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## Biosafety AND Biosecurity

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## Biosafety AND Biosecurity

# Foreword

Communicable diseases remain a leading cause of death globally and account for nearly one-third of world deaths. The emergence of newly identified pathogens, as well as the re-emergence of pathogens with public health significance, exacerbates the global threat of infectious diseases. For example, it has been reported that between 1973 and 2003 over 36 newly emerging infectious diseases had been identified. Research and diagnostic activities involving pathogenic microorganisms are critical to global security as this research elucidates knowledge and leads to products that improve the health, welfare, economy, quality of life and security for all persons around the globe.

Advancements in technology as well as the cross-fertilization of formerly disparate scientific disciplines have led to technical capabilities never before realized in the life sciences. This technical progress is exemplified by the *de novo* synthesis of poliovirus and the recreation of the 1918 H1N1 influenza virus, which was the causative agent of the *Spanish flu* pandemic, the deadliest single event in recorded history killing an estimated 50 million people world-wide.

In addition to the threat to public health and welfare caused by pathogenic microorganisms derived from nature, including newly emerging or re-emerging diseases, there is also the threat posed by the intentional release of disease-causing microorganisms whether through state-sponsored biological warfare or through the intentional use of pathogens to elicit terror. The impact of such a terrorist event was demonstrated vividly in 2001 during the Amerithrax episode. Highly refined (i.e., weaponized) spores of *Bacillus anthracis* were released on an unsuspecting public, resulting in five deaths, illness in 17 U.S. citizens, and an untold economic impact.

The combined threats to public health resulting from emerging diseases and the potential for deliberate release of a pathogenic microorganism altered the research and public health agenda not only for the U.S., but also for countries around the globe. For example, in 2003 the U.S. National Institute of Allergy and Infectious Diseases (NIAID) established Regional Centers of Excellence for Biodefense and Emerging Infectious Diseases Research to serve as regional foci for developing and conducting cutting edge research. The centers were created to develop countermeasures to these threats, including vaccines, therapeutics, and diagnostics, among others. At the same time, the U.S. Department of Homeland Security provided financial support to fund the construction and expansion of a laboratory infrastructure to support this infectious diseases research agenda. This expansion of infrastructure and funding was not unique to the U.S., and can be observed internationally.

Concerns raised by the threat of potential biological terrorism in the national security apparatus of the U.S. and other countries resulted in the promulgation of regulations intended to control and limit the numbers of persons with access to certain pathogenic microorganisms. This regulatory approach focused on the establishment of a security-based infrastructure and security-based programs to manage the important research directed toward understanding the fundamental biology of, and generating medical countermeasures against, certain dangerous pathogens.

Biosafety and biosecurity, while distinctly different concepts, are inexorably linked; one cannot consider a biosafety program to be robust in the absence of biosecurity, and most certainly, biosecurity cannot exist in the absence of a strong commitment to biosafety. It has become abundantly clear that a holistic approach to the management of risks associated with research involving pathogenic microorganisms is critical. Facilities and infrastructure construction and maintenance, education, training and competency (not only of the scientific staff but also all support staff ancillary to the research program), reliability of the entire workforce, public outreach and political support, strong leadership committed to the management of biorisk (i.e., biosafety and biosecurity), and a culture of responsible research are all elements that must be integral to life sciences research, especially this particular research enterprise.

In the early to mid-1970s, a new technology, termed "recombinant DNA technology," was developed and utilized. The scientific community responsible for developing and utilizing this work also realized that the new technology posed potential risks and threats to the health and well being of society. To address the public and political concerns, the scientific community in the U.S. came together to craft guidelines within the structure of the National Institutes of Health (*Guidelines for Research Involving Recombinant DNA Molecules*) by which biosafety risks from this research could be systematically assessed and through which these biosafety risks could be specifically mitigated and managed. These guidelines were not prescriptive, but rather were performance based, allowing for flexibility in the manner by which these risks could be mitigated. Most critically, the guidelines provided mechanisms for local oversight by the scientists themselves, their research institutions, and the funding agency. While this approach toward management of biosafety risks associated with research involving pathogenic microorganisms is clearly important, this approach alone is incomplete as it does not address biorisk in a holistic manner.

This book proposes a new paradigm for evaluating, mitigating, and managing biorisk and terms this paradigm *AMP: Assessment/Mitigation/Performance.* While specific individual components of this new paradigm are currently being employed in biosafety programs built upon the existing *"biosafety level"* systems, many biosafety programs fail to comprehensively approach risk assessment, risk mitigation, and performance evaluation. For example, a comprehensive risk analysis of both biosafety and biosecurity (*biorisk*) is generally lacking in these traditional approaches. Similarly, where traditional biosafety level-based systems discuss levels of controls to mitigate risk (usually built upon *mitigation control measures* that include engineering controls, administrative controls, practices and procedures, and personal protective equipment), few *routinely evaluate* the effectiveness of these risk mitigation strategies.

In the Summer of 2014 several highly publicized incidents and accidents involving the potential release of some of the world's most dangerous pathogens (e.g., smallpox, *Bacillus anthracis,* Highly Pathogenic Avian Influenza H5N1, and Ebola) from the laboratories of several U.S. Federal agencies resulted in a strong negative response from the public, who were understandably fearful of the threat to public health posed by these releases. Following on fears of the citizenry and resultant backlash against the scientific community conducting this research, political pressure on these same

government agencies resulted in a funding pause in the U.S. of important research involving influenza as well as SARS and MERS coronaviruses. Investigations into the root causes leading to these accidents and incidents revealed that a contributing factor may have been the prioritization of security procedures over safety practices.

As a result of these incidents, the Secretary of the U.S. Department of Health and Human Services ordered an external review of safety programs in DHHS labs, including the CDC. A report to the CDC by this independent external advisory group conveyed many of the same observations made about these incidents and detailed in Chapter 10 of this book. The case study analyses of these incidents provided in this chapter concluded that a comprehensive approach to biorisk management was absent at the CDC at the time of these incidents. In fact, many of the recommendations proposed by the external advisory group are consistent with and reflect the comprehensive approach to risk management presented in this book.

As already stated, research activities involving pathogenic microorganisms elucidate basic knowledge and lead to products and technologies that improve the welfare, economy, and quality of life for people globally. It is important that the scientific community embrace a holistic approach to the management of biorisks because biorisk management is a responsibility shared by principal investigators, bench scientists, support staff, students, postdoctoral fellows, and the leadership of the institutions conducting and funding this vital research. Furthermore, it is equally important that the scientific community speak loudly and proudly of the benefits of their research activities to educate and gain public support for, and acceptance of, this work. It is also vital to inspire youth to become conversant in and enthusiastic about the benefits of basic science.

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# Preface

The central premise of this book is that the biological research, clinical, diagnostic, and production/manufacturing communities need to embrace and implement biorisk management systems in their facilities and operations. In most countries, the current system mitigates the risk of accidental infection, accidental release, and intentional misuse of pathogens and toxins based on general, predetermined biosafety levels and/or prescriptive biosecurity regulations. Although this approach may have sufficed when the biological life science community was relatively small, and work with particularly dangerous organisms was limited to a few countries and facilities, the life sciences have grown significantly in the last two decades—in both scope and sophistication. Much of this growth has extended well beyond North America and Western Europe, and deep into the developing world. Simply, there are more people in more places working with, and even creating, more dangerous pathogens and toxins than ever before—and that trend shows no sign of abating in the future.

Increased risk inevitably comes with this expansion. The past 20 years have been marked by multiple safety and security incidents at bioscience facilities around the world, including many notable incidents at so-called sophisticated facilities in North America and Western Europe. Clearly, the current system that is based on biosafety levels and security regulations does not work effectively enough. It is time for the bioscience community to learn some lessons from other high-consequence industries that have experienced devastating accidents, and that have intellectually evolved their own approaches to safety and security well beyond generic, predetermined, technical checklists. These industries have almost universally adopted what is now referred to as risk management systems. This book urges the global bioscience community to embrace biorisk management—before a devastating accident threatens to jeopardize the entire bioscience enterprise.

This book is organized into 11 separate chapters, and each chapter focuses on a different element of a biorisk management system. Different experts from around the world have written each chapter, demonstrating that the biorisk management system espoused by this book is globally applicable. The first chapter defines biorisk management, details the history of the field of biosafety and biosecurity, and makes a case for implementing biorisk management to prevent a major incident by drawing comparisons to disasters in other industries. The second chapter describes the AMP model, which is a framework that uses the components of assessment, mitigation, and performance to structure and implement a comprehensive biorisk management system. Chapter 3 defines the risk assessment process, and explains how to assess and prioritize various risks, and ensure that a risk assessment fits into a biorisk management system. The fourth chapter illustrates how to use the risk assessments to inform a design strategy to avoid overengineering a facility and wasting valuable resources.

The fifth chapter evaluates the roles of the different mitigation measures, including laboratory practices and procedures, safety and security equipment, and personnel management. The specific combination of mitigation measures should be determined based on the risk assessment, and evaluated according to specific

performance metrics. Chapter 6 argues that a flexible and adaptable training plan is more effective than a rigid standardized compliance plan, since it can be strategically implemented to manage risk in a number of different settings and contexts with the ability to meet the challenge of new hazards or threats.

Chapter 7 argues that reliability-centered maintenance should be the framework for a biorisk management maintenance program. The eighth chapter advocates for utilizing specific performance indicators, instead of relying on failure data, for proactive activities and outcomes to make effective changes and improvements to a biorisk management system. The ninth chapter suggests that a comprehensive biorisk management system must include a risk communication plan designed to address both normal operations and emergency situations from an internal and an external perspective.

Chapter 10 is a case study that examines the biosafety incidents that took place at the US Centers for Disease Control and Prevention and the US National Institutes of Health in 2014. Finally, Chapter 11 identifies some of the most important challenges that face the biorisk management community by examining current gaps and shortcomings in contemporary biorisk management understanding and approaches. It also presents a series of opportunities to enhance the practice of biorisk management in the future.

# Acknowledgments

This book could not have been written or even attempted without the tremendous hard work, commitment, and support of so many of our mentors, colleagues, friends, and families. Our work around the world for more than the last decade has shaped our evolving views of biorisk management. We have not created the field of biorisk management, but have been fortunate to be among those who have helped shape its current form. Nevertheless, there are hundreds of experts around the world who successfully manage the risks of working with dangerous biological materials on a daily basis, and we have had the privilege to learn from the experiences of many of them.

In particular, we are grateful for the support and kindness offered to us by so many technical experts in our field, who have taught, guided, and encouraged us to contribute to the intellectual debate of how best to manage the risks of working with biological materials in research, diagnostic, and clinical laboratories, as well as in healthcare and field settings. Many of those experts have contributed chapters to this book. Among those who are not authors here, but deserve our recognition and deep appreciation, are Stefan Waggener, Paul Huntly, Vips Halkaer-Knudsen, Jim Welch, Maureen Ellis, Bob Ellis, Nicoletta Previsani, Ingegerd Kallings, Joe Kozlovak, Debra Hunt, and Heather Sheeley. We have been significantly influenced by all of these mentors, and we are humbled to be able to call them colleagues.

We are also grateful for the collaborations that we have had with the American Biological Safety Association, the European Biosafety Association, the Asia-Pacific Biosafety Association, the International Federation of Biosafety Associations, the World Health Organization, the World Organization for Animal Health, and the European Committee for Standardization. The US Department of State's Biosecurity Engagement Program and the US Defense Threat Reduction Agency's Cooperative Biological Engagement Program have given both of us, as well as our program at Sandia, the opportunity to work with hundreds of institutions and thousands of scientists from around the world to advance biorisk management. All of these international engagements on behalf of the US government have also helped shape our views on this topic.

This book is the product of countless discussions with the staff who work for Sandia's International Biological Threat Reduction (IBTR) program. Several IBTR staff contributed to these chapters as authors, and several other IBTR staff extensively peer-reviewed drafts of the chapters. The IBTR team is too large to mention every one of them here, but we are grateful for their tireless and global commitment to the pursuit of biorisk management. A few in particular, though, deserve special mention. Jason Bolles, Lyle Beck, and Laurie Wallis helped create the figures and table for this book. Laurie Wallis single-handedly managed the entire book project from beginning to end, cajoling the authors to complete their chapters, keeping the editors on task, negotiating with lawyers, ensuring proper reviews and approvals, and corresponding with the staff at CRC Press. Without Laurie, this book would not have seen the light of day; we cannot express enough gratitude for Laurie's efforts.

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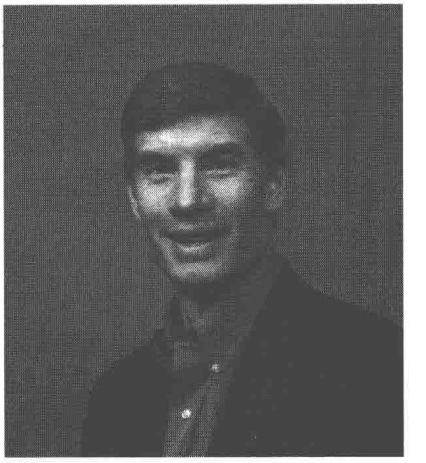
This book would not have been possible without the very significant contributions of all of these great mentors and colleagues, and we cannot overstate our deep gratitude to all of them. Nevertheless, all of the mistakes and shortcomings of this manuscript remain ours and ours alone.

Finally, we extend our deepest gratitude to our significant others, Jennifer Salerno and Damian Donckels. Each of them has sacrificed by allowing us to dedicate our professional lives to advancing biorisk management. Without their support and encouragement, this book would not have come to fruition.

*Albuquerque, New Mexico*

# About the Editors



**Reynolds M. Salerno** is the senior manager for Cooperative Threat Reduction Programs at Sandia National Laboratories in Albuquerque, New Mexico. His programs enhance US and international security by reducing biological, chemical, and nuclear threats worldwide. Recognized as a leading expert on laboratory biosecurity, Salerno and his Sandia team have worked extensively in laboratory biosafety, biosecurity, biocontainment, and infectious disease diagnostics and control internationally. Salerno is a coauthor of the *Laboratory Biosecurity Handbook* (CRC Press, 2007). As a technical advisor to the World Health Organization (WHO), he was a member of the WHO's international team that inspected the Maximum Containment (smallpox) Laboratory at the State Research Center of Virology and Biotechnology VECTOR, Koltsovo, Novosibirsk, Russia, in December 2009. He is a principal developer of the WHO train-the-trainers course, "Biorisk Management Advanced Training Program," which was delivered in all six WHO regions in 2010. He was recently the vice chairman of the board of directors of the International Federation of Biosafety Associations. Salerno received his PhD from Yale University in 1997.

**Jennifer Gaudioso** leads the International Biological Threat Reduction (IBTR) and International Chemical Threat Reduction (ICTR) programs at Sandia National Laboratories in Albuquerque, New Mexico. These programs enhance US and international security by promoting safe, secure, and responsible use of dangerous biological and chemical agents. They have organized many international conferences, trainings, and workshops to build local capacity to address these issues. The team currently consults in more than 40 countries specifically on biosecurity and chemical security issues. Gaudioso and her Sandia team work with international partners, such as the World Health Organization and the International Federation of Biosafety Associations. Her program is a World Organisation for Animal Health (OIE) Collaborating Centre for Laboratory Biorisk Management. Gaudioso has served on the National

Academies' Committee on Education on Dual Use Issues in the Life Sciences and their Committee on Anticipating Biosecurity Challenges of the Global Expansion of High Containment Biological Laboratories. She is the author of numerous journal articles and has presented her research at national and international meetings. She also coauthored the *Laboratory Biosecurity Handbook* (CRC Press, 2007). Gaudioso has served on Sandia's Institutional Biosafety Committee, and is an active member of the American Biological Safety Association. She earned her PhD in chemistry at Cornell University.

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