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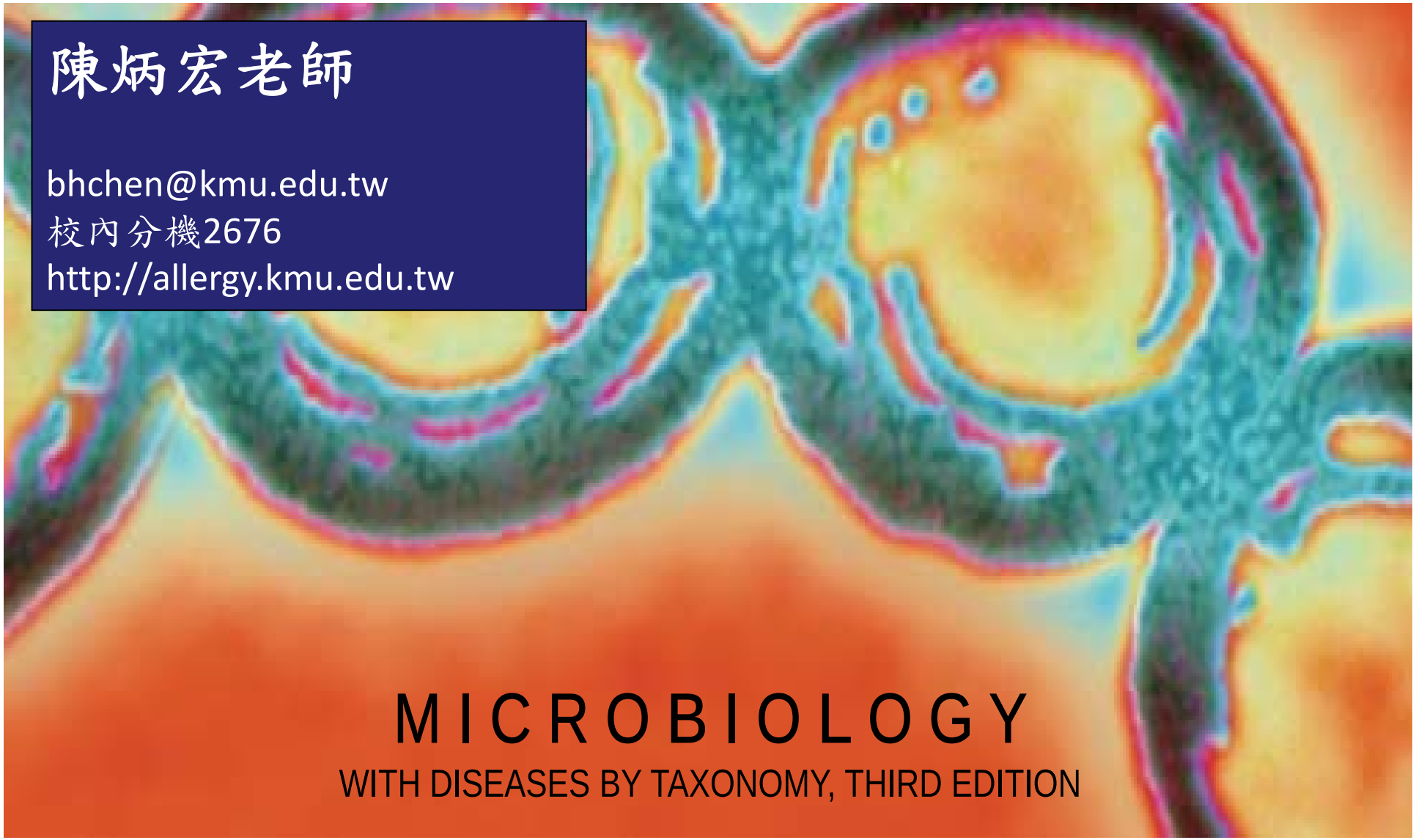


# MICROBIOLOGY

WITH DISEASES BY TAXONOMY, THIRD EDITION

## Chapter 20 Pathogenic Gram-Negative Cocci and Bacilli

## 致病性革蘭氏陰性球菌與桿菌

# 學習目標

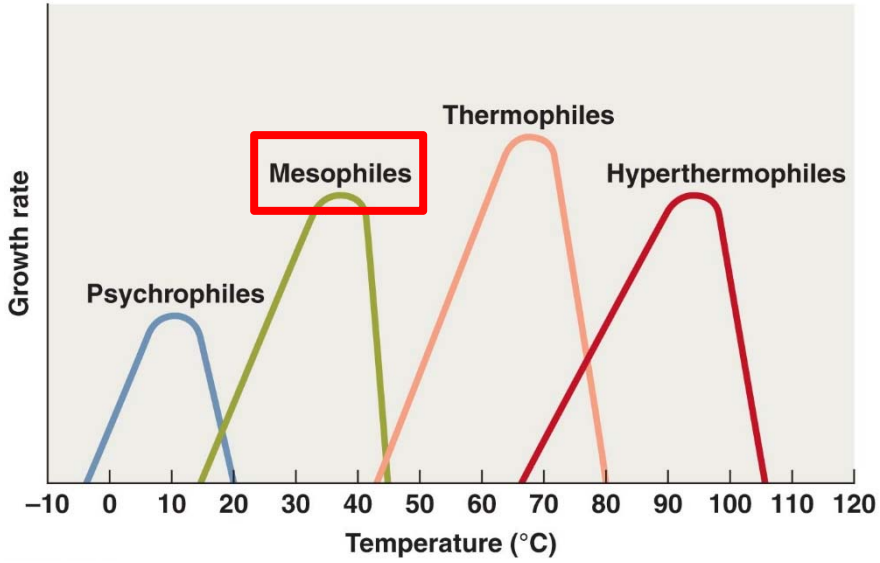


- Understand the characteristics of clinically important G(-) bacteria
  - *Neisseria*
  - Pathogenic facultatively anaerobic Bacilli
  - Pathogenic aerobic Bacilli
  - Pathogenic anaerobic Bacilli

# Gram-Negative Bacteria



- Constitute largest group of human bacterial pathogens
  - Due in part to lipid A in the bacterial cell wall
    - Triggers fever, vasodilation, inflammation, shock, DIC
- Most Gram-negative bacteria that breach skin or mucous membranes grow at 37°C



# Pathogenic Gram-Negative Cocci: *Neisseria*



- Only genus of Gram-negative cocci that regularly causes disease in humans
- Nonmotile, aerobic bacteria
- Often arranged as diplococci
- Oxidase positive
  - Distinguishes from many Gram-negative pathogens
- Two species pathogenic to humans
  - *N. gonnorhoeae*
  - *N. meningitides*

# Pathogenic Gram-Negative Cocci: *Neisseria*



- The Gonococcus: *Neisseria gonorrhoeae*
  - Pathogenesis, epidemiology, and disease
    - Causes gonorrhea
    - Gonococci adhere to the genital, urinary, and digestive tract
    - Gonorrhea in men
      - Painful urination and pus-filled discharge
    - Gonorrhea in women
      - Often asymptomatic
      - Can trigger pelvic inflammatory disease
    - Infection of children can result during childbirth

# Diplococci of *Neisseria gonorrhoeae*



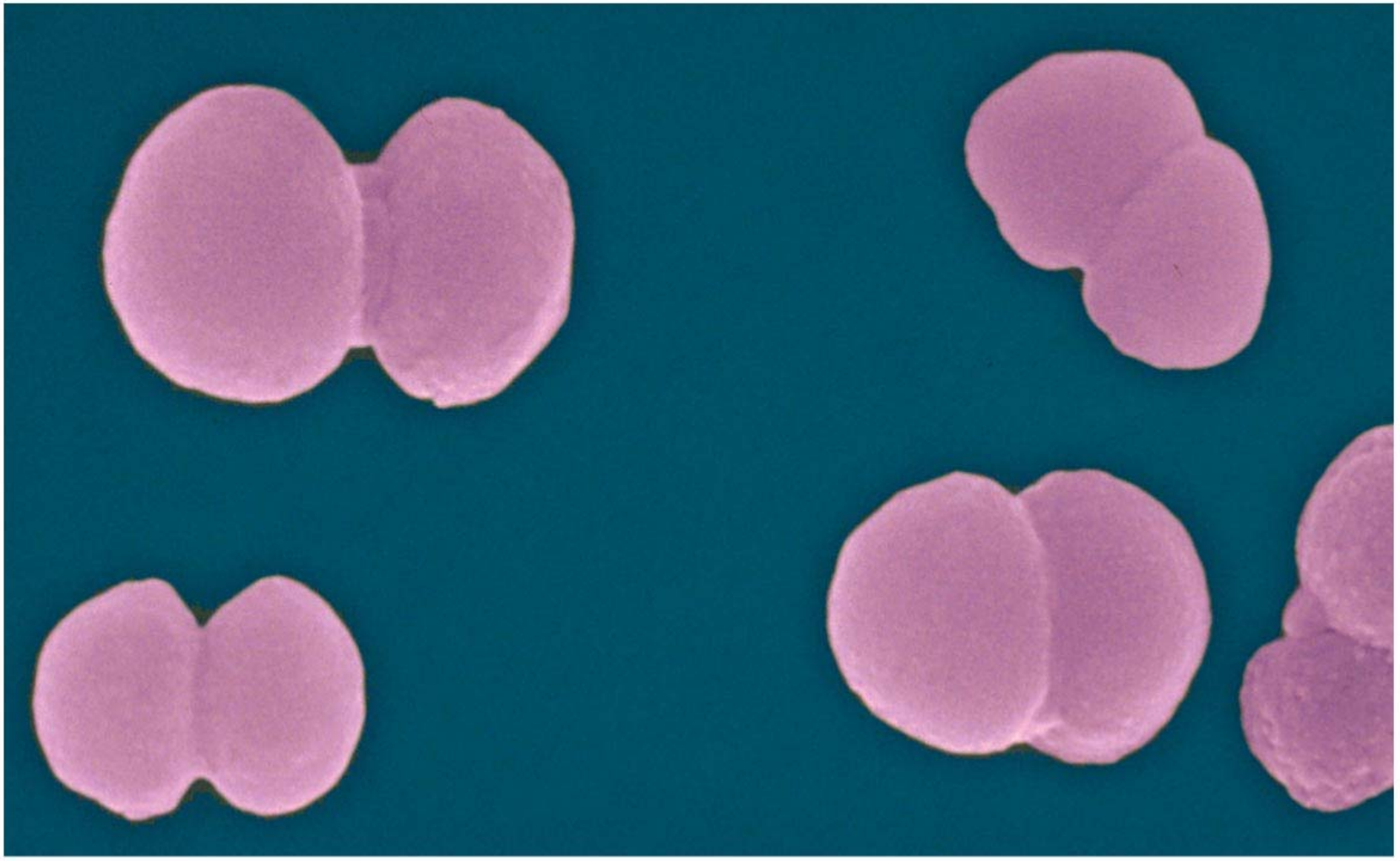
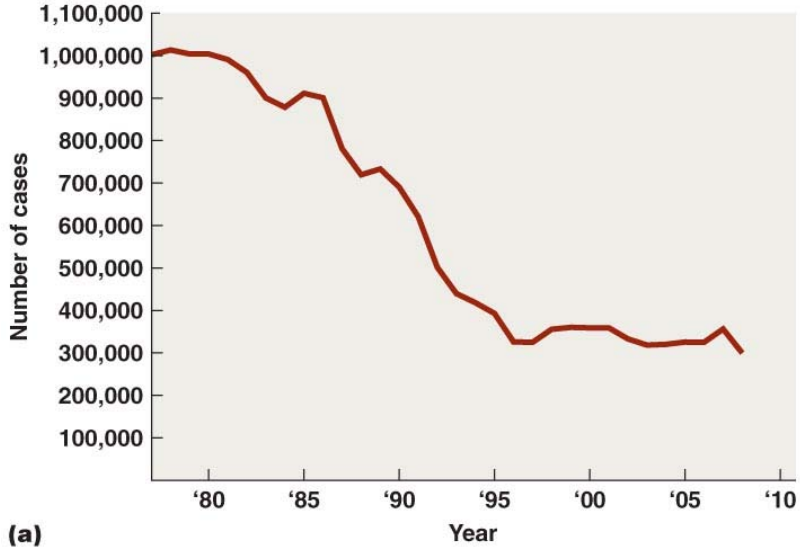





Figure 20.1

# The incidence of gonorrhea in the United States





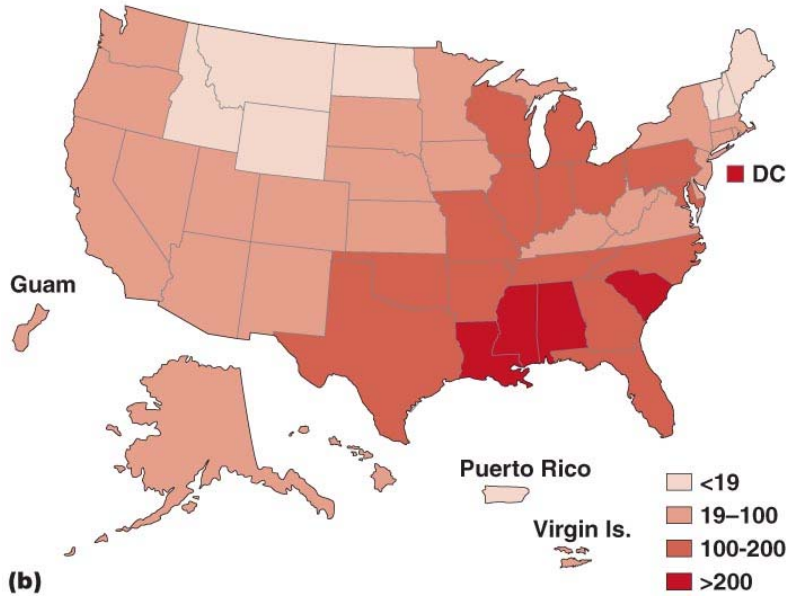






Figure 20.2

# Pathogenic Gram-Negative Cocci: *Neisseria*



- The Gonococcus: *Neisseria gonorrhoeae*
  - Diagnosis, treatment, and prevention
    - Diagnosis
      - Asymptomatic cases identified with genetic probes
      - Gram-negative diplococci in pus from inflamed penis
    - Treatment
      - Complicated due to resistant strains
      - Broad-spectrum antimicrobial drugs
    - Prevention
      - Sexual abstinence

# Pathogenic Gram-Negative Cocci: *Neisseria*



- The Meningococcus: *Neisseria meningitidis*
  - Pathogenicity, epidemiology, and disease
    - Can be normal microbiota of the upper respiratory tract
    - Life-threatening when bacteria invade blood or cerebrospinal fluid
    - Most common cause of meningitis in individuals under 20
    - Bacteria transmitted among people living in close contact
    - Meningitis can cause death within 6 h of symptoms
    - Septicemia can also be life threatening

# Petechiae in meningococcal septicemia



(a)

(b)



Figure 20.3

# Pathogenic Gram-Negative Cocci: *Neisseria*



- The Meningococcus: *Neisseria meningitidis*
  - Diagnosis, treatment, and prevention
    - Diagnosis
      - Gram-negative diplococci in phagocytes of the CNS
    - Treatment
      - Intravenous antibiotics
    - Prevention
      - Asymptomatic carriers make eradication unlikely

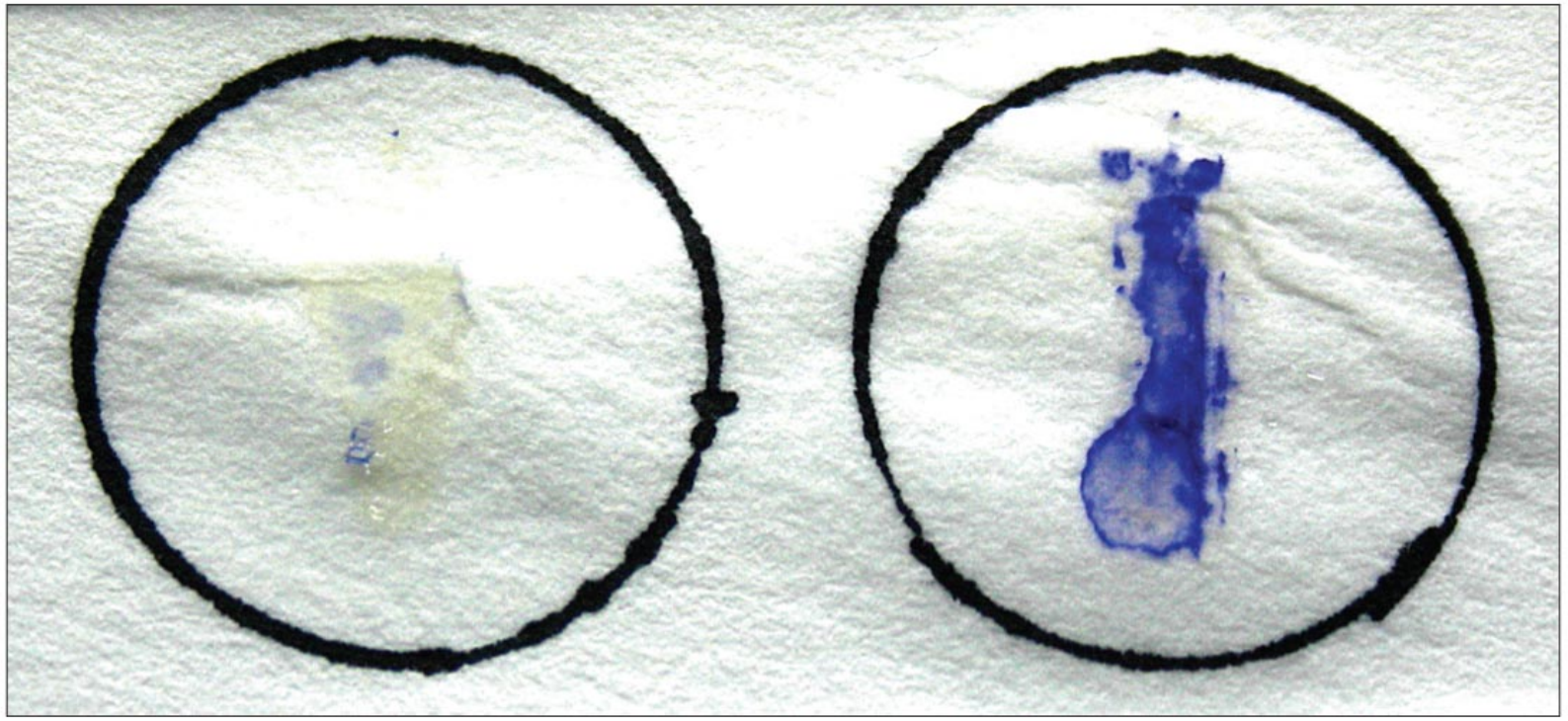
# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli



- Two families contain most human pathogens
  - Enterobacteriaceae 腸桿菌
  - Pasteurellaceae 巴斯德菌桿菌
- Oxidase test distinguishes between these families
- Includes important nosocomial pathogens

# The oxidase test





***Enterobacteriaceae***
Oxidase (-)

***Pasteurellaceae***
Oxidase (+)

N,N,N′,N′-tetramethyl-p-phenylenediamine (TMPD)
(reduced form, 無色)

→ cyto. c oxidase →

TMPD
(oxidized, 紫色)



Figure 20.4

# Causes of nosocomial infections in the United States



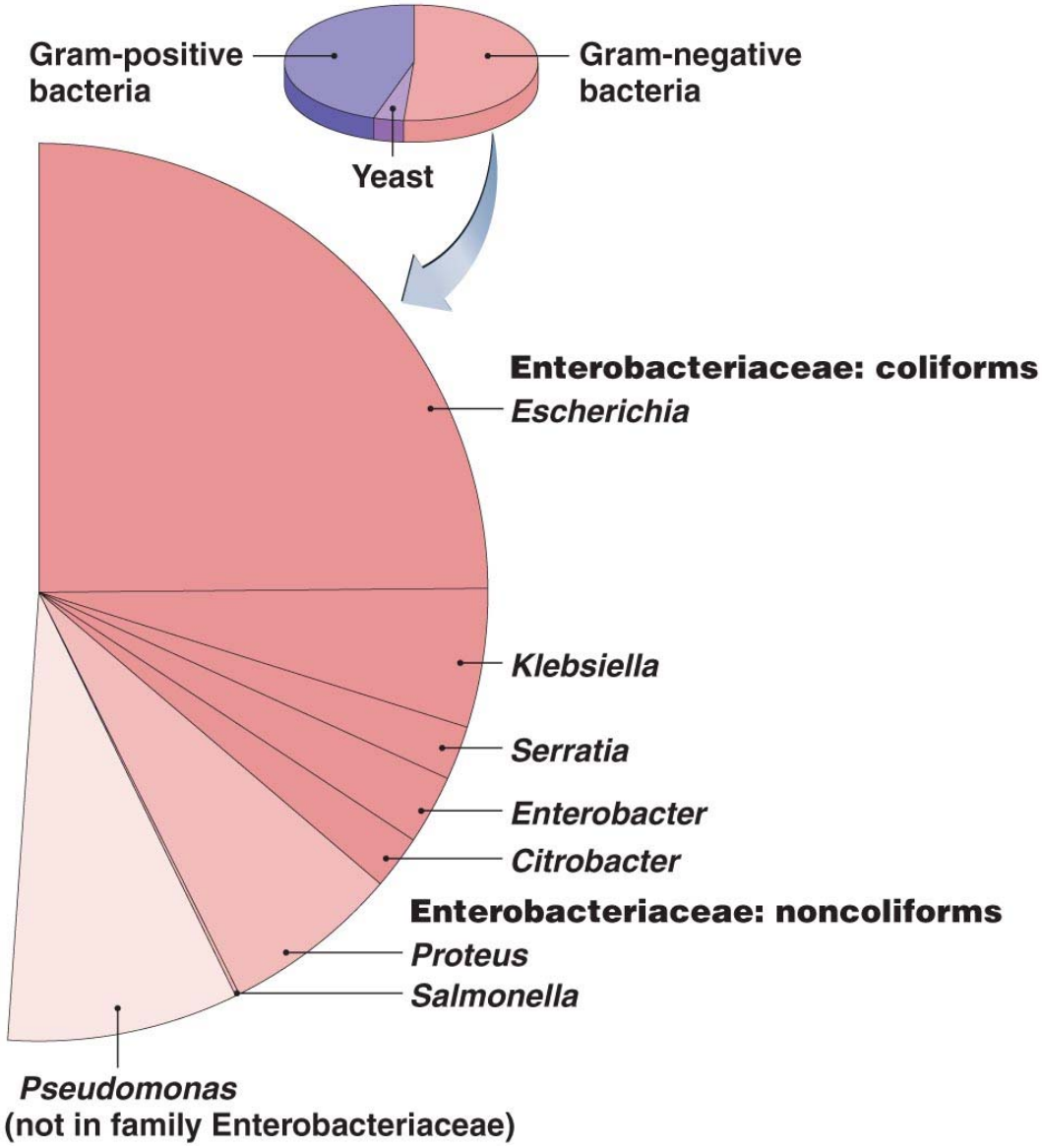




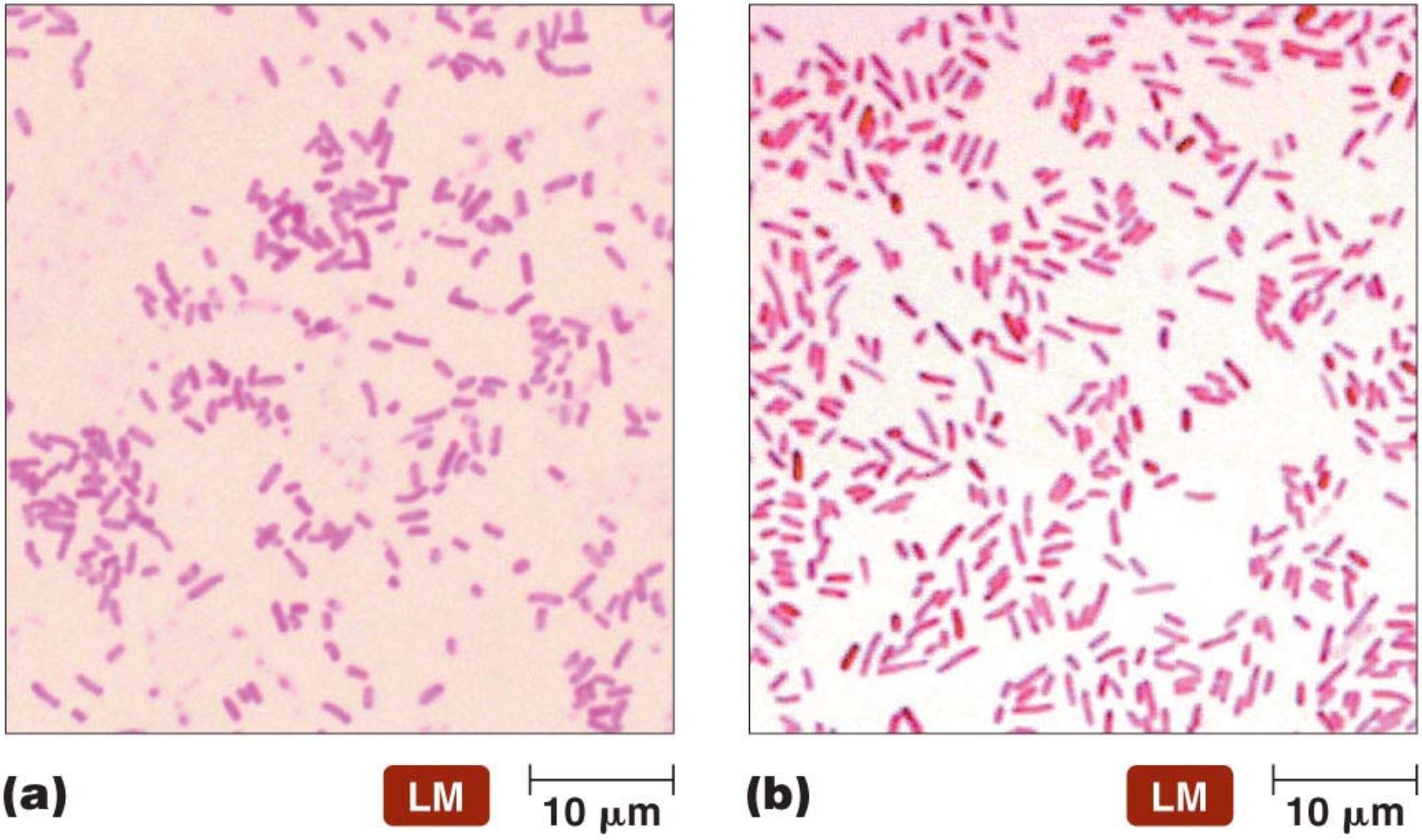

Figure 20.5

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Enterobacteriaceae: An Overview
  - Intestinal microbiota of most animals and humans
  - Ubiquitous in water, soil, and decaying vegetation
  - Enteric bacteria are the most common Gram-negative pathogens of humans

# Gram stains of bacteria in the family Enterobacteriaceae






***Enterobacter aerogenes*** ***Escherichia coli***



Figure 20.6

# Dichotomous key for distinguishing enteric bacteria



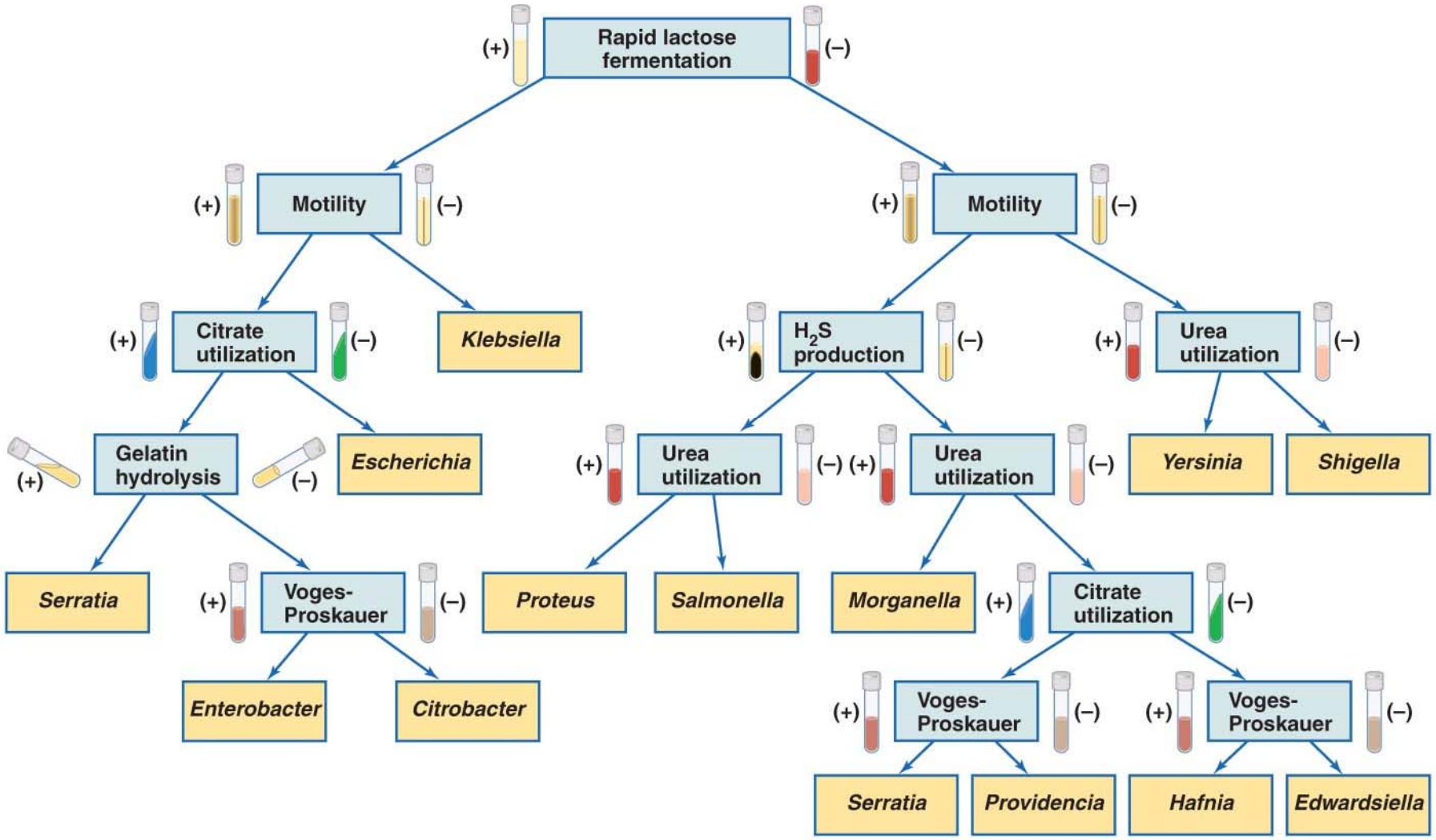





Figure 20.7

# Antigens and virulence factors of typical enteric bacteria



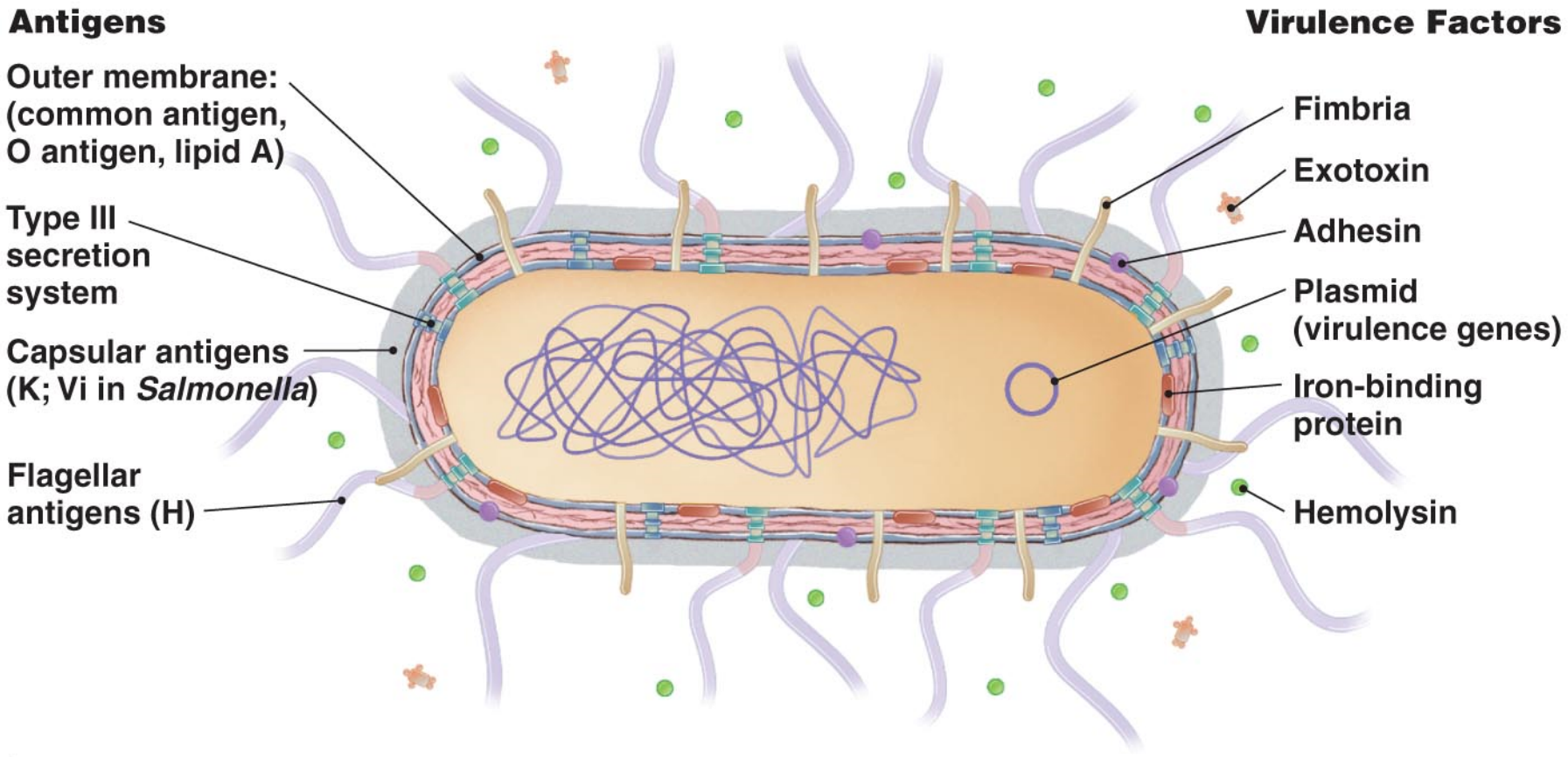





Figure 20.8

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Diagnosis, Treatment, and Prevention of Diseases of the Enterobacteriaceae
  - Diagnosis
    - Enteric bacteria in urine, blood, cerebrospinal fluid
    - Biochemical tests rapidly identify enteric bacteria
  - Treatment
    - Diarrhea is typically self-limited
  - Prevention
    - Good personal hygiene and proper sewage control

# The use of MacConkey agar



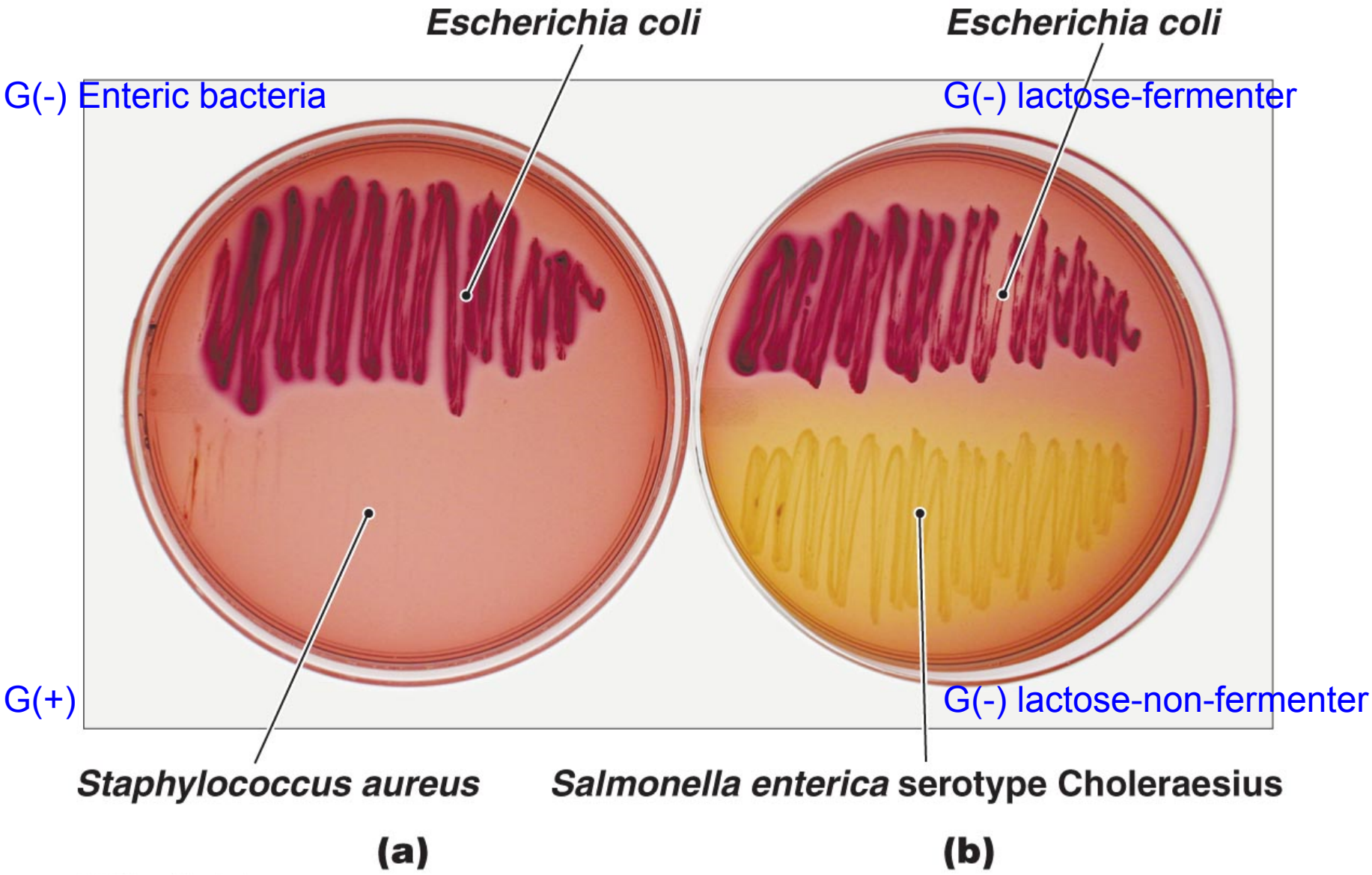





Figure 20.9

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Pathogenic Enterobacteriaceae often classified into three groups
  - Coliforms
    - Rapidly ferment lactose
    - Normal microbiota but may be opportunistic pathogens
    - *E. coli, Klebsiella, Serratia, Enterobacter, Hafnia, Citrobacter*
  - Noncoliform opportunists
    - Do not ferment lactose
    - *Proteus, Morganella, Providencia, Edwardsiella*
  - True pathogens
    - *Samonella, Shigella, Yersinia*

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Coliform Opportunistic Enterobacteriaceae
  - Coliforms
    - Aerobic or facultatively anaerobic, Gram-negative, rod-shaped bacteria that ferment lactose to form gas on lactose broth
  - Commonly found in soil, on plants, and on decaying vegetation
  - Colonize the intestinal tracts of animals and humans
  - Coliforms in water indicative of impure water and poor sewage treatment

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Coliform Opportunistic Enterobacteriaceae
  - *Escherichia coli*
    - Most common and important of the coliforms
    - Virulent strains have virulence plasmids
    - Gastroenteritis is most common disease
      - Often mediated by exotoxins
    - Common cause of non-nosocomial urinary tract infections
    - *E. coli* O157:H7
      - Most prevalent pathogenic *E. coli* in developed countries
      - Causes diarrhea, hemorrhagic colitis, hemolytic uremic syndrome

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Coliform Opportunistic Enterobacteriaceae
  - *Klebsiella*
    - In digestive and respiratory systems of humans and animals
    - Can cause opportunistic infections
    - Capsule protects the bacteria from phagocytosis
    - *K. pneumoniae*
      - Most commonly isolated pathogenic species
      - Causes pneumonia
      - May be involved in bacteremia, meningitis, wound infections, UTIs

# The prominent capsule of *Klebsiella pneumoniae*



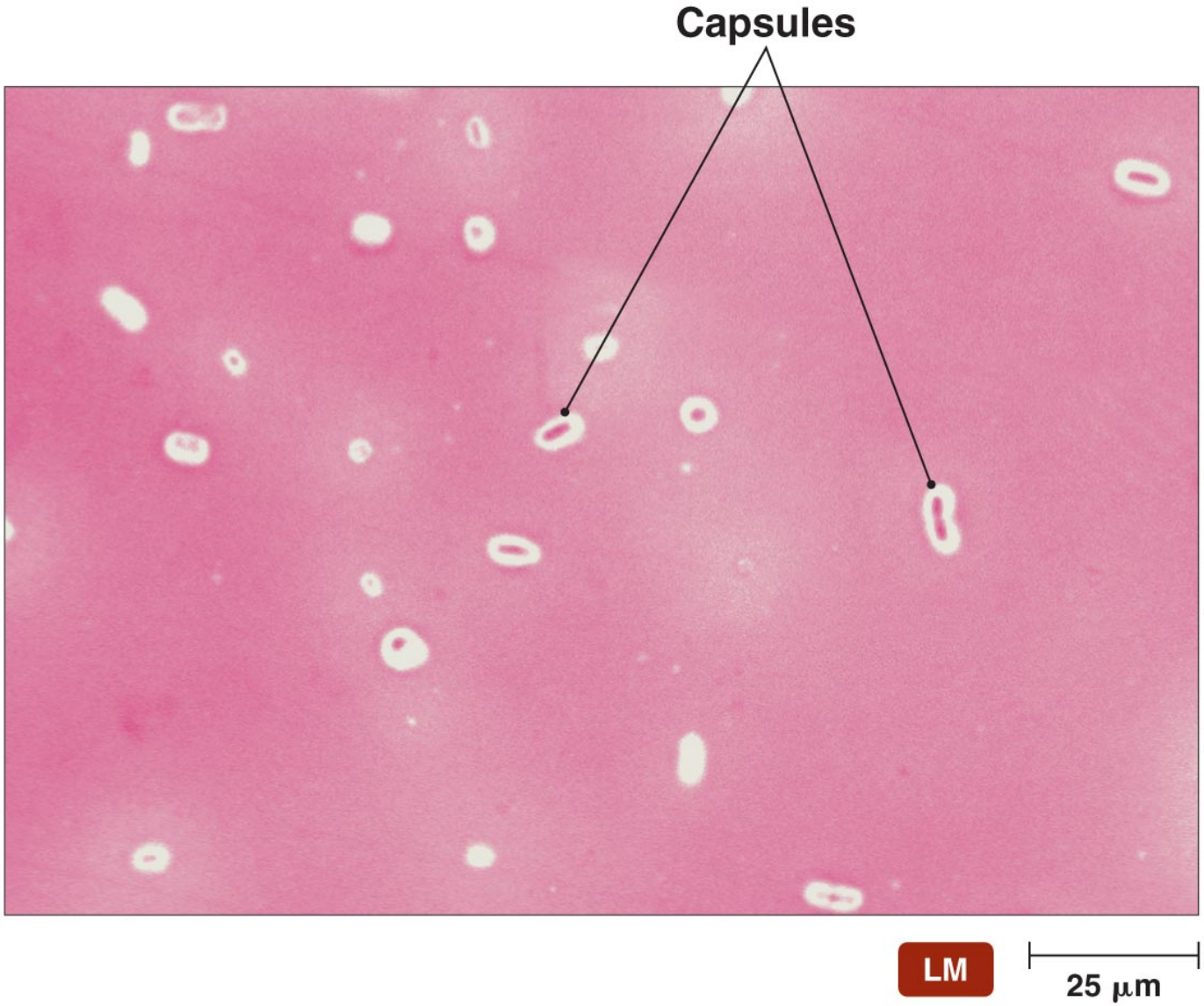





Figure 20.10

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Coliform Opportunistic Enterobacteriaceae
  - *Serratia*
    - Produce a red pigment when grown at room temperature
    - Can grow on catheters, in saline solutions, and on other hospital supplies
    - Can cause life-threatening opportunistic infections in immunocompromised patients
    - Difficult to treat due to resistance to antimicrobial drugs

# Red colonies of *Serratia marcescens*



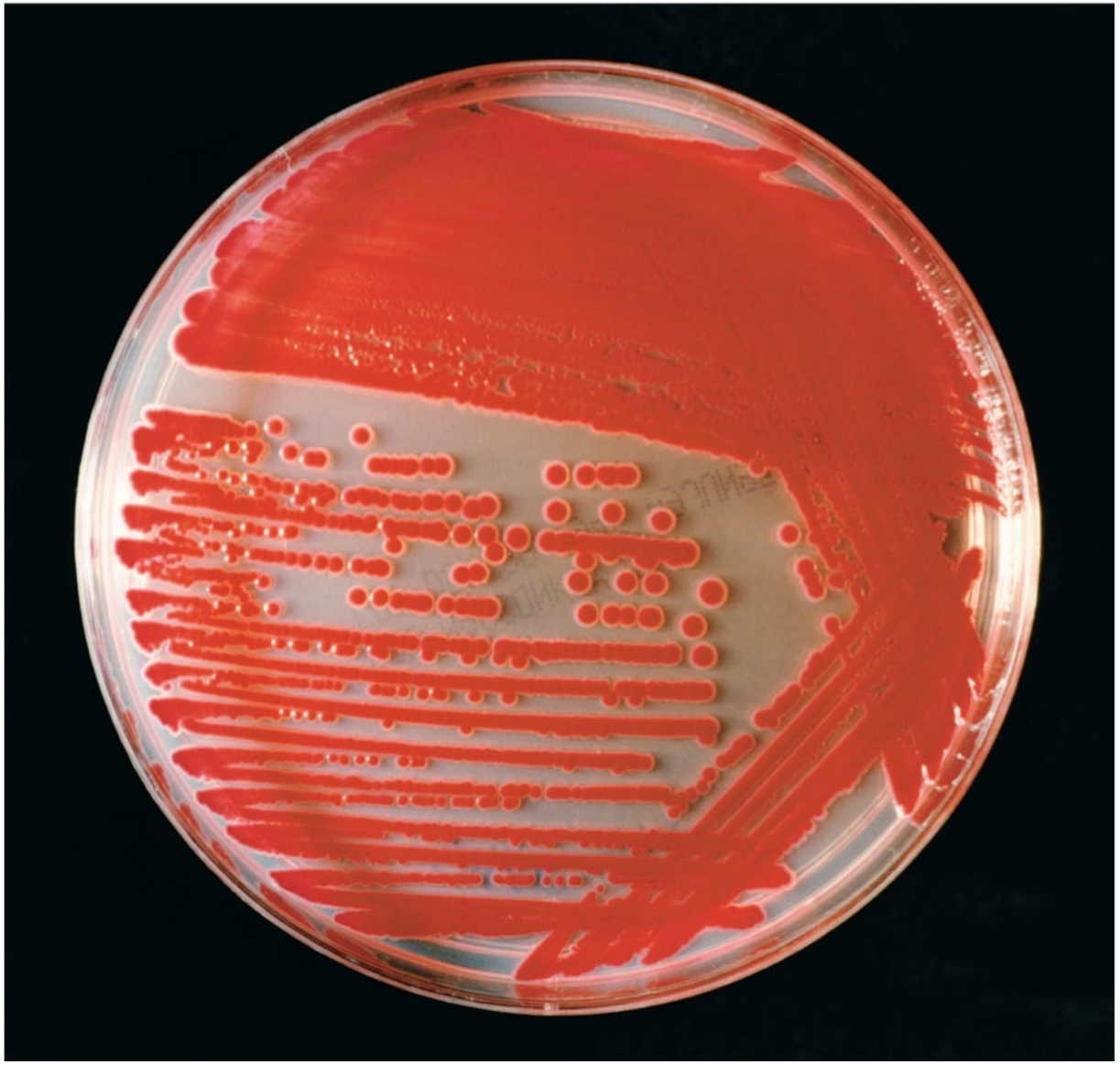




Figure 20.11

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Coliform Opportunistic Enterobacteriaceae
  - *Enterobacter*, *Hafnia*, and *Citrobacter*
    - Found in soil, water, decaying vegetation, and sewage
    - Reside in the digestive tracts of animals and humans
    - All can be opportunistic pathogens
    - Frequently involved in nosocomial infections of immunocompromised patients
    - Difficult to treat due to resistance to antimicrobial drugs

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Noncoliform Opportunistic Enterobacteriaceae
  - *Proteus*
    - Gram-negative, facultative anaerobe
    - *Proteus mirabilis* is most commonly associated with human disease
      - Urinary tract infections in patients with long-term urinary catheters
      - Infection-induced kidney stones can develop
      - Resistant to many antimicrobial drugs

# The concentric rings of *Proteus microbilis*



A characteristic '**swarming**' feature of *Proteus mirabilis*



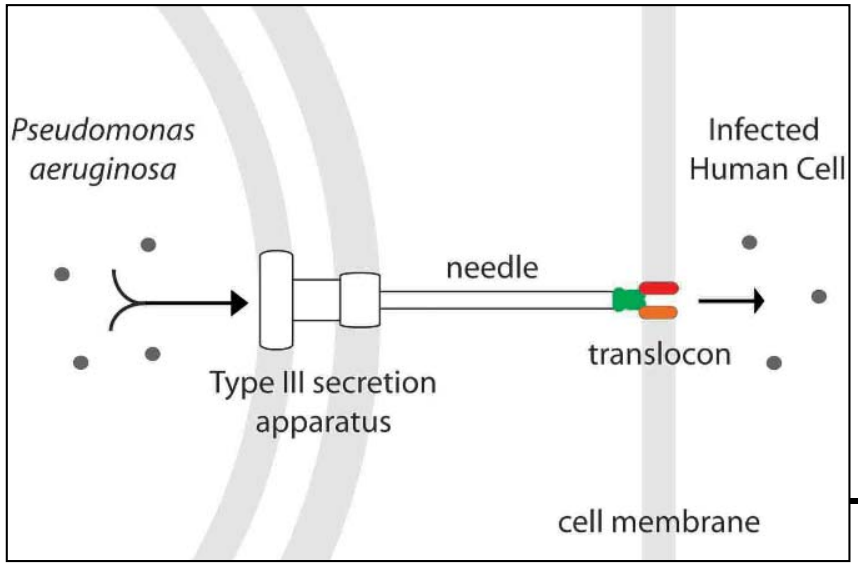
Figure 20.12

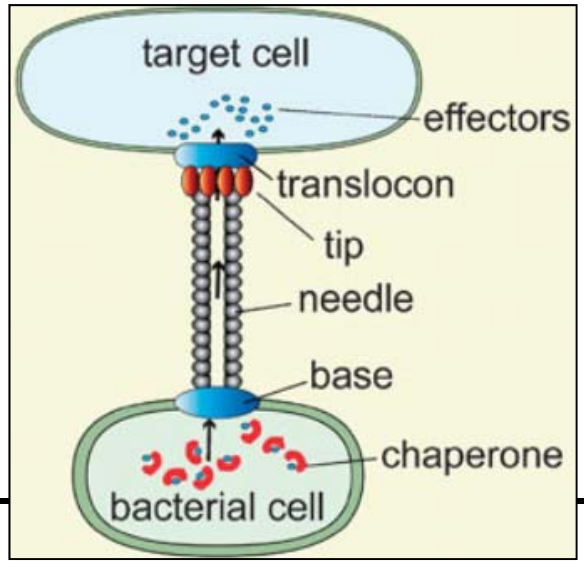
# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Noncoliform Opportunistic Enterobacteriaceae
  - *Morganella*, *Providencia*, and *Edwardsiella*
    - Nosocomial infections in immunocompromised patients
    - Primarily involved in urinary tract infections

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Truly Pathogenic Enterobacteriaceae
  - Include *Salmonella*, *Shigella*, *Yersinia*
  - Almost always pathogenic due to numerous virulence factors
  - Produce type III secretion systems
    - Introduce proteins that inhibit phagocytosis, rearrange the cytoskeletons of eukaryotic cells, or induce apoptosis



# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Truly Pathogenic Enterobacteriaceae
  - *Salmonella*
    - Gram-negative, motile bacilli
    - In the intestines and feces of birds, reptiles, and mammals
    - Most human infections due to consuming food contaminated with animal feces
    - Poultry and eggs are also common sources of *Salmonella*
    - Can cause salmonellosis and typhoid fever

# The events in salmonellosis



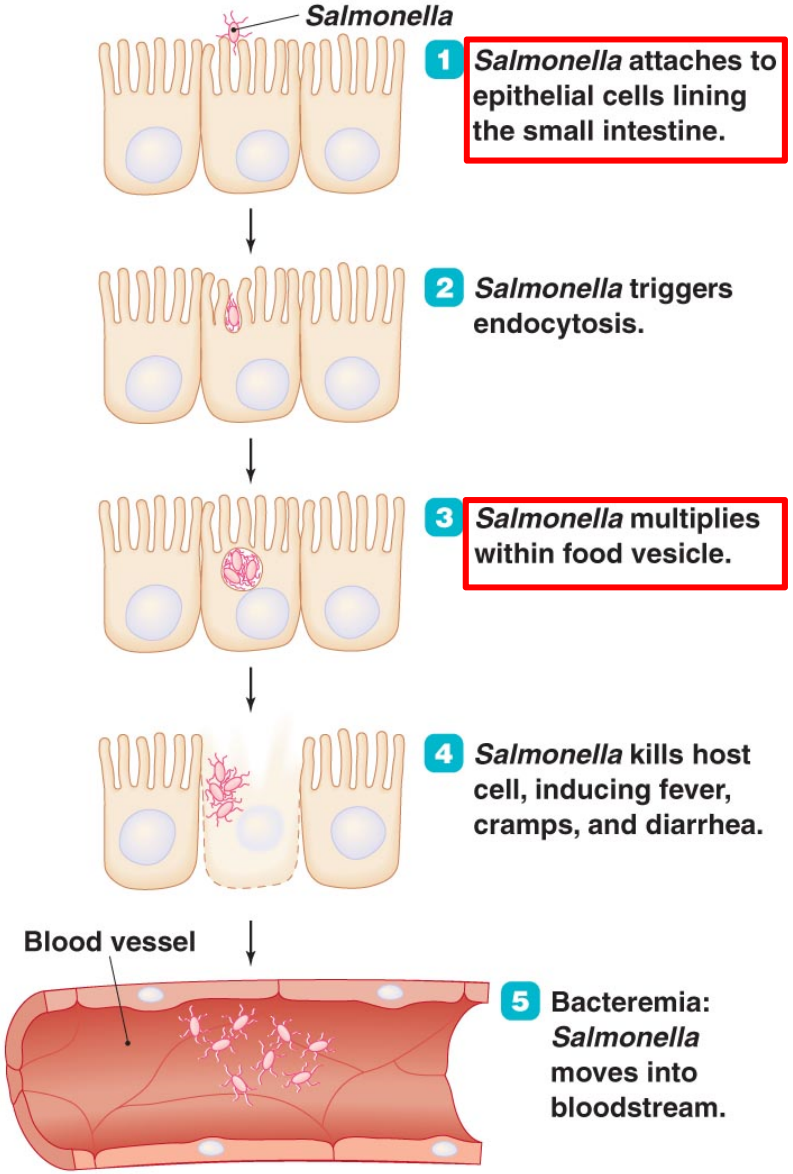





Figure 20.13

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Truly Pathogenic Enterobacteriaceae
  - *Salmonella*
    - Typhoid fever
      - Caused by *Salmonella enterica* serotype typhi
        - Humans are the only host
      - Ingest bacteria in contaminated food or water
      - Bacteria can pass through intestines into the bloodstream
      - Peritonitis can result
      - Treat with fluid and electrolyte replacement
      - Vaccines provide temporary protection to travelers

# Incidences of diseases caused by *Salmonella*



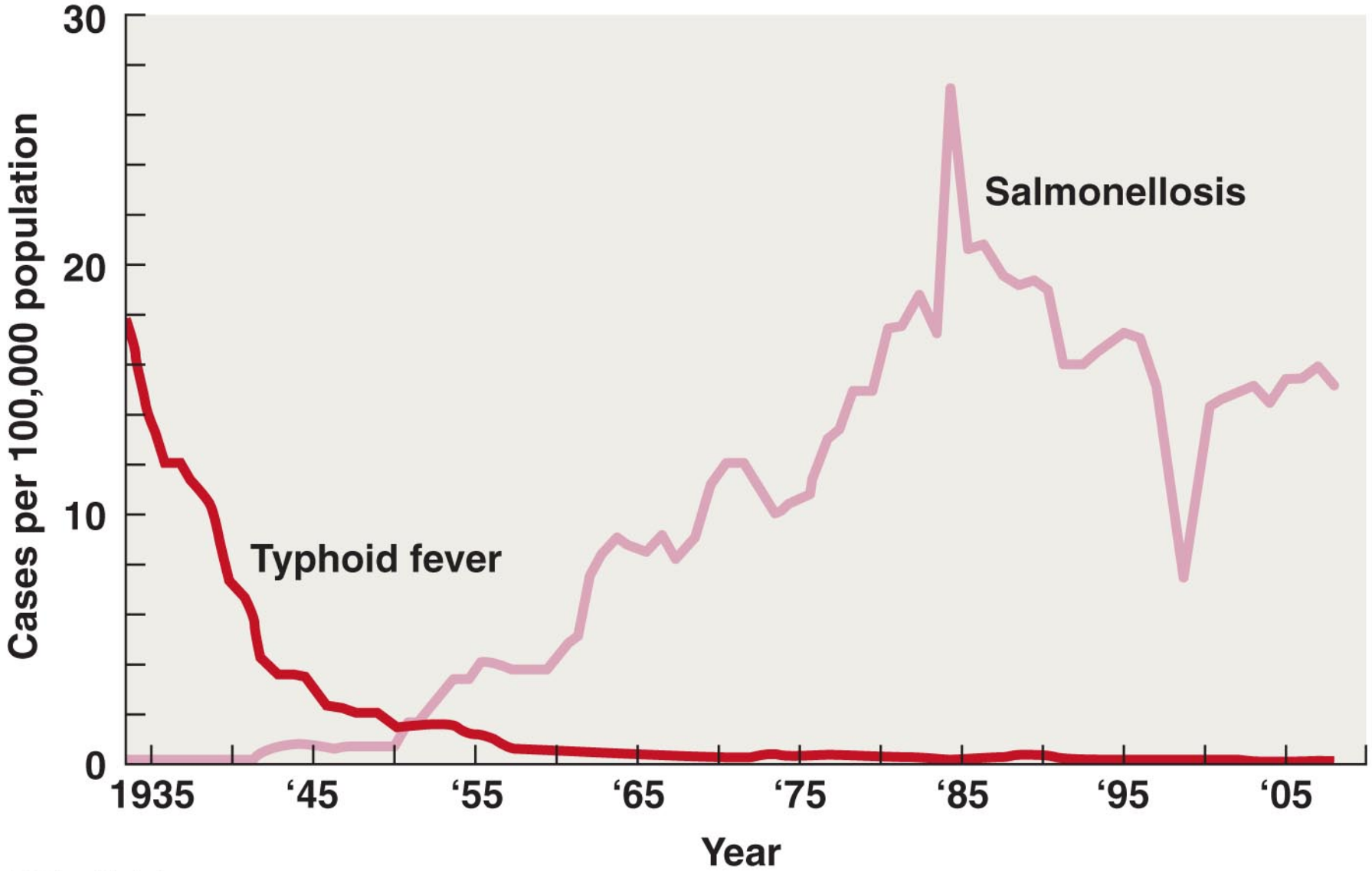





Figure 20.14

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Truly Pathogenic Enterobacteriaceae
  - *Shigella*
    - Gram-negative, nonmotile
    - Primarily a parasite of the digestive tract of humans
    - Produce diarrhea-inducing enterotoxin
    - Cause shigellosis
    - Four well-defined species
      - *S. dysenteriae*
      - *S. flexneri*
      - *S. boydii*
      - *S. sonnei*

# The events of shigellosis



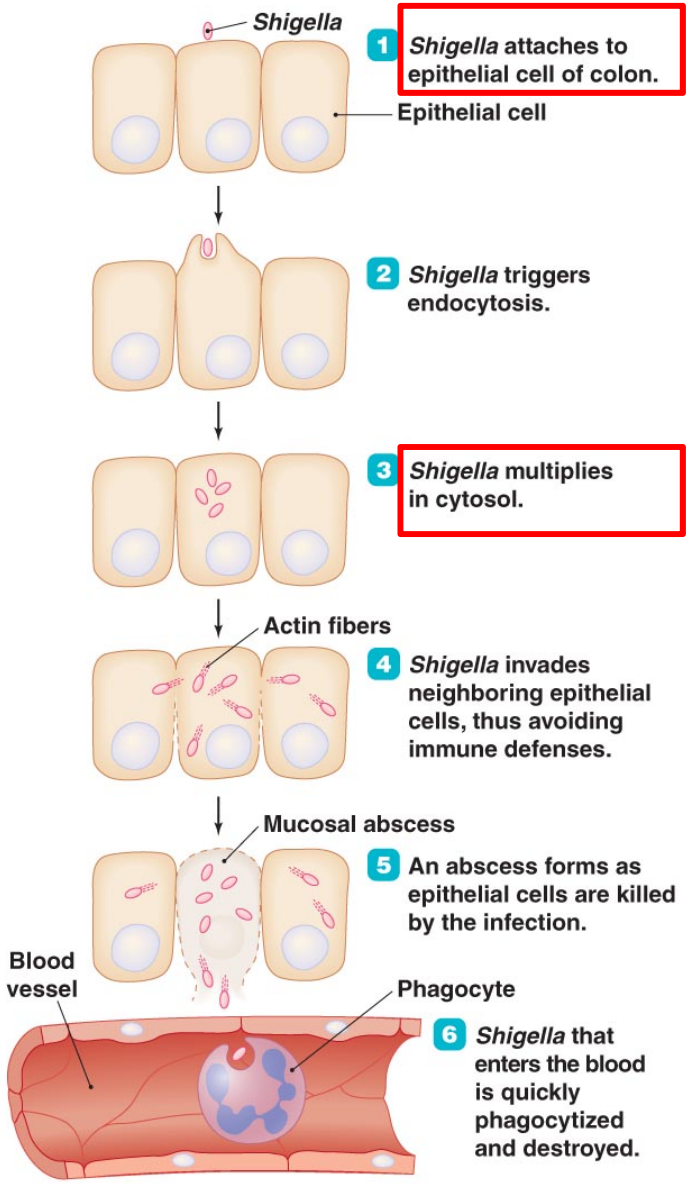





Figure 20.15

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Truly Pathogenic Enterobacteriaceae
  - *Yersinia*
    - Normal pathogen of animals
    - Three important species
      - *Y. enterocolitica*
        - Causes inflammation of the intestinal tract
      - *Y. pseudotuberculosis*
        - Similar to *Y. enterocolitica* but less severe
      - *Y. pestis*
        - Causes bubonic and pneumonic plague

# The transmission of *Yersinia pestis*



3 major routes of transmission

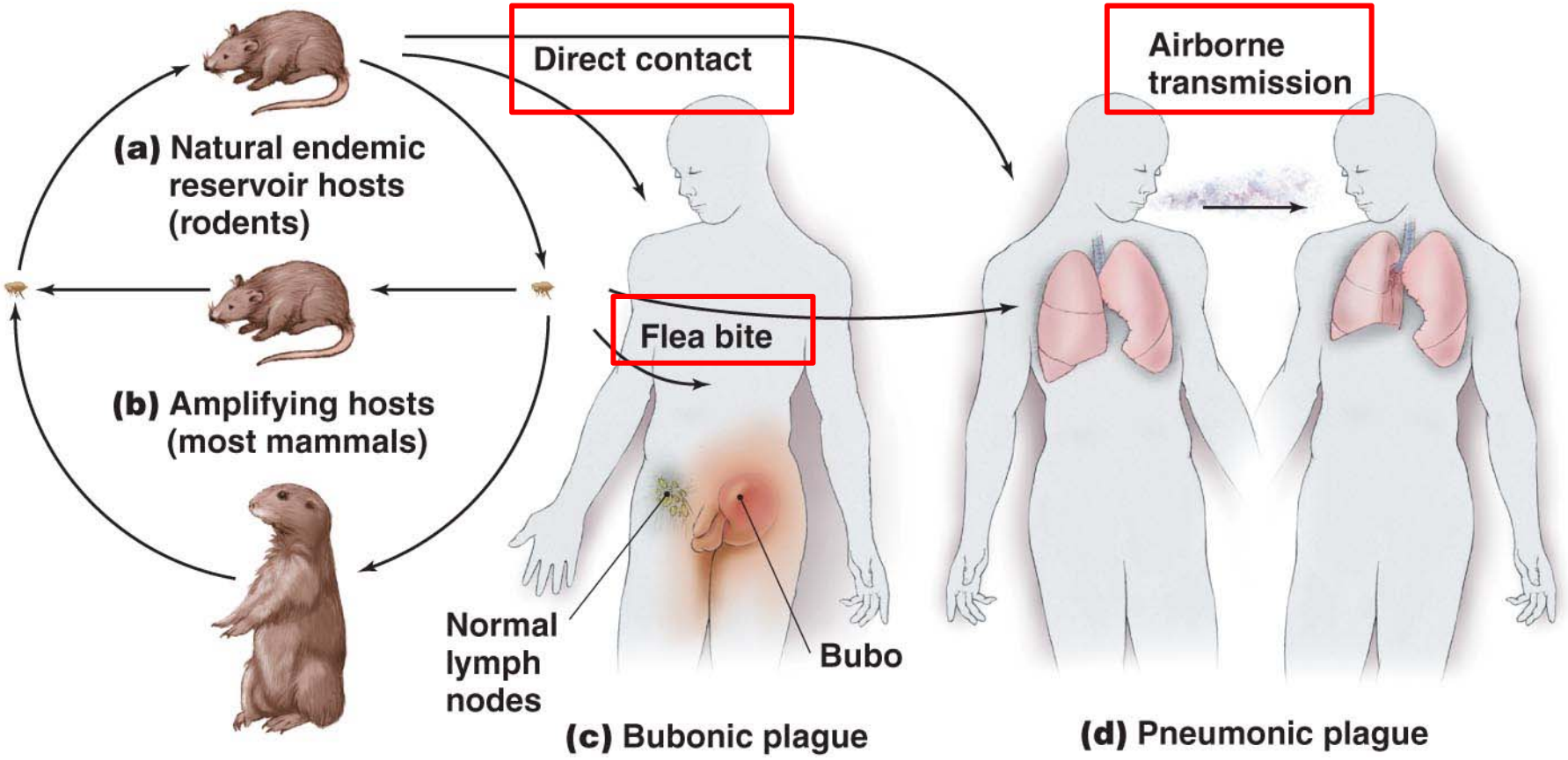





Figure 20.16

# Buboe





Figure 20.17

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- Truly Pathogenic Enterobacteriaceae
  - *Yersinia*
    - Diagnosis and treatment must be rapid
      - Fast progression and deadliness of the plague
    - Diagnosis
      - Characteristic symptoms usually sufficient for diagnosis
    - Treatment
      - Many antibacterial drugs are effective against *Yersinia*

# Sites of infection of members of the Enterobacteriaceae



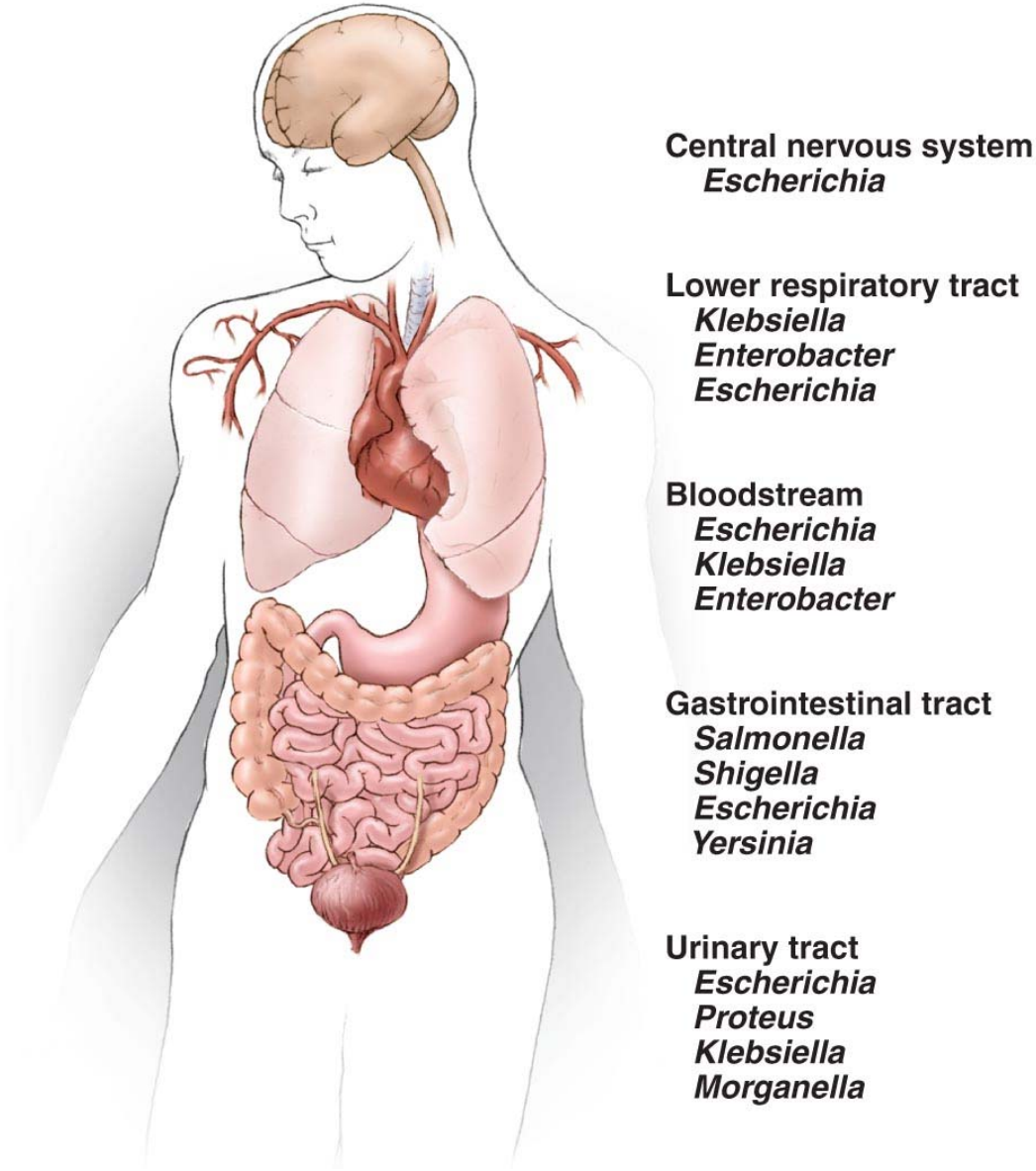





Figure 20.18

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- The Pasteurellaceae
  - Most are small, nonmotile, facultative anaerobes
  - Require heme or cytochromes for growth
  - Two genera contain most human pathogens of this family
    - *Pasteurella* 巴斯德氏桿菌
    - *Haemophilus* 嗜血桿菌

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- The Pasteurellaceae
  - *Pasteurella*
    - Normal microbiota in oral and nasopharyngeal cavities of animals
    - Humans infected via animal bites or inhalation of aerosols
    - Most cases produce localized inflammation
    - Diagnosis is by identification of bacteria in patient specimens
    - Antibacterial drugs are effective treatment

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- The Pasteurellaceae
  - *Haemophilus*
    - *Haemophilus influenzae*
      - Most strains have capsule that resists phagocytosis
      - *H. influenzae* type b is most significant
        - Common cause of meningitis prior to vaccine
        - Hib vaccine has eliminated most disease by *H. influenzae* in the United States
        - Can cause other diseases in children

# *Haemophilus influenzae*



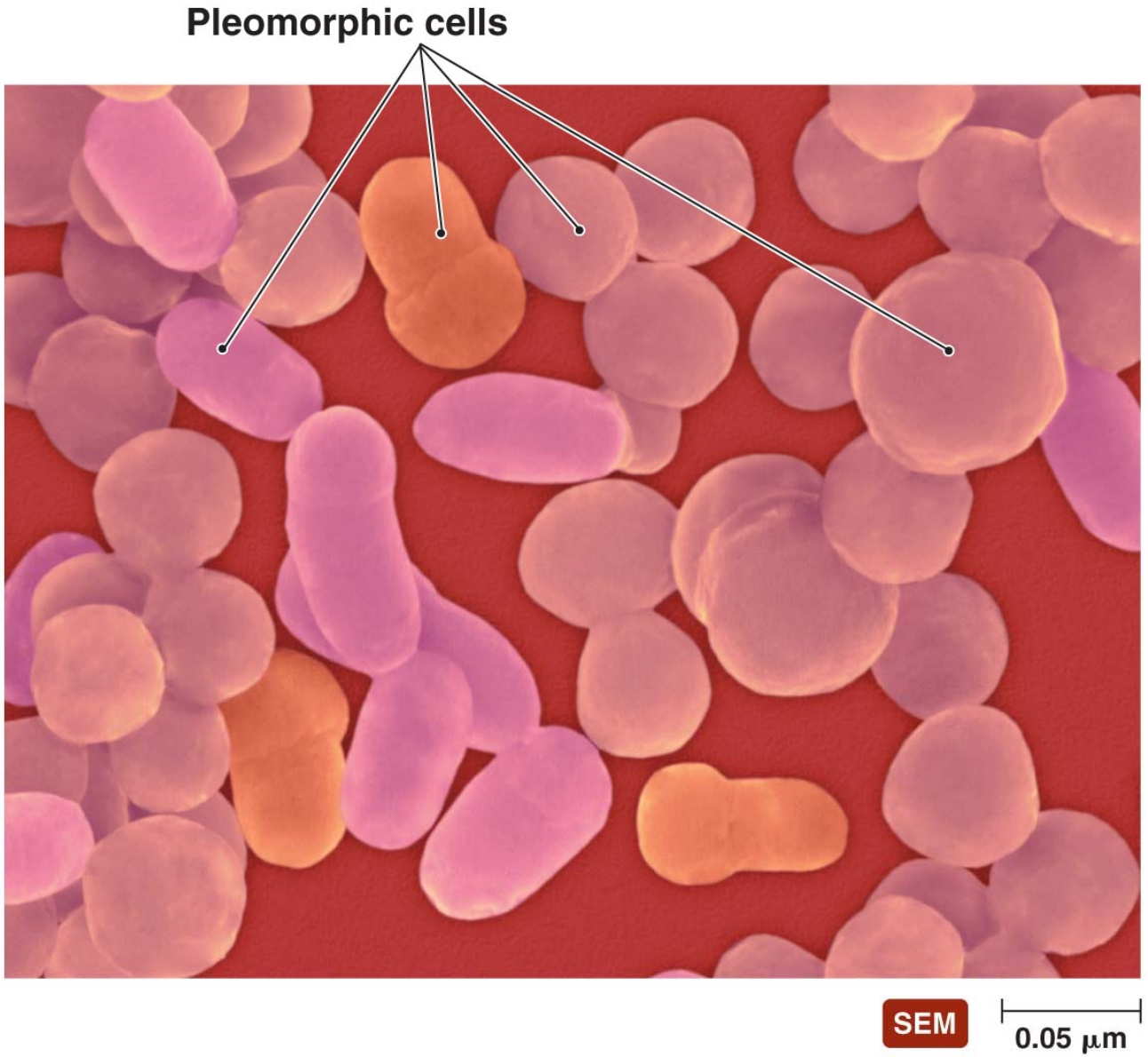
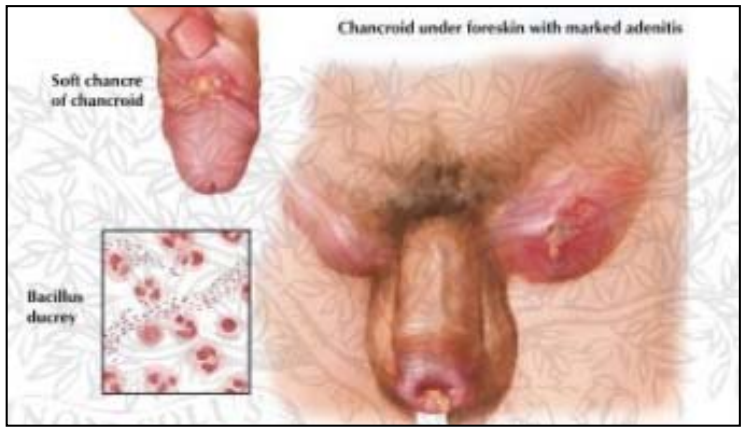


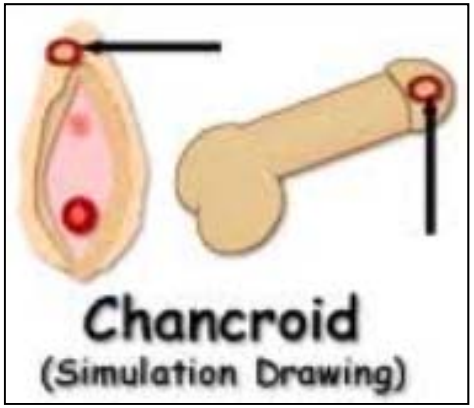



Figure 20.19

# Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli 

- The Pasteurellaceae
  - *Haemophilus*
    - Sexually transmitted *Haemophilus*
      - Caused by *H. ducreyi*
      - Causes genital ulcer called chancroid 軟性下疳
      - Often asymptomatic in women



# Chancroid





Figure 20.20

# Pathogenic, Gram-Negative, Aerobic Bacilli



- *Bartonella*
  - Aerobic bacilli
  - Found in animals but only causes disease in humans
  - Three species are pathogenic
    - *Bartonella bacilliformis*
      - Causes bartonellosis
    - *Bartonella quintana*
      - Causes trench fever
    - *Bartonella henselae*
      - Causes cat-scratch disease

# Cat-scratch disease





Figure 20.21

# Pathogenic, Gram-Negative, Aerobic Bacilli



- *Brucella*
  - Small, nonmotile, aerobic coccobacilli
  - Can infect animals or humans
  - Causes brucellosis
    - Often an asymptomatic or mild disease
    - Illness is characterized by a fluctuating fever
    - Human infection due to contact with contaminated dairy products or infected animal parts

# Incidence of brucellosis in humans in the United States



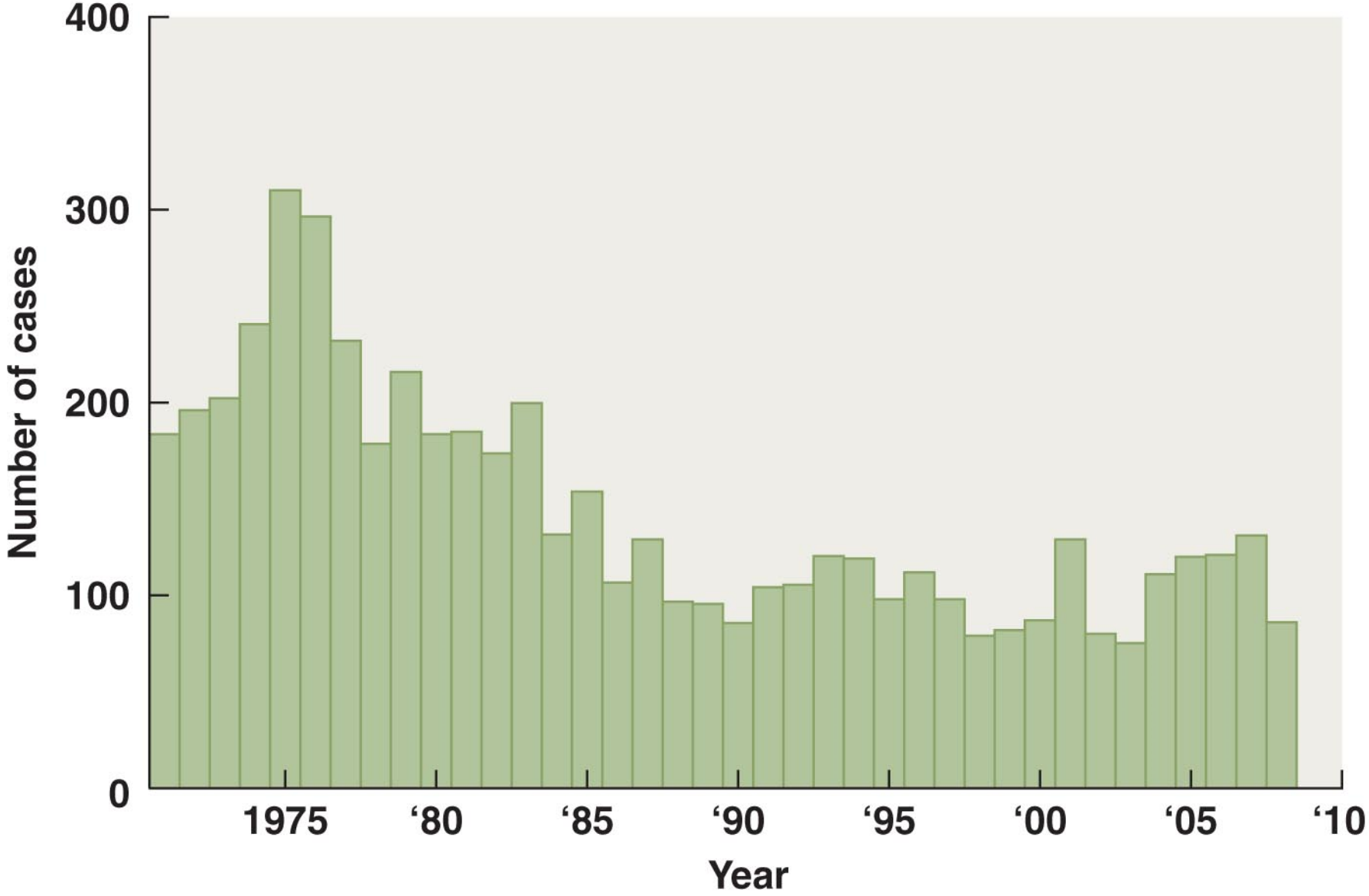





Figure 20.22

# Pathogenic, Gram-Negative, Aerobic Bacilli



- *Bordetella*
  - Pathogenesis, epidemiology, and disease
    - Small, aerobic, nonmotile coccobacillus
    - *B. pertussis* is the most important
      - Causes pertussis (whopping cough)
      - Most cases of disease are in children
      - Adhesins and toxins mediate the disease
      - Bacteria inhaled in aerosols and multiply in epithelial cells

# Reported cases of pertussis in the United States



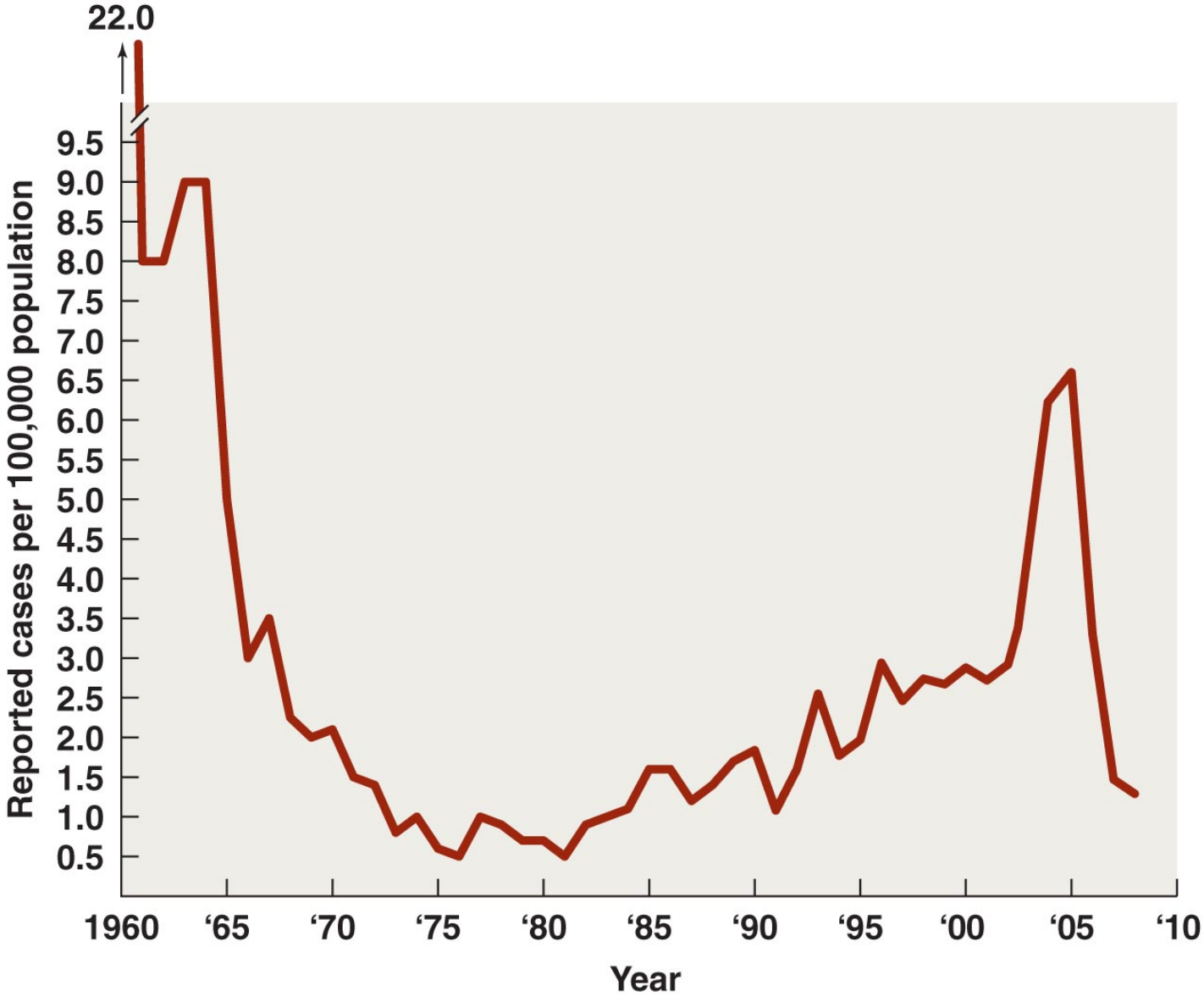
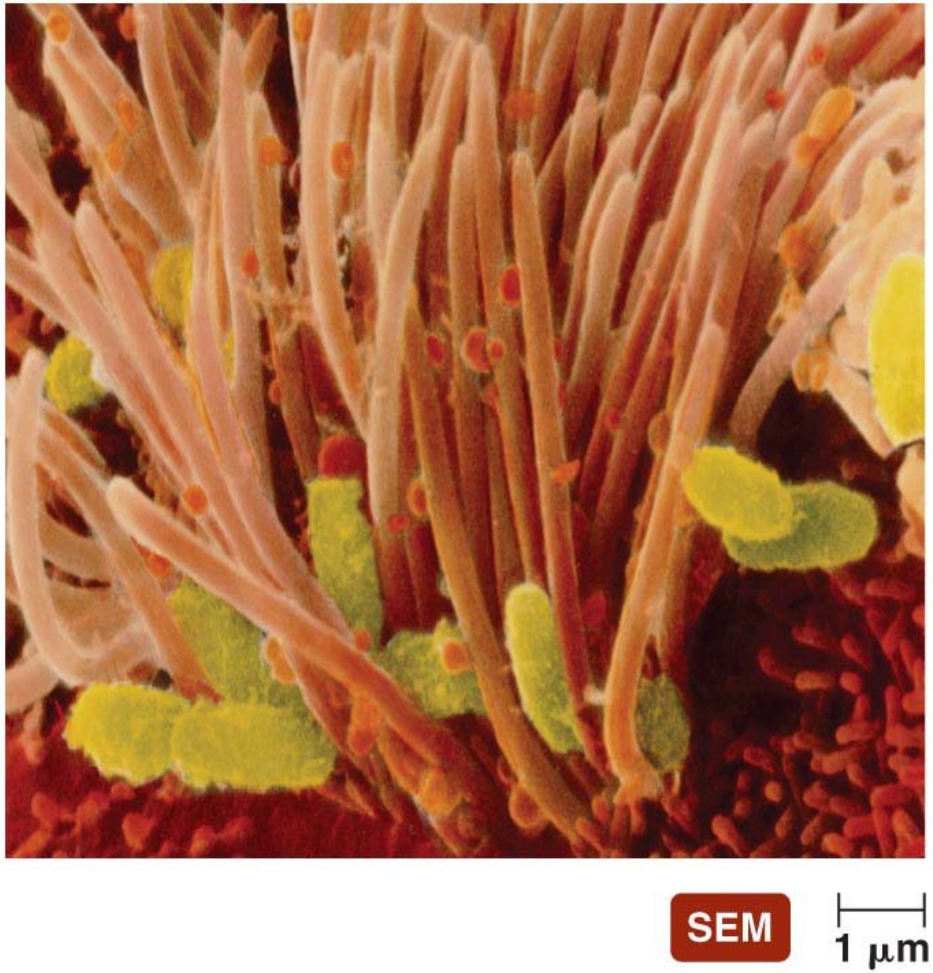





Figure 20.23

# *Bordetella pertussis*






*B. Pertussis* infecting ciliated epithelial cells of the trachea.

# Time course for the progression of pertussis



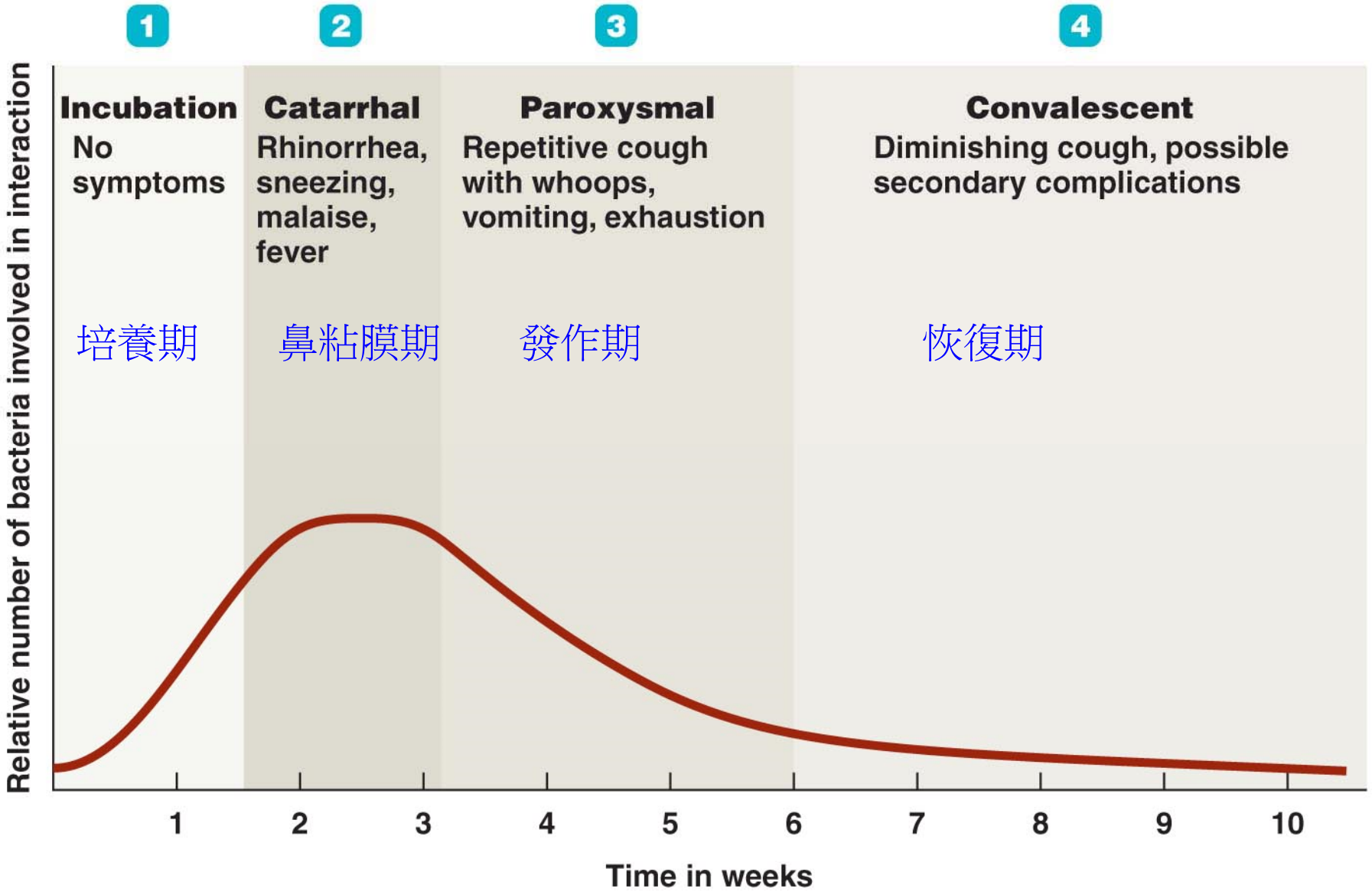





Figure 20.25

# Pathogenic, Gram-Negative, Aerobic Bacilli



- *Bordetella*
  - Diagnosis, treatment, and prevention
    - Diagnosis
      - Pertussis symptoms usually diagnostic
    - Treatment
      - Primarily supportive
    - Prevention
      - Immunization with DTaP or Tdap vaccine

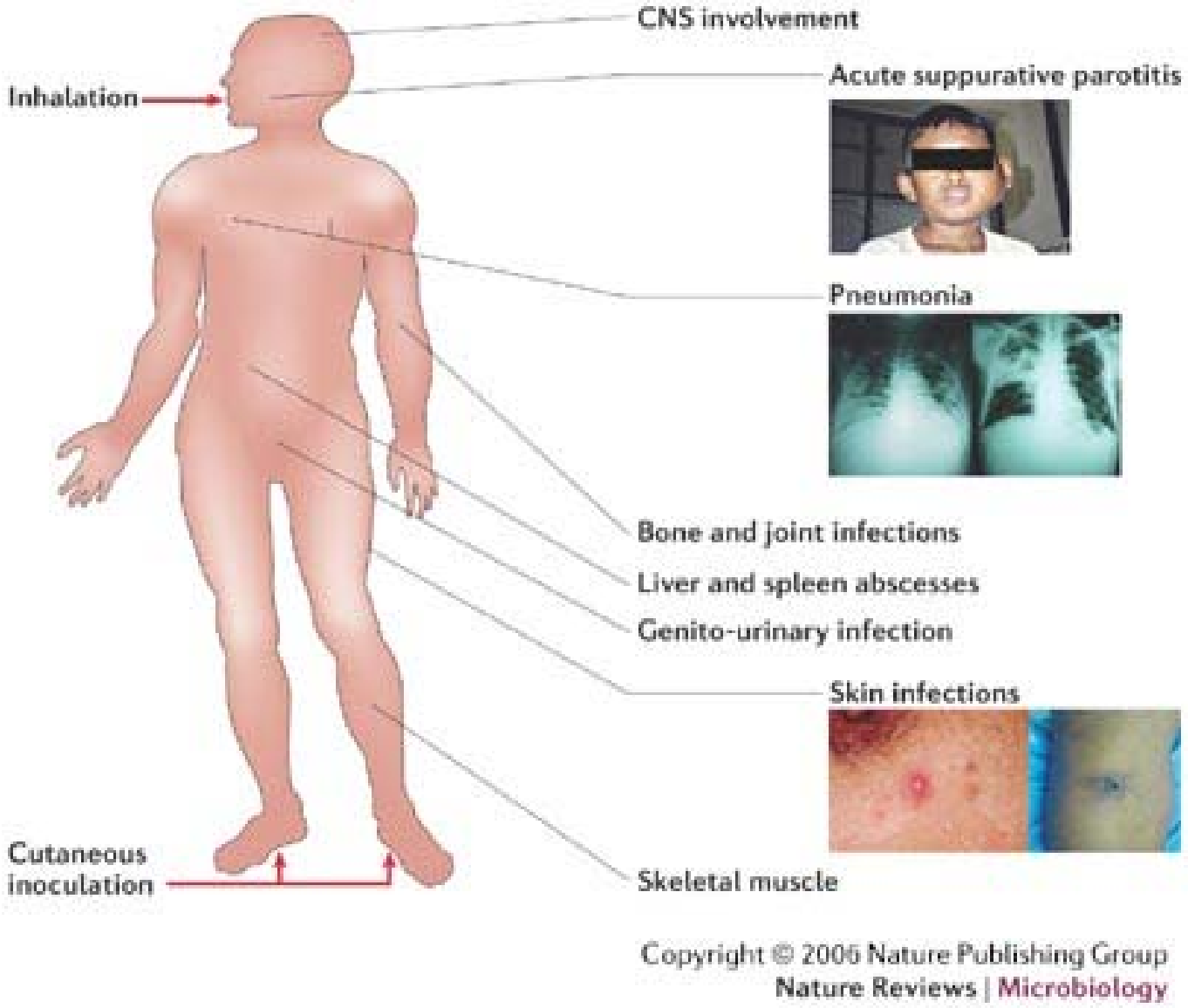
# Pathogenic, Gram-Negative, Aerobic Bacilli



- *Burkholderia*
  - Aerobic, flagellated betaproteobacterium
  - Can decompose a broad range of organic molecules
  - Likely involved in clean up of contaminated environmental sites
  - Used by farmers to reduce fungal infection of plant crops
  - Opportunistic pathogen of cystic fibrosis patients
  - Resistant to many antimicrobial drugs
  - Also causes melioidosis 類鼻疽

# Melioidosis 類鼻疽





# Pathogenic, Gram-Negative, Aerobic Bacilli



- Pseudomonads
  - Gram-negative, aerobic bacilli
  - Ubiquitous in soil, decaying organic matter, moist environments
  - Problematic in hospitals
  - Opportunistic pathogens

# Pathogenic, Gram-Negative, Aerobic Bacilli



- Pseudomonads
  - *Pseudomonas aeruginosa*
    - Rarely part of normal human microbiota
    - Rarely causes disease
    - Only an opportunistic pathogen
    - Can colonize almost any organ or system
    - Often infects the lungs of cystic fibrosis patients
      - Biofilm protects bacteria from phagocytosis
    - Treatment is difficult due to drug resistance

# A *Pseudomonas aeruginosa* infection





Figure 20.26

# Pathogenic, Gram-Negative, Aerobic Bacilli



- Pseudomonads
  - *Moraxella* and *Acinetobacter*
    - Aerobic, short, plump bacilli
    - *Moraxella catarrhalis*
      - Opportunistic infections of the sinuses, bronchi, ears, and lungs
    - *Acinetobacter*
      - Grows in soil, water, and sewage
      - Opportunistic infections of the respiratory, urinary, and central nervous systems

# Pathogenic, Gram-Negative, Aerobic Bacilli



- Pseudomonads
  - *Francisella tularensis*
    - Nonmotile, strictly aerobic coccobacillus
    - Intracellular parasite of animals and amoebae in water
    - Causes the zoonotic disease tularemia (rabbit fever)
      - Spread through bite of an infected tick or contact with an infected animal
      - The bacteria is highly infectious
      - Tuleremia may be misdiagnosed
      - Vaccine available to at-risk individuals

# Pathogenic, Gram-Negative, Aerobic Bacilli



- Pseudomonads
  - *Legionella*
    - Aerobic, slender, pleomorphic bacteria
    - Universal inhabitants of water
    - Humans inhale bacteria in aerosols from water sources
    - Intracellular parasites
    - *L. pneumophila* causes most disease in humans
    - Causes Legionnaires' disease
      - Results in pneumonia
    - Elimination of the bacteria is not feasible

# *Legionella pneumophila*



The buffered '**charcoal yeast extract agar**' is required for growing *Legionella spp.*

-Contains iron salts

-High concentrations of Cysteine



Figure 20.27

# Pathogenic, Gram-Negative, Aerobic Bacilli



- Pseudomonads
  - *Coxiella burnetii*
    - Extremely small, aerobic bacteria
    - Infective body enables survival in harsh environmental conditions
    - Obligate intracellular parasite
    - Originally thought to be a virus
    - Causes Q fever
    - Farm animals and pets are associated with human disease
    - Transmission occurs by inhalation of the infective bodies

# *Coxiella burnetii*



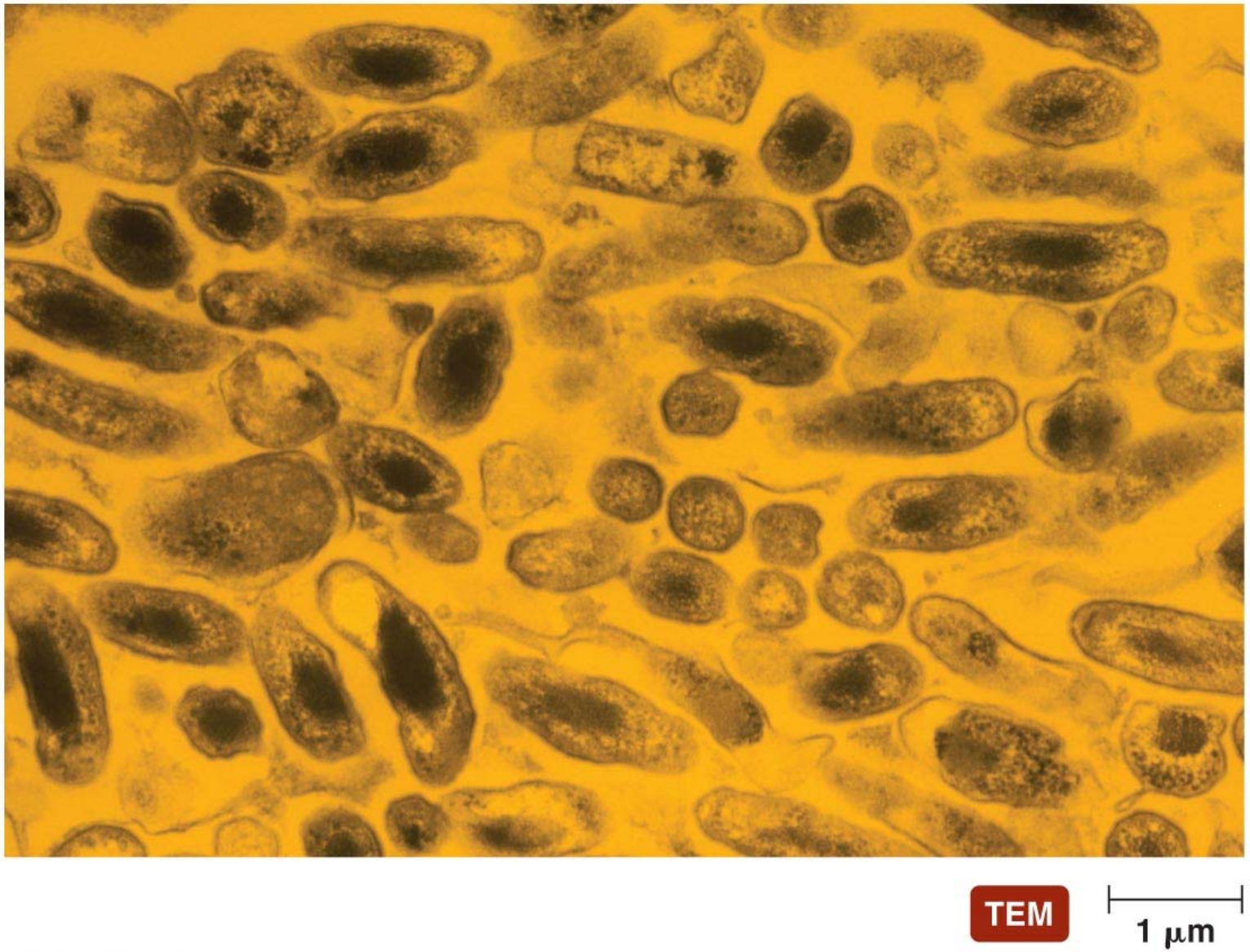





Figure 20.28

# Pathogenic, Gram-Negative, Anaerobic Bacilli



- Predominant microbiota of the gastrointestinal, urinary, reproductive, and lower respiratory tracts
- Important for human health
  - Inhibit the growth of most pathogens
  - Synthesize vitamins and vitamin precursors
  - Aid in digestion of food
- Cause disease when introduced into other parts of the body

# Pathogenic, Gram-Negative, Anaerobic Bacilli



- *Bacteroides* 類桿菌/擬桿菌
  - Normal microbiota of the intestinal and upper respiratory tracts
  - *Bacteroides fragilis* is the most important
  - Involved in a variety of conditions
    - Abdominal infections
    - Genital infections in women
    - Wound infections of the skin

# *Bacteroides fragilis*



The '**bile-esculin agar**' is commonly used for growing anaerobes
-(selective) **Bile** suppresses growth of most aerobes and facultative anaerobes
-(differential) **Esculin** is hydrolyzed *Enterococci* and *B. fragilis*. The hydrolyzed products react with ferric citrate to form insoluble iron salts.



Figure 20.29

# Pathogenic, Gram-Negative, Anaerobic Bacilli



- *Prevotella*
  - Normal microbiota of urinary, genital, and upper respiratory tracts
  - Involved in various conditions
    - Sinus and ear infections
    - Almost all periodontal infections
    - Gynecological infections
    - Brain abscesses
    - Abdominal infections

# End of Chapter