicate that these much later observations of biological changes can replace the immediate determinations of physical dose, which are of life-saving importance in determining immediate actions for survival — particularly in the event of exposures of large populations as would occur in terrorist attacks.

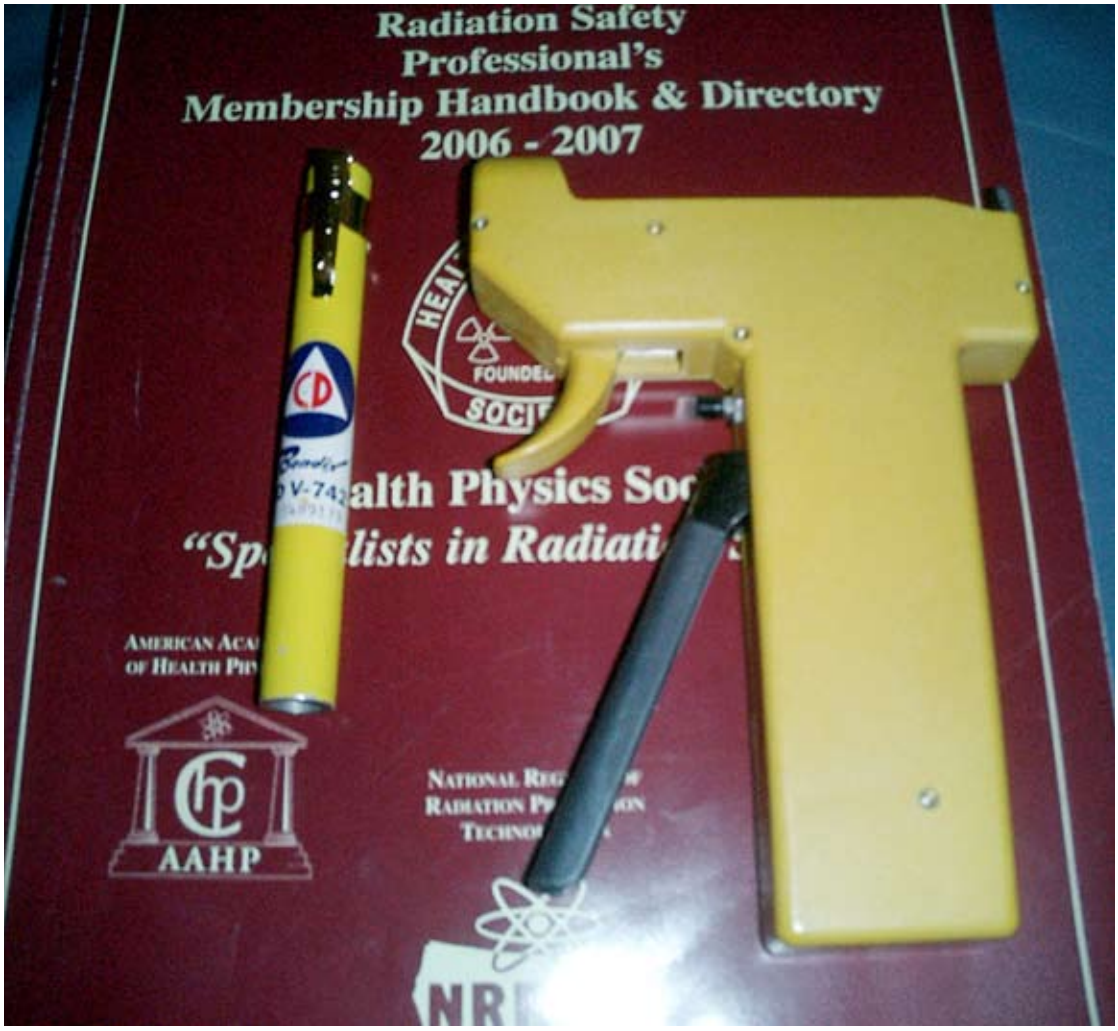


EXHIBIT 42 — A Civil Defense Pocket Chamber, CD V-742 Pocket Dosimeter, and Charger.

(The dosimeter and charger are displayed on the handbook of the Health Physics Society, where those specializing in radiation safety are listed (see definitions).) These are the types of pocket dosimeters made available in the mid-1950s and 1960s, which are still around; many are still working well. By viewing through the cylinder toward a light, one can immediately see the amount of radiation exposure received. By timing any change in exposure, the exposure rate can also be estimated. Some of the chambers came with chargers that were operated by battery. This charger has a trigger that creates a voltage by producing static charge. The chamber I wear goes up to 200 R. The recommended limit of exposure for responders usually given is 25 R, but some lifesaving or recovery might make it acceptable for an informed (and old as I) volunteer to accept more (especially for a mission like saving my wife, and I hope she reads this book). Except in extreme circumstances, a responder should not go into any area where he might receive more than 100 R (half scale on this dosimeter), for above that level there could be some risk of acute harm. (See risk tables in Chapter 4.) If I were to risk my life to save someone, I might want even a higher chamber, up to 500 R, to be aware of how likely and how fast I would become history if it took a certain while longer for the rescue at very high exposure rates.



EXHIBIT 43 — An Example of the Kind of Panic That Could Result without Personal Self Assurance that No Serious Exposure is Received.

Adapted with permission from a slide provided by Dr. Gordhan Patel.

Most experts agree that in the event of a dirty bomb attack, the greatest number of casualties would result from panic and worry.





EXHIBIT 44 — Panic and Inappropriate Evacuation Can Provide Only More National Tragedy.

Adapted with permission from a slide provided by Dr. Gordhan Patel

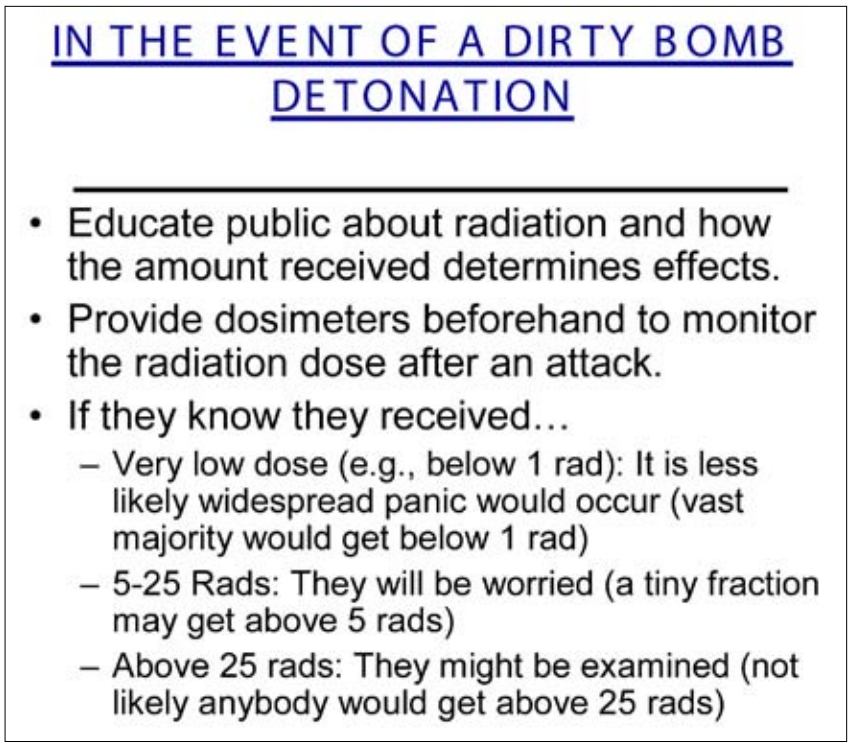


EXHIBIT 45 — The Importance of Buying and Wearing Dosimeters Before Tragedy Occurs.

Adapted with permission from a slide provided by Dr. Gordhan Patel.

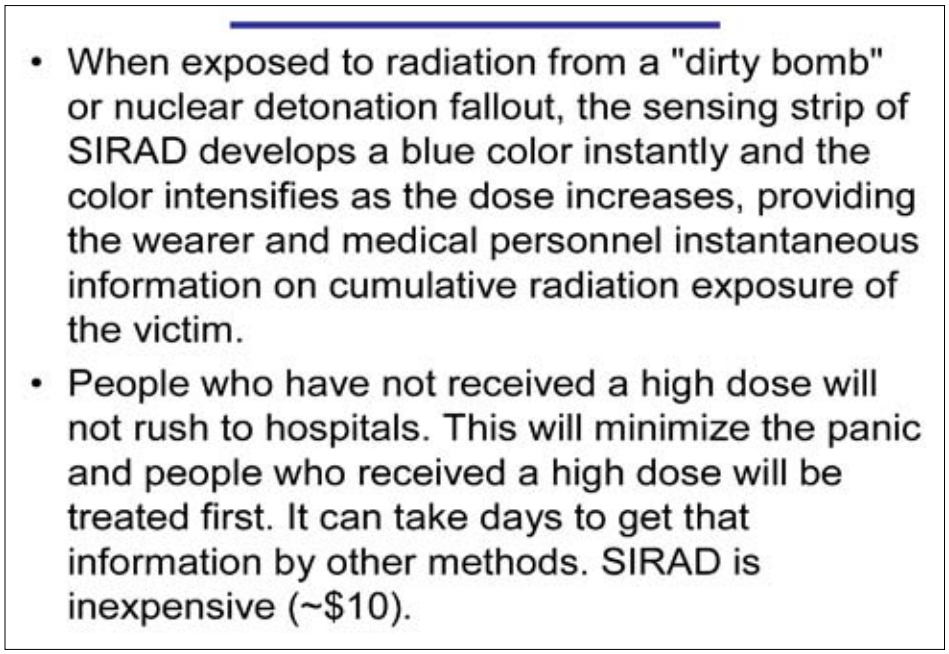


EXHIBIT 46 — How a Pocket Dosimeter Can Prevent Panic, Avoid Hospital Destruction, and Direct the Public to Sensible Protective Measures.

Adapted from a slide provided courtesy of Dr. Gordhan Patel.

CHAPTER 9

SUMMARY OF LIFE-SAVING ACTIONS FOR LAYMEN AND LEADERS

As indicated in Chapter 2, many of my professional colleagues have talked and written about the "fear factor" associated with the spread of detectable radioactive material in the public environment. That is why I described in that Chapter how we can prevent unreasoned fear with public knowledge, understanding, training (on **"things to do"**), and a resolve to minimize harm in the event of an attack. This chapter will be kept very brief in order to emphasize the most important information most citizens need to remember to take the most appropriate life-saving actions.

Actions for All Citizens

Actions that would greatly increase the saving of life and minimize panic in the event of a terrorist attack with weapons of mass destruction, for all citizens no matter what their role is during such an emergency, are:

- Know the basic facts for protection:
  - Post a version of Appendix C appropriate to your office and home locations and regularly review the suggested actions so you can immediately "do the right thing" in the event an attack or emergency occurs. Carry one of the brief action cards at the end of Appendix C.
  - Post and regularly review brief tables of radiation effects, such as Exhibits 7 and 8.
- Obtain a color-changing dosimeter like the ones shown in Chapter 8, and keep it available in a pocket or purse. It will likely confirm, in the event an attack with radioactive materials occurs, that you have not received a harmful dose of radiation if you stayed indoors in the immediate hours after an attack, or even outdoors in the early minutes after attack if you are far outside the zone of blast damage, as explained in Chapter 5. As also discussed in Chapter 5, you will also be unlikely to receive a significant internal dose even if you are outdoors and receive a higher external dose, unless you are unlucky enough to be in the passing cloud of smoke from the explosion (or on a mountain intersected by a mushroom cloud from an atomic weapon). If you can organize a community or county to purchase them in large quantities, you might even be able to buy a SIRAD type dosimeter for ten dollars or less. It could be a life saver.

- Prepare emergency kits for your home, offices, and autos, containing enough food, water, and supplies for at least three days and preferably non-perishable snacks for two weeks while remaining sheltered. Suggested lists are given in Chapter 6.
- Include in your emergency kits, battery-operated radios, radiation detection and measuring equipment to determine the relative intensities of radiation to which you might be exposed, and extra batteries for both the radios and radiation instruments. In order to reduce the costs of the radiation instruments, form groups to purchase them in quantity, and consult the companies in Appendix F that sell such instruments, as well as Conner's web site (Connor 2008), to find good used as well as new equipment.
- Prepare shelters as recommended in Chapter 7, or at least stock supplies of concrete blocks, bricks, sandbags or other material for quickly building ad hoc shelters when they are needed. Stock the shelters with emergency supplies, and keep in mind the non-perishable or sealed foods that might be in your own kitchen.
- Keep informed. Reviewing the parts of this book of interest to you is a good start. Knowledge of "**things to do**" will reduce risks and prevent panic. Also, get to know your county and local plans and officials involved in homeland security and emergency response. Be familiar with their plans, and check their appropriateness for your situation with the information provided in this book, and some of the references suggested.

Actions for Top Leaders

The actions recommended below are for the top leaders and scientists of governments, emergency response organizations, industries, and private companies. I have found that organization **culture flows down from the top**. I have tried in a number of ways to reach a broad segment of responders and the public with my messages through professional organizations or at second-tier levels of government and industry. I hope to be more effective with the publication of this book. I believe that the myths about small exposures to radiation will only begin to disappear when top officials in government and industry state clearly the need to understand how low levels of radiation, as described in Chapter 4, do not pose serious health risks and how the public can be protected against larger exposures.

Sometimes, as discussed about the recent EPA booklet on communication (US EPA 2007), government documents for the public still continue to make statements that would scare people even when they are exposed only to small fractions of the amount received from natural radiation sources, in which the human race has evolved. I found, when working at the AEC in the 1950s, as well as at the NRC in 1975-1986, that the public information offices often did not send their journalists and communicators to even the shortest introductory courses in order to provide them with a basic understanding of radiation issues. We scientists on the staff often needed to help them with the most elementary questions. Every government agency communicating with the public about scientific issues should send their public information personnel to at least one short course per year on the scientific issues on which they translate public policy or government actions in their press releases and other communications (see Karam et al. 2004).

Also, industry leaders and organizations have not provided clear explanations of the nature of radiation risks and how they are kept at acceptable levels in the nuclear industry, when they place advertisements about their industries and the benefits of their products. There is insufficient exposure of the myths that are propagated about the many insignificant incidents involving radiation exposures (see my own experience in Exhibit 3, where my name was misused to distribute false information to the public). There is also inadequate public information

about the remarkably low level of deaths and injuries from radiation in the USA compared to other risks occurring in industry and popular activities. Information on the relatively low levels of radiation risk from the low level exposures in peacetime is presented in Chapter 4.

Therefore, with the need in mind of the importance of re-educating the public about radiation risks and protection, the following actions are recommended for top leaders and managers:

- First, prepare for your own protection, and that of your families and co-workers, as suggested in the first section of this chapter.
- Find a way to give top priority and support to the wide distribution, to the public as well as responders, of easily-read, lightweight, and inexpensive, dosimeters, and their brief interpretation sheets, such as one of the SIRAD dosimeters described in Chapter 8. The personal availability of such dosimeters and brief instruction sheets will be extremely valuable in preventing panic by the vast majority of the public who will not receive serious radiation exposures. The few who might receive high exposures should know when and where to receive medical assistance. Nobody should rush to hospitals or clinics for decontamination, which can be done safely at home, as explained in this book. Top leaders can do much to ensure distribution of dosimeters at little cost.
- Fund responder organizations in State and local governments for the specific purchase in large quantity of high-range ionization chamber survey meters that can cover ranges of up to about 500 R per hour, and require training instructions to responders to include the entire range of intensities to which they might be confronted, as well as the relative risks and the higher levels at which significant personal harm could be incurred. As indicated in the text, many official responder courses are unfortunately emphasizing detection of levels in the mR per hour range, in which responders such as police and firefighters could spend many hours without serious harm.
- Provide check sources for instruments and food and water check sources, as described in Chapter 5, either by Government Issue or at inexpensive prices at distribution centers throughout the nation, fed by mass production initially funded by a very small portion of the Homeland Security budget, or by venture capital.
- Do not rush to legislate or require the use of the so-called newer System International (SI) units for radiation protection or emergency response within the United States. From my experience in teaching these units and using them professionally for many years, I find that the dangers and inconveniences of these units in practical field use far outweigh any presumed advantage of having equations on paper that have only unity (1) as a multiplier. Appendix E summarizes some of the disadvantages of requiring the so-called newer SI units in practice and emergency response, in pictures without a lengthy dissertation. In regard to providing compatibility with European and other information exchanges, it is easy to convert any radiation monitoring data in conventional units to the new SI units, without needing to use these units in immediate emergency operations. Also, many instruments, the Nuclear Regulatory Commission in its current regulations, and the training of many of the long-term senior police and firemen, have used the conventional units that are safer and more practical.
- Provide a matrix of gamma and neutron dosimetry distributed around and within population centers, some electronically or radiowave-connected to homeland security or responder operations centers. There will be a need after any attack to rapidly assess individual and population exposures. This need will pertain to emergency lifesaving and recovery operations, and well as in later assessments of medical care, further exposure limitation, and followup studies of population effects. At Hiroshima and Nagasaki, many millions

were spent to attempt to reconstruct exposures to members of the population by the teams under Dr. Auxier (Auxier 2004), and by many individuals involved in later refinements of these exposures using indirect methods and assumptions about the shielding of individuals.

There are some publications cited in the references of this book that could provide inexpensive methods for stationary dosimeters to be placed around a population center in protected boxes. The chemical dosimeters discussed in Chapter 8 would be rather rugged for measuring received gamma ray doses if placed within strong, light-tight packages within and without buildings in major cities. Special photodensitometers could be provided to response teams to read them accurately after an attack. Neutron exposures within areas close to detonation of atomic bombs could be assessed using some of the relatively inexpensive detection methods that I and associated colleagues used on the hydrogen bomb tests, as described earlier (Hanscome et al. 1955; Hurst et al. 1954; Brodsky et al. 1956; Brodsky et al. 1958; Auxier 2004). There is also a list of vendors in Appendix F who can provide electronic dosimetry for immediate monitoring at homeland security operations centers, just as is already done in our nation's nuclear power plants. Such immediate monitoring will be invaluable for recovery operations, as it was performed by helicopter in the two days before I was sent in to recover my neutron spectrometers in 30,000 mR per hour, three days after an H-bomb detonation, as shown in the cartoons of Exhibits 4a-c. Monitoring services determined from a helicopter that the planned second-day recovery could not be accomplished in the gamma-ray field that day; my time on the island was postponed to the third day. This was fine for the recovery of instruments; persons in danger of dying cannot wait that long. Thus, immediate monitoring systems are needed for every population center.

- Provide all technical and management personnel in homeland security organizations and teams with the 2004 comprehensive Health Physics Society book (Brodsky et al. 2004), which includes chapters from several dozen experts on all aspects of radiological, chemical, and biological weaponry, protective measures, and communication concepts. None of us who contributed free time received remuneration for our work, nor do we receive any royalties from its sale. I am urging its sale simply because the book will help in saving lives, and the Health Physics Society editor and the publisher, www.medicalphysics.org produced an excellent product. The book might seem expensive to some, but it would be a bargain to any person involved in planning or managing emergency response to a terrorist attack or an accident releasing large quantities of toxic agents.
- Provide the types of continuity of government, and sheltered alternate sites of government, that were available to leaders and high officials during the earlier years of the "cold war." As often as possible, station alternate leaders (e.g., vice presidents) in separate locations and places less likely to be included in terrorist attack plans, and provide them with protected offices at evacuation centers. Discourage the false bravado exhibited by some Congressmen who were requested to leave their offices during the anthrax scare. Think what would have happened to our nation if the brave passengers had not brought down the airplane headed for the Capitol or White House. Bring back some of the protected alternate sites for continuity of government that were highly protective, but have now been turned into museums. Maximize our possibilities for survival of the greatest number of our leaders and citizens. Our nation cannot survive without its leaders, just as it cannot survive with a citizenry who are in fear and panic, confused about survival, and not trained and oriented to rise up again and continue as a society and nation. Prepare in the event of any attack to preserve the greatest human history of a nation continuing to grow in personal freedom of its citizens and its care and hope for all of humanity — the United States of America.
- Last but not least, obtain views of scientists working on national defense and other projects at the working level before allowing cancellation of projects that do not seem high priority to middle managers, who

might be reluctant to defend them for political reasons. See, for example, the loss of very capable scientific staff in the discussion of the importance of retaining the NTPR team that could be vital in the aftermath of a terrorist attack, in Chapter 5. Obtaining and respecting views of scientists and engineers at the working level is important in maintaining their morale in carrying out government scientific projects, and in promoting a national atmosphere that welcomes new students into careers important to our future economy and national defense. Top leaders will also obtain information from those at the working level that often would not otherwise be available for the solution of national problems.

How to Boost Construction, Eliminate Unemployment, Improve the Economy, and Save Lives

As done in Switzerland and other nations in the 1950s, require with high priority that building codes include adequate tornado-fallout shelters in all new home construction, and retrofitting of an area in each existing home (and in other buildings where strong shelter is not already available). A taxpayer cost of only a small fraction of our annual wartime budget, say 20 to 40 billion, could probably do the job if this were done on a mass design-production basis. This is not space science. Some references to design and supply requirements, supported by taxpayer research in the early nuclear test operations, are given in Chapter 7.

AFTERWORDS

The good news about nuclear destruction

by Shane Connor

(Updated 12/17/2010 from www.ki4u.com)

What possible good news could there ever be about nuclear destruction coming to America, whether it is dirty bombs, terrorist nukes or ICBMs from afar?

In a word, they are all survivable for the vast majority of American families, *if* they know what to do beforehand and have made even the most modest preparations.

Tragically, though, most Americans today won't give much credence to this good news, much less seek out such vital life-saving instruction, as they have been jaded by our culture's pervasive myths of nuclear un-survivability.

Most people think that if nukes go off, then everybody is going to die, or will wish they had. That's why you hear such absurd comments as: "If it happens, I hope I'm at ground zero and go quickly."

This defeatist attitude was born as the disarmament movement ridiculed any alternatives to their agenda. The sound Civil Defense strategies of the 60s have been derided as being largely ineffective, or at worst a cruel joke. With the supposed end of the Cold War in the 80s, most Americans neither saw a need to prepare, nor believed that preparation would do any good. Today, with growing prospects of nuclear terrorism, we see emerging among the public either paralyzing fear or irrational denial. People can no longer envision effective preparations for surviving a nuclear attack.

In fact, though, the biggest surprise for most Americans, if nukes are really unleashed, is that they will still be here!

Most will survive the initial blasts because they won't be close enough to any "ground zero," and that is very good news. Unfortunately, few people will be prepared to survive the coming radioactive fallout, which will eventually kill many times more than the blast. However, there is still more good news: Well over 90 percent of the potential casualties from fallout can be avoided if the public is pre-trained through an aggressive national Civil Defense educational program. Simple measures taken immediately after a nuclear blast, by a trained public, can prevent agonizing death and injury from radiation.

The National Planning Scenario No. 1, an originally confidential internal 2004 study by the Department of Homeland Security, demonstrated the above survival odds when they examined the effects of a terrorist nuke going off in Washington, D.C. They discovered that a 10 kiloton nuke, about two-thirds the size of the Hiroshima bomb, detonated at ground level, would result in about 15,000 immediate deaths and another 15,000 casualties from the initial blast, thermal flash and radiation release. As horrific as that is, the surprising revelation here is that over 99 percent of the residents in the D.C. area will have just witnessed and survived their first nuclear explosion. Clearly, the good news is most people will survive the initial blast.

The study also determined that another 250,000 people would soon be at risk from lethal doses of radiation from the fallout drifting downwind toward them after the blast. These much larger casualty numbers are avoidable, and that's more good news, but only for those pre-trained by a Civil Defense program in what to do before it arrives.

Another study, released this month by the Rand Corporation, looked at a terrorist 10-kiloton nuke arriving in a cargo container and being exploded in the Port of Long Beach, Calif. Over 150,000 people were estimated to be at risk downwind from fallout, again, many more than from the initial blast itself.

Today, lacking any meaningful Civil Defense program, millions of American families continue to be at risk and could perish needlessly for lack of essential knowledge that used to be taught at the grade school level.

The public urgently needs to be instructed in Civil Defense basics, like the good news that thousands can be saved employing the old "Duck and Cover" tactic, without which most people will instead run to the nearest window to see what the big flash was just in time to be shredded by the glass imploding inward from the shock wave. They need to know when promptly evacuating, doing so perpendicular to the coming downwind drift of the fallout would be their best strategy. They must also be taught how to effectively shelter in place for a brief time while the radioactive fallout loses 90 percent of its lethal intensity in the first seven hours and 99 percent of it in two days. For those requiring sheltering from fallout, the majority would only need a couple or three days of hunkering down, not weeks on end.

This good news is within easy grasp of most people because an effective improvised family fallout shelter can be put together at home both cheaply and quickly, but only *if* the public is trained beforehand, as was begun in the 60s with our national Civil Defense program.

Unfortunately, our government today is doing little to promote nuclear preparedness and Civil Defense instruction among the general public. Regrettably, most of our officials, like the public, are still captive to the same illusions that training and preparation are ineffective against a nuclear threat.

Department of Homeland Security head Michael Chertoff demonstrated this attitude last year when he responded to the following question in USA Today:

Q: "In the last four years, the most horrific scenario ? a nuclear attack ? may be the least discussed. If there were to be a nuclear attack tomorrow by terrorists on an American city, how would it be handled?"

A: "In the area of a nuclear bomb, it's prevention, prevention, prevention. If a nuclear bomb goes off, you are not going to be able to protect against it. There's no city strong enough infrastructure-wise to withstand such a hit. No matter how you approach it, there'd be a huge loss of life."

Mr. Chertoff fails to grasp that most of that "huge loss of life" is preventable if the survivors of the blast and those downwind knew what to do beforehand. He only acknowledges that the infrastructure will be severely compromised, responders won't be responding. Civil Defense training of the public is clearly the only hope for those in the fallout path. Of course, the government should try and prevent it happening first, but the answer he should have given to that question is: "preparation, preparation, preparation" for when prevention might fail.

The federal government must launch a national mass media, business-supported and even school-based effort, superseding our most ambitious public awareness campaigns like for AIDS, drug abuse, drunk driving, seat belts, anti-smoking and smoke detectors. The effort should percolate down to every level of our society. Let's be clear: we are talking about the potential to save, or lose, many times more lives than those saved by all these other noble efforts combined!

Instead, Homeland Security continues to be focused primarily on two missions:

1. Interdiction: stopping nuclear materials and terrorists at the border
2. COG: Continuity of Government for when No. 1 fails

The most important mission has been largely ignored:

3. Continuity of the Public: proven mass media Civil Defense training of the public that would make the survival difference for the vast majority of Americans affected by a nuclear event.

This tragic and deadly oversight won't change until the crippling myths of nuclear un-survivability are banished by the good news that a trained and prepared public can, and ultimately has to, save themselves.

National Civil Defense is an issue we hope and pray will come to the forefront politically this fall, with both parties vying to outdo each other in proposing aggressive Civil Defense educational programs. We are not asking billions for provisioned public fallout shelters for all, like what already awaits many of our politicians. We are just asking for a comprehensive mass media, business- and school-based re-release of the proven practical strategies of Civil Defense education, similar to what already has been embraced by the Chinese, Russians, Swiss, Israelis and even Singapore.

In the meantime, though, don't wait around for the government to instruct and prepare your own family and community. Educate yourself today and begin establishing your own nuclear survival preparations by reading the free nuke prep primer "What To Do If A Nuclear Disaster Is Imminent!"

Then pass copies on to friends, neighbors, relatives, churches and even local news media, and to your local elected representatives with a brief note attached saying simply: "We hope/pray we never need this, but just in case, read it now, and keep it close for later on!" You might also forward them a copy of this article to help spread the good news that's liberating Americans from the deadly myths of nuclear un-survivability!

Shane Connor is the CEO of http://www.ki4u.com/
Consultants and developers of Civil Defense solutions to
Government, NPO's and Individual Families. (See Connor's website!)

APPENDIX A

MORE WORD DEFINITIONS AND CONCEPTS FOR FURTHER READING

Words and concepts for those wanting to read more deeply into the subject of radiation risks, radiation protection, and nuclear matters, are as follows:

Alpha (α) Particles — These were discovered in the early 1900s to be helium nuclei, without their orbital electrons, that were emitted from heavier radioactive elements that had the electrical force of many protons in the nucleus to push these particles out. The alpha particle mass, with two protons and two neutrons, is several thousand times that of an electron. They usually carry several MeV of energy, but because of the relatively large particle mass they travel more slowly for the same amount of energy, and their two positive charges have longer to interact with charges in material through which they pass. Therefore, they do not penetrate more than a piece of paper or the dead layer of skin (see Exhibit 4). Therefore, radioactive nuclides that emit only alpha particles can not be harmful if the contamination is outside the body or only on skin. However, if the contamination is absorbed into body tissues by inhalation or ingestion, the alpha particles emitted can bombard the tissue at close range with a much denser energy deposition per length of track. A "radiation weighting factor" for alpha particles is applied to the absorbed dose in rad, because animal experiments indicate a greater damage to tissue per unit amount of energy absorbed from alpha particles, compared to electrons. However, the animal experiments that show radiation effects from alpha emitters (Stannard 1988) have been conducted with much larger amounts (concentrations in tissue) of alpha-emitting radioactive material than is likely to be absorbed from a "dirty bomb, RDD", or even from an atomic bomb, at distances where survival from blast is likely. The effects of alpha emitters taken into the body are summarized in Chapter 4.

Anti-Nuclear Activist (or Scientist) (ANA) — This is an oversimplified term often used to describe persons who with more zeal than knowledge usually tend to exaggerate the effects of even very low doses of radiation, and oppose any uses of nuclear energy or other byproduct technologies, even when presented with evidence of inconsequential or zero risks for great human benefits. I want to emphasize that my use of this term is only for brevity. I would call myself: an "anti-dangerous-nuclear activist," an "anti-nuclear-weapon activist against the spread of nuclear weapons, especially among nations or people who show the desire to use them," and a "pro-safe-nuclear activist" who has only supported nuclear applications when they have been safe, which has been much more often than most people realize (Waltar 1995, 2004; Domenici 2004). My experience tells me that the uses

of nuclear energy and byproducts as they are designed and maintained in the USA, and in most civilized nations, can be and are beneficial and essential. However, for purposes of this book, suffice it to say that much of the information presented to the public by the news and book media, and to students in the schools, has exaggerated radiation risks. (See Appendix D for a sample of Dr. Rockwell's answers to the many myths about radiation.) In the definitions below, radiation risks will be further put into perspective, so that after a radiological attack, citizens can make the best judgments and take the best actions to minimize exposures and risks without the panic that would cause undue harm.

Becquerel (Bq) — A more recent unit of radioactivity, which is just 1 disintegration per second (1dps). Thus, one Ci = 37 billion Bq. This unit is part of a "System Internationale (SI)" units recommended by the International Commission on Radiological Units in the latter part of the 20th century, which is a set of units designed to provide all equations with only a numerical factor of one preceding the algebraic symbols for measurable quantities. However, although I have found the SI system useful when I worked as a medical physicist measuring radiation doses to patients, I and many others in the United States have found inconveniences and some increased chances for error when using the SI units for protecting workers and the public from radiation. Many responders in the United States have already been trained using instruments reading in roentgens or other conventional and convenient units; many of us think that forcing the so-called new SI units on responders can lead to serious errors and is detrimental to homeland security. Some of our government institutions, military organizations, and scientific journals use the SI units to conform to uses in other nations and thus expedite international communication. However, the conventional units can be easily converted to SI units by scientists when this is necessary. Most of the older civil defense and other commercial instruments available for homeland citizen protection have instrument dials reading out in conventional units. Many of the newer ones also read out in conventional units; e.g. R/hour or mR/hour, and international commercial calibration services still provide calibrations of instruments in these units.

Beta Particles (or Rays) — These are electrons that are emitted from hundreds of radioactive nuclides, each particular nuclide (combination of neutrons and protons) having its own "fingerprint" of energy distributions from a maximum value down to zero. They are called "beta particles" because they are emitted by unstable nuclei decaying, or transforming, into different chemical atoms when a nucleus with too many neutrons emits an electron at high energy and becomes a proton. This causes the atom to transform to one place further up the periodic table of elements. A few unstable nuclei may, in contrast, capture an electron and convert a proton into a neutron, causing the atom to transform down one place in the chemical element order. Most radioactive material spread from RDDs (unless they contain alpha emitters), or from atomic bombs (better called nuclear bombs), will be beta emitters. Fission products, which are the nuclei formed in the fission process of an atomic bomb, all emit beta particles for our practical purposes. A few, like strontium-90, emit only beta particles and no concurrent gamma rays. Beta particles, because they have one electronic charge, interact with tissue as soon as they enter through skin. They follow a short straggling path and the highest energy beta particles generally can be stopped in the thickness of your palm. However, since the density of their energy deposition is hundreds of times greater than for most gamma or x rays, they can produce skin burns and damage from outside the body even in gamma fields that are not quite sufficient to cause likely health effects from energy absorption in internal organs. A general rule of thumb is that skin doses from fallout material on the ground or on the skin can be 10 to 100 times greater than the whole body gamma dose (Barss and Weitz 2007). Thus, when contamination of the outside of the body is suspected, it is important to immediately wash with soap, after discarding clothing. It is also desirable to cover the body with thick clothing if you are to be working on rescue or other activities in high-intensity radioactive fallout fields (e.g., more than 1 R per hour). However, it is also true that you are not likely to receive very high beta or gamma doses unless you are in the limited areas of high contamination. When I was involved in the hydrogen bomb tests in the Pacific, or at the lower yield tests in Nevada, only a few persons — mainly those associated with aircraft that penetrated the mushroom clouds for a matter of seconds to obtain samples of the fission products — were

known to have received serious beta radiation burns. On the other hand, many of the Rongelap natives who were exposed to fallout from the BRAVO H-bomb shot, when the wind unexpectedly changed direction, received up to 6,000 rads to the skin, particularly in areas of skin folds, while fortunately receiving almost up to about 200 R of gamma radiation to the whole body. The whole body dose, fortunately, was not quite enough to cause lethal effects. I had occasion to estimate this maximum skin dose to the natives from my own information when I was consulted as a faculty member at the University of Pittsburgh. After I estimated the 6,000 rad dose, I found that physicians had estimated this same maximum dose from observations of the serious skin lesions that resulted from fallout remaining on skin. While some of us who participated in the tests were sent below decks on ships receiving the same fallout, the natives were initially unaware of the nature of the particles falling from the sky. The natives were accustomed to maintaining coconut oil on their hair and not washing for a number of days. On the ship, I measured that I had received only 0.1 rad from the fallout, due to sheltering below decks and within a crowd of others, while the decks were hosed down with sea water. I received no beta radiation of the skin at all, only the 0.1 rad of gamma radiation. This experience yields lessons for protection from terrorist attacks: staying indoors if not in a damaged building, and simply washing with soap and water if any contamination at all is suspected.

Curie (Ci) — The conventional unit of radioactivity, named after Madame Curie, the discoverer of radium. It has been the unit most used in the United States in its regulations and in radiation protection practice. One Ci of radioactivity is equal to 37 billion atoms transforming (or sometimes said to be "disintegrating") per second. Often in routine practice the **microcurie (μCi)**, which is a unit of radioactivity that is one millionth of a curie, is used to avoid using large numbers. A convenient way to remember the microcurie is to know it is also equal to 2.22 million atoms disintegrating per minute. Often the number disintegrating per minute (abbreviated dpm) is more readily determined because a second is too short a time in which to accurately turn on and off a counter. The symbol "μ" (pronounced "micro') is a letter of the Greek alphabet that is customarily used to mean "one millionth" in scientific writings. There are many other subdivisions of units. In the main chapters of this book, a minimum of new words are used so that most citizens can understand concepts for their own protection without needing to memorize unnecessary information

Dirty Bombs (better called "Radiological Dispersal Devices," "Radioactive Material Dispersing Devices," or "RDDs") — Bombs with ordinary explosives that are laced with stolen radioactive material in order to contaminate areas and scare the public with radioactive contamination. Alvarez (2004) discusses the nature of dirty bombs, and their potential and limitations in dispersing radioactive material. Many authors write about the "fear factor" of these RDDs that will result from the fact that members of the public have been exposed to the myths this book hopes to dispel. An understanding, and personal observation, of the smaller levels of radiation dose that would be received by the vast majority of the public is needed to prevent unnecessary panic and the deaths it could cause. Confirmation of this statement and further information may be obtained by contacting the Health Physics Society website (see website appendix) and obtaining views from professionals most experienced with radiation effects.

Dose — The word "dose" in this book will usually refer to a radiation dose, but some discussions of chemical or biological dose will be in units other than those for dose given above. Radiation doses will be given as discussed above in units of **rad** or **rem**, sometimes with the corresponding SI units Gy or Sv in parentheses. Again, the unit of rad is based on the amount of energy absorbed per gram of tissue; the unit of rem has a modifying factor for radiations other than x, gamma, or beta radiation, to take into account observed greater effectiveness of protons or alpha particles in animal experiments per unit dose in rad. This modifying factor, sometimes called "quality factor (QF)", "Q", or "radiation weighting factor (w_r)" is rounded to a convenient number; e.g., 1 for external gamma or beta radiation, 10 for external neutron radiation, or 20 for alpha radiation emitted within body tissues. No more detail is needed for purposes of this book. In the body of this book, different units and abbreviations of units will

be interspersed to familiarize the general reader with the units and the ways they will find them written. For this reason, consistency will be "thrown to the winds." This would not be allowed in a scientific journal.

For most immediate protective purposes after a nuclear or dirty bomb attack, the dose in rad may be assumed to be close enough to the dose in rem in regard to actions to take, or just remaining calm.

Exposure — Exposure refers to the amount of radiation incident, or passing through, an area in which a person might be present. Units of exposure to gamma radiation are: photon fluence rate, in photons per square centimeter per second; or roentgens (R) as defined above, which is related by its definition in terms of electric charge produced per cubic centimeter of air to the photon fluence, energy per photon, and fraction of energy absorbed per centimeter traveled. It is important to know that 1 milliroentgen (1mR) is one thousandth of 1 R.

Other units are also used, but are not needed here. In my opinion, as stated ealier, the SI unit of exposure to air, coulombs of charge per kilogram (C/kg) of air, is not useful for routine protection purposes and could be a dangerous unit. Only 1 C/kg unit is equivalent to 3,881 R, which would be many times a lethal exposure, causing death in a matter of hours. A person mistaking 1 SI unit of exposure for 1R could cause great harm. Fortunately, this SI unit of exposure has never been used in radiation protection practice, to my knowledge. The expression of exposure in C/kg of air **is** most useful for physicists involved in the use of radiation for cancer therapy. For the small ionization chambers used for high therapy doses, and charge readout in coulombs, this SI unit has advantages. I have taught my students how to make such measurements with small ion chambers and translate them to doses to human tissue (see Brodsky 2004). However, it is unfortunate that governments forced the adoption of SI units for radiation protection practices in many nations; the recommendation to replace the roentgen with the C/kg unit for protection practice was, in my opinion, ill conceived. The R unit is still widely used in the United States, and sometimes in other nations around the world, despite some official mandates. International calibration services continue to calibration radiation survey meters in conventional, as well as the newer SI units, to meet practical demands. So, both sets of units must be familiar to health physicists and other working in radiation science, radiation medicine, and radiation protection. Elementary familiarity with both sets of units for measuring radiation doses and radioactive material quantities is thus also important for responders and members of the public who will be monitoring themselves.

External Radiation Exposure (or just external exposure) — Exposure to the absorption of energy from radiations emitted from materials or machines external to the body (e.g, from radioactive materials outside of the body). In addition to radioactive sources, external sources can be x ray machines, "atom smashers" such as Van de Graaff generators, or TV sets not properly shielded, that might accelerate electrons to high energies and smash them against targets or screens. (Tighter regulations have for a long time ensured safer TV sets.) The difference between external and internal exposure for radionuclides may be thought of as an analogy of being exposed to chest x-rays from a machine outside of your body, versus being exposed to a miniature x ray machine implanted inside of your body. (However, radioactive materials that have entered and lodged in the body will continue to emit radiation as they decay away at their natural decay rates, and they cannot be turned off unless their elimination can be enhanced by administration of selected agents (see Brodsky and Wald 2004)). Sometimes greater protection factors are used against internal exposure because once radioactive materials enter into the body, there is more uncertainty in determining the amount in your body without cutting you open (which HPs do not want to do). Mathematical models of physiological transportation of radionuclides within the body are used to estimate amounts in the body from successive measurements in materials eliminated from the body, and by the whole body counting of gamma rays, if present, as mentioned above. For readers wanting more detail, examples of such measurements and calculations required are covered in Brodsky and Wald (2004). (See Exhibit 1-7 for a contrast between internal and external exposure.)

Gamma Rays (or "Photons") — The pulses of electromagnetic energy emitted from the nuclei of radioactive atoms after they emit beta radiation, in order to complete their transformation to a stable form of the transformed atom. These electromagnetic pulses are called "photons," because in addition to exhibiting some electromagnetic wave properties such as diffraction, they also have been shown to act like particles. This dual nature of gamma rays (as well as particles) is explained in elementary physics textbooks. Gamma rays are similar in nature to x rays, and have overlapping energy ranges, depending on their origins. The only difference in calling photons gamma rays or x rays is that: **gamma rays are emitted from the nuclei** of radioactive atoms usually after emission of a beta ray; **x rays are emitted from outer electronic shells** of an atom when an excited atom whose electrons are misplaced into higher orbits changes to a ground (or more stable) atomic state. There are groups of about 17 keV x rays emitted from plutonium or other heavy radioactive atoms after a nuclear decay that emits an alpha particle but leaves the entire atom in an excited orbital state. The x rays emitted after alpha emission are usually emitted by electrons falling into the innermost atomic shell (K shell) in a very small fraction of a second after the alpha decay.

For a simple visual model for our purposes, gamma photons may be visualized as small wavelets of oscillating electric and magnetic fields, bunched into a tiny envelope that travels at the speed of light (which it is), 186,000 miles per second. When they come near electrons in passing through matter, the oscillating fields can kick out electrons from atoms; that is why I sometimes refer to them as gamma ray "bullets," although some of my colleagues think that is not a good term for the public. Professor Arthur Compton, in the early 1900s, showed that if each photon were assumed to have a certain momentum related by a specific equation to its wavelength, then when it came near an electron it kicked out electrons with angles and energies related by a chance (probability) distribution to its own energy exactly in the same way billiard balls would do to other balls. (For his work he received the Nobel Prize in Physics.) That is why it is convenient in talking to the public as if gamma photons are bullets. However, as we know from high school science, matter is largely composed of space between the orbital electrons and nuclei. If a gamma photon does not by chance come near another charged particle as it goes through the body (or other material), some of the photons can come through even a thick material without interacting or depositing energy. The fraction of photons that can penetrate through a given thickness of matter or body tissue varies according to the energy of the photons. Most of the 1.46 MeV photons from the natural potassium-40 in the body, discussed above, come out of the body without interacting and can therefore be easily detected by a detector above a person sitting in a chair, or lying on a table, in the "whole body counter." Lower energy x or gamma rays, such as those from a chest x ray (many less than about 0.05 MeV), or from the decay of excitation in plutonium atoms after emission of an alpha particle (less than about 0.02 MeV), will be mostly absorbed before exiting the trunk of the body. For the average energy of fission product gamma rays in fallout from a nuclear bomb, about 70 percent of the gamma energy impinging on the body is absorbed by the body, and about 30 percent simply passes through without interacting (Brodsky et al. 2004).

Geiger counter (or Geiger-Mueller (GM) counter — a radiation detector that detects and estimates the intensity or flow rate through space of ionizing radiation such as beta or gamma radiation. It is designed with a fine wire "anode" that is placed at a high positive voltage, typically about 1,000 volts or more, with respect to a negative or ground voltage voltage of zero at the wall surrounding the wire, which is insulated from the wall. With a thick wall of metal (perhaps only in millimeters) beta radiation can not be detected, so the counter can detect only gamma radiation. Although most gamma rays of interest can penetrate the wall, enough gamma photons interact with the wall and release electrons into the chamber to produce an electrical pulse. These electrons are fast enough, so that they knock out electrons from atoms of the gas (or air) in the chamber with such energy that, under the high attractive positive voltage at the anode wire, they cause a huge avalanche of electrons that saturate the anode with a pulse of current, which is registered by an appropriate electronic circuit that then restores the proper voltage to the anode to allow recording a following pulse. Restoration of voltage can occur within a millisecond interval

so that thousands of pulses per minute can be recorded by a GM counter. The amplification in a geiger counter avalanche is such that about 100 billion electrons arrive at the anode for a pulse initiated by only one electron knocked into the gas by a gamma ray (science standards now recommend no capitalization of the word Geiger, even though it was a scientist's name). If a very thin window is cut into the wall of the chamber and sealed with a thin plastic membrane protected by a screen, so that the gas in the chamber can not escape or be infiltrated, then when the detector is placed near a surface contaminated with a beta emitter, the betas (fast electrons) can then immediately be detected very sensitively by the counter. The counter is connected to an electronic circuit and meter that indicates the number of counts per unit time, which, if no betas are entering the chamber, sometimes is roughly indicated on a scale to indicate the exposure rate of gamma radiation in mR per hour, for a certain range of gamma energy and within certain limits of accuracy. The range of gamma radiation for which exposure is roughly indicated within a certain accuracy is specified in the information provided with the instrument. Sometimes, the count-rate is also connected to an integrating circuit that can accumulate the counts as well as the indication of total exposure. Therefore, a Geiger or GM counter is most suitable under peacetime conditions for making surveys of laboratories or industries where one wants sensitive detectors, because workers might be exposed to gamma or beta radiation over a lifetime on the job or many years of work.

(**Note:** The definitions and descriptions of radiation detecting and measuring instruments in this book have been simplified so that the reader interested in the scientific bases of these devices can have at least some concise idea of how they work. (More detailed descriptions and concepts may be found in the textbooks by Cember (Cember and Johnson (2008), Evans (1955), and Turner (1995), listed in the References section. The chapter by Johnson (2004d) describes all types of radiation instruments as they might be used by emergency responders.)

Gray — A unit of radiation dose that, like the rad, defines an amount of energy deposited per gram of material or tissue. A gray (Gy) of radiation dose is the same as 100 rad. Therefore, to change from rad to Gy, the dose is multiplied by 0.01, not the other way around. To convert from Gy to rad, the dose is multiplied by 100. Thus, 1 Gy = 100 rad. Any confusion about this could be dangerous. If someone already trained to use the conventional unit of rad is reading a dose in Gy, and thinks it is in rad, the person could be receiving 100 rad, which could have immediate harmful effects. Thinking that the 100 rad was only 1 rad, which would be well within the legally accepted limit for a one year worker exposure, a responder could think it was safe to stay in an area and receive more dose. This could be lethal. The Gray (Gy) was adopted as a recommended unit of dose by the International Commission on Radiological Units (ICRU) in the late 19th century, along with the adoption of other metric units that were incorporated into a new "Systeme Internationale (SI)" system of units, that was presumed to simplify certain equations in radiological physics by requiring only the unit 1 as a numerical factor. This advantage has turned out to be of value only to theorists who write equations on paper. Any computerized calculation, or electronic calculator, can just as easily incorporate the number 1 or any other number into a calculation, without giving up the convenience of using the original "conventional" units. Although many nations have adopted these ICRU units as law or regulations, for practical radiation protection many in the United States have deemed that the ICRU recommendations could lead to changes in terminology that would not be convenient, and in some cases could even be lethal. Upon receiving comments and serious consideration, the U.S. Nuclear Regulatory Commission (NRC) did not incorporate the new SI units into its major change in Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," (10 CFR 20) published to be effective in 1992. However, although the U.S. may adopt, or not adopt, in its regulations certain recommendations of international bodies according to the judged appropriateness to our national welfare, a number of government and military organizations have made it policy to use the new SI units in much of their work; this has often been done to be able to communicate easily with other national programs, such as in the transportation of radioactive sources between nations. In teaching radiation science and protection to undergraduates and graduates, I have taught them to use both sets of units, but have found many problems with the new SI units and shown the students how to avoid

them. Only the simplest information needed by the general public for protection in the event of terrorist attacks, without confusion, is presented in the main chapters of this book. There are other problems with these units that are not balanced by their advantages, but further discussion of these units is beyond the scope of this book.

Half-Life — The time it takes a particular type of radioactive atom (i.e., with a particular number of protons and neutrons in the nucleus) to transform (on the average) to a more stable atom. The more stable atom can still be an unstable atom of another chemical element and decay further. This is called "chain decay." Sometimes an entire series of unstable progeny atoms are changed into before a stable atom is reached. There are four radioactive series in nature, one of which is the uranium-238 series. After several progeny, and millions of years, uranium-238 in the earth changes into the element radium-226 (written ^{226}Ra in scientific notation). Madame Curie separated very small amount of radium from rocks containing uranium in 1998, and later was awarded two Nobel Prizes for that and other discoveries. Movies and books have been written about Madame Curie, who is probably the most famous woman scientist in history. Also, she worked and became famous at a time when it was not easy for a woman to receive recognition in the sciences.

Health Physics (sometimes called radiological health or radiation protection engineering) — A profession including scientists, engineers, doctors, lawyers, technologists and all others working in, or interested in, matters of protection of workers, the public, or the environment from harmful effects of radiation.

Health Physicist (HP) — A person working in the field of health physics, including those not necessarily having more than an elementary knowledge of the physical principles of radiation protection. The name, "health physicist" was given during World War II to those working to develop an atomic bomb under the "Manhattan Project", because at that time physicians in charge of health protection knew that portable physical instruments (such as Geiger counters and ion chambers) and personal dose measuring devices would be needed to monitor the radiation exposures of workers processing radioactive materials. Health physicists in general are dedicated to promoting safe operations that will permit the beneficial uses of nuclear energy and radioactive materials. Health physicists ARE OPPOSED to unsafe applications, and many have put their jobs at risk to oppose unsafe operations.

Health Physics Society (HPS) — A professional society with a membership of about 6,000 individuals, and a number of companies that sell equipment or services for radiation protection. It is the primary society for those whose careers are mainly in radiation protection. It was originally established in 1956 and welcomed technicians in the field of radiation protection who had not completed high school, as well as those with formal college educations. During its formation, some consideration was given to organizing it as a section of the American Industrial Hygiene Association (AIHA). However, because of the enormous increase in need for safety in radiation applications brought about by the advent of nuclear energy, the majority of founding members decided a separate HPS was needed to exchange the increased new information and protection methods between members. The membership handbook of the society (Health Physics Society 2007) includes the statement, "Society activities include encouraging research in radiation science, developing standards, and disseminating radiation safety information. Society members are involved in understanding, evaluating, and controlling the potential risks from radiation relative to the benefits." These endeavors include the design of laboratories for safe operations, establishing safe procedures to avoid release of radioactive materials and intake of these materials by workers or the public, monitoring daily work practices to ensure compliance with standards and regulations, and auditing the overall performance of radiation protection programs. The Health Physics Society handbook includes a Code of Ethics on its inner cover, which includes the statements, "Members shall never compromise public welfare and safety in favor of an employer's interest," and, "Professional statements made by members shall have sound scientific bases." There are other related professionals, such as nuclear engineers and medical physicists, who also have subsidiary assignments in radiation protection, and may also become members of the Health Physics Society,

in addition to their memberships in such organizations as the American Nuclear Society (ANS) or the American Association of Physicists in Medicine (AAPM). Health physics can also be viewed as a subfield of public health, and some health physicists are also members of the American Public Health Association.

Industrial Hygienist (IH) — Professionals, often with backgrounds in chemistry or chemical engineering, involved in protection against all types of harmful exposure in the workplace. They are now also involved in such public protection as ensuring the safety of indoor air. IH professionals will sometimes also be involved in radiation protection, as well as protection against chemicals, noise, work stresses, and other tasks that sometimes overlap those of safety engineers. Some join both the HPS and the American Industrial Hygiene Association (AIHA), and related societies. Although the interest of members of the AIHA now include environmental protections beyond those connected with industries, as with the Health Physics Society, the membership has consistently voted to retain the historic name.

Internal Radiation Exposure (or just internal exposure) — Exposure to the absorption of energy from radiations emitted inside of your body or within your internal organs, as a result of breathing in or eating radioactive material, or absorbing it through wounds or skin. (Contrast this with External Radiation Exposure below.)

International Commission on Radiological Protection (ICRP) — An international organization of physicians, physicists, biologists, chemists, and other experts in fields related to biological effects of radiation and the means of protection. This organization was begun under a different name in 1928 at the Second International Congress of Radiology, and continues to publish recommendations on limits to radiation exposure and methods of protection. The nations of the world generally recognize the expertise of the ICRP and try to promulgate radiation protection regulations that are consistent with the recommendations of the ICRP. However, some competent scientists are critical of ICRP recommendations for protection at low levels as over-conservative, and argue that linear extrapolations of risk at high levels not be used to estimate risks at very low levels without taking into account phenomena that indicate the existence of protective effects of low-level radiation (see the discussion of hormesis in Chapter 4.

Ion chamber (or ionization chamber) instruments — These chambers are much less sensitive than the geiger counters and are used to measure radiation intensities in the thousands of mR per hour, or R per hour. These are usually larger chambers but with much lower voltage on the anodes, perhaps a few hundred volts or less. In these chambers, there is no large amplification of the number of electrons reaching the anode. Only the electrons produced from the knocked out electrons from the wall or in the gas are collected by the anode and feed into the reading circuits. Limiting readings to count the pulses by circuit or gas design is usually not employed. Often, Geiger counters are too sensitive for use in emergencies where it is necessary to assess whether higher intensities or exposures might be accumulated within the minutes or hours of exposure before adequate shelter or evacuation can be effected. In emergencies, it is necessary to have available the much less sensitive ionization chamber survey instruments, in which levels of radiation just below or approaching those likely to give health effects might provide appropriate warnings of the limits of stay time. When I was called one night in about 1960 to survey a leaking nuclear fuel cask in the Baltimore train yard, my GM counter battery turned out to be dead, but I was glad anywat to have a higher-range ion chamber survey meter called a "Cutie Pie," as named in the early atomic energy lingo. I was able to not only monitor any gamma radiation that might occur, but also with the thin window of the chamber open, I was able to calculate as I drove to the train yard the fact that I would be able to estimate radioactive iodine concentrations in air from the chamber ionizations of the betas from the iodine isotopes with the window of the chamber open. Iodine nuclides, being the most volatile and likely to escape from the fuel elements, could help me estimate the limiting exposures that I might find. This ensured me that I could properly manage the situation with any radiation risks to persons or the environment that I might find on arrival. I had calculated that I could

have detected a concentration equal to one thousand times the routine maximum permitted beta concentration in time to order evacuation of personnel in one minute, if necessary. Fortunately, when I arrived at the leaking cask, I found no readings from beta particle concentrations in air, and any gamma exposure rates were not dangerous to the workers in the area. (More detailed descriptions and concepts may be found in the textbooks by Cember (Cember and Johnson (2008), Evans (1955), and Turner (1995), listed in the References section. The chapter by Johnson (2004d) describes all types of radiation instruments as they might be used by emergency responders.)

MeV — A million electron volts of energy. One electron volt (eV) is the amount of kinetic energy (energy of motion) gained by an electron when it falls through an electric potential of one volt. One MeV is the same amount of energy as 1.6 millionths of an erg. There are 10 million ergs to one Joule and about 4.13 heat calories for one Joule. A heat calorie (which is one thousandth of a kilocalorie, is termed "calorie" in describing food energy) is the amount of heat that would raise one gram of water one degree centigrade. There is no need to know all of this for radiation protection; it is given only to indicate the concepts of energy. Radiation energy absorbed in tissue knocks electrons out of atoms; as the electron energies are absorbed in the tissue, their kinetic energies ultimately turn into heat as they are slowed down by interactions with atomic electrons in the medium. But the heat from even a lethal dose of gamma rays will not be felt initially; the syndrome of illness and death at high levels sometimes will not be felt for hours (Goans 2004, page 378). Therefore, I believe that each individual should have an affordable personal dosimeter that can be worn to determine if significant radiation exposure has been received or is on the increase. Some dosimeters, such as the SIRAD credit-card-sized colorimetric dosimeter (Patel 2007) have been developed that could be made affordable if sold in large quantities; however, our governments have not taken sufficient actions to support the distribution or sale of these cheaper dosimeters to all members of the public. Also, I hope that monitoring instruments such as Geiger counters and ion chamber survey meters will be available at affordable prices for the general public, or at least to groups in a neighborhood or area. Some manufacturers are recommended in Appendix F so that members of the public can know for themselves whether radiation exposure intensities require additional protective actions, or whether exposures are not in a dangerous range.

National Council of Radiation Protection and Measurement (NCRP) — A US national organization that chooses its members from the diversity of expert backgrounds needed to publish recommendations for use in the United States. A predecessor of this organization was formed by a young physicist of the National Bureau of Standards, Dr. Lauriston S. Taylor, in 1929 after he returned from meetings of the Second International Congress of Radiology. The organization was chartered by Congress in 1964 to provide recommendations on radiation safety for use in the USA. The NCRP recommendations throughout the years have generally been consistent with those of the ICRP, especially in regard to the recommended limitations of dose for radiation workers and members of the public.

Neutron Radiation — Neutrons are emitted when elements are bombarded by high-energy particles or rays (e.g., x rays, electrons, protons, etc.) in high-energy accelerators ("atom smashers"), from sources of alpha emitters mixed with certain elements (such as polonium-210 or plutonium-238 mixed with beryllium), or in very high quantities from nuclear explosions. Nuclear power plants rely on the chain reactions of multiple neutrons emitted from each fissioning uranium-235 atom being further absorbed into other uranium atoms and causing more fissions after slowing down in water, and so forth. Because there are more than two neutrons emitted during each fission of uranium, a chain reaction can be produced by the proper configuration of size and shape of uranium and its surrounding materials that reflect back some neutrons. In a nuclear reactor, as opposed to a nuclear bomb, the chain reaction is controlled at a required energy production level by the inserting and removal of "control rods" made of a neutron absorbing material. Even a controlled chain reaction produces a high fluence (flow) of fast and slow neutrons within the core of nuclear reactors (but these are well shielded from workers or the public by the thick shields built into such plants). For hydrogen bombs in the megaton energy release region, the devastation

area precludes anyone still alive from receiving lethal amounts of neutron radiation. For atomic bombs in the kiloton energy region, there can still be a limited amount of area in which persons still living can receive serious neutron exposures. However, this book will not dwell much further on neutron radiation, because the assessment of neutron exposures in a limited portion of the population after a nuclear attack would require expert diagnosis by trained medical and medical physics personnel. For the interested reader, additional information about neutron radiation emitted from atomic explosions may be found in Auxier (2004)., My own measurements of neutron spectrum and dose versus distance from a nuclear explosion (Hanscome et al. 1955), made on the second H bomb tests, are in adequate agreement with those presented by Auxier and associates (Auxier 2004). Most members of the public will be sufficiently sheltered or distant from nuclear detonations that they will not become ill from neutron or other exposures to instantaneous ("initial") radiation, and may assume that they have not received significant neutron exposures. This book is focused mainly on information that helps most members of the public take appropriate actions and understand radiation issues on which they can have an influence.

Probability — Probability means the same thing as "chance," for the purposes of this book. The rest of this definition can be skipped; a further insight into the concept of probability is not needed here

In textbooks of mathematical statistics, some rather detailed and long definitions of probability are given, for use in proving certain theorems of probability theory. As used in this book, and usually in everyday language, the probability of a particular event occurring in a certain number of trials or observations of a particular larger class of events, some of which also contain the particular event, is simply estimated by the ratio of the number of particular events of interest divided by the number of larger class events that have been observed. For example, if the particular event of interest is the obtaining of two heads and one tail, in three flips of a coin (the trial), then the probability (chance) of the particular event occurring in 100 trials (three flips made 100 times, could be estimated by counting the number of 3-flip trials that yielded 2 heads, and dividing by the number of flips, 100. This is called "estimating" in the field of statistics. However, if the coin is known to be balanced and fair, and the flipping is done by a machine throwing the coins with a random amount of thrust and rotation, the probability of 2 heads can be calculated exactly in this case from knowing the nature of the coin — one side head, the other side tail, each with a probability of 0.5 for one flip. The number of possibilities for 3 flips can be seen to be comprised of only 8 possible combinations, shown in 8 vertical columns:

H	H	H	T	T	T	H	T
H	H	T	H	T	H	T	T
H	T	H	H	H	T	T	T

The number of 3 flip events with 2 heads and one tail can be seen to be 3 out of the 8 possible ways the 3-flip result is obtained. Therefore, the probability, or chance, of 2 heads and 1 tail in a 3 flip sequence would be 3/8, which equals 0.375, and which is the same as 37.5 %. It is an advantage for any member of the public to understand at least this much of the language of probability.

In human epidemiologic or followup studies of any kind, the number of factors involved that produce a disease — such as environmental, physiologic, and genetic factors — are so great and variable from one individual to another, and within the same individual from day to day, that there is no way to calculate the probability of a disease from measurements or observations of the individual factors. Therefore, statistical methods have

been developed to deduce probabilities of disease from large population studies, compiled case studies, or animal experiments that can in some ways be extrapolated to humans. These methods comprise the field of biostatistics. The interested reader can take courses in these studies in order to examine the fundamental literature, or refer to modern textbooks. Concise summaries of the use of probability theory and concepts in basic statistical methods, and their use in biological or epidemiologic studies, with useful tables, may be found in Brodsky (1982b) and Redmond (1982).

Proportional counters — These are somewhat similar in principle to GM detectors, except that they are operated at lower voltages (for a given chamber geometry) so that the number of electrons reaching the wire anode is proportional to the initial ionization produced in the chamber, and not always 100 billion. In this way, heavily ionizing particles such as alpha particles can be discriminated electronically from beta radiation, when surfaces or clothing are monitored. (More detailed descriptions and concepts may be found in the textbooks by Cember (Cember and Johnson (2008), Evans (1955), and Turner (1995), listed in the References section. The chapter by Johnson (2004d) describes all types of radiation instruments as they might be used by emergency responders.)

rad — An absorbed dose of 100 ergs of energy per gram of tissue (or any other material) at some point, or region of tissue, where the dose from an exposure is measured or calculated. The dose might, or might not, be received and referred to an entire body exposure; when appropriate, the amount of tissue or organ exposed should be indicated. If a small volume of tissue, such as a finger, is exposed in air away from the body, an exposure of one roentgen (1 R) will result in an absorbed dose of about 95 rad in the finger. Exposing the body to 1 R would result in decreasing doses in rad at increased depths within the body, the rate of decrease with depth depending on the photon energy of the x or gamma quantum in MeV. Thus, for emergency purposes, it is best to dispense with all of these complexities, and assume that 1 R results in about 1 rad to the body. This would give a conservative estimate of dose in favor of safer actions.

Radiation — The general term "radiation" is usually used for the transmission of any type of energy through space from one point to another. HPs are involved in protection against harmful exposures to laser radiation and microwave radiation, but most are involved with protection against nuclear radiations and x rays. Sound radiation, noise, and ultraviolet radiation are usually within the responsibilities of industrial hygienists. This book is focused mainly on nuclear radiations and x rays, for the reasons of public need presented in the Preface.

Radioactive Nuclide — An atom with a certain number of neutrons and protons in the nucleus that is not among the stable atoms, but is one that has some rate of transformation into a more stable atom and emits radiations — alpha, beta, or gamma rays — from its nucleus during each transformation. (See Exhibit 4.) Each transformation might actually have a different fractional release of specific radiations, as indicated above for the fraction (10.7%) of potassium-40 atoms that emit a 1.46 MeV gamma ray. Some of my earlier colleagues, especially Dr. Walter Snyder and L. Thomas Dillman, have performed brilliant work for the International Commission on Radiological Protection (ICRP) in translating nuclear data tables into the decay schemes and radiation energies needed for HPs to calculate radiation exposures for hundreds of radioactive nuclides (ICRP 1983).

Radioactive Material — Any material that includes some measurable concentration of interest of one or more radioactive nuclides. Many natural substances already contain naturally occurring radioactive nuclides, such as potassium-40, uranium (several types of nuclides), thorium, and radium. Thus, many familiar materials in everyday life may be considered to be radioactive materials: your own body, red brick in your homes, granite block, salt, and bananas, for example. The important question is "how much" of "what" radioactive nuclides are contained in materials to which you are exposure or which you might eat.

Radioactivity — The phenomenon of atoms changing and emitting radiation. The word "radioactivity" may also be used to refer to the presence of radioactive material, which means that the material contains one or more radioactive nuclides, not necessarily in pure form but perhaps diluted (as usual) by much larger amounts of other matter in which it is dispersed.

rem — A practical unit used for managing radiation protection programs, such that a dose in rad to a human tissue is multiplied by a constant factor called "quality factor, QF" or "radiation weighting factor, w_T" to take into account all of the relative biological effects of a radiation such as alpha particles emitted from radioactive material internal to the body, or protons knocked out by neutrons incident upon the body. For practical purposes of learning the important actions to take for citizen protection, it would be sufficient to assume that the dose received in rem is lower than the exposure read in roentgens (R) or rad, as interpreted from readings of a portable Geiger counter or ionization chamber. Any internal exposure from alpha particles, or external exposure from neutrons, would very likely be much less than exposures from the more prevalent gamma or beta external radiation after an attack involving radioactive material. In any event, the few individuals who might have inhaled substantial amounts of radioactive material can in time be examined and appropriately treated by expert physicists and physicians. Too much scare information has been given to the public about radioactive contamination from such attacks. My own experiences, those of others, and reasons for these statements can be found in Brodsky et al. (2004).

risk — As used in this book, the word "risk" will simply means "chance." It does not, by itself, imply danger. The risk of dying of cancer to a person of average age in the general U.S. population, if that person receives a dose of 1 rad of gamma radiation or 1 rem of any radiation to the entire body (about 1 R exposure), is estimated to be about 5 chances in 10,000, which can be stated to be a chance of 0.0005, 0.05 %, or 5×10^{-4} in scientific abbreviations (notations). Thus stated, the risk associated with an exposure of 1 R (1,000 mR) is very much lower than the risk of dying from driving a car for a lifetime. (See Chapter 4.) Yet, we still drive cars. I have been driving for 64 years, albeit in some circumstances with a bit of fear.

Many of my good friends in the radiation sciences do not believe that most members of the public can properly understand many of the concepts of radiation dose and risk that I am introducing in this book. I believe from my experience in talks with the public that they are wrong, and that more of the competent and expert scientists who understand the issues should learn to present them to the public, to counter all of the misinformation. I have been a professor in three universities, teaching concepts of radiation interaction, dose and risk to graduate and some undergraduate students. Working with these students on hundreds of papers, theses, and dissertations, I believe I have found it possible to judge intelligence. From talks that I have given to the public, I sense that when I explain phenomena in words and analogies with which most members of the public are familiar, and dramatize my demonstrations of radioactivity and the absorption of radiations by my hand as well as other materials, they generally react with interest and understanding. (After one mock TV interview and demonstration in my granddaughter's seventh grade class, she later told me that one boy said, "He's the smartest person I've ever seen." This boy does not yet know the advantages of many years of university study.) Scientists need to keep in mind the differences in communication styles and the receiving of information among most members of the public, in comparison to their own methods of communicating with other scientists (Johnson 2004a, 2004b).

I recently had an experience with our cleaning lady, Katie Conforti, that showed me she was probably at least as smart as this old professor. I had noticed how quickly she organized her work and cleaned our 5-bedroom, 2.5-bath, home spotless in about 2 hours. I spent about an hour trying to get the DVD player to show a video on the TV in anticipation of a visit by our grandchildren. I asked for her help. In five minutes, without the instructions for our particular equipment, Katie was able to get everything working and explain to me how to use my system. Considering the enormous number of possibly effective permutations on today's combinations of TV-VCR-CD-DVD hand-held controls, I believe such a feat requires rapid memory and sequential organization of a long series

of logical syllogisms. I am ready to recommend Katie for matriculation in physics if she is ever ready to go to college.

Another experience that is pertinent occurred the day before this writing. My friend and frequent assistant with office work, Denise Donovan, and her 17-year old daughter Rachel, were with me on Saturday afternoon when we sorted out records in my rented storage bin to keep or throw away files and books that had been saved for more than six decades. I had wasted thousands of dollars renting these storage bins. So I could show my anxious wife, Phyllis, that I had made progress, I wanted to photograph with my cell 'phone the pile of boxes filled with trash to throw away. I could not remember or decipher the ways to take a picture. Rachel set the cell phone into the picture mode in less than one minute. I took the picture, but could not take another. Denise, in the next minute, then also figured out how to take the second picture and show it to my wife. Again, I would recommend Denise or her daughter for matriculation into any scientific, engineering, or other program that they might choose to enter in any college of their choice. Following patient explanation with the use of appropriate vocabularies, most members of the public will be able to understand concepts of dose and risk, or other scientific concepts, at the levels they need for their own protection, and for citizen participation in public policy matters. So I proceed with further discussion of risks.

Sometimes in the literature, the word "risk" includes the amount of harm, expressed in some numerical form, times the chance of an event. This connotation will not be used in this book. The harm of an event will be expressed separately, together with the chance of the event. For example, in order to compare harmful effects of radiation to effects of other risks already encountered in various workplaces, the ICRP has included loss of healthy life years lost due to illness for those not dying of cancer but sustaining long illnesses (reviewed in Brodsky 1996). In the 1990 ICRP recommendations (ICRP 1990), an additional 3 chances in 10,000 were added to the risk of 5 chances in 10,000 to obtain a total risk of harm per rad or rem received by the average worker. This additional risk also considered and incorporated the smaller chances of genetic effects, as observed in the Hiroshima-Nagasaki studies.

roentgen — A unit of exposure to x or gamma radiation. A simple definition is the amount of x or gamma radiation that, passing through air, creates 1 electrostatic unit of charge (of each sign) per cubic centimeter of air at a "standard temperature and pressure" (STP) of 0 degrees centigrade and 760 mm of mercury atmospheric pressure. It can be measured accurately only by large laboratory ion chambers, and only for x and gamma ray photon energies below about 3 MeV as described in Cember (2004). (Although x and gamma rays were initially thought to be waves, they were later found to exist as wave bundles that often knocked out electrons from atoms as if they were particles having mass.) However, smaller secondary ionization chambers are available for adequate checking and calibration of field survey instruments and personal dosimeters worn in the pocket. The secondary ionization chambers are calibrated by comparison with the larger standard "air" chambers, or in standard radiation fields, at the National Institute of Standards and Technology (NIST). Calibrations are performed according to standards developed by NIST in cooperation with standards committees formed within the cognizant professional societies. A summary of definitions and concepts of radiation exposure andf dose is presented in Brodsky et al.(2004).

scintillation detectors — These are solid or liquid detectors that provide light scintillations when activated by ionizing radiation absorbed within them. Light flashes are then sent as pulses through a circuit that provides counts per minute. As a result of their greater mass, they can interact more often with gamma rays (or neutrons for hydrogen-rich scintillators) and thus be even more sensitive than GM counters, and can with appropriate circuitry tell something about the unit photon or neutron energies encountered. Usually, they would be more expensive than other detectors and not as suitable for the higher exposure rates encountered in early phases of emergencies. Thus, no further description of these types of instruments is within the scope of this book. (More

detailed descriptions and concepts may be found in the textbooks by Cember (Cember and Johnson (2008), Evans (1955), and Turner (1995), listed in the References section. The chapter by Johnson (2004d) describes all types of radiation instruments as they might be used by emergency responders.)

Sievert (Sv) — This is a unit of biological dose similar to the rem, but as above for the relationship between rad and Gy, 1 Sv = 100 rem. The same important precautions as given in the previous paragraph are also of vital importance here.

solid state detectors — These are detectors that are more often needed to more accurately assess the energies or energy spectra of ionizing types of radiation. They would be used by specialists who know their characteristics and uses after a nuclear or radiological emergency. Many designs are used. Thus, no further descriptions of these detectors are appropriate here. A good summary for the interested reader is that by Johnson (2004d).

stochastic process — A process or series of events that follow some law or laws of probability, often with the probability as a function of time of exposure in the case of radiation studies. Radioactive decay of a particular kind of unstable atom is a frequent example in the sciences of radiation protection.

The probability of decay of a radioactive atom in a given time small time interval is given as the decay constant of the particular atom, which is equal to the natural logarithm of 2, divided by the half-life of the particular radioactive atom. The decay constant gives the fraction of atoms that have remained undecayed that will decay in the next time small time interval; it really gives the chance that an atom will decay in a short time interval. It would only give something close to the exact fraction if a very large number of atoms were decaying. The development of the mathematical formulae for radioactive decay may be examined in Brodsky (1982c) for those interested in the exact calculus. The explanations here are only for those curious to better understand the words used in discussing concepts of radioactivity.

APPENDIX B

A REPRINT OF PRESENTATIONS GIVEN IN EARLY CIVIL DEFENSE TRAINING

Note: *This paper was developed by the author for lectures to government officials and training for police officers, firefighters, and other first-responders to nuclear weapons attacks. It is presented here as an informational paper of possible value in planning responses to certain types of terrorist attacks. The material in regard to nuclear weapons could still be useful as a supplement to information on "dirty bombs" as presented in the chapters, and in training materials available from the web sites in Appendix D.*

Radioactivity Hazards in Survival Planning

Allen Brodsky
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(June 1957)

Editor's Note: *This paper was developed by the author for lectures to government officials and training for police officers, firefighters, and other first-responders to nuclear weapons attacks. It is presented here as an informational paper of possible value in planning responses to certain types of terrorist attacks.*

INTRODUCTION

This paper is intended to present some basic information on the hazards of radioactivity that must be considered in survival planning. We must be prepared to understand and meet the problems of defense associated with gross radioactive contamination of our country. Our preparedness in these matters would not only seriously affect the preservation of our freedom, but also the preservation of the human race.

First, some background information will be given on weapons phenomena, the physical principles of radioactivity, and the threat of radioactive fallout and associated problems to be encountered in survival planning. Then, methods of organizing a radiological defense unit and incorporating radiological protection into other emergency services will be briefly outlined.

In matters of radiological safety, as in other fields, one must have a menta1 picture of the phenomenon he is dealing with to guide him in handling unusual situations. Radioactive fallout has increased a thousand-fold in emphasis with the advent of the H-bomb, and is a relatively new subject to many. However, once a few simple principles are understood, fallout becomes a hazard against which you can buy a great deal of protection with a pocketful of preparedness. Therefore, some of the simpler concepts involved in weapons phenomena, radioactive fallout and its effects on human beings, and the relationship of those concepts to survival planning, are explained below.

Blast damage is caused by an outgoing high-pressure wave of air, followed by an outgoing low-pressure wave that is produced when a nuclear bomb releases tremendous amounts of energy in a small volume during a short time. The tremendous heat developed causes the bomb to expand and blow apart, pushing blast waves of air out in al1 directions at approximately the speed of sound, The important things to keep in mind are the distances over which the blast damage is propagated, and the time that it takes for this blast to reach various distances after the instant of explosion.

Nuclear bomb energy yield is expressed in megatons (MT). One MT is equivalent to one million tons of TNT. A kiloton (KT) is one thousand tons of TNT. For a rule of thumb, we may remember that the radius of the A-ring of complete destruction is 2 miles for a one-megaton weapon; the radius of each successive ring, i.e., severe, moderate, and light destruction, respectively, increases by an additional 2 miles for each ring. From this data, we may easily compute the radii of destruction for any larger or smaller size weapons by remembering a simple principle. The energy of the weapon's blast must be distributed over a volume proportional to the amount of energy released. Since the volume of a sphere surrounding the point of detonation is $4\pi r^3/3$, it is proportional to $r \times r \times r$. This means that if you multiply the radii of destruction by 2, the weapon size increases to 8 MT. An 8-MT weapon will have distances of 4, 8, 12 and 16 miles for rings of complete, severe, moderate and light destruction, respectively.

Another important thing to remember about the blast is that it travels at an average speed of about one mile in four seconds. Thus, if a person ten miles away from the point of detonation sees a blinding flash of light, he knows that he has about 40 seconds to take cover. Of course, he may be momentarily blinded by the flash of light, particularly if he was looking toward the weapon when it exploded. Approximately the same speed of travel applies to the blast of any size weapon.

The thermal radiation, or heat effects, travel with the speed of light and reach out to all distances almost instantly; however, the source of the heat has a duration of several seconds. Thus, a person standing in the open may be able to reduce his burn by quickly ducking behind some nearby wall, since the degree of burn depends on the duration of exposure to the source of heat. At great enough distances, light colored clothing would be considerably better than dark clothing, since dark clothing tends to absorb heat while light clothing tends to reflect it.

The table below will show the extent of some of the immediate effects of the detonation of a nuclear bomb:

Bomb TNT Equivalent	Radius of Total Destruction	Radius of Moderate Skin Burns	Radius of 400R (Mid-lethal) Dose from Immediate Radiation
20 KT	0.6 miles	1.9 miles	0.8 miles
1 MT	2.0 miles	6.5 miles	1.4 miles
10 MT	5 miles	10 miles	2.0 miles

It can be seen from this table that the effect of the initial nuclear gamma and neutron radiation is ordinarily dissipated within the area where blast and heat effects are predominant. This is because the initial nuclear radiation that originates in the materials of the bomb at the point of detonation is more highly absorbed by interaction with the air molecules along the path of flight than are the blast and heat waves. However, some radioactive materials are produced inside the bomb during its detonation and these radioactive materials can produce a very serious lingering effect as a result of two prime factors:

1. One by one these radioactive atoms in the bomb debris give off their radiations in a number of hours, days, months, or years, as well as seconds, depending on the particular type of atom.

2. The bomb debris is carried in the form of fine particles or dust all over the countryside. This lingering radioactivity can spread Itself over thousands of square miles, and permeate the air with intensities of radiation that would produce death in a matter of days or weeks to all persons who did not take the necessary precautions. This lingering contamination of the countryside is called "residual radiation" and results from "fallout." Here are some facts about fallout of which we must be aware.

Let us start in the order of events as they would occur upon the delivery of a nuclear weapon to one of our cities. Figure 1 shows what takes place Inside a nuclear weapon at the instant of detonation. Two types of nuclear reactions, fission and fusion, proceed in rapid chain reaction. The fission of an atom of uranium occurs when a particle called a neutron hits and is captured by a uranium nucleus, causing it to break in two, or fission. Fusion (or the combining of two light elements to form a heavier one) occurs when two nuclei of light atoms such as hydrogen are excited by the tremendous heat released from the triggering fission bomb, and they run around bumping into each other and sticking together. In the process of sticking together, these atoms release further energy of their own.

A neutron is an elementary particle that is one of the building blocks of the core of an atom. High-speed neutrons to trigger the reaction can be produced by certain types of radioactive material. The atom contains a small, dense core called the nucleus, which in turn, contains a number of protons and neutrons surrounded by a system of negative electrical charges called electrons. The neutrons are so named because they have no electrical charge, but are neutral. Some of the neutrons that are released from the splitting uranium core escape from the surrounding bomb and do not participate in the explosive reaction, but they are absorbed in atoms of the bomb casing or surrounding target area, causing these atoms to become radioactive, However, most of the neutrons given off in each reaction are absorbed in other uranium atoms of the bomb material and cause repeated fissioning of the uranium atoms within a small fraction of a second. This is known as a "chain reaction."

The fragment atoms produced by the fissioning process are called "fission products." These fission products and surrounding materials that have absorbed the escaping neutrons are unstable. That is, they have more energy than needed to hold together their particular arrangement of particles, and they give off three kinds of radiation with which we are concerned: alpha particles, beta particles, and gamma rays (or particles). These are the radiations that we refer to when we say that fallout material is "radioactive." These radioactive bomb products are vaporized by the tremendous energy released in the fission and fusion processes. After the bomb explodes, these products rise as hot vapor, together with materials of the surrounding earth that have been sucked into the hot fireball. They form part of the mushroom cloud shown in Figure 2.

FIGURE 1. DETONATION

- Occurs in fraction of a second
- Produces blast damage and all radioactive elements within 1-2 minutes

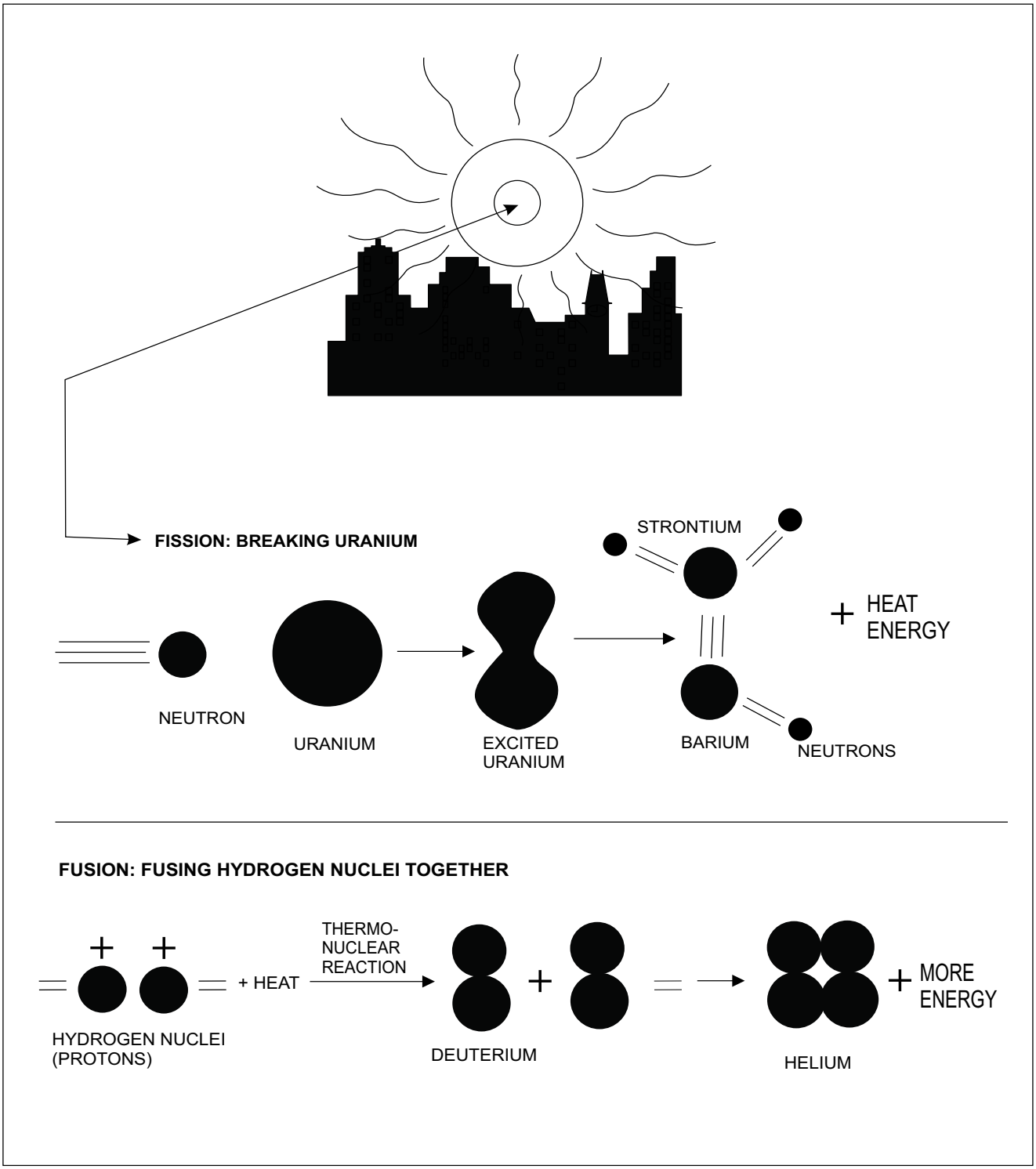
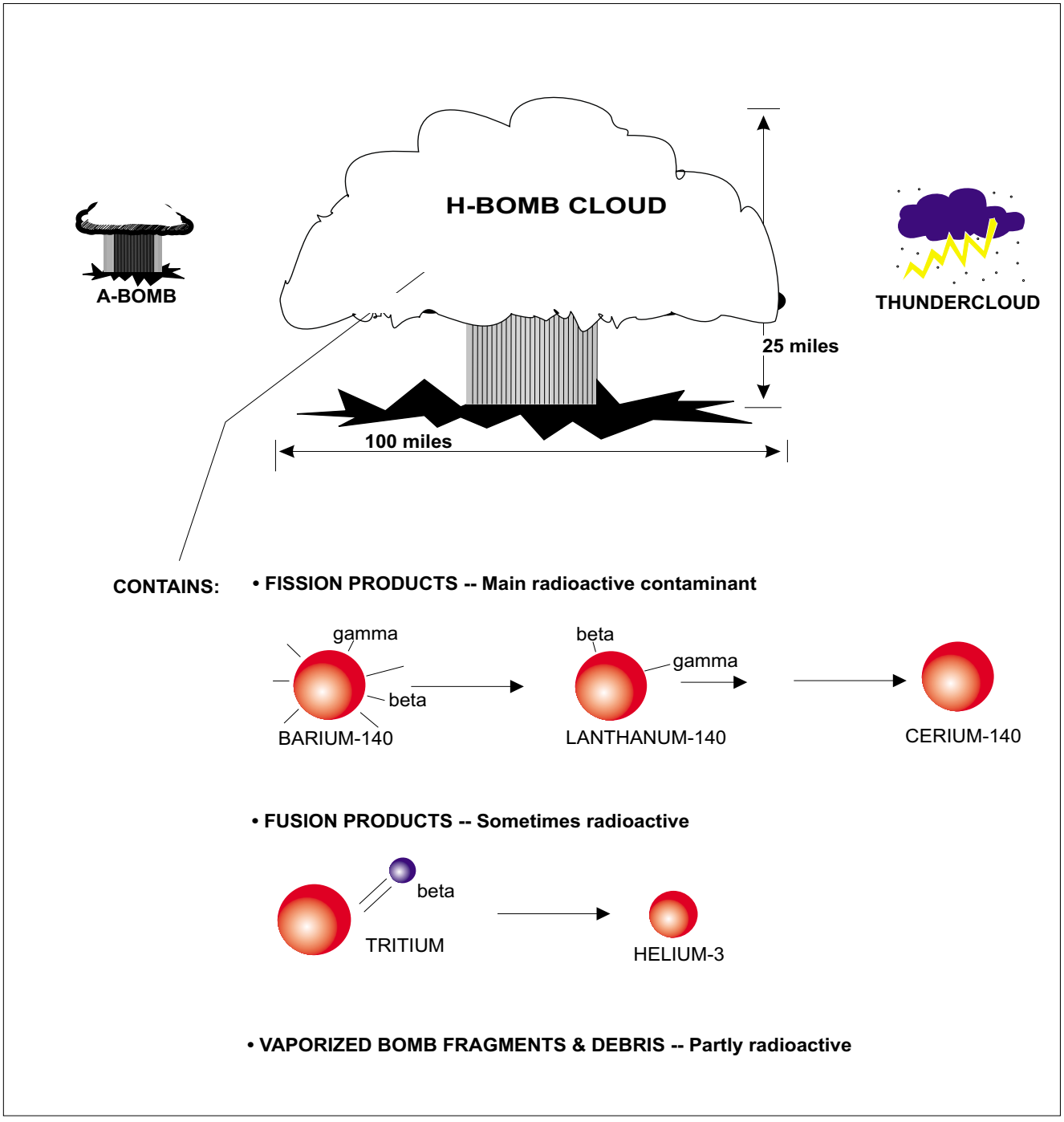


FIGURE 2. RISING CLOUD

Cloud forms and rises to the stratosphere in about 12 minutes



As the cloud is dispersed in a pattern determined by the directions and speeds of winds up to 80,000 feet in altitude, the cloud begins to cool and some of the heavier vapor begins to condense into particles. These particles may contain both radioactive and non-radioactive atoms from the bomb materials and the earth and buildings that have been sucked up by the fireball. The particles will fall out of the cloud and reach the ground at varying distances from ground zero, depending on the sizes of the particles and the velocities of the winds. These particles may cover areas of thousands of square mi1es with amounts of radioactive material sufficient to cause death to all inhabitants who are unprotected and uninformed. Thus, shelter from radioactive fallout (and preferably, from the blast also) must be provided for all persons outside of probable blast areas, as well as those inside. Ways of getting evacuees into such shelter as quickly as possible must be provided, since most of the dose of radiation delivered to an area is delivered during the first few days. Fire-fighting, rescue operations, movement of people, must be restricted and controlled in accordance with intelligence on the existing radiological situation.

The principles to be considered in protecting persons against fallout are shown in Figure 3. Once an area of several hundred yards surrounding a particular location has received all of the fallout particles that will drop on this area, persons in the area have recourse to two factors for self-protection — distance and shielding. As shown in Figure 3, more rays are received by a person close to a single particle (or small group of particles), than one who is farther away, just as a light seems brighter to those closer to it.

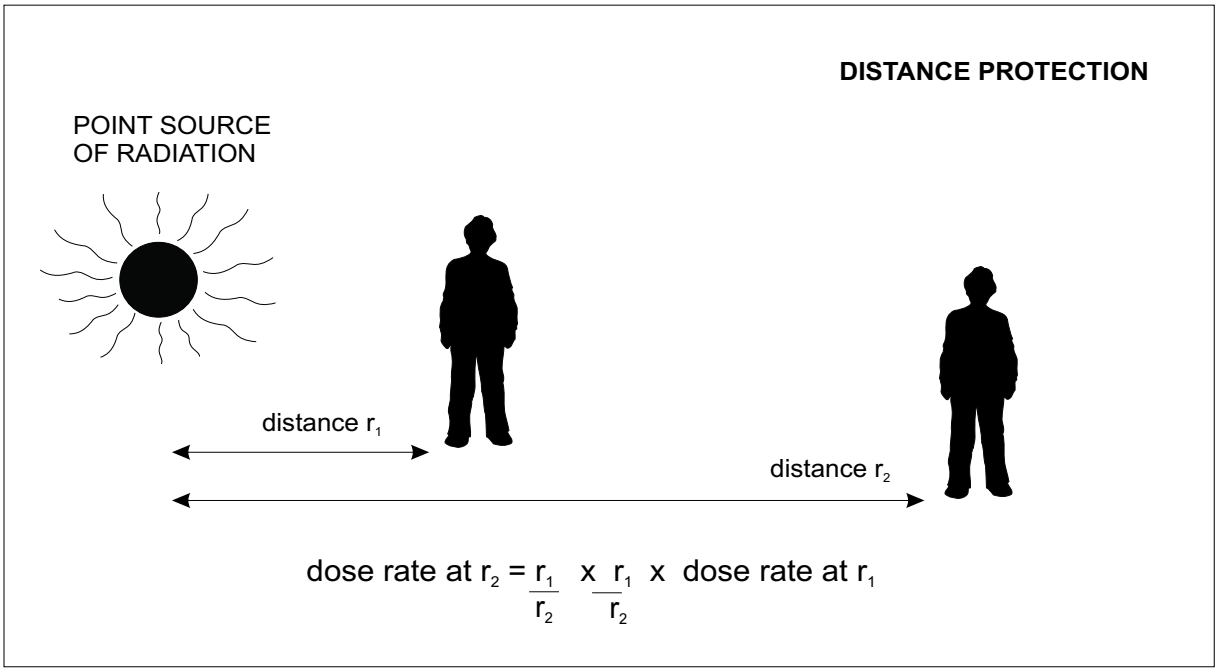
However, when particles cover the ground uniformly, they produce a field of gamma radiation that is almost constant, whichever way you move. The most practical shielding for people against such a field produced by particles at ground level is in shelters below ground level. Under such conditions, most of the primary gamma rays coming directly toward the persons from the radioactive "fallout" are absorbed in the surrounding earth. By rule of thumb, this reduces the exposure to about one-tenth of that received in the open. However, gamma rays, being high in energy, put up a tough fight before they are stopped. Many of the rays coming from the material on the ground will bounce off electrons in the air near the shelter, with only a fractional reduction in their energy, and may be redirected down toward the persons in the shelter. This is called "scattering" of the gamma radiation.

Such scattering may also be intensified by dense materials above ground near the shelter, which are exposed to gamma rays coming from the radioactive material on the ground, and which can serve to reflect secondary gamma rays down into the shelter. Thus, a minimum ceiling of 12 inches of concrete must be provided, preferably below ground level, to further reduce the scattered radiation by another multiplying factor of 1/100. It is recommended that 2 feet of concrete, or 3 feet of dirt be used to give good protection against the radiation from fallout (a reduction factor of 1/5000 in addition to the factor of 1/10 provided by shelters below ground level). This is equivalent to providing about 300 pounds of dense building material behind each square foot of wall or ceiling surface. This would reduce the exposure of persons in the shelter so that they would be relatively safe to remain until such time when the radioactivity has dissipated itself sufficiently to allow escape from the area without accumulating too much additional exposure.

We have mentioned the dissipation of the radioactivity or the lowering of its intensity with time. This is called "decay." Decay in the radioactive sense simply means the breaking down of the radioactive atoms by their emitting excess energy as radiation and becoming stable, non-radioactive atoms. This principle is illustrated in Figure 4. For a particular type of atom, there is a characteristic time, the "half life," during which one-half of a group of these atoms will change to more stable atoms. Thus, since the rate at which radiation is given off is proportional to the number of radioactive atoms present, it is clear that the intensity of radiation emitted by this material will decrease by one-half during this half-life. Now in the fallout material, there are many types of radioactive atoms, so that there is no single characteristic half-life. Once all of the fallout has been deposited in a particular area, the radiation intensity in the area decreases with time in a complicated way resulting from a superimposition of the many different half-lives. However, for practical purposes, we may use the rule of thumb that the dose rate varies inversely as the time after the explosion, i.e., if at five hours after the explosion all of the material that is going to fall on a locality has already fallen and a dose rate of 100 R/hr is measured at five hours, then at 10 hours (twice the time) the dose rate will be about 50 R/hr; at 15 hours, 33 R/hr; etc. Assuming fission products are the main source of the radioactivity, a slightly more accurate estimate of intensity levels and accumulated doses may be obtained as described in FCDA Technical Bulletin 11-22. Figures 5 and 6 show how the radiation intensity

FIGURE 3. FALLOUT

High-intensity, close-in fallout is deposited within hours or days



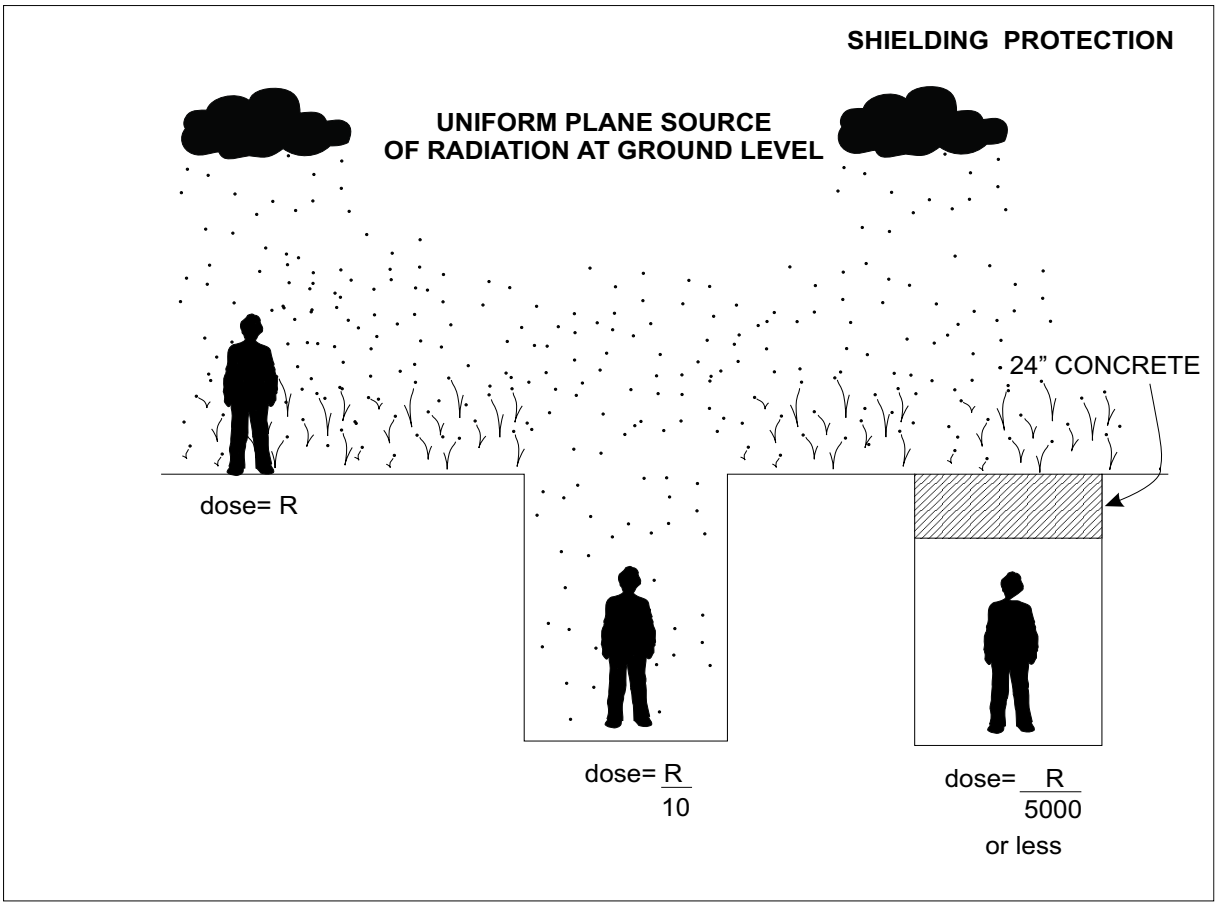
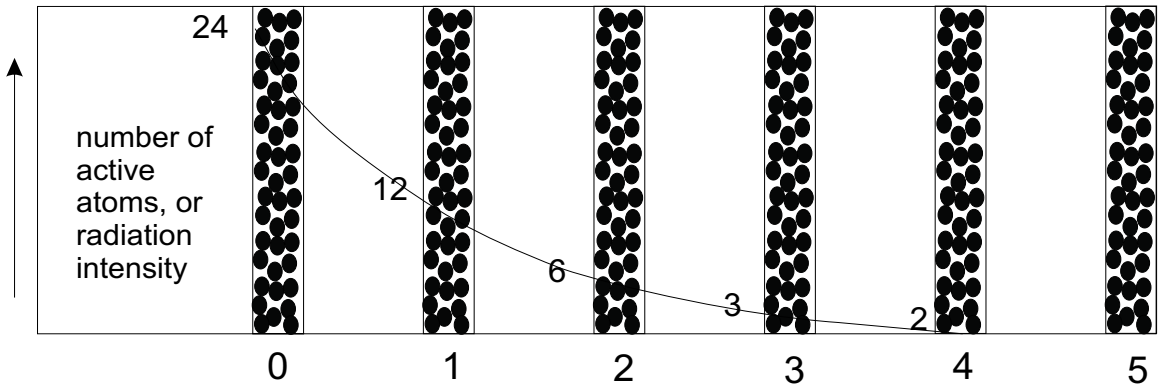


FIGURE 4. RADIOACTIVE DECAY

Takes minutes, hours, days, or years

PARTICULAR TYPE OF ATOMS



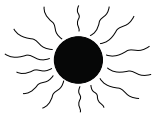
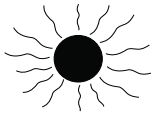
TIME IN HALF-LIVES

AVERAGE FOR TYPES OF ATOMS IN FALLOUT

No over-all half-life is applicable. It takes increasingly longer for the remaining activity to decrease by half.

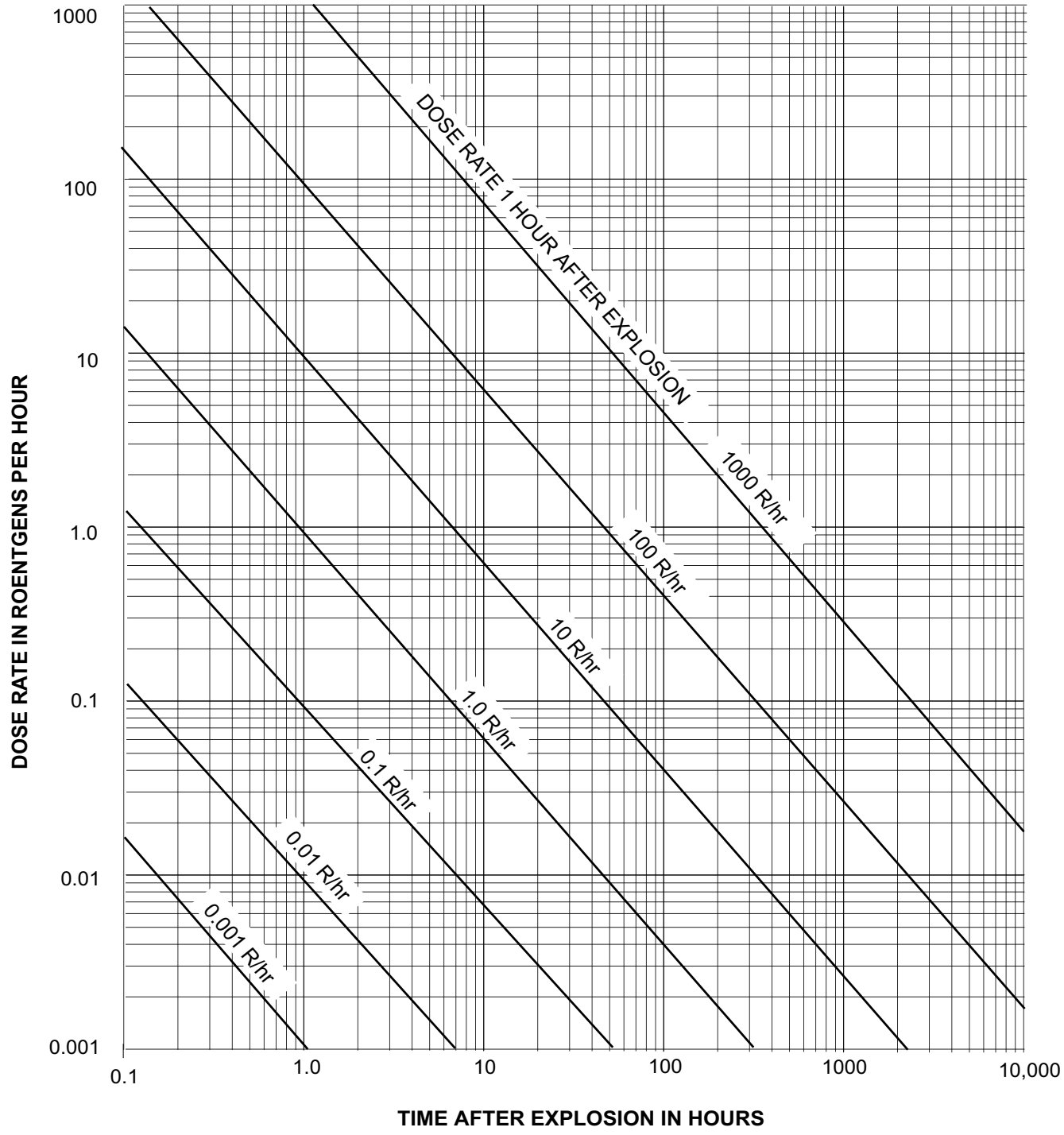
RULE OF THUMB FOR FISSION PRODUCTS

Intensity decreases in inverse proportion to time elapsed since explosion, if all fallout particles have deposited on the ground (approximate).

e.i.  4 R/hr at 1 hr   1 R/hr at 4 hr

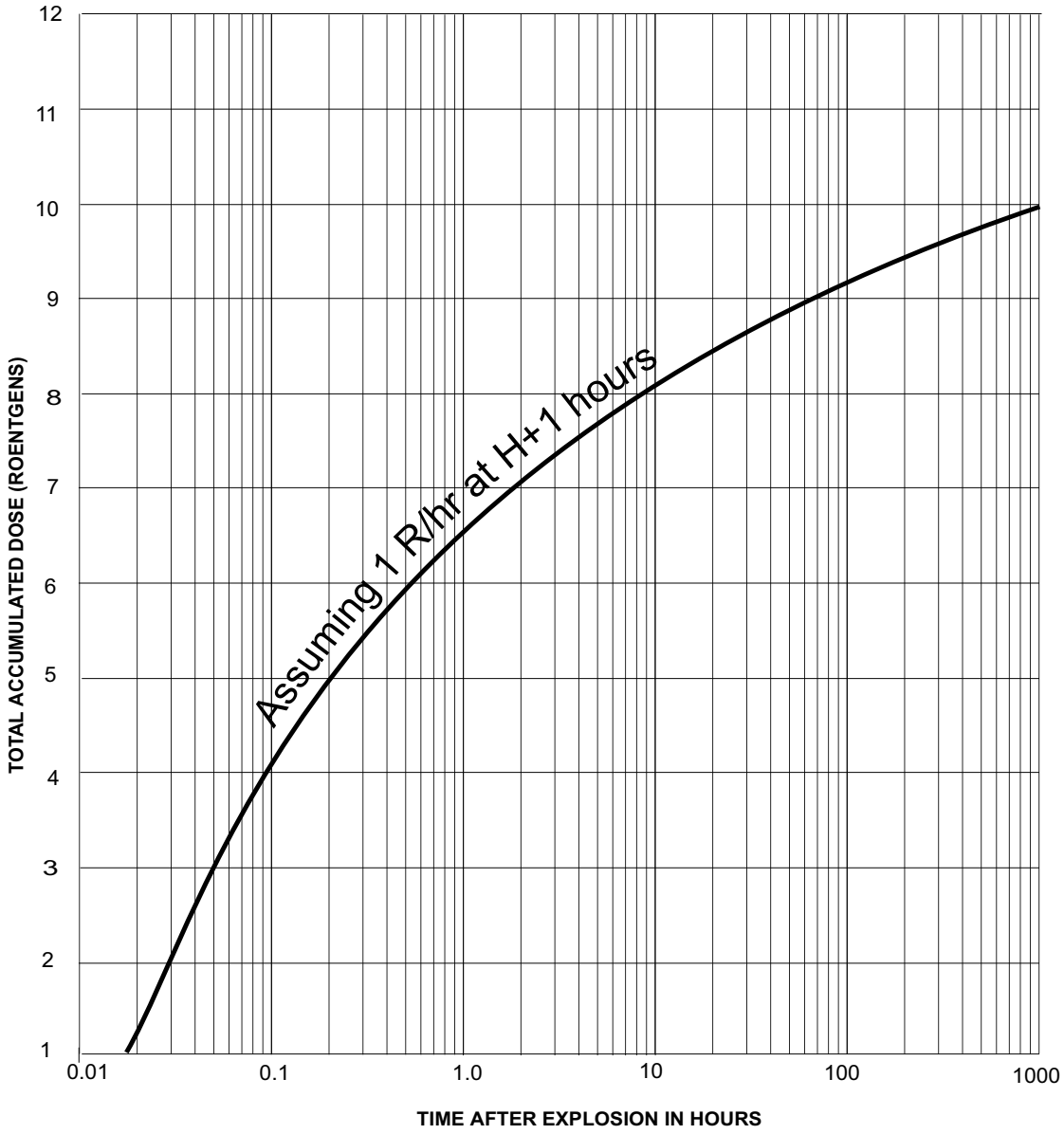
$$\text{R/hr at Time 2} = \frac{\text{Time 1}}{\text{Time 2}} \times \text{R/hr at Time 1}$$

FIGURE 5. DECAY OF FALLOUT RADIATION



NOTE: The decrease in intensity follows these curves only if all of the fallout has desposited on the ground and remains there.

FIGURE 6. INCREASE OF DOSE DURING EXPOSURE



NOTE: For dose rates other than those corresponding to one R per hour, multiply the values of dose by the dose rate in R/hr that the fallout material would produce if deposited at one hour after the bomb explosion. Obtain the dose rates from Figure 5.

To obtain dose between two times, subtract dose at entry time from dose at exit time as given on graph. Then, multiply by R/hr at one hour after explosion.

decreases with time, and how the accumulated dose increases with time at a decreasing rate.

As you know the "R" unit (to which we have been referring) for measuring total dose of persons exposed to gamma radiation is shorthand terminology for the Roentgen. "Roentgen" was the name of the man who discovered x-rays in 1895.

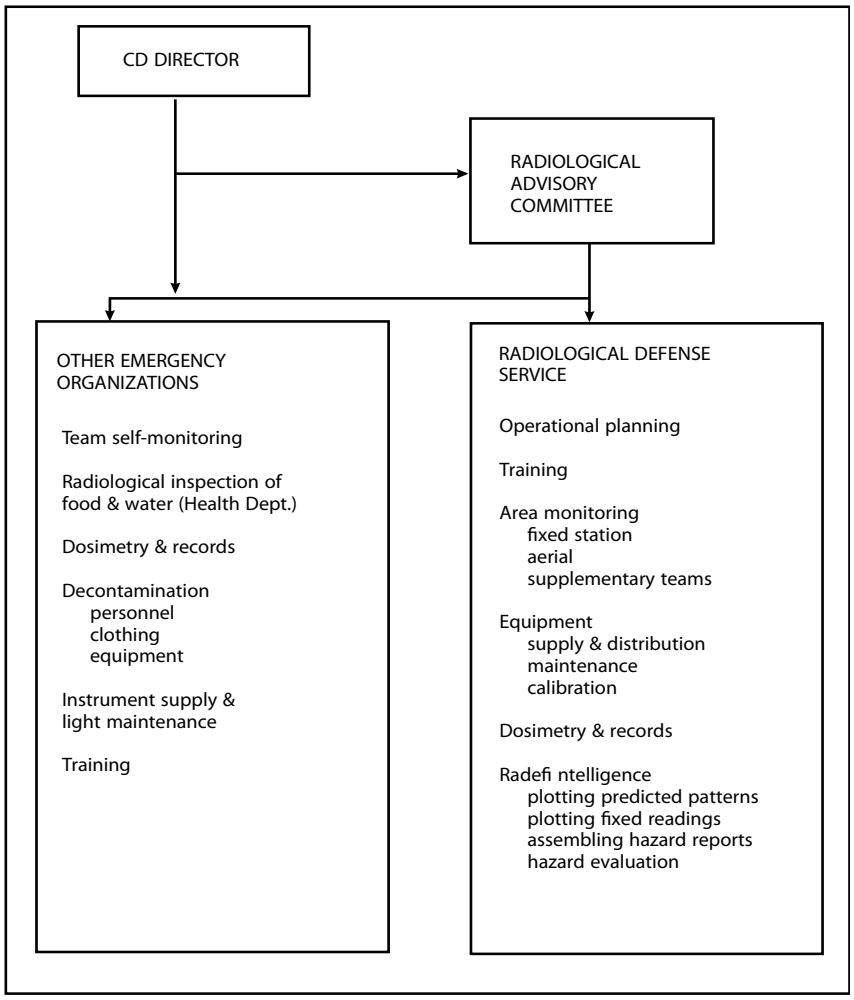
Gamma rays and x-rays are identical in nature and differ only in origin. The roentgen is proportional to the number of gamma particles (or "photons") that have passed per unit of volume through the portion of the body being exposed. For civil defense purposes, it is assumed that the entire body is in a field of radiation, and that the number of roentgens per hour measured by a survey meter indicates the rate at which the body is receiving radiation damage. The body is receiving what is called a "whole body dose," or just "dose" for short. A dose of 400 to 450 R over the entire body within a few days will kill about one-half of the persons exposed. Maximum doses of 25 R may be accepted under emergency conditions, but should be limited, when possible, to those beyond the age for procreation, since doses of this magnitude received by large numbers of the population may seriously affect the health of future generations. Also, each roentgen of whole body radiation received may result in a shortening of life span from 2 to 15 days. In individual cases only, critical missions may require that a person be exposed to a maximum of 25 R in any one week for 8 weeks, totaling no more than 200 R. (However, it is recognized that in some cases, individuals may be called upon to accept greater exposure in the interest of national survival.) Also, we must take every precaution to avoid the entry of radioactive particles or dust into the body, where they can lodge and bombard sensitive vital organs at close range year after year. The beta and alpha radiation become important when introduced into the body in close contact with living tissue.

Up to this point, only a few considerations of radioactivity hazards of warfare have been presented. Such a grounding should be helpful to the planner in enabling him to recognize a radiation hazard problem when it presents itself. Now we shall briefly point out some areas of survival planning where the radioactive hazard must be considered.

1. **SHELTER:** Since high intensities of radiation may be expected to cover much of the rural and industrial areas, shelter must contain adequate shielding against radiation, as well as ventilating systems adequate to filter out radioactive dusts, and chemical and biological warfare agents.
2. **EVACUATION:** Evacuation plans for blast areas must include subsequent sheltering of the evacuees as soon as possible from the widespread fallout. Except under very special circumstances, persons outside blast areas must not evacuate but must enter the nearest fallout shelter available before fallout occurs in their area. Persons outside the blast area may have from l to 24 hours to enter shelter, but in the absence of radiation instrument readings, should do so as soon as possible. All condensation falling from the skies should be assumed radioactive until proved otherwise.
3. **WELFARE:** Replacement clothing and decontamination facilities must be provided in reception areas.
4. **MEDICAL:** Facilities are needed for screening out contamination from hospitals and aid stations. Instruments should be available to examine wounds for radioactive contamination.
5. **FIRE AND RESCUE:** Monitors are needed with each team to advise on radiation intensities and augment the regular monitoring services.
6. **TRANSPORTATION:** Decontamination for vehicles must be provided since tires and grease spots pick up and retain contaminated materials. It is essential that information be gathered and maintained current regarding road net contamination.
7. **COMMUNICATIONS:** A capability is needed for relaying necessary data on radiation levels throughout the countryside, informing all emergency teams and the public of existing hazards.
8. **REHABILITATION:** A large part of the country will be uninhabitable on a permanent basis for perhaps several years as a result of lingering, long-lived radioactivity. Emergency dwellings in uncontaminated areas may have to be provided for millions of people. Factories may need extensive decontamination or relocation to safe areas. These examples serve to indicate the scope of the problem.

The division of responsibility for radiological defense procedures between the Radiological Defense Service and the other state and local emergency services is shown in Figure 7. The manner of

FIGURE 7. DIVISION OF RESPONSIBILITY FOR RADIOLOGICAL DEFENSE



organizing the Radiological Advisory Committee and the Radiological Service will vary with the availability of qualified personnel in existing agencies as wel1 as other qualified persons. The chart in Figure 7 indicates only the responsibilities that must be assigned and does not designate an organizational pattern. One or several responsibilities 1isted under the Radiological Service may be combined under one assistant chief, depending upon the size of the organization and the availability of personnel.

Note that other emergency services will have considerable responsibility for self-protection against radiological hazards. It would not be possible or desirable to staff a large enough organization of radiological defense personnel to deal with all of the individual field problems of other services. Furthermore, the members of an emergency service can accomplish most of the radiological tasks encountered by other services working in the field after a limited amount of training in the use of survey meters and dosimeters. Thus each of the emergency services will have to provide service monitoring to enable their commanders to ascertain, under field conditions, when their personnel may enter specific areas, how long they may stay, and how fast and by what route they must leave the area.

They must also have some capability for rough estimation of the safety of food and water for ten or thirty-day consumption, to answer questions that they may encounter in the field. The Emergency Medical Service must in addition have a capability for monitoring wound contamination and the hazard due to ingestion of food and water that may be contaminated with chemical or biological as well as radiological agents.

Each service must provide dosimetry for all personnel and keep a cumulative record of each individual's exposure. In this way, leaders can determine which of their personnel have received their maximum allowable exposure and which are still available for further field missions. A capability must exist in each service so that its members may decontaminate themselves or their equipment from hazardous amounts of radioactivity that may have been picked up in outdoor operations. Instruments for surveying intense radiation fields as well as Geiger counters for decontamination and food monitoring must be available to each service team operating out of cover. Simple maintenance procedures such as changing batteries and adjusting the calibration screw must be performed to ensure a maximum operable duty cycle. Major repairs requiring electronic technicians should be referred to a maintenance center operated by the Radiological Service. Since sufficient numbers of personnel who have experience with radiological hazards are not available, each of the services must establish, with the help of the Radiological Service, a training program to train members in the above functions as they are related to their primary mission.

The Radiological Service must be able to perform all of the above functions for the protection of its own members and to support its field operations. Its primary mission, however, is to advise those in command on radiological considerations affecting operational plans, and on the existing radiological situation as it may affect post-attack operations. To fulfill this requirement, the Radiological Service must be prepared to collect intelligence on the existing situation. Some information may be obtained from the reports of other services on unusually hazardous conditions that they may meet in their work. But a reliable intelligence system requires the establishing within the Radiological Service of a coordinated system of aerial and ground monitoring.

The ground system will consist of a number of fixed stations dispersed about the area concerned in the best manner indicated by the fallout probability analyses and the latest forecasts obtainable. These stations should be operated by persons well shielded below ground if possible, or with short periods of exposure above ground, to obtain early readings at fixed times and locations during the time of most intense fallout, Later, when the fallout has cleared from the air, aerial survey teams will obtain a rapid picture of the radiological situation to detect any "hot spots" that were not detected by the fixed stations and to substantiate the intensity contours that have been synthesized from the fixed-location readings. This type of survey lends itself to the most rapid communications, and is the most practicable method of obtaining a quick picture of the situation once the aerial survey planes can be allowed in the air. The Atomic Energy Commission and FCDA are presently developing a special instrument and techniques for performing aerial surveys.

Another type of area survey that must be provided by the Radiological Service is that provided by mobile monitoring specialists, who should be available as those in command may require to assist the other emergency teams in their field operations, to ascertain that radiological safety requirements are being met, and to solve unusual radiological problems that may be beyond the capability of the monitors belonging to the other teams. The number of such mobile monitoring teams required depends more upon the number of people involved in an area than upon the size of the area itself. These teams should be highly trained in radiological safety and should be required to survey only areas that are occupied by people who require radiological information on the spot. They may also report information to Radiological Service headquarters by radio when it has immediate or potential intelligence value.

The Radiological Service should also maintain personnel and facilities for electronic maintenance and periodic calibration of all radiological instruments within the emergency organization. They should also log and control the distribution of instruments as directed by higher authority in order to assure maximum use of the instruments available.

A plotting section should be provided within the Radiological Service to plot all intelligence in a form convenient for the use of the Radiological Chief and the Radiological Advisory Committee in keeping the operations director informed of the current situation. This intelligence in the early pre- and post-attack period should include the predictions obtained from U.S. Weather Bureau UF forecasts. Personnel dosimetry of its own members and others designated by the director shall also be provided by the Radiological Service for use in determining casualty rates and in formulating decisions on allowable exposure times for personnel. The Radiologica1 Service should also provide the other emergency services with trained radiological monitor instructors, as well as providing necessary technical and emergency operations training to its own members.

The following breakdown into branches is suggested for the Radiological Service, with the responsibilities for each branch indicated. Two or more branches may be combined, or any branch may be further subdivided when desirable for reasons of administration.

- Monitoring Operations Branch—responsible for ground fixed and mobile monitoring, aerial monitoring, communications for reporting.
- Radiation Intelligence Branch—responsible for plotting fallout predictions, evaluating and plotting monitoring readings, predicting radiological casualties, preparing reports for the use of operations directors and for public information.
- Personnel Dosimetry Branch—responsible for issuing dosimeters, obtaining exposures of personnel, maintaining exposure records, advising those in command regarding allowable exposure of personnel through the Radiological Advisory Committee.
- Instrument Branch—responsible for distribution, maintenance, repair and calibration of all radiation

detection instruments and communication equipment used by the monitoring teams. Responsible for improvising special radiological instruments needed for unusual situations or for measuring long-term hazards.

All of these branches should participate in the radiological training programs and in operational planning, lending their specia1 knowledge and skills for preparing other emergency services to deal with the radiological hazards of nuclear warfare. It is hoped that this outline of the radiological problem will be helpful in planning and organizing for survival after nuclear attack.

Present FCDA planning assumptions that must be emphasized are:

l) The enemy will attempt to contaminate a vast area of our country with deadly radioactivity.

2) Many bombs will be dropped, causing an overlap of fallout patterns, perhaps at different times.

3) It may be unwise for a person outside of the blast area to try to escape the fallout area, since he increases the hazard by exposing himself in an open country during the most dangerous hours. Also, when escaping upwind of one fallout pattern, he may be running head-on into a pattern from another city.

Key Words

Emergency response
Fallout
First response
Radiation
Survival planning
Terrorism

About the Author

Dr. Allen Brodsky received a BE in chemical engineering and an MA in physics from Johns Hopkins, and an ScD in biostatistics and radiation health from the University of Pittsburgh, and was a Radiological Physics (Health Physics) Fellow at Oak Ridge National Laboratory, 1949-50. He holds certifications by the American Board of Health Physics, American Board of Industrial Hygiene (radiological aspects) and American Board of Radiology (Therapeutic Physics). His experience includes participation in nuclear weapons development, civil defense programs at Federal and local levels, dose and risk evaluation, as well as development of radiation safety standards and regulations in the Atomic Energy Commission and Nuclear Regulatory Commission. He has also been radiation safety officer at the Naval Research Laboratory and several universities, technical director of an in vivo and bioassay facility at the University of Pittsburgh assisting Dr. Neil Wald in evaluating persons exposed to the inhalation of a variety of nuclides and to external radiation, and faculty member and advisor to graduate students at several universities. He is the Editor-in-Chief and contributor of chapters to the four-volume series, “CRC Handbook of Radiation Measurement and Protection,” (1979-82) and the author of “Review of Radiation Risks and Uranium Toxicity,” published by RSA Publications in 1996. He is currently Senior Scientist, Science Applications International Corporation, performing radiation dose assessments for veterans of nuclear tests and developing statistical methods of data analysis. He has also been Adjunct Professor of Health Physics at Georgetown University since 1987, teaching health physics courses and advising graduate students.

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APPENDIX C

POSTER: ACTIONS THAT YOU, THE PUBLIC, CAN TAKE FOR PROTECTION IN A TERRORIST ATTACK*

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(Revised June 10, 2004)

Although the Federal, State, and local governments have been preparing to prevent terrorist attacks, and have provided certain training to responders, I find that many of my family and friends have no knowledge of simple measures for their protection. Immediate measures, within seconds or minutes, can save many lives. A person with proper knowledge will do the right thing to save life, and will not panic.

If you have warnings from an explosion, an extremely bright flash of light, a recognized siren warning, or the news that a dispersal of radioactivity or biological or chemical agents has occurred, you probably have time to take some of the following actions:

1. If you are at home, go immediately to an inner room, preferably one without windows, and shut the door. Do not stay near windows in case flying glass might be produced by a blast. It takes about 5 seconds per mile for a blast wave to travel, so if you are 5 miles from the detonation, for example, you have 25 seconds to get to a safer location. If you have prepared a shelter, go into it. This will decrease exposure to any agents that might have been dispersed in the outside air. If you protect against external radiation, the radiation dose from inhaled material will not present a serious risk. Any radioactive contamination can be adequately removed by washing with soap and water. The risk of intake of radioactive contamination has often been greatly exaggerated. Do not run to a hospital just to wash off radioactive contamination. It is not necessary for removal of contamination. Hospitals will be overwhelmed. Do not evacuate, unless you are certain no further exposures will be released, roads are clear, and your transportation is in good shape and full of fuel. It is usually better to stay indoors, unless the building you are in is on fire. Any clouds from the bomb that contain radioactivity, chemicals, or

biological agents of breathable aerosol size will likely blow by within about one minute, and the breathable size particles will remain with the wind streams as they pass your building. It is unlikely that the concentrations of dangerous materials in air will remain around long enough to enter inside your home or shelter through even small cracks.

2. If you are in or near an apartment or office building, go to a middle floor to use the concrete floors to shield from radiation coming from the roof or ground, or to get away from radioactive, biological, or chemical agents that are probably concentrated near ground level. Within hours, these agents will be dispersed by the wind, and you will probably be advised it is safe to venture out for food, or to evacuate to a safe location.
3. If you are in a department store or place with many people and know that only radioactive material has been dispersed outside, go to the basement or ground level; or go to a mid-level floor above if chemical or biological agents are prevalent. Get everyone to form groups where individuals circulate in to the center and out. September 11 events show that Americans will cooperate in an emergency. People are mostly made of water. Every 4-5 inches of water will reduce any gamma radiation another factor of one-half. The other solid materials stacked around will reduce radiation to safe levels. Considering also your distance to any radioactive contamination on the roof, and the shielding of floors above, you will be protected from radiation effects. Radiation levels from any conceivable dirty bomb are not likely to be that high anyway, if you are at a safe distance from the blast. If in a subway, stay well below ground and in a closed train.
4. If you really think that you need to reduce inhalation exposure because you expect harmful agents are in the passing air, you can breathe in through your mouth, shielded by about 16 thicknesses (the usual 4 folds) of a handkerchief. In any case, you are not likely to inhale enough radioactive material to cause serious harm. If you want to use masks, that requires prior selection and fitting to be most effective. You should consult your local emergency office, or a professional society involved in agent protection.
5. Obtain beforehand, if possible, and wear an inexpensive, credit-card sized, or pocket pencil size, radiation dosimeter. Credit card dosimeters are available now at low cost.** It will probably assure you that you and your family have not received a significant exposure in your shelter. If you are a rare person who sees a readable dose, you can then decide whether to seek help medical help, or surround yourself with additional improvised shielding materials.

REMEMBER: Radiation decreases with time both by radiological decay and by weathering. Biological and chemical agent concentrations will also decrease by weathering. Trained local responders can also provide decontamination in many instances, but ordinary washing with soap, mild detergent, should remove any dangerous levels of contamination. You will not likely starve nor need to remain in a shelter or an evacuation site for a long time. Keep a portable radio or TV, fresh batteries, and some food and water with you whenever possible. **Do not evacuate unless instructed by authoritative persons**. **Do not go to a hospital, if you are not injured.** Simple washing will eliminate any early radioactive contamination to low-enough levels; specialists might provide additional advice after a few days.

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*This is a revision of an article published in one of the author's local newspapers. The material should be adapted to the circumstances of a person's local community in cooperation with the local or county emergency director, and provided with the county's ordinary list of emergency preparations, including the stocking of food, water, flashlights, emergency radios, batteries, toilet supplies, suitable fitted half-masks (if advisable), blankets, extra clothing, soap and detergent, entertainment items, and any other desired supplies for at least a two-week stay at home or in shelter. See also Exhibit 34 for a more comprehensive list of emergency supplies.

**Contact JP Labs, Dr. G. Patel, 732-469-6670 and ask for price and product information.

Handy Pocket Card, Homeland Security Committee of the Health Physics Society

These numbered rules can be folded and printed half on each side of a card.

v2.6

JUST-IN-TIME: NUCLEAR DETONATION – 10 RULES FOR EMERGENCY RESPONDERS

Adapted by: Homeland Security Committee of the Health Physics Society - http://hps.org/hsc/

① **Duck & cover when you see a flash.** Stay down behind cover for at least two full minutes. Any type of cover could prevent serious burns and injuries from flying and falling debris such as broken glass. Keep eyes closed during the bright light to prevent blindness.

② **Go in. Stay in. Tune in.** Shelter-in-place by going underground or to the center of the middle floor of a nearby, stable large building. Minimize the time exposed to radiation (Rule 9). Maintain communications (Rule 5).

③ **Radioactive fallout** occurs soon after the detonation and it will fall and accumulate on the ground. The direction of the fallout plume spread is dependent on surface AND upper level winds. Generally, stay upwind especially if you can see the direction of the plume's movement. Fallout may or may not be visible on the ground. Radioactive fallout can be detected ONLY by using radiation monitoring instruments.

④ **Use the "Inverse" 7/10 Rule:** Fallout loses 90% of its radioactivity in the first 7 hours after a detonation and an additional 90% for every 7-fold increase in time. It is reduced: by 90% in the first seven hours; by 99% in 49 hours (two days); and, by 99.9% in 343 hours (two weeks)

⑤ **Maintain communications** with local, tribal, and state authorities and other response elements; provide a scene assessment for the regional situation assessment center (e.g., EOC). Report visible fallout and approximate radiation levels in the area and the times they were taken at regular intervals. Monitor the media including radio, TV, and the Internet.

⑥ **PPE for emergency responders.** External fallout contamination will collect on outer garments and exposed body parts. No PPE will protect responders from external gamma radiation. Although inhalation and ingestion are a secondary concern compared to external gamma radiation exposure, masks or improvised respiratory protection may be used during fallout plume passage, for smoke and dust, and for high indoor radiation levels.

⑦ **Contamination removal.** Most external contamination can be removed by taking off the outer layer of clothes, wiping exposed hair and skin areas, and/or by taking a shower.

⑧ **Fight fires.** The detonation will cause fires in the area where populations are sheltered; take actions to slow the spread of fire.

⑨ **Responders with radiation monitoring instruments** should initially shelter using these instruments to monitor shelter conditions and not exit the shelter if it requires entering a dangerous radiation zone (>10 R/hr) unless there is a time critical safety issue such as avoiding fire, a building collapse, or an evident lifesaving mission. Provided outdoor radiation levels are below 10R/hr, perform scene assessment of the immediate area for hazards. Stay close to shelter locations and closely monitor radiation levels and immediately shelter if radiation levels increase rapidly. Responders without radiation monitoring equipment should shelter as long as practical or until informed that they are not in the dangerous radiation zone (> 10 R/hr).

⑩ **Establish safe evacuation routes** from dangerous radiation zones (>10 R/hr) and identify evacuation priorities. Establish triage, decontamination, and casualty collection points outside of dangerous fallout zones (In areas <10mR/hr).

Handy Pocket Card Prepared by Steve Jones, Physicians for Civil Defense

Note: Writing on card would be condensed so the two sides would fit a shirt pocket.

side one

60-SECOND N-DETONATION TRAINING FOR FIRST RESPONDERS

A.

Drop & ***cover*** when you see a flash. Stay down behind cover for two full minutes. Even covering with a newspaper can prevent burns. Keep eyes closed during bright light to prevent blindness.

B.

7/10 Rule: Fallout loses 90% of its radioactivity in the first 7 hours after a detonation and an additional 90% for every 7-fold increase in time: 90% in the first seven hours; 99% in 49 hours (two days) and 99.9% in two weeks.

C.

Fallout looks like sand, ash or grit as it falls and accumulates on the ground. If no fallout is visible on ground, there is no radiation! To be sure place a piece of white paper, a dinner plate or anything with a smooth surface on the ground & check every 15 minutes for fallout particles

side two

If visual indications of fallout appear take shelter for two or three days underground or behind thick walls. (These tips are generally true.)

This card may be the only nuclear training you get. Knowing A, B, & C can save your life and your department.

Give a card to each emergency responder in your jurisdiction.

These principles were developed during nuclear weapons tests from the 1940s-1960s and remain valid today!

The laws of physics do not change.

This card by: PhysiciansForCivilDefense.org

APPENDIX D

A SAMPLE OF TED ROCKWELL'S SOCRATIC ANSWERS TO RADIATION MYTHS

(*The following is a small sample of truthful answers by Ted Rockwell that explode the many myths about radiation and nuclear matters that have been prominent in the media. His book (Rockwell 2003) is interesting and important reading, and has many, many more. The following is reproduced with Ted Rockwell's permission.)*

Turning Silk Purses into Sows' Ears

By Theodore Rockwell

Fear is a great motivator. It sells papers, it creates grant money, it makes reputations. Nuclear fear caused the Japanese to surrender and kept the Soviet army at bay. It was a motivator for ecological protection and it stopped nuclear power construction in its tracks. But **fear can be an obstacle** in the search for Truth when it turns nuclear benefits into mythical problems:

***Myth**: Man created radiation. It's unnatural, little-understood, an unprecedented threat to the earth.*

Facts: Radiation has been with us since the dawn of time. Life evolved in a sea of radiation. Our soil, our water and our bodies are naturally radioactive. Radioactive processes light the sun and the stars, keep the earth's core molten and our environment livably warm. Radiation is better understood than most environmental challenges. Tests show it is probably essential to life.

***Myth:** We're fouling our nest and degrading the gene pool by continually adding to the earth's radioactivity.*

Facts: Fission changes long-lived uranium into shorter-lived fission products, ultimately decreasing earth's radioactivity. All the radioactivity we produce is less than the natural decay that continually decreases earth's radioactivity each year.

***Myth:** The quantity of nuclear waste is so great! What can we do with it?*

Facts: Nuclear plants produce less than a millionth of the volume of waste from an equivalent coal-fired plant, so it can be put into sealed drums and controlled, rather than dumped into the environment. The 50,000 tons of radwaste

destined for Yucca MTN was produced by all 103 US nuclear plants over the past 40 years. This is less than 2 pounds per person served. This is small compared to wastes produced by most other industries, or even our homes. The waste volumes associated with construction and operation of solar, wind, and other renewables are larger, on a per-kilowatt-hour basis, than nuclear wastes.

***Myth**: Radwaste stays toxic for thousands of years. Humanity has never faced such a long-term hazard.*

Facts: Radioactive wastes continually decrease in toxicity, whereas other toxic wastes like mercury, lead, arsenic, selenium, cadmium, chromium, etc. retain full toxicity forever. After 500 years, you could eat a pound of it. We bury it 2000 feet underground. The top 2000 feet of US soil contain millions of times more lethal doses of natural poisons than all the nuclear power waste together. We make 10,000 times more lethal doses of chlorine each year, and put it in our drinking water to kill germs.

***Myth:** Shipping these* **"Mobile Chernobyls"** *(**spent fuel casks**) past schools and homes is a terrible risk.*

Facts: These casks pose no significant risk. They are nearly indestructible, being tested by collision, explosives and fire. They contain no liquids and can't "go critical" like a reactor. In tests, armor-piercing missiles blew a hole in one side, but the small amount of radioactivity released was not harmful.

***Myth**: Nuclear power is an especially unforgiving technology. A momentary slipup, and it's catastrophe.*

Facts: Just the opposite. Nuclear plants are uniquely robust. They can resist earthquakes, hurricanes, power loss, sabotage and operator errors. Even if the core were to melt, even with containment breached, analyses and tests show that few, if any, persons would be seriously injured or killed. Hundreds of nuclear plants worldwide, operating for decades, have confirmed this.

***Myth**: But Chernobyl killed thousands of people and disabled millions.*

Facts: Not true. Thirty workers and firefighters at the plant were killed. But a 16-year investigation by the UN and WHO concluded that there were no public radiation deaths or injuries No significant increase in any illness resulted except for 2000 cases of childhood thyroid cancer, a highly treatable disease from which there have been few if any deaths. But fear of radiation led to unnecessary evacuation of large population groups, causing unemployment, depression, alcoholism and suicides. In the year after the accident, there were 100,000 additional abortions downwind of the accident, presumably in unwarranted fear of bearing a "nuclear mutant." Deformed "Chernobyl victims" used to raise money for relief were later found to be unrelated to the accident. Some were from far away, others were deformed before the accident.

Many people maintain contradictory beliefs about nuclear matters. For example:

1. The UK applies a carbon tax to fossil fuels, to encourage power sources that do not generate global warming gases. When asked if this tax would be applied to nuclear plants that generate no such gases, the Energy Minister replied, "Of course! Otherwise nuclear would have an unfair advantage over coal."
2. Many patients at the Taipei Municipal Hospital are given a diagnostic "radioactive cocktail," assured that it will not hurt them. After some hours, some of the cocktail is excreted in the urine, which is collected in a tank to allow the 8-hour half-life to decay before disposal. On Jan 14, 2003, some of this urine was spilled, creating a "radioactive contamination emergency." The treatment center and the intensive care unit were shut down and sealed off, the press reported the "health scare," and a formal incident investigation was performed. The radioactivity was

deemed not harmful when all of it, fresh, was inside a person's body, but was a full-blown public health emergency when a small portion of it, decayed for many hours, was spilled.

3. The European Community has been struggling with the fact that many substances are naturally radioactive, some in excess of regulations for nuclear facilities. Current regulations address this by requiring that materials released from nuclear facilities be less than 1% as radioactive as materials with "natural" radioactivity, even when the radioactivity is from the same radioisotope.

4. 4. Soil over most of the earth contains uranium, some in quite high amounts. Careful studies show that this has not harmed the health of inhabitants. When this uranium is processed for use for in nuclear power, most of the radioactivity, is removed, leaving "depleted uranium." This depleted uranium is thereafter falsely characterized as a special health hazard.

5. In many diverse cultures world-wide, natural radon spas have been used for centuries to treat a variety of illnesses. Patients are often sent there by physicians, with the treatment paid for by the national health insurance. The evidence for benefit is impressive. Yet, while spas boast of their high radon, elsewhere "radon police" warn people that radon in their homes, although much lower than at the spas, is a health hazard.

6. Nuclear power plants are forced to go to great extremes to reduce any potential environmental pollution to far below natural levels. Yet when it is suggested that coal miners should stop pushing the tops of mountains into pristine streams, it is objected that this would make coal plants uneconomical.

7. Europeans are particularly concerned about the safety of their food. Luxembourg prohibits the import of any irradiated food and inspects it at the borders. But the only sure test that food has not been irradiated is the presence of pathogens, So they test to BE sure there are pathogens.

8. An intensive program during the 1970s and 80s, in which the federal government participated, measured the release of radioactivity from molten reactor fuel and monitored its dispersion in the air. It was found that nearly all the radioactivity stayed bound in the fuel, or dissolved in the water, or plated out on adjacent structure. Very little escaped into the air, and that did not remain long in respirable form. This confirmed results of the Three Mile Island and Chernobyl accidents, where few if any fatalities occurred among the public. Yet government-sponsored "studies" are repeatedly released, claiming tens of thousands of deaths would result from such accidents, even hundreds of miles away.

9. The only way one can "predict" large numbers of deaths from a nuclear accident is to multiply the expected trivial individual radiation doses by very large populations assumed to be exposed. This practice has been called scientifically indefensible, even by the organizations who recommend it as a "prudent course." Yet emergency plans are all based on such "predictions."

10. ALARA, the practice of requiring that cumulative radiation dose by As Low As Reasonably Achievable, restrains workers from performing inspections (e.g. for leakage and corrosion) and preventive maintenance in radiation zones, decreasing assurance of plant safety in the name of "prudence."

APPENDIX E

SUMMARY OF PROBLEMS WITH THE NEW SI UNITS IN REGARD TO USA HOMELAND SECURITY

The following slides are from a talk (Anastas et al. 2003) in which I participated. They show some few advantages of the newer "Special" SI units in radiation therapy physics, but indicate the many difficulties and even some dangers of requiring their use in routine radiation protection, particularly in emergency response operations. This information has not yet been written as a paper for publication, but perhaps for use here the pictures and brief material on slides is better for an overview of the problem. As it is said, "A picture is worth a thousand words."

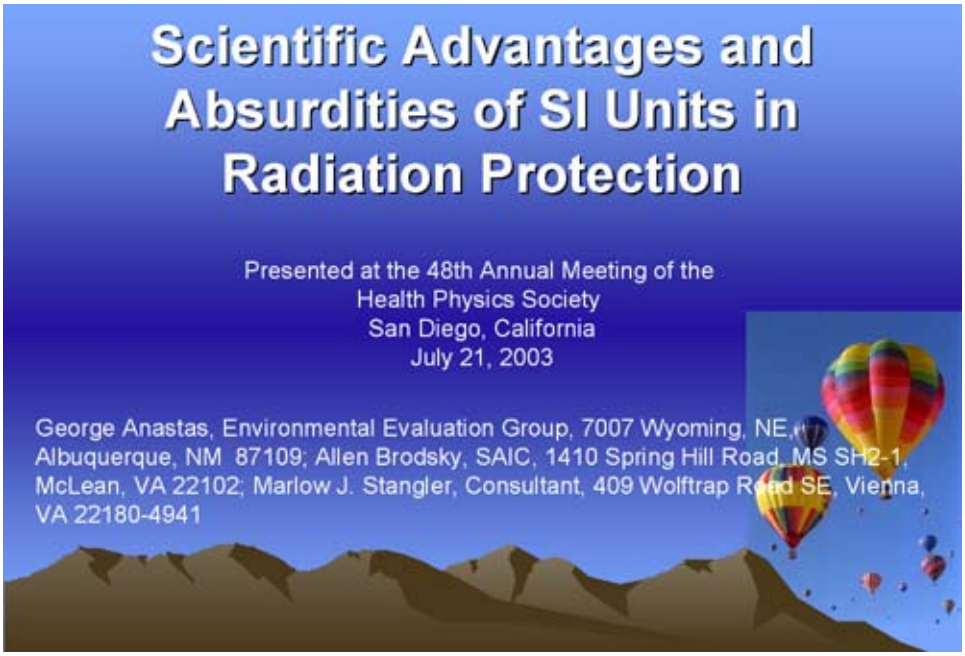
Included among the disadvantages of these more recent SI units are: the dangers of inadvertent or uninformed interpretation of them as the more conventional units that have been used since the early twentieth century, which were defined by the pioneers of radiation science for their convenience in scientific and practical radiation usage. The dangers include: 1) If a reading of an instrument in Sv is thought to be in rem, then 1 Sv would be interpreted as 1 rem rather than the higher dose of 100 rem, where serious biological harm begins to occur for acute exposures; 2) an exposure of 1 coulomb per kilogram is equivalent to about 3800 R, so if an exposure of 1 C/kg is thought to be 1 R then an exposure far above lethal would be thought not to result in significant harm; 3) if an amount of radioactivity that is relatively low in terms of human risk is given in Becquerels (Bq) instead of curies (Ci) or microcuries (μCi), the large number could frighten or panic many citizens; for example, a relatively low amount of tritium, 0.01 μCi, which if taken totally into the body in the form of water would give a dose of less than a few millirem, would be equal to 370 Bq.

Disadvantages of the newer SI units include: 1) the exposure unit of R, if instruments read that way, may be close to the level of mean whole body dose in rem, as discussed in Chapters 3 to 5, but this is not true for the ICRU adopted unit of exposure corresponding to dose in gray (Gy) or sievert (Sv); 2) setting up differential geometries to represent small volumes of tissue at given locations in the body, in order to perform calculations of dose to tissues or organs, cannot be easily visualized, particularly by those not familiar with differential geometries needed for the use of calculus, as shown in some of the slides below.

The original committees of the ICRP who were asked to review the proposed newer special units in the early 1970s were not actually comfortable with them, and the Executive Secretary of the ICRP at that time made a

statement such as, "I guess we will need to adopt them, but I hope it will not be in my lifetime." More recently, a careful review of these units for possible adoption in the revision of the basic Federal regulation, 10 CFR Part 20, "Standards for Protection Against Radiation," resulted in retention of the original conventional units in that regulation. Even more recently, the NCRP Commentary (NCRP 2005) gives evidence of a realization that the original units are better for emergency responders, in that the convention of listing the newer units first is discarded and the newer SI units are given only in parentheses where they are used at all.

To conserve space and not bore the reader, further discussion of this issue is closed. Also, note that some of the slides below are not intended for study by most citizens. They have been retained for the scientists involved in, or interested in, radiation dosimetry who can easily see some of the advantages of the original units in estimations or theoretical calculations of exposure and dose.



Short History

- May 1973 (30 years ago) - ICRU issued SI units proposal for comment, to be adopted in 10 y.
- 1973 proposal states, "Main field for…use of …exposure…will be…medical diagnosis." (ICRU composed of medical and theoretical physicists.)
- F. D. Sowby, Secy. ICRP, Feb. 1974: "My impressions of the replies…SI system should…eventually be used in radiological protection - but, please, not in our lifetime."
- No ICRP consensus existed (see Taylor, pp. 10-441 and 10-442, 1982)
- The ICRP committees received split and inconclusive votes in 1974. How many of those here over 55 voted?
- In 1979-80, in order to obtain dose conversions in Sv/Bq, ICRP-2 was forced to use the well-known formulation:
  - $H_{50,T} = 1.6 \times 10^{-10} \quad U_S$ Ã SEE(T<---S) where SEE is in units of MeV-g^{-1}-t^{-1}
  - So much for "coherence" in our most important internal dose equations.

Advantages of SI "Special" Units

- Convenient in cavity chamber measurements -- in air, or in phantom -- because charge measurements in coulombs has been customary.
- Purportedly, "coherence" of all formulas (coefficient constants of unity) -- only applicable if always willing to work in time units of seconds, and revise all nuclear tables to energy units of joules vs. MeV.

HPS [Anastas, Brodsky, Stanglel] 7/21/03, San Diego, pg. 4

Advantages of SI Units

- "...SI dramatically facilitates the teaching of health physics." (D. J. Strom 1989)
  - Note in current health physics texts/literature the use of SI units, providing traditional units in parentheses, using cGy, or by making additional complex conversions.
  - Note the awkwardness of representing a differential area (m^2), or volume (m^3).
- International exchange of information and data (Strom 1989). But that can be done by simple conversion of results after they are obtained.

HPS [Anastas, Brodsky, Stanglel] 7/21/03, San Diego, pg. 5

One Major Advantage of SI: Cavity Chamber Measurements

- Ideal in radiation therapy physics:
  - Dose to gas = $\frac{\text{charge (coulombs)} \times 34\ \text{J/C}}{\text{mass of gas in cavity (kg)}}$
  - = Dose to gas (in Gy)
  - Multiplying by ratio of mass stopping powers, wall-to-gas gives dose to chamber wall; then, multiplying by ratio of mass-energy absorption coefficients, tissue-to-wall, gives dose to small volume of tissue in air. Convert with TARs.

HPS [Anastas, Brodsky, Stangler] 7/21/03, San Diego, pg. 6

Scientific Disadvantages of SI Units

- Not convenient (even absurd) for setting up calculations of exposure or dose from different geometrical sources.
- It is difficult to illustrate how to set up integrals for calculating exposure in air or dose to tissue to differential volumes near points of interest.
- The unit of time, seconds, is too short for practical or research measurement use (except in radiation fields of 3600 R/h = 1 R/s). If other time units are used, the purported advantage of "coherence" is lost.
- Nobody has offered to convert all nuclear transition energies from MeV to joules.
- Other advantages—too many to discuss here. Check journals critically.

HPS [Anastas, Brodsky, Stangler] 7/21/03, San Diego, pg. 8

Example Exposure Calculation:
Exposure Rate Above Center of Circular Contaminated Plane

$SC(C) := 2.221\,10^{6} \cdot 60 \cdot C$ dis./hour per sq. cm $\mu en := 0.02940.001293$ $\mu en = 3.801 \times 10^{-5}$ cm^{-1}

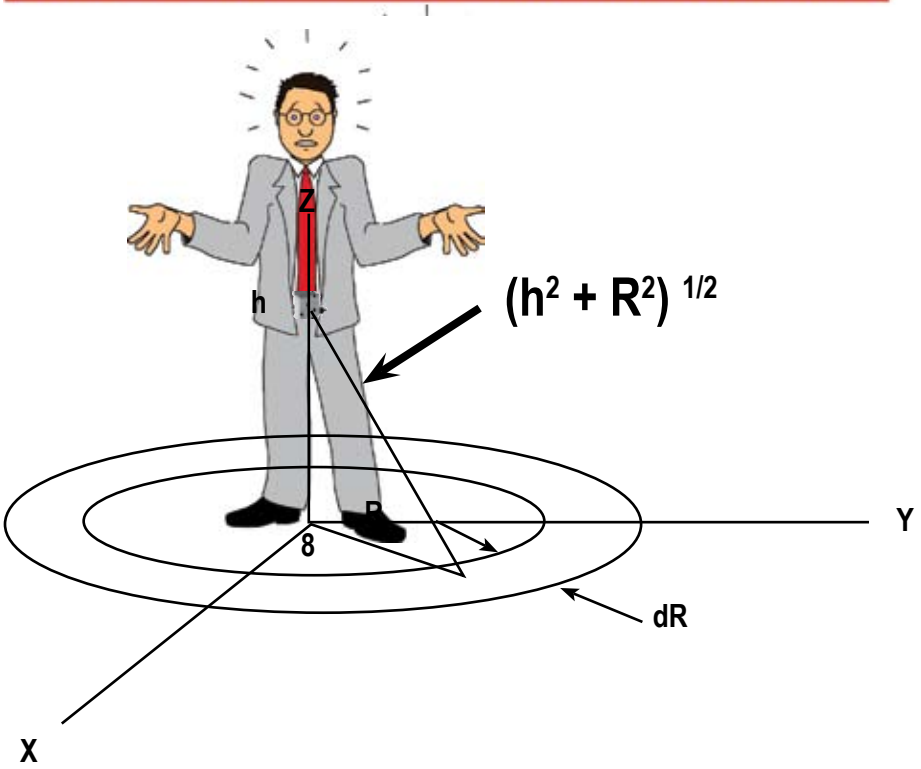
$$Eatten(h, C, Rmax) := \int_{0}^{Rmax} \int_{0}^{2\cdot\pi} \left[SC(C)\, e^{-\mu en \left(R^2+h^2\right)^{\frac{1}{2}}} \cdot R \cdot \mu en \cdot 0.6616 \cdot \frac{10^{6}}{4\cdot\pi\left(R^2+h^2\right)} \right] \left(4.8 \cdot \frac{10^{-}}{34}\right)^{0} d\,d\theta\,R$$

$Eatten(100, 1.800) = 0.049$ $Eatten(100, 1.1600) = 0.064$ $Eatten(100, 1., 3200) = 0.079$

$Eatten(100, 1.2000) = 0.11$ $Eatten(100, 1.100000) = 0.118$ $Eatten(100, 1, 1000000) = 0.118$

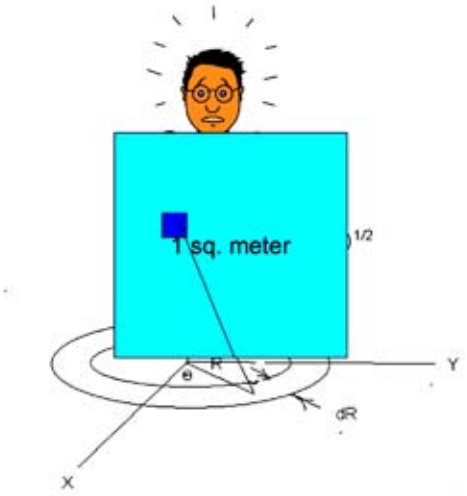
NOTE: Result for infinite plane agrees with EPA FGR Report 12 for cesium-137. Factors in integrand are easy to recognize.

Convenient Differential Elements, cm^2, cm^3



Inconvenient Differential Surrogates, m^2, m^3

Where's the target tissue???



HPS [Anastas, Brodsky, Stangler] 7/21/03, San Diego, pg. 12

Practical Disadvantages of SI Units

- After 30 years, new calibration installations and instrument manufacturers using national and international standards, and serving international markets, still use R/h and Ci.
- Loss of convenience that 1 gram ^{226}Ra has 1 Ci of activity
  - Now, in SI units, we need to remember that: 1 kg ^{226}Ra has 37 TBq (terabequerels)
- Year is not an SI unit.

HPS [Anastas, Brodsky, Stangler] 7/21/03, San Diego, pg. 13

Practical Disadvantages of SI Units of Activity

- Laboratories count in minutes, hours - seconds are inconvenient in practice.
  - Units of Bq/min or Bq/hour are not SI, and do not provide "coherence".
- Thousands of U.S. nuclear medicine departments still use mCi, rad, etc.
  - MIRD documents and references use conventional units.
  - Nuclear medicine personnel are a valuable resource for training and medical response

HPS [Anastas, Brodsky, Stangler] 7/21/03, San Diego, pg. 14

Practical Disadvantages of SI Units of Activity

- The best texts and teachers (e.g., Cember, Turner) attempt (valiantly) to use and teach in SI units
  - Examine their texts and count the pages that use maneuvers or mixed units.
  - See the calculations of carbon-14 dose in part of problem 6.19, Cember and Johnson, pp. 183-184, teaching SI units (2 pages).
  - See calculations on next slide, with μCi, MeV, rad (one-quarter page).

C-14 Dose Calculation in Conventional Units

$a(t) := A(t) \cdot 27.027$ to get a(t) in mCi vs. time

The dose rate in rem/day given by the (ICRPII era) formula is (Quimby):

$\varepsilon := 0.05$ MeV -- average per transformation as used by Cember on p.501 $m := 50000$ grams C-14 compartment

$R(t) := \frac{51.2 a(t) \cdot \varepsilon}{m}$ where a(t) is given above,

7-day dose $D(T) := \int_0^T R(t)\,dt$ $D(7) = 0.019$ **rad - same as Cember, problem 6.19**

14-day dose: $D(14) = 0.026$ **rad -- same as Cember**

Absurdities of the Application of SI Units in Radiation Protection

- The unit of exposure in SI special units is C/kg. 1 C/kg = 3881 R. A mistake in units could be lethal, very rapidly.
- The many advantages of the roentgen exposure unit, tabulated f factors (by former ICRUs), and tissue-air ratios, for calculating exposures and organ doses, is lost.
- Mistaking 1 Sv/hour for 1 R/hour could lead someone to receive 25 Sv = 2500 rem in an emergency.

Recommendations

- The United States should continue use of conventional units where safer and advantageous to efficiency and productivity. We can convert to SI units whenever necessary.
- It is exceedingly imperative to avoid SI units when their use increases the likelihood of dangerous mistakes.

APPENDIX F

LIST OF COMPANIES SELLING INSTRUMENTS AND PROTECTIVE EQUIPMENT THAT CAN BE HELPFUL IN PERSONAL PREPARATIONS

(From the Health Physics Society Handbook, as updated to about 2009)

2009-10 AFFILIATE LISTING & BUYER'S GUIDE

AMERIPHYSICS LLC, Attn: Benjamin Sirhan, 5320 South National Drive, Knoxville, TN 37914. Phone: 865-654-9200 Fax: 865-531-0092.

APANTEC LLC, Attn: Bill Bushnell, 4500 N Cannon Rd, PA 19446. Phone: 267-436-3991 website: www.apantec.com

APPLIED HEALTH PHYSICS, INC.[8*] Attn: Todd Mobley, 2986 Industrial Boulevard, Bethel Park, PA 15102. Phone: (412) 835-9555 or (800) 332-6648, Fax: (412) 835-9555, E-mail: ahp.inc@comcast.net , website: www.appliedhealthphysics.com

ARROW-TECH, INC., Attn: David LePerry Lafountain, 417 New Ave West, Rolla, ND 58367. Phone: 701-477-6461, Fax: 701-477-6464 Email: perry@arrowtechinc.com

BEST MEDICAL INTERNATIONAL, Attn: Richard Oswald, 7643 Fullerton Rd, Springfield, CA 22153. Phone: (703) 451-2378, Fax: (703) 451-0922 richard.oswald@teambest.com

BIONOMICS INC, Attn: John McCormick, PO Box 817, Kingston, TN 37763. Phone: (865) 376-0053, Fax: (865) 376-4291 Email: j_mccormick_bionomics@msn.com

CANBERRA, Attn: Tammy Pattison, 800 Research Pkwy, Meriden, CT 06450. Phone: (203) 238-2351, Fax: (203) 235-1347

CBI POLYMERS, Attn: Mike O'Neill, 1946 Young St, Honolulu, HI 96826. Phone: (808) 949-2208, Fax: (808) 949-2209 moneill@cellularbioengineering.com

CHASE ENVIRONMENTAL GROUP, Attn: John O'Neil, 109 Flint Road, Knoxville, TN 37830-7033. Phone: (865) 584-0833, Fax: (865) 584-1961 joneil@chaseenv.com

CHESAPEAKE NUCLEAR SERVICES, INC., Attn: Gail Ward, 788 Sonne Drive, Annapolis, MD 21401. Phone: 410-266-9174, Fax: 410-266-5811 Email: gail@chesnuc.com

DADE MOELLER & ASSOCIATES, INC., Attn: Paula Tumlinson, Suite 200, 1835 Terminal Dr, Richland, WA 99354. Phone: 509-946-0410 Fax: 509-946-4412 Email: ptumlinson@moellerinc.com

DATACHEM SOFTWARE INC, Attn: Cliff Goede, 69 Milk Street, Suite 300, Westborough, MA 01581. Phone: 508-366-5277, Fax: 508-366-5278 cliff.goede@datachemsoftware.com

ECKERT & ZIEGLER ANALYTICS, Attn: Daniel M. Montgomery, 1380 Seaboard Industrial Blvd, Atlanta, GA 30318. Phone: (404) 352-8677, Fax: (404) 352-2837 dan.montgomery@ezag.com

ECKERT & ZIEGLER IPL, Attn: Melanie Harrison, 24937 Ave Tibbitts, Valencia, CA 91355. Phone: (861) 309-1010, Fax: (661) 257-8303 Melanie.Harrison@lezag.com

ECOLOGY SERVICES, Attn: Paul Marshall, 10220 Old Columbia Rd, Columbia, MD 21046. Email: PMarshall@Ecologyservices.com Phone: 800-932-7299, Fax: 410-381-9322

8* *Applied Health Physics, Inc. was listed in the previous year's file, so it has been added here. Its service was listed this time only under instrument calibration, but it is still in business since 1960.*

ENERGY SOLUTIONS, LLC, Attn: Barbara Bastenbeck, 143 West Street, Ste 11, New Milford, CT 06776-3599. Phone: 860-210-3007, Fax: 860-210-3015 Email: bbastenbeck@energysolutions.com

F&J SPECIALTY PRODUCTS, INC., Attn: Frank Gavila, 404 Cypress Rd, Ocala, FL 34472. (352)-680-1177 FAX: (352)-680-1454 Email: fandj@fjspecialty.com

femto-TECH, INC., Attn: Richard L. Straub, 25 Eagle Court, Carlisle, OH 45005. Phone: 937-746-4427, Fax: 937-746-9134 Email: femtotech@aol.com

FLUKE BIOMEDICAL, Attn: Heidi Stuelpnagel, 6920 Seaway Blvd, MS 202A, Everett, WA 98203. Phone: 425-446-5664

G/O CORPORATION, Attn: Ty Finley, 70161 Highway 59 Suite E, Abita Springs, LA 70420. Phone: (800) 933-8501, Fax: (985) 809-7440 Email: tyfinley@gocorp.com

GAMMA PRODUCTS, Attn: Walter Meier, 7730 W 114th Pl, Palos Hills, IL 60465. Phone: (708) 974-4100, Fax: (708) 974-0071 Email: wmeier@gammaproducts.com

HEALTH PHYSICS INSTRUMENTS, Attn: John Hand loser, Jr., Suite D, 330 S Kellogg Avenue, Goleta, CA 93117. Phone: (805) 964-3615, Fax: (805) 964-3162 Email: jsh@fwt.com

HI-Q ENVIRONMENTAL PRODUCTS CO., Attn: Marc Held, 7386 Trade St, San Diego, CA 92121. Phone: (858) 549-2820, Fax: (858) 549-9657 Email: info@hi-q.net

HOPEWELL DESIGNS, INC., Attn: ROB Ruston, 5940 Gateway Drive, Alpharetta, GA 30004. Phone: 770-667-5770, Fax: 770-667-7539 Email: Rorushton@hopewelldesigns.com

RISK, INC., Attn: Sean C. Chapel, 17 Norfolk Rd, Holbrook, MA 02343. Phone: 877-266-0794 Email: schapel@irsc-inc.com website: www.irsc-inc.com

J. L. SHEPHERD & ASSOCIATES, Attn: Mary Shepherd, 1010 Arroyo Ave, San Fernando, CA 91340-1822. Phone: (818) 898-2361, Fax: (818) 361-8095 Email: mary.f.shepherd@gte.net

JP LABORATORIES, INC. Attn: Gordhan Patel, 120 Wood Avenue, Middlesex, NJ 08846. USA Phone: (732) 469-6670 Email: sirad@jplabs.com.

K&S ASSOCIATES, INC., Attn: Vivian Denton, 1926 Elm Tree Drive, Nashville, TN 37210. Phone: (615) 883-9760, Fax: (615) 871-0856 Email: vdenton@kslab.com

LAB IMPEX SYSTEMS, LTD., Attn: Neil Clarke, Impex House 21 Harwell Rd, Nuffield Industrial Estate, Poole, Dorset, BH17 0GE United Kingdom. Phone: 01202 684848, Fax: 01202 683571

LANDAUER, Attn: Bill Megale, 2 Science Road, Glenwood, IL 60425. Phone: 708-755-7000, Fax: 708-755-7011 Email: sales@landauerinc.com

LAURUS SYSTEMS, INC., Attn: Laura Lynch, 3505 Ellicott Mills Dr, Ellicott City, MD 21043. Phone: 410-465-5558, Fax: 410-465-5257 Email: LauraLynch@LaurusSystems.com

LND, INC., Attn: Bill Lehnert, 3230 Lawson Blvd, Oceanside, NY 11572. Email: wjl@lndinc.com.com

LUDLUM MEASUREMENTS, Attn: Dwane Stevens, PO Box 810, Sweetwater, TX 79556. Phone: (915) 235-5494, Fax: (915) 235-4672 dstevens@ludlums.com

MACTEC, INC., Attn: Steven D. Rima, Rad Services, Suite 300, 1105 Lakewood Parkway, Alpharetta, GA 30004. Phone: (303) 278-3100, Fax: (303) 273-5000

MIRION TECHNOLOGIES, Attn: Sheena Martin, 2652 McGaw, Irvine, CA 92614. Phone: (949) 419-1000, Fax: (949) 296-1144 Email: jsims@mirion.com

MJW TECHNICAL SERVICES, Attn: Carol Haas, 243 Root Street, Suite 100, Olean, NY 14760. Phone: 716-372-5300 Fax: 716-372-5307, Email: chaas@mjwts.com website: www.mjwts.com

OAK RIDGE ASSOCIATED UNIVERSITIES, Attn: Paul Frame, Mailstop 11, Bldg. 2714-G, 246 Laboratory Rd, Oak Ridge, TN 37831. (865)-576-3576 FAX: (865)-576-9383 Email: registrar@orau.gov

ORTEC, Attn: Susie Brockman, 801 S. Illinois Ave, Oak Ridge, TN 37830. Phone: (865) 482-4411, Fax: (865) 425-1380 Email: Susie.brockman@ametek-online.com

PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION/ BRP, Attn: David Allard, 400 Market St, 13th Floor, Harrisburg, PA 17101. (717)-787-2480 FAX: (717)-783-8965 Email: djallard@state.pa.us

PACIFIC NORTHWEST NATIONAL LABORATORY, Attn: Brittney Drollinger, 902 Battelle Blvd, PO Box 999, Richland, WA 99352. Phone: 509-375-2334 Email: Brittney.drollinger@pnl.gov

PerkinElmer, Life And Analytical Sciences, 940 Winter Street, Waltham, MA 02451. Phone: 781-663-6900, Fax: 203-944-4904 website: www.perkinelmer.com

PHILOTECHNICS, LTD., Attn: Annette Hansen, PO Box 4489, Oak Ridge, TN 37831-4489. Phone: 1-888-RADWASTe Email: ahansen@philotechnics.com

PROTEAN INSTRUMENT CORPORATION, Attn: Darrell Scoggins, 231 Sam Rayburn Pkwy, Lenoir City, TN 37771. Phone: 865-717-3456, Fax: 865-717-3456

QAL-TECH, ASSOC., Attn: Travis Snowder, 3998 Commerce Circle, Idaho Falls, ID 83401. (208) 523-5557 FAX: (208) 524-8470 Email: tsnowder@qaltek.com

RADECO., Attn: Brad Lovendale, 509 Norwich Ave, Taftville, CT 06380. (860)-823-1220 FAX: (860)-823-1521 Email: blovendale@radecoinc.com

RADIATION SAFETY & CONTROL SERVICES, Attn: Frederick Straccia, 91 Portsmouth Ave, Stratham, NH 03885.
Email: ladunn@radsafety.com

RADIATION SAFETY ASSOCIATES, Attn: K. Paul Steinmeyer, PO Box 107, 19 Pendleton Drive, Hebron, CT 06248. (860)-228-0487 FAX: (860)-228-4402 Email: rsa@radpro.com

S.E. INTERNATIONAL, INC., Attn: Beth Cramer, PO Box 39, Summertown, TN 38483-0039. Phone: 931-964-3561, Fax: 931-964-3564
Email: beth@seintl.com

SOLUTIENT TECHNOLOGIES, LLC,, Attn: Michael Paessun, 7857 Freedom Ave NW, North Canton, OH 44720. Phone: (330) 497-5905, Fax: (330) 497-2045 Email: MPaessun@sikytuebtecg,cisolutientech.com

SPECTRUM TECHNIQUES, Attn: Roger Stevens, 106 Union Valley Rd, Oak Ridge, TN 37830-8044. Phone: (865) 482-9937,
Fax: (865) 483-0473 Email: spectech@esper.com

SUPERTECH, INC., Attn: David McNitt, PO Box 186, Elkhart, IN 46515-0186. Phone: 574-264-4310, Fax: 574-264-9551
Email: sales@supertechx-ray.com
website: http://www.supertechx-ray.com

TECHNICAL ASSOCIATES, Attn: Robert I. Goldstein, 7051 Eton Ave, Canoga Park, CA 91303. Phone: (818) 883-7043, Fax: (818) 883-6103 Email: tagold@nwc.net Class: C

Category: 02/04/05/06/10/12/13/16/17/20/27/28/29/32/39/41/44

TELETRIX CORPORATION, Attn: Michael Podobnik, PO Box 14209, Pittsburgh, PA 15239. (412)-798-3636 FAX: (412)-798-3633 Email: mikep@teletrix.com Class:C, Category: 12/13/15/28/36/37/41/45

THERMO FISHER CORP., Attn: Adam Grosse, Sales Director, 27 Forge Parkway, Franklin, MA 02038. Phone: 888-777-1954, Email: Customerservice.eid@thermofisher.com

BUYER'S GUIDE

Air and Ventilation Systems
Lab Impex Systems Ltd.
Thermo-Fisher Scientific

Air Samplers and Supplies
F&J Specialty Products, Inc.
Fluke Biomedical
HI-Q Environmental Products Co.
Lab Impex Systems Ltd.
Laurus Systems, Inc.
Protean Instrument Corp.
Technical Associates
Thermo-Fisher Scientific

Analytical Laboratory Services
Ecology Services
Laurus Systems, Inc.
PerkinElmer
Radiation Safety & Control Services
Radiation Safety Associates

Analytical Laboratory Instrumentation
Canberra
femto-TECH, Inc.
Fluke Biomedical
Lab Impex Systems Ltd.
PerkinElmer
Protean Instrument Corp.
Technical Associates
Thermo-Fisher Scientific

Analytical Laboratory Products
F&J Specialty Products, Inc.
HI-Q Environmental Products Co.
PerkinElmer
Technical Associates
Thermo-Fisher Scientific

Calibration Standards
Arrow-Tech, Inc.
Eckert & Ziegler IPL
Hopewell Designs, Inc.
PerkinElmer
ISpectrum Techniques
Technical Associates
Thermo-Fisher Scientific

Employment Service Consultants
Radiation Safety & Control Services

Exposure Monitoring Software
Radiation Safety & Control Services
Environmental Consulting
Applied Health Physics, Inc.
Chase Environmental Group
Chesapeake Nuclear Services
Dade Moeller & Associates, Inc.
Eckert & Ziegler IPL
Energy Solutions, LLC
IRSC, Inc.
Philotechnics, Ltd.
Radiation Safety & Control Services
Radiation Safety Associates

Geiger-Mueller Tubes and Probes
Apantech
Fluke Biomedical
Health Physics Instruments
Lab Impex Systems Ltd.
Laurus Systems, Inc.
LND, Inc.
ORTEC
Spectrum Techniques
Technical Associates
Thermo-Fisher Scientific

Health Physics Consultation
Applied Health Physics, Inc.
Chase Environmental Group
Chesapeake Nuclear Services
Dade Moeller & Associates, Inc.
Ecology Services
IRSC, Inc.
K&S Associates, Inc.
MJW Technical Services
Philotechnics, Ltd.
Radiation Safety & Control Services
Radiation Safety Associates
Solutient Technologies, LLC

Health Physics Instrumentation
Apantech
Canberra Industries
Chase Environmental Group
Chesapeake Nuclear Services

F&J Specialty Products, Inc.
Fluke Biomedical
Gamma Products, Inc.
Health Physics Instruments
Hi-Q Environmental Products Co.
Lab Impex Systems Ltd.
Laurus Systems, Inc.
Ludlum Measurements, Inc.
Mirion Technologies
ORTEC
Protean Instrument Corp.
Radiation Safety & Control Services
S. E. International Inc.
Technical Associates
Teletrix Corporation
Thermo-Fisher Scientific

HP Equipment and Supplies
F&J Specialty Products, Inc.
G/O Corporation
Health Physics Instruments
HI-Q Environmental Products Co.
Lab Impex Systems Ltd.
Mirion Technologies
ORTEC
Radiation Safety & Control Services
Technical Associates
Teletrix Corporation
Thermo-Fisher Scientific

Health Physics Services
Applied Health Physics, Inc.
Chase Environmental Group
Chesapeake Nuclear Services
Ecology Services
Energy Solutions, LLC
IRSC, Inc.
K&S Associates
MJW Technical Services
Philotechnics, Ltd.
Radiation Safety & Control Services
Radiation Safety Associates
Solutient Technologies, LLC

Health Physics Training
Canberra Industries
Chase Environmental Group
Chesapeake Nuclear Services
Dade Moeller & Associates, Inc.
IRSC, Inc.
Oak Ridge Associated Universities
Radiation Safety & Control Services
Radiation Safety Associates
Solutient Technologies, LLC
Teletrix Corporation
Thermo-Fisher Scientific

Instrument Calibration Services
Apantech
Applied Health Physics
Ecology Services
F&J Specialty Products, Inc.
femto-Tech, Inc.
Fluke Biomedical
Health Physics Instruments

Instrument Calibration Services (con't)
Hi-Q Environmental Products Co.
Hopewell Designs, Inc.
J. L. Shepherd & Associates
K&S Associates
Laurus Systems, Inc.
Ludlum Measurements, Inc.
MJW Technical Services
PerkinElmer
Radiation Safety & Control Services
Radiation Safety Associates
Technical Associates
Thermo-Fisher Scientific

Instrument Repair Services
Applied Health Physics, Inc.
Apantech
F&J Specialty Products, Inc.
femto-Tech, Inc.
Fluke Biomedical
Health Physics Instruments
Hi-Q Environmental Products Co.
K&S Associates
Laurus Systems, Inc.
Ludlum Measurements, Inc.
MJW Technical Services
PerkinElmer
Radiation Safety & Control Services
Radiation Safety Associates
Technical Associates
Thermo-Fisher Scientific

Kinetic Phosphorescence Analyzers

Laboratory Analysis Service
Canberra Industries
Ecology Services
PerkinElmer
Radiation Safety Associates

Liquid Scintillation Counters
Canberra Industries
Laurus Systems, Inc.
PerkinElmer
Technical Associates

LLRW and Mixed Waste Services
Applied Health Physics, Inc.
Bionomics, Inc.
Chase Environmental Group
Chesapeake Nuclear Services
Ecology Services
Philotechnics, Ltd.
Radiation Safety & Control Services
Solutient Technologies, LLC

Microwave Monitoring Devices

MCA Equipment and Instrumentation
Apantech
Canberra Industries
Gamma Products, Inc.
ORTEC
Spectrum Techniques

NDT Equipment and Supplies
Arrow-Tech, Inc.
Hopewell Designs, Inc.
ORTEC
Radiation Safety & Control Services

Power Plant Services
Chesapeake Nuclear Services
Radiation Safety & Control Services

Personnel Monitoring Instrumentation
Apantech
Canberra Industries
Fluke Biomedical
Health Physics Instruments
JP Laboratories, Inc.
Lab Impex Systems Ltd.
Laurus Systems, Inc.
Ludlum Measurements, Inc.
Mirion Technologies
ORTEC
Radiation Safety & Control Services
S. E. International, Inc.
Technical Associates
Thermo-Fisher Scientific

Personnel Monitoring Dosimeters
Apantech
Arrow-Tech, Inc.
Fluke Biomedical
Health Physics Instruments
JPLaboratories, Inc.
Landauer Inc.
Laurus Systems, Inc.
Mirion Technologies
Radiation Safety & Control Services
S. E. International, Inc.
Technical Associates
Teletrix Corporation
Thermo-Fisher Scientific

Radiation Monitoring Systems
- Apantech
- Canberra Industries
- Chesapeake Nuclear Services
- Fluke Biomedical
- Gamma Products, Inc.
- Health Physics Instruments
- HI-Q Environmental
- JP Laboratories, Inc.
- Products Co.
- Lab Impex Systems Ltd.
- Laurus Systems, Inc.
- Ludlum Measurements, Inc.
- ORTEC
- Radiation Safety & Control Services
- S. E. International, Inc.
- Technical Associates
- Thermo-Fisher Scientific
- Unitech Services Group

Record Management Services
- Laurus Systems, Inc.
- Radiation Safety & Control Services

Protective Clothing
- F&J Specialty Products, Inc.
- Fluke Biomedical
- G/O Corporation
- Laurus Systems, Inc.

Radon Monitors
- Apantech
- F&J Specialty Products, Inc.
- femto-Tech, Inc.
- HI-Q Environmental Products Co.
- Landauer, Inc.
- Laurus Systems, Inc.
- ORTEC
- Radiation Safety & Control Services
- Technical Associates
- Thermo-Fisher Scientific

Radiation Signs, Labels & Tapes
- Applied Health Physics, Inc.
- Fluke Biomedical
- G/O Corporation
- Radiation Safety & Control Services

Radiation Calibration Devices
- Arrow-Tech, Inc.
- Hopewell Designs, Inc.
- J. L. Shepherd & Associates
- Laurus Systems, Inc.
- Spectrum Techniques

Radiation Protection Services
- Applied Health Physics, Inc.
- K&S Associates
- Laurus Systems, Inc.
- MJW Technical Services
- Radiation Safety & Control Services
- Radiation Safety Associates
- Solutient Technologies, LLC

Radiation Protection Supplies
- Applied Health Physics, Inc.
- G/O Corporation
- Laurus Systems, Inc.
- Radiation Safety & Control Services
- Teletrix Corporation

Radiation Protection Training
- Chesapeake Nuclear Services
- Laurus Systems, Inc.
- MJW Technical Services
- Oak Ridge Associated Universities
- Radiation Safety & Control Services
- Radiation Safety Associates
- Solutient Technologies, LLC
- Teletrix Corporation

Radioisotope Analysis and Lab Service
Eckert & Ziegler IPL
Ecology Services
PerkinElmer
- Radiation Safety & Control Services
- Radiation Safety Associates

Reactor Instruments and Monitors
- Apantech
- Energy Solutions, LLC
- Lab Impex Systems Ltd.
- Ludlum Measurements, Inc.
- Radiation Safety & Control Services
- Technical Associates
- Thermo-Fisher Scientific

Radiation Shielding Design
- Chesapeake Nuclear Services
- Gamma Products, Inc.
- Hopewell Designs, Inc.
- IRSC, Inc.
- K&S Associates
- Radiation Safety Associates
- Thermo-Fisher Scientific

Radiation Monitoring Instrumentation
- Apantech
- Arrow-Tech, Inc.
- Canberra
- Chesapeake Nuclear Services, Inc.
- femto-TECH, Inc.
- Fluke Biomedical
- Gamma Products, Inc.
- Health Physics Instruments
- HI-Q Environmental Products Co.
- Laurus Systems, Inc.
- Ludlum Measurements, Inc.
- ORTEC
- Protean Instrument Corp.
- Radiation Safety & Control Services
- S. E. International, Inc.
- Technical Associates
- Teletrix Corporation
- Thermo-Fisher Scientific

Respiratory Protection Equipment

Sealed Sources and Safety Supplies
- Fluke Biomedical
- G/O Corporation
- Hopewell Designs, Inc.
- J. L. Shepherd & Associates
- Laurus Systems, Inc.
- Spectrum Techniques
- Thermo-Fisher Scientific

Tritium Gas Monitors
- Apantech
- femto-Tech, Inc.
- HI-Q Environmental Products Co.
- Lab Impex Systems Ltd.
- Laurus Systems, Inc.
- ORTEC
- Technical Associates

Training Programs
- Chesapeake Nuclear Services, Inc.
- Dade Moeller & Associates, Inc.
- femto-TECH, Inc.
- IRSC, Inc.
- Laurus Systems, Inc.
- Oak Ridge Associated Universities
- ORTEC
- Radiation Safety & Control Services
- Radiation Safety Associates
- Teletrix Corporation
- Thermo-Fisher Scientific

Training Videotapes
- Radiation Safety & Control Services

Transportation Services
- Adco Services, Inc.
- Bionomics, Inc.
- Chase Environmental Group
- Ecology Services
- Philotechnics, Ltd.
- **VR Equipment Compactors and Shredders**

VR Services
- Chase Environmental Group

Waste Services, Radioactive
- Bionomics, Inc.
- Canberra Industries
- Chase Environmental Group
- Chesapeake Nuclear Services, Inc.
- Ecology Services
- ORTEC
- Philotechnics, Ltd.
- Radiation Safety Associates
- Solutient Technologies, LLC

Other
- Applied Health Physics, Inc.
- Chase Environmental Group
- Energy Solutions, LLC
- G/O Corporation
- HI-Q Environmental Products Co.
- IRSC, Inc.
- J. L. Shepherd & Associates
- Nuclear Energy Institute
- PA Department Of Environmental Protection/BRP
- Pacific Northwest National Laboratory
- Radiation Safety & Control Services

NOTE: The manufacturer of the SIRAD colorimetric dosimeters discussed in Chapters 8 and 9 is not currently an Associate Member of the Health Physics Society. See the following Appendix G for specifications and ordering of the SIRAD dosimeters, or for requests for special modifications.

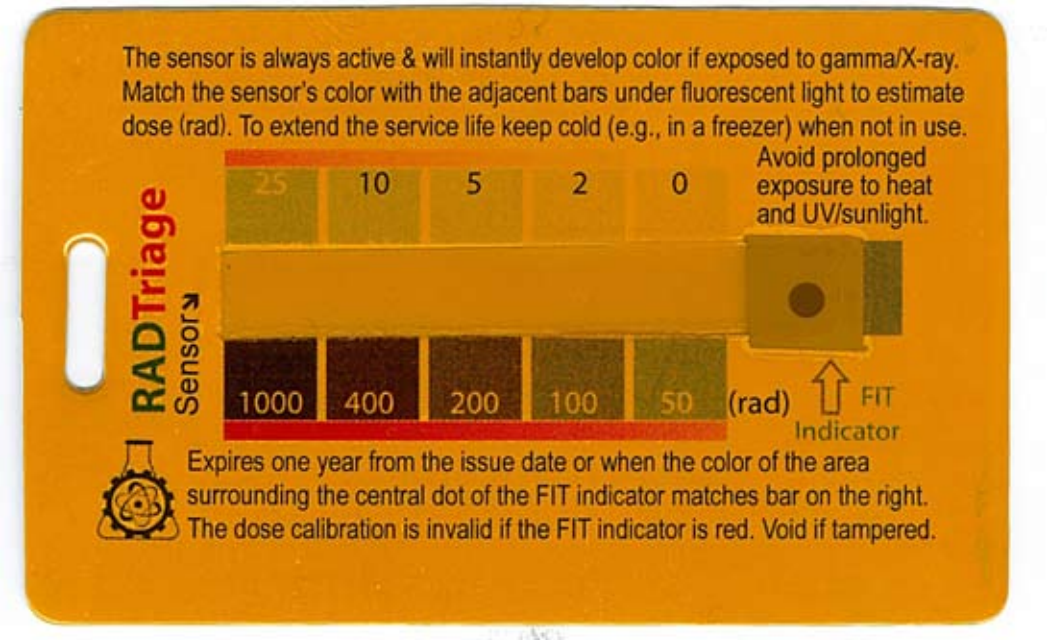
APPENDIX G

SPECIFICATION AND CONTACT INFORMATION FOR SELF-INDICATING COLORIMETRIC PERSONAL MONITORS

RADTriage-FIT™

A FULL DOSE RANGE SMART CASUALTY DOSIMETER
From the Award-Winning SIRAD® Family of Dosimeters

Available from JP Laboratories, Inc. (see Appendix F)



RADTriage-FIT is instantly color developing, credit card sized, casualty dosimeter. It is always ready, requires no power and has no electronics or moving parts. It is also reliable, rugged and useful for triaging radiation exposure information and medical treatment. It will give you peace of mind and minimize your worry that you

have not been exposed to harmful high dose or it will indicate if you need medical treatment. By carrying a RADTriage-FIT, one minimizes the possibility of becoming a dosimeter (e.g., by taking and analyzing a blood sample), or of suffering from panic at lower dose levels than detectable by the RADTriage, which in an emergency situation represent insignificant risks. Ordinary Geiger counters provided to responders will have high click rates at levels that can be safely received for many days.

RADTriage-FIT™, a part of the **SIRAD**® (**S**elf-indicating **I**nstant **R**adiation **A**lert **D**osimeter) family of SMART dosimeters, gives you peace of mind that you are reliably monitoring your radiation exposure. RADTriage-FIT with amber filter provides significantly longer life under sunlight. It has a sensor with 2, 5, 10 and 25 rad reference bars above it and 50, 100, 200, 400 and 1,000 rad reference bars below it for triaging information in emergencies. The revolutionary **FIT™** indicator (on the right hand side of the sensor) simultaneously monitors false positives & negatives, overexposure to heat & UV/ sunlight, service—life and covers a portion of the sensor to monitor UV exposure. RADTriage-FIT is an affordable radiation dosimeter that is always active and ready to use, enabling disaster and emergency response personnel to measure their radiation exposure while dealing with the aftermath of a "dirty bomb" attack, nuclear explosion or an accident at a nuclear power plant. Batteries, calibration, and maintenance are unnecessary.

For use by:

- First responders (i.e., Fire, Police, and Medical Personnel)
- Military (Army, Navy, Air Force, Marines, Coast Guard, and National Guard)
- Those who live near nuclear power plants
- General public who live in cities at high risk of terrorist attacks and/or those worried about radiation exposure
- Radiologists or radiation oncologists who need an inexpensive radiation monitor to avoid excessive doses to patients
- Employees of radiation workers who wish to provide a simple back-up monitor to prove that employees do not exceed an annual limit of 2 or 5 rem, in the event that routine personnel dosimeters fail or are lost.

Properties of RADTriage-FIT™

- **Two sensors** (for triaging radiation exposure and monitoring false positives/negatives):
  - **Casualty Sensor:** Develops a blue color to provide an early warning (2 -25 rad) to users and guides physicians (50-1,000 rad) in determining medical treatment
  - **FIT™** (**F**alse positive/negative, **I**nactivation and **T**amper) **Indicator**: Multi-purpose indicator (1) blue color indicates the dosimeter is active and changing from blue to red detects false negatives/ inactivation of the sensor due to exposure to temperatures higher than 195°F/90°C (2) turning darker blue simultaneously monitors service-life expiration and/or if a false positive has occurred due to prolonged exposure to high temperatures and UV/sunlight.
- **Dose Integration**: Cumulative
- **Response retention**: Full
- **Response time**: Instant, 90-95% color development within minutes, the rest within hours
- **Uncertainty**: Visually: ±20%, Colorimetry: ±10%

- **Effect of Dose rate**: Negligible
- **Dimensions:** Credit card size (Length 8.5 cm, Width 5.5 cm, Thickness 0.1 cm, Weight: 5g)
- **Energy dependency**: Independent of energy, some attenuation of low energy radiation
- **Effect of temperature of radiation**: Negligible (less than 0.2%/°C over -20°C to 60°C)
- **Effect of average humidity**: None
- **Laundry resistance**: Passes a few residential laundry cycles
- **Maximum operating temperature**: ~195°F/90°C for a maximum of six hours (Temperature on a car's dashboard under direct sunlight can reach 185°F/85°C). FIT™ Indicator will monitor such exposure
- **Effect of sunlight:** Little for a week under average sunlight. FIT™ Indicator will monitor over exposure to UV/sunlight
- **Effect of ambient light:** Negligible for a month
- **Support equipment**: None needed to estimate dose

Some Facts about RADTriage-FIT™ & SIRAD® Technology

On February 22, 2007 the Department of Homeland Security's (DHS) Science and Technology (S&T) Directorate's Counter Measures Test Beds published the Self-Indicating Instant Radiation Alert Dosimeter (SIRAD) Test Results Final Report on a field test with 800 first responders for one year. The test results provide confirmation that SIRAD Technology is appropriate for use in radiological exposures. As stated in the report: "**The device fills a technology gap for first responders as they do not routinely carry radiation dosimetry.**" RADTriage is a passive, disposable dosimeter that changes color upon exposure to a medically significant radiation dose. It's convenient format and low cost allows for pre-distribution and stockpiling to provide immediate indication of any significant radiation exposure. This provides reduced anxiety and response delays when exposure is low, and support for tactical response decisions when exposure is high. The Operational Assessment of RADTriage as performed by Department of Homeland Security, Environmental Measurements Laboratory is posted on the Responder Knowledge Base at

http://www.rkb.us/contentdetail.cfm?content_id=195444 .

- Recipient of the 2004 Frost & Sullivan "Excellence in Technology" Award and the 2005 "R&D 100" Award as one of the 100 Most Technologically Significant New Products of the Year
- Widespread press coverage in the Wall Street Journal (front page), Chicago Sun-Times, Associated Press (worldwide), and ABC (headline) & BBC World News
- Developed with funding from Technical Support Working Group (with additional support from the DHS, DoS, DoJ and DoD).
- The first generation of SIRAD was field tested by DHS with 800 first responders in the states of NJ, NY and IL for 9 months (Report # DHS/S&T/SED/CMTB-2007-D03). It has been in the field for 5 years with no complaints.
- RADTriage is included in the recently released FEMA SAVER Technote dated July 2008

- The DHS Authorized Equipment List (AEL) includes RADTriage as Item 07RD-01-DOSS and is an allowable expenditure for the following grants:

  State Homeland Security Program (SHSP)
  Urban Area Security Initiative (UASI)
  Buffer Zone Protection Program (BZPP)
  Law Enforcement Terrorism Prevention Program (LETPP)
  Intercity Bus Security Grant Program (IBSGP)
  Chemical Buffer Zone Protection Program (Chem BZPP)
  Metropolitan Medical Response System (MMRS)
  Transit Security Grant Program (TSGP)
  Port Security Grant Program (PSGP)

The Target Capabilities of the National Preparedness Goal as supported by the dosimeter are:

8. Counter-Terror Investigation and Law Enforcement
9. CBRNE Detection
18. Responder Safety and Health
19. Emergency Public Safety and Security Response
22. Explosive Device Response Operations
23. Fire Incident Response Support
24. WMD and Hazardous Materials Response and Decontamination
27. Search and Rescue (Land-Based)

Badges are deployed nationally and internationally with CBP, military forces, Special Forces, SWAT Teams, 1st Responders, MMRS, Police, Fire and Rescue.

APPENDIX H

DEPARTMENT OF HOMELAND SECURITY PLANNING GUIDANCE

(from Federal Register, Vol. 73, No. 149/Friday, August 1, 2008)

This following document contains some Federal guidance that is considered useful in planning for responses to radiation emergencies.

All counties within the State of Nebraska are eligible to apply for assistance under the Hazard Mitigation Grant Program.

(The following Catalog of Federal Domestic Assistance Numbers (CFDA) are to be used for reporting and drawing funds: 97.030, Community Disaster Loans; 97.031, Cora Brown Fund; 97.032, Crisis Counseling; 97.033, Disaster Legal Services; 97.034, Disaster Unemployment Assistance (DUA); 97.046, Fire Management Assistance Grant; 97.048, Disaster Housing Assistance to Individuals and Households In Presidential Declared Disaster Areas; 97.049, Presidential Declared Disaster Assistance—Disaster Housing Operations for Individuals and Households; 97.050 Presidential Declared Disaster Assistance to Individuals and Households—Other Needs, 97.036, Disaster Grants—Public Assistance (Presidentially Declared Disasters); 97.039, Hazard Mitigation Grant.)

R. David Paulison,

Administrator, Federal Emergency Management Agency.

[FR Doc. E8–17688 Filed 7–31–08; 8:45 am]

BILLING CODE 9110–10–P

DEPARTMENT OF HOMELAND SECURITY

Federal Emergency Management Agency

[FEMA–1780–DR]

Texas; Major Disaster and Related Determinations

AGENCY: Federal Emergency Management Agency, DHS.

ACTION: Notice.

SUMMARY: This is a notice of the Presidential declaration of a major disaster for the State of Texas (FEMA–1780–DR), dated July 24, 2008, and related determinations.

DATES: *Effective Date:* July 24, 2008.

FOR FURTHER INFORMATION CONTACT: Peggy Miller, Disaster Assistance Directorate, Federal Emergency Management Agency, Washington, DC 20472, (202) 646–2705.

SUPPLEMENTARY INFORMATION: Notice is hereby given that, in a letter dated July 24, 2008, the President declared a major disaster under the authority of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. 5121–5206 (the Stafford Act), as follows:

I have determined that the damage in certain areas of the State of Texas resulting from Hurricane Dolly beginning on July 22, 2008, and continuing, is of sufficient severity and magnitude to warrant a major disaster declaration under the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. 5121–5206 (the Stafford Act). Therefore, I declare that such a major disaster exists in the State of Texas.

In order to provide Federal assistance, you are hereby authorized to allocate from funds available for these purposes such amounts as you find necessary for Federal disaster assistance and administrative expenses.

You are authorized to provide assistance for emergency protective measures (Category B), including direct Federal assistance, under the Public Assistance program in the designated areas; Hazard Mitigation throughout the State; and any other forms of assistance under the Stafford Act that you deem appropriate subject to completion of Preliminary Damage Assessments (PDAs), unless you determine that the incident is of such unusual severity and magnitude that PDAs are not required to determine the need for supplemental Federal assistance pursuant to 44 CFR 206.33(d).

Consistent with the requirement that Federal assistance be supplemental, any Federal funds provided under the Stafford Act for Public Assistance and Hazard Mitigation will be limited to 75 percent of the total eligible costs, except for any particular projects that are eligible for a higher Federal cost-sharing percentage under the FEMA Public Assistance Pilot Program instituted pursuant to 6 U.S.C. 777. If Other Needs Assistance is later warranted, Federal funding under that program will also be limited to 75 percent of the total eligible costs.

Further, you are authorized to make changes to this declaration to the extent allowable under the Stafford Act.

The Federal Emergency Management Agency (FEMA) hereby gives notice that pursuant to the authority vested in the Administrator, Department of Homeland Security, under Executive Order 12148, as amended, Sandy Coachman, of FEMA is appointed to act as the Federal Coordinating Officer for this declared disaster.

I do hereby determine the following areas of the State of Texas to have been affected adversely by this declared major disaster:

Aransas, Bexar, Brooks, Calhoun, Cameron, Hidalgo, Jim Wells, Kenedy, Kleberg, Nueces, Refugio, San Patricio, Starr, Victoria, and Willacy Counties for Public Assistance Category B (emergency protective measures), including direct Federal assistance.

All counties within the State of Texas are eligible to apply for assistance under the Hazard Mitigation Grant Program.

(The following Catalog of Federal Domestic Assistance Numbers (CFDA) are to be used for reporting and drawing funds: 97.030, Community Disaster Loans; 97.031, Cora Brown Fund Program; 97.032, Crisis Counseling; 97.033, Disaster Legal Services Program; 97.034, Disaster Unemployment Assistance (DUA); 97.046, Fire Management Assistance; 97.048, Individual and Household Housing; 97.049, Individual and Household Disaster Housing Operations; 97.050, Individual and Household Program—Other Needs; 97.036, Public Assistance Grants; 97.039, Hazard Mitigation Grant Program.)

R. David Paulison,

Administrator, Federal Emergency Management Agency.

[FR Doc. E8–17686 Filed 7–31–08; 8:45 am]

BILLING CODE 9110–10–P

DEPARTMENT OF HOMELAND SECURITY

Federal Emergency Management Agency

[Docket ID FEMA–2004–0004]

[Z–RIN 1660–ZA02]

Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents

AGENCY: Federal Emergency Management Agency, DHS.

ACTION: Notice of final guidance.

SUMMARY: The Department of Homeland Security (DHS) is issuing final guidance entitled, ''Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents'' (the Guidance). This Guidance is intended for Federal agencies, State and local governments, emergency management officials, and the general public who should find it useful in developing plans for responding to an RDD or IND incident. The Guidance recommends ''protective action guides'' (PAGs) to support decisions about actions that should be taken to protect the public and emergency workers when responding to or recovering from an RDD or IND incident. The Guidance outlines a process to implement the recommendations, discusses existing operational guidelines that should be useful in the implementation of the PAGs and other response actions, and encourages federal, state and local emergency response officials to use these guidelines to develop specific operational plans and response protocols for protection of emergency workers responding to catastrophic incidents involving high levels of radiation and/or radioactive contamination.

DATES: This notice is effective August 1, 2008.

FOR FURTHER INFORMATION CONTACT: Craig Conklin, Director Sector Specific Agency Executive Management Office, Office of Infrastructure Protection,

Department of Homeland Security at 703–235–2850 (phone), or *craig.conklin@dhs.gov* (e-mail), or, John MacKinney, Deputy Director, Nuclear/Radiological/Chemical Threats and Science and Technology Policy, Office of Policy, Department of Homeland Security, at (202) 447–3885 (phone), or *john.mackinney@dhs.gov* (e-mail).

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Background

This Guidance was developed to address the critical issues of protective actions and protective action guides (PAGs) to protect human health and to mitigate the effects caused by terrorists' use of a Radiological Dispersal Device (RDD) or Improvised Nuclear Device (IND). This document provides guidance for site cleanup and recovery following an RDD or IND incident, and affirms the applicability of existing 1992 EPA PAGs for radiological emergencies.

The development of this Guidance was directed by the White House, Office of Science and Technology Policy, through the National Science and Technology Council, Committee on Homeland and National Security, Subcommittee on Standards (SoS). In 2003, the SoS convened a senior level Federal working group, chaired by DHS, to develop guidance for response and recovery following a radiological dispersal device (RDD) or improvised nuclear device (IND) incident. The working group consisted of senior subject matter experts in radiological/nuclear emergency preparedness, response, recovery, and incident management. The following Federal departments and agencies were represented on the working group: DHS, EPA, Department of Commerce (DOC), Department of Energy (DOE), Department of Defense (DOD), Department of Labor (DOL), Department of Health and Human Services (HHS), and Nuclear Regulatory Commission (NRC).

On January 3, 2006, DHS issued the ''Preparedness Directorate; Protective Action Guides for Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents; Notice'' (71 FR 174, Jan. 3, 2006), and requested public comments on this interim Guidance. Some changes to the Guidance were made as a result of these comments. A summary of the comments on the interim Guidance document and responses are available at Docket ID No. FEMA–2004–0004 at *http://www.regulations.gov*.

In addition to the issuance of this Guidance, in response to interagency working group discussions and public comments, further guidance will be provided for the consequences that would be unique to an IND attack. This Guidance was not written to provide specific recommendations for a nuclear detonation (IND), but to consider the applicability of existing PAGs to RDDs and INDs. In particular, it does not consider very high doses or dose rate zones expected following a nuclear weapon detonation and other complicating impacts that can significantly affect life-saving outcomes, such as severely damaged infrastructure, loss of communications, water pressure, and electricity, and the prevalence of secondary hazards. Scientifically sound recommendations for responders are a critical component of post-incident life-saving activities, including implementing protective orders, evacuation implementation, safe responder entry and operations, and urban search and rescue and victim extraction. In the interim, this Guidance should be used until the IND guidance is developed.

The intended audience of this document are Federal, State, and local radiological emergency response and incident management officials. This Guidance is not intended to impact site cleanups occurring under other statutory authorities such as the Environmental Protection Agency's (EPA) Superfund program, the Nuclear Regulatory Commission's (NRC) decommissioning program, or other Federal and State cleanup programs. In addition, the scope of this Guidance does not include situations involving U.S. nuclear weapons accidents.

In addition to the issuance of this Guidance, further guidance is being planned for the devastating consequences that would be unique to INDs. In the interim, the present document will provide general RDD and IND guidance.

By agreement with the Environmental Protection Agency (EPA), the Guidance being published today is final and its substance will be incorporated without change into the revision of the 1992 EPA Manual of Protective Actions Guides and Protective Actions for Nuclear Incidents (the PAG Manual). This notice of final guidance will therefore sunset upon publication of the new EPA PAG Manual (see, *http://www.epa.gov/radiation/rert/pags.html*). The reader will then be directed to the

new EPA PAG Manual, where these provisions may be found.

(a) Introduction

For the early and intermediate phases of response, this document presents levels of projected radiation dose at which the Federal Government recommends that actions be considered to avoid or reduce adverse public health consequences from an RDD or IND incident. This document incorporates guidance and regulations published by the EPA, Food and Drug Administration (FDA), and the Occupational Safety and Health Administration (OSHA). For the late phase of the response, this Guidance presents a process for establishing appropriate exposure levels based on site-specific circumstances. This Guidance addresses key radiological protection questions at each stage of an RDD or IND incident (early, intermediate, and late) and constitutes advice by the Federal government to Federal, State, and local decision makers.

The objective of the Guidance is to aid decision makers in protecting the public, first responders, and other emergency workers from the effects of radiation, and cleaning up the affected area, while balancing the adverse social and economic impacts following an RDD or IND incident. Restoring the normal operation of critical infrastructure, services, industries, business, and public activities as soon as possible can minimize adverse social and economic impacts.

This Guidance for RDD and IND incidents is not a set of absolute standards. The guides are not intended to define ''safe'' or ''unsafe'' levels of exposure or contamination; rather they represent the approximate levels at which the associated protective actions are justified. The Guidance provides Federal, State and local decision makers the flexibility to be more or less restrictive, as deemed appropriate based on the unique characteristics of the incident and local considerations.

This RDD/IND Guidance can be used to select actions to prepare for, respond to, and recover from the adverse effects that may exist during any phase of a terrorist incident—the early (emergency) phase, the intermediate phase, or the late phase. There may be an urgent need to evacuate people; there may also be an urgent need to restore the services of critical infrastructure (*e.g.,* roads, rail lines, airports, electric power, water, sewage, medical facilities, and businesses) in the hours and days following the incident—thus, some response decisions must be made quickly. If the decisions affecting the recovery of critical infrastructure are not made quickly, the disruption and harm caused by the incident could be inadvertently and unnecessarily increased. Failure to restore important services rapidly could result in additional adverse public health and welfare impacts that could be more significant than the direct radiological impacts.

(b) Characteristics of RDD and IND Incidents

A radiological incident is defined as an event or series of events, deliberate or accidental, leading to the release, or potential release, into the environment of radioactive material in sufficient quantity to warrant consideration of protective actions. Use of an RDD or IND is an act of terror that results in a radiological incident.

(1) Radiological Dispersal Device (RDD)

An RDD poses a threat to public health and safety through the malicious spread of radioactive material by some means of dispersion. The mode of dispersal typically conceived as an RDD is an explosive device coupled with radioactive material. The explosion adds an immediate threat to human life and property. Other means of dispersal, both passive and active, may be employed.

There is a wide range of possible consequences that may result from an RDD, depending on the type and size of the device and how dispersal is achieved. The consequences of an RDD may range from a small, localized area, such as a single building or city block, to large areas, conceivably several square miles. However, most experts agree that the likelihood of impacting a very large area is low. In most plausible scenarios, the radioactive material would not result in acutely harmful radiation doses, and the primary public health concern from those materials would be increased risk of cancer to exposed individuals. Hazards from fire, smoke, shock (physical, electrical, or thermal), shrapnel (from an explosion), hazardous materials, and other chemical or biological agents may also be present.

(2) Improvised Nuclear Device (IND)

An IND is an illicit nuclear weapon bought, stolen, or otherwise originating from a nuclear State, or a weapon fabricated by a terrorist group from illegally obtained fissile nuclear weapons material that produces a nuclear explosion. The nuclear yield achieved by an IND produces extreme heat, powerful shockwaves, and prompt radiation that would be acutely lethal for a significant distance. It also produces radioactive fallout, which may spread and deposit over very large areas. If a nuclear yield is not achieved, the result would likely resemble an RDD in which fissile weapons material was utilized.

(3) Differences Between Acts of Terror and Accidents

Most radiological emergency planning has been conducted to respond to potential nuclear power plant accidents. RDD and IND incidents differ from a nuclear power plant accident in several ways, and response planning should take these differences into account. First, the severity of an IND incident would be dramatically greater than any nuclear power plant accident. An IND would have grave consequences for the human population and create a large radius of severe damage from blast and fires, which could not occur in a nuclear power plant accident.

Second, the radiological release from an RDD or IND may start without any advance warning and would likely have a relatively short duration. In a major nuclear power plant accident, there is likely to be several hours or days of warning before the release starts, and the release is likely to be drawn out over many hours. This difference means that most early phase, and some intermediate phase, protective action decisions, which may be made in a timely fashion during power plant incidents, must be made much more quickly (and with less information) in an RDD or IND incident if they are to be effective.

Third, an RDD or IND incident is more likely to occur in a major city center with a large population. Because of the rural setting in which many nuclear facilities are located, the lower number and density of people affected by a nuclear plant incident would be less, making evacuations much more manageable, and the amount of critical infrastructure impacted is also likely to be smaller.

Fourth, large nuclear facilities have detailed emergency plans developed over years that are periodically exercised including specified protective actions, evacuation routes, and methods to quickly alert the public of the actions to take. This would not be the case for an RDD or IND incident. This level of radiological emergency planning typically does not exist in most cities and towns without nearby nuclear facilities.

Fifth, the radioactive material releases from a nuclear power plant incident would be well known in advance based on reactor operational characteristics

whereas releases associated with an RDD or IND would not.

Sixth, in an act of terrorism, the incident scene becomes a crime scene. As such, the crime scene must be preserved for forensic investigation. This may impact emergency responders during the early and intermediate phases of response. It should be noted that other personnel responding to the incident (*i.e.,* law enforcement, security personnel) will be involved in addition to emergency responders.

(c) Phases of Response

Typically, the response to an RDD or IND incident can be divided into three time phases—the early phase, the intermediate phase, and the late phase—that are generally accepted as being common to all radiological incidents. The phases represent time periods in which response officials would be making public health protection decisions. Although these phases cannot be represented by precise time periods, and may overlap, they provide a useful framework for the considerations involved in emergency response planning.

(1) Early Phase

The early phase (or emergency phase) is the period at the beginning of the incident when immediate decisions for effective protective actions are required, and when actual field measurement data generally are not available. Exposure to the radioactive plume, short-term exposure to deposited radioactive materials, and inhalation of radioactive material are generally taken into account when considering protective actions for the early phase. The response during the early phase includes initial emergency response actions to protect public health and welfare in the short term, considering a time period for protective actions of hours to a few days. Priority should be given to lifesaving and first-aid actions. In general, early phase protective actions should be taken very quickly, and the protective action decisions can be modified later as more information becomes available. If an explosive RDD is deployed without warning, however, there may be no time to take protective actions to significantly reduce plume exposure. Also, in the event of a covert dispersal, discovery or detection may not occur for days or weeks, allowing contamination to be dispersed broadly by foot, vehicular traffic, wind, rain, or other forces.

If an IND explodes, there may only be time to make early phase protective action recommendations (*e.g.*, evacuation, or shelter-in-place) many miles from the explosion to protect areas against exposure to fallout. Areas close to the explosion will be devastated, and communications and access will be extremely limited. Assistance will likely not be forthcoming or even possible for some hours. Self-guided protective actions are likely to be the best recourse for most survivors (*e.g.*, evacuation perpendicular to the plume movement if it can be achieved quickly, or sheltering in a basement or large building for a day or more after the incident [1]). Due to the lack of communication and access, outside guidance and assistance to these areas can be expected to be delayed. Therefore, response planning and public outreach programs are critical measures to meet IND preparedness objectives.

(2) Intermediate Phase

The intermediate phase of the response may follow the early phase response within as little as a few hours. The intermediate phase of the response is usually assumed to begin after the incident source and releases have been brought under control and protective action decisions can be made based on measurements of exposure and radioactive materials that have been deposited as a result of the incident. Activities in this phase typically overlap with early and late phase activities, and may continue for weeks to many months, until protective actions can be terminated.

During the intermediate phase, decisions must be made on the initial actions needed to recover from the incident, reopen critical infrastructure, and return to a state of relatively normal activity. In general, intermediate phase decisions should consider late phase response objectives. However, some intermediate phase decisions will need to be made quickly (*i.e.*, within hours) and should not be delayed by discussions on what the more desirable permanent decisions will be. Local officials must weigh public health and welfare concerns, potential economic effects, and many other factors when making decisions. For example, it can be expected that hospitals and their access roads will need to remain open or be reopened quickly. These interim decisions can often be made with the acknowledgement that further work may be needed as time progresses.

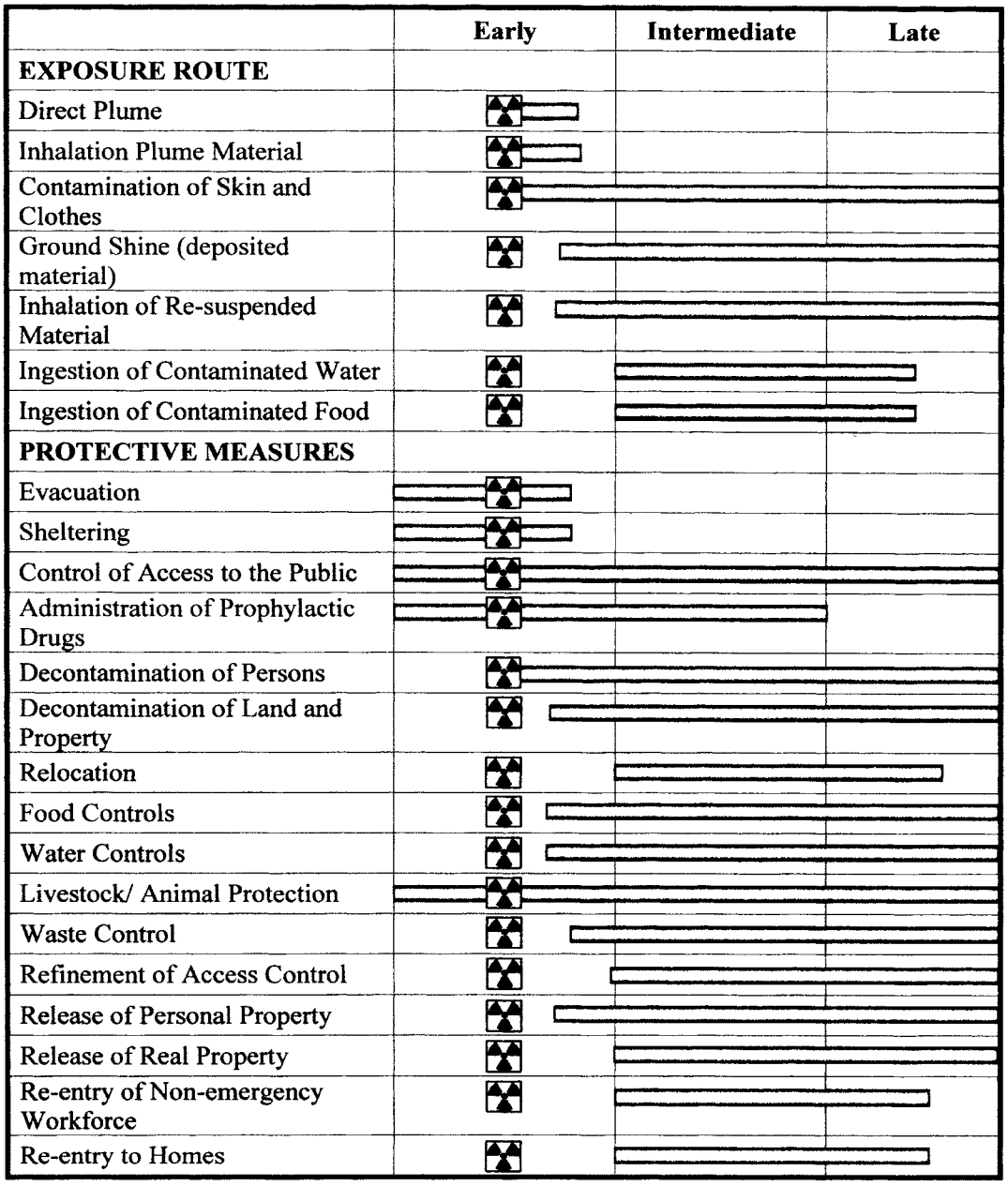
(3) Late Phase

The late phase is the period when recovery and cleanup actions designed to reduce radiation levels in the environment to acceptable levels are commenced. This phase ends when all the remediation actions have been completed. With additional time and increased understanding of the situation, there will be opportunities to involve key stakeholders in providing sound, cost-effective cleanup recommendations that are protective of human health and the environment. Generally, early (or emergency) phase decisions will be made directly by elected public officials, or their designees, with limited stakeholder involvement due to the need to act within a short timeframe. Long-term decisions should be made with stakeholder involvement, and can also include incident-specific technical working groups to provide expert advice to decision makers on alternatives, costs, and impacts. The relationship between typical protective actions and the phases of the incident response are outlined in Figure 1. There is overlap between the phases; this framework should be used to inform planning and decision-making.

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[1] Additional protective action guides and recommendations are needed for the close-in zones after an IND. A follow-on Federal effort is underway to address this critical need.

Figure 1.—Relationship between Exposure Routes, Protective Measures, & Timeframes for Effects[a, b]



Radiological release incident occurs — Exposure or action occurs

[a] For some activities, the figure indicates that protective actions may be taken before a release occurs. This would be the case if authorities have prior warning about a potential RDD/IND incident.

[b] In certain circumstances, food and water interdiction may occur in early phases. In addition, some exposure routes (e.g., ingestion of contaminated food) may occur earlier than depicted in the figure, depending on the unique characteristics of the incident.

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(d) Guidance for RDD and IND Incidents

This section defines protective actions and protective action guides, and provides guidance for their implementation in RDD and IND incidents. In addition, this section provides guidance for protection of emergency workers, and a strategy for devising cleanup plans, criteria, and options.

(1) Protective Actions

Protective actions are activities that should be conducted in response to an RDD or IND incident in order to reduce or eliminate exposure of the public to radiation or other hazards. These actions are generic and are applicable to RDDs and INDs. The principal protective action decisions for consideration in the early and intermediate phases of an emergency are whether to shelter-in-place, evacuate, or relocate affected or potentially affected populations. Secondary actions include administration of medical countermeasures, decontamination (including decontamination of persons evacuated from the affected area), use of access restrictions, and use of restrictions on food and water. In some situations, only one protective action needs to be implemented, while in others, numerous protective actions should be implemented. Many factors should be considered when deciding whether or not to order a protective action based on the projected dose to a population. For example, evacuation of a population is much more difficult and costly as the size of the population increases.

(2) Protective Action Guides (PAGs)

A PAG is the projected dose to a reference individual, from an accidental or deliberate release of radioactive material, at which a specific protective action to reduce or avoid that dose is recommended. Thus, protective actions are designed to be taken before the anticipated dose is realized.

The Environmental Protection Agency (EPA) has published PAGs in the ''Manual of Protective Action Guides and Protective Actions for Nuclear Incidents'' (EPA 400–R–92–001, May 1992), in coordination with the Federal Radiological Preparedness Coordinating Committee (FRPCC). The PAGs presented in this manual, hereafter referred to as the 1992 EPA PAGs, are non-regulatory. They are designed to provide a flexible basis for decisions under varying emergency circumstances. The 1992 EPA PAGs meet the following principal criteria and goals: (1) Prevent acute effects, (2) reduce risk of chronic effects, and (3) require optimization to balance protection with other important factors and ensure that actions taken result in more benefit than harm.

The 1992 EPA PAG Manual, however, was not developed to address response actions following radiological or nuclear terrorist incidents and does not address long-term cleanup. The 1992 EPA PAG Manual was written to address the kinds of nuclear or radiological incidents deemed likely to occur. While intended to be applicable to any radiological release, the 1992 EPA PAGs were designed principally to address the impacts of commercial NPP accidents, the worst type of incident under consideration at that time. This is important for two reasons: Commercial nuclear power plant accidents are almost always signaled by preceding events, giving plant managers time to make decisions, and giving local emergency managers time to communicate with the public and initiate evacuations if necessary. In addition, the suite of radionuclides present at nuclear power plants is well-known, and is dominated by relatively short-lived isotopes.

The 1992 EPA PAG Manual provides a significant part of the basis of this document and should be referred to for additional details. In deriving the recommendations contained in this Guidance, new types of incidents and scenarios that could lead to environmental radiological contamination were considered. The interagency working group determined that the 1992 EPA PAGs for the early and intermediate phases, including emergency responder guidelines, are also appropriate for use in RDD and IND incidents. This Guidance is intended to supplement the 1992 EPA PAG Manual for application to RDD and IND incidents, including providing new late phase guidance.

The RDD/IND Guidance provides generic criteria based on balancing public health and welfare with the risk of various protective actions applied in each of the phases of an RDD or IND incident. The RDD/IND Guidance is specific to radiation and radioactive materials, and must be considered in the context of other chemical or biological hazards that may also be present.

Though the early and intermediate PAGs in this Guidance are values of dose to be avoided, published dose conversion factors and derived response levels may be utilized in estimating doses, and for choosing and implementing protective actions. Other quantitative measures and derived concentration values may be useful in emergency situations; for example, for the release of goods and property from contaminated zones, and to control access into and out of contaminated areas.

Because of the short time frames required for emergency response decisions in the early and intermediate phases, it is likely there will not be opportunities for local decision makers to consult with a variety of stakeholders before taking actions. Therefore, this Guidance incorporates the significant body of work done in the general context of radiological emergency response planning from the development of the 1992 EPA PAGs, and represents the results of scientific analysis, public comment, drills, exercises, and a consensus at the Federal level for appropriate emergency action.

In order to use the early and intermediate phase PAGs to make decisions about appropriate protective actions, decision makers will need information on suspected radionuclides; projected plume movement, and radioactive depositions; and/or actual measurement data or, during the period initially following the release, expert advice in the absence of good information. Sources of such information include on-scene responders, as well as monitoring, assessment, and modeling centers.

(3) Early and Intermediate Phase Protective Action Guides for RDD and IND Incidents

The early and intermediate phase RDD/IND PAGs are generally based on the following sources: The 1992 EPA PAGs developed by EPA in coordination with other Federal agencies through the Federal Radiological Preparedness Coordinating Committee; guidance developed by the FDA for food and food products and the distribution of potassium iodide. Table 1 provides a summary of the early and intermediate phase PAGs for protection of the general public in an RDD or IND incident and key protective actions.

TABLE 1—PROTECTIVE ACTION GUIDES FOR RDD AND IND INCIDENTS

Phase	Protective action recommendation	Protective action guide
Early	Sheltering-in-place or evacuation of the public[a].	1 to 5 *rem* (0.01–0.05 *Sv*) projected dose.[b]
	Administration of prophylactic drugs—potassium iodide[c,e] Administration of other prophylactic or decorporation agents[d].	5 *rem* (0.05 *Sv*) projected dose to child thyroid.[c,e]
Intermediate	Relocation of the public	2 *rem* (0.02 *Sv*) projected dose first year. Subsequent years, 0.5 *rem*/y (0.005 *Sv*/y) projected dose.[b]
	Food interdiction	0.5 *rem* (0.005 *Sv*) projected dose, or 5 *rem* (0.05 *Sv*) to any individual organ or tissue in the first year, whichever is limiting.
	Drinking water interdiction	0.5 *rem* (0.005 *Sv*) projected dose in the first year.

[a] Should normally begin at 1 *rem* (0.01 *Sv*); take whichever action (or combination of actions) that results in the lowest exposure for the majority of the population. Sheltering may begin at lower levels if advantageous.
[b] Total Effective Dose Equivalent (TEDE)—the sum of the effective dose equivalent from external radiation exposure and the committed effective dose equivalent from inhaled radioactive material.
[c] Provides thyroid protection from radioactive iodine only.
[d] For other information on other radiological prophylactics and medical countermeasures, refer to *http://www.fda.gov/cder/drugprepare/default.htm, http:/www.bt.cdc.gov/radiation*, or *http://www.orau.gov/reacts*.
[e] Committed Dose Equivalent (CDE). FDA understands that a KI administration program that sets different projected thyroid radioactive dose thresholds for treatment of different population groups may be logistically impractical to implement during a radiological emergency. If emergency planners reach this conclusion, FDA recommends that KI be administered to both children and adults at the lowest intervention threshold (*i.e.*, >5 *rem* (0.05 *Sv*) projected internal thyroid dose in children) (FDA 2001).

In the early and intermediate phases of an RDD or IND incident there may not be adequate information to determine radiation levels or make dose projections because there may be little or no advance notice of an attack, the characteristics of the RDD or IND may not be immediately known, monitoring equipment may not be available to make measurements, or there may not be time to do measurements or projections before emergency response actions need to be initiated. Therefore, to use this guide to determine whether protective action is needed in a particular situation, it may be necessary to compare the PAGs to results of a dose projection. In general, it should be emphasized that realistic assumptions, based on incident-specific information, should be used when making radiation dose projections so that the final results are representative of actual conditions rather than overly conservative exposures. It is very important that local officials responsible for carrying out emergency response actions conduct advance planning to ensure that they are adequately prepared if such an incident were to occur.

(A) Early Phase PAGs

For the early phase, the 1992 EPA PAGs for evacuation and sheltering-in-place are appropriate for RDD and IND incidents (see Table 1). Early phase protective action decisions in an RDD or IND must be made quickly, and with very little confirmatory data. While sheltering-in-place should be carried out at 1 *rem* (0.01 *Sv*) sheltering-in-place can begin at any projected dose level.

FDA guidance on the administration of stable iodine is also considered appropriate (useful primarily for NPP incident involving radioiodine release). The administration of other medical countermeasures should be evaluated on a case-by-case basis and depend on the nature of the event and radionuclides involved.

The initial zone should be established and controlled around the incident site, as is the case for other crime scenes and hazards. This Guidance allows for the refinement of that area if the radiation exposure levels warrant such action. Advance planning by local officials for messaging, communications, and actions in the event of an RDD or IND are strongly encouraged.

(B) Intermediate Phase PAGs

The decisions in the intermediate phase will focus on the return of key infrastructure and services, and the rapid return to normal activities. This will include decisions on allowing use of roads, ports, waterways, transportation systems (including subways, trains, and airports), hospitals, businesses, and residences. It will also include responses to questions about acceptable use and release of real and personal property such as cars, clothes, or equipment that may have been impacted by the RDD or IND incident. Many of the activities will be concerned with materials and areas that were not affected, but for which members of the public may have concern. Thus, the RDD/IND Guidance serves to guide decisions on returning to impacted areas, leaving impacted areas, and providing assurance that an area was not impacted. The intermediate phase is also the period during which planning for long-term site cleanup and remediation should be initiated.

For the intermediate phase, relocation of the population is a protective action that can be used to reduce dose. Relocation is the removal or continued exclusion of people (households) from contaminated areas in order to avoid chronic radiation exposure, and it is meant to protect the general public. For the intermediate phase, the existing relocation PAGs of 2 *rem* (0.02 *Sv*) in the first year and 0.5 *rem* (0.005 *Sv*) in any subsequent year are considered appropriate for RDD and IND incidents. However, for IND incidents, the area impacted and the number of people that might be subject to relocation could potentially be very large and could exceed the resources and infrastructure available. For example, in making relocation decisions, the availability of adequate accommodations for relocated people should be considered. Decision makers may need to consider limiting action to those areas most severely affected, phasing relocation implementation based on the resources available.

The relocation PAGs apply principally to personal residences, but may impact other locations as well. For example, these PAGs could impact work locations, hospitals, and park lands, as well as the use of highways and other transportation facilities. For each type of facility, the individual occupancy time should be taken into account to determine the criteria for using a facility or area. It might be necessary to avoid continuous use of homes in an area

because radiation levels are too high; however, a factory or office building in the same area could be used because occupancy times are shorter. Similarly, a highway could be used at higher contamination levels because the exposure time of highway users would be considerably less than the time spent by residents in a home.

The intermediate phase PAG for the interdiction of food is set at 0.5 *rem* (0.005 *Sv*) projected dose in the first year, and the intermediate phase PAG for the interdiction of drinking water is set at 0.5 *rem* (0.005 *Sv*) projected dose for the first year for RDD and IND incidents. These values are consistent with those now used or being considered as PAGs for other types of nuclear/radiological incidents.

The use of simple dose reduction techniques is recommended for personal property and all potentially contaminated areas that continue to be occupied. This technique is also consistent with the 1992 EPA PAGs developed for other types of nuclear/radiological incidents. Examples of simple dose reduction techniques would be washing all transportation vehicles (*e.g.*, automobiles, trains, ships, and aircraft), personal clothing, eating utensils, food preparation surfaces, and other personal property before next use, as practicable and appropriate.

(4) Late Phase Guidance

The late phase involves the final cleanup of areas and property at which radioactive material is present. Unlike the early and intermediate phases of an RDD or IND incident, decision makers will have more time and information during the late phase to allow for better data collection, stakeholder involvement, and options analysis. In this respect, the late phase is no longer a response to an ''emergency situation,'' and is better viewed in terms of the objectives of cleanup and site recovery.

Because of the extremely broad range of potential impacts that may occur from RDDs and INDs (*e.g.*, light contamination of one building to widespread destruction of a major metropolitan area), a pre-established numeric cleanup guideline is not recommended as best serving the needs of decision makers in the late phase. Rather, a process should be used to determine the societal objectives for expected land uses and the options and approaches available, in order to select the most acceptable criteria. For example, if the incident is an RDD of limited size and the impacted area is small, it might reasonably be expected that a complete return to normal conditions can be achieved within a short period of time. However, if the impacted area is large, achieving low cleanup levels for remediation of the entire area, and/or maintaining existing land uses, may not be practicable.

It should be noted that an intermediate phase PAG is not equivalent to a starting point for development of the late phase cleanup process. However, contamination and radiation levels existing after an incident (*e.g.*, concentrations, or dose rates), as well as actions already taken, provide practical starting points for further action and cleanup. The goal of cleanup is to reduce those levels as low as is reasonable. It is possible that final criteria for reoccupation at a given incident site may be either below or above the intermediate phase PAG dose value, since no dose or risk cap for the late phase is explicitly recommended under this Guidance.

Late phase cleanup criteria should be derived through a site-specific optimization process, which should include potential future land uses, technical feasibility, costs, cost-effectiveness, and public acceptability. Optimization is a concept that is common to many State, Federal, and international risk management programs that address radionuclides and chemicals, although it is not always referred to as such. The Risk Management Framework described in Appendix 2 provides such a process and helps assure the protection of public health and welfare. Decisions should take health, safety, technical, economic, and public policy factors into account. Appendix 3 utilizes the framework as a basis for RDD and IND site cleanup planning.

Broadly speaking, optimization is a flexible, multi-attribute decision process that seeks to weigh many factors. Optimization analyses are quantitative and qualitative assessments applied at each stage of site recovery decision-making, from evaluation of remedial options to implementation of the chosen alternative. The evaluation of cleanup alternatives, for example, should factor in all relevant variables, including areas impacted (*e.g.*, size and location relative to population), types of contamination (chemical, biological, and/or radioactive), human health, public welfare, technical feasibility, costs, and available resources to implement and maintain remedial options, short-term effectiveness, long-term effectiveness, timeliness, public acceptability, and economic effects (*e.g.*, on residents, tourism, and business, and industry).

Various Federal, and State agencies, along with other organizations (*e.g.*, national and international advisory organizations), already have guidance and tools that may be used to help establish cleanup levels. The optimization process allows local decision makers to draw on the thought processes used to develop the dose and/or risk benchmarks used by these State, Federal, or other sources. These benchmarks, though developed within different contexts, may be useful for analysis of cleanup options. Decision makers might reasonably determine that it is appropriate to move up or down from these benchmarks, depending on the site-specific circumstances and balancing of other relevant factors.

In developing this Guidance, the Federal Government recognized that experience from existing programs, such as the EPA's Superfund program, the NRC's standards for decommissioning and decontamination to terminate a plant license, and other national and international recommendations, may be useful in planning the cleanup and recovery efforts following an RDD or IND incident. This Guidance allows the consideration and incorporation, as appropriate, of any or all of the existing environmental program elements.

The site-specific optimization process includes quantitative and qualitative assessments applied at each stage of site cleanup decision making, from initial scoping and stakeholder outreach, to evaluation of cleanup options, to implementation of the chosen alternative. The evaluation of options for the late phase of recovery after an RDD or IND incident should consider all of the relevant factors, including:

- Areas impacted (*e.g.*, size, location relative to population).
- Types of contamination (chemical, biological, and radiological).
- Other hazards present.
- Human health risk.
- Public welfare.
- Ecological risks.
- Actions already taken during the early and intermediate phases.
- Projected land uses.
- Preservation or destruction of places of historical, national, or regional significance.
- Technical feasibility.
- Wastes generated and disposal options and costs.
- Costs and available resources to implement and maintain remedial options.
- Potential adverse impacts (*e.g.*, to human health, the environment, and the economy) of remedial options.
- Short-term effectiveness.
- Long-term effectiveness.
- Timeliness.
- Public acceptability, including local cultural sensitivities.

• Economic effects (*e.g.*, on employment, tourism, and business).
• Intergenerational equity.

The site-specific optimization process provides the best opportunity for decision makers to gain public confidence through the involvement of stakeholders. This process should begin during, and proceed independently of, intermediate phase protective action activities.

Appendix 3 provides additional details on a process that may be used to implement this Guidance, describing the role of the Federal Government and how it could integrate its activities with State and local governments and the public. For some radiological terror incidents, States may take the primary leadership role in cleanup and contribute significant resources toward recovery of the site.

As explained in Appendix 3, the Incident Command or Unified Command should develop a schedule with milestones for conducting the optimization process as soon as practicable following the incident. While the goal should be to complete the initial optimization process as soon as possible following an incident (depending on the size of the incident), the schedule must take into consideration incident-specific factors that would affect successful implementation. This schedule may need to reflect a phased approach to cleanup and is subject to change as the cleanup progresses.

(5) Emergency Worker Guidelines

The response during the early phase includes initial emergency response actions to protect public health and welfare in the short term. Priority should be given to lifesaving and first-aid actions. Following an IND detonation in particular, the highest priority missions should also include actions such as suppression of fires that could result in further loss of life.

For the purposes of this Guidance, ''emergency worker'' is defined as any worker who performs an early or intermediate phase work action. Table 2 shows the emergency worker guidelines for early phase emergency response actions. In intermediate and late phase actions (*i.e.*, cleanup and recovery), standard worker protections, including the 5 *rem* (0.05 *Sv*) occupational dose limit, apply.

TABLE 2—EMERGENCY WORKER GUIDELINES IN THE EARLY PHASE [2]

Total effective dose equivalent (TEDE) [a] guideline	Activity	Condition
5*rem* (0.05 *Sv*)	All occupational exposures	All reasonably achievable actions have been taken to minimize dose.
10 *rem* (0.1 *Sv*)	Protecting valuable property necessary for public welfare (*e.g.*, a power plant).	• All appropriate actions and controls have been implemented; however, exceeding 5 *rem* (0.05 *Sv*) is unavoidable. • Responders have been fully informed of the risks of exposures they may experience. • Dose >5 *rem* (0.05 *Sv*) is on a voluntary basis. • Appropriate respiratory protection and other personal protection is provided and used. • Monitoring available to project or measure dose.
25 *rem* (0.25 *Sv*) [b]	Lifesaving or protection of large populations. It is highly unlikely that doses would reach this level in an RDD incident; however, worker doses higher than 25 *rem* (0.25 *Sv*) are conceivable in a catastrophic incident such as an IND incident.	• All appropriate actions and controls have been implemented; however, exceeding 5 *rem* (0.05 *Sv*) is unavoidable. • Responders have been fully informed of the risks of exposures they may experience. • Dose >5 *rem* (0.05 *Sv*) is on a voluntarily basis. • Appropriate respiratory protection and other personal protection is provided and used. • Monitoring available to project or measure dose.

[a] The projected sum of the effective dose equivalent from external radiation exposure and committed effective dose equivalent from internal radiation exposure.

[b] EPA's 1992 PAG Manual states that ''Situations may also rarely occur in which a dose in excess of 25 *rem* for emergency exposure would be unavoidable in order to carry out a lifesaving operation or avoid extensive exposure of large populations.'' Similarly, the NCRP and ICRP raise the possibility that emergency responders might receive an equivalent dose that approaches or exceeds 50 *rem* (0.5 *Sv*) to a large portion of the body in a short time (Limitation of Exposure to Ionizing Radiation, National Council on Radiation Protection and Measures, NCRP Report 116 (1993a). If lifesaving emergency responder doses approach or exceed 50 *rem* (0.5 *Sv*) emergency responders must be made fully aware of both the acute and the chronic (cancer) risks of such exposure.

This Guidance document and the emergency worker guidelines were developed for a wide range of possible radiological scenarios, from a small RDD that may impact a single building to an IND that could potentially impact a large geographic region. Therefore, the 5, 10 and 25 *rem* guidelines (Table 2) should not be viewed as inflexible limits applicable to the range of early phase emergency actions covered by this Guidance. Because of the range of impacts and case-specific information needed, it is impossible to develop a single turn-back dose level for all responders to use in all events, especially those that involve lifesaving operations. Indeed, with proper preparedness measures (training, personal protective equipment, etc.) many radiological emergencies addressed by this document, even lifesaving operations, may be manageable within the 5 *rem* (0.05 *Sv*) occupational limit. Moreover, Incident Commanders should make every effort to employ the ''as low as reasonably achievable'' (ALARA) principle after an incident. Still, in some incidents medically significant doses above the annual occupational 5 *rem* (0.05 *Sv*) dose limit may be unavoidable. For instance, in the case of a catastrophic incident, such as an IND, Incident Commanders may need to consider raising the lifesaving and valuable property (*i.e.*, necessary for public welfare) emergency worker guidelines in order to prevent further loss of life and prevent the spread of massive destruction. Ensuring that emergency workers have full knowledge of the

[2] In the intermediate and late phases, standard worker protections, including the 5 *rem* occupational dose limit, would normally apply.

associated risks prior to initiating emergency action and medical evaluation of emergency workers after such exposure is essential. (See Appendix 1 for additional discussion of ALARA.)

Ideally, the Incident Commanders should define and enforce the emergency dose limits in accordance with the immediate risk situation and the type of emergency action being performed (see Table 2). However, in the case of an attack it may not be possible to conduct dose measurements or projections before initiating emergency response activities. Therefore, it is crucial that officials responsible for carrying out emergency response actions in the early phase conduct thorough advance planning to ensure that they are adequately prepared if such an incident occurs. Planning should include evaluating data and information on possible or anticipated radiation exposures in RDD or IND incidents, developing procedures for reducing and controlling emergency responder exposures to allowable dose limits (Table 2), obtaining appropriate personal protective equipment (*e.g.*, respirators, clothing) for protecting emergency responders who enter contaminated areas, and developing appropriate decision-making criteria for responding to catastrophic incidents that may involve high radiation exposure levels. Planning should also include informing and educating emergency workers about emergency response procedures and controls as well as the acute and chronic (cancer) risks of exposure, particularly at higher dose levels. Effective advance planning will help to ensure that the emergency worker guidelines are correctly applied and that emergency workers are not exposed to radiation levels that are higher than necessary in the specific emergency action.

In addition, as part of advance planning, officials should develop a process for assessing hazards and for determining appropriate actions in incidents that may involve high radiation doses. Decisions regarding emergency response actions in incidents involving high radiation exposures require careful consideration of the benefits to be achieved by the ''rescue'' or response action (*e.g.*, the significance of the outcome to individuals, large populations, general welfare, or valuable property necessary for public welfare), and the potential health impacts (*i.e.*, acute and chronic) to emergency workers. The planning for a potential high radiation exposure incident should consider how to weigh the potential for and significance of the success of the emergency response/rescue operation against the potential for and significance of the health and safety risks to the emergency workers. Federal, state and local emergency response officials should use these guidelines to develop specific operational plans and response protocols for protection of emergency response workers.

(e) Operational Guidelines for Early and Intermediate PAGs

Implementation of the early and intermediate PAGs may be supported by operational guidelines that can be readily used by decision makers and responders in the field. Operational guidelines are levels of radiation or concentrations of radionuclides that can be accurately measured by radiation detection and monitoring equipment, and then related or compared to the PAGs to quickly determine whether actions need to be implemented. Federal agencies are continuing development of operational guidelines to support the application of this Guidance, and other site-level decisions; therefore, they are provided here in overview only.

Some values already exist that could potentially serve as operational guidelines for RDD and IND response and recovery operations, and there are various tools available to help derive operational guidelines for response planning. Appendix 4 presents a summary of the types of operational guidelines for RDD and IND response operations currently under development.

Additional tools and assessment methodologies to aid in planning and development of operational guidelines for use with PAGs for a wide range of situations are available from the Federal Radiological Monitoring and Assessment Center (FRMAC). These tools and methods are written to support FRMAC operations during radiological and nuclear emergency responses. The FRMAC manuals provide detailed methods for computing Derived Response Levels (DRLs) and doses based on measurement or modeling results and suggest input parameters for various situations.[3]

Some examples of existing values that can be used as operational guidelines for RDD and IND response operations and tools that could be used to establish site-specific operational guidelines include, derived response levels, derived intervention levels for food, and radiation levels for control of access to radiation areas.

(1) Derived Response Levels (DRLs)

The 1992 EPA PAG Manual contains guidance and Derived Response Levels (DRLs) for various potential exposure pathways, including external exposure, inhalation, submersion, ground shine, and drinking water, for application in the early and intermediate phases. These values serve as, or can be adapted to serve as, operational guidelines to readily determine if protective actions need to be implemented. The summed ratios of radionuclide concentrations obtained through field measurements can be compared to the DRLs to determine whether the PAGs are likely to be exceeded. If concentrations of radionuclides obtained through field measurements are less than the DRLs, the PAGs are not likely to be exceeded and, thus, a protective action may not need to be taken.

(2) Derived Intervention Levels (DILs) for Food

The FDA has developed Derived Intervention Levels (DILs) for implementation of the early and intermediate PAGs for food. These DILs establish levels of contamination that can exist on crops and in food products and still maintain dose levels below the food PAGs, and could therefore be used as operational guidelines for RDD and IND incidents. More information on DILs can be found in ''Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies'' (U.S. Department of Health And Human Services, Food and Drug Administration, August 13, 1998).

(3) Radiation Levels for Control of Access to Radiation Areas

Additional operational guidelines for use in the early and intermediate phases of response are being developed for issues such as clearance of personal and real property, land and facility access, and for response actions. A DOE project supported by an interagency effort is developing needed tools and operational guidelines that address continued use, or necessary control for personal property (*e.g.*, vehicles, equipment, personal items, debris) and real property (*e.g.*, buildings, roads, bridges, residential and commercial areas, national monuments and icons) that may be impacted by an RDD or IND incident. The effort includes consideration of short and long term use

[3] These materials and additional information on the FRMAC can be obtained at *http://www.nv.doe.gov/nationalsecurity/homelandsecurity/frmac.*

or access to areas. A DOE report [4] is available for review, and use as appropriate. The report includes proposed operational guidelines and their technical derivation, and provides tools such as the computer model RESRAD–RDD [5] for calculating incident-specific guidelines and worker stay-time tables for access control, and dose-based soil and building contamination levels to assist in the site-specific optimization process. The goal of the DOE report is to provide sufficient information to assist decision makers and responders in executing their responsibilities in a safe way. Appendix 4 of this Guidance provides a more detailed overview of the operational guidelines contained in the DOE draft report and their intended applications.

Appendix 1—Planning for Protection of Emergency Workers Responding to RDD and IND Incidents

The purpose of this appendix is to provide Federal, state, and local decision makers with information on how to prepare for, and implement emergency worker guidance in RDD and IND incidents. Because there may not be adequate information or time for determining radiation levels or making dose projections in the early phase of an RDD or IND incident, it is very important that emergency management officials conduct worker health and safety planning and training in advance to ensure they are adequately prepared if such an incident occurs.

Planning should include evaluating data and information on possible or anticipated radiation exposures in RDD and IND incidents and on acute and chronic risks of radiation exposures, developing procedures for reducing and controlling emergency worker exposures, obtaining appropriate personal protective equipment (*e.g.*, respirators, protective clothing) to help protect emergency workers who enter exposure areas, and developing appropriate decisionmaking criteria for responding in catastrophic incidents, such as an IND, that may involve high exposure levels. Planning should also include training and educating emergency workers about emergency response procedures in radiological environments, radiation exposure controls and the risks of exposure, particularly at higher levels. Effective planning and training will help to ensure that exposures to emergency workers are kept to the lowest radiation levels necessary for the particular emergency response action.

This appendix provides information to assist local, State, and Federal authorities, and emergency workers in planning for radiological emergencies, in particular those related to terrorist attacks using RDDs and INDs. The appendix is not intended to provide comprehensive training guidance. Other information useful in the planning process may be available from the following organizations:

- The National Council on Radiation Protection and Measurements,
- the International Commission on Radiological Protection,
- the International Atomic Energy Agency,
- the American Nuclear Society,
- the Health Physics Society, and
- the Conference of Radiation Control Program Directors.

(a) Guidelines for Emergency Workers in Responding to RDD and IND Incidents

Table 2 in Section (d)(5) of the Guidance shows the emergency worker guidelines for the early phase. In the intermediate and late phases, standard OSHA and other worker health and safety standards apply. The DOE and NRC also have standards that govern worker health and safety for normal operations at their owned or licensed facilities. OSHA's occupational radiation dose limit (1.25 *rem* (0.0125 *Sv*) per annual quarter, or 5 *rem* (0.05 *Sv*) total in one year) minimizes risk to workers consistent with the Occupational Health and Safety Act (29 U.S.C. 651 et seq.).

In many radiological incidents, particularly RDD situations, the actual dose to emergency workers may be controlled to less than 5 *rem* (0.05 *Sv*). However, in other radiological incidents precautions may not be sufficient or effective to keep emergency worker doses at or below 5 *rem* (0.05 *Sv*), because of the magnitude of the incident and because certain measures typically used to control exposures in normal operations may not be applicable. For example, one of the major radiation protection controls used in normal radiological operations is containment of the radioactive material. Another is to keep people away from the source material. During emergency response to an RDD or IND incident use of these controls may not be possible due to the nature of the incident and the urgency of response actions. As a result, high radiation exposures for emergency responders may be unavoidable and have the potential to exceed regulatory limits used for normal operations. Therefore, the 5, 10 and 25 *rem* guidelines found in Table 2 should not be viewed as absolute standards applicable to the full range of incidents covered by this guidance, but rather serve as decision points for making worker protection decisions during emergencies.

Emergency response actions in catastrophic incidents that involve high exposure levels require careful consideration of both the benefits to be achieved by the ''rescue'' or response action (*e.g.*, the significance of the benefit to individuals, populations, valuable property necessary for general welfare), and the potential for acute and chronic health impacts to individuals conducting the emergency response operation. That is, in making an emergency response decision, the potential for the success of the response/rescue operation and the significance of its benefits to the community should be weighed against the potential for, and significance of, the health and safety risks to workers.

(b) Controlling Occupational Exposures and Doses to Emergency Workers

Appropriate measures should be taken to minimize radiation dose to emergency workers responding to an RDD or IND incident. With proper preparedness measures (*e.g.*, training, personal protective equipment), many emergencies that this document addresses, including lifesaving actions, may be possible to manage within the 5 *rem* (0.05 *Sv*) occupational limit. Emergency management officials responsible for an incident should take steps to keep all doses to emergency workers ''as low as reasonable achievable'' (ALARA). Protocols for maintaining ALARA should include the following health physics and industrial hygiene practices:

- Minimizing the time spent in the contaminated area (*e.g.*, rotation of emergency responders);
- Maintaining distance from sources of radiation;
- Shielding of the radiation source;
- Using hazard controls that are applicable to the work performed;
- Properly selecting and using respirators and other personal protective equipment (PPE), to minimize exposure to internally deposited radioactive materials (*e.g.*, alpha and beta emitters); and
- Using prophylactic medications, when appropriate, that either block the uptake or reduce the retention time of radioactive material in the body.

To minimize the risks from exposure to ionizing radiation, all emergency responders should be trained and instructed to follow emergency response plans and protocols and be advised on how to keep exposures as low as reasonably achievable. Health physics and industrial hygiene practices should include the use of dosimetry for monitoring of individual exposure with real-time readings (*i.e.*, real-time electronic dosimeters) and permanent records (*e.g.*, film badges, optically stimulated luminescent [OSL], or thermoluminescent dosimeters [TLDs]). Also, employers should (1) develop procedures and training that relate measurements to dose and risk, (2) understand and practice ALARA procedures with workers, and (3) address other issues related to performing response in a radiological environment.

(c) Understanding Radiation Risks

If there is the possibility that emergency workers would receive a radiation dose higher than the 5 *rem* (0.05 *Sv*) guideline, emergency workers should be trained to understand the risk associated with such doses, including a thorough explanation of the latent risks associated with receiving doses greater than 5 *rem* (0.05 *Sv*), and acute risks at higher doses. Emergency workers should be fully aware of both the projected acute and chronic risks (cancer) they may

[4] Preliminary Report on Operational Guidelines Developed for Use in Emergency Preparedness and Response to a Radiological Dispersal Device Incident, DOE/HS–0001. The report and associated material will be available at *http://www.ogcms.energy.gov*.

[5] RESRAD–RDD is derived from RESRAD, which is a computer model designed to estimate radiation doses and risks from residual radioactive materials. The RESRAD model has been applied to determine the risk to human health posed at over 300 sites in the United States and abroad that have been contaminated with radiation.

incur in an emergency response action. Furthermore, emergency workers cannot be forced to perform a rescue action involving radiation doses above regulatory limits, and they should be given reasonable assurance that normal controls cannot be utilized to reduce doses to less than 5 *rem* (0.05 *Sv*). After the event, it is essential that emergency workers be provided with medical follow up.

The estimated risk of fatal cancer [6] for healthy workers who receive a dose of 10 *rem* (0.10 *Sv*) is about 0.46 percent over the worker's lifetime (*i.e.*, 4–5 fatal cancers per 1000 people, or 0.4–0.5 percent). The risk scales linearly. For workers who receive a dose of 25 *rem* (0.25 *Sv*), the risk is about 1.1 percent. The risk is believed to be greater for those who are younger at the time of exposure. For example, for 20–30 year olds the estimated risk of fatal cancer at 25 *rem* (1.75 percent) is about twice as large as the risk for 40–50 year olds (0.8 percent).

Above 50 *rem* (0.5 *Sv*) acute effects are possible. Where lifesaving actions may result in doses that approach or exceed 50 *rem* (0.50 *Sv*), such as in an IND incident, emergency workers need to have a full understanding of the potential acute effects of the expected radiation exposure, in addition to the risk of chronic effects. The decision to take these lifesaving actions must be based on the estimation that the human health benefits of the action exceed the safety and health risks to the emergency workers.

It is important to note that the approach used to translate dose to risk in this discussion is a simplistic approach for developing rough estimates of risks for comparative purposes. Other more realistic and accurate approaches are often used in assessing risks for risk management decisions (other than for emergencies) when more complete information about the contaminants and the potential for human exposure is available. These approaches rely on radionuclide-specific risk factors (*e.g.*, found in Federal Guidance Report No. 13 and EPA Health Effects Assessment Summary Tables), and are typically used in long-term assessments, such as environmental cleanup.

(d) Preparedness

To prepare for large radiological disasters, local officials and Incident Commanders will need to have a decision-making process already developed and ready to implement when they can no longer use standard occupational dose limits or when there is the possibility that they may face decisions involving exposures approaching or exceeding 25 *rem* (0.25 *Sv*) for lifesaving operations. Preparedness entails investigating the nature of the RDD and IND incident for which local officials must be prepared, having appropriate worker health and safety plans and protocols for such incidents, and training and exercises to assure a level of readiness among officials and responders.

Incident Commanders and emergency responders should thoroughly understand the emergency worker guidelines for radiological emergency response, including specific emergency responder health and safety procedures and ALARA principles. The reader is referred to the EPA PAG Manual (May 1992), the FRMAC Radiological Emergency Response Health and Safety Manual (May 2001), and the Hazardous Waste Operations and Emergency Response (HAZWOPER) regulations. The EPA has a Worker Protection (40 CFR part 311) standard that applies the HAZWOPER standard to State and local workers in States that do not have their own occupational safety and health program.

The HAZWOPER regulations, found in 29 CFR 1910.120 and 1926.65, were promulgated to protect personnel working at a hazardous waste site, or a treatment, storage, or disposal facility, or performing emergency response. This standard also covers employers whose employees are engaged in emergency response without regard to the location of the hazard (unless specifically exempted or where a more protective safety and health standard applies). If an employer anticipates that their employees will respond to a potential hazard, HAZWOPER requires such actions as (1) the development of an emergency response plan (including personnel roles, lines of authority, training, communication, personal protective equipment, and emergency equipment), (2) procedures for handling a response, (3) specific training requirements based on the anticipated roles of the responder, and (4) medical surveillance. For specific interpretations regarding HAZWOPER and/or other occupational safety and health standards, employers should consult the appropriate implementing agency (*e.g.*, appropriate Federal agencies, State Occupational Safety and Health Programs, or State Radiation Control Programs).

Appendix 2—Risk Management Framework for RDD and IND Incident Planning

This appendix contains a description of a risk management framework for making decisions to protect public health and welfare in the context of cleanup and site recovery following an RDD or IND incident. The framework is based on the report, ''Framework for Environmental Health Risk Management,'' mandated by the 1990 Clean Air Act Amendments published by the Commission on Risk Assessment and Risk Management in 1997. This appendix provides specific material for RDD and IND incidents, and reference to the report is encouraged for the details of the general framework. A plan for implementing this framework for RDD and IND incidents is provided in Appendix 4.

The ''Framework for Environmental Health Risk Management'' is considered generally suitable for addressing the long-term cleanup issues for RDDs and INDs. Given the time frames following an RDD or IND incident there is generally not sufficient time in the early phase to conduct a full risk assessment and get stakeholder involvement. In order for the framework to be most useful it must be used in planning and preparing for a radiological or nuclear incident. Many of the basic risk management principles were also used in development of the 1992 EPA PAGs.

The framework is designed to help decision makers make good risk management decisions. The level of effort and resources invested in using the framework should be commensurate with the significance of the problem, the potential severity and economic impact, the level of controversy surrounding the problem, and resource constraints. The health and environmental hazards that must be considered are radiation hazards, and potentially chemical or biological hazards. Other factors to be considered include the continued disruption in normal activities, loss of, or limited access to critical infrastructure and health care and general economic damage.

The framework relies on the three key principles of (1) broad context, (2) stakeholder participation, and (3) iteration. Broad context refers to placing all of the health and environmental issues in the full range of impacts and recovery factors following an RDD or IND incident, and is intended to assure that all aspects of public welfare are taken into account. Stakeholder participation is critical to making and successfully implementing sound, cost-effective, risk-informed decisions. Iteration is the process of continuing to refine the analysis base on information available, and improve the decisions and actions that can be taken at any point in time. Together these principles outline a fair, responsive approach to making the decisions necessary to effectively respond to the impacts of an RDD or IND incident.

Risk management is the process of identifying, evaluating, selecting, and implementing actions to reduce risk to public health and the environment. The goal of risk management is scientifically sound, cost-effective, integrated actions that reduce or prevent public health impacts while taking into account social, cultural, ethical, public policy, and legal considerations. In order to accomplish this goal, information will be needed on the nature and magnitude of the hazard present as a result of the incident, the options for reducing risks, and the effectiveness and costs of those options. Decision makers also compare the economic, social, cultural, ethical, legal, and public policy implications associated with each option, as well as the unique safety and health hazards facing emergency responders and ecological hazards the cleanup actions themselves may cause. Often a stakeholder working group can provide input needed to consider all of the relevant information.

Stakeholders can provide valuable input to decision makers during the long-term cleanup effort, and the key decision makers should establish a process that provides for appropriate stakeholder input. Identifying which stakeholders need to be involved in the process depends on the situation. In the case of a site contaminated as a result of an RDD or IND incident, stakeholders may include individuals whose health, economic well-being, and quality of life are currently affected or would be affected by the cleanup and the site's subsequent use, or nonprofit organizations representing such individuals. They may also include those who have

[6] Risk per dose of a fatal cancer for members of the general public is assumed to be about 6×10^{-4} per *rem*. Cancer incidence is assumed to be about 8×10^{-4} per *rem* (see Federal Guidance Report No. 13). Occupational risk coefficients are slightly higher.

regulatory responsibility, and those who may speak on behalf the environment generally, business and economics, or future generations.

Stakeholder input should be considered throughout all stages of the framework as appropriate, including analyzing the risks, identifying potential cleanup options, evaluating options, selecting an approach, and evaluating the effectiveness of the action afterwards. Their input will assist decision makers in providing a reasoned basis for actions to be taken. Further information on the importance and selection of stakeholders can be found in the Framework for Environmental Health Risk Management.

Decision makers can also benefit from the use of working groups that provide expert technical advice regarding the decisions that need to be made during the long-term recovery process. Further information on how to incorporate the use of technical working groups is provided later in this appendix.

(a) The Stages of the Risk Management Framework for Responding to RDD and IND Incidents

The ''Framework for Environmental Health Risk Management'' has six stages:

1. Define the problem and put it in context.
2. Analyze the risks associated with the problem in context.
3. Examine options for addressing the risks.
4. Make decisions about which options to implement.
5. Take actions to implement the decisions.
6. Evaluate results of the actions taken.

Risk management decisions under this framework should do the following:

- Clearly articulate all of the problems in their public health and ecological contexts, not just those associated with radiation.
- Emerge from a decision-making process that elicits the views of those affected by the decision.
- Be based on the best available scientific, economic, and other technical evidence.
- Be implemented with stakeholder support in a manner that is effective, expeditious, and flexible.
- Be shown to have a significant impact on the risks of concern.
- Be revised and changed when significant new information becomes available.
- Account for their multi-source, multimedia, multi-chemical, and multi-risk contexts.
- Be feasible, with benefits reasonably related to their costs.
- Give priority to preventing risks, not just controlling them.
- Be sensitive to political, social, legal, and cultural considerations.

(1) Define the Problems and Put Them in Context

In the case of RDDs, the initial problem is caused by the dispersal of radioactive material. The incident may also result in the release of other types of contaminants (chemical or biological) or create other types of public health hazards. Individuals exposed may include emergency workers and members of the public, and there may be different associated assumptions; for example, how long the individuals will be exposed in the future.

The potential for future radiation exposure of the public from the site must be considered within the context of the societal objectives to be achieved, and must examine cleanup options in the context of other risks members of the community face. There may also be broader public health or environmental issues that local governments and public health agencies have to confront and consider.

The goals of the cleanup effort will extend well beyond the reduction of potential delayed radiation health effects, and may include:

- Public health protection goals, including mitigating acute hazards and long-term chronic issues, and protecting children and other sensitive populations.
- Social and economic goals, such as minimizing disruption to communities and businesses, maintaining property values, and protecting historical or cultural landmarks or resources.
- National security goals, such as maintaining and normalizing use of critical highways, airports, or seaports for mass transit; maintaining energy production; and providing for critical communications.
- Public welfare goals, including maintaining hospital capacity, water treatment works, and sewage systems for protection of community health; assuring adequate food, fuel, power, and other essential resources; and providing for the protection or recovery of personal property.

(2) Analyze the Risks

To make effective risk management decisions, decision makers and other stakeholders need to know what potential harm a situation poses and how great the likelihood is that people or the environment will be harmed. The nature, extent, and focus of a risk analysis should be guided by the risk management goals. The results of a risk analysis—along with information about public values, statutory requirements, court decisions, equity considerations, benefits, and costs—are used to decide whether and how to manage the risks.

Risk analyses can be controversial, reflecting the important role that both science and judgment play in drawing conclusions about the likelihood of effects on public health and the environment. It is important that risk assessors respect both the scientific foundation of risks and the procedures for making inferences about risks in the absence of adequate data. Risk assessors should provide decision makers and other stakeholders with plausible conclusions about risk that can be made on the basis of the available information. They should also provide decision makers with evaluations of the scientific support for their conclusions, descriptions of major sources of uncertainty, and alternative views.

Stakeholders' perception of a risk can vary substantially depending on such factors as the extent to which the stakeholders are directly affected, whether they have voluntarily assumed the risk or had the risk imposed on them, and the nature of their connection with the cause of the risk. For this reason, risk analyses should characterize the scientific aspects of a risk and note its subjective, cultural, and comparative dimensions. Stakeholders play an important role in providing information that should be used in risk analyses and in identifying specific health and ecological concerns.

(3) Examine the Options

This stage of the risk management process involves identifying potential cleanup options and evaluating their effectiveness, feasibility, costs, benefits, cultural or social impacts, and unintended consequences. This process can begin whenever appropriate, after defining the problem and considering the context. It does not have to wait until the risk analysis is completed, although a risk analysis often will provide important information for identifying and evaluating risk management options. In some cases, examining risk management options may help refine a risk analysis. Risk management goals may be redefined after decision makers and stakeholders gain some appreciation for what is feasible, what the costs and benefits are, and how the process of reducing exposures and risks can improve human and ecological health.

Once potential options have been identified, the effectiveness, feasibility, benefits, detriments, and costs of each option must be assessed to provide input into selecting the best option. Key questions include determining (1) the expected benefits and costs, (2) distribution of benefits and costs across the impacted community, (3) the feasibility of the option given the available time, resources, and any legal, political, statutory, and technology limitations, and (4) whether the option increases certain risks while reducing others. Other adverse consequences may be cultural, political, social, or economic. Adverse economic consequences may include impacts on a community, such as reduced property values or loss of jobs, environmental justice issues, and harming the social fabric of a town or tribe by relocating the people away from an area.

Many risk management options may be unfeasible for social, political, cultural, legal, or economic reasons—or because they do not reduce risks to the extent necessary. For example, removing all the soil from an entire valley that is contaminated with radioactive material may be infeasible. On the other hand, the costs of cleaning up an elementary school may be considered justified by their benefits: Protecting children and returning to daily activities and a sense of normalcy. Of course, the feasibility and cost-effectiveness of an option may change in the future.

(4) Make a Decision

A productive stakeholder involvement process can generate important guidance for decision makers. Thus, decisions may reflect negotiation and compromise, as long as risk management goals and intentions are met. In some cases, win-win solutions that allow stakeholders with divergent views to achieve their primary goals are possible. Decision makers should allow the opportunity for public comment on proposed decisions.

Decision makers must weigh the value of obtaining additional information against the need for a decision, however uncertain the

decision may be. Sometimes a decision must be made primarily on a precautionary basis. When sufficient information is available to make a risk management decision, or when additional information or analysis would not contribute significantly to the quality of the decision, the decision should not be postponed.

(5) Take Action To Implement the Decision

When options have been evaluated and decisions made, a plan for action should be developed and implemented. The issuance of protective action recommendations is the responsibility of local officials to protect the public and the environment during emergencies: Long-term cleanup decisions have the same basic risk management framework, but entail substantially more analysis and stakeholder involvement. When government officials and stakeholders have agreed on a strategy, cleanup activities should commence. It may take considerable time for these actions to be completed, and additional decisions may often be necessary as the actions proceed.

(6) Evaluate the Results

Decision makers and other stakeholders must continue to review what risk management actions have been implemented and how effective these actions have been. Evaluating effectiveness involves monitoring and measuring, as well as comparing actual benefits and costs to estimates made in the decision-making stage. The effectiveness of the process leading to implementation should also be evaluated at this stage. Evaluation provides important information about the following: Whether the actions were successful; whether they accomplished what was intended; whether the predicted benefits and costs were accurate; whether any modifications are needed to the risk management plan to improve success; whether any critical information gaps hindered success; whether any new information has emerged which indicates that a decision or stage of the framework should be revisited; whether unintended consequences have emerged; how stakeholder involvement contributed to the outcome; and what lessons can be learned to guide future risk management decisions, or to improve the decision-making process.

Evaluation is critical to accountability and to ensure efficient use of valuable but limited resources. Tools for evaluation include environmental and health monitoring, research, analyses of costs and benefits, and discussions with stakeholders.

(b) Technical Advisory Committee

Making decisions on the appropriate cleanup approaches and levels following an RDD or IND incident will undoubtedly be a challenging task for decision makers. As already noted, the technical issues may be complex. Many potentially competing factors will need to be carefully weighed and decision makers should expect public anxiety in the face of a terrorist act involving radioactive materials. Different regulatory authorities and organizations historically have taken different cleanup approaches for radioactively contaminated industrial sites. Given this context, decision makers will need to determine how best to obtain the necessary technical input to support these decisions and demonstrate to the public that the final decisions are credible and sound.

There are a variety of ways to approach this situation, and decision makers will need to tailor the process to particular site circumstances. This section describes one approach that is available to decision makers, which is based on the ''ad hoc'' mechanisms used for coordinating interagency expertise and assessing the effectiveness in general of the cleanup in response to the 2001 anthrax attacks in Washington, DC. For significant decontamination efforts, the key decision makers may choose to convene an independent committee of technical experts to conduct a deliberative and comprehensive post-decontamination review. The committee would evaluate the effectiveness of the decontamination process and make recommendations on whether the decontaminated areas or items may be reoccupied or reused. It is important to note that although this review may enhance the scientific credibility of the final outcome, final cleanup decisions rest with decision makers.

The committee may consist of experts from Federal agencies, State and tribal public health and environmental agencies, universities and private industries, the local health department, and possibly representatives of local workers and the community. To maximize objectivity, the committee should be an independent group that will provide input to the decision makers, not be a part of the decision-making team.

The scientific expertise in the committee should reflect the needs of the decision makers in all aspects of the decontamination process (*e.g.*, environmental sampling, epidemiology, risk assessment, industrial hygiene, statistics, health physics, and engineering). Agencies on the committee may also have representatives on the technical working group, but in order to preserve the objectivity of the committee, it is best to designate different experts to serve on each group. The chair and co-chair of the committee should not be a part of the decision-making group at the site.

The decision makers should develop a charter for the committee that specifies the tasks committee members are intended to perform, the issues they are to consider, and the process they will use in arriving at conclusions and recommendations. The charter should also specify whether the individual members are expected to represent the views of their respective agencies, or just their own opinions as independent scientific experts. Consensus among committee members is desirable, but may not be possible. If consensus cannot be achieved, the charter should specify how decision makers expect the full range of opinions to be reflected in the final committee report.

In general, the technical peer review committee would evaluate pre- and post-decontamination sampling data, the decontamination plan, and any other information key to assessing the effectiveness of the cleanup. Based on this evaluation, the committee would make recommendations to the decision makers on whether cleanup has reduced contamination to acceptable levels, or whether further actions are needed before re-occupancy.

Appendix 3—Federal Cleanup Implementation

This appendix provides a federally-recommended approach for environmental cleanup after an RDD or IND incident to accompany the risk management principles outlined in Appendix 2. This approach describes how State and local governments may coordinate with Federal agencies, and the public, consistent with the National Response Framework (NRF). The approach does not attempt to provide detailed descriptions of State and local roles and expertise. It is assumed those details will be provided in State and local level planning documents that address radiological/nuclear terrorism incidents.

This site cleanup approach is intended to function under the NRF with Federal agencies performing work consistent with their established roles, responsibilities, and capabilities. Agencies should be tasked to perform work under the appropriate Emergency Support Function, as a primary or support agency, as described in the NRF. This plan is also designed to be compatible with the Incident Command/Unified Command (IC/UC) structure embodied in the National Incident Management System (NIMS).

The functional descriptions and processes in this approach are provided to address the specific needs and wide range of potential impacts of an RDD or IND incident. During the intermediate phase, site cleanup planners should begin the process described below, under the direction of the on-site IC/UC, and in close coordination with Federal, State and local officials. After early and intermediate phase activities have come to conclusion and only long-term cleanup activities are ongoing, the IC/UC structure may continue to support planning and decision-making for the long-term cleanup. The IC/UC may make personnel changes and structural adaptations to suit the needs of a lengthy, multifaceted and highly visible remediation process. For example, a less formal and structured command, more focused on technical analysis and stakeholder involvement, may be preferable for extended site cleanup than what is required under emergency circumstances.

Radiological and nuclear terrorism incidents cover a broad range of potential scenarios and impacts. This appendix assumes that the Federal Government is a primary funding agent for site cleanup. In particular, the process described for the late phase in section (d)(4) of this document assumes an incident of relatively large size. For smaller incidents, all of the elements in this section may not be warranted. The process should be tailored to the circumstances of the particular incident. Decision makers should recognize that for some radiological/nuclear terrorist incidents, states will take the primary leadership role and contribute significant resources toward cleanup of the site. This section does not

address such a scenario, but states may choose to use the process described here.

This implementation plan does not address law enforcement coordination during terrorism incident responses, including how the FBI will manage on-scene activities immediately following an act of terror. Agencies' roles and responsibilities will be implemented according to the NRF and supporting documents. Also, victim triage and other medical response procedures are beyond the scope of this Guidance. The plan presented in this appendix is not intended to impact site cleanups occurring under other statutory authorities such as EPA's Superfund program, the NRC's decommissioning program, or State-administered cleanup programs.

Cleanup Activities Overview

As described earlier in the document, radiological/nuclear emergency responses are often divided roughly into three phases: (1) The early phase, when the plume is active and field data are lacking or not reliable; (2) the intermediate phase, when the plume has passed and field data are available for assessment and analysis; and (3) the late phase, when long-term issues are addressed, such as cleanup of the site. For purposes of this appendix, the response to a radiological or nuclear terrorism incident is divided into two separate, but interrelated and overlapping, processes. The first is comprised of the early and intermediate phases of response, which consists of the immediate and near-term on-scene actions of State, local, and Federal emergency responders under the IC/UC. On-scene actions include incident stabilization, lifesaving activities, dose reduction actions for members of the public and emergency responders, access control and security, emergency decontamination of persons and property, ''hot spot'' removal actions, and resumption of basic infrastructure functions.

The second process pertains to environmental cleanup, which is initiated soon after the incident (during the intermediate phase) and continues into the late phase. The process starts with convening stakeholders and technical subject matter experts to begin identifying and evaluating options for the cleanup of the site. The environmental cleanup process overlaps the intermediate phase activities described above and should be coordinated with those activities. This process is interrelated with the ongoing intermediate phase activities, and the intermediate phase protective actions continue to apply through the late phase until cleanup is complete.

Cleanup planning and discussions should begin as soon as practicable after an incident to allow for selection of key stakeholders and subject matter experts, planning, analyses, contractual processes, and cleanup activities. States may choose to pre-select stakeholders for major incident recovery coordination. These activities should proceed in parallel with ongoing intermediate phase activities, and coordination between these activities should be maintained. Preliminary remediation activities during the intermediate phase—such as emergency removals, decontamination, resumption of basic infrastructure function, and some return to normalcy in accordance with intermediate phase PAGs—should not be delayed for the final site remediation decision.

A process for addressing environmental contamination that applies an optimization process for site cleanup is presented below. As described in this document, optimization is a flexible process in which numerous factors are considered to achieve an end result that considers local needs and desires, health risks, costs, technical feasibility, and other factors. The general process outlined below provides decision makers with input from both technical experts and stakeholder representatives, and also provides an opportunity for public comment. The extent and complexity of the process for an actual incident should be tailored to the needs of the specific incident; for smaller incidents, the workgroups discussed below may not be necessary.

The goals of the process described below are: (1) Transparency—the basis for cleanup decisions should be available to stakeholder representatives, and to the public at large; (2) inclusiveness—representative stakeholders should be involved in decision-making activities; (3) effectiveness—technical subject matter experts should analyze remediation options, consider established dose and risk benchmarks, and assess various technologies in order to assist in identifying a final solution that is optimal for the incident; and (4) shared accountability—the final decision to proceed will be made jointly by Federal, State, and local officials.

Under the NRF, FEMA may issue mission assignments to the involved Federal agencies, as appropriate, to assist in response and recovery. Additional funding may be provided to State/local governments to perform response/recovery activities through other mechanisms. The components of the process are as follows:

(a) General Management Structure

Planning for the long-term cleanup should begin during the intermediate phase, and at that time, a traditional NIMS response structure should still be in place. However, NIMS was developed specifically for emergency management and may not be the most efficient response structure for long-term cleanup. If the cleanup will extend for years, the IC/UC may decide to transition at some point to a different long-term project management structure.

Under the NRF and NIMS, incidents are managed at the lowest possible jurisdictional level. In most cases, this will be at the level of the Incident Command or Unified Command (IC/UC). The IC/UC directs on-scene tactical operations. Responding local, State, and Federal agencies are represented in the IC/UC and Incident Command Post in accordance with NIMS principles regarding jurisdictional authorities, functional responsibilities, and resources provided. For INDs, and large RDDs, multiple Incident Command Posts (ICPs) may be established to manage the incident with an Area Command or Unified Area Command supporting the ICPs and prioritizing resources and activities among them. If the RDD/IND incident happens on a Federal facility or involves Federal materials, the representatives in the UC may change appropriately and the response will be conducted according to the applicable Federal procedures.

Issues that cannot be resolved at the IC/UC or Unified Area Command level may be raised with the JFO and JFO Unified Coordination Group for resolution. The JFO coordinates and prioritizes Federal resources, and when applicable, issues mission assignments to Federal agencies under the Stafford Act. Issues that cannot be resolved at the JFO level may be raised to the DHS NOC, senior-level interagency management groups, and the White House Homeland Security Council.

Day-to-day tactical management, planning, and operations for the RDD/IND cleanup process will be managed at the IC/UC level, but for large-scale cleanups, it is expected that the JFO Unified Coordination Group will review proposed cleanup plans and provide strategic and policy direction. The agency(s) with primary responsibility for site cleanup should be represented in the JFO Unified Coordination Group. The IC/UC will need to establish appropriate briefing venues as the cleanup process proceeds, including the affected mayor(s) and Governor(s).

The discussion below assumes a traditional NIMS IC/UC structure; if the IC/UC transitions later to a different management structure for a longer-term cleanup, the IC/UC would need to determine the appropriate way to incorporate the workgroups described below into that structure.

Appendix 2 presented the general steps in the cleanup process: Analyze the risks, examine the options, make and implement a decision, evaluate the results. This process will be managed by the IC/UC, who ultimately determines the structure and organization of the Incident Command Post, but the discussion below provides one recommended approach for managing the cleanup process within a NIMS ICS response structure. The Incident Command Post Planning Section has the lead for response planning activities, working in conjunction with other sections, and would have the lead for development of the optimization analysis, working closely with the Operations Section. The NIMS describes the units that make up the Planning Section, and allows for additional units to be added depending on site-specific needs. NIMS states that for incidents involving the need to coordinate and manage large amounts of environmental sampling and analytical data from multiple sources, an Environmental Unit may be established within the Planning Section to facilitate interagency environmental data management, monitoring, sampling, analysis, assessment, and site cleanup and waste disposal planning. RDD/IND incidents would involve the collection of not only large amounts of radiological data, but also data related to other environmental and health and safety hazards, and would therefore likely warrant the establishment of an Environmental Unit in the Planning Section. Planning for FRMAC radiological sampling and monitoring activities will be integrated into the Planning Section, and coordinated with other Situation and Environmental Unit data management activities.

The IC/UC would assign the responsibility for coordinating and development of the optimization analysis to a specific unit. For incidents in which the contaminated area is small and the analysis is straightforward, the IC/UC may choose to assign such responsibilities to the Environmental Unit. On the other hand, for large incidents requiring more complicated tradeoffs or the evaluation of cleanup goals with broad implications, the IC/UC may choose to establish a separate unit in the Planning Section (for example, a Cleanup Planning Unit) to coordinate the development of the optimization analysis. The IC/UC may then convene a technical working group and a stakeholder working group, managed by the Environmental or Cleanup Planning Unit, to analyze cleanup options and develop recommendations. The Environmental or Cleanup Planning Unit would coordinate working group processes and interactions and report the results of the optimization analysis and workgroup efforts to the IC/UC through the Planning Section Chief.

The development and completion of the optimization analysis is expected to be an iterative process, and for large incidents, the cleanup will likely proceed in phases, most likely from the ''outside in'' toward the most contaminated areas. The extent of the analysis and process used to develop it would be tailored to the needs of the specific incident, but the following working groups may be convened by the IC/UC to assist decision makers in the optimization process, particularly for large or complex cleanups.

(1) Technical Working Group

A technical working group should be convened as soon as practicable, normally within days or weeks of the incident. The technical working group would be managed by the Planning Section Unit that is assigned responsibility for the optimization analysis. The technical working group may or may not be physically located at the ICP. The group may review data and documents, provide input electronically, and meet with incident management officials. The group may also be asked to participate in meetings with the JFO Unified Coordination Group if needed.

Function: The technical working group provides multi-agency, multi-disciplinary expert input on the optimization analysis, including advice on technical issues, analysis of relevant regulatory requirements and guidelines, risk analyses, and development of cleanup options. The technical working group would provide expert technical input to the IC/UC; it would not be a decision-making body.

Makeup: The technical working group should include selected Federal, State, local, and private sector subject matter experts in such fields as environmental fate and transport modeling, risk analysis, technical remediation options analysis, cost, risk and benefit analysis, health physics/radiation protection, construction remediation practices, and relevant regulatory requirements. The exact selection and balance of subject matter experts is incident-specific. The Advisory Team for the Environment, Food, and Health is comprised of Federal radiological experts in various fields who may warrant representation on the technical working group.

(2) Stakeholder Working Group

The stakeholder working group should be convened as soon as practicable, normally within days or weeks of the incident. The stakeholder working group would be managed by the Planning Section Unit that is assigned responsibility for the optimization analysis. The IC/UC may direct the Public Information Officer (who would coordinate with the JIC) to work with the group, including establishing a process for the group to report out its recommendations. How and where the stakeholder working group would meet to review information and provide its input would need to be determined in conjunction with the group members. The stakeholder working group may also be asked to participate in meetings with the JFO Unified Coordination Group if needed.

Makeup: The stakeholder working group should include selected Federal, State, and local representatives; local non-governmental representatives; and local/regional business stakeholders. The exact selection and balance of stakeholders is incident specific.

Function: The function of the stakeholder working group is to provide input to the IC/UC concerning local needs and desires for site recovery, proposed cleanup options, and other recommendations. The group should present local goals for the use of the site, prioritizing current and future potential land uses and functions, such as utilities and infrastructure, light industrial, downtown business, and residential land uses. The stakeholder working group would not be a decision-making body.

(b) Activities

(1) Optimization and Recommendations

The IC/UC directs the management of the optimization analysis through the Planning Section. Technical and stakeholder working groups assist in performing analyses and developing cleanup options and provide input to the IC/UC, and may be asked to participate in meetings with the JFO Unified Coordination Group if needed. The IC/UC reviews the options described in the optimization analysis and selects a proposed approach for site cleanup, in close coordination with Federal, State and local officials. Again, depending on the incident size, it may be necessary to conduct the cleanup in phases. Thus, decisions on cleanup approaches may also be made in phases. As appropriate for the magnitude of the cleanup task, the IC/UC would brief relevant Federal, State, and local government officials on proposed cleanup plans for approval. This may involve the office of the affected mayor and Governor. At the Federal level, it may involve the JFO Unified Coordination Group and higher-level officials.

(2) Public Review of Decision

The IC/UC should work with the POI and JIC to publish a summary of the process, the options analyzed, and the recommendations for public comments. Public meetings should also be convened at appropriate times. Public comments should be considered and incorporated as appropriate. A reconvening of the stakeholder and/or technical working groups may be useful for resolving some issues.

(3) Execute Cleanup

Cleanup activities should commence as quickly as practicable, and allow for incremental reoccupation of areas as cleanup proceeds. For significant decontamination efforts, the IC/UC may choose to employ a technical peer review advisory committee to conduct a review of the effectiveness of the cleanup. The technical peer review advisory committee is discussed in more detail in Appendix 2.

Appendix 4—Operational Guidelines for Implementation of Protective Action Guides and Other Activities in RDD or IND Incidents

During all phases of an incident, many decisions will need to be made at the field-level, such as making protective action decisions, opening critical infrastructure, limited re-entry of citizens to homes or businesses, release of personal property, and others. This appendix presents operational guidelines being developed to assist decision makers and emergency responders in implementing protective actions and making other on-site decisions.[7] Operational guidelines are levels of radiation or concentrations of radionuclides that can be accurately measured by radiation detection and monitoring equipment that can then be compared to PAGs, or field-level radiation dose decision points (such as for the release of personal property) to quickly determine what action should be taken. In most situations, the operational guidelines will be given in terms of external gamma rates or media-specific (*e.g.*, surfaces, soil, or water) radionuclide concentration units. Both external and internal exposure potential were considered in the development of the operational guidelines.

This appendix discusses the operational guidelines qualitatively and does not provide actual numeric values. The operational guidelines are being developed to provide reasonable assurance that field-level radiation dose decision points and the PAGs recommended in this document can be met under different circumstances. The operational guidelines also address, to some extent, the impact of protective actions, such as controlling wash water after rinsing vehicles to remove contamination. Actual conditions may warrant development of incident-specific guidelines. To support this need, the RESRAD–RDD[8] software tool was developed to allow for easy and timely calculation of site-specific operational

[7] For purposes of this appendix, ''relocation area'' refers to an area that local officials have determined is not safe for prolonged occupation by the public, based on the intermediate phase PAGs, and have recommended that the public be relocated.

[8] RESRAD–RDD is a computer modeling tool developed by the U.S. Department of Energy for calculating radiation concentrations on different media, and doses and dose rates following an RDD incident.

guidelines that can be tailored to the specific emergency and the required response.

The operational guidelines are organized into seven groups that are generally categorized by the phase of emergency response in which they would be implemented or used for planning purposes. Individual groups are further categorized into subgroups as appropriate. Table 3 summarizes operational guideline groups and subgroups. A summary description of these groups and subgroups is provided below. Detailed descriptions of the operational guidelines, to include their technical derivation, intended application, and tools to assist in their application, are provided in the Preliminary Report on Operational Guidelines Developed for Use in Emergency Preparedness and Response to a Radiological Dispersal Device Incidents (DOE/HS–0001, available at *http://www.ogcms.energy.gov*).

TABLE 3—OPERATIONAL GUIDELINES: GROUPS AND SUBGROUPS

Groups	Subgroups
A. Access control during emergency response operations	1. Life and property-saving measures. 2. Emergency worker demarcation.
B. Early-phase protective action	1. Evacuation. 2. Sheltering.
C. Relocation from different areas and critical infrastructure utilization in relocation areas	1. Residential areas. 2. Commercial and industrial areas. 3. Other areas, such as parks and monuments. 4. Hospitals and other health care facilities. 5. Critical transport facilities. 6. Water and sewer facilities. 7. Power and fuel facilities.
D. Temporary access to relocation areas for essential activities	1. Worker access to businesses for essential actions. 2. Public access to residences for retrieval of property, pets, records.
E. Transportation and access routes	1. Bridges. 2. Streets and thoroughfares. 3. Sidewalks and walkways.
F. Release of property from radiologically controlled areas	1. Personal property, except wastes. 2. Waste. 3. Hazardous waste. 4. Real property, such as lands and buildings.
G. Food consumption	1. Early-phase food guidelines. 2. Early-phase soil guidelines. 3. Intermediate-phase soil guidelines. 4. Intermediate- to late-phase soil guidelines.

(a) Group A: Access Control During Emergency Response Operations

These operational guidelines are designed to assist responders in decision making for worker health and safety in the early to intermediate phases of response when the situation has not been fully stabilized or characterized. They are designed to guide responders in establishing radiological control zones or boundaries for the areas directly impacted by the RDD or IND incident where first responders and emergency response personnel are working. They are not intended to restrict emergency worker access, but rather to inform workers of potential radiological hazards that exist in the area and to provide tools to those responsible for radiation protection during response activities. These operational guidelines may be used to restrict the access of nonessential personnel and members of the public to specific areas. Examples of operational guidelines developed in this group include life- and property-saving measures and emergency worker zone demarcation.

Group A operational guidelines are expressed as a series of reference ''stay time'' tables for responders who may have only limited health physics information and personal protective equipment at the time of the response. For example, the health physics information available to them could include or be limited to measurements of the external exposure rate, gross alpha surface contamination, beta/gamma surface contamination, and/or air concentration. Radionuclide-specific correction factors as well as radionuclide-specific and respiratory protection-specific tables are also provided. Stay times are provided for a range of doses (*i.e.*, 0.1 *rem* (.001 *Sv*), 0.5 *rem* (.005 *Sv*), 1 *rem* (.01 *Sv*), 2 *rem* (.02 *Sv*), 5 *rem* (.05 *Sv*), 10 *rem* (.10 *Sv*), 25 *rem* (.25 *Sv*), 100 *rem* (1 *Sv*), many of which correspond to guidelines used for workers and the public).

(b) Group B: Early-Phase Protective Action (Evacuation or Sheltering)

Group B operational guidelines are designed to help decision makers make timely protective action decisions, such as whether to evacuate or shelter the general public in the early phase. These operational guidelines are similar to values presented in the FRMAC Assessment Manual for evacuation and sheltering. Group B operational guidelines are typically expressed as limiting concentrations of radioactivity in surface soil.

(c) Group C: Relocation and Critical Infrastructure Utilization in Affected Areas

These operational guidelines are intended for early-to intermediate-phase protective actions. They are designed for use in deciding whether to relocate the public from affected areas for a protracted period of time. Screening values are provided to delineate areas that exceed the relocation PAGs. These areas include residential areas, commercial/industrial areas, and other areas such as parks, cemeteries, and monuments. Group C operational guidelines also assist in efforts to ensure that facilities critical to the public welfare can continue to operate, if needed. These facilities include hospitals, airports, railroads and ports, water and sewer facilities, and power and fuel facilities. These operational guidelines are typically expressed as soil, building, or street-surface contamination concentrations (*e.g., pCi*/m^2).

(d) Group D: Temporary Access to Relocation Areas for Essential Activities

Group D operational guidelines pertain to intermediate phase protective actions. They are designed to assist in determining constraints necessary to allow for temporary access to restricted (relocation) areas. For example, the public, or owners/employees of businesses, may need temporary access to residences, or commercial, agricultural, or industrial facilities in order to retrieve essential records, conduct maintenance to protect facilities, prevent environmental damage, attend to animals, or retrieve pets. These operational guidelines describe the level and timeframes at which these actions can be taken without supervision or radiological protections. The public or employees may occasionally (*e.g.*, a few days per month) access areas that do not exceed these guidelines. Temporary access to

relocation areas that exceed these levels should be permitted only under the supervision, or with the permission of, radiation protection personnel. The guidelines are typically expressed in terms of stay-times during which the public or employees may access the areas without receiving a predetermined dose.

(e) Group E: Transportation and Access Routes

These operational guidelines apply to intermediate phase actions. They are designed to assist in determining whether transportation routes (*e.g.*, bridges, highways, streets) or access ways (*e.g.*, sidewalks and walkways) may be accessed by the public for general, limited, or restricted use. The relocation PAGs serve as the basis for these operational guidelines. For example, operational guidelines may be defined for industrial or commercial use of various roads, bridges, or access ways. These may be necessary to allow for access between non-relocation areas via a highway that passes through a relocation area or for access to recovery areas in the immediate area of an incident. These operational guidelines assume regular or periodic use and are not appropriate for one-time events, such as evacuation or relocation actions. They are typically expressed as surface contamination concentrations (*e.g., pCi*/m^2).

(f) Group F: Release of Property From Radiologically Controlled Areas

Group F operational guidelines are intended for intermediate to long-term recovery-phase protective actions. During response and recovery operations, property and wastes must be cleared from radiologically controlled areas (relocation areas). Property includes personal property, debris and non-radiological wastes, hazardous waste, and real property (*e.g.*, buildings and lands). These operational guidelines support such actions. Because subsequent retrieval of cleared, or released, properties will be difficult, these levels should be consistent with late-phase cleanup goals wherever practicable. For this reason, they should not be applied to property that will continue to be used within controlled areas. These operational guidelines should also be used for screening property that was located outside the controlled area for possible contamination. In general, the operational guidelines in this group provide reasonable assurance that the cleared property is acceptable for long-term, unrestricted use (or appropriate disposition, in the case of wastes) without further radiological reassessment or control.

For personal property such as vehicles and equipment, the operational guideline values were derived using the ANSI N13.12 standard clearance screening levels.[9] These draft operational guidelines are available for review and use as appropriate at *http://www.ogcms.energy.gov.* The guidelines establish three property categories: at greater than 200 times ANSI N13.12 screening levels, monitored remediation or control is recommended; at levels between 10 and 200 times the levels, self-remediation (conventional washing) of the property is recommended as soon as practical; and below the self-remediation levels, no control or protective action is necessary.

Operational guidelines for real property (buildings and lands) are designed to assist on-scene decision-making, and in development of the cleanup options described in section (d)(4), Late Phase Guidance, of this document. Section (d)(4) on long-term cleanup incorporates the principle of site-specific optimization, and highlights stakeholder involvement and shared accountability. The guidelines for real property are unique in that there is no one specific, predefined numeric criterion (*i.e.*, expressed in terms of concentration, dose, or risk) on which to base decisions. These guidelines are intended to be utilized in the optimization process, which will likely consider the magnitude and extent of the contamination and the radionuclide(s) involved, the proposed long-term land and building use in the affected areas, the need for expedited recovery, public welfare issues, the cost impacts for each proposed cleanup option, the ecological considerations, and other factors. Real property operational guidelines are provided as reference values (*e.g.*, soil and building-surface concentrations or risks) that can be used as a starting point for evaluating options and impacts relative to a range of dose or risk-based benchmarks (*e.g.*, 500, 100, 25, or 4 *millirem* per year; lifetime risk ranges, and others) that could be considered as part of cleanup options analysis. Thus, they are not regulatory dose limits or criteria, but serve as concentration values that provide support to the optimization analyses.

(g) Group G: Food Consumption

Group G operational guidelines apply to early through long-term recovery phase protective actions, as needed. They are designed to aid in decision making about the need for placing restrictions on consumption of contaminated foods or on agricultural products during and following an RDD or IND incident. Four subgroups were developed (Subgroups G.1–G.4; see Table 4A), which are intended for use in conjunction with the operational guidelines in other groups. Subgroup G.1 guidelines pertain to food consumption in the early response phase immediately after an incident. These guidelines can be used to screen against measured concentrations taken from previously harvested food or from animal products exposed during the incident. Subgroup G.1 guidelines also can be used to determine the need for a food embargo, or restrictions on consumption of contaminated foods. Subgroup G.2 guidelines, soil guidelines, also apply to the early phase of response, but they are intended for use in evaluating crops or animal products exposed during the RDD incident (*e.g.*, after the plume has passed). They serve as a comparison with measured concentrations taken from surface soil in which plant foods and fodder had been growing during the incident. Subgroups G.3 and G.4 are intended for use of soil in the intermediate to long-term recovery phases and can be used for placing land use restrictions on agricultural activities after an RDD incident. They can be used to determine if crops can be grown on residually contaminated soil to produce a harvest that would be acceptable for public consumption.

(h) Derivation of Operational Guidelines

Operational guidelines for each group are being derived through a systematic approach in which, (1) applicable release/exposure scenarios for each group were defined, (2) appropriate human receptors for each scenario were identified, and (3) the receptor doses from applicable exposure pathways were estimated. Operational guidelines (Groups A–G; see Table 4A), which correspond to specific PAGs, were derived for 11 potential RDD radionuclides:[10] Am-241, Cf-252, Cm-244, Co-60, Cs-137, Ir-192, Po-210, Pu-238, Pu-239, Ra-226, and Sr-90. The concepts and overarching methodology used to derive operational guidelines for RDD-related radionuclides could also be generally applied, with modifications, to radionuclides associated with an IND.

Additional RDD or IND incident scenarios were analyzed to support the derivation of the operational guideline groups and subgroups described above. Two of these additional scenarios involve the use of water to flush streets and clean vehicles. Accordingly, operational guidelines for street flushing and cleaning contaminated vehicles are also provided. The operational guidelines will be submitted in the **Federal Register** for comment prior to finalization.

Appendix 5—References and Resources

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''Guidance: Potassium Iodide as a Thyroid Blocking Agent in Radiation Emergencies.'' Food and Drug Administration, 66 FR 64046, Dec. 11, 2001.

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[9] The American National Standards Institute (ANSI) produces consensus based national standards. ANSI standard N13.12, Surface and Volume Radioactivity Standards for Clearance, can be found at *http://hps.org/hpssc/N13_12_1999.html.*

[10] These radionuclides were determined by a joint DOE and NRC study to be the most likely sources available for potential terrorist use in an RDD (Interagency Working Group on Radiological Dispersal Devices, May 2003) (DOE/NRC 2003).

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''Standards for Protection Against Radiation.'' Nuclear Regulatory Commission. 10 CFR part 20.
''Surface and Volume Radioactivity Standards for Clearance.'' American National Standards Institute (ANSI), N13.12 (1999).

Appendix 6—Acronyms/Glossary

AMS Aerial Measuring System—A DOE technical asset consisting of both fixed wing and helicopter systems for measuring radiation on the ground; a deployable asset of the NIRT.
ALARA As low as reasonably achievable—A process to control or manage radiation exposure to individuals and releases of radioactive material to the environment so that doses are as low as social, technical, economic, practical, and public welfare considerations permit.
ANSI American National Standards Institute.
ARS Acute Radiation Syndrome.
CERCLA Comprehensive Environmental Response, Compensation, and Liability Act, commonly known as Superfund. This legislation was enacted by Congress in 1980 to protect households and communities from abandoned toxic waste sites.
CFR Code of Federal Regulations.
CMS Consequence Management Site Restoration, Cleanup and Decontamination Subgroup.
DEST Domestic Emergency Support Team—A technical advisory team designed to pre-deploy and assist the FBI Special Agent in Charge. The DEST may deploy after an incident to assist the FBI.
DHS U.S. Department of Homeland Security.
DIL Derived Intervention Level—The concentration of a radionuclide in food expressed in Becquerel/kg which, if present throughout the relevant period of time (with no intervention), could lead to an individual receiving a radiation dose equal to the PAG.
DOD U.S. Department of Defense.
DOE U.S. Department of Energy.
DRL Derived Response Level—A level of radioactivity in an environmental medium that would be expected to produce a dose equal to its corresponding PAG.
EMP Electromagnetic Pulse—Electromagnetic radiation from a nuclear explosion.
EMS Emergency Medical Service.
EOC Emergency Operations Center—A response entity's central command and control center for carrying out emergency management functions.
EPA U.S. Environmental Protection Agency.
ESF Emergency Support Function—The ESFs provide the structure for coordinating Federal interagency support for domestic incident response.
FBI Federal Bureau of Investigation, U.S. Department of Justice.
FCO Federal Coordinating Officer—Appointed by the Director of the Federal Emergency Management Agency, on behalf of the President, to coordinate federal assistance to a state affected by a disaster or emergency.
FDA Food and Drug Administration, U.S. Department of Health and Human Services.
FRMAC Federal Radiological Monitoring and Assessment Center—A coordinating center for Federal, State, and local field personnel performing radiological monitoring and assessment—specifically, providing data collection, data analysis and interpretation, and finished products to decision makers. The FRMAC is a deployable asset of the NIRT administered by DOE. For more information, see *http://www.nv.doe.gov/nationalsecurity/homelandsecurity/frmac/default.htm*.
FRN **Federal Register** Notice.
Gy One *gray* is equal to an absorbed dose (mean energy imparted to a unit of matter mass) of 1 *joule/kilogram*. 1 *gray* (*Gy*) = 10,000 *erg/g* = 100 *rad*.
HHS U.S. Department of Health and Human Services.
HAZWOPER Hazardous Waste Operations and Emergency Response Standard (29 CFR 1910.120).
HSPD Homeland Security Presidential Directive—Executive Order issued to the Federal agencies by the President on matters pertaining to Homeland Security.
IC/UC Incident Command/Unified Command—A system to integrate various necessary functions to respond to emergencies. The system is widely used by local responders. Under Unified Command, multiple jurisdictional authorities are integrated.
ICP Incident Command Post—The field location where the primary functions are performed. The ICP may be co-located with the incident base or other incident facilities.
ICRP International Commission on Radiological Protection.
ICS Incident Command System—A standardized, on-scene, all-hazard incident management concept. ICS is based upon a flexible, scalable response organization providing a common framework within which people can work together effectively.
IND Improvised Nuclear Device—An illicit nuclear weapon that is bought, stolen, or otherwise obtained from a nuclear State, or a weapon fabricated by a terrorist group from illegally obtained fissile nuclear weapons material and produces a nuclear explosion.
JFO Joint Field Office—The operations of the various Federal entities participating in a response at the local level should be collocated in a Joint Field Office whenever possible, to improve the efficiency and effectiveness of Federal incident management activities.
JFO Unified Coordination Group JFO structure is organized, staffed and managed in a manner consistent with NIMS principles and is led by the Unified Coordination Group. Personnel from Federal and State departments and agencies, other jurisdictional entities and private sector businesses and NGOs may be requested to staff various levels of the JFO, depending on the requirements of the incident.
JIC Joint Information Center—A focal point for the coordination and provision of

information to the public and media concerning the Federal response to the emergency.

JOC Joint Operations Center—The focal point for management and coordination of local, State and Federal investigative/law enforcement activities.

KI Potassium Iodide.

LNT or LNT model—Linear no-threshold dose-response for which any dose greater than zero has a positive probability of producing an effect (*e.g.* , mutation or cancer). The probability is calculated either from the slope of a linear (L) model or from the limiting slope, as the dose approaches zero, of a linear-quadratic (LQ) model.

MERRT Medical Emergency Radiological Response Team—Provides direct patient treatment, assists and trains local health care providers in managing, handling, and treatment of radiation exposed and contaminated casualties, assesses the impact on human health, and provides consultation and technical advice to local, State, and Federal authorities.

NCP National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR part 300)—The Plan provides the organizational structure and procedures for preparing for and responding to discharges of oil and releases of hazardous substances, pollutants, and contaminants.

NCRP National Council on Radiation Protection and Measurements.

NIEHS National Institute for Environmental Health Sciences.

NIMS National Incident Management System—The Homeland Security Act of 2002 and HPSD–5 directed the DHS to develop NIMS. The purpose of the NIMS is to provide a consistent nationwide approach for Federal, State, and local governments to work effectively and efficiently together to prepare for, respond to, and recover from domestic incidents.

NIRT Nuclear Incident Response Team—Created by the Homeland Security Act of 2002, the NIRT consists of radiological emergency response assets of the DOE and the EPA. When called upon by the Secretary for Homeland Security for actual or threatened radiological incidents, these assets come under the ''authority, direction, and control'' of the Secretary.

NOC National Operations Center.

NPP Nuclear Power Plant.

NRC U.S. Nuclear Regulatory Commission.

NRF National Response Framework—The successor to the National Response Plan. The Framework presents the doctrine, principles, and architecture by which our nation prepares for and responds to all-hazard disasters across all levels of government and all sectors of communities.

OSHA Occupational Safety and Health Administration, U.S. Department of Labor.

PAG Protective Action Guide—The projected dose to a reference individual, from an accidental or deliberate release of radioactive material at which a specific protective action to reduce or avoid that dose is recommended.

PFO Principal Federal Official—The PFO will act as the Secretary of Homeland Security's local representative, and will oversee and coordinate Federal activities for the incident.

PIO Public Information Officer—The PIO acts as the communications coordinator or spokesperson within the Incident Command System.

PPE Personal protective equipment.

R Roentgen—Measure of exposure in air.

Rad Radiation absorbed dose. One rad is equal to an absorbed dose of 100 *erg/gram* or 0.01 *joule/kilogram*. 1 *rad* = 0.01 *gray* (*Gy*).

RAP Radiological Assistance Program—A DOE emergency response asset that can rapid deploy at the request of State or local governments for technical assistance in radiological incidents. RAP teams are a deployable asset of the NIRT.

RDD Radiological Dispersal Device—Any device that causes the purposeful dissemination of radioactive material, across an area with the intent to cause harm, without a nuclear detonation occurring.

REAC/TS Radiation Emergency Assistance Center/Training Site—A DOE asset located in Oak Ridge, TN, with technical expertise in medical and health assessment concerning internal and external exposure to radioactive materials. REAC/TS is a deployable asset of the NIRT.

Rem Roentgen Equivalent Man; the conventional unit of radiation dose equivalent. 1 *rem* = 0.01 *sievert* (*Sv*).

REMM Radiation Event Medical Management—A Web-based algorithm providing just-in-time information for medical responders. It is also useful for education and training. Developed by the Office of Assistant Secretary for Preparedness and Response and the National Library of Medicine. Available at *http://www.remm.nlm.gov*.

RERT Radiological Emergency Response Team—An EPA team trained to do environmental sampling and analysis of radionuclides. RERT provides assistance during responses and takes over operation of the FRMAC from DOE at a point in time after the emergency phase. RERT is a deployable asset of the NIRT.

Shelter-in-Place The use of a structure for radiation protection from an airborne plume and/or deposited radioactive materials.

SI International System of Units.

Stakeholder A stakeholder is anybody with an interest (a 'stake') in a problem and its solution. The involvement of stakeholders (*i.e.*, parties who have interests in and concern about a situation) is seen as an important input to the optimization process. It is a proven means to achieve incorporation of values into the decision-making process, improvement of the substantive quality of decisions, resolution of conflicts among competing interests, building of shared understanding with both workers and the public, and building of trust in institutions. Furthermore, involving all concerned parties reinforces the safety culture, and introduces the necessary flexibility in the management of the radiological risk that is necessary to achieve more effective and sustainable decisions.

Sv Sievert; the SI unit of radiation dose equivalent. 1 *Sv* = 100 *rem*.

TEDE Total effective dose equivalent—The sum of the effective dose equivalent from external radiation exposure and the committed effective dose equivalent from internal exposure.

Dated: July 18, 2008.

Michael Chertoff,

Secretary, U.S. Department of Homeland Security.

[FR Doc. E8–17645 Filed 7–31–08; 8:45 am]

BILLING CODE 9110–21–P

DEPARTMENT OF HOMELAND SECURITY

Transportation Security Administration

Extension of Agency Information Collection Activity Under OMB Review: TSA Customer Comment Card

AGENCY: Transportation Security Administration, DHS.

ACTION: 30 Day Notice.

SUMMARY: This notice announces that the Transportation Security Administration (TSA) has forwarded the Information Collection Request (ICR) abstracted below to the Office of Management and Budget (OMB) for review and approval of an extension of the currently approved collection under the Paperwork Reduction Act. The ICR describes the nature of the information collection and its expected burden. TSA published a **Federal Register** notice, with a 60-day comment period soliciting comments, of the following collection of information on May 9, 2008, 73 FR 26404. TSA uses a customer comment card to collect passenger comments including complaints, compliments, and suggestions at airports.

DATES: Send your comments by September 2, 2008. A comment to OMB is most effective if OMB receives it within 30 days of publication.

ADDRESSES: Interested persons are invited to submit written comments on the proposed information collection to the Office of Information and Regulatory Affairs, Office of Management and Budget. Comments should be addressed to Nathan Lesser, Desk Officer, Department of Homeland Security/TSA, and sent via electronic mail to *oira_submission@omb.eop.gov* or faxed to (202) 395–6974.

FOR FURTHER INFORMATION CONTACT: Joanna Johnson, Communications Branch, Business Management Office, Operational Process and Technology, TSA–11, Transportation Security Administration, 601 South 12th Street, Arlington, VA 22202–4220; telephone

APPENDIX I

LATE BREAKING NEWS

After I returned home on July 2, 2010 from over a week in Salt Lake City (SLC) to attend the annual meeting of the Health Physics Society, see friends, and tour some of the city with Phyllis, I have had thoughts the following months about what I learned in SLC and after, and that I should share them here.

The Good News

Two of the mornings in SLC, I met and spent time with Steve Jones, a painting contractor, who on his own time and away from his work in SLC has spent three decades visiting firehouses, police stations, other responder organizations. He has been successful in Utah and some other states in distributing thousands of pieces of information and some SIRAD and RADSticker samples to those who would be called upon for responses to any nuclear or RDD attacks (see also Jones (2009)). I learned from Steve some approaches and techniques that could be useful to health physicists or others involved in instructing responders to accidental or terrorist dispersals of radioactive material. Steve is doing on many days a year what I had hoped about 6,000 members of the HPS would be doing, each at least once per year, following organizational and procedural recommendations developed in 2001-2002 by the Ad Hoc Committee on Homeland Security. I still hope that more professionals, and those trained by them, will go out to responders and the public and better prepare them to deal appropriately with radioactivity spread to the environment. (See "The Hart Model" (Brodsky 2005).)

One of the lessons I learned from Steve is that it is possible with perseverance to find a journalist who will report accurately the information quickly presented about radiation phenomena and means of protection. Exhibit 47 shows a news article and picture published the day after the HPS meeting, from an interview arranged by Steve after a number of approaches to newspaper offices and calls to reporters, even while Steve drove with me around to visit informally with a number of responders at different locations. I let Steve introduce me and Dr. Patel, the inventor and manufacturer of the SIRAD dosimeters, and we all talked rapidly to the reporter and her photographer in the limited time available to the reporter after Dr. Patel's HPS talk. We tried not to interrupt each other, but were apparently able to get our main points across in this rapid, informal discussion. The main thrust of the reporter's article is accurate. Only my participation in the first two hydrogen bomb tests is somewhat reversed, but that does not affect the main message we wanted to give to the public. To me, this is an unusual happening that a reporter, without checking back with the person interviewed, comes out with the accurate information intended. Thus, I am encouraged that with enough perseverance, there are still chances to get necessary information out to the public through capable reporters, despite some of the experiences with the media that I have shared in Chapter 1.

http://www.deseretnews.com/article/700045334/Scientist-promotes-personal-devices-to-monitor-radiation-levels.html
Saturday, July 3, 2010 — Last update: 1:17 a.m. MDT
http://www.deseretnews.com/home/

Scientist promotes personal devices to monitor radiation levels

By Amy Joi O'Donoghue

Deseret News • Published: Friday, July 2, 2010 11:10 p.m. MDT



Gordhan Patel, founder of JP Laboratories, and Dr. Allen Brodsky display a RADTriage, a radiation dosimeter. Laura Seitz, Deseret News

SALT LAKE CITY — Too many people, including first responders like police and firefighters, have an irrational fear of exposure to even small doses of radiation — fear that one noted physicist says will lead to chaos in a nuclear or radiological attack.

Allen Brodsky, who was in town this week for a meeting of the Health Physics Society, said the public's lack of understanding about radiation and a reluctance by policymakers to educate the nation leaves the country vulnerable.

"More people will be injured or die in the panic of an attack than will die from radiation itself," Brodsky said. "Even the ill-equipped first responders will scream and run away, and so what is the public going to do?"

Brodsky, an adjunct professor at Georgetown University and the society's first chairman of the homeland security committee, stressed the need for first responders and even the public to have a personal dosimeter that monitors radiation exposure.

Such knowledge, he argued, is essential to assess the degree of exposure, if evacuation is necessary and, alternately, if panic can be avoided because there are no long-term health risks.

Brodsky, 82, is well acquainted with those risks, having worked on prompt radiation measurements at the nation's first H-bomb test, MIKE shot at Operation IVY, at Enewetak Atoll in 1952. Brodsky — an Army scientist at the time — drove a truck up a muddy beach to calibrate the gamma detectors. After the first two H-bomb detonations at the 1954 Operation CASTLE, Brodsky dropped off a helicopter to pick up his neutron spectrometers for about five minutes in a field of 30,000 mR per hour, which is more than one million times the

highest U.S. natural background exposure rate. His adventures are described in his book, Actions for Survival, to be published in 2011.

Such experiences, coupled with his academic career, have led Brodsky and others to push police officers, firefighters and the public in general to get a SIRAD, a self-indicating instant radiation alert dosimeter, or the smaller RADSticker, which uses radiosensitive ink.

After 9/11, the Department of Defense hired Gordhan Patel, founder of JP Laboratories, to develop the devices for use by the military and police. Patel said he sank $1 million of his own money into the products' development, while another $3 million was funded by the government.

Since then, the products have been distributed free to thousands of police officers or firefighters across the country. At least 18 police or fire agencies in Utah are using them, including South Salt Lake, Layton and the Davis County Sheriff's Office, said Stephen Jones, who describes himself as a "social entrepreneur" trying to get the word out.

Jones was in Layton earlier this year and met with the city's assistant manager, Jim Mason, who oversees the city's emergency response functions.

"I tell them the long training takes 42 seconds and the short training takes 30 seconds," explained Jones, who hands out a billfold-size piece of paper on steps to take in the event of radiation exposure. The training includes handing out the SIRAD, which is the size of a credit card, color-blind friendly and non-electronic, or the RADSticker, which is about the size of a postage stamp. Both have a sensor material that turns blue upon polymerization by radiation. They cost less than $10 but are available free via grants to emergency responders.

Jones, who belongs to Physicians for Civil Defense, said that organization makes them available to emergency responders, as well.

Mason said when he was approached about the products and the training, he was intrigued.

"My feeling was 'what do we have to lose?' If you look at all the hazards that could potentially occur, it is something that we ought to be aware of," he said. "While that hazard in Utah may be lower than others, my goal is to protect against all of them."

More information on the personal dosimetry devices can be found at the government's website, www.tswg.gov, by searching "SIRAD."e-mail: amyjoi@desnews.com
http://www.deseretnews.com/mobile/article/700045334/Scientist-promotes-radiation-monitor.html

EXHIBIT 47 — An Accurate Newspaper Article About the Need for Distributing Personal Monitors to Responders and the Public.

The above article (O'Donoghue 2010) is an example of the possibility of getting competent reporters to present the needed factual information about radiation exposures and risks. The reader of this book may note that my participation on the first H-bomb test, Operation Ivy, involved developing the detectors that measured prompt radiation signals for diagnostic use and calibrating them in the field with an intense gamma source that I drove onto an island in a truck. I was not exposed to high gamma fields on Operation Ivy because others entered onto the island to retrieve data then. It was on Operation Castle that I jumped from a helicopter onto an island in 30,000 mR per hour to retrieve my neutron spectrometers as shown in Exhibits a, b, and c. However, one could not expect the reporter, Amy Joi O'Donoghue, to be concerned about that superfluous information while trying to take notes on a pad from three different interviewees, who sometimes interrupted each other in the haste to provide understandable information to a very busy reporter. The accuracy of the **most important** information as presented is a tribute to Amy's professionalism.

Some other things I learned from Steve were: 1) it sometimes takes 5 or more visits to a site to find someone who will listen to an unexpected visitor; 2) one must be prepared to talk from only 30 seconds to minutes, and hope for future visits; 3) handing out the simpler types of handy pocket cards of the HPS Homeland Security Committee or that developed by Steve Jones, as presented in Appendix C, together with free samples of the RADTriage and/or small RADSticker and information about obtaining them, is usually met with gratitude and understanding by responders; and 4) it is best to give more priority to visiting fire stations than police stations, since police often depend on the firemen or associated responders to monitor the environment in an emergency.

Steve also suggested, as he has done, to find supporters who are able to pay for a supply of dosimeters as a charitable gift for homeland security, sending it to Dr. Jane Orient, President of Doctors for Disaster Preparedness, and President of Physicians for Civil Defense, so that their gift may be deductible. While most Federal and State officials have not yet seen the need to urge State and local officials to buy dosimeters in large quantities for their responders using the Department of Homeland Security grant funds, Steve feels that local responders will welcome and put to use such dosimeters with minimal instruction, as long as they are provided free of cost. Dr. Orient may be contacted at jorient@mindspring.com . Crowe and Company may be contacted at sales@croweandco.com for assistance to State and local agencies in applying for RadTriage card dosimeters under Federal grants; and Dr. Gordhan Patel may be contacted at gnpatel@jpl.com for information on the smaller RADSticker. Dr. Patel has also set up a new website that provides more details about the advantages of the RADSticker, as well as information that could be put on a brief information handout, such as those in Appendix C. The new website is http://www.jplabs.com/sticker.html.

Shane Connor, whose website is http://www.ki4u.com, may also soon be involved in supplying RADStickers, as well as many other provisions and references for use in homeland security. The RADTriage cards, which have been tested and approved by DHS and provide easier readings in the low rad range, are available with assistance on grant applications, from JP Laboratories, Inc. These cards should be provided to all responders together with RADStickers for their wallets.

The following information is adapted from this new website with Dr. Patel's permission. I think that it is very well written to explain the importance of distributing this dosimeter to the U.S. population, to prevent panic, allow any necessary triage, and obtain early information on the doses received throughout the affected populations. In presenting Dr. Patel's statements in bold font below, I am not intending to supercede any other statements made in this book. I happen to believe that everyone should carry not only RADStickers in wallets, etc., but also have the larger and government-tested SIRAD card in a pocket or purse, as indicated in Chapter 8. Purchased in bulk, the larger card at about $10 apiece should not be beyond affordability, considering its long life and potential for saving life.

WHY EVERYONE SHOULD CARRY A RADSticker™

Why we need to carry a dosimeter: People and governments around the world are concerned about incidents, such as terrorist attacks using a dirty bomb or a small nuclear device, an accident at a nuclear power plant (e.g., Chernobyl, Ukraine) and mishandling of a radiation source (e.g., Goiania, Brazil). Such incidents could cause wide spread panic, massive disruption of our lives and worries about the exposure to radiation. The problem with radiations is that they can't be seen, smelled or felt and can cause cancer, injuries or deaths. Hence, affected people want to know their radiation exposure immediately, *"Did I receive a lethal exposure to ionizing radiation, will I be OK or will I develop cancer in future?"*. First responders (military, police, firefighters, medical personnel, etc.) need to quickly assess radiation exposure among the affected to ensure that treatment is first provided to those who need it the most. RADSticker, a member of SIRAD® (**S**elf-Indicating **I**nstant **R**adiation **A**lert **D**osimeter) family of dosimeters answers those questions instantly and cheaply. Carry a RADSticker to instantly know your exposure to harmful dose 24/7.

A FEW MINUTES OF RADIATION TRAINING

Only basic information & steps are provided here. Additional information and actions on these complex matters are provided in the references cited (in Dr. Patel's website).

Basic information: Avoid unnecessary exposure to ionizing radiation (e.g., gamma or X-rays); in large enough amounts they can cause cancer, injuries and death. Diagnostic dosages (chest X-rays = ~0.05 rad (0.5 mSv) and CT scan = ~1 rad/10 mSv) are considered acceptable risks (except for fetus and children). The public is advised to limit exposure to 5 rad/50 mSv per year and 25 rad/250 mSv for lifetime and emergency workers to 50 rad/500 mSv http://hps.org/publicinformation/ate/faqs/regdoselimits.html. There are no symptoms or medical treatment below ~50 rad/500 mSv exposure. Contact an emergency room if exposed to dosages higher than 50 rad/500 mSv. Depending upon the dose and the dose period, nausea, vomiting and hair loss are usually the early symptoms after receiving radiation doses above 100 rad/1,000 mSv. If you are contaminated go to the nearest place and take a shower.

Nuclear bomb explosion: If you hear a huge explosion and/or see an extremely bright flash, drop and cover yourself for a few minutes. Keep eyes closed. Dangerous level of radioactive materials can fall (fallout) over a few tens of square miles. The fallout from the explosion looks like sand, ash or grit. Fallout loses 90% of its radioactivity every 7 hours, 99% in 2 days and 99.9% in 2 weeks, so stay indoors far from outside and behind heavy materials.

Dirty bomb/RDD: The major objectives of a radiological dispersion device (RDD) are to cause panic, worry and mass disruption. The radioactivity of the barely noticeable fallout is likely to be very low and limited to a few miles. While the area may be deemed unlivable, barely a few people may get doses higher than 5 rad/50 mSv. There is no need to panic.

Accident at a nuclear power plant/reactor: If it is a minor radiation leakage, it is extremely unlikely you will receive a harmful dose. If the accident is major/serious, e.g., a meltdown (as that of Chernobyl nuclear reactor, Ukraine), the dose could be fatal (>600 rad/6,000 mSv) for those who are near the reactor. Remain behind a thick object/wall or basement. Wait for instructions from the authority/government.

Improper handling of radiation sources: You will learn about these types of incidents (e.g., that of Goiania, Brazil) only after a handler is seriously injured. Once the incident becomes known, do not go near the affected area unless permitted by the authority. If you had been near the incident for a prolonged time, contact the authority. In case of a mishap with a X-ray or radiation therapy type machine, only the operator or patient may get over-exposed.

To minimize panic & worry purchase a radiation dosimeter: It is less likely that a radiation incident will occur and you will receive a dose higher than 5 rad/50 mSv. However, you cannot know how much dose you have received without a personal dosimeter. Accidents due to panic can cause more injuries and deaths than exposure to radiation. Therefore, to minimize panic and worry, carry a dosimeter, e.g., wearable, instantly color-developing, pre-calibrated, always ready, reliable, rugged, federally funded and tested, field proven and affordable SIRAD® (RADTriagehttp://www.jplabs.com/1_radtriage-fit.pdf or RADSticker) for monitoring and triaging exposure information and treatment. RADSticker which weighs only 0.2 gram can be applied on many objects and carried with you for a couple of years. A SIRAD may compliment, but cannot replace any other dosimeter/detector you may be required to use.

INFORMATION ON RADSTICKER: RADSticker™ is a peel-&-stick postage stamp sized, instantly color developing, casualty dosimeter which costs less than a penny a week, you can carry 24/7, always ready and with you, for any future radiation emergency. Needs no power, has no electronics or moving parts, reliable, robust,

rugged and useful for triaging radiation exposure information and medical treatment in a major radiological incident, such as a nuclear or dirty bomb explosion, nuclear power plant accident or mishandling of radiation sources. RADSticker is made under USP # 7,227,158; 7,476,874 and others. The technology was developed with multimillion dollar funding from several US agencies, such as DHS, DOJ, DOS, DOD, DHHS and TSWG and was field tested by the DHS with 800 first responders in the states of NJ, NY and IL.

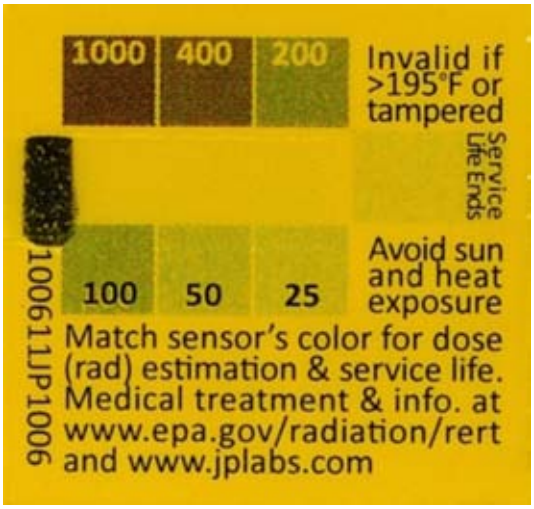




EXHIBIT 48 — GM Reading of Nearly 10 mR/hour Compared to 25 rad Position Pointed to on RADSticker. Even 1,000 hours of exposure in a 10 mR/hour field of gamma would not darken either the RADTriage card or the RADSticker to a level of the emergency suggested limit of 25 rad for responders. A quick demonstration of the equivalent gamma dose rate 10 mR/hour switching from the count rate scale reading about 16,000 counts/minute. I emphasized, "Should anyone panic at 16,000 counts per minute when a responder (or any family member) could stay 1,000 hours (about 6 weeks) without shelter and still not receive near the 25 rad (or rem or 0.25 seivert) suggested limit for responders in emergencies??" This demonstration was found to be possible to be presented in a minute or two!!

The GM counter reads 16,090 counts per minute, but about 10 mR/hour when switched to the mR/hour scale. A RADSticker exposed for 1,000 hours in such a count rate from a gamma radiation measuring GM counter would indicate, with a light grey center strip, that the wearer had received about 10 R, within the suggested review level of 25 R for routine rescue work after a terrorist attack. Please do not scare responders at a 10 mR/hour exposure rate, in which they could spend 1,000 hours or more!!

The view from Exhibit 26 of the GM counter reading 16,090 counts per minute (see the multiplier icon on the counter scale) is mostly due to betas from the uranium glaze. When the upper switch on the instrument was placed in the mR/hr position, the reading with the GM counter screaming at this high count rate was only about 7 to 10 mR/hr. I first indicated by placing my hand between the uranium glaze and the counter that these invisible rays stopped in my hand, but I knew that even this high level of count rate would not give me an appreciable

chance of damage or long-term cancer to my hand even if kept there for a minute. (See Exhibits 26 to 29.) So, I could tell responders, "So much for 'no safe dose of radiation,' or '**any** radiation being **dangerous**.'"

Then, I explained in more detail, when there was time, that even if my entire body was exposed in a gamma field giving such a count rate, I would be receiving an exposure rate of no more than about 10 mR/hr and a whole body average dose rate of less than 10 mrad (or mrem) per hour. I then indicated that this was a level that a worker in peacetime industries was allowed under national safety standards to receive on the average up to 10 hours per week, for a number of years (even though by U.S. safety management practices in peacetime, the vast majority of workers are not allowed to receive anywhere near that much). Then, I said, with emphasis, that since m means milli (one thousandth), you could be in such an area for **1,000 hours**, and still get only 10 R (less than 10 rad or rem), which would be less than the 25 R allowed for life saving by Federal (FEMA or DHS) standards. Thus, if you saw on your RADSticker, that the middle strip was less dark than the square with the 25, you would still not expect any significant short or long-term harm. Therefore, do not be concerned if anyone tells you to stay out of a boundary of 10 mR/hour; this probably results from the fact that most persons involved with radiation measurements nad protection have not adequately considered the time durations and effects of risks for non-lifetime, emergency exposures when their experience has been in regulated or limiting radiation exposures according to peacetime standards.

With experience, the presentation of the kind of information in the above two paragraphs would take only about 2 minutes, even while most of the time looking the responder in the eye. With more time, you could explain quantitatively that, even with the assumed risk factor of 5 chances in 10,000 of cancer death per rem (over time, and neglecting hormetic effects or tissue repair, which can be mentioned), a dose of 10 rem would **not** yield a long-term cancer death risk of more than 5 chances in 1,000 (0.5%) added to an average chance of about 20% of dying of cancer in later years. Certainly, the risks faced by firemen and policemen on a daily basis should place risks received on the order of 10 to 25 rad or rem (once explained) in a category of no concern, in the event life-saving missions are required after a nuclear or radioactivity-dispersing terrorist attack should occur. The responders with whom I and Steve Jones talked seemed to be grateful for this information and the gift of a free RADSticker.

I am now confident I can approach responders this way on my own. In such a demonstration, one can point to the respective places in the pictures of Exhibit 48 while giving the type of information in this paragraph. This connects the reading on the GM counter with an area less dark than the 25 rad square, providing an immediate connection and visual understanding of the lack of receiving more than a 10 rad total dose in 1,000 hours, when in a field reading this high a count rate, equivalent to about 10 mR per hour.

Other good news: Crow and Company (sales@croweandco.com; (800) 761-0358) was finally beginning to get orders for the RADTriage SIRAD cards. However, since this was written, Fay Crowe was forced to, at least temporarily, close down operations due to lack of receiving expected large orders from Government agencies. Dr. Patel is getting marketing assistance for RADStickers not only from Steve Jones, with assistance from Physicians for Civil Defense, but also from Shane Connor (http://www.ki4u.com). Orders for RADTriage SIRAD cards should now go directly to http://www.jplabs.com/. The latest information on the successful development of the RADSticker was presented at the Health Physics meeting (Patel and Watanabe 2010).

The presentations at the annual meeting of the Health Physics Society in Salt Lake City, June 27 to July 1, 2010, and the meeting of the Homeland Security Committee chaired by Dr. John Lanza, indicates to me that: plans for coordinating agency responses at Federal and State levels are relatively complete; resources and analytical methods of analysis of radiation intensities after various exercise scenarios are rather well developed; and plans for response and recovery by the existing scientific personnel at the Federal levels whenever they can be mustered after an attack are well developed. Presentations at the meeting that were particularly interesting or encouraging to me were as follows. Buddemeier (2010) presented a talk on recent improvements in response planning after a

nuclear detonation that provide more realistic assessments of blast, heat, and radiation effects, indicating that our nation's scientific teams are working in concert together. Bushberg (2010) summarized activities of the National Council on Radiation Protection and Measurements (NCRP), indicating the completion and near completion of many reports for medical institutions that provide important information for responding to both the internal and external exposures that would be received by members of the public in a terrorist attack. Groves and Poston (2010) presented further information on NCRP reports that update and coordinate information for responding to radiological or nuclear terrorism.

There were many other papers at the Health Physics Society meeting that provide information for preparing for, or responding to, terrorist attacks. The abstracts of these talks can be found in the special edition of HEALTH PHYSICS given in the references of the above paragraph.

Many of the papers at the meeting dealt with ways of communicating information to the public. Some sites where such information can be obtained were recently received in an e-mail from Dr. Lanza; these web sites are listed below.

The following references helpful in communicating risk information were included in a presentation developed by the Health Physics Society Homeland Security Committee, chaired by Dr. John Lanza, in cooperation with the Society's public information programs under Kelly Classic. Much additional information of value developed for preparing the nation to survive and minimize loss of life in the event of a radiation-releasing attack my be obtained from the Health Physics Society website, www.hps.org/, and clicking on successive items of interest.

- Crisis and Emergency Risk Communication. CDC. October 2002.
  Available at: http://www.bt.cdc.gov/cerc/pdf/CERC-SEPT02.pdf
- Communicating Radiation Risks. Crisis Communications for Emergency Responders. EPA-402-F-07-008. September 2007.
  Available at: http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=500025HA.txt
- CDC STARCC Principle: *http://emergency.cdc.gov/erc/leaders.pdf• •77 Questions Commonly Asked by Journalists During an Emergency or Crisis (Vincent Covello). Available at: https://njlmn.rutgers.edu/cdr/docs/covello2_09-29-09.pdf
- Crisis + Risk Communications—By Leaders For Leaders.
  Available at: http://emergency.cdc.gov/erc/leaders.pdf
- Message Mapping (Vincent Covello).

  Available at: http://publichealth.yale.edu/ycphp/messagemapping.pdf
- Mental Noise Theory (definition).
  Available at: http://www.ahrq.gov/research/altsites/altsite7.htm#Mental

The Bad News

The bad news might well be worse than the good news is good, if someone important in America does not very soon begin to understand that a nation, especially all of its citizens, must have immediate access to information about exposures and **proper** "things to do" in the seconds, minutes, and hours after an attack. Plans and resources for response, many of which were presented at the Health Physics Society meeting, that might take many minutes or hours to be available after an attack or accident, with insufficient resources in humanpower and prepared medical institutions, will be for naught if the public is in panic and rushes onto highways or into hospitals by the thousands or more.

In the old civil defense program, initiated under the Eisenhower administration with the leadership of scientists like Jack Greene and Marlow Stangler (see Dedications), early plans included the development and purchase of rugged high level ion chamber survey meters as well as GM counters, and the provision of low and high range pocket ionization chambers to all responder organizations. Much of this equipment was already available when I joined Federal Civil Defense Administration in 1956, and I was able to distribute these instruments with training to my Region II States. In 1979, I was still able to stop at a State Police station on the Pennsylvania Turnpike and borrow a 500 R pocket dosimeter on my way to assist Ken Miller at the Hershey hospital in case any contaminated victims of the Three Mile Island accident should arrive. The instrument program was destroyed in most States after FEMA cancelled program direction and assistance in 1996. Before that time, Marlow Stangler indicated that about ten years of research was conducted to develop a dosimeter for wide distribution that could replace the pocket ionization chambers and be purchased at reasonable cost. Over 50 million dollars was spent on instrument purchase development between 1956 and 1964, some of it spurred by the Cuban Missile Crisis. In addition, a program of assistance to the States (all but the two who would not participate) was developed in which almost about 3 million dollars per year was provided for instrument maintenance. However, the research program, carried out at several national laboratories, could not develop a suitable, less-expensive, chemical or other dosimeter to replace the pocket ionization chambers, which required regular recharging. Now, thanks to Dr. Patel and some contracts from DoD and DHS, we have the SIRAD dosimeters, with all the advantages in peace or war listed in Chapter 8.

Now, 50 million dollars in 1956 to 1964, according to the costs of my homes through the years, would be over 2 billion dollars today. With this amount of money, every person in the United States could be provided with a SIRAD RADTriage dosimeter. With his current capabilities, Dr. Patel can gear up to make 5,000 RADTriage dosimeters per day, and can produce 50,000 RADStickers per day . Contracting out with a label manufacturer, Dr. Patel could produce at least 1,000,000 RADStickers per day. With assistance, the population could hopefully be provided at least the RADStickers before an attack occurs. I hope that at least every responder team could be provided with the well-tested (Buddemeier (2007); Klemic et al. 2007) SIRAD RADTriage card, which can be read more precisely in the lower rad (1 to 25 rad) range. Certainly, at least one person on every responder team could be provided with a dosimeter within months, if we could just speed up the ordering processes within our agencies.

I first learned about an early model of the SIRAD dosimeter when I was given a sample dosimeter by Dr. Gordon Riel about a year or so after FEMA cancelled its radiation instrument program in 1996. Dr. Riel was a physicist and program manager for a Navy installation that was supporting Dr. Patel's development of the dosimeter. I wore this dosimeter for several years and found it seeming to stay in good condition. At the time I obtained the volunteer lecturers and authors and completed the text for the Health Physics Society 2004 Summer School, I was not aware of the advances in development of the SIRAD series and did not include significant information about the dosimeters in my chapters. I recommended the more expensive pocket ionization chambers and other instruments in that book. However, when I learned about Dr. Patel's SIRAD dosimeters after the Summer School, I visited his plant to observe his research and production methods, and was impressed with his quality assurance and long interest and dedication in developing this dosimeter and other products for human health and safety.

Although my congressman, Wayne Gilchrest, had written a letter to Secretary Tom Ridge to meet with me before the 2004 Summer School, the Secretary sent only a lower level official to attend the Summer School, for only one day. After learning about the SIRAD dosimeters and the patents and awards they had one, and visiting Dr. Patel, I arranged through another high official to have a meeting with an Undersecretary of DHS. I took Marlow Stangler with me to the meeting, where we found Brooke Buddemeier attached to DHS and working for the Undersecretary. He sat in with us at the meeting. I do not know whether the meeting with Marlow and

me influenced the Undersecretary, but a couple of years later I heard the presentations in 2007 by Buddemeier and Klemic et al. about the successful tests of the dosimeters. I have thought that by now DHS would have recommended that the SIRAD dosimeters be purchased using a part of the billions of funds given to the States to purchase homeland security related equipment. To my knowledge, no such DHS requirement or Presidential order has been issued, and Crowe and Company and Dr. Patel have not received much compensation for all of their efforts — at least not yet.

I have also met with the Maryland Governor O'Malley, his Adjutant General, emergency management staff, and members of the Maryland State and Worcester County legislatures, among many others. It almost seems futile to get officials to order these personal dosimeters, but yet there is hope. The activities and energy of someone like Steve Jones is part of that hope. Perhaps more health physicists, nuclear engineers, and others with expertise in radiation measurements and risks will join in a national effort to inform officials and the public.

One reason it is slow to get government agency orders is the extreme complexity of the many government agents with statutory responsibilities for aspects of homeland security. The interrelationships that have grown among agencies has been described by Stangler (2004) who worked in Federal civil defense programs for 40 years and lived with the many reorganizations of civil defense responsibilities. A more up-to-date summary was provided by Crowe (2008), and the abstract of her talk is quoted below to provide a brief view of the situation for the uninitiated.

Brief summary of interagency responsibilities (Crowe 2008)

In support of the National Strategy for Homeland Security and the National Strategy for Combating Terrorism, the National Response Framework outlines the roles, responsibilities and relationships between state, local, community, tribal, territories, Federal government, Non-Governmental Organizations and the private sector. Homeland Security Presidential Directive 5 (HSPD-5), Management of Domestic Incidents, provides the guidance for federal support at the national, regional and field levels. Military forces are prepared and trained for acts of war and in countermeasures for Weapons of Mass Destruction (WMD) incidents. However, the Posse Comitatus Act (18 U.S.C. § 1385) prohibits most members of the federal uniformed services from exercising state law enforcement or police powers that maintain "law and order" on non-federal property, under 18 U.S.C. § 831, the Attorney General — the chief law enforcement officer of the United States - may request that the Secretary of Defense provide emergency assistance if civilian law enforcement is inadequate to address threats involving the release of nuclear materials, such the possible use of Weapons of Mass Destruction. Such assistance may be provided when it does not adversely affect U.S. military preparedness. The Secretary of Defense retains command of DOD military forces providing Defense Support of Civil Authorities. The National Guard under the command and control of a Governor are not DOD forces. The Coast Guard is exempt from the Posse Comitatus Act. The Coast Guard enforces U.S. laws, even when operating as a service for the Navy. The Nuclear/Radiological Incident Annex describes the policies, situations, concepts of operations, and responsibilities of the Federal departments and agencies governing the immediate response and short-term recovery activities for incidents involving release of radioactive materials to address the consequences of the event. Although much federal funding has rightfully been spent to develop policy and guidance for incident management, still the guidance, planning and preparation at the local level remains woefully inadequate. Much has been and is being done by the Department of Homeland Security as well as various Federal and State agencies with regard to detection, prevention and preparation for WMD incidents but the vulnerability of First Responders remains high. These men and women are "first on the scene" as a natural or man-made disaster unfolds and must take action as soon as possible, because Federal response resources will not be available for hours or even days after an incident. According to the Department of Homeland Security (DHS) there are approximately two million first responders across the United States. Rarely are these individuals trained in health physics. Even with proper training, there will not be enough responders such as police, fire, or paramedic teams to help most citizens in the critical early time after an incident. Given the "invisible" nature of radiation exposure, the average citizen needs

access to adequate information about radiation levels and proper actions to take immediately after an incident. If such information is available, every individual can become a 'first responder" who can take appropriate action immediately to avoid panic and human tragedy. Training and user-friendly equipment will encourage active citizen participation and preparedness to provide the needed critical surge capacity to supplement government efforts during a radiological or nuclear incident. As the society at large is not trained in health physics, the non-radiological (e.g. economic, social and psychological) consequences of an event may be worse than the radiological impacts as a result of a lack of pre-established response guidance and protective measures understandable to the public and officials. The wealth of knowledge and expertise that exists within the Health Physics Society should be leveraged to develop training for the public to prevent unreasoned fear through knowledge, understanding, and training. Reassurance, proper guidance and training will keep panic from overwhelming the public health care system and hopefully will avoid unnecessary large scale evacuations.

Considering the importance of informing and protecting the public immediately after a release of radioactivity, it is unfortunate that old laws slow down processes for information. It seems that Congress needs to consider revisions to the Posse Comitatus Act, and ensure that adequate and immediate protection is available to the public through National Guard troops and government response capabilities that within each State and local area are authorized to provide immediate aid to our citizens after an attack. Current threats to our nation do not now occur only overseas at great distances, but can occur without notice with overwhelming death and destruction on our own shores and in our own cities. America must wake up to reality. A nation can not survive with the majority of its citizens in confusion, fear, and panic. I am sure that Al Qaeda knows this. Previous sections of this book provide actions that can be taken by the public both for preparation before an attack, and immediately upon an attack if exposures and risks are understood.

Citizens must know that our nation can survive, if appropriate preparations are made for survival and the will to fight on. We must not give up our American experiment with freedom of life, liberty, pursuit of happiness, and opportunities for private enterprise.

The sad parts of the news above, and more recently sent to me, may be summarized as follows:

- Orders and contracts for providing SIRAD dosimeters to all responders and at least an adequate sample of the public are still coming in too slowly, and possibly more slowly than the development of nuclear bombs and RDDs by those intent on destroying democracy. The paper by Crowe (2008) and her exhibit should have provided more stimulus by health physicists to promote their distribution throughout the United States.

- The slow distribution of dosimeters for early triage and avoidance of panic is occurring while some medical institutions are being provided millions per year to develop systems for biodosimetry, which can only be of use for a small number of highly exposed individuals and only many hours or days after they would have scattered in panic if not provided with immediate information about their exposures, how low risk most of them would be, and proper immediate protective measures. The few medical institutions adequately prepared to use these biodosimetry methods would likely also be inundated with the "worried well" if adequate dosimeters and information are not provided to the public at large. Also, how would anyone locate the relatively small number of individuals who should receive biodosimetry among the thousands who might be panicked without immediate personal information? How would even local responders, with their ambulances and fire engines, get through the traffic and perform rescues, when the streets are filled with stalled autos driven by panicked drivers? How would hospitals be able to treat even the most simple lacerations when a panicked public rushes in for decontaminations that they could easily accomplish with a simple wash or shower at home or at work?

Yet, articles recently issued, some of which are referenced in Chapter 8, show that some scientists involved in such biodosimetry research are claiming there is no other way of triaging the exposed population. GIVE ME A BREAK! If they are interested in homeland security, not just research funding, can they not know there are other methods of early dosimetry available, even if they have not heard of SIRAD? Can they believe that they will locate those individuals with mean body doses greater than 10 rad without the public having access to personal monitors? Have they ever had to find a needle in the haystack, particularly a chaotically moving haystack?

- Having been a professor in three universities, I am certainly not against research. Please, let us keep funding those biodosimetrists who are seeking the better mousetrap; it could lead to better knowledge for many medical purposes. However, while researchers are busy developing and selling better methods of biodosimetry, let it be known that back in the 1960s, Dr Niel Wald, physician and Chairman of the Department of Radiation Health, University of Pittsburgh, used his already well-developed methods of chromosome analysis to help manage and save a human life with a timely bone transplant (see the chapter Brodsky and Wald (2004)). Also, he had the vision to obtain grant funds and install a whole body counter and bioassay laboratory in Presbyterian-University Hospital, in order to provide the Western Pennsylvania region, where many new nuclear industries were then operating, and some possible accidental exposures to external radiation and the inhalation of plutonium or fission products seemed possible. At a 1969 annual meeting of the Health Physics Society, he announced that his dose estimates from counting rings and dicentrics were the same as the early mean dose estimates to bone marrow that I had obtained with film, thermoluminescence, and ionization chamber dosimeters. The dosimeters were spread around and in a phantom mocked up at the position of the more highly exposed worker. Measured doses were also compared to those on film badges of the highly exposed worker who also had hands and feet in the beam and his two less-exposed coworkers. Here was one of a few physicians who understood the need for immediate physical dosimetry combined with later confirmatory biodosimetry for those triaged to need it. Where are these physicians now that we need them? As discussed in more detail in the text of Chapter 8, some of the best scientists in the field of biodosimetry still seem unaware of, or not interested in, the inexpensive and immediately available colorimetric SIRAD dosimeters. The importance of SIRAD dosimeters for early triage, identification of the minority who are highly exposed, and avoidance of panic by the vast majority of exposed populations, following a radiation-releasing attack, and the valuable uses in peacetime accident cases and accident prevention, are listed in Chapter 8. I hope that now the distribution of this book will line up more supporters of personal dosimeters for responders and the public.
- Adding further mental pain and frustration, just before leaving for Salt Lake City I received sad e-mail news from Niel Wald (the only physician who has served as President of the Health Physics Society), informing me that the powers-that-be at Presbyterian-University Hospital had torn down the *in vivo* counter and cut up the steel shield. The hospital is going to replace the old Radiation Medicine Department with a Starbucks Coffee Shop. Of course, we will need another Starbucks Coffee shop to save lives after a nuclear attack. The Radiation Medicine Department was operated by staff of the Graduate School of Public Health (GSPH), University of Pittsburgh for about 45 years. It was one of the best equipped in the nation and served to manage the types of cases reported in the chapter cited above. The in vivo counter and bioassay laboratory for determining intakes and doses from radioactive materials entering the bodies of workers exposed in the then growing nuclear industry around Pittsburgh was established in 1964-1965 with a Federal grant from the Public Health Service. It was a 2,500 square foot facility right off the lobby of a major university hospital, initially planned, designed, and operated by the GSPH faculty team of Niel Wald, Francis J. Bradley, and me. The overall shielding, including the thick pre-nuclear-test

iron room, provided a radiation exposure rate only about 2% of the natural background in the vicinity in order to provide sensitive detection of emissions of gamma radiation from internal radioactive materials in the human body. An air intake protection system with multiple filters in series prevented the entry of any radioactivity concentrations in air, including those of natural radon or thoron decay products, or the nuclear test fallout descending into the biosphere in measurable quantities in those days. A number and variety of important cases of worker intakes were evaluated and triaged there, and some were provided with decorporation therapy by Dr. Wald. The most important and informative cases are reviewed, with the major data, in the Brodsky and Wald (2004) chapter, with references to publications on other cases. After the Three Mile Island accident, there was a public demand to check the population for the possible intake of fission products released from the accident. A portable whole body counter was used in that case by Dr. Reginald Gotchy, of the Nuclear Regulatory Commission, to show the public that nobody received any appreciable internal dose from the accident. Now, if a future attack were to take place, how would anyone be able to triage the population quickly for internal exposure without many portable units, and without prepared and calibrated fixed-shield *in vivo* counters, shielded from the likely higher backgrounds that would exist everywhere? Crapo (2004) has explained the need for such fixed installations. There are too few portable units around today to serve the public's interest, and extremely few fixed shield facilities. Even if portable counters were adequately available, those individuals found to have higher intakes would need to be sent to centers such as that now destroyed at the University of Pittsburgh, in order to have more accurate immediate and long-term in vivo counting and bioassays of excreta, together with the necessary medical management by physicians like Dr. Wald, now retired as Professor Emeritus.

- About two months before going to the annual HPS meeting, I met with a Professor who directs one of the GSPH centers on homeland security research. Although I gave him a draft copy of this book, the destruction of this national resource at Presbyterian-University Hospital had already occurred. Perhaps some of this result is due to GSPH dropping the health physics teaching programs of the Department of Radiation Health, and the Industrial Hygiene and Occupational Medicine programs, despite my protestations to a Medical Center Vice President. These earlier teaching programs emphasized not only the importance of more research on toxic agents, but also the practical public health facilities and procedures for protecting workers and the public. I have found from my experiences in government agencies, in universities, and in consulting, that there is a great need for better coordination between basic research programs and the application of scientific and field exposure information to public health practice. Perhaps too many individuals are receiving advanced graduate education today that involve only basic research into mechanisms of toxicity and cancer induction, without any introduction into how to put scientific information and past protection experience into practice in protecting workers and the public. I have had many rich experiences in this interface area.
- Rubbing more salt into my wounds, Dr.Richard E. (Dick) Toohey (recent Past President of the Health Physics Society) told me at the Salt Lake City meeting that the whole body counting facility at the Oak Ridge Associated Universities(ORAU) has been disassembled. Dick Toohey has been associated with major responses of the Radiation Emergency Assistance Center/Training Site (REAC/TS) to international incidents involving human exposures to large doses of radiation, as well as having directed the ORAU program reconstructing for the National Institute of Occupational Safety and Health (NIOSH) the radiation doses of nuclear energy workers throughout the United States. The REAC/TS center is part of ORAU. ORAU is the national center supported by the Department of Energy (DOE) that is most important in providing medical assistance in the event of overexposures to radiation, and its team of top scientists and physicians have responded to requests for assistance all over the world. Dick Toohey previously operated

the Argonne National Laboratory in vivo counter for measurements for many patients with intakes of radioactive material, served as a scientist evaluating the physiological distribution of tissues from workers with intakes of radioactive material who willed their bodies to the United States Transplutonium and Uranium Registry (USTUR) at Washington State University, and recently for many years managed the dose reconstruction projects at ORAU. Dick, with a Ph.D. in physics, is one of the very top scientists in the nation in this field. Yet, he was somehow not able to stop the desecration of this national facility for determining intakes and internal radiation doses.

- **There seems to be a lack of scientists and administrators at the highest levels of DOE and other cognizant agencies who understand the need for these very sensitive in vivo counter facilities in order to evaluate intakes of radioactive material by workers after nuclear accidents in the workplace, or intakes by members of the public who will be concerned about their risks after exposure to inhalation of radioactive materials after terrorist attacks. These major in vivo installations are being destroyed when they will be needed to provide the most accurate assessments of radioactive materials within the human body, and provide further information useful to the medical community for followup therapies.**

- Another very sad message also came by e-mail recently from Dr. Anthony (Tony) C. James. Tony has for a number of years headed the United States Transuranium and Uranium Registries (USTUR) at the College of Pharmacy, Washington State University. Tony is a fine physicist and computer guru who has been continuing, with his staff of chemists and pathologists, the analysis of uranium, plutonium, and transplutonium elements in human samples kindly donated by deceased workers of the nuclear industries who have accidentally inhaled these radioactive species in their work places. The USTUR program was a dream to be instituted by the scientists and physicians with whom I worked in the late 1950s at the Biology and Medicine Division of the Atomic Energy Commission, including the Division Director Dr. Charles L. Dunham, M.D., and his top occupational medicine physicians, including Dr. H. David Bruner, M.D., Ph.D. The analysis of the distribution of these relatively radiotoxic nuclides in the different tissues of the body, and examinations of related tissue pathologies, provides unique data for understanding the distribution, biokinetics, physiologic transport, and toxicity of these elements in the human body.

  It is also basic to determining the levels at which cancers or other effects might arise in these tissues, as functions of quantities inhaled and deposited. It also provides banks of human organ tissues for research on other information about human physiology, and genetic transformations that might be related to measurable internal radiation exposures. These and more studies of such tissues can be important to medical research in general. Yet, billions of dollars are being spent each year on other projects without the recognition of the minimum funding requirements to continue this irreplaceable data bank and research. Of necessity, as is the case with any program in which registrants are signed up while healthy and well in advance of death, early data collection was slow and sporatic. Although good use could be and was made of the data as it was collected, the program now has matured to the point where the body of data is much more complete and ripe for further and more detailed analysis. To defund the program at this time would be to walk away from an investment of more than 40 years and several tens of millions of dollars just at the time when the maximum return was beginning. (Kathren 1999.) To me, if the value of this program is not immediately recognized and adequately funded, this will be another indication of Federal research agency insanity.

The USTUR is another unique national resource about to be destroyed by the lack of scientists high enough in the Department of Energy research programs who understand the important links between human tissue analysis and the fundamental biogenetic research within which they are immersed. It also indicates how these scientists are unaware of the importance of the USTUR program to providing basic information for protecting workers from overexposure to these elements in the event of accidental releases within the industry, or to the public from dispersal of these elements in

the event of terrorist attacks. The work and tissue samples at the USTUR are irreplaceable, and could also be of much value in unveiling mechanisms of cancer induction, and should be of interest to the National Cancer Institute of the National Institutes of Health, as well as to DOE, the Nuclear Regulatory Commission, and other agencies who depend on radiation effects data.

Anyone in high places who can assist Tony James in saving this important national resource will hopefully examine his site at www.ustur.wsu.edu, and contact him immediately at tjames@tricity.wsu.edu. He might not be there for long. My Foreword writer, Professor Ron Kathren, a previous director of USTUR, can also provide extensive information and reports on the USTUR, and can be reached at kathren@bmi.net.

- Reading the Health Physics News that recently arrived, I now have additional heartburn. Another top scientist, who should be a member of the Health Physics Society, makes the statement, "While there are very sophisticated and widely available instruments for measuring contamination, tools for measuring radiation dose are either primitive or poorly available. If a mass casualty incident occurred right now, our only method for rapid dose assessment is 'time to emesis.'" (Moulder 2010).

I hope that those promoting research in biodosimetry will soon come to the realization that in the event of widespread fallout over hundreds or thousands of square miles, no biodosimetric or other preparations for saving life and avoiding panic will have any effect without prior education of the public about levels of risk as related to amount of dose, and the immediate availability of a personal monitor to inform them of dose. No triage would otherwise be possible.

Apparently, even this scientist who leads a major research effort is not aware of the papers presented at Health Physics Society meetings about the SIRAD dosimeter properties and availability. Time to emesis would be of no use when thousands of persons are panicked. Some of them would be throwing up just out of fear, with no personal dosimeter to tell them they are not likely exposed to significant amounts of radiation, or otherwise tell them to report to some appropriate medical center (assuming they could find one not destroyed by the panicked crowd). The situation after a nuclear bomb or RDD detonation, with radioactivity spread over thousands of square miles in quantities that would make sensitive counters scream, is not the same as that in the Goiânia accident (Christensen et al. 2010), where the few individuals of immediate concern could be identified, if procedures are in place for them to know when and where to report. I hope to send Dr. Moulder a copy of this book when published, or perhaps this appendix when finished.

When putting the final finishing touches on this book today, the November 2010 issues of the journal HEALTH PHYSICS and its companion OPERATIONAL HEALTH PHYSICS, arrived. Research papers from the Armed Forces Radiobiology Research Institute (AFRRI) indicate that the programs for biodosimetry developed for evaluation and prognosis of persons who might have been injured by radiation exposure have been tested and evaluated as consistent with some observed radiation case history. (Melanson 2010; Sandgren et al. 2010; Blakely et al. 2010; Goans 2010.) However, although these papers do not state that other immediate physicial dosimetry is not available, they still do not recognize the marriage that must exist between their methods, which are useful only above the 1,000s of mrem dose range, and the inexpensive SIRAD dosimeters that must first be worn throughout the community to prevent immediate panic and used to screen for which small proportion of the community these "biodosimetric" methods should be employed. Although the fine 200-strong research team at AFRRI should continue to received support, why can not someone high in DoD or DHS insist that the need for the SIRAD badges also be supported with urgency? Perhaps the AFRRI team is concerned that availability of

the badges might lessen support for the biodosimetry research. **Thus, some on high at DHS and DoD need to be made aware of the fact that hundreds of millions of dollars have been made available for biodosimetry development, and it would be unfortunate if our leaders can not soon realize that all of this biodosimetry effort will be wasted if responders and the public are not urgently provided with SIRAD dosimeters at a fraction of the biodosimetry costs. A Presidential Order could provide these essential dosimeters to the public within a fraction of the funds allocated to States by DHS!!!**

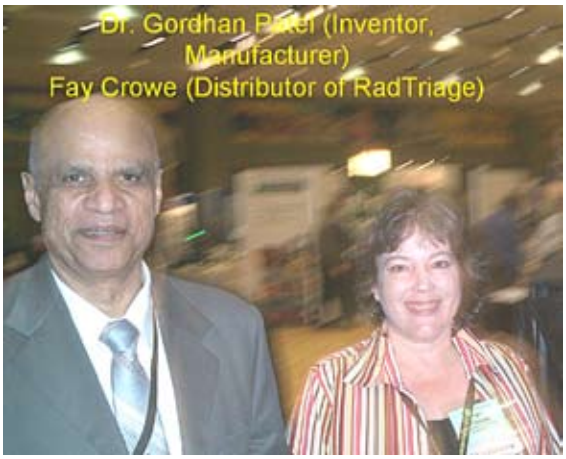
- I found after returning from the Health Physics meeting that a competent and diligent member of the Society was going to present a course to a group of intelligent responders in Montgomery Count, Maryland. However, I needed to advise that the usual recommendations in some of the government-provided training materials to designate 10 mR/hour and 2 mR/hour boundaries needed either to be discarded, or to be explained as levels that in peacetime could be important as control levels for persons who might be exposed for many hours per week during a lifetime, but that responders or members of the public should know that exposure at such levels for hundreds of hours before sheltering or evacuation would not lead to the likelihood of either long-term or acute health effects. (See Exhibit 48.)

Apparently, my discussions and writings on this matter have so far not reached, or have been ignored by decision makers on high. I must now quickly finish and distribute this book.

The News of Hope

Hope rests with the efforts of good and able people, ready to exert leadership in informing responders and the public properly. Many in our professional societies have spent much volunteer time developing plans, methods, and equipment for homeland security programs. I have cited a few, as authors in the talks at the HPS meeting, whom I know have worked continuously on homeland security issues since 9/11. I am hopeful that many will find inspiration in this book to also urge the provision of radiation dosimeters, or call them "personal monitors," to responders and the public, and as far as possible to adopt many of the other protective measures suggested in this book. The dosimeters and their brief inserted instructions will by themselves open the eyes of all citizens to ways in which most of them can survive nuclear or radiological attacks. Knowing just immediate actions ("things to do"), and immediate dose information from simple personal equipment, can save thousands of lives and prevent panic.

In the meantime, I am adding to those civil defenders mentioned in the Dedications the following persons who are my recently adopted heroes, for their singular and sometimes lonely efforts to provide life-saving information to the public. The nature of their efforts has been described in previous paragraphs.



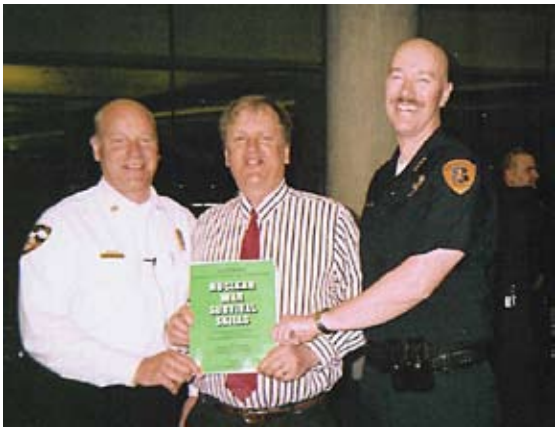


EXHIBIT 49 — My Newest Heroes: Dr. Gordhan Patel, Fay Crowe, and Steve Jones. Left picture — Dr Gordhan Patel on left, Fay Crowe on right. Right picture — Steve Jones in middle, Kurt Cook, Salt Lake City Fire Chief, on left, Chris Burbank, Salt Lake City Police Chief, on right.

Dr. Patel has spent many years of scientific ingenuity, development, quality production, and much of his private funds to develop the SIRAD dosimeters, to save lives in the event of radiation accidents or terrorist attacks. His SIRAD inventions have received awards and Federal approvals. He has also developed many other products beneficial to humankind. Fay Crowe established a company just a couple of years ago to market the RADTriage dosimeter, because she believed in the importance of its distribution and Dr. Patel needed his own time for further laboratory work and development of production processes. It also seemed to be a product that, with the cooperation of agencies responsible for homeland security, would soon sustain her efforts. She worked tirelessly to understand Federal agency responsibilities and obtain further approvals for distribution. Steve Jones is a unique individual who, making a living for his family as a house painter, still has taken a considerable portion of each month for the past three decades to educate responders and the public of the need for prior protection in order to avoid many mass casualties that could occur, either during the cold war, or now in face of the new terrorist threats. He is going out for hours every week to talk with responders and the public.

Another hero of mine is Dr. Jane Orient, a practicing physician who for many years has cared about our nation's preparation to save lives in the event of terrorist or natural disasters. She is President of Doctors for Disaster Preparedness and Physicians for Civil Defense, and an editor of the Journal of American Physicians and Surgeons, and manages many aspects of the meetings and publications of these organizations. She is usually a behind-the-scenes worker and I have met her only within the past year, by introduction of Steve Jones. She has supported Steve's travels to enhance civil defense for many years. She is also an excellent editor and writer, and I am grateful to her for showing me how to rewrite my final manuscript for acceptance by editors of the Journal (Brodsky 2010a). I hope that more physicians throughout the nation will join with her and enhance the nation's abilities to save lives and survive. I spoke at the annual meeting of DDP about the important role physicians can play in properly informing and preparing the public for personal protection.

Steve Jones has spent many days a year to inform responders and the public about protective measures available in the event of a nuclear bomb attack. I had hoped that the Health Physics Society Board would accept and act on all of the recommendations in 2002 of the first Ad Hoc Committee on Homeland Security, and provide organizational structure nationally, and recommendations to chapters, so that all health physicists might spend on the average only one day or night a week to train or instruct a group of about 10 responders. The recommendations, including documented responsibilities and procedures in each chapter's Bylaws and Rules, adapted to their own membership, would pass from year to year to each set of officers and committee chairs. The 2001-2002 committee

also had developed simple model information sheets to send to local papers, and sets of training material for responders. However, many decided to wait for uniform Federal guidance before engaging the public in homeland security matters, hoping to see a uniform program of training for all responders throughtout the nation that would be provided by the Federal government (one-size-fits-all training). If the suggested Society program had been pursued, and perhaps on the average each of 6,000 members had given a training session once a year, 60,000 responders would have been reached each year, and many of the more likely target areas would have properly trained responders.

Chapter meetings still focus as they should on enjoyment of fellow members and listening to informed speakers, but efforts to engage the average member in important volunteer work have been minimal and meetings do not allow for reporting or discussion of serious chapter accomplishments. I believe that this is one reason chapter membership has decreased in many areas. Professional people need more purpose and active leadership into important volunteer services in order to be motivated to leave their homes and families in the evenings. A short summary of the type of organizational and procedural changes that I still hope could be adopted by professional and scientific organizations, whose members already understand the phenomena of nuclear radiations, has been presented as "The Hart Model" (Brodsky 2005). This model has been presented at meetings of the Baltimore-Washington HPS Chapter and the DC Section of the American Nuclear Society. Yet, I find that responders even from some of most trained and equipped units respond to my question, "What would you do if you saw a Geiger counter go upscale?," with a response like, "I would run." How can we think we have made progress on homeland security if even a responder does not know how to assess his own relative risks, nor have the personal monitors and equipment to know the radiation levels to which he is exposed?

So, some hopeful news might be as follows:

- Promised orders have started coming in to JP Laboratories, Inc. for the RADTriage credit card size dosimeters, from responder agencies in the United States and abroad.
- Steve Jones has been successful in interesting many responder organizations in Arizona and Massachusetts in obtaining the RADSticker as an available inexpensive dosimeter that can be pasted in a wallet and remain usable for up to 5 years or more. He has provided hundreds of samples, with his simple version of an emergency instruction card, to individual responders.
- Steve Jones arranged an interview with a Salt Lake City reporter during the annual HPS meeting, which resulted in an accurate news article the next day (see above), followed up with a reprint of the article in the national newsletter Fire Engineering (O'Donoghue 2010). This shows how an ordinary unknown health physicist like me can spread some useful information nationally. I hope that more health physicists will seek such opportunities to better prepare the public.
- Dr. Jane Orient invited me to submit a paper to the Journal of American Physicians and Surgeons on the need for distribution of personal dosimeters (Brodsky 2010a) and give an hour talk on my book at the annual meeting in Florida (Brodsky2010b). I found this meeting full of outstanding physicians and scientists who understood the needs for natural disaster and terrorist attack preparations. I shared a story told to me by Herman Cember about the vast potential through practicing physicians to properly prepare the public for all kinds of disasters and emergencies. I hope that the membership of Dr. Orient's two organizations will expand and become an important resource in national preparations for disasters and attacks. (See my selection of Dr. Orient as one of my recent heroes in the paragraphs under Exhibit 49.)
- Dr. Patel is finding ways to produce his dosimeters at a sufficient rate so that it can be expected that a large proportion of the responders in America, and in other nations, may be supplied with wearable dose monitors within a matter of months.

- Dr. Wald informs me that a "Global Health Network Supercourse" group has been established that is reaching a large global network, in a number of languages, with training materials for "training the trainers." Information on this program may be obtained from the website www.pitt.edu/~super1/ - 17k - 2010-06-12 .

  Lecture and slide material may be contributed to this site, or obtained from it. An extensive library of training materials is being developed in a number of languages. This can be a boon for those educated or trained in radiation phenomena in providing assistance with training materials for tailoring training courses or short presentations to specific groups. The website for the HPS Homeland Security Committee also is a source of training materials, as is the chapter by Buddemeier (2004).

- I am also hopeful that members of scientific and professional societies involved with nuclear energy and radiation protection will establish more effective programs such as suggested by The Hart Model. Now that a resurgence in nuclear power is obtaining more support, active participation in homeland security and the distribution of dosimeters can be inroads to informing the public about the ways safety is ensured for the regulated nuclear industry, dispelling the myths so widely propagated in the past. The material in this book documenting the misinformation propagated after the Three Mile Island accident, and that showing the impossibility of dispersing radioactive material by terrorists attacking nuclear power plants, may provide helpful educational material used in concert with providing "actions for survival."

- On July 28, 2010, I saw on TV an ad by a company that is offering to build shelters of various sizes for protection of the public, not only from nuclear and RDD attacks but also from typhoons, hurricanes, floods, and other natural disasters. It is high time that we thought about public protections, instead of just sighing and entertaining ourselves with the daily reports of human tragedy on our weather stations. As discussed in the body of this book, government agencies and the military have failed over the years to recognize the need for adequately protecting citizens on our own homeland, such as the Swiss did by national legislation in 1950, or which could have been done simply by appropriate home construction requirements within every county. As I also pointed out, a national program for building shelters would also enhance employment in a much more sensible way than promoting the overbuilding of homes that has already flooded and destroyed our real estate market. I am now hoping that some private entrepreneurs will take the lead in preparing better protections for the public. When I was in the Federal Civil Defense Administration in the 1950s, we also were encouraging shelter construction (see the shelter exhibits in the text), but later government managers and politicians dropped the ball on these programs following the Cuban Missile Crisis. While the TV ads I saw on July 28 were advertising shelters in the range of twenty thousand dollars and up, the promotion of such a national shelter program should also educate the general public on the possibilities for protecting themselves and their families with the types of home-made shelters shown in this book's exhibits and described in the references. The firm that is now providing shelters for blast and fallout protection, as well as natural disasters, may be found by searching for "Shelters" on Google. The products of other firms providing various types of shelters may also be found in this search.

- A recent preprint (Jaworoski 2010) sent to me in September 2010 by Ted Rockwell provides data from the Chernobyl accident that confirms my conclusions in Chapter 5, from the evidence from the fuel element burning experiments, that all of this fear about a terrorist attack on a nuclear plant releasing vast amounts of radioactivity is totally uncalled for. As I noted, there is no likelihood that even an airplane crashed into a U.S.-made nuclear plant could release significant amounts of radioactivity that would harm the public — unless of course a nuclear bomb is exploded at the plant; then there would be other concerns that would need to be addressed by the preparations recommended in this book.

Nevertheless, the organizations inspired by the "Anti-Nuclear Activists" (see definition of ANAs in Appendix A) continue to thrive. Among several occasions in which I have been concerned about their influence in America in the past several months, I attended, at the invitation of Ted Rockwell (the top scientist-engineer on Admiral Rickover's projects to develop the nuclear-powered submarine) and Ken Rogers (twice a Presidential appointee to the Nuclear Regulatory Commission), on September 15, 2010, a meeting at the Cosmos Club in Washington, DC. At this meeting, Dr. Janette Sherman was the presenter of a report on "Consequences of the Catastrophe for People and the Environment" (Yablokov et al. 2009).

Ted and Ken invited me to join them at this meeting because they were concerned that such a report would be published under the auspices of the New York Academy of Sciences without being properly vetted by our best USA epidemiologists. In attending the meeting with them, I found that there was an overwhelming presence of good persons believing that Dr. Sherman's presentation represented additional evidence of the dangers of even low levels of radiation and the need to oppose the use of nuclear energy. The audience included Ralph Nader, whose organizations have generally opposed the development of nuclear energy in the USA, exaggerating dangers and not recognizing the safety records achieved, despite the Three Mile Island accident that did not cause serious health or environmental effects, as noted previously in this book. I had the chance to tell Ralph Nader that he was my hero when he first pushed for auto safety, but not after he attacked nuclear power. I was also able, along with Ted and Ken, to indicate my doubts about the scientific integrity of the report by Yablokov et al., having previously read many reports such as that of Jaworoski (2010) and others I have known as investigators that showed, surprisingly, the relatively low prevalence of health and environmental effects of Chernobyl, even though the reactor did not have the safeguards required in the U. S. nuclear power plants.

Nevertheless, I believed Dr. Sherman to be a person truly dedicated to human health and the environment, and asked her if she could get me a copy of the Yablokov report. She kindly sent me a copy at reduced rate and I have examined the report in these weeks before finalizing this book. I am sorry that I must reject the findings and methods used in this Russian report. As one very important reason for rejection, I note in the front matter that Dr. Ernest J. Sternglass was one of the consultants, and did not see any references to publications of those like Simon et al., whom I know to be world-class epidemiologists. I learned from my experience reviewing reports of my former colleague Sternglass (see Exhibit 3 and related discussion), and others whom I have needed to reject as incompetent investigators of health studies, that the ANA "scientists" who get most of the attention of the American news media can select data in an unscientific manner to prove a point that would take an expensive, properly controlled, study to refute.

I thus concluded long ago, as a student and teacher of scientific methods, and a reviewer of research proposals for several agencies, to give major weight to the reputations of those involved in preparing any scientific report. There is not enough time in one lifetime to refute all of the baloney that these pseudo-scientists can dream up with their selected or improperly collected data, improper applications of statistical methods of analysis, and biased reporting of conclusions. (See my discussions of a sample of my experience in Chapter 1, particularly that associated with an Associated Press article by Sternglass after the Three Mile Accident presented as Exhibit 3.) Then, these ANA "scientists" run to the media with their "findings," with eloquent pleas that seem serious to most reporters and news media, who do not seek out, or perhaps know how to seek out, those scientific reviewers who are known in the relevant science communities as authentic investigators. My bottom line: I hope that those who seek truth and care about human healtha and the environment will believe the article by Jaworoski (2010) and not that of Yablokov et al. (2009).

Please also refer back to my other experiences in Chapter 1, as well as some of the traps to watch out for in studies or presentations of radiation risk as presented near the end of Chapter 4.

Let us conclude with hopeful thoughts for America.

NO. WAIT!! More breaking news has just come in: GOOD NEWS!

There seems these days to be an endless flow of articles related to homeland security and radiation health. It has been difficult to finish this book. The August issue of my favorite scientific journal, HEALTH PHYSICS, arrived at my home on July 15. This issue of the journal contains a number of articles about recently completed, and rather comprehensive, studies of the external and internal doses received by natives of the Marshall Islands, as well as doses received by the scientists and other test participants of the many atomic and hydrogen bomb tests conducted by the United States at the Pacific Test Sites. The results of these studies published in this issue have also been derived and reported by teams led by top scientists of the National Cancer Institute (NCI) in Bethesda, Maryland. I have known a number of them for their excellent scientific work over the years. As capable as they are, I am still happily surprised that they were able to accomplish such difficult studies of massive data pertaining to many thousands of exposed individuals for many years.

Not only am I glad as a scientist to see such valuable data on exposures and risks from nuclear fallout captured by these excellent teams, I am also glad that their findings support many of my conclusions in the body of this text about the fact, except for persons exposed within a passing cloud of debris containing fission product mixtures from an explosion, that doses and estimated risks are much greater from external irradiation than those from internal exposure to radioactive material breathed or ingested into the body. The only situations I know where persons were exposed within a passing cloud, or within "mushroom clouds", except for the partially protected pilots who sampled radioactive material in rapid passes through high mushroom clouds in the nuclear tests before 1963, is the accidental exposure of groups of persons in May 1974 to the debris from an underground Soviet test of a 150 kiloton nuclear bomb. The declassified information from this human exposure case is summarized after Exhibit 20 in this book, and reported in somewhat more detail in Brodsky and Reeves (2009).

The information obtained after the Soviet test exposures tends to confirm my estimates in Chapter 5 that it takes an inhalation of about 300 microcuries of gross fission products less than 30 days old (within a factor of about two as indicated in Exhibit 20) to approximate the short- and long-term risks of an external exposure to 25 R of gamma radiation. (As indicated in Exhibit 20, this rule of thumb should also be applicable in order of magnitude even for just a pure iodine nuclide release.) This rule of thumb should, of course, be applied with large safety factors for use in any emergencies. However, in any case, someone with a four folded handkerchief over the mouth while mouth breathing in a passing fission product cloud would find that the handkerchief would send an ordinary Geiger counter off the highest scale with its beta window open. Such rules of thumb should in any case be useful in helping the public to avoid panic for smaller count rates.

My own conclusions were obtained independently from those of the NCI, mainly from other data, personal calculations (Brodsky 1965; Brodsky et al. 1971), and my own experiences with nuclear fallout. Hopefully, these observations will help avoid unnecessary panic about radioactive contamination in the immediate hours after an RDD or nuclear bomb attack, and persuade most of the public that: simple dusting off and washing of open areas of skin and putting contaminated clothing in plastic bags for later examination will avoid any serious risks from intake of radioactive fallout. Such simple actions would also most likely avoid serious skin burns from beta emitters in the fallout. More support of these conclusions is given in the text.

I will present below just a few of the findings from some of the articles of the NCI teams, just to tease into reading the August issue of HEALTH PHYSICS those scientists familiar with subjects of radiation epidemiology and risk, or others who might want to learn the definitions and concepts of Appendix A (or at least the few definitions in Chapter 3) and dip their toes into the subject. Some of the information presented by Simon's teams in the August issue of the journal were summarized in talks at the HPS meeting, with abstracts in the July supplementary issue of HEALTH PHYSICS. However, little quantitative information is available in these abstracts. The published papers are thorough and impressive.

Simon, Bouville, Land, and Beck (Simon et al. 2010a) found that, "Except for internal doses to the thyroid gland, external exposure was generally the major contributor to organ doses, particularly for red bone marrow and stomach wall." In Chapters 4 and 5 of this book, I show evidence for the fact that, for a fission product release from a nuclear bomb, thyroid doses (including from short-life iodine species), and other internal doses, will not result in serious harm unless the exposed subject is in the mushroom cloud. The natives and other persons in the NCI study were not exposed in a passing cloud, but only to fallout on the ground, on their skins, and in their food. Moreover, the limited but large quantities of radioactivity that can be inhaled in the immediate aftermath of an attack without likely harm are estimated and provided in tables.

Beck, Bouville, Moroz, and Simon (Beck et al. 2010) provided an analysis of fallout deposition that was confirmed by a comparison of their predictions of cesium-137 deposition with contemporary radiochemical analyses of the soils on the 23 inhabited atolls that received significant fallout. Their data are a gold mine for any further studies of the fate of fallout radionuclides in the ecosystems of these islands.

Bouville, Beck, and Simon (Bouville et al. 2010) presented doses from external irradiation of Marshall Islanders on Enewetak and Bikini. Their methods and data are presented in exquisite detail. Of immediate interest here is that their estimates of the doses to natives of the northern atolls from the Castle Bravo shot range up to "…over 1,000 mGy, even though the populations of the three most exposed communities…were evacuated shortly after the test." As indicated by unit definitions, more than 1,000 mGy is more than 100 rad. In the subtitle of Exhibit 11 in this book, I provided an estimate that I have used for many years that external gamma exposure to Rongelap Atoll natives ranged up to almost 200 rem (same as rad here), and skin exposures were up to about 6,000 rad because the natives initially did not know that they needed to wash fallout particles off of their skins.

Simon, Bouville, Melo, Beck, and Weinstock (Simon et al. 2010b) provide a detailed analysis of intakes and doses from 63 fission product nuclides from all Pacific tests, for the Marshallese populations. Among extensive findings, they conclude that 99 percent of the thyroid dose to the Rongelap natives (who were exposed to the same fallout as I after the Castle BRAVO shot) was attributable to the BRAVO shot, after which the winds unexpectedly shifted in unfortunate directions. Since, as indicated above and in relation to risk information in Chapter 4, even the high thyroid dose would not be expected to cause as high a health risk as the external exposure, we can conclude again that external exposures are more serious than internal exposures for such fission product fallout, excluding exposure in the passing cloud of debris, usually high aloft.

Harris, Simon, and Ibrahim (Harris et al. 2010) present much of the original urine data collected after the BRAVO shot, needed for estimating internal doses from fallout at the various atolls, and on the Japanese vessel, the *Lucky Dragon*. Much of this data has never been published in the open literature. It has been valuable in the analyses of the other papers in this journal issue, and will continue to be valuable for future studies.

Simon's dedication to the memory of Payne Harris, M.D. (Simon 2010c) is, to me, also a very important article. I was sad to learn from this article that Payne had passed on. We had become fast friends after about 1997 when I began work on the Nuclear Test Personnel Review, and shared many lunch discussions. He would call me to have lunch with him even on short visits to see his daughter in Virginia, after he returned to Albuquerque, where he had practiced medicine. Unfortunately, I had misplaced his telephone number after a move, and have not called him for a couple of years. In his memory, I must add his name to my dedications of this book. He was a fine physicist and physician who worked on many physics, radiobiological, and field research projects both in the laboratories at Los Alamos as well as at the Pacific and Nevada Test Sites. He was dedicated to scientific truth and its applications for establishing health protection standards. A report that I have read showed me that it was he who derived mathematically, from excretion data of the patients injected in Langham's early experiment with presumed terminal patients, the Langham equations that I and others used in the 1960s and earlier to obtain early triage of plutonium intakes by accident victims from their excretion data. He was the first to enter the high

radiation fields after the Ivy MIKE shot to attempt to open the bunkers containing the basic data on the function of the first hydrogen device. He was always interested in practical field experience as well as basic laboratory research findings, and to our advantage he saved for many years his vast files of papers so that we can now benefit from their value in the publication of Harris et al. (2010). Kudos to Dr. Steven Simon for that accomplishment.

I am also grateful to Steven Simon for the publication of Payne's dedication (Simon 2010c). One page can not do justice to this person of strong character, broad talents in the sciences and medicine, and a great sense of humor and humanity. On one of my visits to his home in Virginia, I captured about two hours of video while interviewing him about his life. A copy of this video should be in the Health Physics Society history library. Otherwise, if necessary, I might be able to retrieve it from one of my boxes in the garage, still unpacked years after my last move. Whoever steps up to write my obituary, please do not let my wife throw out anything without prior inspection of my bookshelves and boxes by a certified health physicist.

Wait, some more afterthoughts from Steve Jones memos:

On one last going through my letters of comment and checking the proofs, I find that, although I have already adopted some of his changes in the text, I have not done justice to the copious letters of comment from my hero Steve Jones (see picture above). He should write his own book, because he has fired off so many long letters that I can not take time to rewrite this book, and on a few issues I might not totally agree with his emphasis on priorities, even though I do agree with his overall views about the urgent needs to strengthen radiological aspects of our civil defense. For one, I still believe that everything I said in Chapter 8 about the need to provide the public, responders, and medical centers with the card-size SIRAD is valid. However, considering Steve's long experiences with the public and responders on these issues, his views deserve consideration. Thus, I will just place here a few quotes from selected e-mails to indicate some of his major concerns:

From two pages of an e-mail of July 2, 2009: "I believe that if you lead in with the SIRAD badge most people if not everyone won't have a clue as to what you are talking about and will be too embarrassed to show their ignorance…Lead in with the no-cost solutions of the Nuclear War Survival Skills…" (see Kearny 2001)… "From there the PCD (Physicians for Civil Defense) wallet card is the most training most first responders will ever get before we are nuked…I have a degree in special education. That means I'm trained in teaching difficult material… I hope you have a SIRAD card to give to every policy maker and staffer you meet. I am getting ready to buy a couple of hundred of them with PCD money to give away as samples to emergency managers."

From a three-page e-mail of July 5, 2009: "Most intelligent educated people have the mistaken idea that there are government agents or a government agency capable of handling a national nuclear disaster…because of their misperception the SIRAD badge may seem crude or backward compared to the sophisticated equipment our policy makers imagine that our emergency managers have or are proficient with."…"But, if you turn back the page of history a few years you'll see that the government funded a national plan for untrained emergency managers and public to go into effect **even post attack!** That is, for the plan to work, emergency managers only need to have the Nuclear War Survival Skills manual on hand. They don't need to read it until a nuke goes off. The key to the plan is the Kearny Fallout Meter, a dosimeter that they have to make themselves."…"You can point out that the entire state of Arizona is going by the Nuclear War Survival Skills plan and emergency managers in Utah are just beginning to adopt it as the state's only plan." (These facts are due to the energetic and continuous efforts of Steve throughout the years. I wish all of us professionals in the related sciences and engineering could be as energetic in these matters.)…"You might consider putting the first 35 pages of Nuclear War Survival Skills and the 24 page instruction for the Kearny Fallout Meter in your appendix." (I did not do so, because I feel that the SIRAD card is much better, much more rugged and accurate, and more easily read under emergency conditions; I did put in the reference to the manual and the meter, and they can all be obtained on Google or from the reference to

Shane Connor's web site.)…"The SIRAD dosimeter is the only manufactured technical device that could save the country in the near term."

From a 4-page e-mail of November 11, 2009: "…The Southwest Free Press has asked me to write about civil defense so I'll be able to break the new SIRAD card story. The paper is distributed throughout eight states…"…"You are a media event as soon as you publish your book."…"The 60-second responder cards should go with your SIRAD cards when you present them."…"Physicians for Civil Defense has spent nearly 100,000 dollars developing this approach. Don't ignore it and try to reinvent the wheel. I doubt you'll ever get high government endorsement for SIRAD but you'll get plenty of high people in government to assist you if you use our simple approach." "Finally, I believe we should use the press as the 4th branch of government. We win them every time and we can achieve through the press what we had hoped to achieve through the formal institutions of government."

From a 17-page e-mail of November 30, 2009: In regard to a shorter pamphlet prepared from information in the book: "While I had expected a more general 'what-to-do' guide for the untrained I was pleasantly surprised and elated at this pamphlet for use as a marketing tool with the media. This is the kind of document reporters like. Also it gives solid informational back-up in a short form the kind trainers like (vs. a book). This is a needed marketing tool and critically important endorsement of the SIRAD monitor…80% of the pamphlet is over the top good. Killer material, especially the biographical information and personal experiences, busting rad myths and the reprint of the article containing info about rotating in a crowd, etc."… "Up until the end of the pamphlet seems very 'scientific' but too commercial at the end." (The rest of the 17 pages also include a suggested revision of my pamphlet, some of the comments also pertaining to this book.)

From a 3-page e-mail of March 17, 2010: (after Steve visited in December 2009 Dr. Ghordan Patel's laboratory and manufacturing process for the SIRAD dosimeters, which Steve prefers to call monitors when talking with those not used to the term "dosimeter."):

> "Thank you for sending me the flyer for your book. It is a timely publication and a giant step towards proper civil defense. I see it as a bridge between the unsavory but necessary expedients available today through the Nuclear War Survival Skills plan and the proper Switzerland-type of civil defense we could or should have tomorrow." "…it gives civil defense advocates around the country a new injection of 'blood' or fresh energy as well as new information obtained through my meeting with Todd Brethauer of TSWG."…"…make it clear that SIRAD was created by the U.S. Department of Defense." "Credit should also be given to the DoD for doing their job of protecting America and putting our tax dollars to excellent use. Todd Brethaur should go down in history as a 'hero of America'." "Certainly Dr. Patel has made a great contribution. But we want government at federal, state, and local levels to embrace SIRAD and explaining to them up front that SIRAD is a creation of DoD breaks down all resistance…This is one time where it's important to brag on government." "That said the next point is to update the SIRAD information itself to include the RadSticker that will be available soon for about $2.00. It is not a good substitute for the credit card version but rather a stepping stone to it. Once people become familiar with the RadSticker they will not settle for less than the credit card version. This is pure strategy. This is how things work in the real world. People can only handle milk before meat."… "Since I last communicated with you I've discovered that the Health Physics Society Homeland Security Committee has developed a new "card" for the public…It would be more appropriate to include the new card…than 'my' 60-Second Training Card." … "Strategy needs to focus all efforts to get emergency responders equipped with SIRAD followed by all essential workers. The public will then naturally follow but

> not until then." …"Until every emergency responder is equipped with SIRAD no private citizen should have it and we should not waste what little time, energy, and resource we have on private citizens…"

One can see in these paragraphs the change over time since I have first corresponded and spoken with him of Steve's changes in emphasis on the Kearny meter toward the SIRAD dosimeters, and his further increasing interest in priority over initial distribution of the smaller RadSticker. I am not sure that I can agree with Steve's last sentence. Time for preparing the public might be short, and the dosimeter is an entry way into convincing members of the public that there are ways to radically reduce risks after a spread of radioactive material and that they can monitor and understand their own risks and actions needed to save the lives of their families. This is true just as it has been in talking with the firemen and police as indicated in the early Salt Lake City news article at the beginning of this appendix. In addition, presenting the SIRAD to members of the public and local authorities improves chances that they will prevail in convincing those at the top levels of government homeland security agencies of the importance of ordering these dosimeters to save lives in the event of an attack, as well as to prevent or monitor accidental exposures (see Chapter 8). These dosimeters, also so low in cost, can be ordered by state and local governments using only a small portion of the funds allocated to states by the Department of Homeland Security. Also, we need to realize that my heroes Dr. Patel and Fay Crowe urgently need to receive more orders for SIRAD dosimeters to stay in business and have this remarkable invention available for saving lives and preserving our national will. In addition, Steve has now taken to favor earlier distribution of the smaller RadSticker, while I favor explaining the need for both at the same time. Many health physicists and others who should be engaged in educating officials and the public will find that the improved ability to read in the lower rad range the larger credit-card SIRAD, which has been tested and approved by DHS, will make them more likely to support the card's distribution.

I hope that these few paragraphs will at least give some attention to the long experience and many recommendations of Steve Jones.

Now may I rest in peace after getting this book off to the publisher.

No, wait!! The book is still in final page makeup, and now the Japanese disaster has occurred. I must inform my readers about the radiation exposure and radioactive fallout information now becoming available (May 21, 2011). So, here is another section:

Japanese Disaster and Releases of Radioactivity and Radiation Levels from Fukushima Reactors

Beginning after the second page of the introductory paragraphs of this section is a news release that I prepared on April 6, 2011 to help journalists to understand some of the language and concepts used in discussing how much radiation exposure or intake of radioactive material is dangerous or likely to cause health effects. This is much longer than any news release usually given to the media, because it is essential that journalists and the public are provided a better understanding of issues of radiation exposure and risks. In the news reports following the Japanese nuclear disasters, cited as references at the end of this release, and in many others, the only statements usually related to amounts of radiation exposure are like, "…a significant increase in radiation has been measured…," or "…radioactive iodine has been detected in milk…," or "… a high concentrations of cesium-137 has been found in…"

Very sensitive indications of the presence of additional radiation or radioactivity are made by scientists that are called "significant" increases. In measurement parlance, scientists mean by "significant" that a statistical increase has been observed in a measurement, NOT that the radiation or radioactivity observed would cause a "significant" health effect. Also, when scientists use the word "risk," they often are using it as another word for "chance," and are not implying "danger." I was once admonished by another scientist, Dr. Otto Raabe, for not realizing that the word "risk" often means "danger" to the public. Note, in Exhibits 26-29 in this book, the extreme sensitivity of a simple Geiger counter to the beta radiation emanating from a uranium-glazed plate, and the extremely negligible risk of exposing my hand to that plate. Such dinnerware used to be on many dining tables until the latter 1900s. One of the exhibits of Appendix I (Exhibit 48) is included with this news release, showing the intense count-rate on such a Geiger counter is, in a gamma radiation field, only 10 mR per hour, which a responder could remain exposed to for about 6 weeks and still not receive the approximately 25 R allowed for saving life.

Exhibit 50, following the news release, is an illustration of the radiation dose contours around the Fukushima reactors that enclose areas of various total dose for those standing in the open without evacuating for one year. This illustration is from a slide presentation of April 18, 2011, by the National Nuclear Security Agency, which is part of the Department of Energy. As indicated in other slides of the presentation, the dose is high-sided by the assumption that the exposed person never goes indoors during the year. The doses also include high-sided estimates of equivalent doses from internal radiation exposure due to inhalation of material resuspended from the ground, not considering wash out of this material, but considering only radioactive decay. As I have indicated in Chapter 4 of this book, the literature and my own experience with patients at the University of Pittsburgh would indicate that the risks of internal exposure that we estimate for safety in peacetime applications are likely very high-sided themselves, so it is likely that the external exposures are the main indicators of any future radiation effects. Because the radiation levels decrease rapidly for those nuclides giving most of the external exposure, it is likely that those persons evacuated from within the 30 kilometer range will be able to soon return to their homes, as long as they do not eat anything grown in their own gardens before their harvests are analyzed for any radionuclides that may be present. Chapter 5 provides some information on acceptable levels of radioactivity in food and water for both limited time emergency use and for long-term use.

In Exhibit 50, it can be seen that no person on the mainland, away from the island with the nuclear reactors, has received or will receive an amount of radiation exposure that is likely to produce any health effects. Also, because the doses for one year in Exhibit 50 were estimated for a person standing in the open from the beginning of releases, any doses to persons who return home a month or two after the releases will receive much less radiation dose. Note that a dose of 2 rad or rem, from an even higher exposure in R, is less than the dose (averaged over my body) that I had in one hour when I retrieved my neutron spectrometers after the second two H-bomb detonations in 1954 (see Exhibits 35A-C and related paragraphs). This exposure occurred 57 years ago, and I am still playing tennis.

As indicated in the paragraphs after Exhibit 1 of the following news release, although the emissions of cesium-137 might well be a major contribution of the external radiation in Exhibit 50 in the vicinity of the Fukushima reactors, the fallout in the United States from Fukushima contains measurable, but negligible, amounts of cesium-137 in regard to health effects. Radiation Facts to Reduce Fear and Save Lives*

In addition to cesium-137, the iodine nuclides are among …except for noting the report in *The Washington Post* by Andrew Higgins (2011) that includes at the end, 'And, so far at least, the Okubos are healthy: a recent radiation screening declared them clean'."

News media have reported radioactivity concentrations thousands of times the natural amounts in sea water and some plants. When I obtain the actual concentrations, I will make my own calculations and discuss their risks or lack thereof in future news releases. So far, based on previous experience, I do not expect serious harm to those in the Japanese population, except possibly for the workers trying to contain the damage in the nuclear energy plants.

News Release No. 1, April 6, 2011, By

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Abstract: The purpose of this article is to provide all levels of citizens, responders, and media investigators with the most basic background information needed to help them understand issues related to radiation exposures after accidental or terrorist releases of radioactive material to the environment. Such an understanding is necessary to prevent undue fears of low radiation levels as well as to alert them to the higher ranges that are dangerous to health. Media reporters have generally done a good job of covering events during the disastrous tsunami and resulting dispersal of radioactivity from damaged nuclear plants. Several weeks after the initial destruction of the Japanese reactors, an April 4 article in The Washington Post by Will Englund indicated that most of the released fission products were deposited within the nuclear plant area, as references in my books predicted. On April 5, an article by Andrew Higgins discussed the confusion existing over radiation levels and risks, and pointed out that a Japanese farmer within 15 miles of the reactors who refused to evacuate, and who with his family had been drinking their cows' milk, were found in final screening to have ingested no detectable radioactive material. The ingestion of iodine radionuclides, in particular, is most subject to detection by sensitive portable detectors. This brief article provides facts about radiation and radioactive materials that will help alleviate unnecessary fears of the lower ranges of radiation levels and radioactive material concentrations – the levels that are not likely to cause serious harm. It will also caution citizens and responders to take appropriate shelter and actions in situations where higher levels would require. The facts in this article are supported by the author's varied personal experiences and research from over sixty years as a physicist, health physicist, biostatistician, and professor, as documented in the references. **These facts are a minimum needed for understanding future News Releases that I or others will prepare.**

Introduction: The facts and recommendations in this article are presented as follows:

- A brief set of definitions and concepts necessary for self protection;
- Ranges of radiation and concentrations of radioactivity from everyday sources;
- Radiation levels and air concentrations that approach risks higher than normal;
- Why we should NOT believe that, "ANY Radiation is 'DANGEROUS';"
- Factors that limit the risks from molten nuclear fuel;

* Requests for further information may be addressed to Dr. Brodsky at ALBRODSKY@AOL.COM .

- Simple actions to take to avoid or reduce radiation exposure;
- Personal affordable dosimeters you can wear for your immediate dose information;
- How to find reliable "experts" – those you can believe.

Definitions and Concepts Used in Discussing Radiation Issues

More detailed words to know and concepts are in the reference (Brodsky 2011) for radiation emergencies. A still brief but more descriptive set is in Appendix A. The minimum words needed to understand current announcements are:

1) **Radiation exposure** – the amount of gamma particles (also called photons) or beta rays (free and fast electrons) **coming to you** per unit area of your body. Gamma radiation is the most penetrating and most likely to cause early or late effects at high quantities. Beta radiation coming from outside the body penetrates no more than about 1 centimeter; levels of contamination on skin that will give high doses is given later in this paper. **In this paper, gamma exposure will be given in the conventional unit of roentgens, R, for simplicity (see why in Appendix A).** Alpha rays (particles) can not penetrate past the dead layer of skin from outside the body.
2) **Radiation dose** – the amount of **energy absorbed** per unit mass of tissue (**100 ergs per gram**) at the point of exposure (perhaps an approximate average when the whole body is exposed) if the person's body is at that point. Dose in conventional units was rounded to 100 ergs per gram originally, because 1 R of exposure would deliver a dose of at most 96 ergs per gram of a small volume of tissue at the point of exposure (a small volume is defined so that no significant tissue before it would significantly decrease the incident exposures). Rather than go further here, just know that stating exposure in R provides a high-sided estimate of the dose in rad (which is 0.01 gray (Gy)). The same is true for biological dose in rem (which is 0.01 sievert (Sv)).
3) **Radioactive material** – any material (food, water, dirt, etc.) that contains any species of unstable atoms that emit ionizing radiation such as alpha, beta, or gamma rays. The unstable atoms are called "**radionuclides.**" Each of the hundreds of radionuclides we deal with has its own radioactive decay rate, which is described by its half-life, and decays away at its own rate. Inside the body, a radionuclide is like a tiny, submicroscopic x-ray machine emitting radiation (alpha, beta, and/or gamma) and bombarding nearby cells at close range, decreasing in intensity at its own rate.
4) **Half-life** – a particular species of radioactive atom has a half-life, which is the time it takes for half of the atoms to change (sometimes called "disintegration" or "transformation"). Half lives are given in units of time, seconds, minutes, hours, days, or years. Measured or calculated disintegration rates (sometimes called transformation rates) are often given in curies (Ci), bequerels (Bq), disintegrations per minute (dpm), disintegrations per second (dps), tpm, or tps. Half-lives and disintegration rates of radionuclides have wide ranges over time and wide rates in terms such as dpm per gram of pure nuclide. Actual risks of given rates or doses depend very widely on which radionuclide(s) are in food, water, or already inside human tissues.
5) **Prefixes** – Because such wide ranges of quantities are discussed, prefixes often preceed units, such as: µBq means millionths of becquerels; mBq means thousandths of Bq; KBq means thousands of Bq; MBq means millions of Bq; and GBq means billions of Bq. The same prefixes are used in stating quantities of exposure or dose. Study them if they are not familiar.

The above terms are a minimum that you must learn to understand announcements about large, small, or insignificant radiation risks, and to begin to know what "experts" are giving you correct information.

Radiations from, and Radioactivity in, Natural Sources

Knowing the meanings of the terms above, you can now just examine the attached Exhibit 1 (The few exhibits in this news release are taken from over sixty in my 2011 book.) to be familiar with natural levels of radiation and radioactivity that are present around you in ordinary everyday life. Reported amounts resulting from radioactive

contamination from a nuclear accident or attack may be compared with this summary of radiation levels and radioactivity in natural products or everyday activities and environments.

Radiation and Radioactivity Levels Ranging from Harmless to Lethal

Exhibit 2 shows the wide ranges of radiation exposure (or dose – see footnotes) often discussed versus human risks. As discussed under the definitions paragraphs, the radiation exposures are generally high-sided for gamma radiation and are given here simply in R units. Other units are presented in parentheses to assist the reader in getting used to the various ways radiation exposures, doses, and risks are presented. Exhibit 3 will provide information about the ranges of risks or safety for various concentrations of radioactivity in food and water, which may be compared to natural concentrations in Exhibit 1.

Why we should NOT believe that, "ANY Radiation is 'DANGEROUS'"?

A more thorough presentation of such concepts in covered in Brodsky (2011), based on literature reviewed in Brodsky (1996), and peer-reviewed articles to the present time. When scientists who seem to have appropriate credentials say, "Any radiation is dangerous," or what is the same in meaning, "There is no safe level of radiation," they really mean that the radiation incidences of cancer at higher levels in the Hiroshima and Nagasaki populations, are extrapolated down to zero dose for purposes of peacetime safety regulations. We do know that risks of radiation go down as dose goes down, and for emergency work, we should not assume there are any long term risks at the low R range or below. Evidence of adaptive effects or repair of cell damage, and even hormetic effects such as boosts to the immune system, at lower radiation levels, as summarized in the references, should be taken into account under emergency conditions. See the relationships between exposure levels and acute and long-term biological effects in Exhibit 4, summarized briefly from the references. Right now, most people need to know immediately whether they are, or are not, being exposed to radiation levels that pose unacceptable risks to their health. Exhibit 5 visually demonstrates how a sensitive Geiger counter reading can be interpreted in terms of radiation dose rates that are easily measurable, but would not result in serious risks even after weeks of exposure.

Factors that limit the risks from molten nuclear fuel: **Experiments in which two nuclear fuel elements, each containing thousands of curies of fission products, were melted down in the Idaho desert in an experiment by one of my supervisors, showed that for the refractory material of which nuclear fuel and its coverings are made, although radionuclides could be measured hundreds of meters downwind, almost all of the nuclear material except volatile gases remained in areas the size of large rooms (Brodsky and Beard 1960, summarized in Brodsky et al. 2004). The truth about emissions (Brodsky 1982, 2011) from the Three Mile Island accident has confirmed this finding. Despite media reports to the contrary taken from less-than-expert scientists, the Pennsylvania health department radioepidemiological studies found no excess cancers in the population after the TMI accident. Further support of my prediction that most of the radioactive fission products deposited locally is found in the recent article by Will Englund (2011). The primarily local deposition in Japan, combined with the great dilution of any radioactive plume and deposition in the vast Pacific ocean for plumes below the stratosphere (not like for hydrogen bombs), results in negligible (really no effective) harmful health effects in the USA. Brown's article (Brown 2011) in the April 6 Washington Post, quoting several government officials, is on the mark.**

Simple actions to take to avoid or reduce radiation exposure: **Exhibit 6 provides a minimum of information that members of the public must know to protect themselves in the immediate moments and hours after radioactive or other toxic materials are released from accidents or natural or terrorist incidents. This exhibit is simplified from one published in some local papers. These simple measures can save many lives. Many more actions for persons who wish to prepare to save life are covered in Brodsky (2011).**

Personal affordable dosimeters you can wear for your immediate dose information: **Exhibit 7 shows pictures of the SIRAD RADTriage and smaller RADSticker radiation monitors (often called dosimeters) that have been distributed for responders in Japan. The research for these dosimeters that measure gamma radiation received was supported over the years by millions of dollars in funds from defense and homeland security agencies in the USA, as well as by Dr. Gordhan Patel, the inventor. They have been well-tested in USA laboratories and are available in quantity at most affordable costs. The many reasons why I believe they should be distributed throughout the general public as well as to responders and medical institutions, in peacetime or before unexpected releases, are presented in Chapter 8 of Brodsky (2011). They can provide persons wearing them conveniently in pockets or pasted to wallets immediate information about possible radiation exposures. Most persons will not see color changes and know they are safe. Those minority who might receive the higher, harmful, exposures will know when observing color changes or darkening when they need to seek better shelter and shielding, or when they need to seek medical care.**

How to find reliable "experts" – those you can believe

In Japan, consult groups of scientists (physicians, physicists, health physicists, and radiobiologists) who are associated with the leading academic institutions and the reliable Radiation Effects Research Foundation (RERF) studying the Hiroshima and Nagasaki populations exposed to atomic bomb radiation. In the USA, consult scientists affiliated with a number of academic and research institutes (such as the members of the National Council for Radiation Protection and Measurement, and officers and committee chairs of the Health Physics Society at http://www.hps.org. Trust those many scientists referenced in my publications who have performed the basic radiation research and are listed as trustworthy in my references.

Conclusions

As news reports are beginning to show, there is little likelihood that members of the public in Japan, or even for any of those within the fifty mile evacuation area recommended for United States citizens, will receive radiation doses that will cause early or late harmful effects. This is partly because radiation exposures received internally will occur over time, be relatively low, and be compensated by natural repair processes (such as slow exposures to the sun do not cause serious burns). Those workers assigned to nuclear plant recoveries, however, could sustain serious health effects or even die if the officials do not enforce well-known safety provisions and emergency limits of exposure. I do believe that the Japanese officials and plant managers are competent in this respect. The facts in this short article are supported by information in my publications and the references provided therein. My opinions result from over sixty years as a physicist, health physicist, biostatistician, radiation science professor at three universities, and co-investigator for more than eight years of a major radiation epidemiology study of radiation workers in the United States. There are some who have been influenced to oppose nuclear power in the USA who have been distributing exaggerated fears of all nuclear plants; it is my prerogative here to caution that these persons do not have adequate backgrounds to support their fears. The latest nuclear facilities proposed have additional safety features that would prevent the occurrence of the type of situation currently in Japan, even for the worst types of earthquakes. It may be noted that France has seen it fit to adopt our pressurized water reactors in the 1970s and now has almost eighty percent of its base electric power obtained from nuclear energy (Brodsky 2010).

The last paragraph above is intended to draw those seeking effective consultations about these issues to the true scientific experts in this complex field of issues. Also, many of the scientists cited in my references are well known to me and comprise a good list of competent sources. I hope that the public, emergency managers, and responders, will be helped by this article.

EXHIBIT 1 – Natural and Common Radiation Doses and Radioactivity Concentrations

Typical Radiation Doses

Annual dose from living near a nuclear power plant < 1 millirem

Flight from Los Angeles to London	5 mrem
Annual public dose limit	100 mrem
Annual natural background	300 mrem
Fetal dose limit	500 mrem
Barium enema (limited part of body)	870 mrem
Annual radiation worker dose limit	5,000 mrem
Heart catheterization (skin dose)	45,000 mrem
Life saving actions guidance (NCRP-116)	50,000 mrem
Mild acute radiation syndrome (if whole body dose)	200,000 mrem
LD 50/60 for human (bone marrow dose) (whole body dose)	350,000 mrem
Radiation therapy (localized & fractionated)	6,000,000 mrem

These numbers represent some USA natural average background and commonly encountered doses, and some regulatory peacetime "limits" (which I have helped promulgate, but which do not indicate thresholds of harm). Similar dose ranges would be applicable in Japan. These numbers can vary somewhat depending on your own activities and where you live. Population medical exposures have been widely reported to have increased due to CT scanning, but unfortunately these reports and exaggerated estimates of harmful effects have not been in context with lives saved (see my book Brodsky 2011). However, the doses to the public in the vicinity of a nuclear power plant in normal peacetime operation are so low as not to be measurable, as seen as the top of the table. In contrast, doses close-in to the failed nuclear plants in the Three Mile Island, The Chernobyl, and the Japanese disasters, have been so high that workers have needed to take turns limited to minutes in order to carry out possible corrective or recovery tasks. This shows the need to understand the effects of radiation doses and intensities over a very wide range.

Exhibit 1 (continued) – Natural and Common Radioactivity Concentrations

About 70 of 340 nuclides found in nature are radioactive. Potassium-40 (K-40) atoms are a small fraction of the potassium atoms that enter with salt intake, and are needed in our bodies to maintain our heart beats. The K-40 can not, and need not, be separated from the non-radioactive K-39 atoms. The dose delivered is not a risk (such a dose is NOT dangerous – see my books to understand why.) The internal dose from K-40 is the highest internal dose from naturally-occurring radioactive material taken into the body, except possibly for the theoretical calculations of dose to lung tissue from radon daughters. Although these K-40 atoms have a half-life of 1.26

billion years, and each atom upon decay emits 1.46 MeV gamma rays only 11% of the time, there are so many of these atoms in our bodies that the internal dose per year from the beta and gamma radiation is in the range of 10 to 20 mrem per year, compared to our overall dose from natural background and radon daughters of about 300 mrem per year. (I have often had my students do a homework problem to calculate their doses from natural K-40.) The gamma radiation from the K-40 is so easy to detect with modern radiation detectors that, when I was Technical Director of Radiation Medicine and Associate Professor of Health Physics (under Chairman Niel Wald, M.D., of the Radiation Health Department), Graduate School of Public Health, University of Pittsburgh. I used my own body sitting in a lawn chair inside our counting room (called a "whole body counter") at the hospital to calibrate my own equipment. Details of this experience are in the references (Brodsky 2011).

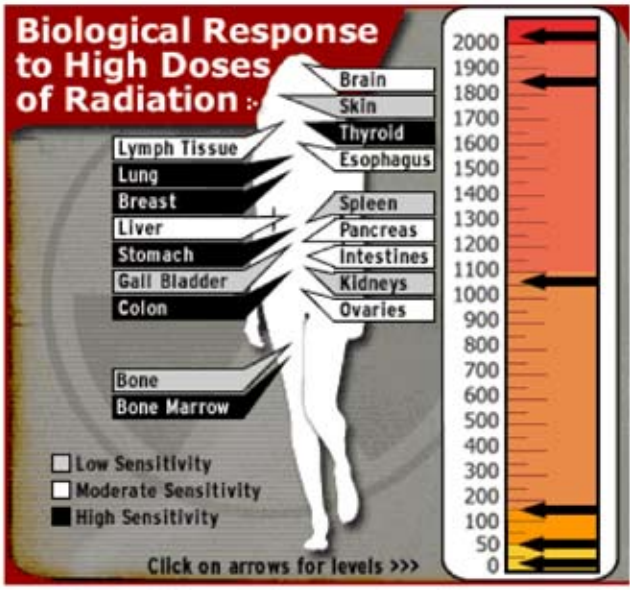
I was also able to measure the amounts of cesium-137 (Cs-137) in my body from worldwide fallout of nuclear bomb tests in my whole body counter. Agreements with the Soviets ended the atmospheric testing of nuclear weapons in 1963. The peak amounts of fallout Cs-137 in our bodies occurred in the USA population in the 1963-64 era; about the same concentrations must have occurred in the Japanese population about that time because. Our whole body counter opened in 1964-1965 for operation to check persons in the Pittsburgh area who had inhaled plutonium, americium, and fission products from the then-blooming nuclear-related operations in Western Pennsylvania (see Brodsky and Wald (2004). Soon after our operations began, I measured about 3 nanocuries total of Cs-137 in my body, mainly distributed in my muscle tissues. I do not remember the dose-rate to my body exactly, but it was certainly well below several millirem per year in 1964, decreasing each year thereafter due to the 30-year half life of Cs-137, the biological half-life of cesium and potassium, and the decreasing amounts from fallout after cessation of the atmospheric nuclear tests. A few milliem per year is nothing to fear. (I can calculate this later if needed.) Certainly, the emissions from the Japanese reactors, without the stratospheric transport and much lower radioactive content than the hundreds of detonated nuclear bombs, could not affect anyone in the United States, and media reports so far indicate that the Japanese will not be seriously affected compared to the extreme suffering caused by the tsunami.

EXHIBIT 2 — Radiation and Radioactivity Levels Ranging from Harmless to Lethal

Simple table of external radiation levels vs. acute effects:

ACUTE RADIATION EXPOSURE

0-25 rads:	No observable effect
25-100 rads	Slight blood changes
100-200 rads	Significant reduction in blood platelets and white blood cells (temporary)
200-500 rads:	Severe blood damage, nausea, hair loss, hemorrhage, death in many cases
>600 rads:	Death in less than two months for over 80%



Estimation of long-term effects such as cancer from external whole body irradiation

The following is quoted from the summary of the literature review in Chapter 4 of Brodsky (2011) may suffice in the interim for a high-sided estimate of likelihood of cancer if exposed beginning at mid-life. More details are in the references, but it is best to commit to memory only simple information:

*The **maximum** estimated chance of dying from long-term cancer for gamma exposures is 5 chances in 10,000 per rem, and this risk factor should be used to calculate cancer risk on the high side only for doses 10 rem or above.*

This estimate of risk was derived using a conservative factor to translate from the instantaneous prompt radiation incident at Hiroshima to longer term exposure from routine or fallout exposures, among many other factors used by the International Commission on Radiological Protection (ICRP). The ICRP methods for derivation of recommended peacetime limits are summarized in some detail in Brodsky (1995), and are still relatively applicable to current standards.

The above probability estimate does not take into account the hormetic (protective) effects of lower levels of radiation exposure, which counteract the carcinogenic risk that would be obtained by projecting the above chances to lower doses than about 10 rem. My personal experiences and findings are given among the many more examples of hormetic effects in the literature in Brodsky (2011). Consider, for the time being, how selenium is now found to be a necessary element for health in small concentrations, whereas its use in hair products originally required a doctor's prescription because it is so poisonous in higher concentrations. Issues such as this are discussed in more detail in my book, with supporting references.

Doses vs. risk from radioactive material inside the body

The following intakes of radionuclides by inhalation that result in about 25 rem maximum to any organ, or a 25 rem equivalent dose to a 25 rem external whole body dose, are taken from a table in Brodsky (2011).

A conservative (in the interest of safety) view of dose vs risk may be obtained using the external dose risk factor above for an equivalent dose-risk estimate. My discussion, in the book, of risks from internal exposure are more complex, but simple estimates from the following table will certainly at least high side any long-term risks of internal emitters, if the dose equivalents in the table for given intakes are proportionally extended for both dose and risk, above ten rem. Although the table is for inhaled intakes, it will be even more high-sided for ingested intakes because material deposited in the lung as aerosols of maximum deposition are generally taken up into the body more than those ingested, due to the longer residence times for physiological dissolution in the lung as well as other factors.

EXHIBIT 3 – Limits on Food and Water Concentrations in Peacetime or under Emergency Conditions

The following table of concentrations of radioactive materials, including individual nuclides as well as gross fission product mixtures in reactor fuel (for less than 30 day decay) are taken from Brodsky and Stangler (2004). The suggested limits for 10-day ingestion under emergency conditions may be extended for longer time periods by reducing the intakes in inverse proportion to time. Concentration values can be converted to adult intakes, if needed, by assuming a water intake of about 2,000 cubic centimeters per day, or a food intake of at least 2,000 kilocalories (Calories) per day at an energy value of about 4 Calories per gram (for combined carbohydrate, fat, and protein). Assuming a rounded density of 1 gram per cc for food results in a food intake on the order of 500 cc per day.

The following table is taken from Exhibit 31 in Brodsky (2011), derived as in Brodsky and Stangler (2004). For an informed layman with only a simple end-window Geiger counter, to avoid all the detail in this table, the rule of thumb derived in Brodsky (2011) may be used for any of these individual or combined mixtures to check for allowable for 10-day ingestion: **an open-window geiger counter at 1 cm from an ointment tin-sized sample of a few ounces of food or water will indicate it is safe for emergency consumption for 10 days if the Geiger counter reads less than about 1,000 counts per minute of beta radiation.** (Suggested limits for alpha emitters like plutonium are also given in the book, but this information is deemed much less important for this current news release.) These concentrations were derived to be consistent with early civil defense guidance derived by professors of toxicology at the University of Rochester. Other early criteria, criteria of official agencies for lifetime consumption of food and water, and instructions for preparing check sources for food and water, are included in the 2011 book. Also, the references in the footnotes to the following table are given in the 2011 book and not listed in this article.

EXHIBIT 4 – External Radiation Levels vs. Early and Late Effects

Early effects: Effects from short-term exposures, not compensated by repair that can take place when exposures are drawn out.

	Degree of severity and corresponding dose range				
Symptoms Listed Below	**Mild (1-2 Gy)***	**Moderate (2-4 Gy)**	**Severe (4-6 Gy)**	**Very severe (6-8 Gy)**	**Always lethal (8 Gy +)**
Vomiting onset % Incidence	2 hours after dose 10-50%	1 to 2 hours after dose 70 to 90%	Earlier than 1 hour after dose 100%	Earlier than 30 min. after dose 100%	Earlier than 10 min. after dose 100%
Diarrhea Onset % Incidence	None —— ——	None —— ——	Mild 3 to 8 hours Less than 10%	Heavy 1 to 3 hours More than 10%	Heavy Within 1 hour Almost 100%
Headache Onset % Incidence	Slight —— ——	Mild —— ——	Moderate 4 to 24 hours 50 %	Severe 3 to 4 hours 80 %	Severe 1 to 2 hours 80 to 90%
Consciousness Onset % Incidence	Unaffected —— ——	Unaffected —— ——	Unaffected —— ——	May be altered —— ——	Unconsciousness for secs. or mins. Seconds/mins. 100% @> 5 Gy
Lethality	0%	0 to 50% Onset 6 to 8 weeks	20 to 70% Onset in 4 to 8 weeks	50 to 100% Onset in 1 to 2 weeks	100% Lethal in 1 to 2 weeks
Medical Care Needed	Outpatient observation	Observe in general, treat in special hospital, if needed	Treat in special hospital	Treat in special hospital	Palliative treatment only**

* 1 Gy = 100 rad

** With appropriate supportive therapy, individuals might survive for 6 to 12 months with whole body doses as high as 12 Gy.

Late Effects: As indicated in the body of this document, for peacetime standards it has been assumed that equivalent deaths from cancer over long-term exposures occur according to a linear extrapolation of risks down to zero dose. However, for emergency decisions, it is important to recognize the existence of hormetic effects that overcome low dose effects, and not panic about lower exposure levels below 25 rad or rem. More will be presented to explain this dichotomy in future press releases.

Nuclide Mix	Activity ($\mu Ci\ cm^{-3}$)	Activity ($Bq\ g^{-1}$)	Effective Dose† After 10 Days (Sv)
Gross fission product beta activity (< 30 days decay after burst) (FCDA 1955)	0.09	3,000	0.043 (using Ce-141 as surrogate)
Gross alpha activity from nuclear burst (any period after burst) (FCDA 1955) (Not likely to be detected as important in early fallout material.)	0.005	180	0.9 (Pu-239 as surrogate, but delivered over 50 years)
Phosphorus-32	0.015	500	0.024
Cobalt-60	0.03	1,000	0.068
Strontium-Ytrium-90	0.0003	10	0.0056
Mo-99-Tc-99m	0.08	2500	0.03
Iodine-125	0.03	1,000	0.13
Iodine-131	0.002	60	0.026
Cesium-137-Barium-137m	0.012	400	0.104
Iridium-192	0.03	1,000	0.028
Polonium-210	0.0006	20	0.48
Radium-226 plus daughters	0.000012	0.4	0.0022
Plutonium-238/239	0.003	100	0.50
Americium-241	0.003	100	0.40
Curium-244	0.003	100	0.24
Uranium (natural or depleted)	0.03	1,000	0.9
Thorium (natural)	0.0015	50	0.23

Emergency levels of radioactivity in water and food for 10-day consumption*

*The values for mixed fission products and gross alpha activity after a burst are taken from FCDA (1955). The values for the nuclides deemed in ANS (2003) and Alvarez (2004), plus two additional nuclides that are in widespread use in nuclear medicine, have been obtained by taking the ratios of MPC for water of the nuclides divided by the MPC for Ce-141 of 0.003 $\mu Ci\ cm^{-3}$ as multipliers of the values for gross beta activity in FCDA (1955). These ratios are approximately the same as obtained from the tables of Eckerman (2004).

†The effective dose is the sum of the products of committed dose equivalent over 50 years multiplied by the tissue weighting factors of ICRP 60, as calculated by Eckerman (2004) for single nuclides, except for I-125, where the main dose is to thyroid and the committed dose from NCRP Report No. 70 (NCRP 1982) is multiplied by the weighting factor 0.05 as used for thyroid in ICRP Report 61 (ICRP 1991).

NOTE: The values in the above table may be divided by 3 for 30-day consumption, but should not be used for longer periods of consumption. Values should be reduced for children less than 5 years age and reduced to one-twentieth for infants or pregnant women. (see appendix by Eckerman (2004).

EXHIBIT 5 – Picture of "High" Geiger Counter Readings vs. Possible Stay Times for Rescue or Seeking Shelter



This is an exhibit of how I showed responders such as firemen and police how to understand that high Geiger counter readings do not necessarily mean danger in entering areas for rescue purposes. After showing that the incident radiation from this uranium glazed ashtray gave a seemingly large count rate of about 16,000 beeps per minute, I then switched to the mR per hour scale to show what the exposure rate would be in a gamma radiation field for the same 16,000 per minute count rate. The reading, as seen, is close to 10 mR per hour. Since m means milli (one thousandth as indicated in the definitions), then it would take 1,000 hours (about 6 weeks) for a responder in such a gamma ray field to receive 10 roentgens exposure (10 R), which is less than the 25 R allowed for responders for such life-saving efforts, with some leeway to receive even more. Then, I say to the responder group I am talking with, "When you could stay in such a field for 6 weeks, are you going to fear going in for 10-30 minutes or more to save lives? You would not even see a color change, or darkening, on the middle strip of this SIRAD dosimeter for a 10-30 minute exposure in such a field. In 1,000 hours it would not be up to 25 R. You should be carrying such dosimeters with you all of the time, or at least have the smaller RADTriage badge on your wallets or something you always carry. You certainly face much more risk every time you answer a call for rescue or response to a dangerous situation." Such instruction is necessary, because members of the public often hear statements such as, "Any radiation is dangerous," or "There is no safe level of radiation," even sometimes from officials or scientists who do not realize the needs for understanding levels of dose and risk under emergency conditions.

EXHIBIT 6 – Simple Immediate Actions to Reduce Radiation Dose

The following simples rules, which can be folded and set in plastic, was developed by the Health Physics Society Homeland Security Committee, under Dr. John Lanza.

v2.6

JUST-IN-TIME: NUCLEAR DETONATION – 10 RULES FOR EMERGENCY RESPONDERS

Adapted by: Homeland Security Committee of the Health Physics Society - http://hps.org/hsc/

① **Duck & cover when you see a flash.** Stay down behind cover for at least two full minutes. Any type of cover could prevent serious burns and injuries from flying and falling debris such as broken glass. Keep eyes closed during the bright light to prevent blindness.

② **Go in. Stay in. Tune in.** Shelter-in-place by going underground or to the center of the middle floor of a nearby, stable large building. Minimize the time exposed to radiation (Rule 9). Maintain communications (Rule 5).

③ **Radioactive fallout** occurs soon after the detonation and it will fall and accumulate on the ground. The direction of the fallout plume spread is dependent on surface AND upper level winds. Generally, stay upwind especially if you can see the direction of the plume's movement. Fallout may or may not be visible on the ground. Radioactive fallout can be detected ONLY by using radiation monitoring instruments.

④ **Use the "Inverse" 7/10 Rule:** Fallout loses 90% of its radioactivity in the first 7 hours after a detonation and an additional 90% for every 7-fold increase in time. It is reduced: by 90% in the first seven hours; by 99% in 49 hours (two days); and, by 99.9% in 343 hours (two weeks)

⑤ **Maintain communications** with local, tribal, and state authorities and other response elements; provide a scene assessment for the regional situation assessment center (e.g., EOC). Report visible fallout and approximate radiation levels in the area and the times they were taken at regular intervals. Monitor the media including radio, TV, and the Internet.

⑥ **PPE for emergency responders.** External fallout contamination will collect on outer garments and exposed body parts. No PPE will protect responders from external gamma radiation. Although inhalation and ingestion are a secondary concern compared to external gamma radiation exposure, masks or improvised respiratory protection may be used during fallout plume passage, for smoke and dust, and for high indoor radiation levels.

⑦ **Contamination removal.** Most external contamination can be removed by taking off the outer layer of clothes, wiping exposed hair and skin areas, and/or by taking a shower.

⑧ **Fight fires.** The detonation will cause fires in the area where populations are sheltered; take actions to slow the spread of fire.

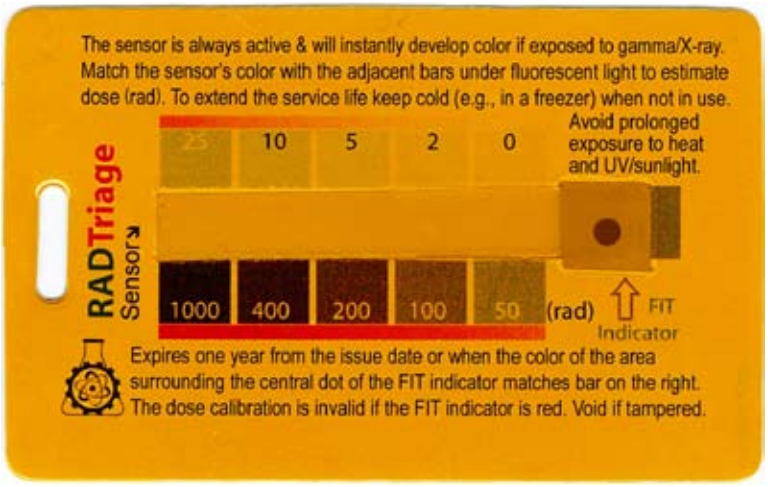
⑨ **Responders with radiation monitoring instruments** should initially shelter using these instruments to monitor shelter conditions and not exit the shelter if it requires entering a dangerous radiation zone (>10 R/hr) unless there is a time critical safety issue such as avoiding fire, a building collapse, or an evident lifesaving mission. Provided outdoor radiation levels are below 10R/hr, perform scene assessment of the immediate area for hazards. Stay close to shelter locations and closely monitor radiation levels and immediately shelter if radiation levels increase rapidly. Responders without radiation monitoring equipment should shelter as long as practical or until informed that they are not in the dangerous radiation zone (> 10 R/hr).

⑩ **Establish safe evacuation routes** from dangerous radiation zones (>10 R/hr) and identify evacuation priorities. Establish triage, decontamination, and casualty collection points outside of dangerous fallout zones (in areas <10mR/hr).

EXHIBIT 7 – An Affordable, Simple, Personal Radiation Monitor

From the Award-Winning SIRAD® Family of Dosimeters

Available from JP Laboratories, Inc.
ATTN: Dr. Gordhan Patel
120 Wood Avenue
Middlesex, NJ 08846
USA telephone (732) 469-6670
E-mail: sirad@jplabs.com



RADTriage-FIT™, a part of the **SIRAD®** (**S**elf-indicating **I**nstant **R**adiation **A**lert **D**osimeter) family of SMART dosimeters, gives you peace of mind that you are reliably monitoring your radiation exposure. RADTriage-FIT with amber filter provides significantly longer life under sunlight. It has a sensor with 2, 5, 10 and 25 rad reference bars above it and 50, 100, 200, 400 and 1,000 rad reference bars below it for triaging information in emergencies. The revolutionary **FIT™** indicator (on the right hand side of the sensor) simultaneously monitors false positives & negatives, overexposure to heat & UV/ sunlight, service–life and covers a portion of the sensor to monitor UV exposure. RADTriage-FIT is an affordable radiation dosimeter that is always active and ready to use, enabling disaster and emergency response personnel to measure their radiation exposure while dealing with the aftermath of a "dirty bomb" attack, nuclear explosion or an accident at a nuclear power plant. Batteries, calibration, and maintenance are unnecessary.

APPENDIX A TO NEWS RELEASE

MORE ABOUT WORDS USED IN DISCUSSING RADIATION LEVELS AND RISKS

Roentgen (R) An R of exposure means simply, at a point of measurement in air, the gamma photons knock out 1 electrostatic unit of fast electrons per cc of air at standard conditions of temperature and pressure – an easy number to remember and concept to imagine. In this paper, I use the original conventional units. My reference (Brodsky 2011 – see attached flier) summarizes the dangers of using the so-called special SI units, which nations other than the USA have adopted in most of their policies and statements. The recent mistakes in official Japanese and news pronouncements may be noted, such as the mistaken announcements of millions of microseiverts when thousands were the true values.

Half-Life -- Different radioactive atoms (sometimes called "radionuclides") have different half-lives, which range from small fractions of a second to billions of years. Disintegration rates are often given in disintegrations per minute (dpm), disintegrations per second (dps), Bequerels (Bq)(1 Bq = 1 dps), or curies (Ci) (1 Ci = 37 billion dps). Prefixes are often used: milli (m), which is one thousandth); micro (μ), which is one millionth; kilo (K), which is one thousand; and mega (M), which is one million. Other prefixes are used less frequently. An example of the inconvenience and dangerous mistakes using special SI units: One announcement we heard in the USA was that some concentrations were 10,000,000 microbequerels. Since micro means one millionth, why did they not simply say 10 Bq, which is only 10 dps? Later, someone admitted this was a mistake, the unit should have been millibequerels. This use of too-large numbers is only one source of mistakes of those indicated in my book.

Some brief study of Exhibit 2, and keeping it available for reference, will allow the average citizen or responder to know whether danger (high risk) is present, or whether risks are so much lower than everyday risks that the situations would be under the common understanding of "safe" -- as in the perception that certain automobiles are "safe," due to their construction and operating designs.

Press Release References

Allen Brodsky, *Actions for Survival: Saving Lives in the Immediate Hours afterRelease of Radioactve or Other Toxic Agents,*" about 380 pages with illustrations, in publication (pre-publication copies at reduces rates are available, together with free radiation dosimeters of the type distributed by Dr. Gordhan Patel to Japan, using the attached flier) April 2011; to be published by MJR Publications, LLC, Essex, Maryland, June 2011.

Allen Brodsky, a review of a book on the history of France's nuclear power program, *Radiance of France: Nuclear Power and National Identity After World War II*, Health Physics, Vol. 99, No.6, pp. 814-815, December 2010.

Allen Brodsky, Raymond H. Johnson, Jr., and Ronald E. Goans, Editors, *Public Protection from Nuclear, Chemical, and Biological Terrorism*, Medical Physics Publishing, Madison, Wisconsin, 2004.

Allen Brodsky and Marlow J. Stangler, "Rules of Thumb and Risks of Food and Water Contamination," in Brodsky et al., ibid, 2004, pp. 513-517.

Allen Brodsky and Niel Wald, "Experience with early emergency response and rules of thumb," Chapter 20 in Brodsky et al., op. cit., 2004, pp. 335-367.

Allen Brodsky, *Review of radiation risks and uranium toxicity, with application to decisions associated with decommissioning clean-up criteria, RSA Publications, Hebron, CT, 1996.*

Allen Brodsky, "Dose and risk information on Three Mile Island," Appendix A.6.2 in Allen Brodsky, Editor, *Handbook of radiation measurement and protection, Section A, Vol.II*, CRC Press, Boca Raton, FL, 1982.

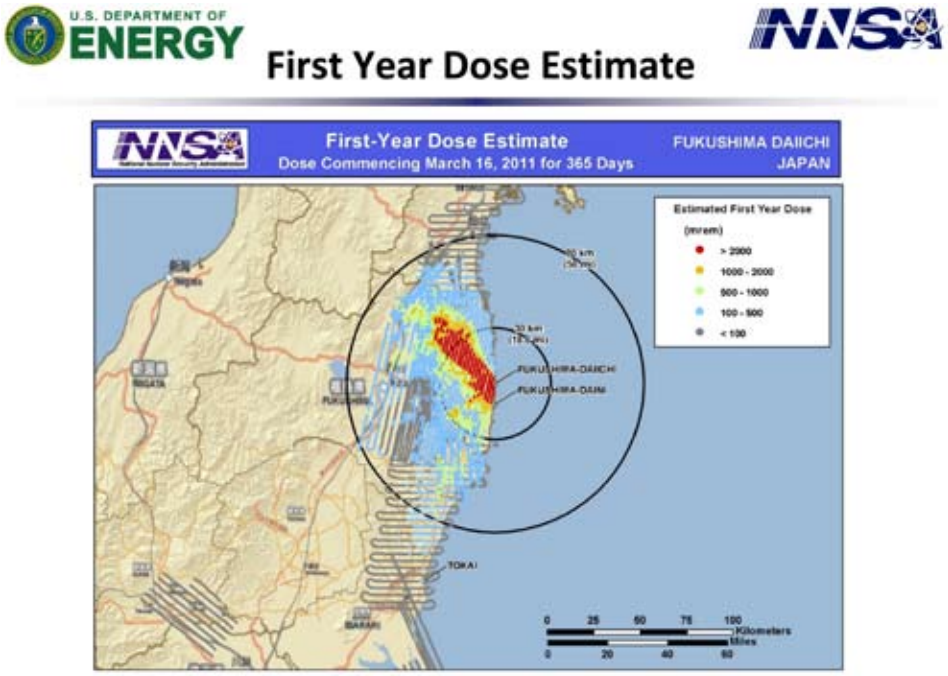
Allen Brodsky and G. Victor Beard, Compilers and Editors, *A compendium of information for use in controlling radiation emergencies*, U. S. Atomic Energy Commission Report TID 8206 (Rev), Washington, DC, September 1960.

David Brown, "No health effects expected in U.S. from Japan's crisis," The Washington Post, April 6, 2011.

Will Englund, "At Chernobyl, warnings for Japan," The Washington Post, April 4, 2011.

Andrew Higgins, "Wrestling with a threat they can't see," The Washington Post, April 5, 2011.

EXHIBIT 50 — CONTOUR MAP OF FIRST-YEAR DOSES AROUND NUCLEAR REACTORS AT FUKUSHIMA, JAPAN



Book References

Note: References included are those cited in the text, many of which are included to support the information and recommendations in the text. Many also are those that might be of interest to scientists or engineers involved in the planning of emergency responses, radiation exposure control, or the development of instruments to detect or measure intensities from fissionable materials or radiation sources.

Many additional sources of information, including detailed planning guidance, are continually being published by government agencies as well as professional societies. Appendix H presents some of the latest policies of the Department of Homeland Security. Other sources of documents are listed in the many web sites and addresses provided in Brodsky, Johnson, and Goans (2004), listed below. The White House Office of Science and Technology Policy, Executive Office of the President (EOP) released on April 19 the document, "Planning Guidance for Response to a Nuclear Detonation, Second Edition, Draft — for Stakeholder Review," with a request for comments by May 3, 2010. Comments were to be submitted to Tammy Taylor, ttaylor@ostp.eop.gov or to Alvin Potter, Potter@orise.orau.gov (EOP 2010).

The EOP document was developed by a large committee from government agencies and professional organizations, with other stakeholder input, but does not replace this present book on Actions for Survival. Although the EOP document accumulates in one place much information useful for technical staff of local governments to plan for recovery operations some days after an attack, the EOP document indicates in its Preface that it is to be used for planning rescue, response, and recovery operations after 24 to 72 hours by local response agencies, in the period when Federal resources are not yet likely to be fully available. This Actions for Survival book is aimed at providing citizens as well as local responders and available scientific personnel information for use in preventing panic and saving lives in the immediate seconds, minutes, and hours after an attack. If tens of thousands of citizens, or more, are in panic and take actions to harm themselves and overwhelm local responders and local medical institutions because they have exaggerated fears of low levels of radiation, without simple knowledge about levels of radiation and effects, and availability of inexpensive radiation monitors to assuage their own fears and lead them to proper actions for self protection, most of the planning for later actions by local or State governments, or medical institutions and professionals, will have been in vain. The entire nation will be reduced to panic and the inability to survive.

Bruria Adini-Weisel, "Informing and Engaging the Public in Preparedness Efforts: The Israeli Experience," presentation at the 46th Annual Meeting of the National Council of Radiation Protection and Measurements, *Communication of Radiation Benefits and Risks in Decision Making,* March 8, 2010 (to be published).

Joseph L. Alvarez, "Defining, Explaining, and Detecting Dirty Bombs," in Allen Brodsky, Raymond H. Johnson, Jr., and Ronald E. Goans, Editors, *Public Protection from Nuclear, Chemical, and Biological Terrorism,* Medical Physics Publishing, Madison, WI; 2004.

Melissa Hurley Alves, "Committee Releases White Paper on Respiratory Protection," The Synergist (news magazine of the American Industrial Hygiene Association), Vol. 21, No. 1, p. 14, January 2010.

American Strategic Defense Association (ASDA), ASDA NEWSLETTER, Jerry Strope, Editor, Vol. 38, Number 1, January-February 2008. (See references to Strope.)

American National Standards Institute (ANSI), "Bioassay Programs for Uranium," ANSI N13.22-1995, developed by a Working Group of the Health Physics Society including members from industry and government; published in Health Physics Society Newsletter, May 1996.

Association of American Physicians and Surgeons, "Public Should Have Radiation Detectors, Scientist Writes," Press Release, June 1, 2010 (www.aapsonline.org).

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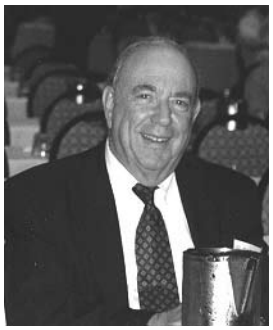
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About the Author*



Dr. Allen Brodsky retired from full-time employment in 1986 but still mentors graduate students in their internships as an Adjunct (part-time) Professor of Radiation Science at Georgetown University. He also occasionally consults on radiation safety issues, but spends most of the time writing articles and books based on information accumulated during his 62-year career since completing college. The majority of his career has been in the fields called "health physics" and "medical physics." In the field of health physics, his research, practice, and teaching has been related to: developing procedures and engineered facilities for protecting the health of workers and the public from harmful amounts of radiation; and writing necessary but reasonable safety regulations and guides so that our society can safely enjoy the benefits of radiation and radioisotope applications, in such practices as nuclear medicine diagnostics, radiation therapy, and industrial products that benefit humankind. In the field of medical physics, he developed methods of administering radiation for cancer therapy, and published procedural and staffing requirements for hospitals and medical institutions to ensure safe applications of radioactive material in diagnosis, therapy, and research.

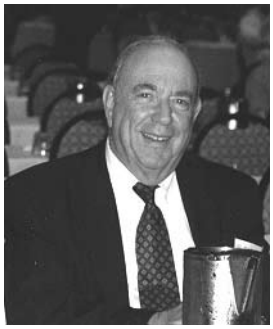
His education includes a bachelor's degree in chemical engineering and master's in physics from Johns Hopkins, and a doctorate in biostatistics and radiation health from the University of Pittsburgh. He also had a one-year graduate fellowship in Radiological Physics at Oak Ridge National Laboratory (1949-50), and is certified by the American Boards of Health Physics, Industrial Hygiene, and Radiology.

His employment positions included Head, Health Physics Unit, Naval Research Laboratory; Physicist on Operations Ivy and Castle (first two H-bomb tests); Physicist in the Federal Civil Defense Administration; Health Physicist in the Atomic Energy Commission; Associate Professor in the Graduate School of Public Health, University of Pittsburgh; Radiation Physicist, Mercy Hospital, Pittsburgh; Adjunct Research Professor, Duquesne University School of Pharmacy; Health Physicist, U.S. Nuclear Regulatory Commission; Senior Scientist at SAIC performing radiation dose assessments of veterans exposed to fallout from atomic tests (retired from over 8 years full-time in this position in 1997 to March 2006); and Adjunct Professor of Radiation Science, Georgetown University (1987 to present). In addition, he has consulted for a variety of medical institutions, industrial facilities, and government research committees, and reviewed research proposals for four government agencies.

He has many publications and his books include: Information for Controlling Radiation Emergencies, 1960, Atomic Energy Commission; CRC Handbooks of Radiation Measurement and Protection, Volumes I-IV, 1978-86, editor and contributor of many chapters; Review of Radiation Risks and Uranium Toxicity, 1996, RSA Publications; and Public Protection from Nuclear, Chemical, and Biological Terrorism, 2004, Medical Physics Publishing, Editor and author of nine chapters and appendices (a chapter summarizing his management and evaluation of radiation accidents can be reviewed on www.medicalphysics.org). This is his eighth book published commercially. *Living with* Insomnia, co-authored with his wife, Phyllis, was recently published by McFarland and Company, Inc., 2011.

His work is summarized in Who's Who in the World and other library biographical references. His awards for research, teaching, and service include: the Founder's Award (1986), Fellow Award (1992), and the Robley D. Evans Medal (2001) of the Health Physics Society; the 1986 Failla Memorial Lecturer Award of the Greater New York Chapter of the Health Physics Society and the Radiological and Medical Physics Society; the Radiation Science and Technology Award (1993) of the American Nuclear Society; the Distinguished Graduate Award (2004) of the Graduate School of Public Health, University of Pittsburgh; and the Vicennial Medal of Georgetown University (2006).

* I must admit that I wrote this myself. Due to lack of space I included only successful experiences and awards; listing my mistakes and failures would have required too many pages.



For those receiving a free RADSticker dosimeter (see Chapter 8 and Appendix I, it will be pasted on the inside of the back cover with a slightly sticky paper. Take that paper off, then carefully peel off the white backing and stick it onto a wallet or something you carry with you all of the time. It will remain there as a reliable indicator, if any shading occurs on the middle strip, of whether you have received any significant exposure to gamma or x radiation while wearing it. In your wallet, it will also be protected from undue exposure to ultraviolet rays from the sun, and will be reliable for several years. To purchase these dosimeters, or the card-size ones that can be read even more reliably at lower levels of exposure, contact the inventor and manufacturer, Dr. Gordhan Patel, at the addresses listed in the appendix of vendors. I guarantee your satisfaction.

Be well and stay safe.

Allen Brodsky March 30, 2011