

# MICROBIAL FOODBORNE DISEASES

*Mechanisms of  
Pathogenesis  
and Toxin  
Synthesis*

EDITED BY

**Jeffrey W. Cary**  
**John E. Linz**  
**Deepak Bhatnagar**

## **Microbial Foodborne Diseases**

a**TECHNOMIC**<sup>®</sup>publication

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## Foreword

**T**HIS very useful and timely volume recognizes that food safety hazards are not confined to *Salmonella*, *Campylobacter* and the pathogenic *E. coli*. But rather these hazards result from a wide variety of toxins produced in crops and food by several agents, including pathogenic gram positive and gram negative bacteria, fungi and algae, parasitic protozoa and viruses, and related agents.

The scientific knowledge regarding these zoonotic pathogens is the basis of our food safety system today. It is science that develops the principles and the technology necessary for methodology that can detect pathogens in amounts that could cause disease. And it is science that develops the interventions that are used by animal and plant based food producers to prevent the survival and growth of pathogens in their food products. Knowledge of the molecular basis of pathogenesis will help point the way toward effective, affordable interventions in the production of both plant and animal based food products. A food safety system based on science also supports quantitative risk assessment, which leads to placing the greatest priority for action against the risks calculated to have the greatest potential impact on assuring a safe food supply.

An understanding of the mechanisms of pathogenesis of foodborne pathogens is particularly timely because of the current recognition of the importance of science in ensuring food safety. The recent report from the National Academy of Science (NAS), "Ensuring Safe Food from Production to Consumption," stated that "The mission of an effective food safety system is to protect and improve the public health by ensuring that foods meet science-based safety standards through the integrated activities of the public and private sectors." This volume will further help to achieve the goals of the NAS Report

to achieve a "science based" food safety system. The work discussed in Chapter 8, "Mechanisms of Pathogenesis and Toxin Synthesis in *Clostridium botulinum*," will help to further assure the effectiveness of low acid canned food technology—which was mentioned in the NAS Report. In addition, several of the chapters in Section I, "Gram Negative Foodborne Bacterial Pathogens," are particularly applicable to the HACCP systems now being developed by the meat and poultry slaughter and processing industries. Verification of the effectiveness of HACCP requires understanding the genetic heterogeneity of pathogens such as variants of *E. coli* in order to develop tests to detect the pertinent virulent pathotypes of food safety concern. Other very relevant discussions regarding the role of science in food safety include (1) the genetics of the virulence of the various *Campylobacter*, which is crucial as the basis of molecular diagnostic techniques to better define the role of the various *Campylobacter* serotypes as etiologic agents of human enteric infection, and (2) the pathogenic determinants of *Listeria monocytogenes*. Extensive recent outbreaks of *Listeria* in prepared meat products have emphasized the importance of learning more about the nature of this bacterial pathogen and the necessity of devising effective control procedures.

Two other contemporary concerns are dependent on a science-based food safety system. The first is international trade where "science-based" recommendations are becoming the standard for international trade agreements such as the export of mycotoxin-contaminated commodities. No longer can a nation exclude a food product for strictly arbitrary reasons. Even though the implementation of this principle is still excruciatingly slow at times, the scientific understanding that is accumulating regarding the nature of food safety hazards will eventually bring rationality to this area of international trade. Secondly, bioterrorism, with respect to both food production and food safety, is a rapidly escalating concern in many developed countries. The wide availability of the basic type of biological information provided in this volume regarding the pathogenic causative agents of hazards to our food supply is an essential component of protection against bioterrorism. This protection requires methodology to detect toxic and infectious agents and track them to their sources; and it requires the availability of effective intervention and control measures to prevent and deal with food supply disasters.

This volume will be an excellent reference for researchers as they seek to provide the food industry and the government agencies with the necessary scientific advances to further assure food safety and meet the expectations of the consuming public.

JANE F. ROBENS  
U.S. Department of Agriculture

## Preface

**F**OODBORNE diseases are major causes of illness and death throughout the world. Though often considered a problem associated with developing, Third World countries, there are millions of cases of illness reported each year in developed countries such as those of the European Union and the United States. It is estimated that in the United States alone, some 9000 people a year, mostly the very young and elderly, die as a result of infections and intoxications from ingestion of contaminated food and water. Ever increasing reports of illness and deaths from ingestion of tainted meats, vegetables and juices, not to mention the anxiety raised worldwide over the possible transmission of "Mad Cow" disease to humans has caused many governments to reassess their policies and industry practices on safeguarding their food supplies. This reassessment was most evident in the United States where beginning in 1997, in an effort to restore American's trust in its own food production system as well as its imports, President Clinton announced the National Food Safety Initiative that pledged 46 million dollars to develop a comprehensive plan to improve the safety of the food supply. The President has requested funding in excess of 100 million dollars for FY 1999 and 2000. Similar food safety initiatives are being undertaken in other countries in response to the public awareness and demands for a safer food supply. Though much of this funding is earmarked for improved surveillance, inspections, education, and training, funds have also been designated for expansion of food-safety research.

Development of efficacious strategies for prevention and treatment of foodborne diseases has relied and will continue to rely to a significant extent on the tools of molecular biology. Through the use of molecular and cellular biological techniques, numerous advances have been made in understanding



the molecular basis of virulence mechanisms and toxin biosynthesis in organisms that routinely contaminate food and feed. *Microbial Foodborne Diseases: Mechanisms of Pathogenesis and Toxin Synthesis* is intended to serve as an advanced text providing useful, up-to-date information by recognized authorities on the molecular mechanisms of pathogenicity and toxin production of what we felt were some of the most significant foodborne pathogens. Selection of the pathogens included in this book depended on the body of molecular biological information available as well as the organism's impact on economics and human health. The main focus of this book, therefore, has been on the molecular and cellular processes that govern pathogenicity and toxin production in foodborne pathogens, be they viral, bacterial, fungal, or protozoan. Additional information presented includes the latest information related to the association of the pathogen with particular foods (water will be considered a food), epidemiology, methods of early detection, toxicology, and economic impact of the pathogen. Topics such as spoilage, preservation methods, fermentation, and food processing techniques that are well documented in other food microbiology texts were not included. In general, this book is designed for scientists involved in food microbiology and food safety, as well as human and veterinary medicine, both at the graduate and post-graduate level. In addition to serving as an invaluable reference resource, this book should be of particular interest to molecular biologists desiring current information emphasizing the molecular mechanisms governing the disease process. This text should also serve as a valuable tool in the rational design of preventative controls and therapeutic approaches to the disease process.

The text is divided into five major sections covering bacterial foodborne pathogens, toxigenic fungi and marine dinoflagellates, protozoan pathogens, and viral and virus-like foodborne pathogens. We feel that the first nine chapters provide in depth, authoritative coverage of the molecular mechanisms of pathogenicity and toxin production in bacterial foodborne pathogens. Chapter 10 represents the most comprehensive review to date on the molecular biology of aflatoxin biosynthesis by *Aspergillus*, whereas Chapters 11 and 12 provide up-to-date information on the molecular biology of trichothecene and fumonisin production by *Fusarium* and the biosynthesis of PSP toxins by marine dinoflagellates, respectively. Two detailed reviews on the factors governing pathogenicity in the protozoan parasites *Toxoplasma gondii* and *Entamoeba histolytica* and *Cryptosporidium parvum* are presented in Chapters 13 and 14. Chapter 15 provides a thorough discussion of the epidemiology and pathogenicity of Norwalk and other human caliciviruses. The book concludes with what we think is a very informative chapter on the molecular biology of prion diseases that are associated with bovine spongiform encephalopathy, "Mad Cow" disease, and Creutzfeldt-Jakob disease in humans.

We are extremely grateful to all of our contributors for taking the time and effort required to produce a comprehensive examination of their respective

subject areas. The editors also want to thank the many reviewers who took the time to provide critical comments and suggestions to the authors in the final preparation of their chapters. We are grateful to the staff at Technomic Publishing Co., Inc., for their careful editing which allowed this book to come together as a cohesive unit. J. W. C. would like to especially thank Eleanor Riemer at Technomic Publishing Company for her guidance, encouragement, and patience throughout the course of preparation of this book.

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