THE ENTEROBACTERIA
SECOND EDITION
The Enterobacteria
SECOND EDITION

J. Michael Janda
Chief
Microbial Diseases Laboratory
California Department of Health Services
Richmond, California

Sharon L. Abbott
Supervisor (Retired), Enteric Bacteriology
Microbial Diseases Laboratory
California Department of Health Services
Richmond, California

ASM PRESS
WASHINGTON, D.C.
To

Marjorie L. Bissett
Chief, Enterics and Special Pathogens Section (Retired)
and
Cathy Powers
Supervisor, Enteric Bacteriology Unit (Retired)
Microbial Diseases Laboratory
California Department of Health Services

Thank you for sharing your knowledge, technical skill, and experience regarding this fascinating group of bacteria with us and for your dedication to the field of public health.
# CONTENTS

Preface • ix

1. Historical Perspectives on the Family  
   *Enterobacteriaceae* • 1

2. The Family *Enterobacteriaceae*: Taxonomic Considerations • 7

3. Medical and Public Health Significance of the Family  
   *Enterobacteriaceae* • 15

4. *Escherichia coli* • 23

5. Other *Escherichia* Species • 59

6. The Genus *Shigella* • 65

7. Nontyphoidal *Salmonella* • 81

8. *Salmonella* Serotype Typhi and *Salmonella* Serotype Paratyphi A, B, and C • 105

9. The Genera *Klebsiella* and *Raoultella* • 115

10. The Genus *Serratia* • 137

11. The Genus *Enterobacter* • 151

12. The Genus *Citrobacter* • 181

13. The Genus *Yersinia* • 205

14. The Genus *Proteus* • 233

15. The Genus *Morganella* • 261

16. The Genus *Providencia* • 279

17. The Genus *Edwardsiella* • 301

18. The Genus *Hafnia* • 321

19. The Genus *Plesiomonas* • 335

20. Uncommon Enterobacterial Genera Associated with Clinical Specimens • 357

21. Phytopathogenic and Miscellaneous Members of the Family  
   *Enterobacteriaceae* • 377

Appendix: Differential Biochemical Tables for Enterobacteria • 385

Index • 395
In the first edition of *The Enterobacteria*, we stated, “No taxonomically defined group of bacteria has had a greater impact on infectious diseases, medical and clinical microbiology, and public health than the enterobacteria.” With the second edition of this book, this statement has been reinforced over the past 7 years with an increasing body of evidence magnifying both the scope and depth of how the family *Enterobacteriaceae* impacts our daily lives.

There are a number of important changes to the second edition of this book, only a couple of which will be highlighted here. The use of 16S rRNA sequencing both as an aid to the identification of unknown enteric bacteria and to classify taxonomic groups appropriately can be seen throughout the text. Such changes include the reclassification of the oxidase-positive genus *Plesiomonas* as a member of this family (chapter 19). The use of molecular probes to identify specific species or genera is also discussed where appropriate. Also, phylogenetic investigations coupled with molecular studies have increasingly revealed a world of enterobacteria not associated with humans or animals, but intimately connected with insects as endosymbionts, as plant pathogens, or in specific environmental niches (chapter 2). The number of hosts and environments impacted by the *Enterobacteriaceae* is expanding at logarithmic rates. A second new feature of this book is an appendix, “Differential Biochemical Tables for Enterobacteria.” In this appendix, one can find tables which will help a microbiologist identify an organism from genus to species level or, conversely, can aid a laboratorian in the initial placement of an isolate into the correct genus on the basis of a single trait (e.g., \( \text{H}_2\text{S} \) production) or multiple unusual phenotypes (e.g., negative for lysine decarboxylase, ornithine decarboxylase, and arginine dihydrolase).

It is hoped that this second edition will serve as a reference source for those microbiologists, physicians, infectious disease specialists, pathologists, epidemiologists, infection control practitioners, and scientists who need in-depth information on these bacteria beyond what is covered in the eighth edition of the *Manual of Clinical Microbiology*.

J. Michael Janda
Sharon L. Abbott
INDEX

Abscess
brain
  
  *Citrobacter*, 186
  *Klebsiella*, 118, 120
  *Proteus*, 239–240
  *Salmonella*, 87
liver
  
  *Edwardsiella*, 310
  *Klebsiella*, 118, 121
  *Yersinia*, 217
muscle
  
  *Enterobacter*, 163
  *Salmonella*, 87–88
pancreatic
  
  *Escherichia coli*, 32
  *Plesiomonas*, 344
psoas muscle, *Klebsiella*, 122
retropharyngeal
  
  *Enterobacter*, 162–163
scrotal, *Cedecea*, 357
skin, *Proteus*, 240
tubo-ovarian, *Edwardsiella*, 310
Acid tolerance, *Salmonella*, 96
Adherence, see also Adhesins
  
  *Plesiomonas*, 350
  *Yersinia*, 222–223
Adherence assays, for *Escherichia coli*, 39
Adherent-invasive *Escherichia coli* (AIEC), 37
Adhesins
  
  *Enterobacter*, 169
  *Escherichia coli*, 48–49
  *Klebsiella*, 126
  *Proteus*, 249
AE lesions, in *Escherichia coli* infections, 47
Aerobacter, *Enterobacter* formerly assigned to, 151
Aerobacter biotype 32011, see *Hafnia alvei*
Aerobactin
  
  *Citrobacter*, 196
  *Enterobacter*, 168–169
  *Klebsiella*, 125–126
Aeromonas shigelloides, 335, 390
Ail protein, *Yersinia*, 222
Alkalascens-Dispar organisms, 65
Amber disease, 139
Ammonia, accumulation of, in *Providencia* infections, 284
Aneurysms, mycotic, *Yersinia*, 216
Animals
  
  *Buttiauxella* in, 380
  *Citrobacter* in, 18
  
  *colibacillosis* in, 24–25
  *Edwardsiella* in, 302–303
  *Enterobacter* in, 154–155
  *Hafnia alvei* in, 322–323
  *Klebsiella* in, 116
  *Kluyvera* in, 361
  *Moellerella wisconsinensis* in, 364
  *Morganella morganii* in, 262
  *Photorhabdus* in, 366
  *Proteus* in, 234–235
  *Providencia* in, 280–281
  *Salmonella* in, 82–84
  *Serratia* in, 138–139
  *Xenorhabdus* in, 381
  *Yersinia* in, 207–211, 215, see also Plague
Ankylosing spondylitis, 18, 241
Antibiograms, *Enterobacter*, 167
Antimicrobial susceptibility, see specific organisms
Aorta, graft infections in, *Edwardsiella*, 308
Aortitis, *Salmonella*, 87
Appendicitis, *Kluyvera*, 362
Arthritis
  
  reactive, see Reactive arthritis
  rheumatoid, 18, 241
  septic, see Septic arthritis
  Asakusa group, see *Edwardsiella*
  Atherosclerosis, *Salmonella* and, 87
  Atrophic rhinitis, *Klebsiella*, 120–121
Bacillus typhi, see *Salmonella* serotype Typhi
Bacteremia
  
  *Cedecea*, 357–358
  *Citrobacter*, 185–188
  *Edwardsiella*, 307–308
  *Enterobacter*, 16, 157–160
  *Escherichia coli*, 16, 25–26, 31
  in animals, 24–25
  *Ewingella americana*, 360
  *Hafnia alvei*, 325–326
  *Klebsiella*, 16, 117–120
  *Kluyvera*, 361, 362
  *Leclercia*, 363
  *Leminorella*, 363
  *Morganella morganii*, 263–266
  *Pantoea*, 379
  *Plesiomonas shigelloides*, 341–343
  *Proteus*, 237–238
  *Providencia*, 284–285
Rahnella, 368
Salmonella, 86–87
Serratia, 140–141
Shigella, 68–69
Tatumella, 369
Yersinia, 211–213
Yokenella, 371
Bacteriological Code, 2–3
Bacteriophage typing, Proteus, 247
Bacterium enterocoliticum, see Yersinia enterocolitica
Bacteriuria
Escherichia coli, 31–32
Morganella morganii, 263
Providencia, 292
Bartholemew group, see Edwardsiella
Bergey's Manual of Determinative Bacteriology, 3–4
β-lactamases
Citrobacter, 197
Escherichia coli, 49
increasing incidence of, 19
Proteus, 252
Salmonella, 97
Biliary system infections, see also Cholecystitis
Edwardsiella, 310
Enterobacter, 174
Hafnia alvei, 329
Biochemical tests, 385–393
arginine dihydrolase-variable organisms, 387
Citrobacter, 191–192
Edwardsiella, 311
Escherichia coli, 61–62
Escherichia coli, 43–45
Hafnia alvei, 327–328
hydrogen sulfide-negative organisms, 386, 387
hydrogen sulfide-positive organisms, 386
Klebsiella, 123–124
lysine decarboxylase-positive organisms, 387
lysine decarboxylase-variable organisms, 387
Morganella, 268–270
ornithine decarboxylase-positive organisms, 387
ornithine decarboxylase-variable organisms, 387
Plesiomonas, 347
Proteus, 243–244
Providencia, 289–290
Raoultella, 123
Serratia, 142–143
Shigella, 71–72
Voges-Proskauer-negative organisms, 387
Voges-Proskauer-positive organisms, 387
Yersinia, 219–220
Biotyping
Citrobacter, 192–193
Edwardsiella, 312–313
Enterobacter, 167
Hafnia alvei, 328–329
Klebsiella, 124
Plesiomonas, 347
Providencia, 290
Serratia, 143
Shigella, 72
Yersinia, 220
Black Death, 211
Blood culture
Salmonella serotype Paratyphi, 108
Salmonella serotype Typhi, 108
Blood transfusions, Yersinia infections in, 212–213
BMEC, see Extraintestinal pathogenic Escherichia coli (ExPEC)
Bone marrow culture, Salmonella serotype Typhi, 108
Brain abscess
Citrobacter, 186
Klebsiella, 118, 120
Proteus, 239–240
Salmonella, 87
Brenneria, 377
Buchnera, 380
Budvicia aquatica, 380, 386
Burn infections
Enterobacter, 163
Klebsiella, 118
Providencia, 286
Bursitis, Enterobacter, 164
Buttiauxella, 380–381, 386–388
Calcium regulation, Yersinia, 221, 223
Calymmatobacterium granulomatis, see Klebsiella granulomatis
Candidatus, 12
Capsular polysaccharides, Klebsiella, 125, 127
Carriage
Edwardsiella, 306–307
Escherichia coli
EIEC, 34
STEC, 36
Klebsiella, 119
Salmonella, 86
Salmonella serotype Typhi, 18, 106
Cedecea, 357–359, 387, 388
Cedecea davisae, 357, 388
Cedecea lapagei, 357, 388
Cedecea neteri, 357, 388
Cellular invasion, see Invasins
Cellulitis
Citrobacter, 189
Enterobacter, 163
Plesiomonas, 344
Proteus, 241–242
Yersinia, 217
Central nervous system infections, see also Meningitis
Citrobacter, 184–187
Enterobacter, 160–162
Klebsiella, 120
Proteus, 238–240
Salmonella, 87
Serratia, 141
Cholangitis, Enterobacter, 174
Cholecystitis
Enterobacter, 174
Hafnia alvei, 329
Kluyvera, 361
Leclercia, 363
Moellerella wisconsensis, 364
Plesiomonas, 344

CHROMagar Orientation medium, for Escherichia coli, 38

Citrobacter, 181–203
animal models of, 195
in animals, 18
antimicrobial susceptibility of, 196–198
in bacteremia, 185–188
in central nervous system infections, 184–187
clinical frequency of, 183–184
clinical significance of, 184–189
environmental distribution of, 182–183
epidemiology of, 182–184
in gastrointestinal infections, 185, 189
in nosocomial infections, 16, 183–184
in osteomyelitis, 185
outbreaks of, 183–184
pathogenicity of, 194–196
in polymicrobial infections, 187
in respiratory infections, 185, 189
taxonomy of, 181–182
in urinary tract infections, 185, 188
in wound infections, 185, 188–189

Citrobacter amalonaticus
antibiotic susceptibility of, 196–198
epidemiology of, 182
laboratory identification of, 190–193
taxonomy of, 181

Citrobacter amnigenus, 190

Citrobacter braakii
antibiotic susceptibility of, 197–198
laboratory identification of, 190–193, 388
taxonomy of, 181

Citrobacter diversus, see Citrobacter koseri

Citrobacter farmeri
clinical significance of, 187
laboratory identification of, 191, 193
taxonomy of, 182

Citrobacter freundii
antibiotic susceptibility of, 196–198
clinical significance of, 186, 187–189
epidemiology of, 182–184
laboratory identification of, 189–194, 386–388
pathogenicity of, 194–196
taxonomy of, 181–182

Citrobacter gillenii
laboratory identification of, 192, 388
taxonomy of, 181

Citrobacter koseri
antibiotic susceptibility of, 196–198
clinical significance of, 186–189
epidemiology of, 183–184
laboratory identification of, 189–194
pathogenicity of, 194–195
taxonomy of, 181–182

Citrobacter murliniae
antibiotic susceptibility of, 197
laboratory identification of, 192, 388
taxonomy of, 181

Citrobacter rodentium
epidemiology of, 183
laboratory identification of, 387, 388
pathogenicity of, 194, 196
taxonomy of, 181

Citrobacter sedlakii
clinical significance of, 186
laboratory identification of, 190–192, 388
taxonomy of, 181

Citrobacter werkmanii
antibiotic susceptibility of, 197
laboratory identification of, 388
taxonomy of, 181

CLDT (cytolethal distending toxin), Escherichia coli, 40

CNF (cytotoxic necrotizing factor), Escherichia coli, 37, 41

Cockroach, Escherichia blattae in, see Escherichia blattae

Colibacillosis, in animals, 24–25

Colitis, hemorrhagic, Escherichia coli, 35–36

Colonization, see also Carriage

Enterobacter, 157
Klebsiella, 119

Colonization factor antigens, Escherichia coli, 47–48

Coma, hyperammonemic, in Providencia infections, 284

Contact lens-induced acute red eye, Serratia, 139

Culture
blood
Salmonella serotype Paratyphi, 108
Salmonella serotype Typhi, 108
bone marrow, Salmonella serotype Typhi, 108
stool, see Stool culture

Cystitis
Enterobacter, 163–164
Escherichia coli, 31–32

Cytolethal distending toxin, Escherichia coli, 40

Cytotoxic necrotizing factor, Escherichia coli, 37, 41

Cytotoxins, Serratia, 144

DAEC, see Diffuse-adhering Escherichia coli (DAEC)

Deaminases, Proteus, 250

Deferoxamine, for iron overload, Yersinia infections and, 212

Diabetes mellitus
Citrobacter infections in, 188
Klebsiella infections in, 118

Diarrhea
Citrobacter, 185, 189
Edwardsiella, 304–307
Escherichia coli, 23, 33–37, 47–49, see also DAEC; EIEC; EPEC; ETEC; STEC; specific strains, e.g., EAEC
Hafnia alvei, 324–325
Kluyvera, 361
Leminorella, 363
Moellerella wisconsensis, 364–365
**Morganella morganii**, 266
organisms causing, 17

**Plesiomonas shigelloides**, 338–341

**Proteus**, 240–241

**Providencia**, 285–286

**Salmonella**, 86

**Shigella**, 67–68
traveler’s, 27, 67–68

**Trabulsiella**, 370
in typhoid fever, 106

**Yersinia**, 213–214

**Dienes test**, Proteus, 246

**Diffuse-adhering Escherichia coli (DAEC)**
clinical frequency of, 29
diarrhea in, 36–37
laboratory identification of, 39
pathogenicity of, 49

**DNA analysis**
Proteus, 247
in taxonomic studies, 4, 9

**Donovanosis**, 119

**Dysentery**
*Escherichia coli*, 33–34
*Shigella*, 68

**EAEC**, see **Enteroaggregative Escherichia coli (EAEC)**

**EAST1 (EAEC heat-stable enterotoxin)**, 30–31, 40

**Eberthella**, 4

**Edwardsiella**, 301–319
in animals, 302–303
antimicrobial susceptibility of, 313–315
in bacteremia, 307–308
in biliary infections, 310
biogroups of, 312–313
carriage of, 306–307
clinical significance of, 304–310
epidemiology of, 302–304
in gastroenteritis, 304–307
laboratory identification of, 310–313, 386, 388
in meningitis, 307–308
in nosocomial infections, 303–304
pathogenicity of, 313–315
in peritonitis, 310
taxonomy of, 301–302
in urinary tract infections, 310
in wound infections, 308–310

**Edwardsiella anguillimortiferum**, 301

**Edwardsiella boshinae**
antimicrobial susceptibility of, 315
clinical significance of, 304
laboratory identification of, 311–313, 388
taxonomy of, 302

**Edwardsiella ictaluri**
antimicrobial susceptibility of, 315
clinical significance of, 304
laboratory identification of, 311–313, 387, 388
pathogenicity of, 313–315
taxonomy of, 302

**Edwardsiella tarda**
antimicrobial susceptibility of, 315
clinical significance of, 304–310
epidemiology of, 302–304
laboratory identification of, 311–313, 386, 388
pathogenicity of, 313–315
taxonomy of, 301–302

**EHEC**, see **Shiga toxin-producing/enterohemorrhagic Escherichia coli (STEC/EHEC)**

**EIEC**, see **Enteroinvasive Escherichia coli (EIEC)**

**Elderly persons**, Enterobacteriaceae infections in, 15

**Empyema**
*Citrobacter*, 189
*Morganella morganii*, 267
*Yersinia*, 216

**Encephalopathy**, in typhoid fever, 108

**Endocarditis**
*Cedecea*, 358
*Enterobacter*, 160
*Klebsiella*, 118, 122
*Serratia*, 139
*Yersinia*, 216

**Endophthalmitis**
*Enterobacter*, 174
*Escherichia coli*, 33
*Hafnia alvei*, 329
*Klebsiella*, 121
*Plesiomonas*, 344
*Proteus*, 241
*Serratia*, 142
*Shigella*, 69

**Endosymbionts**, 380

**Endotoxins**, *Plesiomonas*, 350

**Endovascular infections**, *Salmonella*, 87

**Enteric fever**, see also Paratyphoid fever; Typhoid fever
*Edwardsiella*, 306

**Enteritis**, see Gastroenteritis

**Enteroaggregative Escherichia coli (EAEC)**
clinical frequency of, 28, 29
clinical significance of, 36–37
diarrhea in, 36–37
laboratory identification of, 38–41, 44–45
pathogenicity of, 48–49

**Enterobacter**, 151–180
in animals, 154–155
antimicrobial susceptibility of, 170–173
in bacteremia, 16, 157–160
in biliary disease, 164
biogroups of, 166
in central nervous system infections, 160–162
classification issues in, 152–154
clinical frequency of, 155–157
clinical significance of, 157–164
colonization by, 157
in endocarditis, 160
environmental distribution of, 154–155
epidemiology of, 154–157
genomospecies of, 166–167
laboratory identification of, 164–168, 387, 389
in mediastinitis, 163
in meningitis, 160–162
new species, 173
in nosocomial infections, 16, 155–157
in ocular infections, 164
in osteomyelitis, 164
outbreaks of, 155–157
patrogenicity of, 168–170
in plants, 154–155
proposed nomenclature changes for, 152
in respiratory tract infections, 162–163
taxonomy of, 151–154
in urinary tract infections, 163–164
in vulvovaginitis, 164
in wound infections, 163

*Enterobacter aerogenes*
antibiotic susceptibility of, 171–172
clinical significance of, 158–163
epidemiology of, 154, 156
laboratory identification of, 165–167, 389
patrogenicity of, 169
taxonomy of, 151–153

*Enterobacter agglomerans*, 173
epidemiology of, 154–156
laboratory identification of, 165
taxonomy of, 151, 152, 154

*Enterobacter agglomerans (Leclercia adecarboxylata)*, 362–363, 386

*Enterobacter amnigenus*
antibiotic susceptibility of, 171
clinical significance of, 159
laboratory identification of, 165–166, 389
patrogenicity of, 169

taxonomy of, 152, 154

*Enterobacter asburiae*
clinical significance of, 159, 164
epidemiology of, 155
laboratory identification of, 165–166, 389
photonpic description of, 173
taxonomy of, 154

*Enterobacter cancerogenus*
clinical significance of, 159, 163–164
epidemiology of, 154
laboratory identification of, 165, 166, 389
as plant pathogen, 378
taxonomy of, 152

*Enterobacter cloacae*
antibiotic susceptibility of, 171–172
*Citrobacter freundii* related to, 182
clinical significance of, 157–158, 160–164
epidemiology of, 154–156
genomospecies of, 166–167
hybrids of, 173
laboratory identification of, 165–167, 389
patrogenicity of, 168–170
taxonomy of, 151–154

*Enterobacter covanii*
laboratory identification of, 166
taxonomy of, 152

*Enterobacter dissolvens*
hybrids of, 173
laboratory identification of, 389
as plant pathogen, 378
taxonomy of, 154

*Enterobacter gergoviae*
antibiotic susceptibility of, 171
clinical significance of, 160
epidemiology of, 156
laboratory identification of, 165, 167, 389
patrogenicity of, 168, 169

*Enterobacter hafniae*, see *Hafnia alvei*

*Enterobacter hormaechei*, 173
clinical significance of, 160
laboratory identification of, 165, 166, 389
taxonomy of, 154

*Enterobacter intermedius*
antibiotic susceptibility of, 171
clinical significance of, 159, 164
laboratory identification of, 165–166
patrogenicity of, 169
taxonomy of, 152, 154

*Enterobacter kobei*
laboratory identification of, 166
photonpic description of, 173
taxonomy of, 154

*Enterobacter ludwigii*, 173

*Enterobacter nimipressuralis*
laboratory identification of, 389
as plant pathogen, 378
taxonomy of, 152

*Enterobacter pyrinos*
laboratory identification of, 389
taxonomy of, 152

*Enterobacter radicincitans*, 173

*Enterobacter sakazakii*
antibiotic susceptibility of, 171
clinical significance of, 159–161, 164
*Edwardsiella* similarity to, 302
epidemiology of, 155–156
laboratory identification of, 164–167, 389
patrogenicity of, 169–170
taxonomy of, 151, 154

*Enterobacter taylorae*, see *Enterobacter cancerogenus*

*Enterobacteriaceae*
diseases due to, 15–21, see also *specific diseases and organisms*
in bioterrorism, 19
chronic, 17–19
emerging trends in, 17–19
laboratory identification of, 19–20, see also *specific diseases and organisms*
nosocomial, 15–17, see also Nosocomial infections
public health significance of, 19
epidemiology of, 19
history of, 1–5
photonpic features of, 3
taxonomy of, 7–13
current issues in, 12
definition of, 12
evolution of, 1–5, 10–11
genera in, 7–8, 11–12
graphic representation of, 11–12
methods for, 8–10
polyphasic, 10
species concept in, 7–8
Enterobactin, Klebsiella, 125
Enterohemolysin, Escherichia coli, 42
Enteroinvasive Escherichia coli (EIEC)
in bacteremia, 31
carriage of, 34
diarrhea in, 33–34
epidemiology of, 27–30
in food-borne infections, 27–28
laboratory identification of, 38, 41, 44
outbreaks of, 27–28
pathogenicity of, 48
Enteropathogenic Escherichia coli (EPEC), 26–29
atypical, 27
in bacteremia, 31
diarrhea in, 33
epidemiology of, 26–29
laboratory identification of, 38–40, 44–45
in nosocomial infections, 27
pathogenicity of, 47
Enterotoxigenic Escherichia coli (ETEC)
in bacteremia, 31
clinical frequency of, 27, 28, 30
clinical significance of, 34
diarrhea in, 34
in food-borne infections, 30
laboratory identification of, 38, 40–41, 44–45
outbreaks of, 30
pathogenicity of, 47–48
Enterotoxin(s)
EAEC heat-stable, 30–31, 40
Edwardsiella, 314–315
Escherichia coli, 315
Plesiomonas, 348–349
Salmonella, 96
Yersinia, 225
Environment, Klebsiella in, 116–117
Enzyme immunoassays, for Escherichia coli, 42–43
EPEC, see Enteropathogenic Escherichia coli (EPEC)
Epidemiology, see specific organisms
Erwinia
clinical significance of, 378
laboratory identification of, 379–380
taxonomy of, 377
Erwinia aihii, 377
Erwinia amylovora, 377
Erwinia cacticida, 377
Erwinia carotovora, 377
Erwinia chrysanthemi, 377
Erwinia persicina
clinical significance of, 379
taxonomy of, 377
Erwinia salicis, 377
Erythema nodosum, Yersinia, 215–216
Escherichia
laboratory identification of, 387, 389
in nosocomial infections, 16–17
Shigella evolution from, 75
Shigella related to, 65, 71
taxonomy of, 1–4
Escherichia adecarboxylata (Leclercia adecarboxylata), 362–363
Escherichia albertii, 325
antimicrobial susceptibility of, 62–63
clinical significance of, 60, 61
laboratory identification of, 61–62, 389
taxonomy of, 59
Escherichia blattae
clinical significance of, 59–60
epidemiology of, 59–60
laboratory identification of, 61–62, 387, 389
taxonomy of, 59
Escherichia coli, 23–58
adherent-invasive (AIEC), 37
antimicrobial susceptibility of, 49
in bacteremia, 16, 25–26, 31–33
biochemical identification of, 43–46
carriage of, STEC, 36
clinical frequency of, 25–29
clinical significance of, 31–37
commensal, 23–25
diarrheagenic, 23, 33–37, 47–49, see also specific strains
diffuse-adhering, see Diffuse-adhering Escherichia coli (DAEC)
in drinking water, 25, 29, 30
EAST1 (EAEC heat-stable enterotoxin), 30–31
in endophthalmitis, 33
toxinereaggregative, see Enterotoxigenic Escherichia coli (EAEC)
toxinoinvasive, see Enteroinvasive Escherichia coli (EIEC)
toxinopathogenic, see Enteropathogenic Escherichia coli (EPEC)
toxinotoxigenic, see Enterotoxigenic Escherichia coli (ETEC)
environmental distribution of, 23–25
epidemiology of, 23–31
extrainestinal pathogenic, see Extraintestinal pathogenic Escherichia coli (ExPEC)
in food-borne infections, 25, 27, 29
in gastroenteritis, 23, 33–37, 47–49
isolation of, 37–43
laboratory identification of, 37–46, 389, 392
in meningitis, 26, 32
in nosocomial infections, 16, 25–26, 29–31
O157:H7
antibodies to, 43
clinical frequency of, 27, 29
clinical significance of, 34–38
in food-borne infections, 30
infectious dose of, 30, 35
laboratory identification of, 38, 41–46
outbreaks of, 30
outbreaks of, 29–31
pathogenicity of, 46–49
in peritonitis, 32
in pneumonia, 26
resident population of, 23–24
in respiratory tract infections, 32
Salmonella related to, 82
serotypes of, 45–46
Shiga-toxin producing, see Shiga toxin-producing/
enterohemorrhagic Escherichia coli (STEC/EHEC)
taxonomy of, 1–4, 23
toxins of, 40–41, 47–49
transient population of, 23–24
in urinary tract infections, 25–26, 31–32, 46–47
viable but nonculturable, 25
Escherichia coli ADO (Alkalescens-Dispar organisms), 65
Escherichia fergusonii
antimicrobial susceptibility of, 62
clinical significance of, 60–61
laboratory identification of, 61–62, 389
taxonomy of, 59
Escherichia bermannii
antimicrobial susceptibility of, 62
clinical significance of, 60
epidemiology of, 60
laboratory identification of, 61–62, 389
taxonomy of, 59
Escherichia vulneris
antimicrobial susceptibility of, 62
clinical significance of, 60–61
epidemiology of, 60
laboratory identification of, 61–62, 389
taxonomy of, 59
ETEC, see Enterotoxigenic Escherichia coli (ETEC)
Ewingella americana, 359–360, 386, 387
ExPEC, see Extraintestinal pathogenic Escherichia coli
(ExPEC)
Extended-spectrum β-lactamases
increasing incidence of, 19
Salmonella, 97
Extraintestinal pathogenic Escherichia coli (ExPEC), 23
clinical frequency of, 25–26
epidemiology of, 25–26, 29
laboratory identification of, 37–38
pathogenicity of, 46–47
Eye infections, see also Endophthalmitis
Enterobacter, 164
Hafnia alvei, 329
Morganella morganii, 267
Plesiomonas, 344
Serratia, 139
Fimbriae
Escherichia coli, 47
Hafnia alvei, 330
Klebsiella, 126
Proteus, 249
Salmonella, 96
Serratia, 145
Flagellae
Proteus, 242, 248
Tatumella, 369
Fluorescent actin stain, for Escherichia coli, 39–40
Folliculitis, Citrobacter, 189
Food-borne infections, 19
Escherichia coli, 25
EIEC, 27–28
ETEC, 30
STEC, 27, 29, 30
Plesiomonas shigelloides, 337–338
Proteus, 235
Providencia, 282
Salmonella, 83–86
Serratia, 138
Shigella, 67
Yersinia, 208–210
Francisella philomiragia (now Yersinia philomiragia), 206
Gallbladder infections, see Cholecystitis
Gangrene, Proteus, 240
Gastroenteritis
Citrobacter, 185, 189
Edwardsiella, 304–307
food-borne, see Food-borne infections
Hafnia alvei, 324–325
Klebsiella, 121–122
Klebsiella, 361
Moellerella wisconsensis, 364–365
Morganella morganii, 266
organisms causing, 17
Plesiomonas shigelloides, 338–341
Proteus, 240–241
Providencia, 285–286, 292–293
Salmonella, 86, 305
Shigella, 68
Yersinia, 213–214
Gel electrophoresis, Enterobacter, 167
Granuloma inguinale, Klebsiella, 122
H test, for typhoid fever, 110
Hafnia alvei, 321–333
in animals, 322–323
antimicrobial susceptibility of, 330
biotypes of, 328–329
clinical significance of, 323–326
clusters of, 330–331
epidemiology of, 322–323
in eye infections, 329
genomospecies of, 328–329
laboratory identification of, 327–329, 387
pathogenicity of, 329–330
in peritonitis, 329
taxonomy of, 321–322
transfer from Enterobacter, 151
in urinary tract infections, 326
in wound infections, 326
Hamburgers, Escherichia coli in, 27, 29
Heat-labile enterotoxin, Escherichia coli, 40, 47
Heat-stable enterotoxin, Escherichia coli, 40, 47
Hemagglutinins
mannose-sensitive, Enterobacter, 168
Proteus, 249
Heme uptake, Plesiomonas, 350
Hemochromatosis, Yersinia infections in, 212
### Hemolysins
- **Edwardsiella**, 313–314
- **Enterobacter**, 169
- **Escherichia coli**, 42
- **Morganella morganii**, 272
- **Plesiomonas**, 350
- **Proteus**, 248–249
- **Serratia**, 144

### Hemolytic-uremic syndrome
- **Escherichia coli**, 36
- **Shigella**, 69

### Hemorrhagic colitis
- **Escherichia coli**, 35–36

### History, of Enterobacteriaceae
- 1–5

### Human immunodeficiency virus infection
- with **Klebsiella**, 118
- **Morganella morganii**, 267
- **Salmonella**, 86–87
- **Shigella**, 67

### Hyperammonemic coma
- in **Providencia** infections, 284

### Ileitis
- **Yersinia**, 214

### Immunooassays
- **Salmonella** serotype Paratyphi, 109–110
- **Salmonella** serotype Typhi, 109–110

### Immunodiagnostic tests
- **Citrobacter**, 193
- **Edwardsiella**, 313
- **Enterobacter**, 167
- **Escherichia coli**, 45–46
- **Hafnia alvei**, 329
- **Klebsiella**, 124–125
- **Morganella morganii**, 271
- **Plesiomonas**, 347–348
- **Proteus**, 245–246
- **Providencia**, 291
- **Salmonella**, 91–92
- **Salmonella** serotype Paratyphi, 110
- **Salmonella** serotype Typhi, 110
- **Serratia**, 143–144
- **Shigella**, 72–73
- **Yersinia**, 220

### Immunoglobulin M
- O157:H7, 43

### Immunomagnetic separation
- for **Escherichia coli**, 42

### Indole test
- **Proteus**, 244

### Intestine, hemorrhage of
- in typhoid fever, 107–108

### Inv protein
- **Yersinia**, 222

### Invasins
- **Citrobacter**, 196
- **Edwardsiella**, 313
- **Enterobacter**, 169
- **Plesiomonas**, 348
- **Proteus**, 249
- **Yersinia**, 222

### Invasion assay
- for **Escherichia coli**, 41

### Invasion plasmid
- **Shigella**, 74

### Iron
- see also Siderophores
- **Plesiomonas** infections and, 349–350
- **Yersinia** infections and, 211–212, 221–222

### K antigens
- **Klebsiella**, 125

### Kawasaki syndrome
- **Yersinia** infections in, 214

### Keratitis
- **Shigella**, 69

### Kidney infections
- **Enterobacter**, 163–164

### Klebsiella
- 115–116
  - antimicrobial susceptibility of, 128–129
  - in bacteremia, 16, 117–120
  - biochemical detection of, 123–124
  - carriage of, 119
  - in central nervous system infections, 120
  - clinical frequency of, 117–118
  - clinical significance of, 119–122
  - colonization by, 119
  - environmental distribution of, 116–117
  - epidemiology of, 116–119
  - in gastroenteritis, 121–122
  - genera closely related to, 152
  - isolation of, 123
  - laboratory identification of, 123–125, 389
  - in liver abscess, 121
  - in nosocomial infections, 16–17, 118–119
  - outbreaks of, 118–119
  - pathogenicity of, 125–128
    - vs. **Raoultella**, 389, 390
  - in respiratory infections, 120–121
  - taxonomy of, 8, 115–116
  - typing of, 125
  - in unusual infections, 122
  - in urinary tract infections, 121

### Klebsiella aerogenes
- 115

### Klebsiella edwardsiella
- 115

### Klebsiella granulomatis
- clinical frequency of, 119
- in donovanosis, 122
- laboratory identification of, 122

### Klebsiella mobilis
- 115

### Klebsiella ornithinolytica
- 115

### Klebsiella oxytoca
- antibiotic susceptibility of, 128
- in colitis, 122
- epidemiology of, 116–118
- laboratory identification of, 122–123, 389
- taxonomy of, 115–116

### Klebsiella ozaenae
- antibiotic susceptibility of, 129
- bacteremia, 120
- in central nervous system infections, 120
- epidemiology of, 117
- laboratory identification of, 124, 387, 389
- in respiratory infections, 120–121
- taxonomy of, 115
- in urinary tract infections, 121

### Klebsiella planticola
- 115

### Klebsiella pneumoniae
- in abscesses, 122
- antibiotic susceptibility of, 128
- in bacteremia, 120
- in central nervous system infections, 120
- **Citrobacter freundii** related to, 182
- epidemiology of, 116–118
in gastrointestinal infections, 121–122
laboratory identification of, 122–123, 387, 389, 390
in metastatic infections, 121
pathogenicity of, 127
in respiratory infections, 120
in septic arthritis, 122
taxonomy of, 115, 153
Klebsiella rhinoscleromatis
antibiotic susceptibility of, 129
clinical frequency of, 119
laboratory identification of, 122–123, 387, 389, 390
in metastatic infections, 121
pathogenicity of, 127
in respiratory infections, 120
in septic arthritis, 122
taxonomy of, 115, 153
Klebsiella singaporensis
laboratory identification of, 122, 389
taxonomy of, 115
Klebsiella terrigena, Citrobacter freundii related to, 182
Klebsiella trevisanii, 115
Klebsiella variicola
epidemiology of, 116–117
laboratory identification of, 122
taxonomy of, 115
Kluyvera, 360–362
Citrobacter related to, 182
laboratory identification of, 387, 390
Kluyvera ascorbata, 361–362, 390
Kluyvera citrophila, 360–361
Kluyvera cochleae, 361–362
Kluyvera georgiana, 361–362, 390
Kluyvera intermedia, 154, 361–362, 390
Kluyvera noncitrophila, 360–361
Koserella trabulsii (Yokenella regensburgei), 370–371
KW schema, for Salmonella antigens, 91–92

Laboratory identification, Enterobacteriaceae, 19–20, see also specific diseases and organisms
Lactose fermentation, in classification schemes, 1–2
LCR regulon, Yersinia, 221, 223
LcrV protein, Yersinia, 223
Leclercia, 363
Leclercia adecarboxylata, 362–363, 386
Lemilinella, 363–364, 386, 390
Lemilinella grimontii, 363, 390
Lemilinella richardii, 363, 390
Lipopolysaccharides, Klebsiella, 125, 127
Liver abscess
Edwardsiella, 310
Klebsiella, 121
Yersinia, 217
Low calcium response, Yersinia, 221, 223
Luminescence, Photorhabdus, 366
Lymphadenitis
mesenteric, Salmonella, 88
Plesiomonas, 344
Yersinia, 210, 214, 217
Mediastinitis
Citrobacter, 189
Enterobacter, 163
Meningitis
Citrobacter, 185–187
Edwardsiella, 307–308
Enterobacter, 160–162
Escherichia coli, 26, 32
Klebsiella, 117–118, 120, 121
Plesiomonas shigelloides, 341, 343
Proteus, 238–240
Salmonella, 87
Serratia, 141
Shigella, 69
Meningitis-associated Escherichia coli, see Extraintestinal pathogenic Escherichia coli (ExPEC)
Mesenteric lymphadenitis, Salmonella, 88
Metalloproteases, Serratia, 144
MNEC, see Extraintestinal pathogenic Escherichia coli (ExPEC)
Moellerella wisconsinensis, 364–365, 386
Molecular probes, in taxonomic studies, 9–10
Morganella morgani, 261–277
in animals, 262
antimicrobial susceptibility of, 273
in bacteremia, 263–266
biogroups of, 270
clinical significance of, 263–267
in empyema, 267
epidemiology of, 262–263
in eye infections, 267
in gastroenteritis, 266
laboratory identification of, 267–272, 387, 391
pathogenicity of, 272
in pericarditis, 267
vs. Proteus, 391
in septic arthritis, 266
subspecies of, 261–262, 270
taxonomy of, 261–262
in urinary tract infections, 263, 272
in wound infections, 266–267
Muscle abscess
Enterobacter, 163
Salmonella, 87–88
Mycotic aneurysms, Yersinia, 216
Myonecrosis, Klebsiella, 122
Nails, Proteus infections of, 240
Necrotizing enterocolitis, Klebsiella, 121–122
Necrotizing fasciitis, Klebsiella, 122
Neonates, infections in
Citrobacter, 183–184, 186–187
Edwardsiella, 307, 308
Enterobacter, 156, 160, 161
Klebsiella, 119
Morganella morganii, 264–266
Plesiomonas, 343
Proteus, 238–239
Neurologic disorders, in shigellosis, 69
Nosocomial infections, 15–17
Cedecea, 358
Citrobacter, 183–184
Edwardsiella, 303–304
Enterobacter, 16, 155–157
epidemiology of, 16–17
Escherichia, 16–17
Escherichia coli, 29–31

O antigens, Klebsiella, 125
O test, for typhoid fever, 109–110
O157:H7, see Escherichia coli, O157:H7

Oligonucleotide probes
for Enterobacter, 166
in taxonomic studies, 9–10

Outbreaks
Citrobacter, 183–184
Edwardsiella, 303–304
Enterobacter, 155–156
Escherichia coli, 29–31
EIEC, 27–28
Hafnia alvei, 323
Klebsiella, 118–119
Morganella morganii, 262–263
Plesiomonas shigelloides, 337–338
Proteus, 235
Providencia, 281–282
Rahnella, 368
Salmonella, nontyphoidal, 85–86
Serratia, 139–140
Yersinia, 210–211

Pancreatic abscess
Escherichia coli, 32
Plesiomonas, 344

Pandemics, Shigella infections, 67
Pantoea
clinical significance of, 378
genera closely related to, 152
laboratory identification of, 379–380, 386
taxonomy of, 378
Pantoea agglomerans
biotypes of, 380
clinical significance of, 378–379
laboratory identification of, 379–380, 387, 389
Pantoea ananatis, 379–380
Pantoea dispersa, 379–380
Paracolon bacteria, 1–2, 279
Paratyphoid fever
clinical significance of, 106–108
epidemiology of, 105–106
organism causing, see Salmonella serotype Paratyphi
Pasturella rodentium, see Yersinia pseudotuberculosis

Pathogenicity islands
Citrobacter, 196
Enterobacter, 169
Salmonella, 93, 95

Phenotypic methods
for Enterobacteriaceae, 8
for Escherichia coli, 41–44

Phenylalanine, deamination of, 269
Morganella morganii, 262–263
Plesiomonas shigelloides, 337–338
Proteus, 235
Providencia, 281–282
Salmonella, nontyphoidal, 84–86
Salmonella serotype Typhi, 106
Serratia, 139–140
Shigella, 67–68
Yersinia, 210–211

Photorhabdus, 365–367, 386, 390
Photorhabdus asymbiotica, 365–366, 390
Photorhabdus luminescens, 365–366, 390
Photorhabdus temperata, 365–366
Phytopathogens, 377–379
Plague, see also Yersinia pestis
antibiotics for, 225

Peritonitis
Edwardsiella, 310
Ewingella americana, 360
Klebsiella, 122
Leminorella, 363
Plesiomonas, 344
Shigella, 68

Phytopathogens, 377–379
Photorhabdus, 365–367
Photorhabdus asymbiotica, 365–366
Photorhabdus luminescens, 365–366
Photorhabdus temperata, 365–366
Phytopathogens, 377–379
Plague, see also Yersinia pestis
antibiotics for, 225

Pericarditis
Morganella morganii, 267
Yersinia, 216

Peritonitis
Edwardsiella, 310
Ewingella americana, 360
Klebsiella, 122
Leminorella, 363
Plesiomonas, 344
Shigella, 68

Pharyngitis, Yersinia, 216

Pectobacterium, 377
Pediatric patients, see also Neonates
infections in
Enterobacter, 159–161
Escherichia coli, 31
nosocomial, 16
Plesiomonas, 343
Proteus, 238–239
typhoid fever, 106

Pectobacterium, 377
Pediatric patients, see also Neonates
infections in
Enterobacter, 159–161
Escherichia coli, 31
nosocomial, 16
Plesiomonas, 343
Proteus, 238–239
typhoid fever, 106

Phytopathogens, 377–379
Photorhabdus, 365–367
Photorhabdus asymbiotica, 365–366
Photorhabdus luminescens, 365–366
Photorhabdus temperata, 365–366
Phytopathogens, 377–379
Plague, see also Yersinia pestis
antibiotics for, 225

Phloroglucinolase, 362
Photorhabdus, 365–367
Photorhabdus asymbiotica, 365–366
Photorhabdus luminescens, 365–366
Photorhabdus temperata, 365–366
Phytopathogens, 377–379
Plague, see also Yersinia pestis
antibiotics for, 225

Photorhabdus, 365–367, 386, 390
Photorhabdus asymbiotica, 365–366, 390
Photorhabdus luminescens, 365–366, 390
Photorhabdus temperata, 365–366
Phytopathogens, 377–379
Plague, see also Yersinia pestis
antibiotics for, 225
bacteremia in, 213
bubonic, 211
clinical features of, 215
epidemiology of, 208, 210–211
laboratory tests in, 218–220
outbreaks of, 210–211
pandemics of, 210–211
pathogenesis of, 215, 221, 223–225
pneumonic, 211, 215, 216
transmission of, 208, 210–211, 215

Plants
Brenneria in, 377
Enterobacter cancerogenus in, 378
Enterobacter dissolvens in, 378
Enterobacter in, 154–155
Enterobacter nimipressuralis in, 378
Erwinia in, 377–378
Pantoea in, 377–379
Pectobacterium in, 377
Rahnella in, 368
Serratia in, 138

Plasmid analysis
Citrobacter, 194
Enterobacter, 167
Salmonella, 93

Plasminogen activator, Yersinia, 223–225
Plesiomonas shigelloides, 335–356
in animals, 336–337
antimicrobial susceptibility of, 350–351
in bacteremia, 341–343
biotypes of, 347
clinical frequency of, 337–338
clinical significance of, 338–344
epidemiology of, 336–338
in eye infections, 344
in fatal infections, 341
in gastroenteritis, 338–341
in intra-abdominal infections, 344
laboratory identification of, 344–348, 387, 390
in meningitis, 341, 343
in nosocomial infections, 337–338
outbreaks of, 337–338
pathogenicity of, 348–350
in salpingitis, 344
taxonomy of, 335–336
typing of, 348
in wound infections, 344

Pneumonia
Enterobacter, 162
Escherichia coli, 26, 32
Hafnia alvei, 189
Klebsiella, 117, 118
Leclercia, 363
Pantoea, 379
Providencia, 286
Serratia, 141–142
Shigella, 69
Yersinia, 216

Polymerase chain reaction
for Morganella morganii, 271
for Salmonella serotype Typhi, 110
Polyphasic taxonomy, 10
Pragia, 381
Pragia fontium, 386
Premature infants
Enterobacter bacteremia in, 160
Enterobacter meningitis in, 160–161
Proctitis, Plesiomonas shigelloides, 341
Proteases, Proteus, 249–250
Proteus, 233–259
in animals, 234–235
antimicrobial susceptibility of, 250–253
in bacteremia, 237–238
in central nervous system infections, 238–240
clinical frequency of, 235
clinical significance of, 236–242
in endophthalmitis, 241
epidemiology of, 234–235
in gastroenteritis, 240–241
genomospecies of, 234, 244–245
laboratory identification of, 242–247, 386, 387, 391
vs. Morganella, 391
in nosocomial infections, 235
outbreaks of, 235
pathogenicity of, 247–250
in rheumatic disorders, 241
swarming capacity of, 242, 248
taxonomy of, 233–234
in urinary tract infections, 235–237
in wound infections, 240
Proteus hauseri
laboratory identification of, 245
taxonomy of, 234
Proteus inconstans, 280
Proteus mirabilis
antibiotic susceptibility of, 251–253
clinical significance of, 236–242
epidemiology of, 234–235
laboratory identification of, 242–247, 391
pathogenicity of, 247–250
taxonomy of, 233
Proteus morganii, see Morganella morganii
Proteus myxofaciens
laboratory identification of, 391
pathogenicity of, 250
taxonomy of, 233
Proteus penneri
antibiotic susceptibility of, 251, 253
clinical significance of, 237–238, 240–241
epidemiology of, 235
laboratory identification of, 242–247, 250, 391
pathogenicity of, 248
taxonomy of, 233
Proteus rettgeri, see Providencia rettgeri
Proteus vulgaris
antibiotic susceptibility of, 251–253
clinical significance of, 237–238, 240–241
epidemiology of, 234–235
laboratory identification of, 242–247, 391
pathogenicity of, 248–249
taxonomy of, 233–234
Providencia, 279–299
in animals, 280–281
antimicrobial susceptibility of, 293–295
in bacteremia, 284–285
biogroups of, 290
clinical frequency of, 281–282
clinical significance of, 282–286
environmental distribution of, 280–281
epidemiology of, 280–282
in gastroenteritis, 285–286, 292–293
laboratory identification of, 286–291, 386, 391
in nosocomial infections, 281–282
outbreaks of, 281–282
pathogenicity of, 292–293
in respiratory infections, 286
taxonomy of, 279–280
in urinary tract infections, 282–284, 292
in wound infections, 286
Providencia alcalifaciens
antimicrobial susceptibility of, 293–294
clinical significance of, 285
epidemiology of, 280–282
laboratory identification of, 287–291, 391
pathogenicity of, 292–293
taxonomy of, 279–280
Providencia friedericiana, 280
Providencia hembachae
clinical significance of, 286
laboratory identification of, 289, 391
taxonomy of, 280
Providencia rettgeri
antimicrobial susceptibility of, 293–294
clinical significance of, 284
epidemiology of, 280–281
laboratory identification of, 286–291, 391
pathogenicity of, 292–293
taxonomy of, 233, 279–280
Providencia rustigianii
antimicrobial susceptibility of, 293–294
laboratory identification of, 287–290, 391
taxonomy of, 280
Providencia stuartii
antimicrobial susceptibility of, 293–295
clinical significance of, 283–284
epidemiology of, 280–282, 286
laboratory identification of, 286–291, 391
pathogenicity of, 292
taxonomy of, 279–280
Pseudopseudodendritis
Plesiomonas, 344
Yersinia, 214
Pseudomonas shigelloides, 335
Psosas muscle abscess, Klebsiella, 122
Public health significance, of Enterobacteriaceae, 19
Purple urine bag syndrome, in Providencia
infections, 284
Pyelonephritis
Enterobacter, 163–164
Escherichia coli, 31–32
Pyomyositis
Klebsiella, 122
Morganella morganii, 267
Yersinia, 217
Rahn, Otto, 2–3
Rabellera, 367–369, 386, 387
Random amplified polymorphic DNA analysis, Proteus, 247
Raoultella
epidemiology of, 116–117
vs. Klebsiella, 389, 390
laboratory identification of, 123–124, 389, 390
taxonomy of, 115–116
Raoultella ornithinolytica
antibiotic susceptibility of, 129
clinical frequency of, 117
laboratory identification of, 124, 389
Raoultella planticola
antibiotic susceptibility of, 129
in bacteremia, 120
clinical frequency of, 117
laboratory identification of, 389, 390
in urinary tract infections, 121
Reactive arthritis, 18
Salmonella, 88
Shigella, 69
Yersinia enterocolitica, 18, 215
Red slant, Providencia, 289
Reiter's syndrome, 18, 88
Resistance, to antibiotics, see specific organisms,
antibiotic susceptibility of
Respiratory tract infections, see also Pneumonia
Citrobacter, 185, 189
Enterobacter, 162–163
Escherichia coli, 32
Hafnia alvei, 189
Providencia, 286
Serratia, 141–142
Yersinia, 216
Retropharyngeal abscess, Enterobacter, 162–163
Rettgerella, 279
Rheumatoid arthritis, 18, 241
Rhinitis, atrophic, Klebsiella, 120–121
Rhinoscleroma, Klebsiella, 119–121
Ribotyping, Salmonella, 93
Rose spots, in typhoid fever, 107, 109
rRNA, 16S, in taxonomic studies, 9
Salmonella
 carriage of, 86
vs. Citrobacter, 191, 193
Escherichia coli related to, 82
Downloaded from www.asmscience.org by
IP: 54.70.40.11
On: Thu, 23 May 2019 10:35:47
in food-borne infections, 19, 83–86
in gastroenteritis, 305
laboratory identification of, 391, 392
nontyphoidal, 81–103
in abscesses, 87–88
in animals, 82–84
antimicrobial susceptibility of, 85, 96–97
atherosclerosis and, 87
in bacteremia, 86–87
in central nervous system infections, 87
clinical frequency of, 84
clinical significance of, 86–88
in endovascular infections, 87
environmental distribution of, 83–84
epidemiology of, 82–86
in gastroenteritis, 86
infective dose of, 85
laboratory identification of, 88–93, 386, 387, 391, 392
in mesenteric lymphadenitis, 88
new species of, 97
in osteomyelitis, 88
outbreaks of, 84–86
pathogenicity of, 93–96
in reactive arthritis, 88
serotypes of, 82
subspecies of, 81–82
taxonomy, 81–82
in urinary tract infections, 87
vs. Trabulsiella, 370
Salmonella choleraesuis, see Salmonella, nontyphoidal
Salmonella enterica, see Salmonella, nontyphoidal
Salmonella enterica serotype Typhi, 386
Salmonella serotype Paratyphi
antimicrobial resistance in, 111–112
clinical significance of, 106–108
epidemiology of, 105
laboratory identification of, 108–111, 391
pathogenicity of, 111
1-tartrate-positive variant of, 105
taxonomy of, 105
Salmonella serotype Typhi
antimicrobial resistance in, 111–112
 carriage of, 18, 106
clinical significance of, 106–108
epidemiology of, 105–106
infective dose of, 106
laboratory identification of, 108–111, 391
pathogenicity of, 111
taxonomy of, 105
vaccines for, 111–112
Salpingitis, Plesiomonas, 344
Samsonia, 377
Scombroid poisoning, 235, 262
Scrotal abscess, Cedecea, 357
Sepsis
Citrobacter, 185–188
Edwardsiella, 307–308
Escherichia coli, 31
Hafnia alvei, 325–326
Morganella morganii, 264–266
Plesiomonas shigelloides, 341–343
Proteus, 237–238
Providencia, 284–285
Salmonella, 86
Tatumella, 369
Yersinia, 211–213
Septic arthritis
Klebsiella, 122
Morganella morganii, 266
Pantoea, 378–379
Yersinia enterocolitica, 215
Yokenella, 371
Serotyping, see Immunodiagnostics
Serratia, 137–150
in animals, 138–139
antimicrobial susceptibility of, 145–146
in bacteremia, 140–141
in central nervous system infections, 141
clinical frequency of, 139
clinical significance of, 140–142
environmental distribution of, 138–139
epidemiology of, 138–140
in food-borne infections, 138
Hafnia alvei similar to, 322
laboratory identification of, 142–144, 387, 396, 392
in musculoskeletal infections, 142
in nosocomial infections, 139–140
outbreaks of, 139–140
pathogenicity of, 144–145
in respiratory infections, 141–142
taxonomy of, 137–138
Serratia entomaphila
epidemiology of, 139
laboratory identification of, 143, 392
taxonomy of, 137
Serratia ficaria
clinical significance of, 142
epidemiology of, 138–139
laboratory identification of, 144, 392
taxonomy of, 137
Serratia fonticola
clinical significance of, 142
epidemiology of, 138–140
laboratory identification of, 142–143, 392
taxonomy of, 137
Serratia grimesii
clinical significance of, 142
epidemiology of, 138–130
laboratory identification of, 142–143, 392
taxonomy of, 137
Serratia liquefaciens
clinical significance of, 141
epidemiology of, 138–139
laboratory identification of, 142–143, 392
taxonomy of, 137
Serratia marcescens
antimicrobial susceptibility of, 145–146
clinical significance of, 140–142
discovery of, 1
epidemiology of, 138–140
laboratory identification of, 142–144, 392
pathogenicity of, 144–145
taxonomy of, 137–138

_Serratia odorifera_
clinical significance of, 141
epidemiology of, 139
laboratory identification of, 142, 392
taxonomy of, 137

_Serratia plymuthica_
clinical significance of, 141–142
epidemiology of, 138–139
laboratory identification of, 142–143, 392
taxonomy of, 137

_Serratia proteamaculans_
clinical significance of, 141
epidemiology of, 138–139
laboratory identification of, 142–143
taxonomy of, 137

_Shigella alkalescens_, 65
_Shigella boydii_
antimicrobial susceptibility of, 76
in bacteremia, 69
clinical frequency of, 66–67
laboratory identification of, 70–73
in meningitis, 69
in osteomyelitis, 69
outbreaks of, 68
pathogenicity of, 73
vs. _Plesiomonas_, 337–338
taxonomy of, 65

_Shigella dysenteriae_
antimicrobial susceptibility of, 76
clinical frequency of, 65–66
clinical significance of, 67
in gastroenteritis, 67
in hemolytic uremic syndrome, 69
laboratory identification of, 70–73
outbreaks of, 66–67
pathogenicity of, 73–75
taxonomy of, 65

_Shigella flexneri_
antimicrobial susceptibility of, 76
in bacteremia, 68–69
clinical frequency of, 66
clinical significance of, 68–69
in gastroenteritis, 68
laboratory identification of, 70–73
outbreaks of, 68
pathogenicity of, 73–74
in reactive arthritis, 18
taxonomy of, 65

_Shigella sonnei_
antimicrobial susceptibility of, 76
clinical frequency of, 66–67
in bacteremia, 68–69
laboratory identification of, 70–73
pathogenicity of, 73
vs. _Plesiomonas_, 335, 337–338
taxonomy of, 65

_Shr proteins, Serratia_, 144
_Shock, in Escherichia coli bacteremia_, 31

_Siderophores_
_Enterobacter_, 168–169
_Hafnia alvei_, 330
_Klebsiella_, 126–127
_Serratia_, 144–145
_Yersinia_, 222

_Skin abscess, Proteus_, 240
_Slime, Edwardsiella_, 315
_Sodalis_, 380

_Soil, Escherichia coli in_, 25
_Sorbitol-MacConkey agar, for Escherichia coli_, 41–42
_STEC, see Shiga toxin-producing/enterohemorrhagic Escherichia coli (STEC/EHEC)_

_Stool culture_
_Salmonella_, 88–89
_Salmonella serotype Paratyphi_, 109
_Salmonella serotype Typhi_, 109
_Shigella_, 70
_Yersinia_, 217–218

_Surgical infections_
_Morganella morganii_, 266–267
_Providencia_, 286

_Susceptibility, antimicrobial, see specific organisms_

_Swarming capacity_
_Protens_, 242, 248
Providencia, 286–287
Swimmer cells, Proteus, 248
Tatumella ptyseos, 369–370, 386
Taxonomy, see specific organisms
Thrombotic thrombocytopenic purpura, *Escherichia coli*, 36
Tissue cell assay, for *Escherichia coli*, 42
Toxic megacolon, in shigellosis, 68
Toxins
- *Citrobacter*, 195–196
- in colibacillosis, 24–25
- *Enterobacter*, 168–170
- *Escherichia coli*, 40–41, 47–49, see also Enterotoxigenic *Escherichia coli* (ETEC); Shiga-toxin-producing/enterohemorrhagic *Escherichia coli* (STEC/EHEC)
- *Klebsiella*, 127–128
- *Photorhabdus*, 366
- *Plesiomonas*, 348–349
- *Trabulsiella guamensis*, 370
  - *Edwardsiella* similarity to, 302
  - laboratory identification of, 386
- Transcytosis, *Yersinia*, 222–223
- Transusions, *Yersinia* infections due to, 212–213
- Trauma, *Edwardsiella* infections in, 308–309
- Traveler's diarrhea
  - *Escherichia coli*, 27
  - *Shigella*, 67–68
- TUBES test, for typhoid fever, 110
- Tubo-ovarian abscess, *Edwardsiella*, 310
- Typhoid fever
  - chronic, 18, 106
  - clinical significance of, 106–108
  - epidemiology of, 105–106
  - natural history of, 107
  - organism causing, see *Salmonella* serotype Typhi
  - relapse in, 108
  - vaccines for, 111–112
- Typing
  - *Citrobacter*, 194
  - *Enterobacter*, 167–168
  - *Escherichia coli*, 46
  - *Hafnia alvei*, 329
  - *Klebsiella*, 125
  - *Morganella morganii*, 271–272
  - *Plesiomonas*, 348
  - *Proteus*, 246–247
  - *Providencia*, 291
  - *Salmonella*, 92–93
  - *Salmonella* serotype Typhi, 110–111
  - *Shigella*, 73
  - *Yersinia*, 220
- UPEC, see Extraintestinal pathogenic *Escherichia coli* (ExPEC)
- Urease
  - *Morganella morganii*, 272
  - *Proteus*, 247–248
- Urinary tract infections
  - *Buttiauxella gaviniae*, 381
  - *Citrobacter*, 185, 188
  - *Edwardsiella*, 310
  - *Enterobacter*, 163–164
  - *Hafnia alvei*, 326
  - *Klebsiella*, 117–118, 121
  - *Kluyvera*, 361, 362
  - *Leminorella*, 363
  - *Morganella morganii*, 263, 272
  - *Proteus*, 235–237
  - *Providencia*, 282–284, 292
  - *Rahnella*, 368
  - *Salmonella*, 87
  - *Shigella*, 69
  - *Yersinia*, 217
- Uropathogenic *Escherichia coli*, see Extraintestinal pathogenic *Escherichia coli* (ExPEC)
- Vaccines
  - *Salmonella* serotype Typhi, 111–112
  - *Shigella*, 76
- Vascular permeability factor, *Proteus*, 250
- Vero cell assay, for *Escherichia coli*, 42
- Verocytotoxigenic *Escherichia coli*, see Shiga toxin-producing/enterohemorrhagic *Escherichia coli* (STEC/EHEC)
- Vertebral osteomyelitis, *Enterobacter*, 164
- *Vibrio*, laboratory identification of, 390
- Virulence factors
  - *Citrobacter*, 194–196
  - *Edwardsiella*, 313–315
  - *Enterobacter*, 168–170
  - *Escherichia coli*, 46–49
  - *Hafnia alvei*, 329–330
  - *Klebsiella*, 125–128
  - *Morganella morganii*, 272
  - *Plesiomonas*, 348–350
  - *Proteus*, 247–250
  - *Providencia*, 292–293
  - *Salmonella*, 93–96
  - *Serratia*, 144–145
  - *Shigella*, 73–75
  - *Yersinia*, 221–225
- Virulence plasmids
  - *Salmonella*, 93–95
  - *Shigella*, 74
- VITEK system, for *Citrobacter*, 190–191
- VTEC, see Shiga toxin-producing/enterohemorrhagic *Escherichia coli* (STEC/EHEC)
- Vulvovaginitis
  - *Enterobacter*, 164
  - *Shigella*, 69
- Water
  - *Budvicia aquatica* in, 380
  - *Edwardsiella* in, 302–303
  - *Escherichia coli* in, 25, 29, 30
  - *Ewingella americana* in, 359–360
Hafnia alvei in, 322–323
Plesiomonas shigelloides in, 336
Praga in, 381
Rahnella in, 368
Serratia in, 138
Shigella in, 67
Yersinia in, 207–208

Widal test, for typhoid fever, 109
Wigglesworthia, 380

Wound infections
Citrobacter, 185, 188–189
Enterobacter, 163
Ewingella americana, 360
Hafnia alvei, 326
Kluyvera, 362
Leclercia, 363
Morganella morganii, 266–267
Photorhabdus, 366–367
Plesiomonas, 344
Proteus, 240
Providencia, 286
Rahnella, 368
Serratia, 142
Yersinia, 217

Xenorhabdus, 381, 386
Xenorhabdus luminescens (Photorhabdus), 365–367

YadA protein, Yersinia, 222–224
Yersinia, 205–232
in animals, 207–211, 215, see also Plague
antimicrobial susceptibility of, 225
in arthritis, 215
in bacteremia, 211–213
in chronic illness, 217
clinical frequency of, 209–210
clinical significance of, 211–217
in endocarditis, 216
environmental distribution of, 207–209
epidemiology of, 207–211
in erythema nodosum, 215–216
in gastroenteritis, 213–214
laboratory identification of, 217–220, 386, 387, 393
in liver abscess, 217
in nosocomial infections, 210–211
outbreaks of, 210–211
pathogenicity of, 221–225
in pericarditis, 216
in pharyngitis, 216
in plague, see Plague
in respiratory infections, 216
taxonomy of, 205–207
in wound infections, 217

Yersinia aldovae
antimicrobial susceptibility of, 225
laboratory identification of, 219, 393
taxonomy of, 206

Yersinia aleksicai
epidemiology of, 210
laboratory identification of, 393
taxonomy of, 206

Yersinia bercovieri
antimicrobial susceptibility of, 225
clinical significance of, 214
laboratory identification of, 219, 393
taxonomy of, 206

Yersinia enterocolitica
antimicrobial susceptibility of, 225
clinical significance of, 211–217
epidemiology of, 207–211
laboratory identification of, 217–220, 393
pathogenicity of, 221–225
in reactive arthritis, 18
taxonomy of, 205–206

Yersinia enterocolitica subsp. enterocolitica, 205

Yersinia enterocolitica subsp. palearctica, 205

Yersinia frederiksenii
antimicrobial susceptibility of, 225
clinical significance of, 214
epidemiology of, 208–210
laboratory identification of, 218, 220, 393
pathogenicity of, 222
taxonomy of, 206

Yersinia intermedia
antimicrobial susceptibility of, 225
clinical significance of, 214
epidemiology of, 208–210
laboratory identification of, 218, 220, 393
pathogenicity of, 222
taxonomy of, 206

Yersinia kristensenii
antimicrobial susceptibility of, 225
clinical significance of, 214
epidemiology of, 210
laboratory identification of, 218, 220, 393
pathogenicity of, 222
taxonomy of, 206

Yersinia mollaretii
antimicrobial susceptibility of, 225
clinical significance of, 214
epidemiology of, 210
laboratory identification of, 219, 393
taxonomy of, 206

Yersinia pestis, see also Plague
in animals, 208, 210–211, 215
antimicrobial susceptibility of, 225
atypical (pestoides), 220
clinical significance of, 213
epidemiology of, 208, 210–211
laboratory identification of, 218, 220, 393
pathogenicity of, 221, 223–225
taxonomy of, 205–206

Yersinia pestis biovar Antiqua, 205, 220
Yersinia pestis biovar Medievalis, 205, 220
Yersinia pestis biovar Microtus, 205, 220
Yersinia pestis biovar Orientalis, 205, 220
**Yersinia philomiragia**, 206

**Yersinia pseudotuberculosis**
- antimicrobial susceptibility of, 225
- clinical significance of, 213–217
- epidemiology of, 208, 210
- laboratory identification of, 218–220, 393
- pathogenicity of, 221–224
- taxonomy of, 205–206

**Yersinia rohdei**
- antimicrobial susceptibility of, 225
- clinical significance of, 214

**Yersinia ruckeri**
- antimicrobial susceptibility of, 225
- laboratory identification of, 219, 387, 393
- taxonomy of, 206

**Yokenella regensburgei**, 370–371, 387

**Yop proteins, Yersinia**, 223–224

**ZapA protein, Proteus**, 249–250