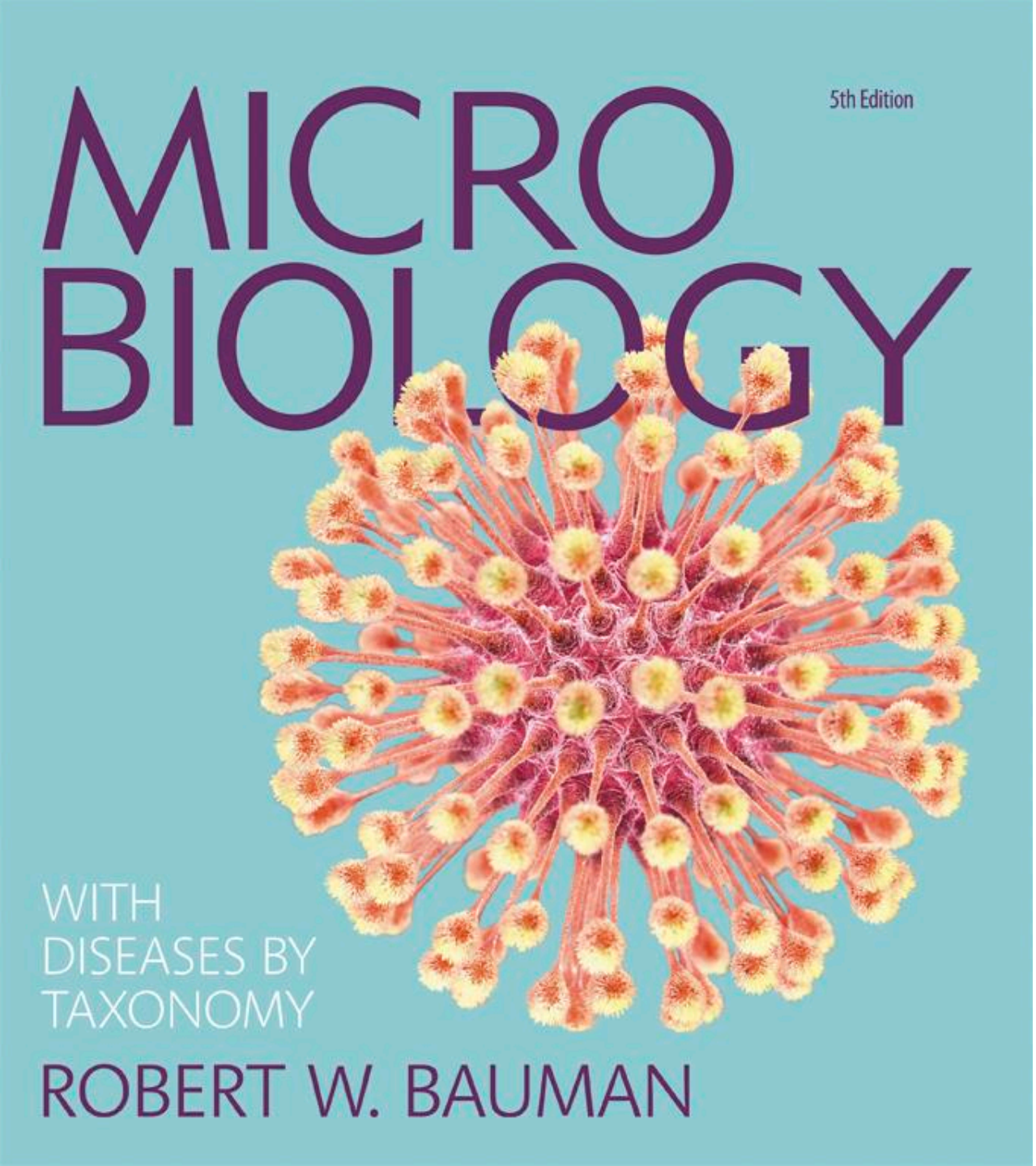
Chapter 19 – Pathogenic Gram-Positive Bacteria

NIMESH PATEL| HLSC 2400

OCTOBER 19, 2017



PowerPoint® Lecture Presentations prepared by Mindy Miller-Kittrell, North Carolina State University

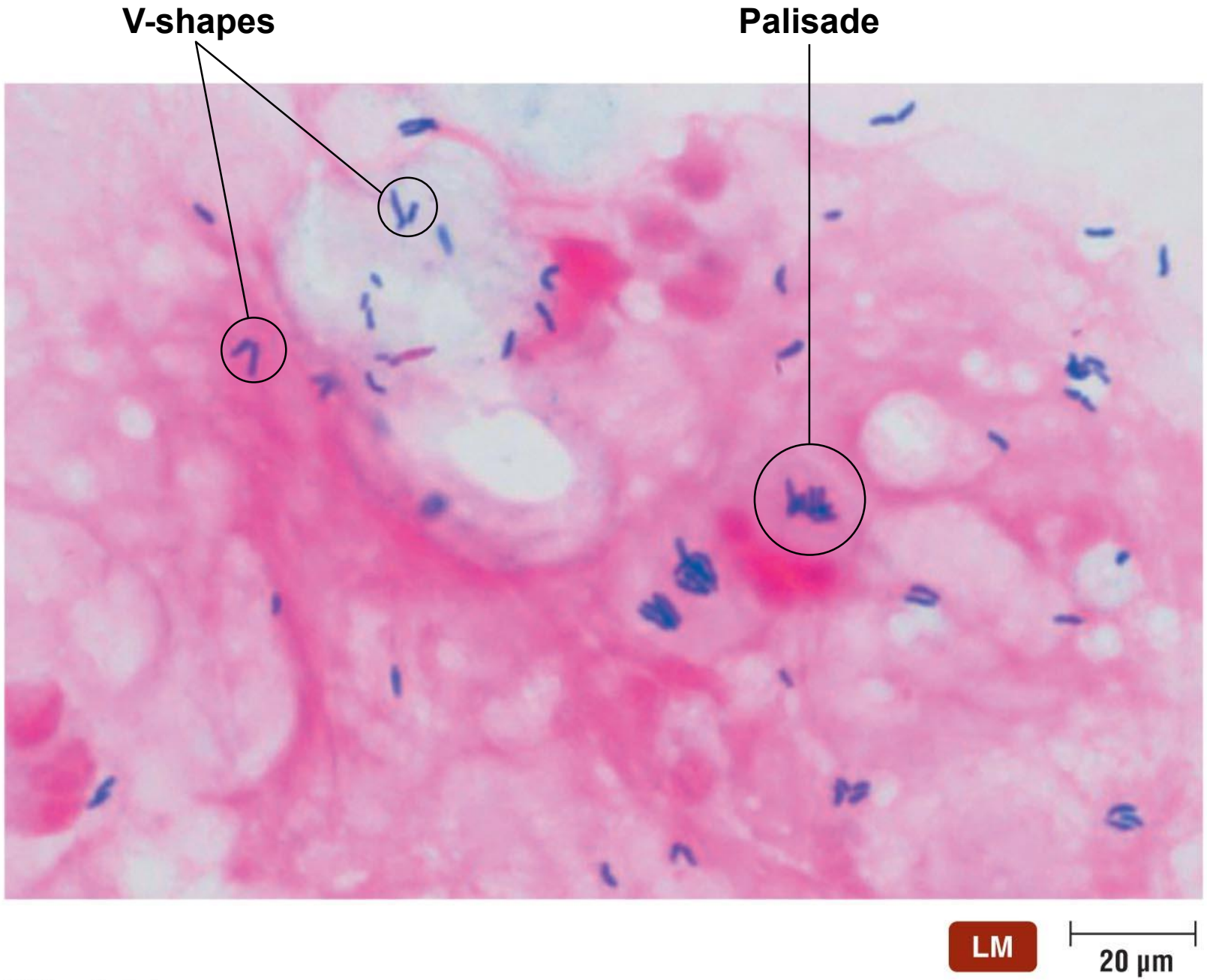
CHAPTER 19

Pathogenic Gram-Positive Bacteria

Corynebacterium

- Pleomorphic, non-endospore-forming bacteria
- Ubiquitous on plants and in animals and humans
- Colonize the skin and respiratory, gastrointestinal, urinary, and genital tracts
- Divide via snapping division

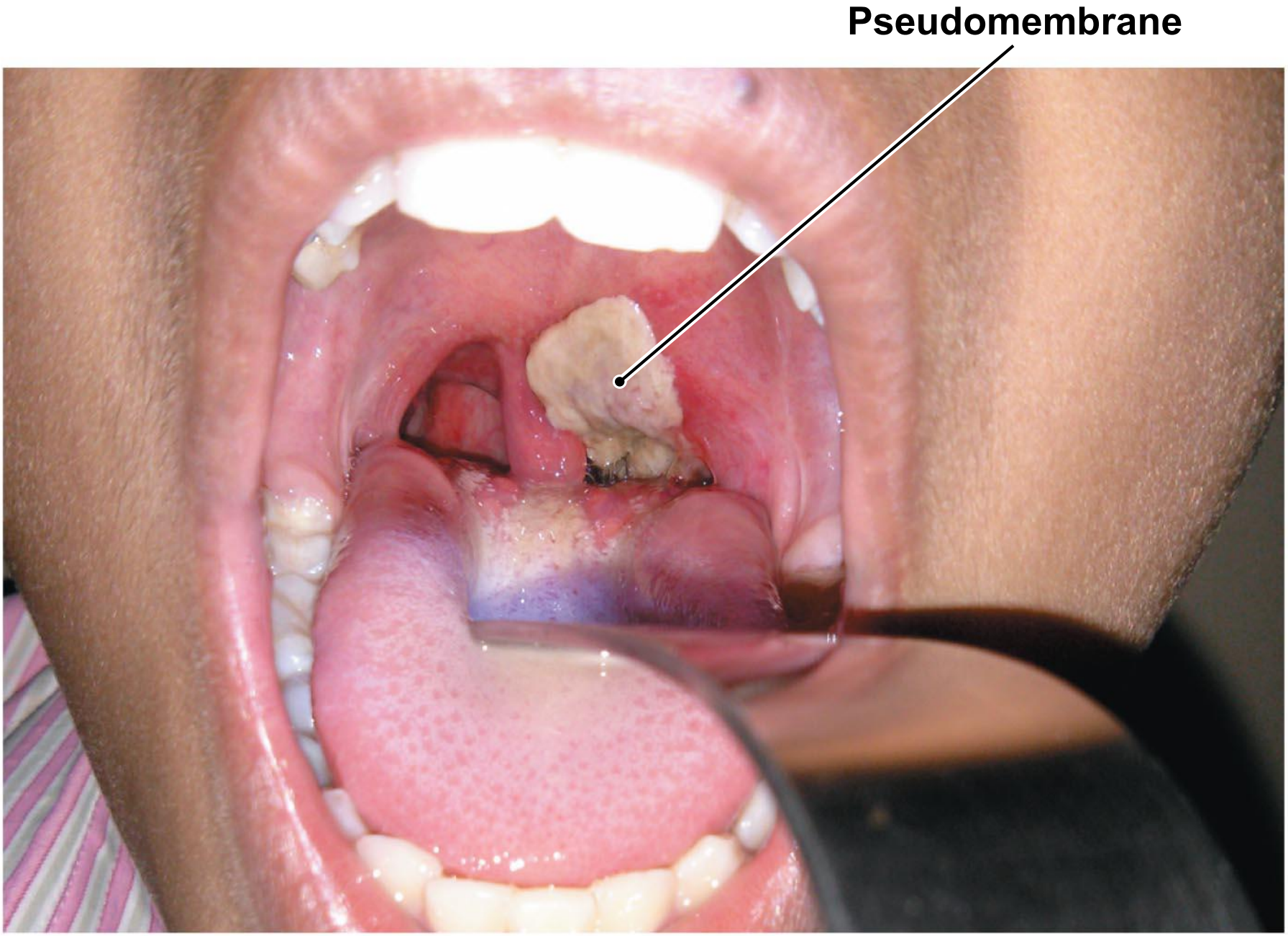
Figure 19.20 Gram-stained *Corynebacterium diphtheriae*.



Corynebacterium

- **Pathogenesis, Epidemiology, and Disease**
  - *Corynebacterium diphtheriae*
    - Causes diphtheria
      - Endemic in poor parts of the world that lack immunization
    - Reservoir: Throat and nasopharynx
    - Transmitted from person to person via respiratory droplets or skin contact
    - Diphtheria toxin causes the signs and symptoms of disease
      - Inhibits polypeptide synthesis in eukaryotes
      - Bacteria that do not produce the toxin are not pathogenic
    - Formation of a pseudomembrane can cause suffocation

Figure 19.21 A pseudomembrane.



Corynebacterium

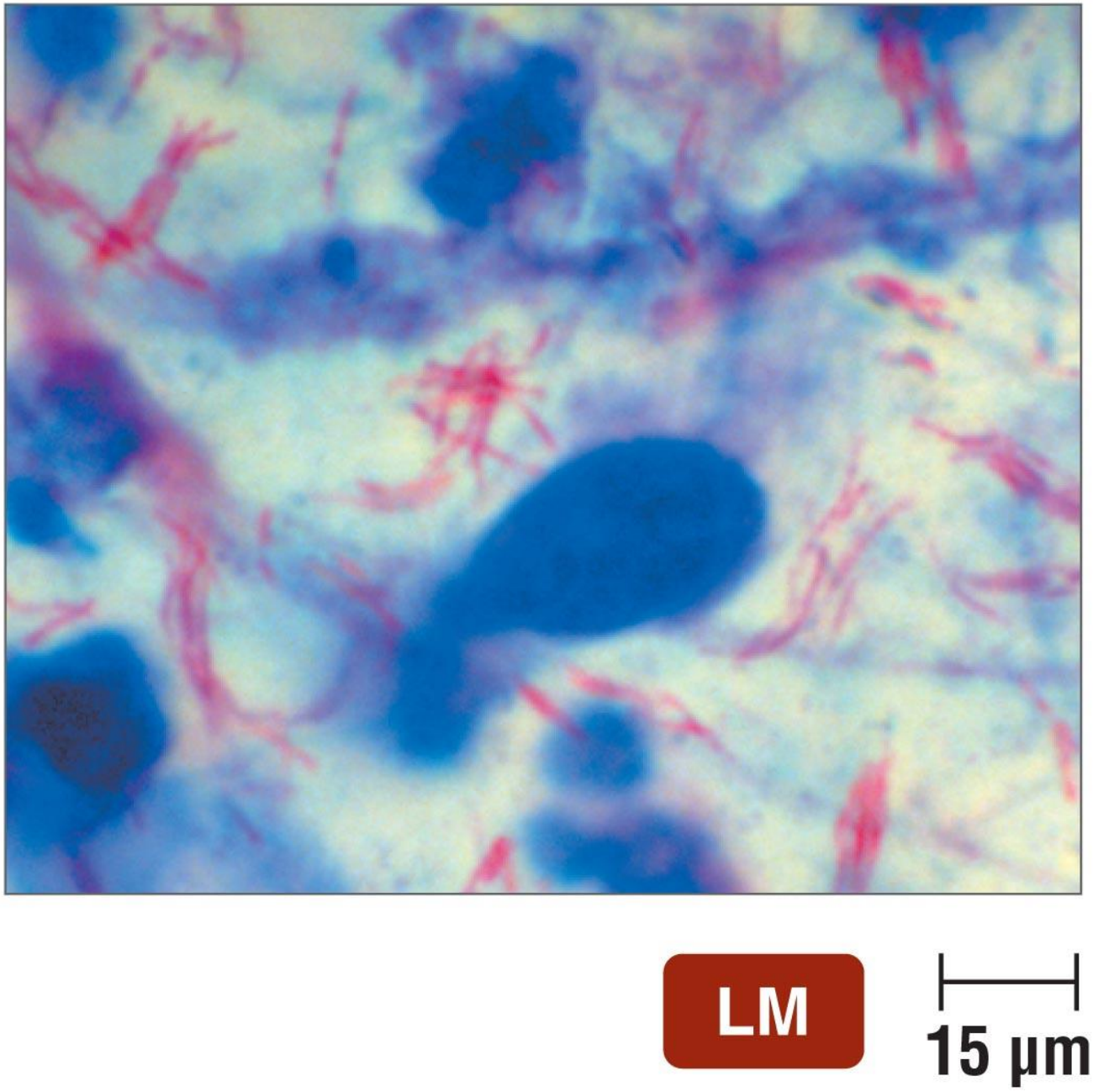
- **Diagnosis, Treatment, and Prevention**
  - Diagnosis
    - Initial diagnosis based on presence of a pseudomembrane
    - Elek test used to confirm diagnosis
  - Treatment
    - Administration of antitoxin neutralizes effects of the toxin
    - Penicillin or erythromycin kills the bacterium
    - Surgery may be needed to open a blocked airway
  - Prevention
    - Immunization is the most effective way to prevent diphtheria

Mycobacterium

- Non-endospore-forming pathogen
- Cell wall contains a waxy lipid called **mycolic acid**
  - Results in a number of unique characteristics
    - Slow growth
    - Protection from lysis after phagocytosis
    - Capacity for intracellular growth
    - Resistance to Gram staining, detergents, many antimicrobial drugs, and desiccation

Mycobacterium

- **Tuberculosis (TB)**
  - Respiratory disease caused by *Mycobacterium tuberculosis*
  - Once referred to as "consumption"
  - *M. tuberculosis* is not highly virulent



Mycobacterium

- **Tuberculosis**
  - Pathogenesis and Disease
    - Three types of tuberculosis:
      - Primary tuberculosis
        - Results from the initial infection with *M. tuberculosis*
      - Secondary or reactivated tuberculosis
        - Reestablishment of active infection after period of dormancy

Mycobacterium

- **Tuberculosis**
  - Pathogenesis and Disease
    - Three types of tuberculosis:
      - Disseminated tuberculosis
        - Results when infection spreads throughout the body
        - Symptoms arise due to complications at the various sites involved

DISEASE
IN DEPTH

TUBERCULOSIS

Mycobacterium tuberculosis

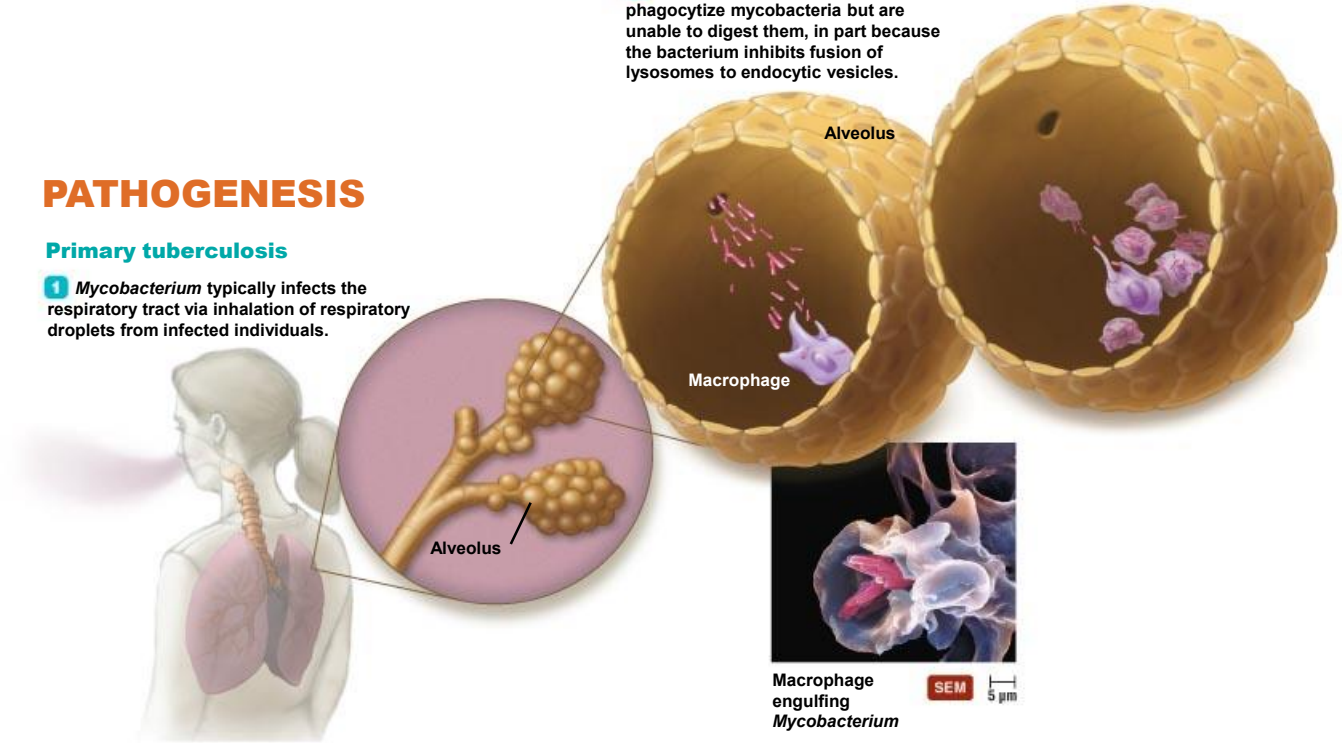
PATHOGENESIS

Primary tuberculosis

1 *Mycobacterium* typically infects the respiratory tract via inhalation of respiratory droplets from infected individuals.

2 Macrophages in alveoli phagocytize mycobacteria but are unable to digest them, in part because the bacterium inhibits fusion of lysosomes to endocytic vesicles.

3 Instead, bacteria replicate freely within macrophages, gradually killing the phagocytes. Bacteria released from dead macrophages are phagocytized by other macrophages, beginning the cycle anew.



Macrophage engulfing *Mycobacterium*

DISEASE
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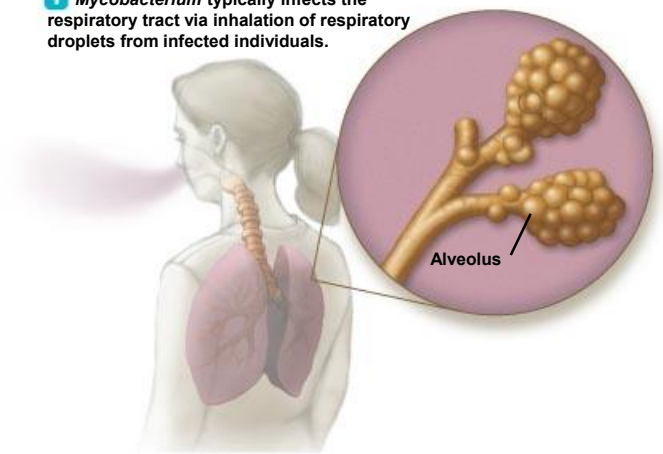

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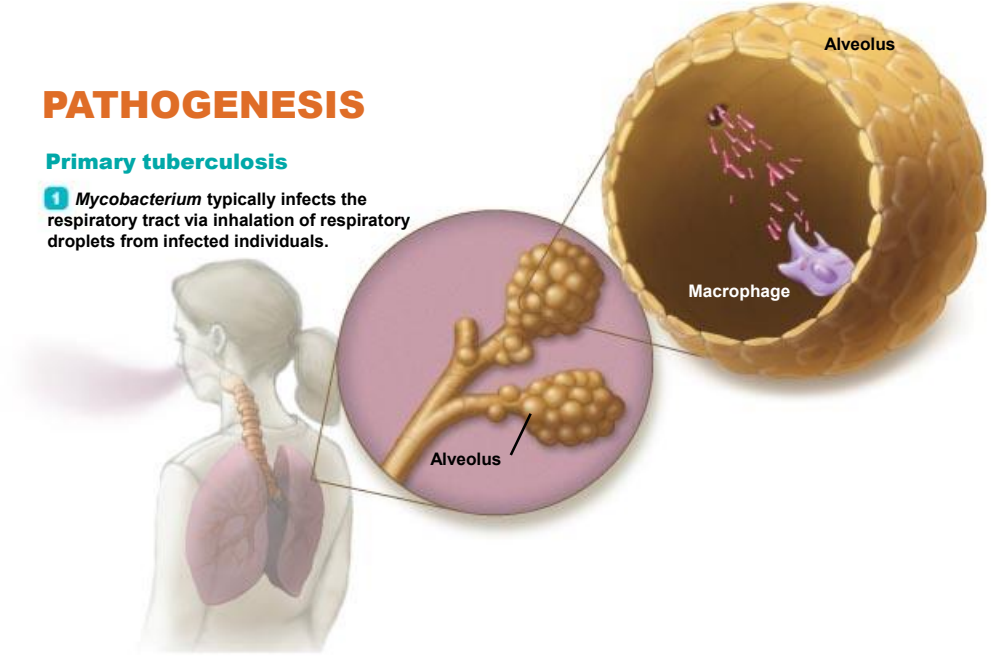

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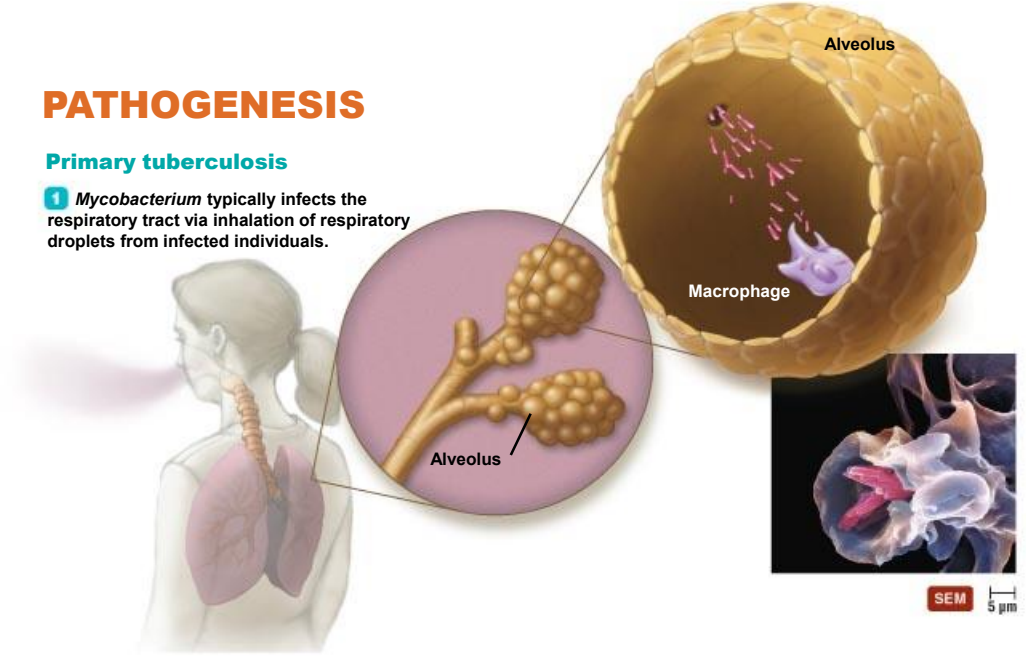

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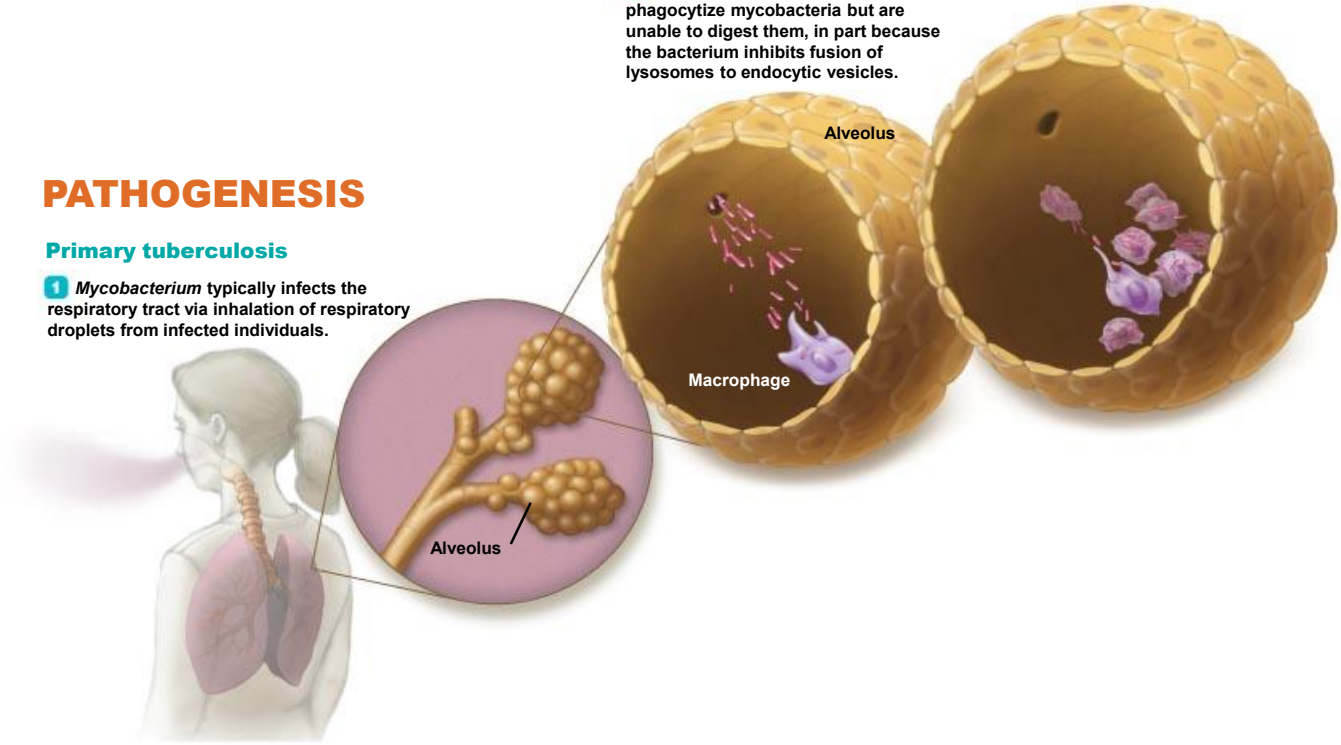
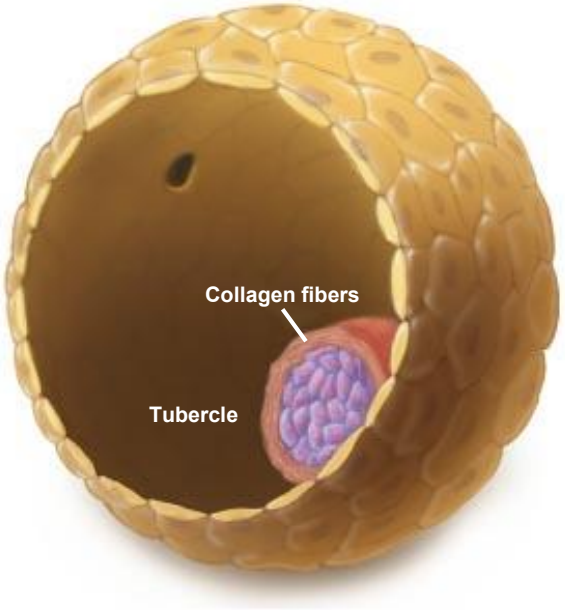


4 Infected macrophages present antigen to T lymphocytes, which produce lymphokines that attract and activate more macrophages and trigger inflammation. Tightly packed macrophages surround the site of infection, forming a tubercle over a two- to three-month period.



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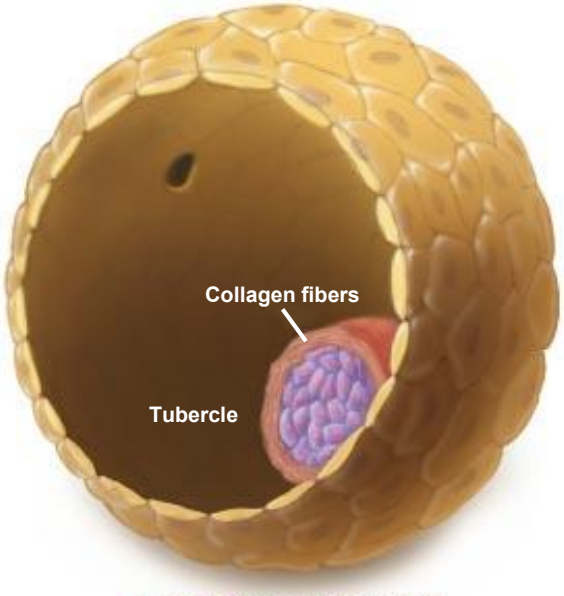
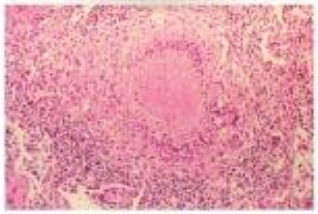




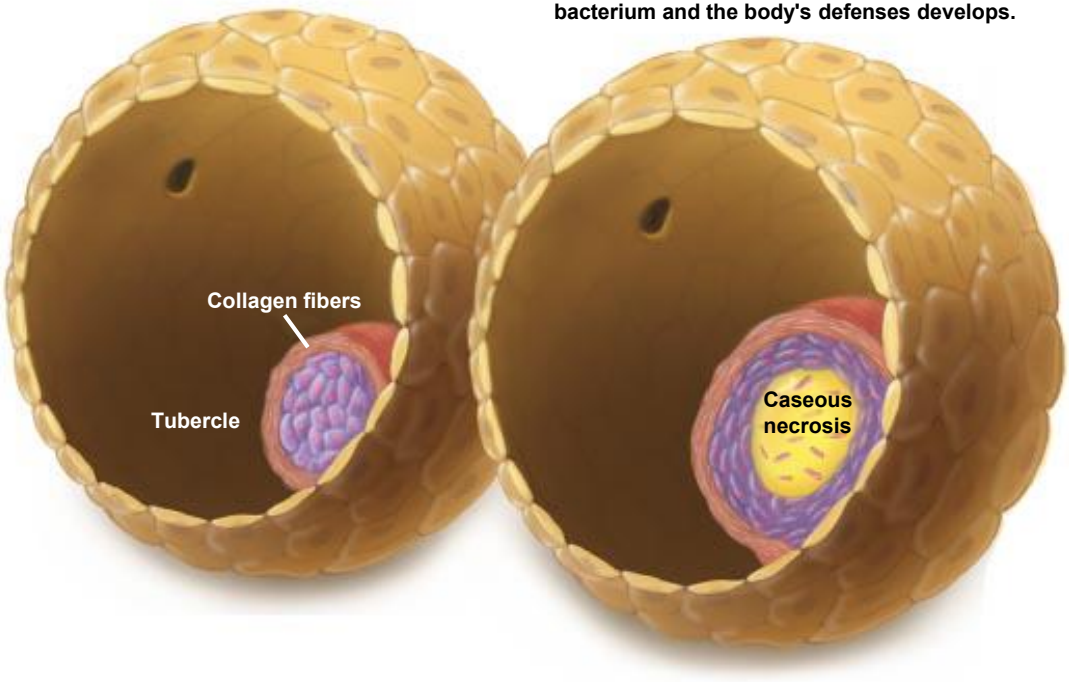
Tubercle in lung tissue

LM

50 µm

4 Infected macrophages present antigen to T lymphocytes, which produce lymphokines that attract and activate more macrophages and trigger inflammation. Tightly packed macrophages surround the site of infection, forming a tubercle over a two- to three-month period.

5 Other cells deposit collagen fibers, enclosing infected macrophages and lung cells within the tubercle. Infected cells in the center die, releasing *M. tuberculosis* and producing caseous necrosis—the death of tissue that takes on a cheese-like consistency due to protein and fat released from dying cells. A stalemate between the bacterium and the body's defenses develops.



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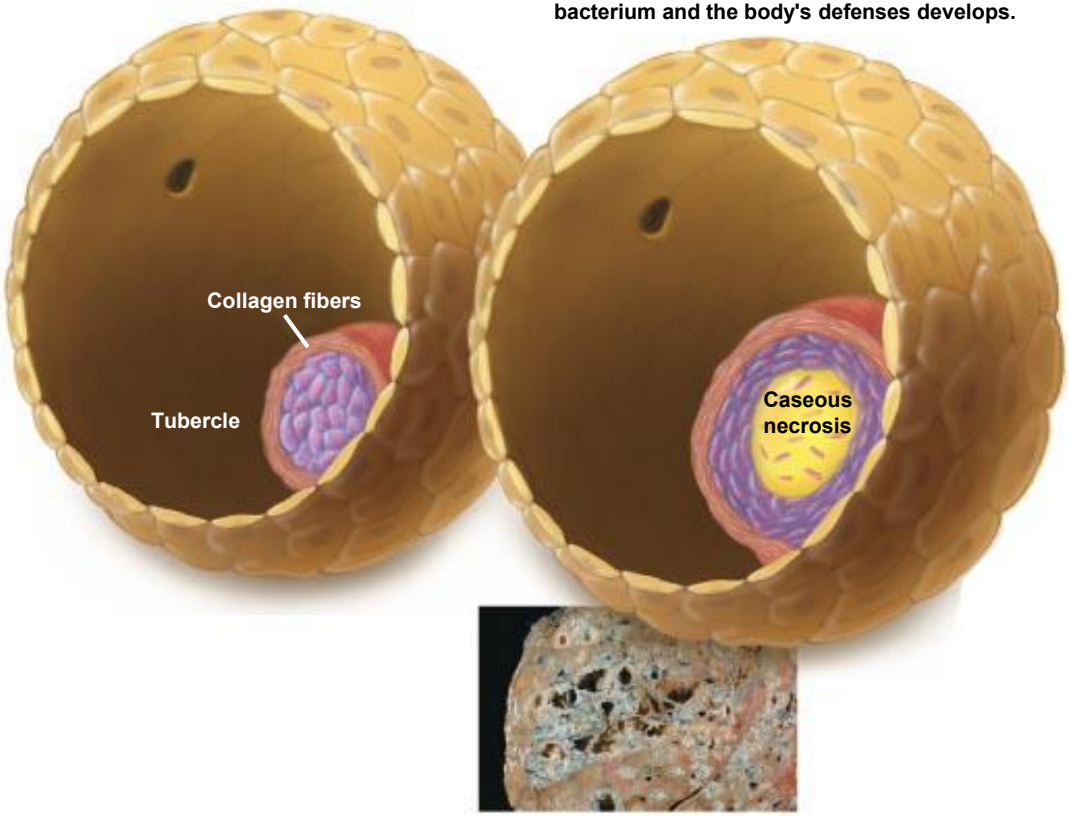

Lung lesions caused by TB

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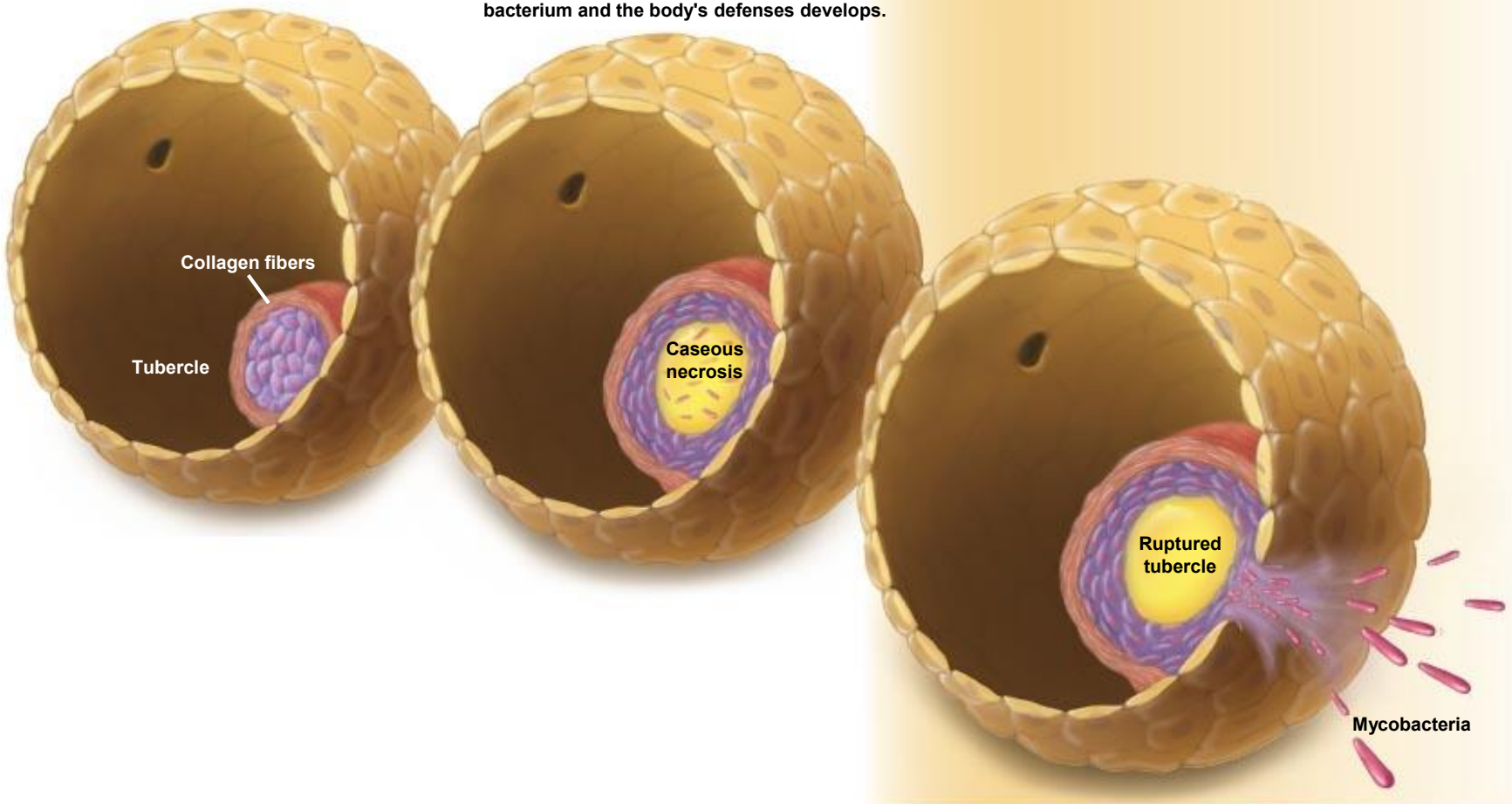
Secondary/reactivated tuberculosis results when *M. tuberculosis* breaks the stalemate, ruptures the tubercle, and reestablishes an active infection. Reactivation occurs in about 10% of patients, especially those whose immune systems are weakened by disease, poor nutrition, drug or alcohol abuse, or other factors.



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Disseminated tuberculosis results when macrophages carry the pathogen via blood and lymph nodes to other sites, including bone marrow, spleen, kidneys, spinal cord, and brain.

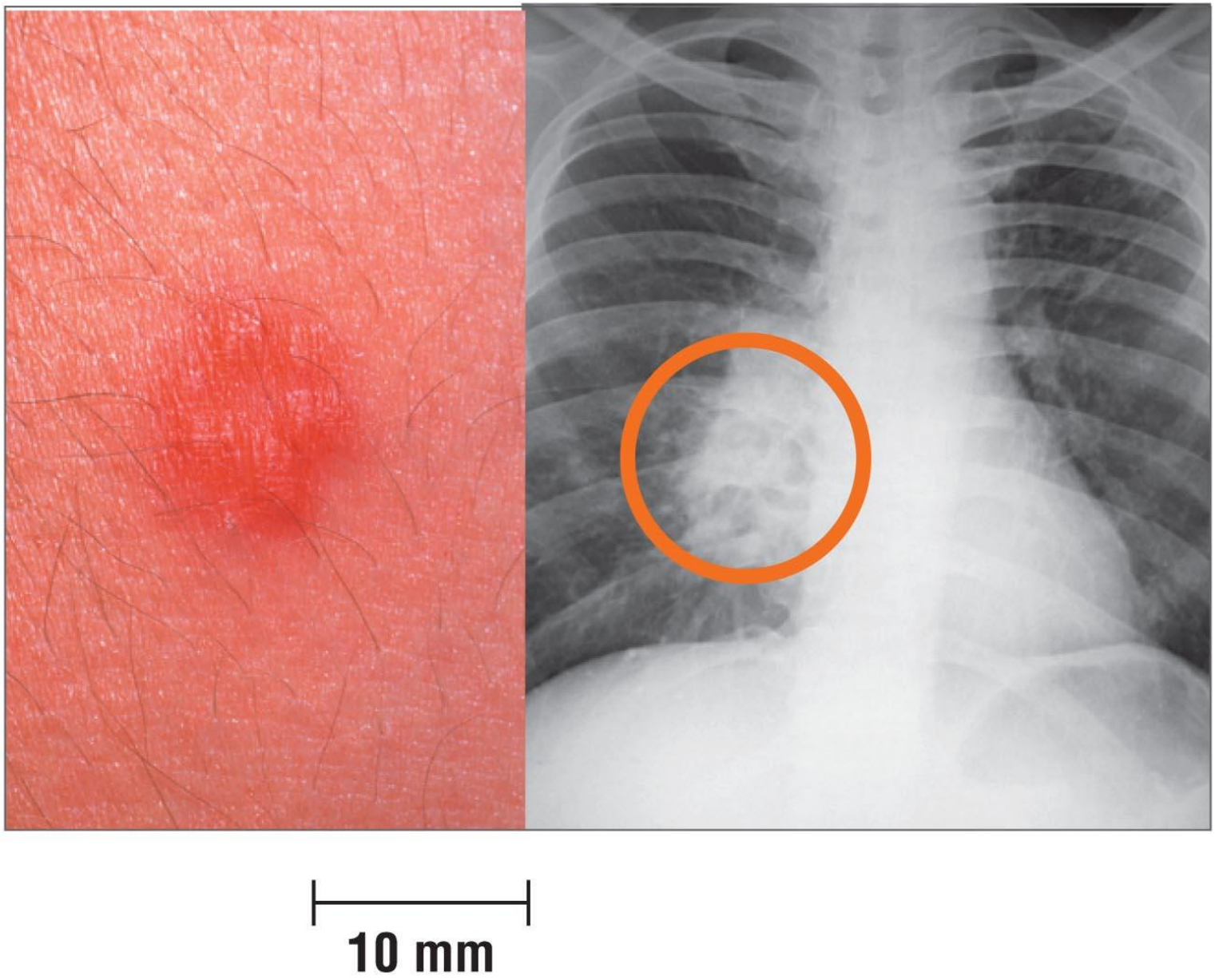
Tuberculosis lesions in spleen

Mycobacterium

- **Tuberculosis**
  - Epidemiology
    - Cases are declining in the United States
    - Most common in Asia and Africa
    - One-third of the world's population is infected
    - Multi-drug-resistant and extensively drug-resistant strains of *M. tuberculosis* have developed in some countries

Mycobacterium

- **Tuberculosis**
  - Diagnosis, Treatment, and Prevention
    - Diagnosis
      - Tuberculin skin test identifies possible exposure
      - Chest X rays identify individuals with active disease
    - Treatment
      - Common antimicrobials ineffective
      - Combination therapy used for months to treat the disease
    - Prevention
      - Immunization with BCG vaccine where TB is common
      - Avoid inhaling respiratory droplets from TB patients



Mycobacterium

- **Leprosy**
  - Also referred to as "Hansen's disease"
  - Caused by *Mycobacterium leprae*
    - Grows best in cooler regions of the human body
    - Bacteria do not grow in cell-free culture
    - Armadillos are the only known host other than humans

Mycobacterium

- **Leprosy**
  - Pathogenesis, Epidemiology, and Disease
    - Two different forms of the disease:
      - Tuberculoid leprosy
        - Nonprogressive form of the disease
        - Due to a strong cell-mediated immune response
      - Lepromatus leprosy
        - More virulent form of the disease
          - Due to a weak cell-mediated immune response
        - Cases are becoming relatively rare
    - Transmitted via person-to-person contact or break in the skin

Figure 19.22 Lepromatous leprosy can result in severe deformities.

Mycobacterium

- **Leprosy**
  - Diagnosis, Treatment, and Prevention
    - Diagnosis
      - Based on signs and symptoms of disease
    - Treatment
      - Combination of antimicrobial drugs
      - Lifelong treatment is sometimes needed
    - Prevention
      - Limiting exposure to the pathogen
      - BCG vaccine provides some protection

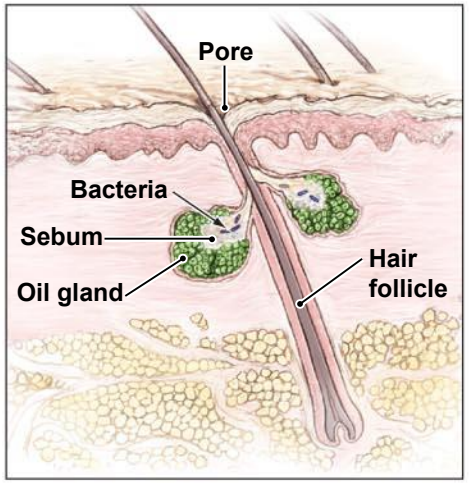
Mycobacterium

- **Other Mycobacterial Infections**
  - *Mycobacterium avium-intracellulare*
    - Most common mycobacterial infection among AIDS patients in the United States
    - Infections result from ingestion of contaminated food or water
    - Affects almost every organ
      - Results in massive organ failure
    - Treatment is difficult due to the disseminated nature of the infection

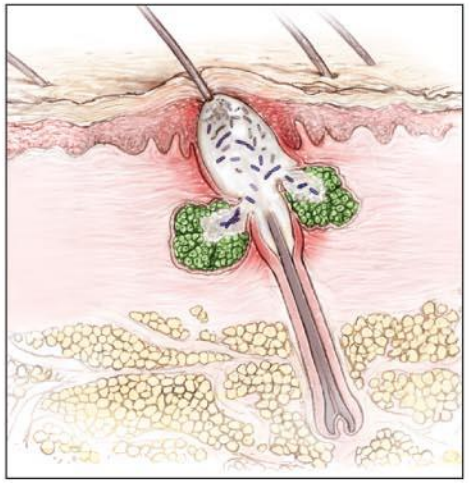
Propionibacterium

- Small, anaerobic rods often found on the skin
- *Propionibacterium acnes*
  - Most commonly involved in human infections
  - Causes acne in adolescents and young adults
  - May also be an opportunistic pathogen
  - Many cases require no treatment
  - Antimicrobial drugs help control bacterium

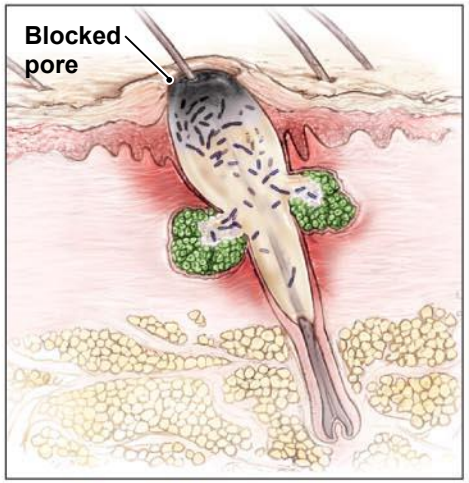
Figure 19.23 The development of acne.



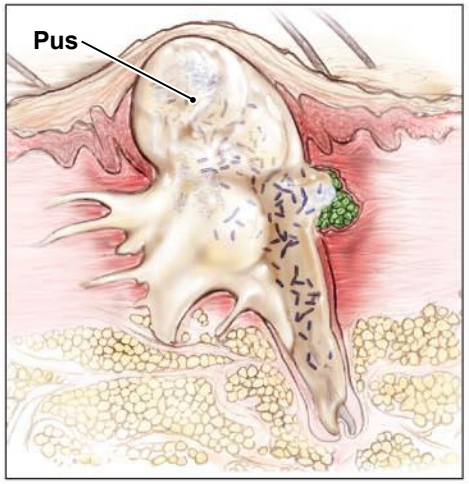
1 Normal skin
Oily sebum produced by glands reaches the hair follicle and is discharged onto the skin surface via the pore.



2 Whitehead
Inflamed skin swells over the pore when bacteria infect the hair follicle, leading to accumulation of sebum, colonizing bacteria, leukocytes, and pus.



3 Blackhead
Dead and dying bacteria and sebum form a blockage of the pore.



4 Pustule formation
Severe inflammation of the hair follicle causes pustule formation and rupture, producing cystic acne, which is often resolved by scar tissue formation.

Nocardia and *Actinomyces*

- ***Nocardia asteroides***
  - Pathogenesis, Epidemiology, and Disease
    - Common inhabitant of soils rich in organic matter
    - Produces opportunistic infections in numerous sites
      - Pulmonary infections
        - Develop from inhalation of the bacteria
      - Cutaneous infections
        - Result from introduction of the bacteria into wounds
        - May produce a mycetoma
      - Central nervous system infections
        - Result from spread of bacteria in the blood

Figure 19.24 Lesions of *Nocardia* on the sole of a left foot.

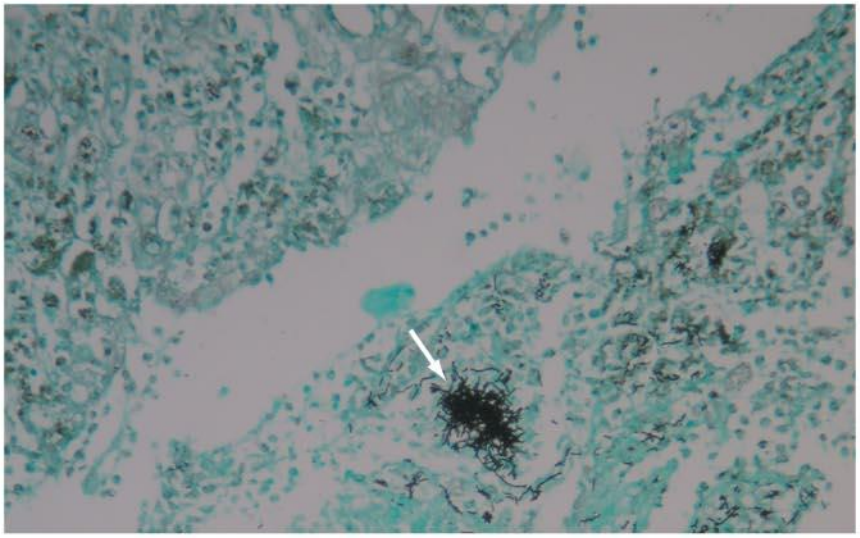
Nocardia and *Actinomyces*

- ***Nocardia asteroides***
  - Diagnosis, Treatment, and Prevention
    - Diagnosis
      - Presence of *Nocardia* in samples is usually diagnostic
    - Treatment
      - Six-week course with sulfonamides
      - Immunocompromised patients have poor prognosis
    - Prevention
      - Avoiding exposure to bacterium in soil

Nocardia and *Actinomyces*

- ***Actinomyces***
  - Pathogenesis, Epidemiology, and Disease
    - Normal microbiota of human mucous membranes
    - Opportunistic infections
      - Occur in the respiratory, gastrointestinal, urinary, and female genital tracts
    - Actinomycosis
      - Bacteria enter through breaks in the mucous membrane
      - Develop abscesses connected by channels in skin or mucous membranes

Figure 19.25 ***Actinomyces.***



(a)

(b)

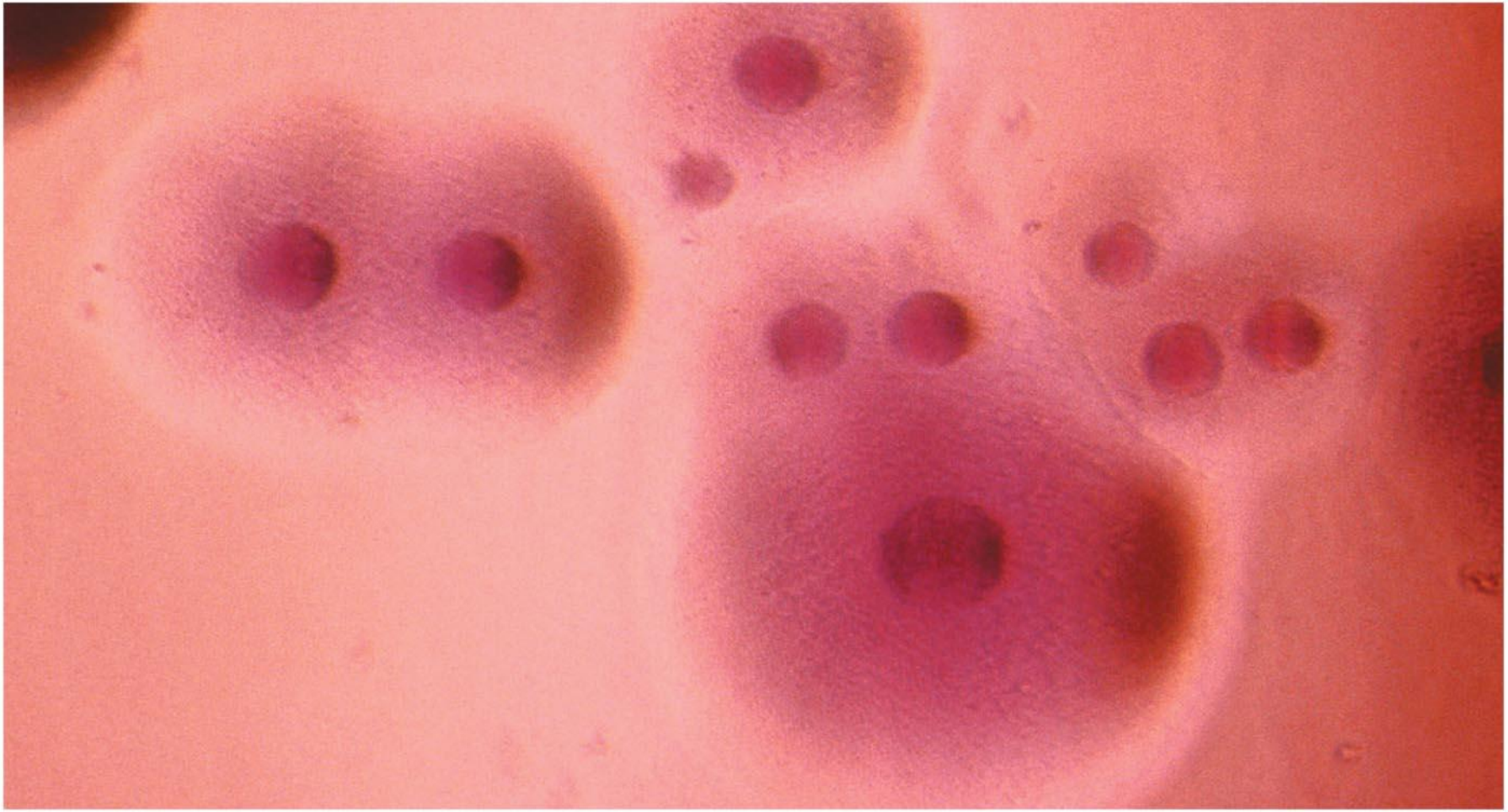
Nocardia and *Actinomyces*

- ***Actinomyces***
  - Diagnosis, Treatment, and Prevention
    - Diagnosis
      - Diagnosis difficult
        - Other organisms cause similar symptoms
    - Treatment
      - Surgical removal of infected tissue
      - Administration of penicillin for several months
    - Prevention
      - Good oral hygiene
      - Prophylactic use of antimicrobials if breach of mucous membranes occurs

Mycoplasmas

- Smallest free-living microbes
- Lack cytochromes, enzymes of the Krebs cycle, and cell walls
- Most have sterols in their cytoplasmic membranes
- Require various growth factors from a host or supplied in laboratory media
- Can colonize the mucous membranes of the respiratory and urinary tracts
- Associated with pneumonia and urinary tract infections
- Only a few species cause significant human disease

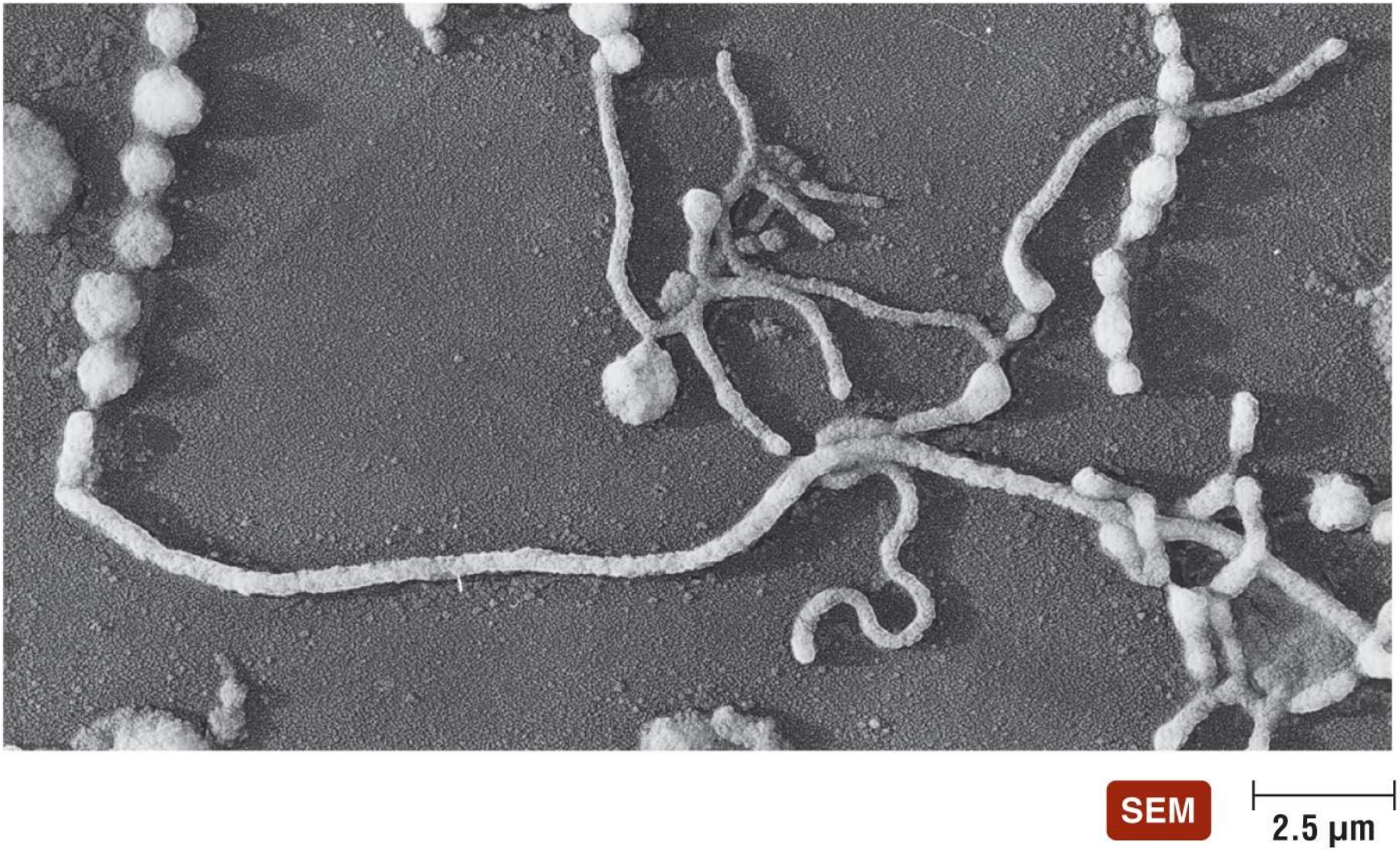
Figure 19.18 Colonies of *Mycoplasma*.



Mycoplasmas

- ***Mycoplasma pneumoniae***
  - Pathogenesis, Epidemiology, and Disease
    - Attaches to epithelial cells lining the human respiratory tract
      - Removal of mucus impaired, allowing bacteria to colonize
    - Causes **primary atypical pneumonia**
      - Early symptoms not typical of other types of pneumonia
      - Not usually severe enough to require hospitalization
        - Sometimes called walking pneumonia
      - Spread by nasal secretions among people in close contact
      - Common in children 5 to 15 years old

Figure 19.19 ***Mycoplasma pneumoniae*.**



Mycoplasmas

- ***Mycoplasma pneumoniae***
  - Diagnosis, Treatment, and Prevention
    - Diagnosis
      - Mycoplasmas are small and difficult to detect
      - Mycoplasmas grow slowly in culture
    - Treatment
      - Macrolides, doxycycline, or fluoroquinilones
    - Prevention
      - Patients often infectious without signs or symptoms
      - Prevent with proper hygiene and avoidance of aerosols and contaminated fomites

Mycoplasmas

- **Other Mycoplasmas**
  - *M. hominis, M. genitalium*, and *Ureaplasma urealyticum*
    - Associated with human diseases
    - Often colonize the urinary and genital tracts of newborn girls
  - *M. genitalium* and *U. urealyticum*
    - Cause nongonococcal urethritis
  - *M. hominis*
    - Can cause **pelvic inflammatory disease (PID)** in women
  - Infections can be treated with various antibiotics
  - Abstinence and safe sex can help prevent the spread of these organisms