ANTISEPSIS, DISINFECTION, AND STERILIZATION
ANTISEPSIS, DISINFECTION, AND STERILIZATION
TYPES, ACTION, AND RESISTANCE

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The control of microorganisms and microbial growth is an important consideration in medical, veterinary, dental, industrial, pharmaceutical, environmental, and food processing settings. This book has been developed to provide a basic understanding of the various chemical and physical antisepsis, disinfection, and sterilization methods used for infection prevention and contamination control. Disinfection and sterilization technologies are used for the control of microorganisms on surfaces, in products, or in air, while antisepsis is particularly associated with microbial reduction on the skin or mucous membranes. Many of these applications have been used over many years and continue to play important roles in our daily lives, including the provision of safe drinking water, production and preservation of products, laboratory safety, food safety, sterilization of medical devices, and disinfection of critical surfaces. The benefits of microbial control have been appreciated since ancient times—for example, in the use of heating, salts, and metals for preservation and wound treatment—despite the absence in those times of any pure understanding of microbiology. Over the last 160 years, we have gained a greater appreciation of microorganisms and their roles in contamination and infection. In parallel, various chemical and physical antisepsis, disinfection, and sterilization methods have been developed and are widely used to render surfaces and products safe for use. Despite these advancements, microbial control issues continue to challenge us. Notable examples include controlling the risk of virus transmission in outbreaks of Zika virus, Ebola virus, and noroviruses; medical device contamination associated with health care outbreaks of infection (such as with flexible endoscopes); the emerging concerns with unique infectious agents (such as prions or other transmissible proteinaceous agents); and the continuing concern of antibiotic-resistant microorganisms in hospitals and the general community. As our knowledge increases in microbiology, so does our understanding of the novel ways that microorganisms can present with mechanisms of surviving the many broad-spectrum contamination control technology that we use, including chemical and physical disinfection and sterilization methods.

As a background to this subject, a brief introduction to microbiology is provided, to include the various types of microorganisms in their major classes. This section also provides the definitions of some key terms widely used in the area, the overall resistance profiles of microorganisms to inactivation, and the variety of methods that are used to test the effectiveness and optimize the use of antimicrobial products and processes.

Disinfection and sterilization can be generally considered as either based on chemical or physical antimicrobial technologies. Chemicals include various types of aldehydes, halogens, and oxidizing agents, while physical processes include the use of heat, filtration, and radiation. For each general group, the various types of technologies are discussed, along with their applications, spectra of
activity, advantages, and disadvantages, and a brief description of their modes of action. A wider range of methods is used for disinfection and antisepsis applications. Many of these are required to reduce the number of microorganisms, or even the number of certain types of microorganisms, to an acceptable level. In contrast, only a limited number of technologies are utilized for sterilization, which has the ultimate goal of rendering a surface, area, or substance free of all viable microbial contamination. For this reason, disinfection and sterilization methods are considered separately, with a specific chapter dedicated to the various antimicrobials used as antiseptics and in antisepsis applications.

The current understanding of the mechanisms of action on microorganisms is considered in chapter 7. It is important to note that the modes of action of these technologies are generally nonspecific and distinct from the more specific mechanisms of action described for anti-infective agents, such as antibiotics and antiviral agents. Most biocides demonstrate a wider range of antimicrobial activity, generally corresponding to nonspecific and varied modes of action. The mechanisms of action of biocides are considered in four general categories: oxidizing agents, cross-linking agents, agents that act by transfer of energy, and other structure-disrupting agents. Despite these general mechanisms, some biocides have been shown to have primary targets similar to those of certain antibiotics, and a better understanding of their mechanisms of action is of interest in the development of the next generation of anti-infectives and/or optimized antimicrobial processes.

Microorganisms demonstrate various natural (intrinsic) and acquired mechanisms to resist the antimicrobial effects of chemical and physical processes. These mechanisms are discussed in further detail in chapter 8 and are important to consider in order to ensure the safe and effective use of these technologies. This topic, and the impact of microbial resistance, has been particularly well published in the use of widely used anti-infectives (notably antibiotic-resistant bacteria like methicillin-resistant *Staphylococcus* and carbapenem-resistant *Enterobacteriaceae*), but similar and distinct mechanisms in microbial resistance to more broad-spectrum antimicrobial products and processes have been described. Biocide resistance in bacteria has been studied in greater detail since the publication of the first edition of this book, with many examples of intrinsic and acquired mechanisms of resistance. Intrinsic mechanisms include biofilm formation, development of dormant endospores, and the accumulation of resistance mechanisms in extremophiles. Acquired resistance mechanisms due to mutations and the acquisition of transposons and/or plasmids, not unlike those described for antibiotics, have also been described in more detail. Although many of these mechanisms allow for the tolerance in the presence of antimicrobial chemicals at normally inhibitory levels, other mechanisms have been shown to dramatically change the response of some microorganisms to biocides and to enable them to survive highly toxic conditions. Further advances have also been made in our understanding of specific mechanisms of resistance in other microorganisms such as viruses, prions, fungi, and protozoa.

Overall, it is intended that this book will give a basic understanding of and reference for the various types, modes of action, and mechanisms of resistance of antiseptics, disinfectants, and sterilization processes for students of microbiology, chemistry, infection prevention, contamination control, public health, and industrial applications. A greater understanding and appreciation of these technologies will continue to ensure their long-term safe and effective use in contamination and infection prevention.
ABOUT THE AUTHOR

Gerald E. McDonnell received a B.Sc. degree in medical laboratory sciences from the University of Ulster (1989) and a Ph.D. in microbial genetics at the Department of Genetics, Trinity College, University of Dublin (1992). His graduate work involved studies on the control of gene expression in *Bacillus subtilis*. He spent 3 years at the Mycobacterial Research Laboratories, Colorado State University, investigating the mechanisms of antibiotic resistance and cell wall biosynthesis in mycobacteria. In 1995 he joined the St. Louis, Mo., operations of ConvaTec, a division of Bristol-Myers Squibb, as a group leader in microbiology in the research and development of skin care, hard surface disinfection, and cleaning chemistries. He worked for STERIS Corporation for 19 years in the USA and in Europe on the development, research, and support of infection and contamination prevention products and services in health care and industrial applications, with a particular focus on cleaning, antisepsis, disinfection, and sterilization. Dr. McDonnell is currently the senior director for sterility assurance for DePuySynthes, a Johnson & Johnson company, and a member of the Johnson & Johnson Sterility Assurance leadership team. He serves as the global technical leader in the areas of microbiology and contamination control including sterilization, aseptic technique, reprocessing, microbiology, and cleanliness requirements. His basic research interests include infection prevention, decontamination microbiology, emerging pathogens, and modes of action and resistance to biocides. His work also includes the development and implementation of international and national guidance and standards in cleaning, disinfection, and sterilization. He has over 180 publications, 22 patents and is a frequent presenter on various aspects of his work internationally.
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