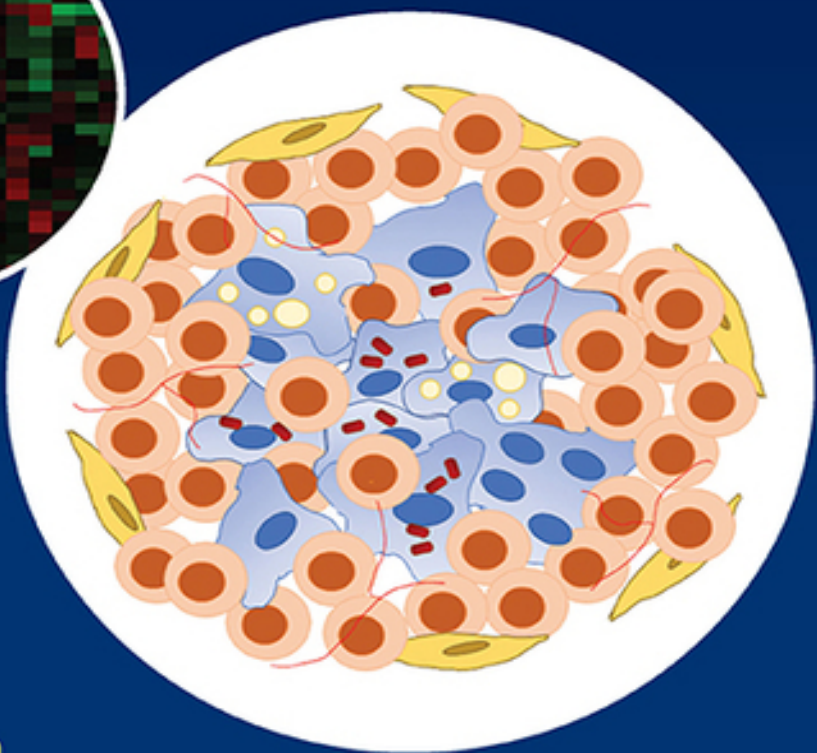
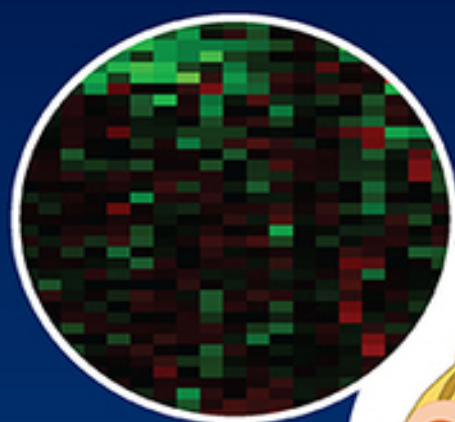


FIFTH EDITION

PATHOGENESIS OF BACTERIAL INFECTIONS IN ANIMALS



EDITED BY

JOHN F. PRESCOTT

JANET I. MACINNES

FILIP VAN IMMERSEEL

JOHN D. BOYCE

ANDREW N. RYCROFT

JOSÉ A. VÁZQUEZ-BOLAND



WILEY Blackwell

Table of Contents

[Cover](#)

[Title Page](#)

[Copyright](#)

[Preface](#)

[List of Contributors](#)

[About the Companion Website](#)

[1 Themes in Bacterial Pathogenesis](#)

[Introduction](#)

[The Basic Elements of Bacterial Pathogenesis](#)

[Concepts of Bacterial Virulence are Being Refined](#)

[Host-Pathogen Communications are Critical](#)

[Pathogenesis in the Post-Genomic Era](#)

[Gaps in Knowledge and Anticipated Directions](#)

[References](#)

[2 Evolution of Bacterial Pathogens](#)

[What are Pathogens and How Do They Emerge?](#)

[Bacterial Fitness and Virulence](#)

[Sources of Genetic Diversity, Population Structure,
and Genome Plasticity](#)

[Pathogenicity Islands](#)

[Bacteriophages and Their Role in Pathogen
Evolution and Virulence](#)

[Examples of Virulence Evolution](#)

[Gaps in Knowledge and Anticipated Directions](#)

[References](#)

3 Understanding Pathogenesis Through Pathogenomics and Bioinformatics

Introduction

How Mutations Generate Bacterial Diversity

Genome Sequencing Technologies

Genome Assembly

Gene Prediction and Annotation

Defining Prokaryotic Species from Genomes

The Pangenome Concept, Reconstruction, and Comparative Analyses

Phylogenomics and Genome-Wide Association Studies

Functional Genomics for Understanding Host-Pathogen Interactions

Reverse Vaccinology

Gaps in Knowledge and Anticipated Directions

References

4 Experimental Approaches to Understanding Pathogenesis

Introduction

Testing Koch's Postulates

Virulence Factors and Main Steps in Pathogenesis

Molecular Koch's Postulates

Refining Animal Usage

Experimental Approaches for Virulence Factor Discovery and Validation

Approaches for Virulence Factor Discovery

Bringing It All Together: Validation and Further Characterization of Virulence Factors

Two Stories of Virulence Factor Discovery and Characterization: *Pasteurella multocida* Capsule, and *Mycoplasma bovis* Adhesins

Gaps in Knowledge and Anticipated Directions

References

5 Subversion of the Immune Response by Bacterial Pathogens

Introduction

Subversion of Innate Responses

Subversion of Adaptive Immunity

Manipulation of Cell Fate

Non-Coding RNA and Host-Pathogen Interactions

Epigenetic and Genetic Modulation

Gaps in Knowledge and Anticipated Directions

References

6 Chinks in the Armor

Introduction

Virulence Factors: Pathogenesis-Based Targets to Combat Bacterial Pathogens

Gaps in Knowledge and Anticipated Directions

References

7 *Escherichia coli*

Introduction

Pathotypes of *E. coli* and Associated Disease and Pathological Changes in Animals

Virulence Factors of Pathogenic *E. coli*

Pathogenesis of Enterotoxigenic *E. coli*

Pathogenesis of Enteropathogenic *E. coli* Disease

Pathogenesis of Shiga Toxin-Producing *E. coli* Disease

Pathogenesis of Extraintestinal Pathogenic *E. coli* Infections

Gaps in Knowledge and Anticipated Directions

References

8 *Salmonella*

Introduction

Characteristics of the Organism

Types of Disease and Pathologic Changes

Salmonella Infections in Different Major Farmed Animal Species

Virulence Factors

Pathogenesis

Immunity to Infection and its Manipulation by *Salmonella*

Antimicrobial Resistance

Gaps in Knowledge and Anticipated Directions

References

9 *Yersinia*

Introduction

Characteristics of the Organism

Pathogenic Species

Taxonomy

Major Virulence Factors of the Highly Pathogenic *Yersinia*

Yersinia pestis

Yersinia pseudotuberculosis and *Yersinia enterocolitica*

Yersinia ruckeri

Yersinia entomophaga

[Control of *Yersinia* Infections](#)

[Gaps in Knowledge and Anticipated Directions](#)

[References](#)

[10 *Pasteurella*](#)

[Introduction](#)

[Characteristics of the Organism](#)

[Source of Infection: Ecology, Evolution, and Epidemiology](#)

[Types of Disease and Pathologic Changes](#)

[Virulence Factors and Pathogenomics](#)

[Regulation of Virulence](#)

[Pathogenesis](#)

[Immunity](#)

[Control](#)

[Gaps in Knowledge and Anticipated Directions](#)

[References](#)

[11 *Mannheimia* and *Bibersteinia*](#)

[Introduction](#)

[Characteristics of the Organism](#)

[Pathogenic Species](#)

[Source of Infection: Ecology, Evolution, and Epidemiology](#)

[Types of Disease and Pathologic Changes](#)

[Virulence Factors and Pathogenomics](#)

[Regulation of Virulence](#)

[Pathogenesis](#)

[Immunity](#)

[Control](#)

[Gaps in Knowledge and Anticipated Directions](#)

References

12 *Actinobacillus*

Introduction

Actinobacillus pleuropneumoniae

Actinobacillus lignieresii

Actinobacillus equuli

Actinobacillus suis

Gaps in Knowledge and Future Directions

References

13 Other Pasteurellaceae: *Avibacterium*, *Bibersteinia*, *Gallibacterium*, *Glaesserella*, and *Histophilus*

Introduction

Avibacterium

Bibersteinia

Gallibacterium

Glaesserella parasuis

Histophilus

References

14 *Pseudomonas*

Introduction

Characteristics of the Organism

Pathogenic Species

Sources of Infection: Ecology, Evolution, and Epidemiology

Types of Disease and Pathologic Changes

Virulence Factors and Pathogenomics

Pathogenesis

Immunity

Control, Prevention, and Treatment

[Gaps in Knowledge and Anticipated Directions](#)

[References](#)

[15 Moraxella](#)

[Introduction](#)

[Infectious Bovine Keratoconjunctivitis](#)

[Pathogenesis of *Moraxella bovis* Infection](#)

[Immunity](#)

[Control](#)

[Gaps in Knowledge and Future Directions](#)

[References](#)

[16 Brucella](#)

[Introduction](#)

[Characteristics of the Organism](#)

[Pathogenic Species](#)

[Source of Infection: Ecology, Evolution, and Epidemiology](#)

[Types of Disease and Pathologic Changes](#)

[Virulence Factors](#)

[Regulation of Virulence](#)

[Pathogenomics](#)

[Pathogenesis](#)

[Immunity](#)

[Control](#)

[Gaps in Knowledge and Anticipated Directions](#)

[References](#)

[17 Bordetella](#)

[Introduction](#)

[Characteristics of the Organisms](#)

[Pathogenic Species](#)

[Source of Infection: Ecology and Epidemiology](#)

[Types of Disease and Pathologic Changes](#)

[Virulence Factors](#)

[Regulation of Virulence](#)

[Pathogenesis](#)

[Immunity](#)

[Control](#)

[Gaps in Knowledge and Anticipated Directions](#)

[References](#)

[18 *Campylobacter*](#)

[Introduction](#)

[Diseases, Etiology, and Ecology](#)

[Clinical Observations and Pathologic Changes](#)

[Pathogenesis and Virulence Factors](#)

[Pathogenomics and Evolution](#)

[Immunity](#)

[Control](#)

[Gaps in Knowledge and Future Directions](#)

[References](#)

[19 *Helicobacter*](#)

[Introduction](#)

[Gastric Helicobacters](#)

[Enterohepatic Helicobacters](#)

[Gaps in Knowledge and Future Directions](#)

[References](#)

[20 *Chlamydia and Coxiella*](#)

[Introduction](#)

Chlamydiae

Coxiella burnetii

References

21 Rickettsiales

Introduction

Family Anaplasmataceae

Family Rickettsiaceae

References

22 *Lawsonia intracellularis*

Introduction

Characteristics of the Organism

Sources of Infection: Ecology and Epidemiology

Types of Disease and Pathologic Changes

Virulence Factors and Pathogenomics

Pathogenesis

Immunity

Control

Gaps in Knowledge and Anticipated Directions

References

23 *Leptospira*

Introduction

Characteristics of the Organism

Leptospira Species

Source of Infection: Ecology, Evolution, and Epidemiology

Clinical Presentation and Signs

Virulence Factors and Pathogenomics

Regulation of Virulence

[Pathogenesis](#)

[Immunity](#)

[Control](#)

[Gaps in Knowledge and Anticipated Directions](#)

[Acknowledgments](#)

[References](#)

[24 *Brachyspira*](#)

[Introduction](#)

[Characteristics of the Organism](#)

[Pathogenic Species and Disease Associations](#)

[Source of Infection: Ecology, Evolution, and Epidemiology](#)

[Virulence Factors and Pathogenomics](#)

[Pathogenesis](#)

[Immunity](#)

[Control](#)

[Gaps in Knowledge and Anticipated Directions](#)

[References](#)

[25 *Staphylococcus*](#)

[Introduction](#)

[Characteristics of the Organism](#)

[Pathogenic Species](#)

[*Staphylococcus aureus* Infections in Cattle](#)

[*Staphylococcus aureus* Infections in Poultry](#)

[*Staphylococcus aureus* Infections in Rabbits](#)

[*Staphylococcus hyicus* Infections in Pigs](#)

[*Staphylococcus pseudintermedius* Infections in Dogs](#)

[Gaps in Knowledge and Future Directions](#)

References

26 *Streptococcus*

Introduction

Characteristics of the Organism

Pathogenic Species

Streptococcus agalactiae

Streptococcus dysgalactiae

Streptococcus uberis

Streptococcus equi

Streptococcus zooepidemicus

Streptococcus canis

Streptococcus suis

Gaps in Knowledge and Anticipated Directions

References

27 *Bacillus anthracis*

Introduction

Characteristics of the Organism: Taxonomy and Phylogeny

Source and Spread of the Infection: Ecology, Evolution, and Epidemiology

Types of Disease and Pathologic Changes

Virulence Factors and Pathogenomics

Regulation of Virulence

Pathogenesis

Immunity and Vaccines

Control and Prevention of Anthrax

Gaps in Knowledge and Anticipated Directions

References

28 Enteric Clostridia

[Introduction](#)

[Clostridium perfringens](#)

[Clostridioides difficile](#)

[Other Enteric Clostridia](#)

[References](#)

[29 Histotoxic Clostridia](#)

[Introduction](#)

[Characteristics of the Organisms](#)

[Source of Infection and Basic Pathogenesis](#)

[Pathogenic Species](#)

[Control](#)

[Gaps in Knowledge and Future Directions](#)

[Acknowledgment](#)

[References](#)

[30 Neurotoxic Clostridia](#)

[Introduction](#)

[Characteristic of the Organisms](#)

[Sources of Infection: Ecology and Epidemiology](#)

[Diseases](#)

[Virulence Factors](#)

[Pathogenesis](#)

[Control](#)

[References](#)

[31 Mycoplasmas](#)

[Introduction](#)

[Characteristics of the Organisms](#)

[Pathogenic Species](#)

[Source of Infection: Ecology, Evolution, and Epidemiology](#)

[Virulence Factors and Pathogenomics](#)

[Regulation of Virulence](#)

[Types of Disease and Pathologic Changes](#)

[Pathogenesis](#)

[Immunity](#)

[Control](#)

[Gaps in Knowledge and Anticipated Directions](#)

[References](#)

[32 *Corynebacterium*, *Arcanobacterium*, and *Trueperella*](#)

[*Corynebacterium*](#)

[*Corynebacterium pseudotuberculosis*](#)

[Bovine Pyelonephritis Caused by *Corynebacterium* Species](#)

[Other Animal Pathogenic *Corynebacterium* Species](#)

[*Arcanobacterium*](#)

[*Trueperella*](#)

[Gaps in Knowledge and Future Directions](#)

[References](#)

[33 *Rhodococcus equi*](#)

[Introduction](#)

[Characteristics of the Organism](#)

[Source of Infection and Epidemiology](#)

[Types of Disease and Pathologic Changes](#)

[Virulence Factors](#)

[Evolution of *Rhodococcus equi* Virulence](#)

[Pathogenesis](#)

[Immunity](#)

[Treatment and Control](#)

[Gaps in Knowledge and Anticipated Directions](#)

[Acknowledgments](#)

[References](#)

[34 *Mycobacterium*](#)

[Introduction](#)

[Characteristics of the Organism](#)

[Sources of Infection](#)

[Source of Infection: Evolution and Epidemiology](#)

[Virulence Factors and Pathogenomics](#)

[Regulation of Virulence](#)

[Types of Disease](#)

[Pathogenesis](#)

[Adaptive Immunity and Mycobacterial Pathogenesis](#)

[Control](#)

[Gaps in Knowledge and Anticipated Directions](#)

[References](#)

[35 *Gram-Negative Anaerobes*](#)

[Introduction](#)

[General Bacterial Pathogenesis Aspects](#)

[*Fusobacterium*](#)

[*Bacteroides*](#)

[*Prevotella* and *Porphyromonas*](#)

[*Dichelobacter nodosus*](#)

[*Treponema*](#)

[Gaps in Knowledge and Anticipated Developments](#)

[Acknowledgments](#)

[References](#)

[Index](#)

[End User License Agreement](#)

List of Tables

Chapter 2

[Table 2.1 Common characteristics of pathogenicity islands.](#)

Chapter 4

[Table 4.1 Three broad approaches to virulence gene discovery.](#)

Chapter 5

[Table 5.1 Examples of bacterial subversion of uptake and killing.](#)

[Table 5.2 Examples of bacterial subversion of cellular responses.](#)

[Table 5.3 Selected pathogenic bacteria and their nucleomodulins.a](#)

[Table 5.4 Selected pathogenic bacteria and their cyclomodulins.a](#)

Chapter 7

[Table 7.1 Overview of categories of *Escherichia coli* found in animals.](#)

[Table 7.2 Major types of *Escherichia coli* implicated in enteric diseases of ...](#)

[Table 7.3 Extraintestinal diseases of animals caused by *Escherichia coli*.](#)

[Table 7.4 Important virulence categories and factors, O serogroups and patho...](#)

[Table 7.5 Important virulence categories and factors, O serogroups and patho...](#)

[Table 7.6 Important pathotypes, hybrid pathotypes, virotypes, and sequence t...](#)

[Table 7.7 Important virulence categories and factors, O serogroups and patho...](#)

Chapter 8

[Table 8.1 General properties of *Salmonella enterica* subsp. *enterica* serovar ...](#)

Chapter 10

[Table 10.1 *Pasteurella* species, hosts, diseases, or location.](#)

Chapter 12

[Table 12.1 *Actinobacillus* sensu stricto and *Actinobacillus*-like species isol...](#)

[Table 12.2 Properties and distribution of *A. pleuropneumoniae* serovars.](#)

Chapter 14

[Table 14.1 Diseases in animals caused by *Pseudomonas aeruginosa*.](#)

[Table 14.2 Cell-associated virulence factors produced by *Pseudomonas aerugin*...](#)

[Table 14.3 The secreted arsenal of *Pseudomonas aeruginosa*.](#)

[Table 14.4 Antibiotic resistance determinants of *Pseudomonas aeruginosa*.](#)

Chapter 15

[Table 15.1 Species of *Moraxella* isolated from animals and their morphology....](#)

Chapter 17

[Table 17.1 *Bordetella* species involved in infections in animals and humans....](#)

[Table 17.2 Expression of main known or suspected virulence factors in veteri...](#)

Chapter 18

[Table 18.1 *Campylobacter* species associated with animal diseases.](#)

[Table 18.2 Summary of generic virulence factors of *Campylobacter*.](#)

Chapter 19

[Table 19.1 *Helicobacter* species and their pathogenic significance for humans...](#)

Chapter 20

[Table 20.1 Pathogenic *Chlamydia* species and their host ranges.](#)

Chapter 21

[Table 21.1 Important rickettsial pathogens of domestic and wild animals.](#)

Chapter 23

[Table 23.1 Disease syndromes caused by infection of animals with *Leptospira* ...](#)

Chapter 24

[Table 24.1 *Brachyospira* species and disease associations.](#)

[Table 24.2 Putative hemolysins in *Brachyspira hyodysenteriae*.](#)

Chapter 26

[Table 26.1 Pathogenic streptococci of animals arranged by Lancefield group a...](#)

Chapter 28

[Table 28.1 Classification of *Clostridium perfringens* strains into toxinotype...](#)

[Table 28.2 Enteric diseases associated with different recognized toxinotypes...](#)

[Table 28.3 Properties of some well-characterized important extracellular deg...](#)

[Table 28.4 *Clostridiodes difficile* disease in animals.](#)

[Table 28.5 Summary of other clostridia associated with enteric disease in an...](#)

Chapter 29

[Table 29.1 Overview of clostridia involved in histotoxic infections in anima...](#)

Chapter 30

[Table 30.1 Botulinum neurotoxin \(BoNT\)-producing clostridia, BoNT types and ...](#)

[Table 30.2 Clostridial neurotoxins, intracellular targets, and cleavage site...](#)

Chapter 31

[Table 31.1 Pathogenic mycoplasmas of domestic animals.](#)

[Table 31.2 Mycoplasma diseases of animals characterized by invasive blood-bo...](#)

[Table 31.3 Mycoplasma diseases of animals characterized by localized extensi...](#)

Chapter 32

[Table 32.1 Main hosts and diseases caused by *Corynebacterium* species.](#)

[Table 32.2 *Arcanobacterium* species that cause infections in different hosts....](#)

Chapter 34

[Table 34.1 Examples of pathogenic *Mycobacterium* infections of animals.](#)

Chapter 35

[Table 35.1 Common examples of mixed aerobic-Gram-negative and anaerobic bact...](#)

[Table 35.2 Major virulence factors of *Fusobacterium necrophorum*.](#)

[Table 35.3 Major virulence factors of *Dichelobacter nodosus*.](#)

List of Illustrations

Chapter 1

[Figure 1.1 Basic processes in the pathogenesis of bacterial infections. The ...](#)

[Figure 1.2 The classic host-pathogen paradigm of infectious disease. The out...](#)

Chapter 2

[Figure 2.1 Theoretical frame for the emergence of new pathogens and evolutio...](#)

[Figure 2.2 Main molecular pathways of virulence evolution. The modes of new ...](#)

Chapter 3

[Figure 3.1 Overview of how pathogenomics and bioinformatics methods can info...](#)

[Figure 3.2 Use of RNA sequencing \(RNA-seq\) for improved genome annotation. R...](#)

[Figure 3.3 Overview of the reverse vaccinology approach to vaccine developme...](#)

Chapter 4

[Figure 4.1 Host-environment-pathogen triangle. The ability of a bacterial sp...](#)

[Figure 4.2 Koch's postulates and molecular Koch's postulates. \(a\) Koch's thi...](#)

[Figure 4.3 High-throughput approaches for discovery of virulence-related gen...](#)

Chapter 5

[Figure 5.1 Microbial interference with phagocytosis and antigen processing. ...](#)

[Figure 5.2 Microbial interference with metabolism, replication, gene regulat...](#)

Chapter 6

[Figure 6.1 Common bacterial virulence factors. Bacteria harness an array of ...](#)

[Figure 6.2 Overview of proposed pathogenesis-based strategies to combat bact...](#)

Chapter 7

[Figure 7.1 Mechanisms of action of *E. coli* enterotoxins. \(a\) STa: Binding of...](#)

[Figure 7.2 Schematic representation of the steps involved in the pathogenesis...](#)

[Figure 7.3 Schematic representation of the steps involved in the pathogenesis...](#)

[Figure 7.4 Schematic representation of the steps involved in the pathogenesis...](#)

[Figure 7.5 Schematic representation of the steps involved in the pathogenesis...](#)

Chapter 8

[Figure 8.1 Grape-tree representation of a maximum likelihood phylogeny of co...](#)

[Figure 8.2 Schematic overview of the different forms and stages of salmonell...](#)

Chapter 9

[Figure 9.1 Schematic representation of the basic pathogenesis of *Yersinia* in...](#)

[Figure 9.2 Phylogeny of the 26 species within the genus *Yersinia*. Maximum-li...](#)

[Figure 9.3 Host-pathogen interactions at the cell surface. Adhesins Invasin ...](#)

Chapter 10

[Figure 10.1 Overview of *Pasteurella multocida* virulence factors and importan...](#)

[Figure 10.2 Schematic representation of the capsular polysaccharide biosynth...](#)

Chapter 11

[Figure 11.1 *Mannheimia haemolytica* virulence factors and the pathogenesis of...](#)

[Figure 11.2 *Mannheimia haemolytica* pneumonia. \(a\) Gross lesions in a colostr...](#)

[Figure 11.3 Role of leukotoxin \(LKT\) and lipopolysaccharide \(LPS\) in virulen...](#)

Chapter 12

[Figure 12.1 Overview of *A. pleuropneumoniae* \(APP\) transmission and developme...](#)

[Figure 12.2 Overview of *A. pleuropneumoniae* pathogenesis. Although adherence...](#)

Chapter 13

[Figure 13.1 Mechanisms of pathogenesis of *Avibacterium paragallinarum*, illus...](#)

[Figure 13.2 \(a\) *Gallibacterium anatis* is a common inhabitant of the upper re...](#)

[Figure 13.3 Main mechanisms of pathogenesis \(in black\) and virulence factors...](#)

Chapter 14

[Figure 14.1 *P. aeruginosa*. \(Left\) Transmission electron micrograph of negati...](#)

[Figure 14.2 Quorum-sensing systems of *P. aeruginosa*. The cascade of events b...](#)

[Figure 14.3 Overview of pathogenesis of infection due to *P. aeruginosa*. Duri...](#)

Chapter 15

[Figure 15.1 Clinical progression of healing in a steer with infectious bovin...](#)

[Figure 15.2 Schematic diagram depicting DNA elements flanking the repeats in...](#)

Chapter 16

[Figure 16.1 Overview of *Brucella* species, natural hosts, target organs, and ...](#)

[Figure 16.2 Overview of *Brucella* systems important for host colonization and...](#)

Chapter 17

[Figure 17.1 Colonization by *Bordetella bronchiseptica* \(red staining\) of the ...](#)

[Figure 17.2 Binding of *Bordetella bronchiseptica* to ciliated tracheal epithe...](#)

[Figure 17.3 Overview of pathogenesis of *Bordetella bronchiseptica* in tracheo...](#)

Chapter 18

[Figure 18.1 Overview of *Campylobacter*-induced animal diseases and pathogenic...](#)

[Figure 18.2 Typical pathological changes associated with chicken spotty live...](#)

Chapter 19

[Figure 19.1 General overview of the pathogenesis of gastric *Helicobacter* inf...](#)

[Figure 19.2 Immunohistochemical *Helicobacter* staining of a pig stomach, show...](#)

[Figure 19.3 Overview of zoonotic gastric *Helicobacter* species and their natu...](#)

Chapter 20

[Figure 20.1 The chlamydial cell cycle. Chlamydial biphasic developmental cyc...](#)

[Figure 20.2 Biogenesis of the *Coxiella*-containing vacuole \(CCV\). Small-cell ...](#)

Chapter 21

[Figure 21.1 *Anaplasma phagocytophilum* interplay with the autophagic pathway ...](#)

[Figure 21.2 Overview of *Ehrlichia chaffeensis* entry, vacuole characteristics...](#)

[Figure 21.3 Overview of *Ehrlichia chaffeensis* multiple short linear motif li...](#)

Chapter 22

[Figure 22.1 Ileal section of a pig infected with *Lawsonia intracellularis*. H...](#)

[Figure 22.2 Transmission electron microscopy photograph of *Lawsonia intracel...*](#)

[Figure 22.3 Cell culture of intestinal 407 cells infected with *Lawsonia intr...*](#)

[Figure 22.4 Pathogenesis of *Lawsonia intracellularis*. \(a\) Schematic represen...](#)

Chapter 23

[Figure 23.1 *Leptospira* species \(a\) Dark field microscope \(bar = 10 \$\mu\$ m\). Sour...](#)

[Figure 23.2 Epidemiology and pathogenesis of leptospirosis. \(1\) Rats are the...](#)

Chapter 24

[Figure 24.1 In swine dysentery, perturbations of the intestinal microbiota a...](#)

[Figure 24.2 Scanning electron micrograph of the surface of an intestinal org...](#)

Chapter 25

[Figure 25.1 Staphylococcal species and their main animal hosts. Colonization...](#)

Chapter 26

[Figure 26.1 Illustration showing genes and functions gained \(red\) and lost \(...\)](#)

[Figure 26.2 Scanning electron micrographs; magnification × 200. \(a\) Attachme...](#)

Chapter 27

[Figure 27.1 Schematic genetic tree summarizing the phylogeography of worldwi...](#)

[Figure 27.2 Overview of the molecular mechanisms of virulence of *Bacillus an...*](#)

Chapter 28

[Figure 28.1 Comparative analysis of *Clostridium perfringens tcp* conjugative ...](#)

[Figure 28.2 Genetic organization of necrotic enteritis-specific loci in *Clos...*](#)

[Figure 28.3 Summary of action of important *Clostridium perfringens* toxins on...](#)

[Figure 28.4 Schematic of the general features of the pathogenesis of enteric...](#)

Chapter 29

[Figure 29.1 Integrated view of the key toxin actions involved in pathogenesi...](#)

[Figure 29.2 Necrotic neck muscles and facia at the site of injection in a sh...](#)

[Figure 29.3 Hindleg muscle with very dark, dry, necrohemorrhagic inflammation...](#)

[Figure 29.4 Sectioned liver showing irregular pale foci of necrosis surround...](#)

Chapter 30

[Figure 30.1 Morphology of *Clostridium botulinum* and *Clostridium tetani*, and ...](#)

[Figure 30.2 Overview of pathophysiology of botulism and tetanus. \(a\) Botulis...](#)

[Figure 30.3 Mechanism of action of botulinum \(BoNT\) and tetanus toxin \(TeNT\)...](#)

Chapter 31

[Figure 31.1 Overview of virulence factors in mycoplasmas and their role in t...](#)

[Figure 31.2 Chondrodystrophic lesions in: \(a\) a turkey poult infected with *M...*](#)

[Figure 31.3 Transmission electron micrograph of *Mycoplasma gallisepticum* att...](#)

[Figure 31.4 Sections of tracheas of 10-week-old chickens: \(a\) uninfected, an...](#)

Chapter 32

[Figure 32.1 Examples of lesions caused by *Corynebacterium pseudotuberculosis*](#)

[Figure 32.2 Scheme of virulence factors present in *Corynebacterium pseudotub...*](#)

Chapter 33

[Figure 33.1 \(a\) *Rhodococcus equi* colonies on LB medium incubated at 30°C for...](#)

[Figure 33.2 Overview of relevant metabolic and virulence-related traits enco...](#)

[Figure 33.3 \(a\) Comparison of the pVAPA and pVAPB circular virulence plasmid...](#)

Chapter 34

[Figure 34.1 The mycobacterial granuloma. Immediately after entry into the bo...](#)

[Figure 34.2 Overview of the pathogenesis of virulent *Mycobacterium bovis* \(Mb...](#)

Chapter 35

[Figure 35.1 Basic pathogenesis of liver abscessation of cattle caused by *Fus...*](#)

Pathogenesis of Bacterial Infections in Animals

Edited by

John F. Prescott

University of Guelph, Guelph, Canada

Janet I. MacInnes

University of Guelph, Guelph, Canada

Filip Van Immerseel

Ghent University, Merelbeke, Belgium

John D. Boyce

Monash University, Clayton, Australia

Andrew N. Rycroft

University of London, Royal Veterinary College,
Hertfordshire, UK

José A. Vázquez-Boland

Microbial Pathogenesis Group, Edinburgh, UK

Fifth edition

WILEY Blackwell