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KR1

MICROBIOLOGY

WITH DISEASES BY TAXONOMY, THIRD EDITION

Chapter 19

Pathogenic Gram-Positive Bacteria

致病性革蘭氏陽性菌

投影片 1

KR1

ms is actually from tax 2e

Kelly Reed, 2009/12/08

- Understand the characteristics of clinically important G(+) bacteria
 - *Staphylococcus*
 - *Streptococcus*
 - *Enterococcus*
 - *Bacillus*
 - *Clostridium*
 - *Listeria*
 - *Corynebacterium*
 - *Propionibacterium*, *Nocardia* and *Actinomyces*

Gram-Positive Bacterial Pathogens

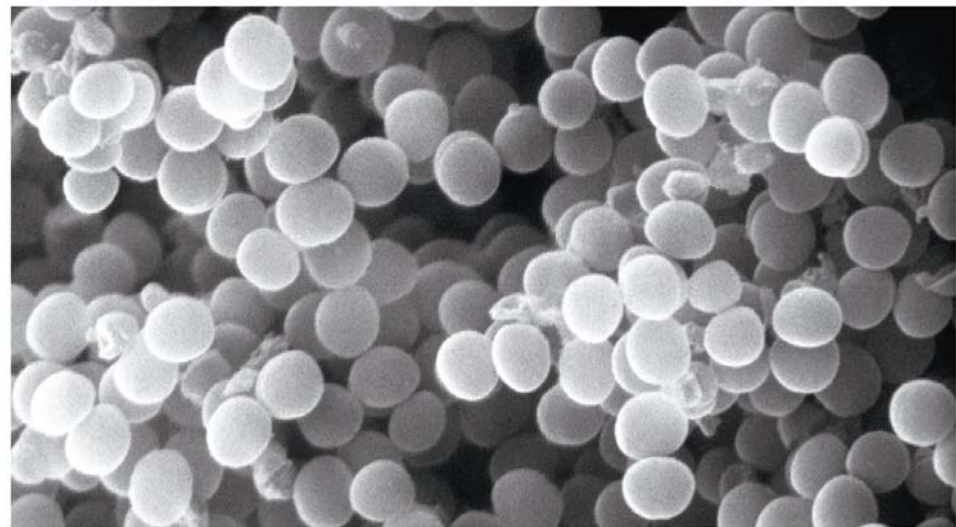
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- Stain purple when Gram-stained
- Two major groups based on DNA
 - Low G + C bacteria
 - High G + C bacteria

Staphylococcus

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- Normal members of every human's microbiota
- Can be **opportunistic pathogens**



SEM | 2 μ m

- Structure and Physiology
 - Gram-positive cocci, nonmotile, facultative anaerobes
 - Cells occur in grapelike clusters
 - Salt-tolerant
 - Tolerate salt on human skin
 - Tolerant of desiccation
 - Survive on environmental surfaces

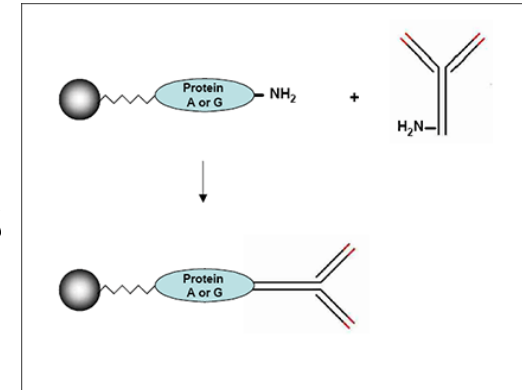
- Structure and Physiology
 - Two species commonly associated with diseases in humans
 - *Staphylococcus aureus*
 - More virulent strain
 - Variety of conditions depending on site of infection
 - *Staphylococcus epidermidis*
 - Normal microbiota of human skin
 - Opportunistic infections

- **Pathogenicity**

- Infections result when staphylococci breach body's physical barriers
- Entry of only a few hundred bacteria can result in disease
- Pathogenicity results from three features
 - Structures that enable it to evade phagocytosis
 - Production of enzymes
 - Production of toxins

- **Structural Defenses Against Phagocytosis**

- Protein A coats the cell surface
 - Interferes with humoral immune responses
 - Inhibits the complement cascade
- Bound coagulase
 - Converts fibrinogen to fibrin molecules
 - Fibrin clots hide the bacteria from phagocytic cells
- Synthesize polysaccharide slime layers (capsules)
 - Inhibit leukocyte chemotaxis and phagocytosis
 - Facilitate attachment of *Staphylococcus* to surfaces



- **Enzymes**

- Cell-free **coagulase**
 - Triggers blood clotting
- **Hyaluronidase**
 - Breaks down hyaluronic acid
 - Enables the bacteria to spread between cells
- **Staphylokinase**
 - Dissolves fibrin threads in blood clots
 - Allows *S. aureus* to free itself from clots

- **Enzymes**
 - Lipases
 - Digest lipids
 - Allow staphylococcus to grow on skin and in oil glands
 - β -lactamase
 - Breaks down penicillin
 - Allows bacteria to survive treatment with β -lactam antimicrobial drugs

- **Toxins**

- *S. aureus* produces toxins more frequently than *S. epidermidis*
- **Cytolytic toxins** 溶胞毒素
 - Disrupts the cytoplasmic membrane of a variety of cells
 - **Leukocidin** can lyse leukocytes specifically
- **Exfoliative toxins** 脫皮毒素
 - Cause skin cells to separate and slough off
- **Toxic-shock syndrome toxin** 中毒性休克症候群毒素
 - Causes toxic shock syndrome
- **Enterotoxins** 腸毒素
 - Stimulate symptoms associated with **food poisoning**

- **Staphylococcal Diseases**

- Three categories

- Noninvasive

- Food poisoning

- Due to ingestion of enterotoxin-contaminated food

- Cutaneous

- Various skin conditions

- Scalded skin syndrome, impetigo, folliculitis

- Systemic



- Variety of infections when bacteria invade deeper tissues



Staphylococcus scalded skin syndrome (SSSS)
葡萄球菌性燙傷樣皮膚症候群



Impetigo 膿包病

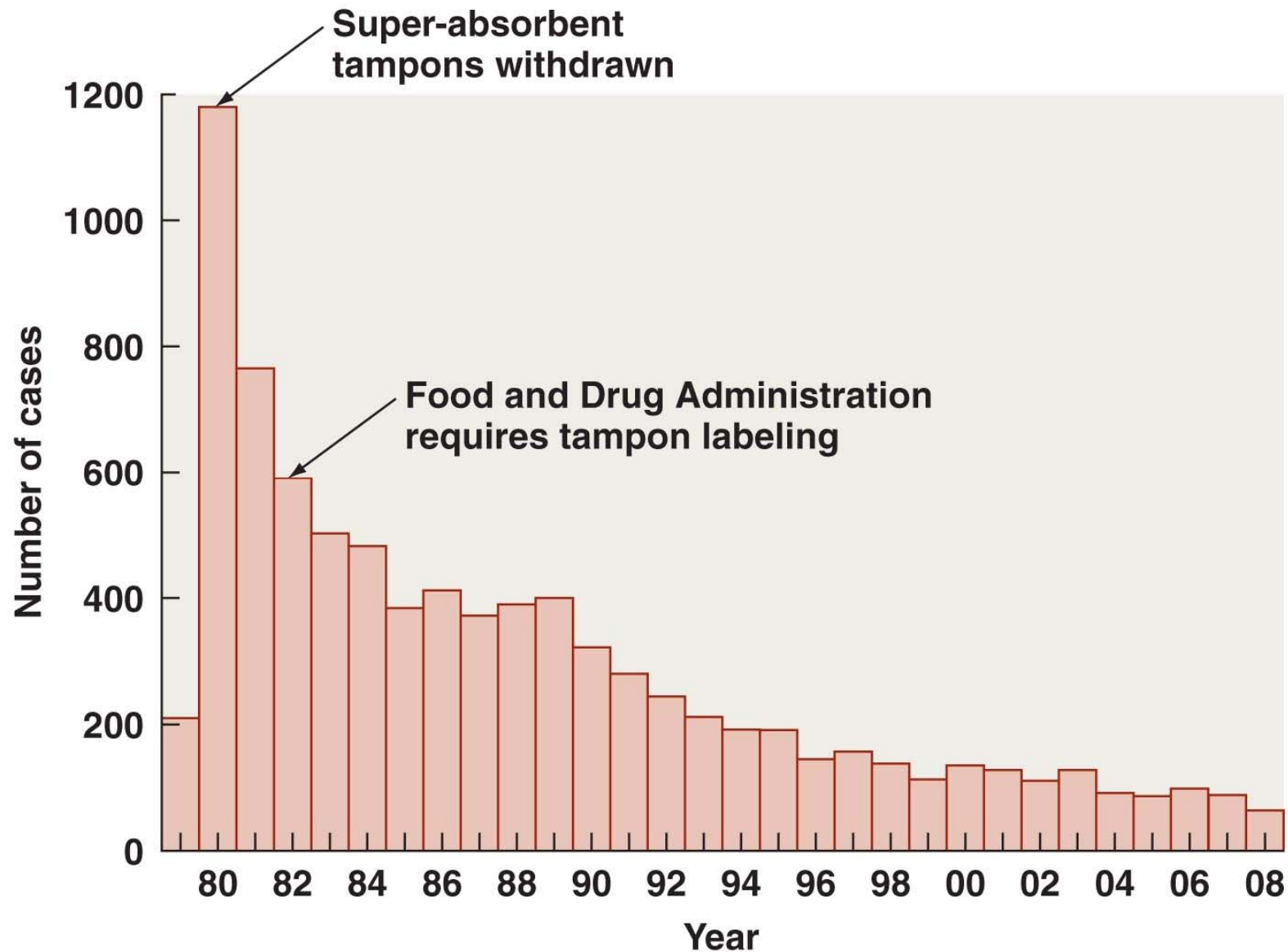
- Staphylococcal Diseases
 - Systemic disease
 - Staphylococcal toxic shock syndrome
 - Bacteremia
 - Endocarditis
 - Pneumonia
 - Osteomyelitis



Staphylococcal toxic shock syndrome

The incidence of staphylococcal toxic shock syndrome

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- Diagnosis, Treatment, and Prevention
 - Diagnosis
 - Detect Gram-positive bacteria in grapelike arrangements
 - Treatment
 - Methicillin
 - Vancomycin used to treat MRSA infections
 - Prevention
 - Hand antisepsis important to prevent nosocomial infections

“Methicillin-resistant *Staphylococcus aureus*”

- Gram-positive cocci, facultative anaerobes
- Arranged in **pairs** or **chains**
- Often categorized based on **Lancefield classification**
 - Divided into **serotypes** based on **bacteria's antigens**
 - Lancefield groups **A** and **B** include the significant human pathogens

- **Group A Streptococcus:** *Streptococcus pyogenes*
 - Pathogenicity
 - Structural components
 - Protein M
 - Hyaluronic acid capsule
 - Enzymes
 - Streptokinases, deoxyribonucleases, C5a peptidase
 - Pyrogenic toxins
 - Streptolysins

- **Group A Streptococcus:** *Streptococcus pyogenes*
 - Group A streptococcal diseases
 - Pharyngitis ("strep throat")
 - Scarlet fever
 -  – Pyoderma and erysipelas 
 - Streptococcal toxic shock syndrome
 - Necrotizing fasciitis
 - Rheumatic fever
 - Glomerulonephritis





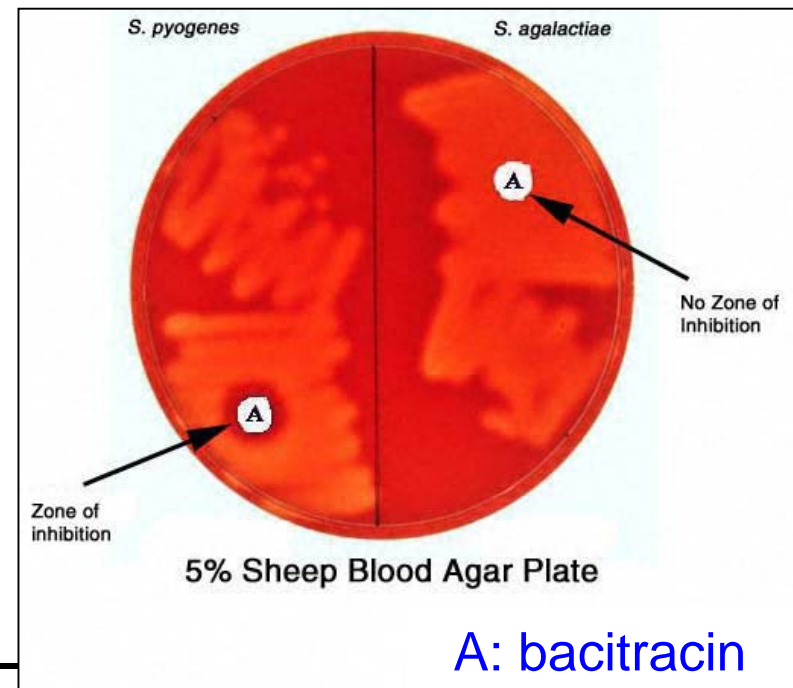
Necrotizing fasciitis 壞死性筋膜炎

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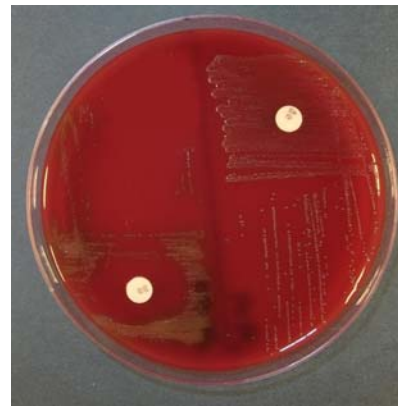
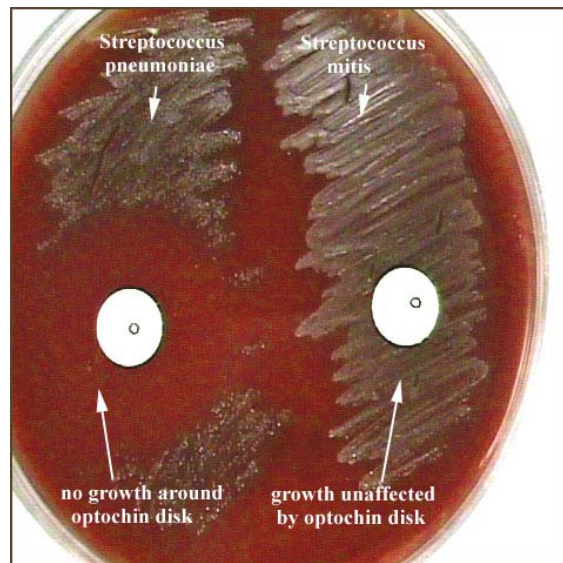
- **Group A Streptococcus:** *Streptococcus pyogenes*
 - Diagnosis, treatment, and prevention
 - Diagnosis
 - Gram-positive bacteria in short chains or pairs
 - Streptococci normally in the pharynx (not diagnostic)
 - Treatment
 - **Penicillin** is effective
 - Prevention
 - Antibodies against M protein provide protection

- **Group B Streptococcus:** *Streptococcus agalactiae*
 - Gram-positive cocci that form chains
 - Distinguished from group A streptococcus
 - Group-specific cell wall antigens
 - Smaller zone of **beta-hemolysis**
 - Resistant to **bacitracin**



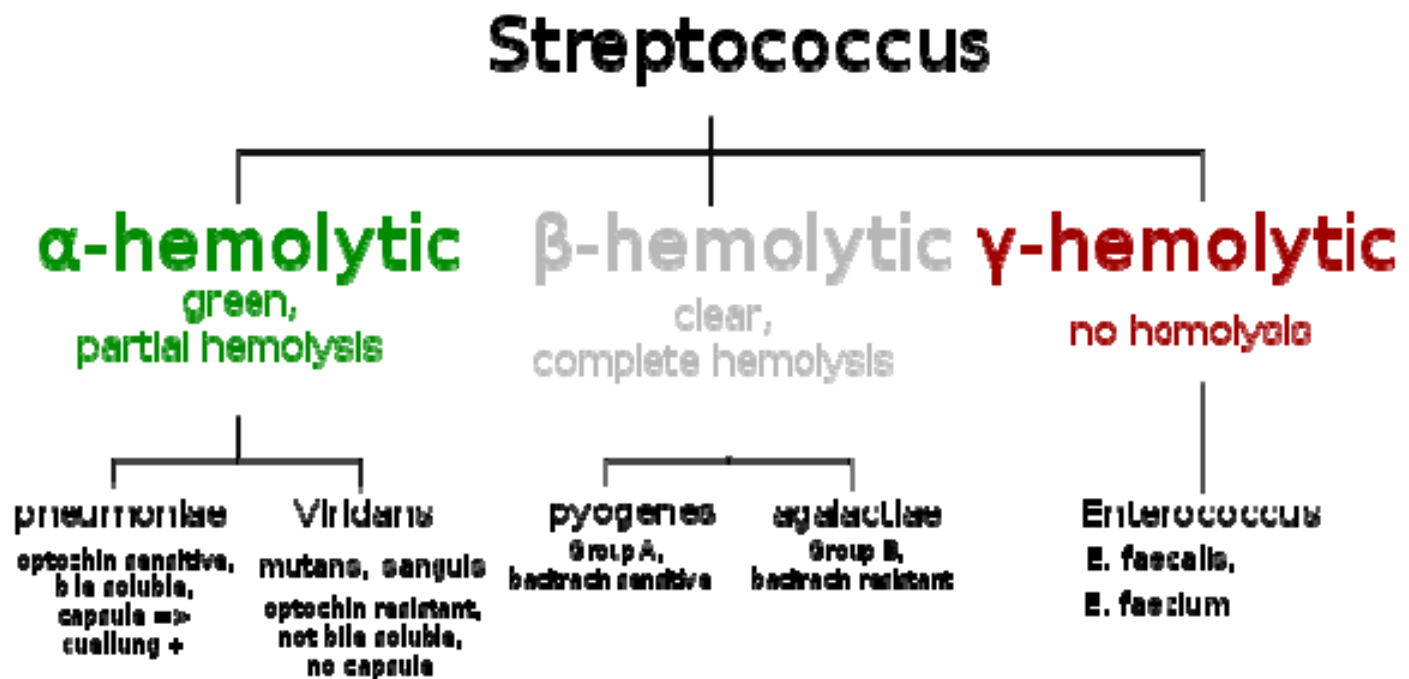
- **Group B Streptococcus:** *Streptococcus agalactiae*
 - Pathogenicity
 - Often infects **newborns** without specific antibodies
 - Produces enzymes whose roles are not yet understood
 - Diseases
 - Associated with **neonatal bacteremia**, **meningitis**, **pneumonia**
 - Older immunocompromised patients also at risk
 - Diagnosis, treatment, and prevention
 - ELISA test used to identify group B streptococcus
 - **Penicillin G** is the drug of choice
 - Immunization of women can protect future children

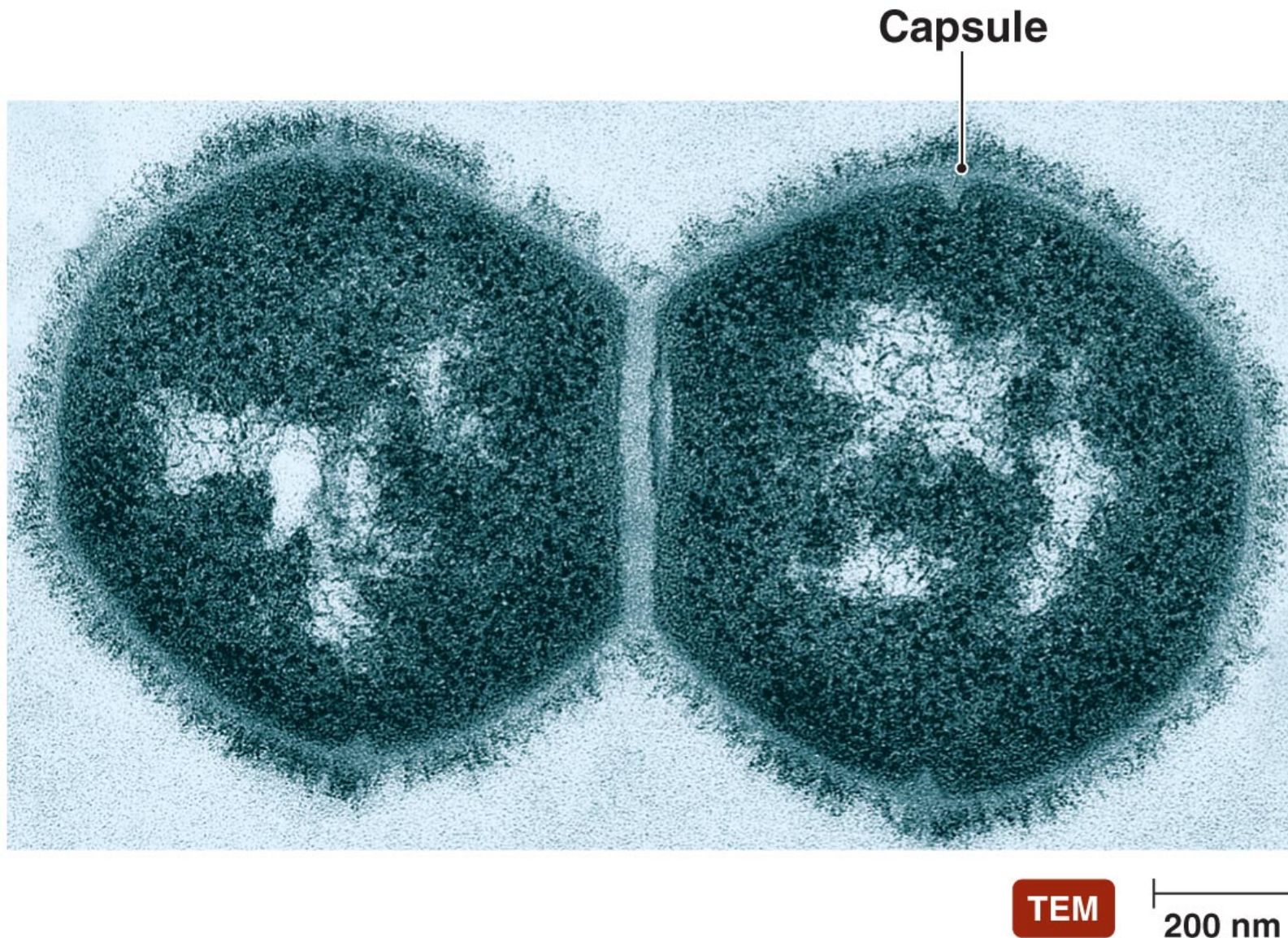
- **Alpha-Hemolytic Streptococci: The Viridans Group**
 - Lack group-specific carbohydrates
 - Cannot be grouped by Lancefield system
 - Many produce a **green pigment** when grown on blood media
 - Inhabit mouth, pharynx, GI tract, genital tract, and urinary tract
 - One cause of **dental caries** and **dental plaques**
 - If enter the blood can cause **meningitis** and **endocarditis**



Optochin Disk Test (OPT test)

- *Streptococcus pneumoniae*
 - Gram-positive cocci that most commonly form pairs
 - Form unpigmented, alpha-hemolytic colonies on blood agar

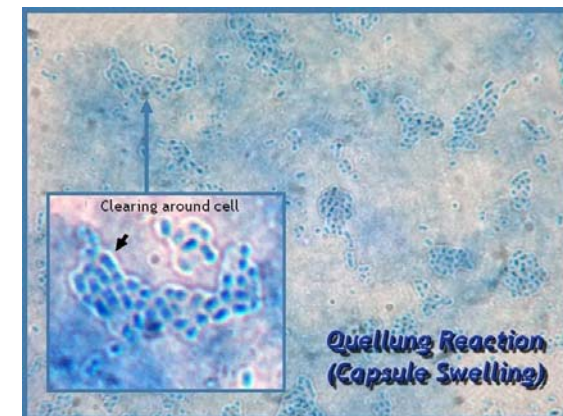
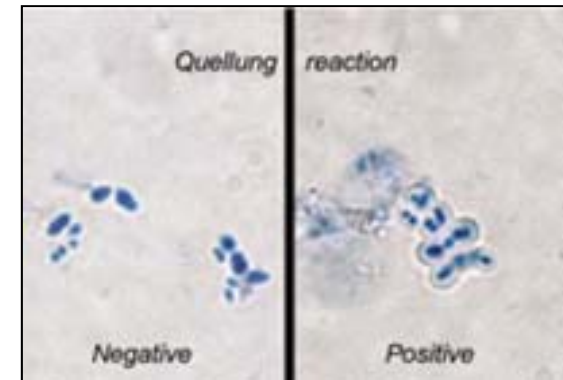




- *Streptococcus pneumoniae*
 - Pathogenicity
 - Polysaccharide capsule
 - Phosphorylcholine
 - Stimulates cells to phagocytize the bacteria
 - Protein adhesin
 - Mediates binding of cells to epithelial cells of pharynx
 - Secretory IgA protease
 - Pneumolysin
 - Lyses epithelial cells

- *Streptococcus pneumoniae*
 - Pneumococcal diseases
 - Pneumococcal pneumonia
 - Sinusitis and otitis media
 - Bacteremia and endocarditis
 - Pneumococcal meningitis

- *Streptococcus pneumoniae*
 - Diagnosis, treatment, and prevention
 - Diagnosis
 - Gram-stain of sputum smears
 - Confirmed with Quellung reaction
 - Treatment
 - Penicillin
 - Prevention
 - Vaccine made from purified capsular material

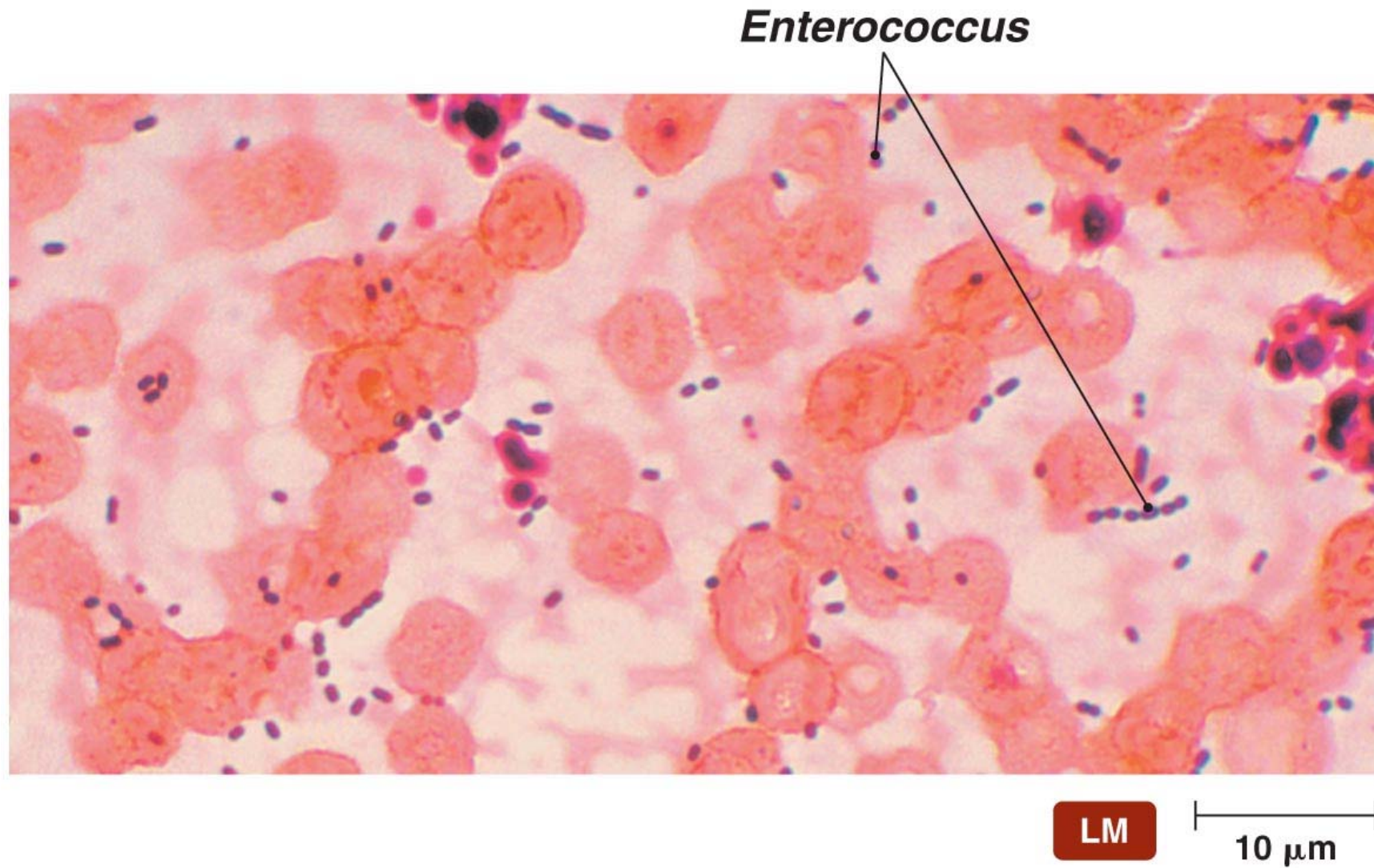


- Previously classified with **group D streptococci**
- Reclassified as a separate genus
- Forms short chains and pairs and **lacks a capsule**
- Found in the **human colon**
 - **Rarely pathogenic at this site**
- Can cause disease if introduced into other parts of the body

- Important cause of nosocomial infections
- Difficult to treat because enterococci often resistant to antimicrobials
- Prevention is difficult in health care setting
 - Patients often have weakened immune systems

Enterococcus faecalis in lung tissue

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- Structure, Physiology, and Pathogenicity
 - Gram-positive bacilli that occur singly, in pairs, or in chains
 - Form endospores
 - Pathogenic strains produce anthrax toxins
- Epidemiology
 - Humans contract via one of three routes
 - Inhalation of spores
 - Inoculation of spores through break in the skin
 - Ingestion of spores

Bacillus anthracis as it appears in tissue

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Bacillus anthracis



SEM

10 μm

- Disease

- *Bacillus anthracis* only causes anthrax
- Three clinical manifestations
 - Gastrointestinal anthrax
 - Rare in humans
 - Cutaneous anthrax
 - Produces ulcer called an eschar
 - Inhalation anthrax
 - Rare in humans
 - High mortality rate



eschar 焦痂

Black eschars are characteristic of cutaneous anthrax

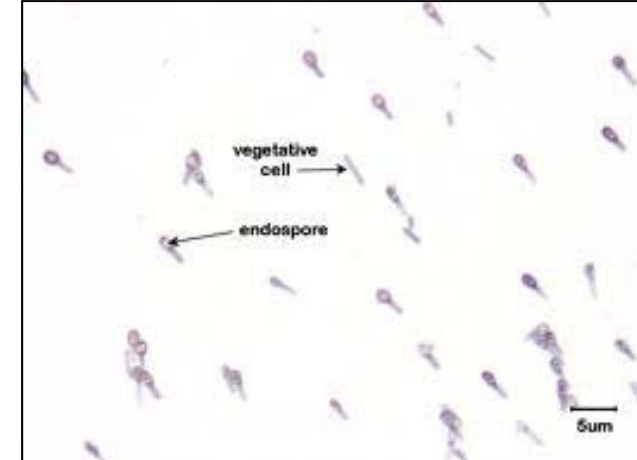
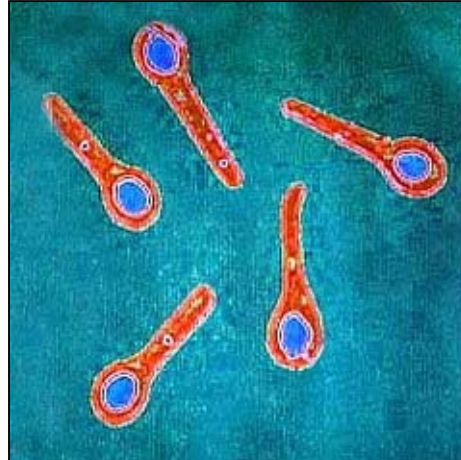
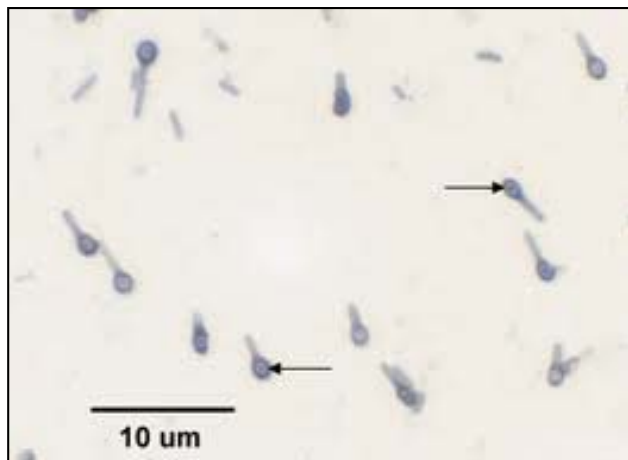
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Eschar

- Diagnosis, Treatment, and Prevention
 - Diagnosis
 - Large, nonmotile, Gram-positive bacilli in lung or skin samples
 - Treatment
 - [Ciproflaxacin](#) and many other antimicrobials
 - Prevention
 - Control of disease in animals
 - Effective vaccine available
 - Requires multiple doses and boosters

- Gram-positive, **anaerobic**, **endospore-forming bacillus**
- Ubiquitous in soil, water, and gastrointestinal tracts of animals and humans
- Endospores allow for survival in harsh conditions



- *Clostridium perfringens* 產氣莢膜桿菌
 - Pathogenesis, epidemiology, and disease
 - Produces toxins that can cause irreversible damage to body
 - Grows in the digestive tracts of animals and humans
 - Diseases
 - Food poisoning
 - Abdominal cramps and watery diarrhea
 - Gas gangrene 氣性壞疽
 - Trauma introduces endospores into body
 - Endospores germinate and cause necrosis

Gas gangrene caused by *Clostridium perfringens*

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- *Clostridium perfringens*
 - Diagnosis, treatment, and prevention
 - Diagnosis
 - Presence of minimum bacterial load in food or feces
 - Gas gangrene usually diagnostic by itself
 - Treatment
 - Food poisoning is self-limited
 - Gas gangrene requires removal of dead tissue and antimicrobials
 - Prevention
 - Difficult to prevent because organism so common

- *Clostridium difficile* 梭狀芽胞桿菌
 - Pathogenesis, epidemiology, and disease
 - Common member of the intestinal microbiota
 - Opportunistic pathogen in patients taking broad-spectrum antimicrobial drugs
 - Minor infections result in self-limiting explosive diarrhea
 - Serious cases can cause pseudomonas colitis
 - Life-threatening

- *Clostridium difficile*
 - Diagnosis, treatment, and prevention
 - Diagnosis
 - Isolation of organism from feces or immunoassay
 - Treatment
 - Discontinue causative antimicrobial drug to resolve minor infections
 - Serious cases treated with antibiotics
 - Prevention
 - Proper hygiene to limit nosocomial infections

Clostridium



- *Clostridium botulinum* 肉毒桿菌
 - Anaerobic, endospore-forming, Gram-positive bacillus
 - Common in soil and water
 - Botulism results when the endospores germinate and produce botulism toxins

Botulism poisoning

Source of trouble
Low-acid foods that were improperly canned.

Trouble signs

- Clear liquids turned milky
- Cracked jars
- Loose or dented lids
- Swollen or dented cans
- An "off" odor

Home canned foods

Prevention

- Examine all canned foods before cooking
- Cook and reheat foods thoroughly
- Keep cooked foods hot (above 140 degrees) or cold (below 40 degrees)

Symptoms after eating

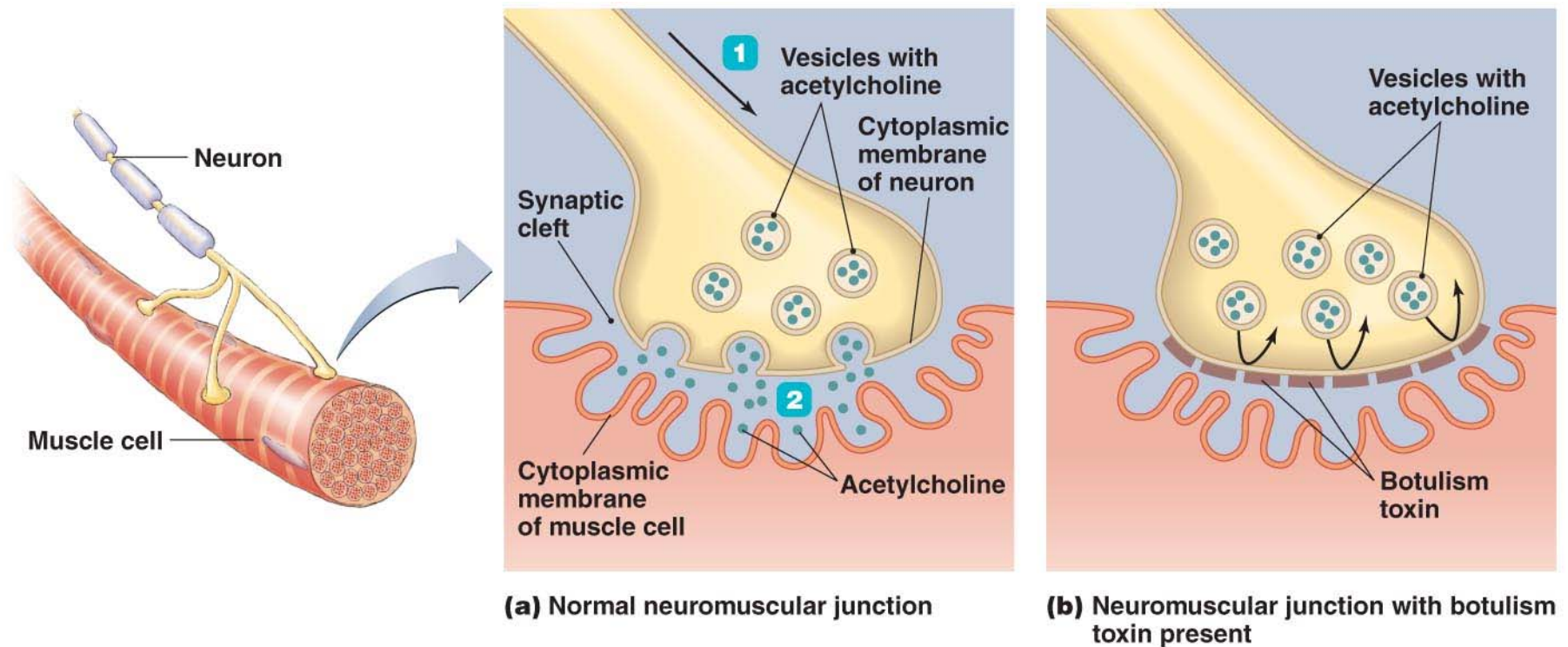
- Double vision
- Droopy eyelids
- Trouble speaking, swallowing or breathing
- Untreated botulism can be fatal

www.wisconsin.gov/foodsafety/poisoning The Roanoke Times



How botulism toxin acts at a neuromuscular junction

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- *Clostridium botulinum*
 - Epidemiology and diseases
 - Botulism is an intoxication
 - Three manifestations
 - Foodborne botulism
 - Death can result from asphyxiation
 - Infant botulism
 - Results from the ingestion of endospores
 - Wound botulism
 - Contamination of a wound by endospores

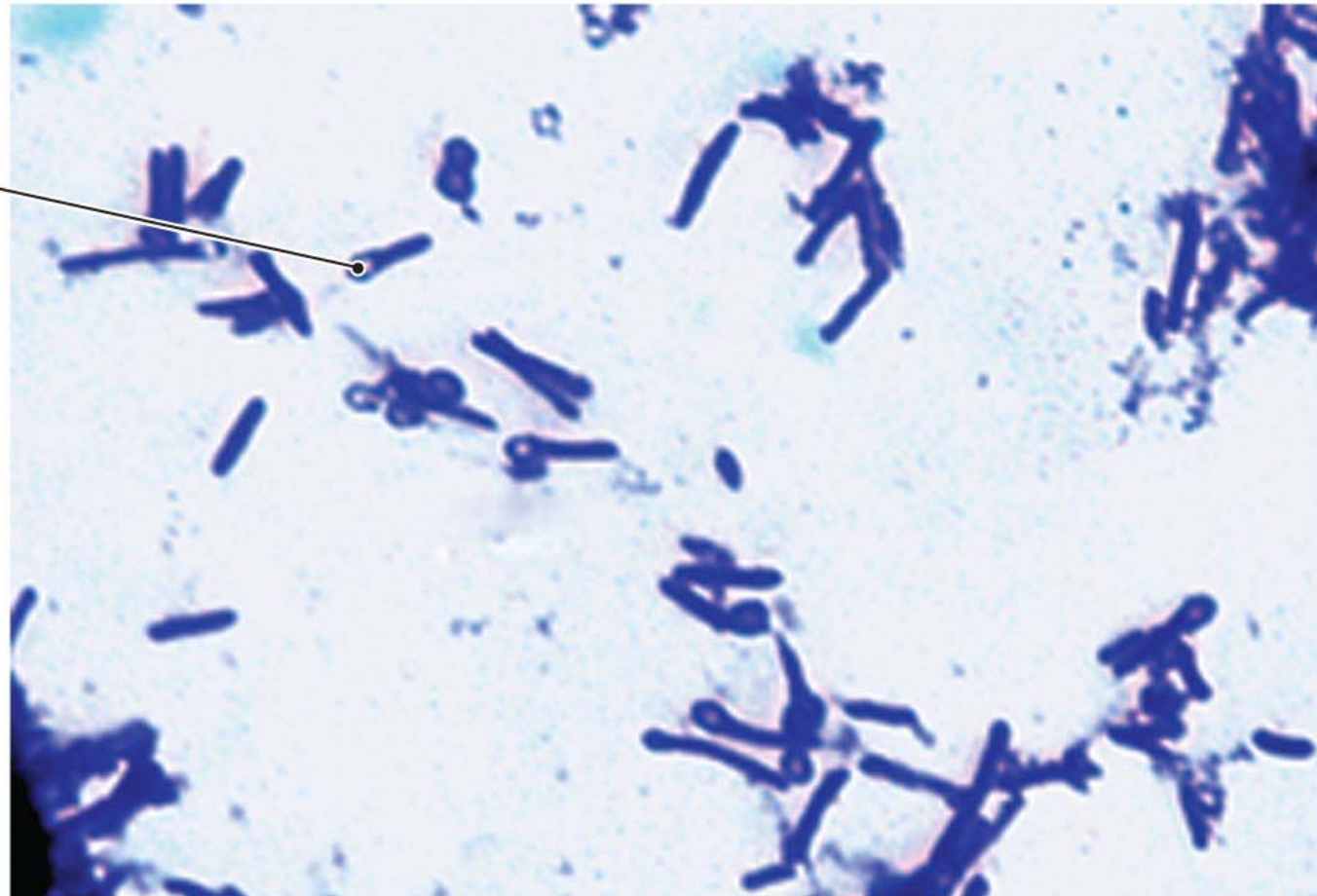
- *Clostridium botulinum*
 - Diagnosis, treatment, and prevention
 - Diagnosis
 - Symptoms are diagnostic
 - Treatment
 - Administer **neutralizing antibodies** against botulism toxin
 - Administer **antimicrobial drugs** in infant botulism cases
 - Prevention
 - Proper canning of food
 - Infants under 1 year should not consume **honey**

- *Clostridium tetani* 破傷風桿菌
 - Endospore-forming, obligately anaerobic, Gram-positive bacilli
 - Ubiquitous in soil, dust, and GI tract of animals and humans
 - Tetanus results when endospores germinate and produce tetanus toxin

Cells of *Clostridium tetani*

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Endospore

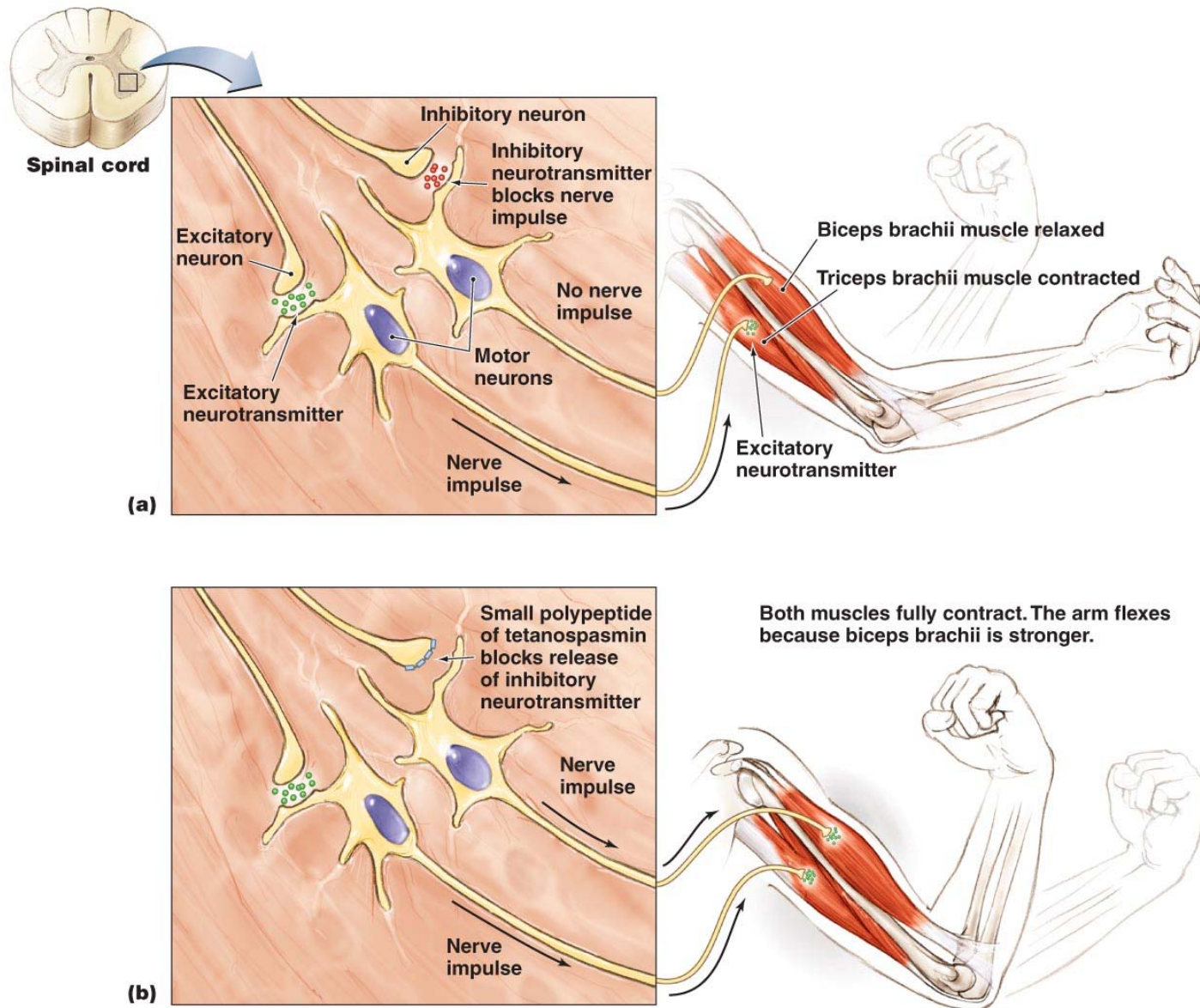


LM

10 μ m

Action of tetanus toxin on a pair of antagonistic muscles

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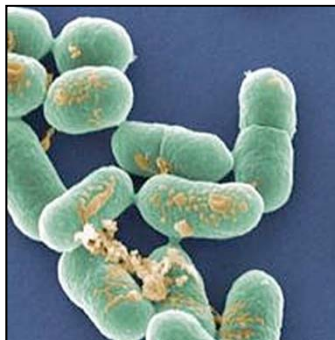
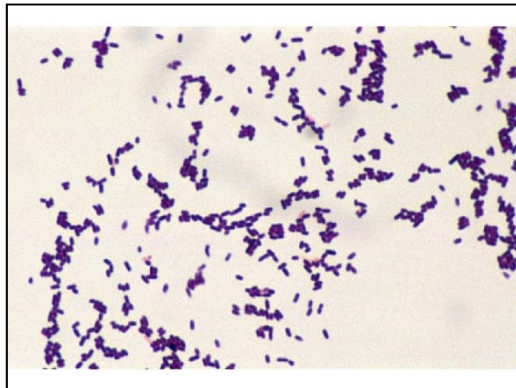
A patient with tetanus

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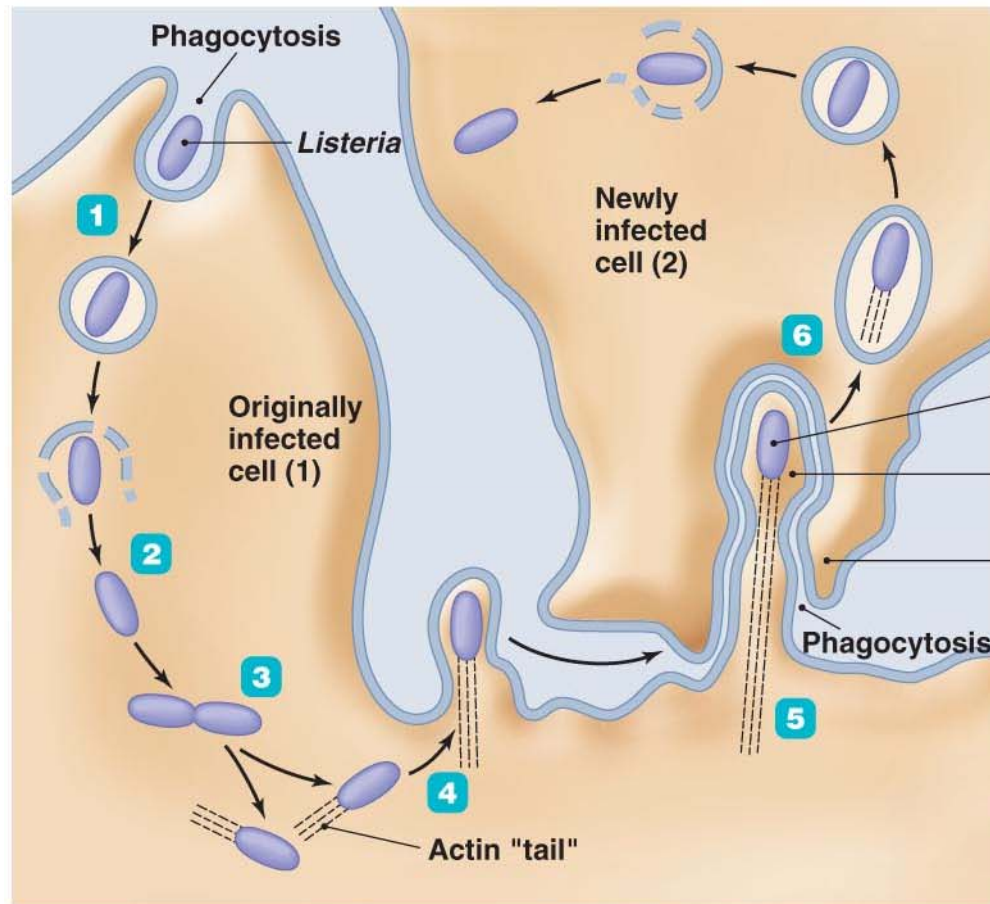
- *Clostridium tetani*
 - Diagnosis, treatment, and prevention
 - Diagnosis
 - Characteristic muscular contraction
 - Treatment
 - Administer immunoglobulin against tetanus toxin
 - Administer antimicrobial drugs
 - Active immunization with tetanus toxoid
 - Prevention
 - Immunization with tetanus toxoid

- Gram-positive, non-spore-forming coccobacillus
- Found in soil, water, mammals, birds, fish, and insects
- Enters body in contaminated food and drink
- *Listeria* produces **no** toxins or enzymes
- Virulence is directly related to the bacteria's ability to live within cells
- Can cause meningitis in certain at-risk groups

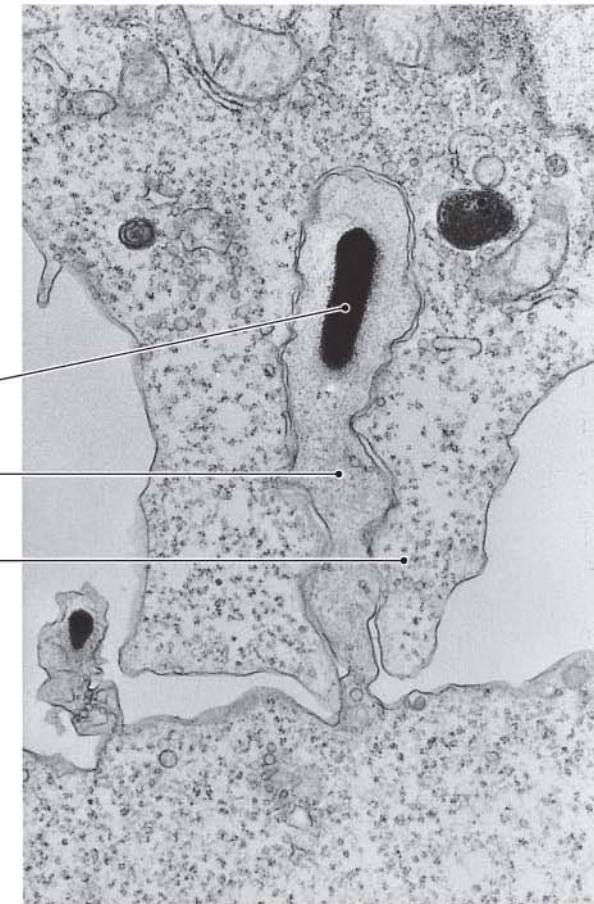


How *Listeria* avoids the host's immune system

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(a)



(b)

TEM 2 μm

- Diagnosis, Treatment, and Prevention
 - Diagnosis
 - Presence of bacteria in the cerebrospinal fluid
 - Rarely seen in Gram stain
 - Treatment
 - Most antimicrobial drugs inhibit *Listeria*
 - Prevention
 - Difficult because organism is ubiquitous
 - At-risk individuals should avoid certain foods

- 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

Pleomorphic forms of *Mycoplasma*

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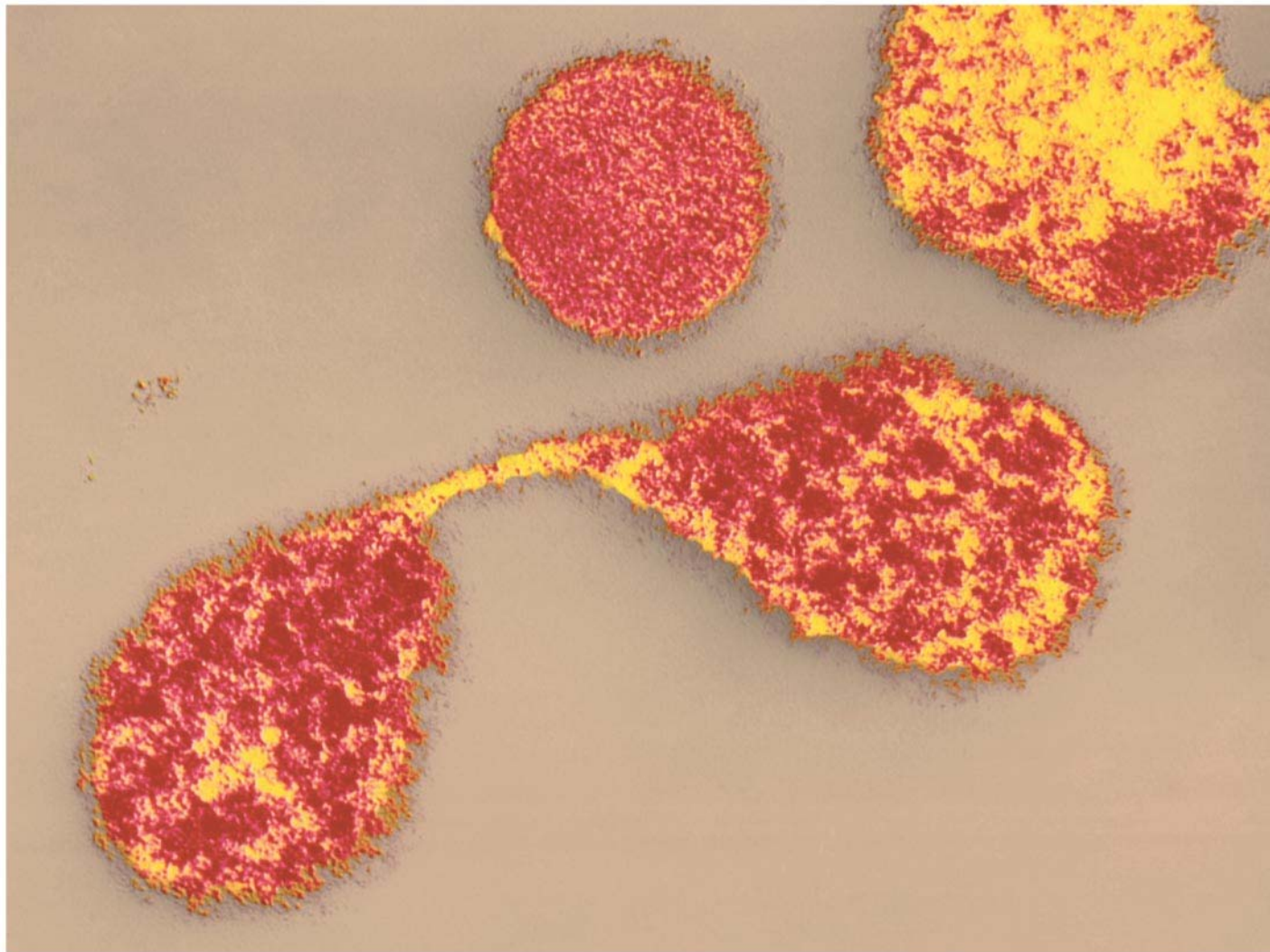
TEM

2.5 μm

- *Mycoplasma pneumoniae*
 - Attaches to epithelial cells lining the respiratory tracts of humans
 - Causes primary **atypical pneumonia** (**walking pneumonia**)
 - Early symptoms not typical of other types of pneumonia
 - Not usually severe enough to require hospitalization
 - Spread by nasal secretions among people in close contact
 - Diagnosis difficult
 - Mycoplasmas are small and difficult to detect
 - Difficult to prevent
 - Patients often infectious without signs or symptoms

Mycoplasma pneumoniae

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TEM

0.3 μm

- Other Mycoplasmas

- Three other mycoplasma associated with human diseases
 - *M. hominis*, *M. genitalium*, and *Ureaplasma urealyticum*
- Often colonize the urinary and genital tracts of newborn girls
- *M. genitalium* and *U. urealyticum* cause inflammation of the urethra
- *M. hominis* can cause pelvic inflammatory disease in women
- Abstinence and safe sex can help prevent the spread of these organisms

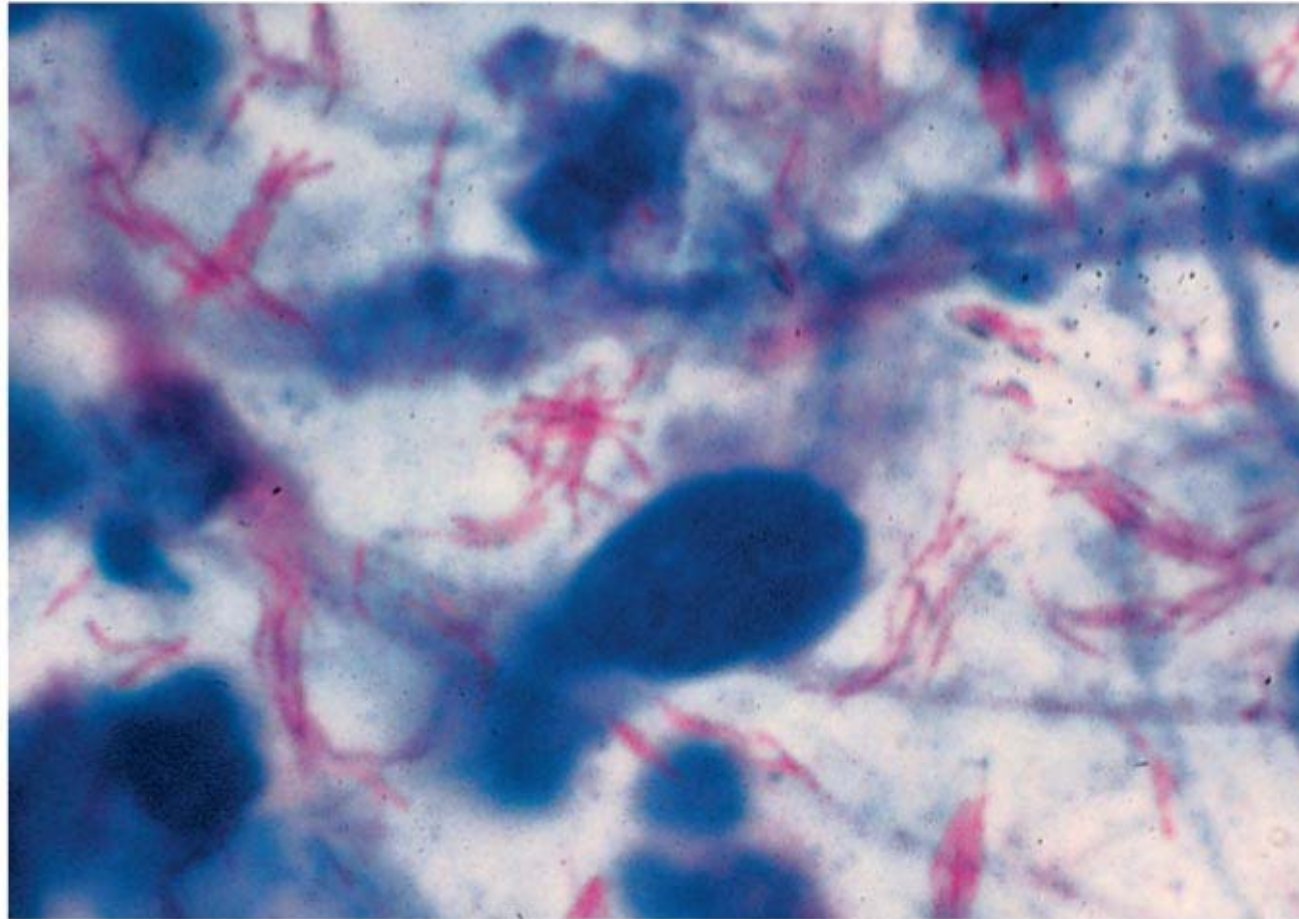
- Cell wall contains a waxy lipid called **mycolic acid**
 - Results in a number of unique characteristics
 - Slow growth
 - Protection from lysis after phagocytosis
 - Capacity for intracellular growth
 - Resistance to Gram staining, detergents, many antimicrobial drugs, and desiccation

- Tuberculosis

- Respiratory disease cause by *Mycobacterium tuberculosis*
- Cases are declining in the United States
- Pandemic in other parts of the world
- Virulent strains of *M. tuberculosis* produce cord factor

Mycobacterium tuberculosis

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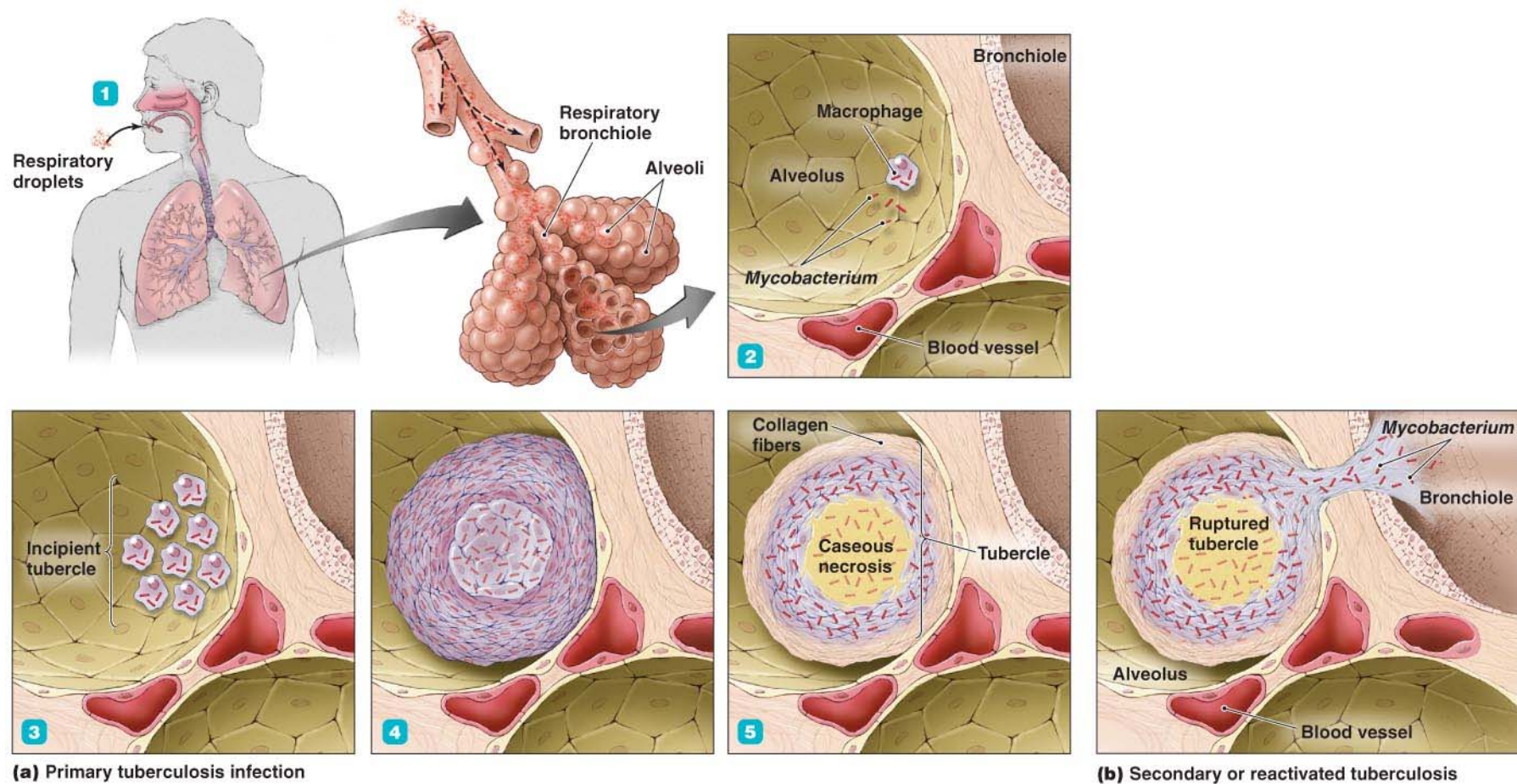
LM

15 μ m

- Tuberculosis
 - Pathogenesis and disease
 - Three types of tuberculosis
 - Primary TB
 - Results from the initial infection with *M. tuberculosis*
 - Secondary TB
 - Reestablishment of active infection after period of dormancy
 - Disseminated TB
 - Results when infection spreads throughout the body

Development of tuberculosis in the lung

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- Tuberculosis
 - Diagnosis, treatment, and prevention
 - Diagnosis
 - Tuberculin skin test
 - Chest Xrays 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

Diagnosis of tuberculosis

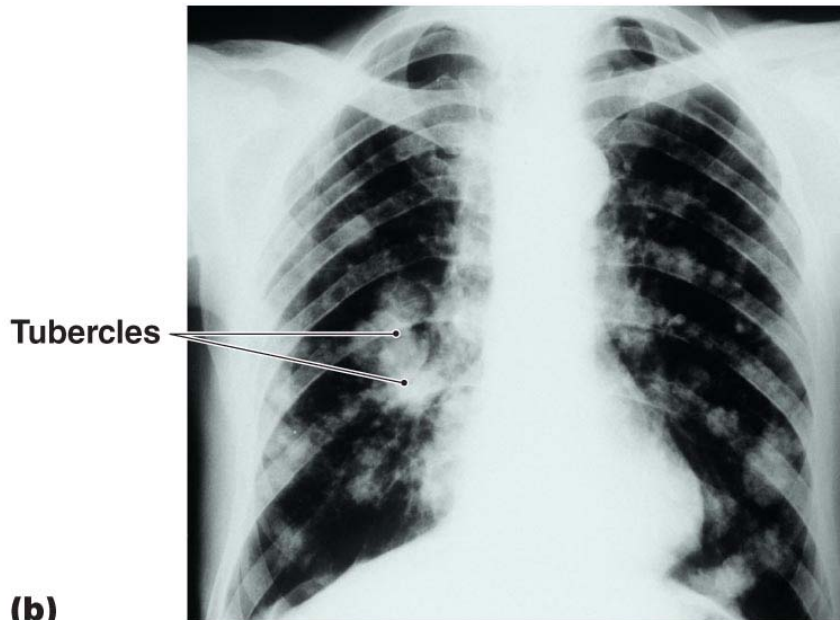
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Tuberculin skin test



(a)

Chest X-ray



(b)

- Leprosy
 - Pathogenesis, epidemiology, and disease
 - Caused by *Mycobacterium leprae*
 - Bacteria do not grow in cell-free culture
 - Cases of leprosy are becoming relatively rare
 - Transmitted via person-to-person contact or break in the skin
 - Two different forms of the disease
 - Tuberculoid leprosy
 - Lepromatous leprosy

A patient with lepromatous leprosy

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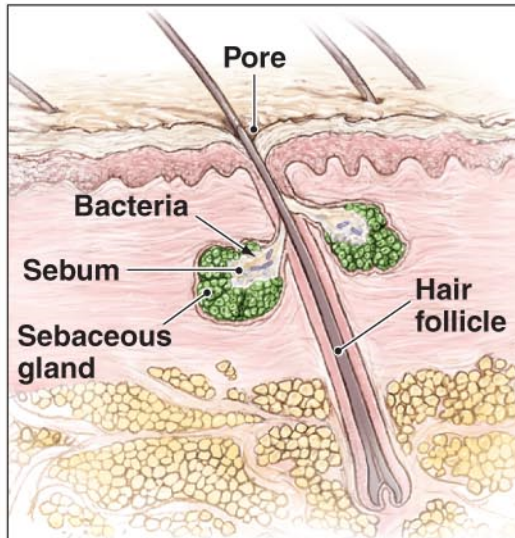
- Leprosy
 - Diagnosis, treatment, and prevention
 - Diagnosis
 - Based on signs and symptoms of disease
 - Treatment
 - Combination of antimicrobial drugs
 - Lifelong treatment is sometimes needed
 - Prevention
 - Limiting exposure to the pathogen
 - BCG vaccine provides some protection

- 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
 - Can affect almost every organ and result in massive organ failure
 - Treatment is difficult due to the disseminated nature of the infection

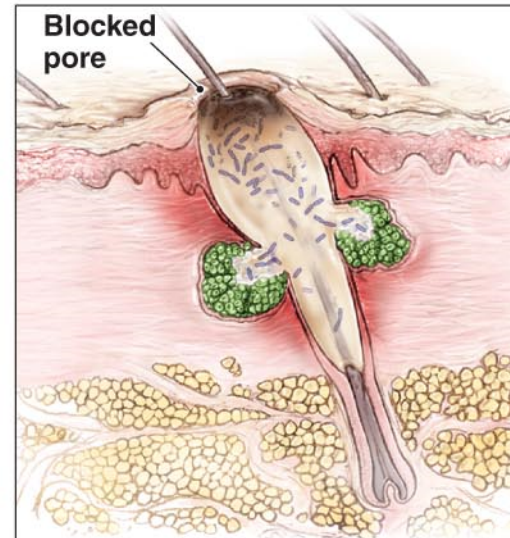
- Small, Gram-positive **rods** often found on the **skin**
- *Propionibacterium acnes* most commonly involved in human infections
- Causes **acne** in adolescents and young adults
- May also be an opportunistic pathogen
- Many cases require no treatment
- Antimicrobial drugs help control bacterium

The development of acne

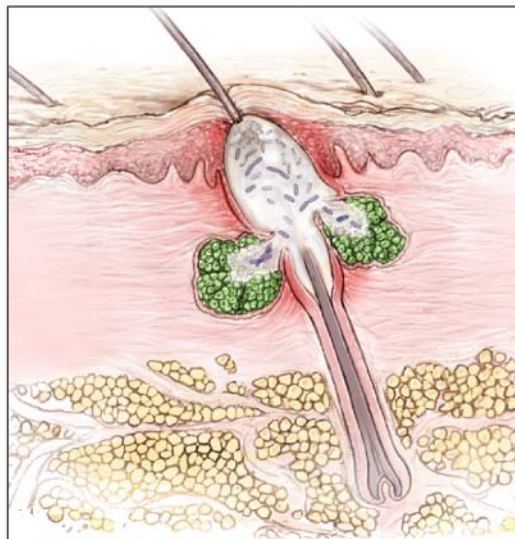
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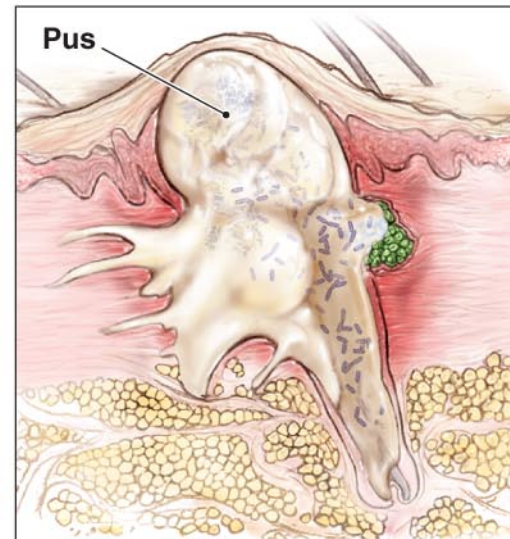
- 1 Normal skin**
Oily sebum produced by glands reaches the hair follicle and is discharged onto the skin surface via the pore.



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



- 2 Whitehead**
Inflamed skin swells over the pore when bacteria infect the hair follicle, causing the accumulation of colonizing bacteria and sebum.



- 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 asteroides*
 - 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
 - Prevention involves avoiding exposure to bacterium in soil

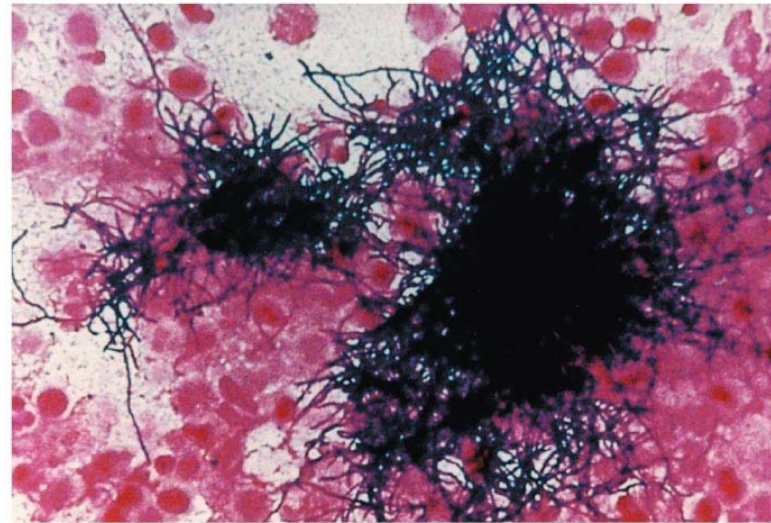
A *Nocardia* infection

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- *Actinomyces*

- Member of the surface microbiota of human mucous membranes
- Opportunistic infections
 - Respiratory, gastrointestinal, urinary, and female genital tracts
- Actinomycosis
 - Results when bacteria enter breaks in the mucous membrane
 - Formation of abscesses connected by channels in skin or mucous membranes
- Diagnosis difficult
 - Other organisms cause similar symptoms



(a)

LM 30 μ m



(b)

End of Chapter

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