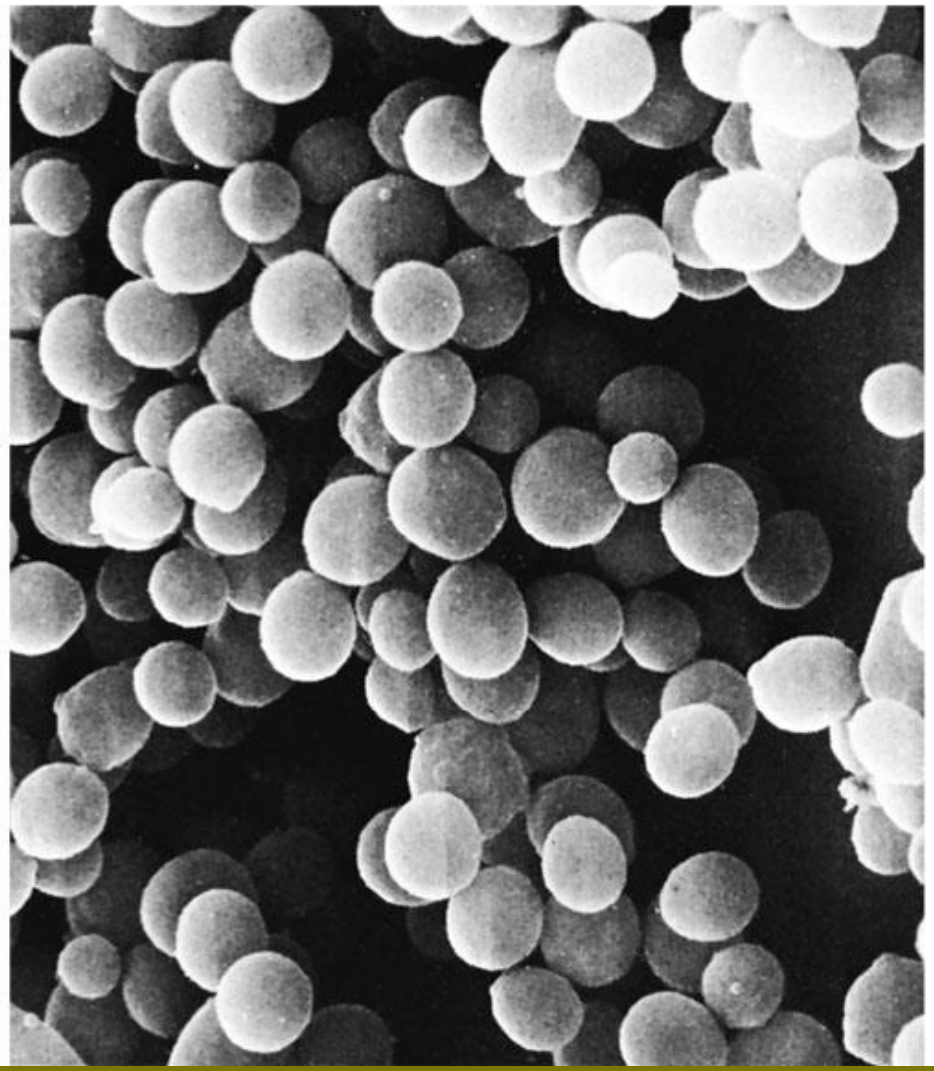
Chapter 38

Human Diseases Caused by Bacteria

General characteristics of the Staphylococci

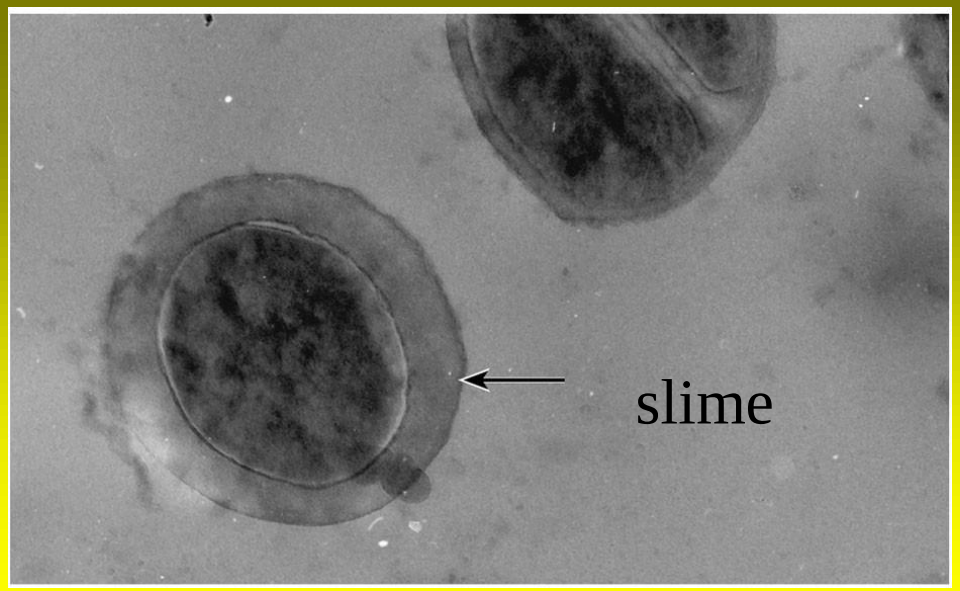
- Spherical cells arranged in irregular clusters
- Gram positive
- Common inhabitant of the skin & mucous membranes
- Lack spores and flagella
- May have capsules
- 31 species

S. aureus



Slime

- viscous extracellular glycoconjugate that allows bacteria to adhere to smooth surfaces and form biofilms
- inhibits neutrophil chemotaxis, phagocytosis, and antimicrobial agents



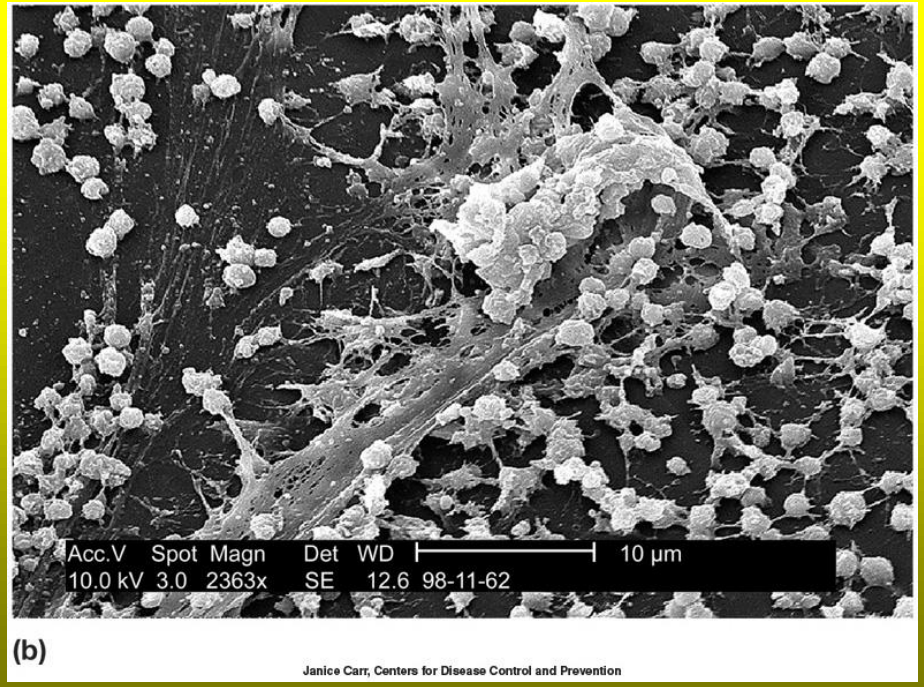
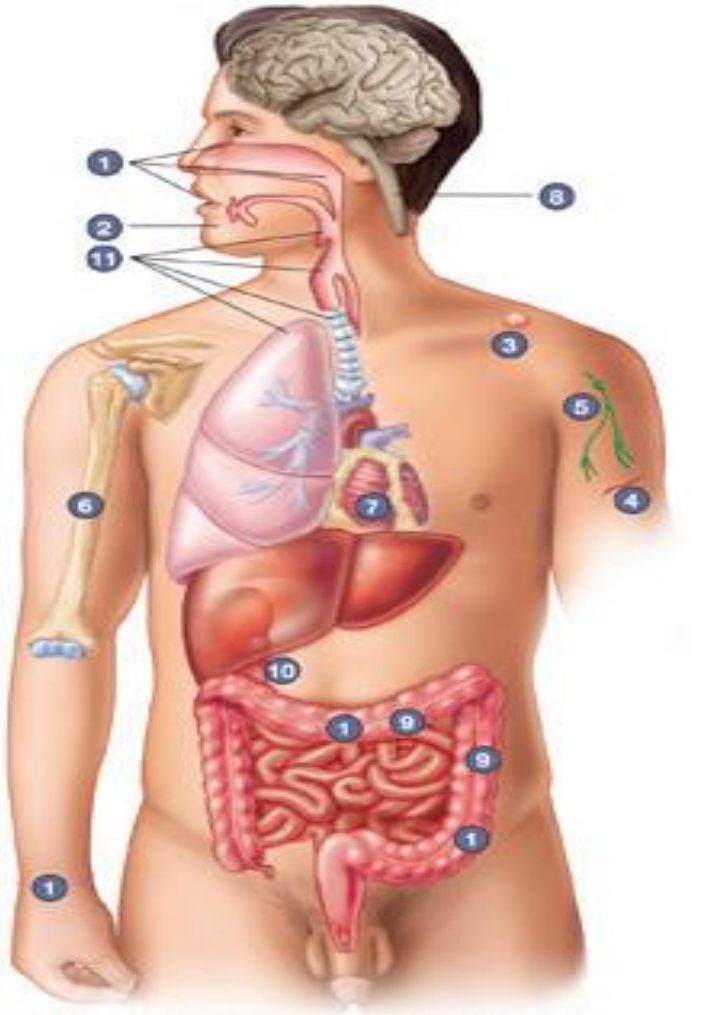


Figure 38.15



1. Tissue where *S. aureus* is often found but does not normally cause disease

Diseases that may be caused by *S. aureus* are:

2. Pimples and impetigo
3. Boils and carbuncles on any surface area
4. Wound infections and abscesses
5. Spread to lymph nodes and to blood (septicemia), resulting in widespread seeding
6. Osteomyelitis
7. Endocarditis
8. Meningitis
9. Enteritis and enterotoxin poisoning (food poisoning)
10. Nephritis
11. Respiratory infections:
    - Pharyngitis
    - Laryngitis
    - Bronchitis
    - Pneumonia

Figure 38.16

Staphylococcal Diseases

- caused by members of genus of ***Staphylococcus***
  - gram-positive cocci, occurring singly, in pairs, tetrads, or grape-like clusters
  - **facultative** anaerobes and usually catalase positive
  - normal inhabitants of upper respiratory tract, skin, intestines, and vagina
  - ***S. aureus*** – coagulase positive, pathogenic
  - ***S. epidermidis*** – coagulase negative, less pathogenic
  - many pathogenic strains are slime producers

Staphylococcus aureus

- grows in large, round, opaque colonies
- optimum temperature of 37ºC
- facultative anaerobe
- withstands high salt, extremes in pH, & high temperatures
- produces many virulence factors

Table 38.4 Various Enzymes and Toxins Produced by Staphylococci

Product	Physiological Action
β-lactamase	Breaks down penicillin
Catalase	Converts hydrogen peroxide into water and oxygen and reduces killing by phagocytosis
Coagulase	Reacts with prothrombin to form a complex that can cleave fibrinogen and cause the formation of a fibrin clot; fibrin may also be deposited on the surface of staphylococci, which may protect them from destruction by phagocytic cells; coagulase production is synonymous with invasive pathogenic potential
DNase	Destroys DNA
Enterotoxins	Are divided into heat-stable toxins of six known types (A, B, C1, C2, D, E); responsible for the gastrointestinal upset typical of food poisoning
Exfoliative toxins A and B (superantigens)	Causes loss of the surface layers of the skin in scalded-skin syndrome
Hemolysins	Alpha hemolysin destroys erythrocytes and causes skin destruction
	Beta hemolysin destroys erythrocytes and sphingomyelin around nerves
Hyaluronidase	Also known as spreading factor; breaks down hyaluronic acid located between cells, allowing for penetration and spread of bacteria
Panton-Valentine leukocidin	Inhibits phagocytosis by granulocytes and can destroy these cells by forming pores in their phagosomal membranes
Lipases	Break down lipids
Nuclease	Breaks down nucleic acids
Protein A	Is antiphagocytic by competing with neutrophils for the Fc portion of specific opsonins
Proteases	Break down proteins
Toxic shock syndrome toxin-1 (a superantigen)	Is associated with the fever, shock, and multisystem involvement of toxic shock syndrome

Table 38.4

Toxins of *S. aureus*

- hemolysins – lyse RBCs;
  – α, β, γ, δ
- leukocidin
- enterotoxins
- exfoliative toxin
- toxic shock syndrome (TSS) toxin

Enzymes of *S. aureus*

- coagulase – coagulates plasma and blood; produced by 97% of human isolates; diagnostic
- hyaluronidase
- staphylokinase
- DNase
- lipases
- penicillinase

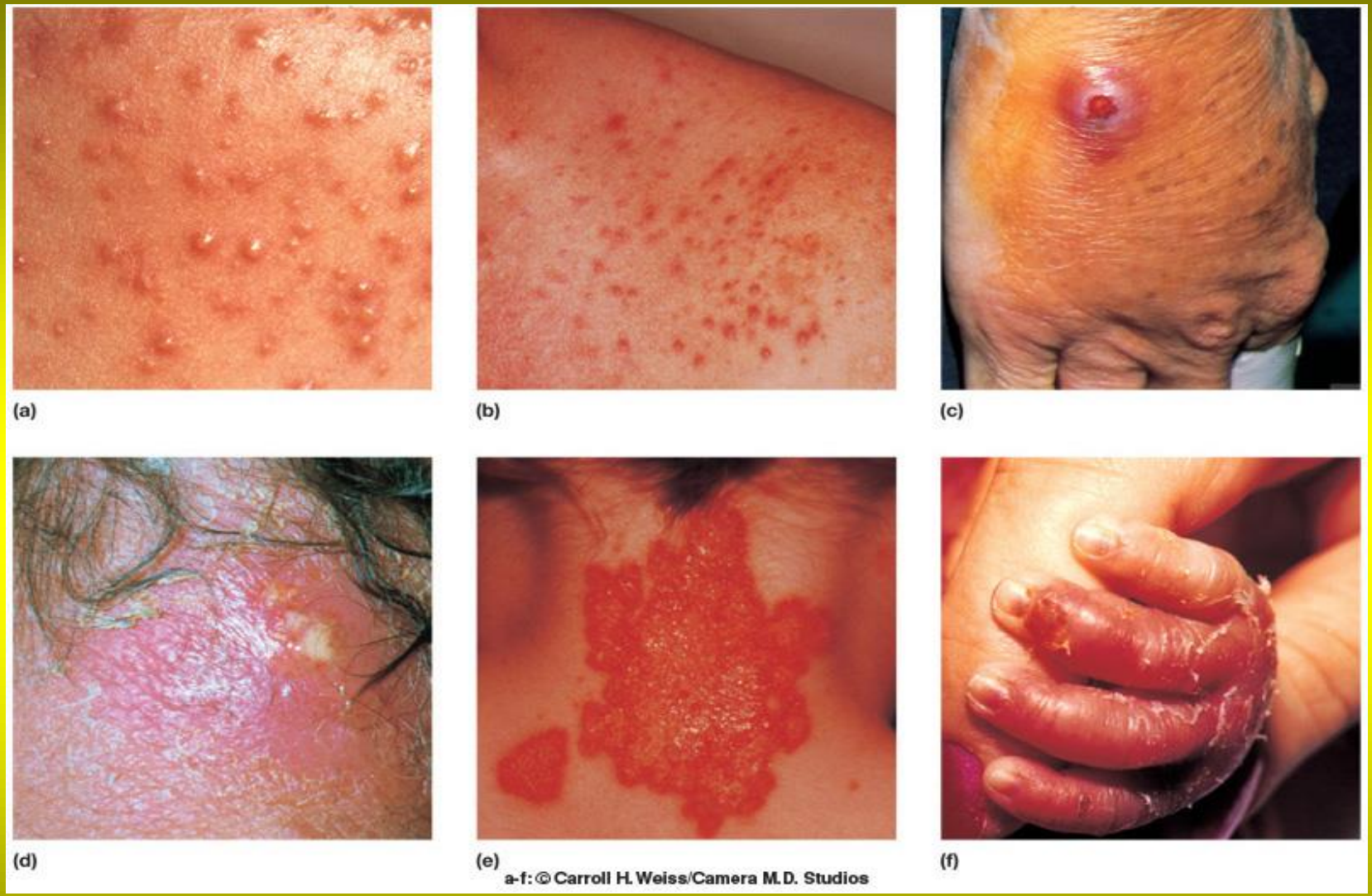


Figure 38.17

a), b) folliculitis (boils); c) furuncle; d) carbuncle; e) impetigo on 2 yr.old; f) scalded skin syndrome in neonate

Carbuncle

S. aureus diseases

- Ranges from localized to systemic
- localized -abscess, folliculitis, furuncle, carbuncle, impetigo
- systemic – osteomyelitis, bacteremia
- toxigenic disease – food intoxication, scalded skin syndrome (SSS), toxic shock syndrome (TSS)

Staphylococcal Lesions

- **localized abscess**
  - when *S. aureus* becomes established in a hair follicle, tissue necrosis results
  - coagulase is produced forming a fibrin wall around lesion, limiting spread
  - liquefaction of necrotic tissue in center of lesion occurs; abscess spreads
  - may be a furuncle (boil) or carbuncle
  - bacteria may spread from area via lymphatics or bloodstream
  - healing occurs

Toxic shock syndrome (TSS)

- caused by *S. aureus* strains that release toxic shock syndrome toxin and other toxins
- most cases occur in females who use superabsorbent tampons
- disease results from body's response to staphylococcal superantigens, which are on Select Agent list
- clinical manifestations
  - low blood pressure, fever, diarrhea, extensive skin rash, and shedding of skin

Staphylococcal scalded skin syndrome (SSSS)

- caused by strains of *S. aureus* that carry a plasmid-borne gene for exfoliative toxin (exfoliatin)
- epidermis peels off revealing red area underneath
- diagnosis
  - isolation/identification of staphylococcus involved or use of commercial kits

Staphylococcal scalded skin syndrome (SSSS)

- **treatment, prevention, and control**
  - isolation and identification based on catalase test, coagulase test, serology, DNA fingerprinting, and phage typing
  - antibiotic therapy
    - many drug-resistant strains
  - personal hygiene, food handling, and aseptic management of lesions

S. aureus

S. aureus

- Present in most environments frequented by humans
- Readily isolated from fomites
- Carriage rate for healthy adults is 20-60%
- Carriage is mostly in anterior nares, skin, nasopharynx, intestine

Staphylococcal Infections

- Pimples, boils, and carbuncles
- Septicemia
- Abscess in any organ
- Food poisoning
- Osteomylitis
- Staphylococcal enteritis
- Wound infections
- Impetigo
- Scalded-skin Syndrome
- Endocarditis
- Meningitis
- Pneumonia
- Toxic Shock Syndrome

Staphylococcal diseases…

- **treatment, prevention, and control**
  - isolation and identification based on catalase test, coagulase test, serology, DNA fingerprinting, and phage typing
  - antibiotic therapy
    - many drug-resistant strains
  - personal hygiene, food handling, and aseptic management of lesions

Clinical concerns

- 95% have penicillinase & are resistant to penicillin & ampicillin
- MRSA – methicillin-resistant *S. aureus* – carry multiple resistance
- Abscesses have to be surgically perforated
- Systemic infections require intensive lengthy therapy

Streptococcus

Streptococci

- Gram-positive spherical/ovoid cocci arranged in long chains or pairs
- Non-spore-forming, nonmotile
- Can form capsules & slime layers
- Facultative anaerobes
- Do not form catalase, but have a peroxidase system
- Most parasitic forms are fastidious & require enriched media
- Small, nonpigmented colonies
- Sensitive to drying, heat & disinfectants
- 25 species

Streptococci

- Lancefield classification system based on cell wall Ag – 14 groups (A,B,C,….)
- Another classification system is based on hemolysis reactions

–β-hemolysis – A,B,C,G & some D strains

–α –hemolysis – *S. pneumoniae* & others collectively called *viridans*

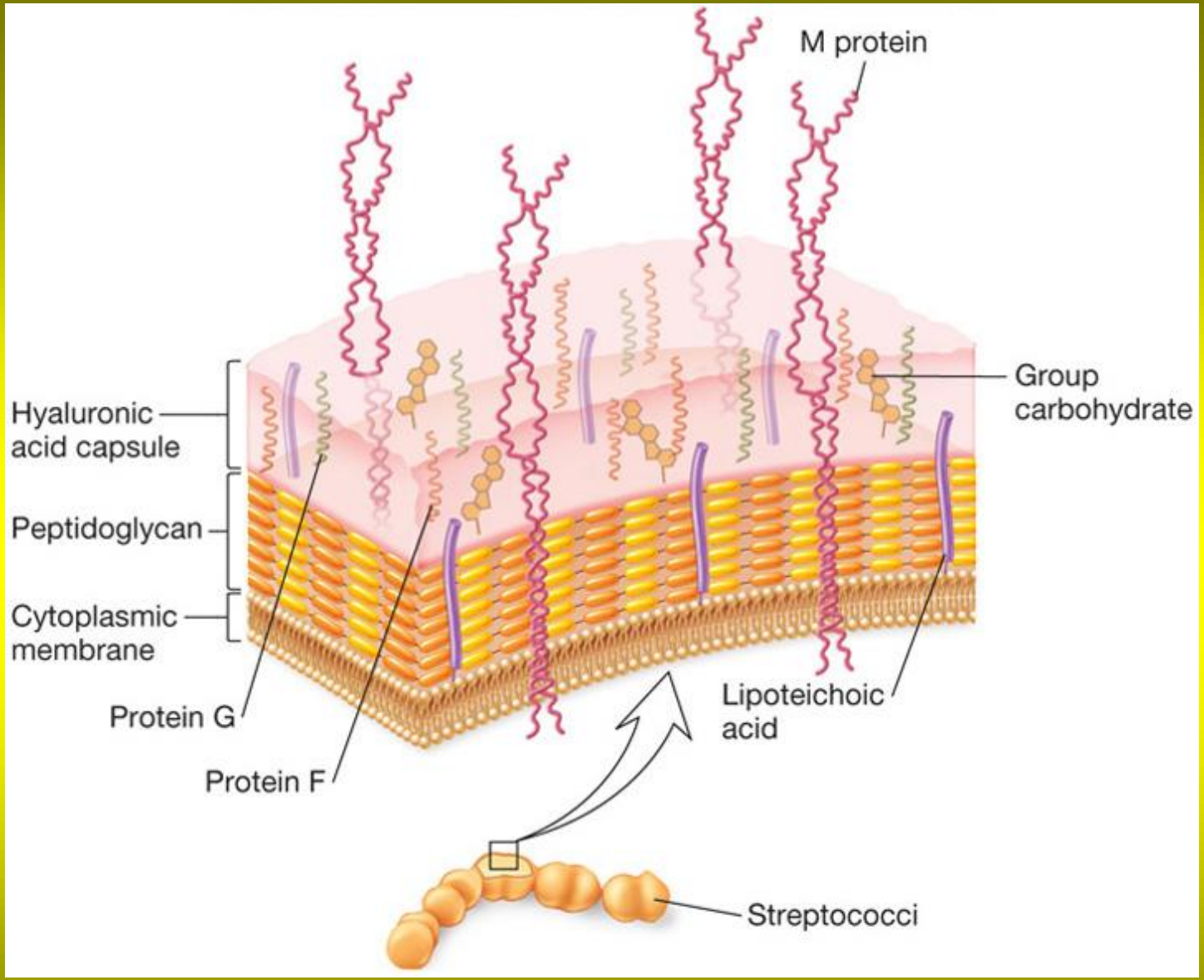

M protein
Hyaluronic acid capsule
Peptidoglycan
Cytoplasmic membrane
Protein G
Protein F
Group carbohydrate
Lipoteichoic acid
Streptococci

Figure 38.4

Streptococcal diseases

- treatment, prevention, and control
  - most treated by antibiotic therapy
  - vaccine available only for streptococcal pneumonia
  - best control is prevention of transmission
    - sanitation and personal hygiene measures

Streptococcal Diseases

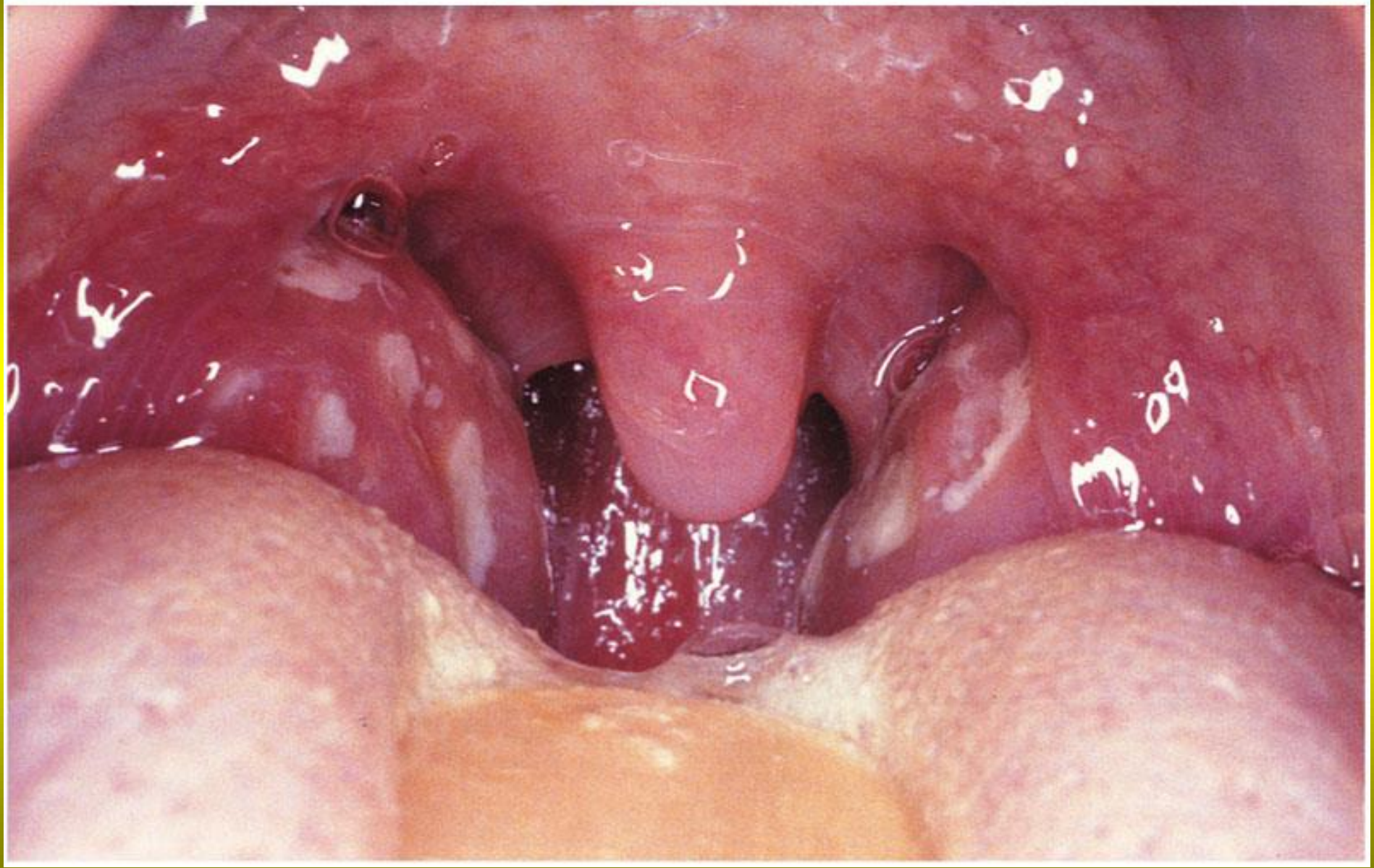
- **caused by strep, group of gram-positive bacteria**
  - *Streptococcus pyogenes* one of most important pathogens in group
- **transmission**
  - respiratory droplets, direct or indirect contact
- **diagnosis**
  - based on clinical and laboratory findings
  - rapid diagnostic tests available

S. pyogenes

- Humans only reservoir
- Transmission – contact, droplets, food, fomites
- Skin infections –pyoderma, impetigo, erysipelas
- Systemic infections – strep throat, pharyngitis, scarlet fever
- Sequelae -rheumatic fever, glomerulonephritis

β-hemolytic *S. pyogenes*

- Group A Strept
- Most serious streptococcal pathogen
- Strict parasite
- Inhabits throat, nasopharynx, occasionally skin
- Produces C-carbohydrates, M-protein (fimbrae), streptokinase, hyaluronidase, DNase, hemolysins (SLO, SLS), pyogenic toxin



Scarlet fever

- scarlatina
- caused by *S. pyogenes* strain lysogenized by a bacteriophage that carries gene for an erythrogenic toxin

Scarlet fever…

- spread by inhalation of infective respiratory droplets
- clinical manifestations
  - after 2 days incubation, rash that spreads from upper body to remainder of body
  - sore throat, chills, fever, headache, and strawberry tongue

Invasive Streptococcus A Infections

- caused by certain strains of *S. pyogenes*
  - carry genes for exotoxins
    - Superantigens (Select Agent)
    - tissue-destroying protease

Cellulitis, impetigo, and erysipelas

- cellulitis
  - diffuse, spreading infection of subcutaneous tissue
  - redness and swelling
- impetigo
  - also caused by *Staphylococcus aureus*
  - superficial cutaneous infection commonly seen in children
  - crusty lesions and vesicles surrounded by red border
- erysipelas
  - acute infection of dermal layer of skin
  - red patches that may occur periodically at same site for years

erysipelas

Figure 38.5

(a)

(b)

Invasive infections…

- clinical manifestations
  - necrotizing fasciitis
    - destruction of sheath covering skeletal muscle
  - myositis
    - inflammation and destruction of skeletal muscle and fat tissue
  - toxic shock-like syndrome (TSLS)
    - precipitous drop of blood pressure, failure of multiple organs, and high fever

Figure 38.6

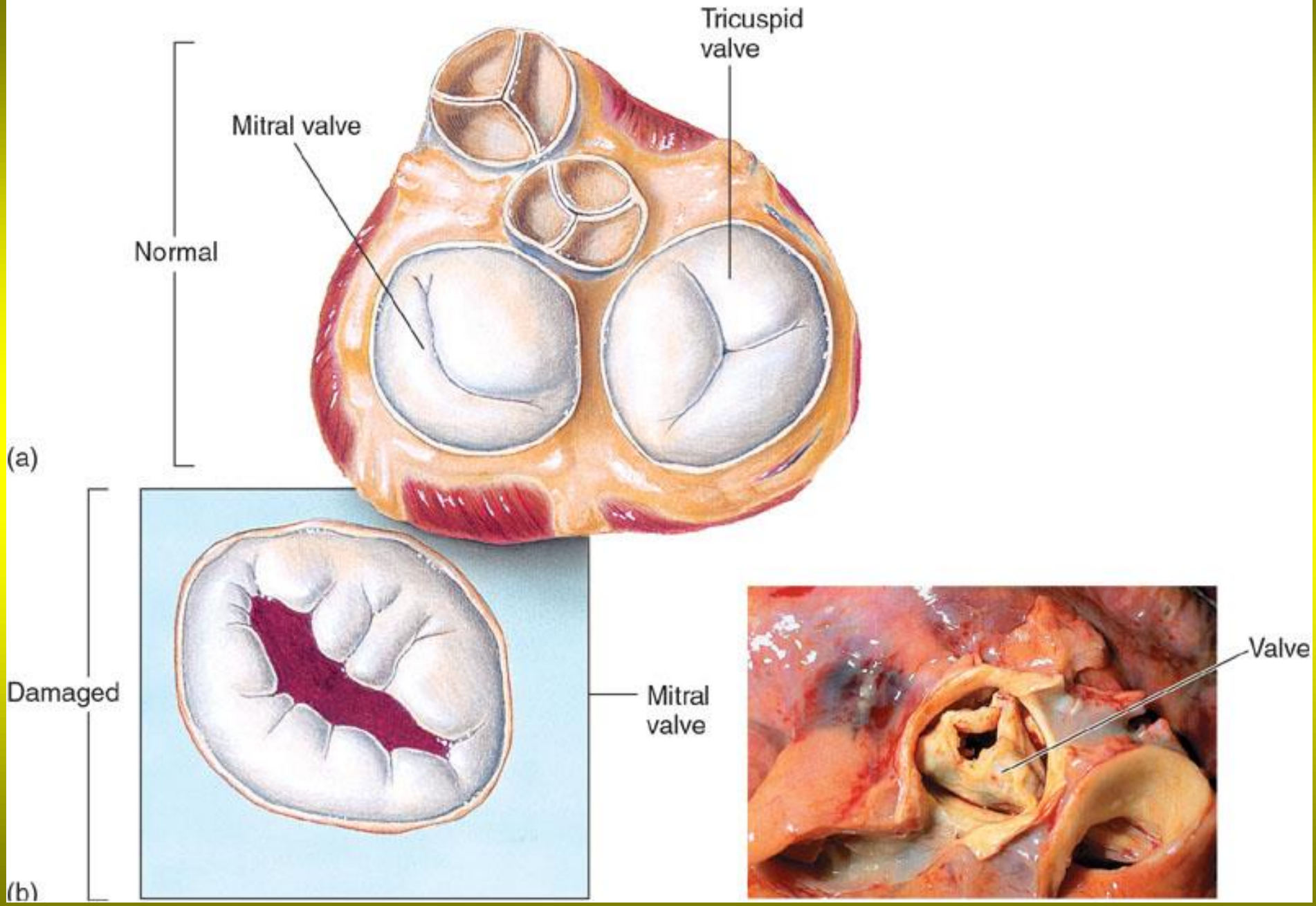
Necrotizing fasciitis

Poststreptococcal Diseases

- occur 1 to 4 weeks after acute streptococcal infection
- glomerulonephritis (Bright's disease) and rheumatic fever
  - both are nonsupporative (non pus-producing)
  - most serious problems associated with streptococcal infections in U.S.

Glomerulonephritis

- inflammatory disease of renal glomeruli
  - a type III hypersensitivity
- clinical manifestations
  - edema, fever, hypertension, and hematuria
  - may spontaneously heal or may become chronic
- treatment, prevention, and control
  - clinical history, physical findings, and confirmatory evidence of prior streptococcal infection
  - antibiotic therapy (to kill residual bacteria), otherwise no specific therapy
  - antibiotic therapy of acute infection



Streptococcal Diseases

- Pharyngitis
- Impetigo
- Cellulitis
- Wound Infections
- Meningitis
- Erysipelas
- Septicemia
- Otitis media
- Endocarditis; acute and subacute
- Urinary Tract Infections
- Brain Abscesses
- Puerperal Sepsis
- Scarlet Fever
- Rheumatic Fever
- Acute Glomerulo-nephritis

Group B Streptococcal Disease

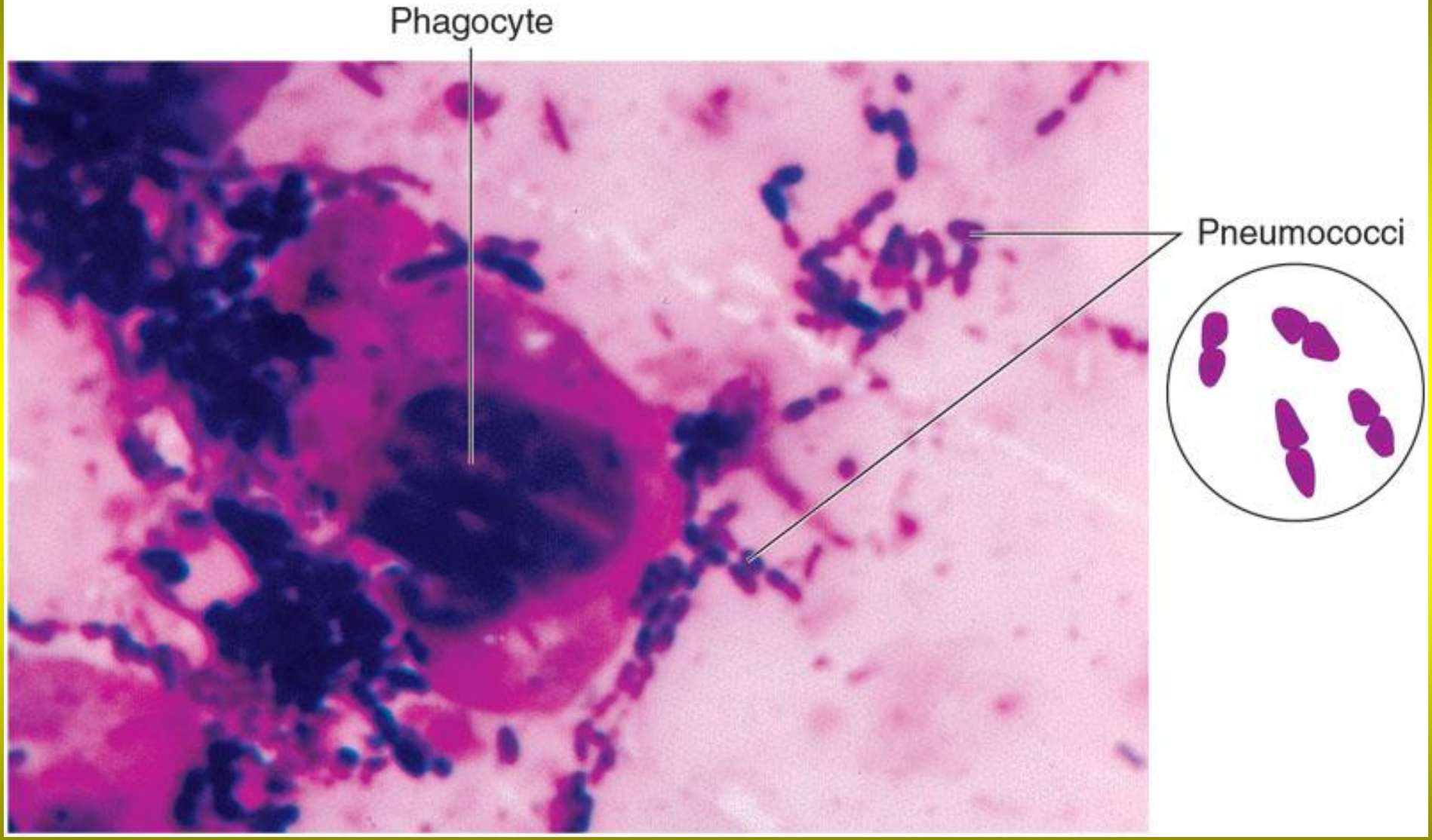
- caused by *Streptococcus agalactiae* or Group B streptococcus (GBS)
- gram-positive
- common cause of neonatal and newborne diseases such as sepsis, meningitis, and pneumonia
- transmitted directly from person-to –person with many people being transient carriers

GBS

- **diagnosis**
  - gram-positive, beta-hemolytic, streptococcal bacteria growth from cultures of otherwise sterile body fluids
- **treatment, prevention and control**
  - antibiotics

S. pneumoniae

- One of three major causes bacterial meningitidis
- Causes 60-70% of all bacterial pneumonias
- small, lancet-shaped cells arranged in pairs and short chains
- Culture requires blood or chocolate agar
- Growth improved by 5-10% CO_2
- Lack catalase & peroxidases – cultures die in O_2



S. pneumoniae

- 5-50% of all people carry it as normal flora in pharynx
- Very delicate, does not survive long outside of its habitat
- Pneumonia occurs when cells are aspirated into the lungs of susceptible individuals
- Pneumococci multiply & induce an overwhelming inflammatory response
- Treated with penicillin

Streptococcal pneumonia

- **endogenous infection**
  - caused by one's own normal microbiota
- **caused by *Streptococcus pneumoniae***
  - produces polysaccharide capsule and a toxin
  - rapidly multiplies in alveolar spaces
- **disease only occurs in individuals with predisposing condition**

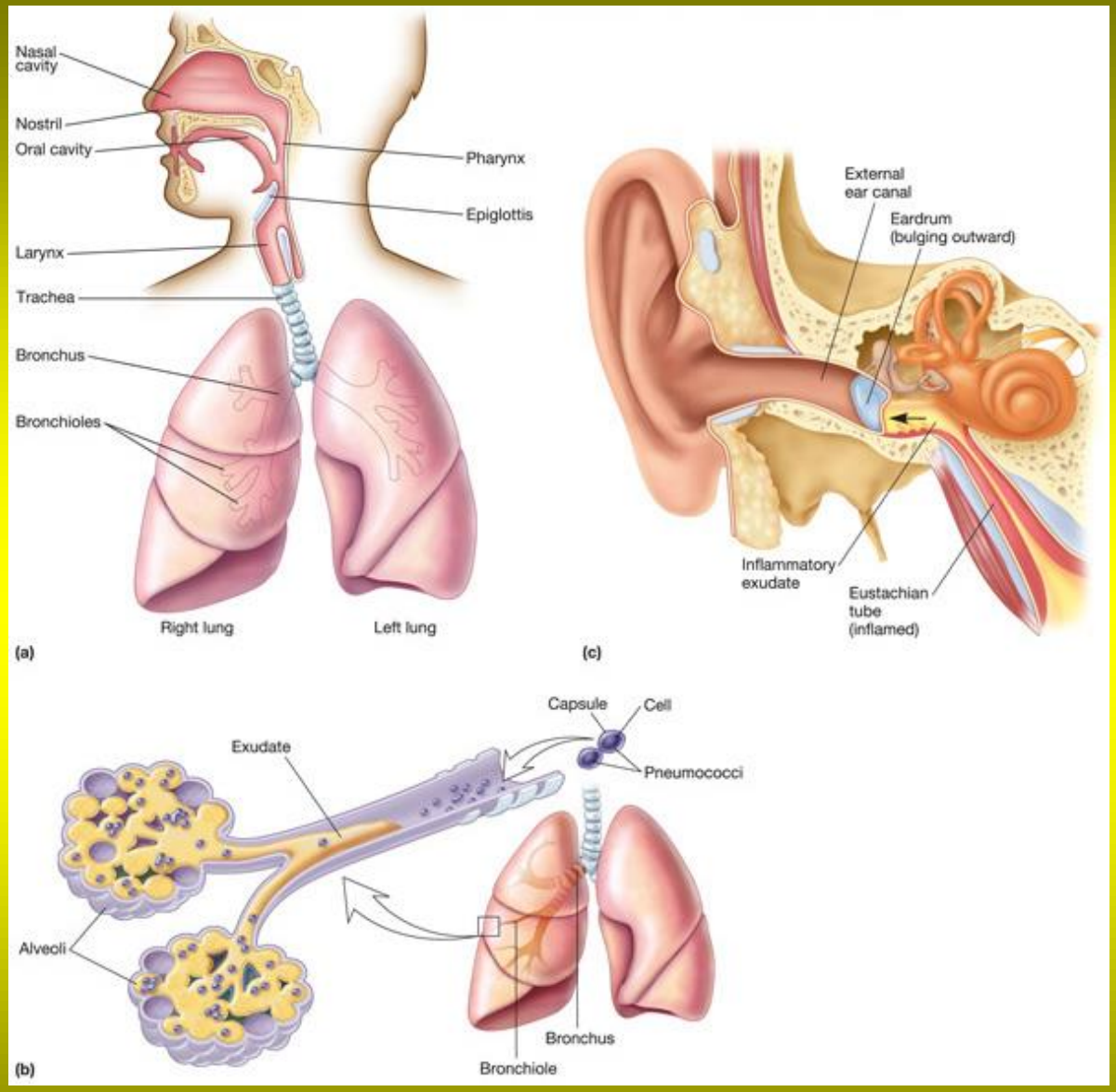

Nasal cavity
Nostril
Oral cavity
Pharynx
Epiglottis
Larynx
Trachea
Bronchus
Bronchioles
Right lung
Left lung
(a)
External ear canal
Eardrum (bulging outward)
Inflammatory exudate
Eustachian tube (inflamed)
(c)
Capsule
Cell
Exudate
Pneumococci
Alveoli
Bronchus
Bronchiole
(b)

Figure 38.7

Bacterial (septic) meningitis

- transmitted in respiratory secretions
- clinical manifestations
  - initial respiratory illness or sore throat interrupted by one of following:
    - vomiting, headache, lethargy, confusion, and stiffness in neck and back
- treatment, prevention, and control
  - culture of bacteria from cerebrospinal fluid and rapid tests
  - antibiotic therapy
  - immunization against *Haemophilus influenzae* type b (HiB)

Meningitis

- inflammation of meninges

Table 39.2 Causative Agents of Meningitis by Diagnostic Category

Type of Meningitis	Causative Agent
Bacterial (Septic) Meningitis	*Streptococcus pneumoniae*
	Neisseria meningitidis
	Haemophilus influenzae type b
	Gram-negative bacilli
	Group B streptococci
	Listeria monocytogenes
	Mycobacterium tuberculosis
	Nocardia asteroides
	Staphylococcus aureus
	Staphylococcus epidermidis
Aseptic Meningitis Syndrome	
Agents Requiring Antimicrobials	Fungi
	Amoebae
	Syphilis
	Mycoplasmas
	Leptospires
Agents Requiring Other Treatments	Viruses
	Cancers
	Parasitic cysts
	Chemicals

Sexually Transmitted Diseases

STDs

Sexually Transmitted Diseases

- major worldwide public health problem
- some also transmitted by nonsexual means
- some cured easily, others difficult or impossible to cure

Syphilis

- caused by *Treponema pallidum* subsp. *pallidum*
- venereal syphilis – **sexually transmitted**
- congenital syphilis – **acquired in utero**

Three Stages of Syphilis

- primary stage – chancre (small, painless, reddened ulcer) at infection site and contains spirochetes
- secondary stage – highly variable skin rash followed by latent period
- tertiary stage – formation of gummas (degenerative lesions) in skin, bone and nervous systems

Syphilis…

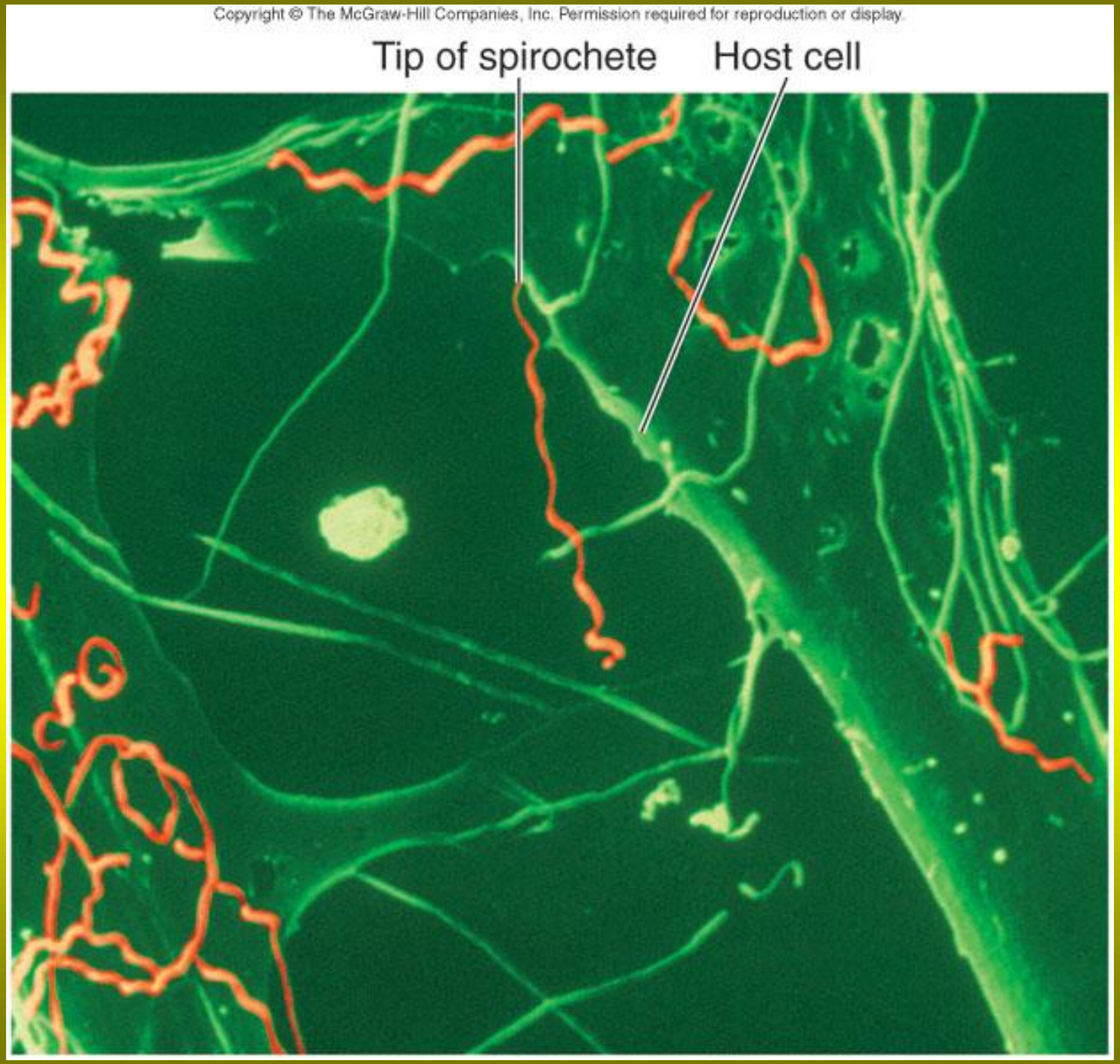
- **diagnosis**
  - clinical history, microscopic examination, and serology
- **treatment, prevention, and control**
  - antibiotic therapy most effective in early stages
  - public education, prompt treatment of new cases, follow-up on sources and contacts, sexual hygiene, and use of condoms

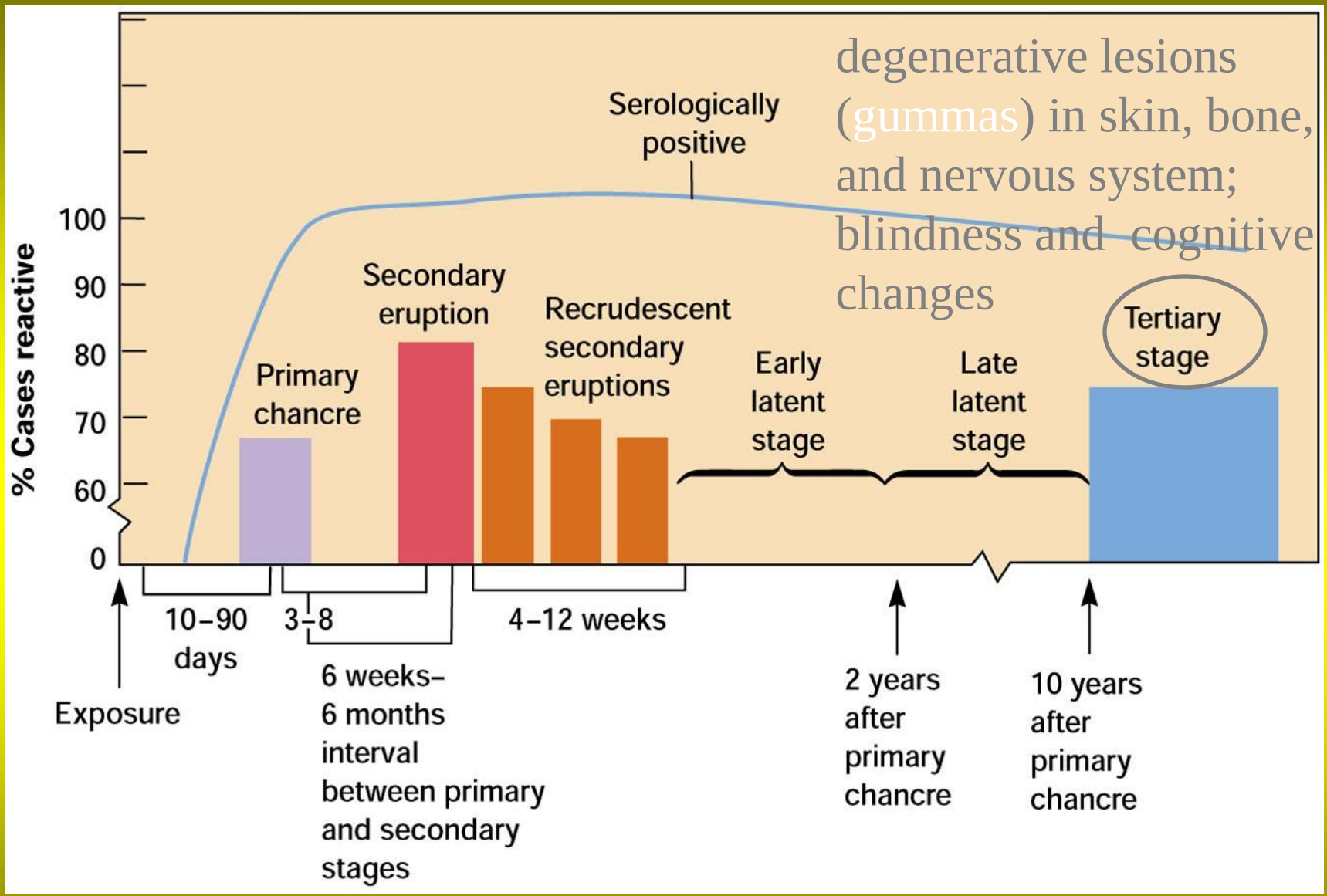
Syphilis

Table 39.4 Summary of the Major Sexually Transmitted Diseases (STDs)

Microorganism	Disease	Comments	Treatment
Bacteria			
Calymmatobacterium granulomatis	Granuloma inguinale (donovanosis)	Rare in the U.S.; draining ulcers that can persist for years	Tetracycline, erythromycin, newer quinolones
Campylobacter (Heliobacter) cinaedi, C. fennelliae	Diarrhea and rectal inflammation in homosexual men	Common in immunocompromised individuals	Metronidazole, macrolides
Chlamydia trachomatis	Nongonococcal urethritis (NGU); cervicitis, pelvic inflammatory disease (PID), lymphogranuloma venereum	Serovars D-K cause most of the STDs in the U.S.; lymphogranuloma venereum rare in the U.S.	Tetracyclines, erythromycin, doxycycline, ceftriaxone
Gardnerella vaginalis	Bacterial vaginosis	Clue cells present	Metronidazole
Haemophilus ducreyi	Chancroid ("soft chancre")	Open sores on the genitals can lead to scarring without treatment; on the rise in the U.S.	Erythromycin or ceftriaxone
Mycoplasma genitalium	Implicated in some cases of NGU	Only recently described as an STD	Tetracyclines or erythromycin
Mycoplasma hominis	Implicated in some cases of PID	Widespread, often asymptomatic but can cause PID in women	Tetracyclines or erythromycin
Neisseria gonorrhoeae	Gonorrhea, PID	Most commonly reported STD in the U.S.; usually symptomatic in men and asymptomatic in women; new antibiotic-resistant strains	Third-generation cephalosporins
Treponema pallidum subsp. *pallidum*	Syphilis, congenital syphilis	Manifests many clinical syndromes	Benzathine penicillin G
Ureaplasma urealyticum	Urethritis	Widespread, often asymptomatic but can cause PID in women and NGU in men	Tetracyclines or erythromycin

- venereal syphilis – sexually transmitted
- congenital syphilis – acquired in utero





degenerative lesions (gummas) in skin, bone, and nervous system; blindness and cognitive changes

Figure 39.21

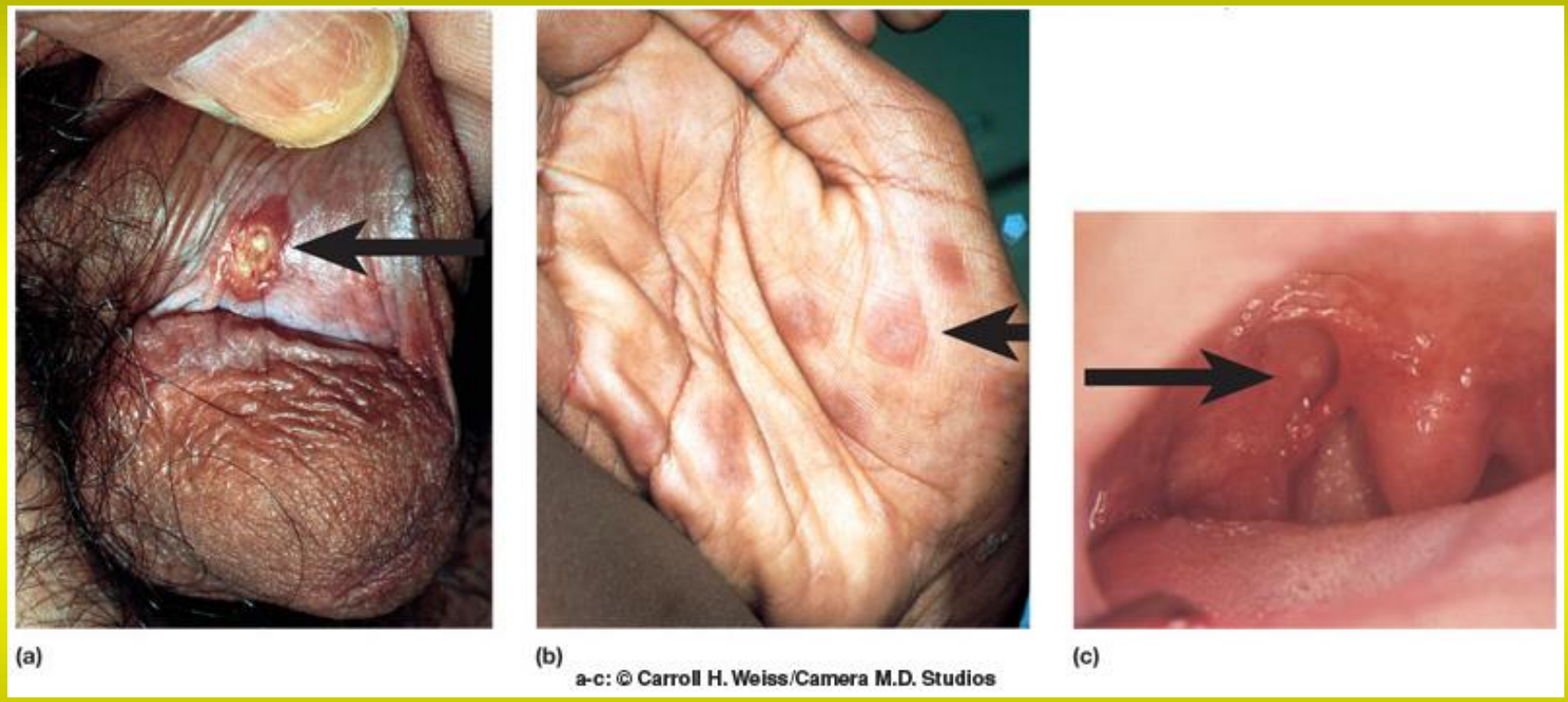
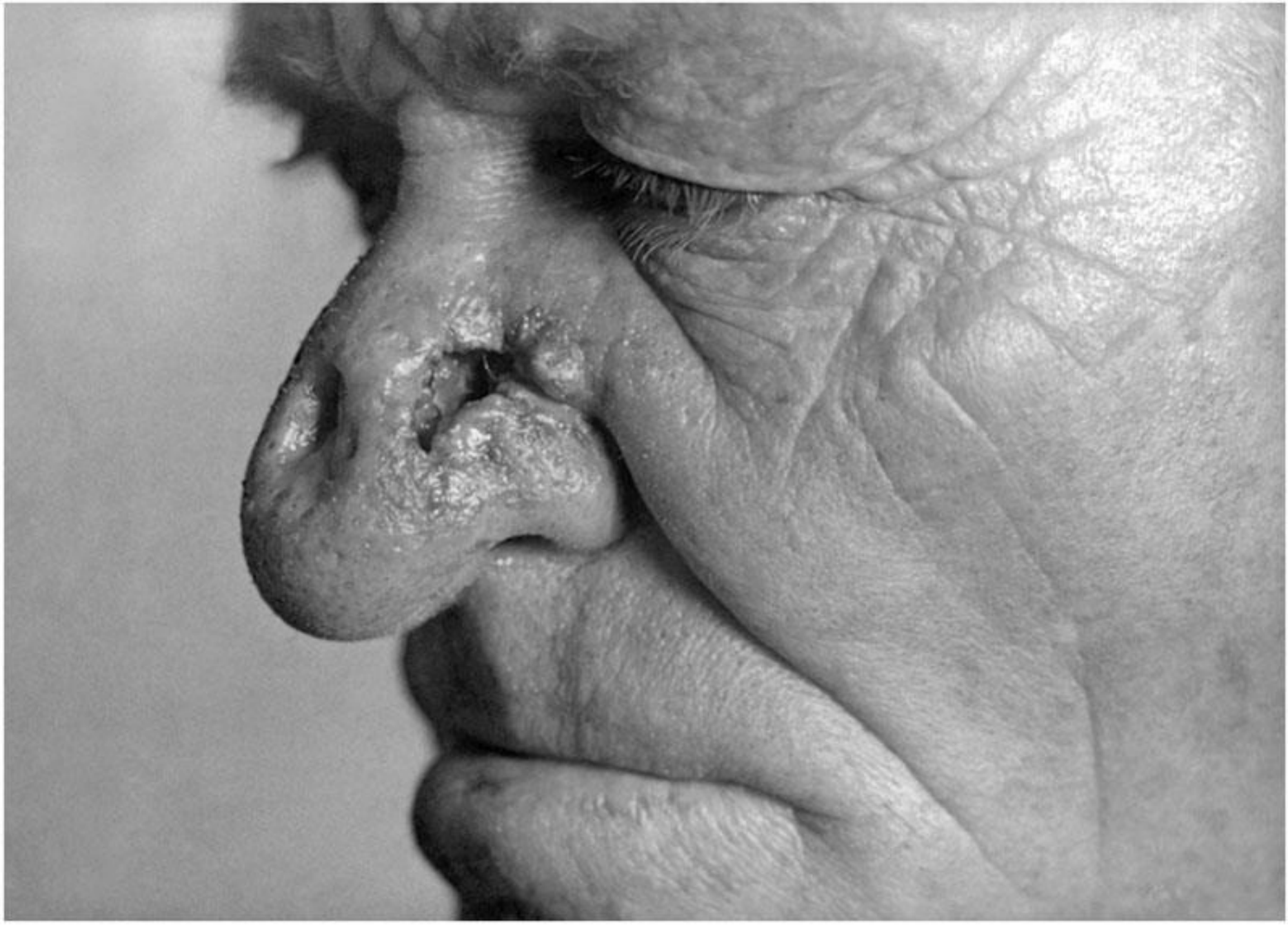


Figure 38.20



(a)

(b)

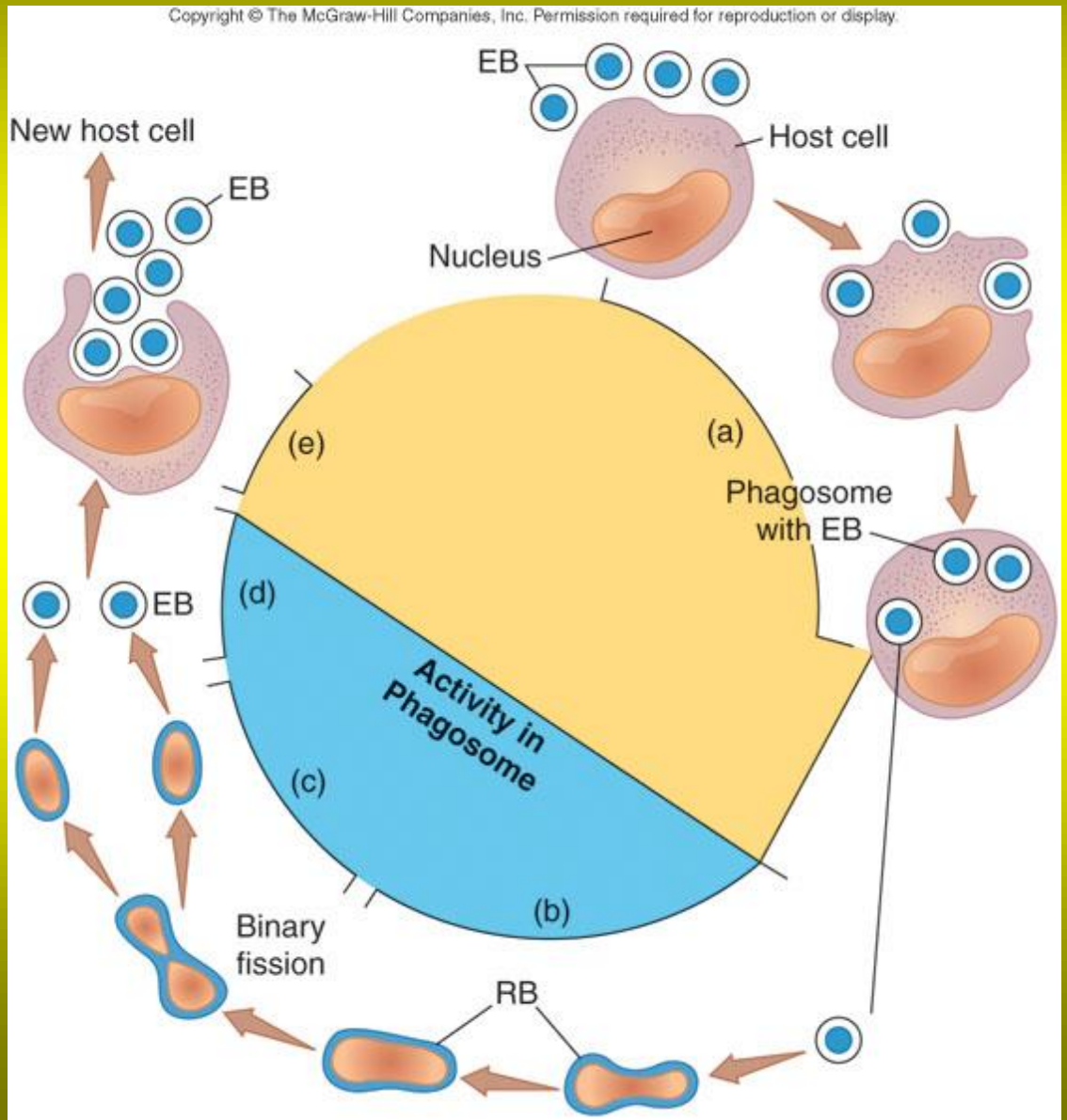
Syphilis…

- **treatment, prevention, and control**
  - clinical history, microscopic examination, and serology
  - antibiotic therapy most effective in early stages
  - public education, prompt treatment of new cases, follow-up on sources and contacts, sexual hygiene, and use of condoms

Chlamydia

- obligate intracellular parasites
- small gram-negative cell wall
- alternate between 2 stages
  - elementary body – small metabolically inactive, extracellular, infectious form
  - reticulate body – grows within host cell vacuoles

Chlamydia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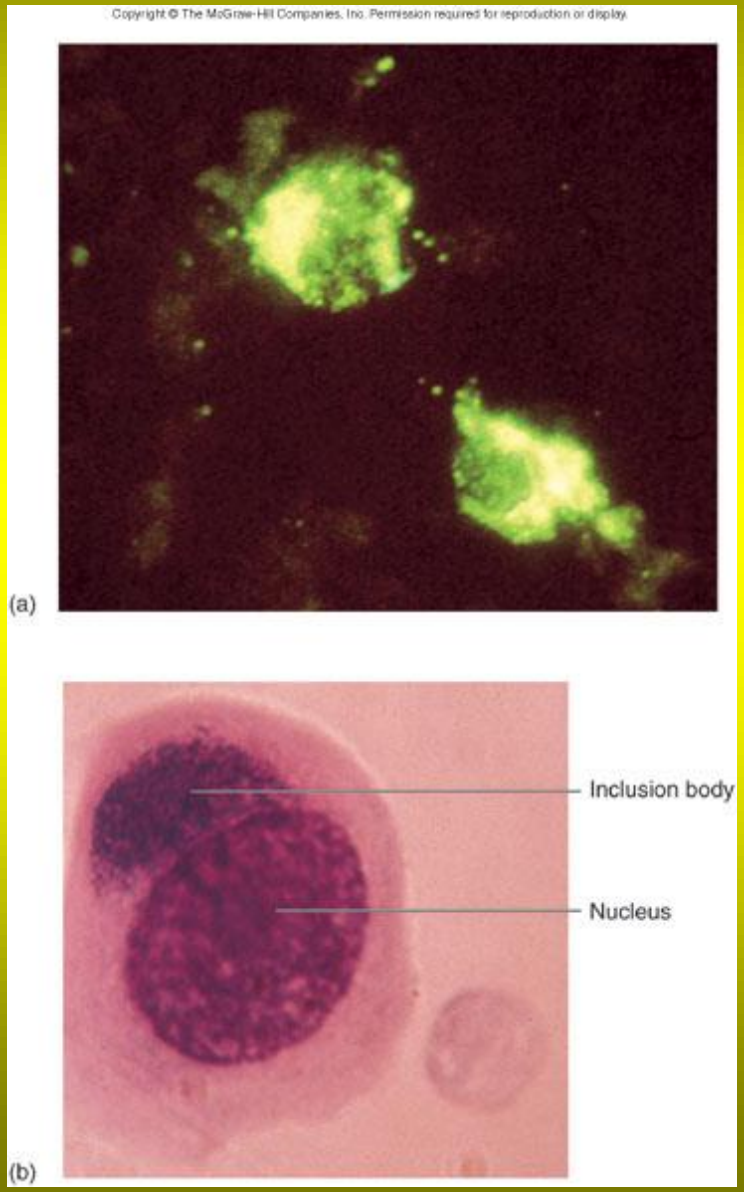
EB
New host cell
Host cell
EB
Nucleus
(e)
(a)
Phagosome
with EB
(d)
EB
Activity in
Phagosome
(c)
(b)
Binary
fission
RB

Chlamydia trachomatis

- human reservoir
- 2 strains
- trachoma – attacks the mucous membranes of the eyes, genitourinary tract & lungs
  - ocular trachoma – severe infection, deforms eyelid & cornea, may cause blindness
  - inclusion conjunctivitis – occurs as babies pass through birth canal; prevented by prophylaxis
  - **STD – urethritis, cervicitis, salpingitis (PID),infertility, scarring**
- lymphogranuloma venereum – disfiguring disease of the external genitalia & pelvic lymphatics

Chlamydia trachomatis



Chlamydia trachomatis

Trachoma

- caused by *C. trachomatis* serotypes A-C
- transmitted by hand-to-hand contact, contact with infected soaps and towels, and flies

Trachoma…

- clinical manifestations
  - first infection
    - abrupt onset of inflamed conjunctiva, leading to inflammatory cell exudate and necrotic eyelash follicles
    - usually heals spontaneously
  - reinfection
    - pannus formation (vascularization of cornea), leading to scarring of conjunctiva
    - if scarring of cornea also occurs, blindness results

Trachoma…

- treatment, prevention, and control
  - diagnosis and treatment same as for inclusion conjunctivitis
  - health education, personal hygiene, and access to clean water for washing

Chlamydia trachomatis

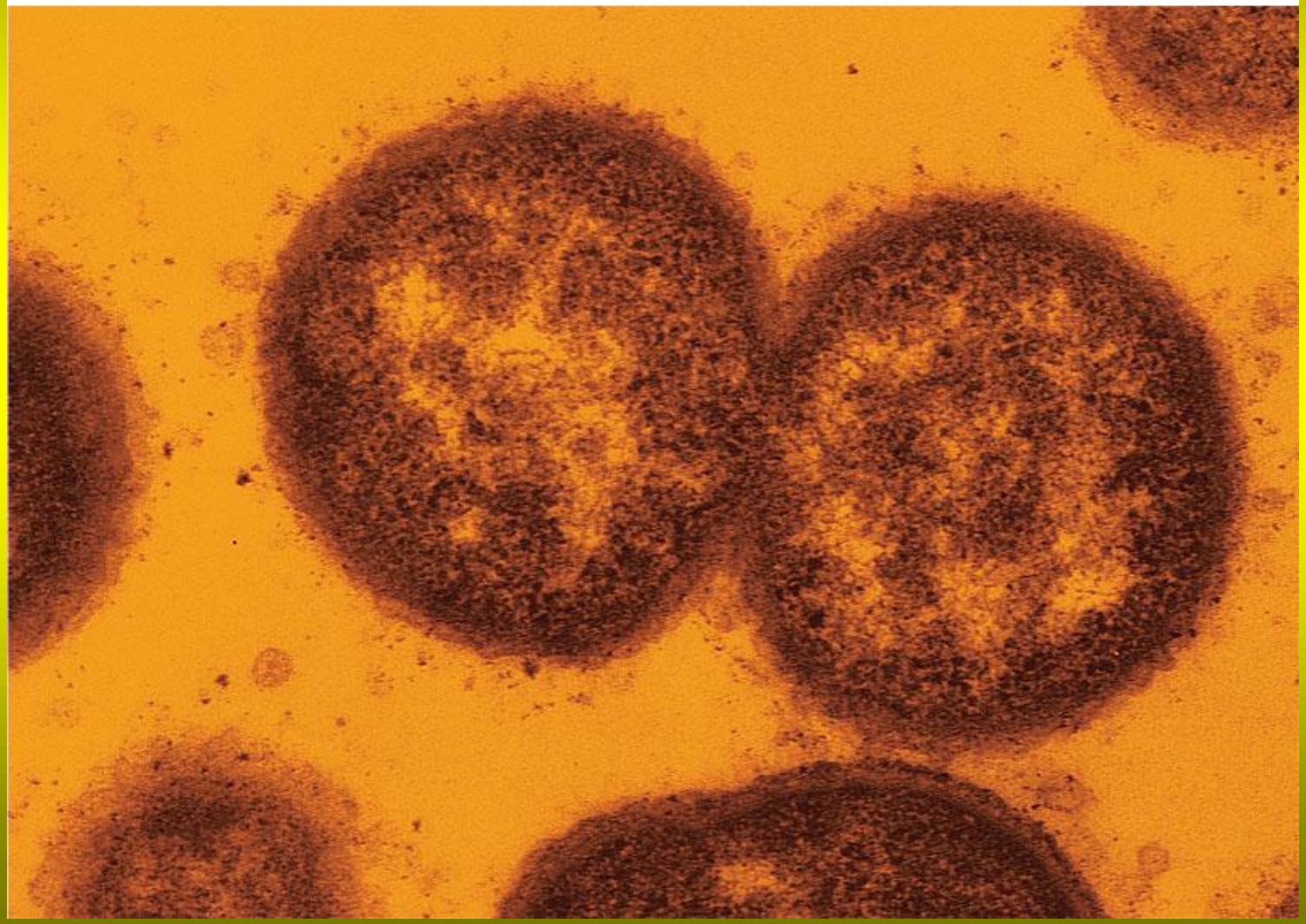
(a)

(b)

Family Neisseriaceae

- Gram-negative cocci
- Residents of mucous membranes of warm-blooded animals
- Genera include *Neisseria, Moraxella, Acinetobacter*
- 2 primary human pathogens
  - *Neisseria gonorrhoeae*
  - *Neisseria meningitidis*

Neisseria



Gonorrhea

Table 39.4 Summary of the Major Sexually Transmitted Diseases (STDs)

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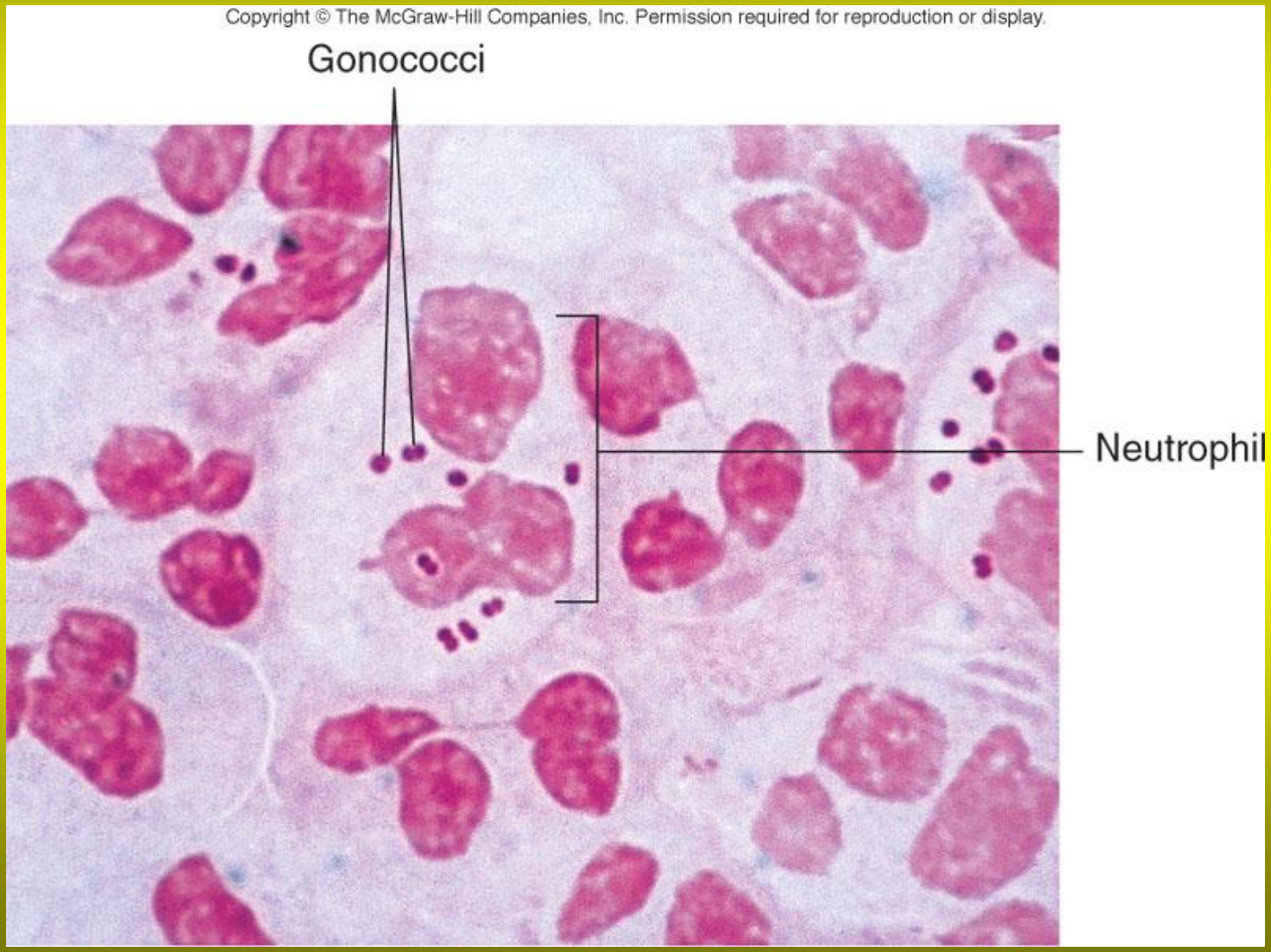
Calymmatobacterium granulomatis	Granuloma inguinale (donovanosis)	Rare in the U.S.; draining ulcers that can persist for years	Tetracycline, erythromycin, newer quinolones
Campylobacter (Heliobacter) cinaedi, C. fennelliae	Diarrhea and rectal inflammation in homosexual men	Common in immunocompromised individuals	Metronidazole, macrolides
Chlamydia trachomatis	Nongonococcal urethritis (NGU); cervicitis, pelvic inflammatory disease (PID), lymphogranuloma venereum	Serovars D-K cause most of the STDs in the U.S.; lymphogranuloma venereum rare in the U.S.	Tetracyclines, erythromycin, doxycycline, ceftriaxone
Gardnerella vaginalis	Bacterial vaginosis	Clue cells present	Metronidazole
Haemophilus ducreyi	Chancroid ("soft chancre")	Open sores on the genitals can lead to scarring without treatment; on the rise in the U.S.	Erythromycin or ceftriaxone
Mycoplasma genitalium	Implicated in some cases of NGU	Only recently described as an STD	Tetracyclines or erythromycin
Mycoplasma hominis	Implicated in some cases of PID	Widespread, often asymptomatic but can cause PID in women	Tetracyclines or erythromycin
Neisseria gonorrhoeae	Gonorrhea, PID	Most commonly reported STD in the U.S.; usually symptomatic in men and asymptomatic in women; new antibiotic-resistant strains	Third-generation cephalosporins
Treponema pallidum subsp. *pallidum*	Syphilis, congenital syphilis	Manifests many clinical syndromes	Benzathine penicillin G
Ureaplasma urealyticum	Urethritis	Widespread, often asymptomatic but can cause PID in women and NGU in men	Tetracyclines or erythromycin

can also be transmitted from mother to child during birth, causing ophthalmia neonatorum (conjunctivitis of the newborn)

Gonorrhea diagnosis



Gonorrhea…

- clinical manifestations
  - symptoms in males
    - urethral discharge of yellow, creamy pus, and painful, burning urination
  - symptoms in females
    - vaginal discharge beginning 7 to 21 days after infection

Gonorrhea…

- pelvic inflammatory disease (PID) results from infection of Fallopian tubes and surrounding tissue
  - major cause of sterility and ectopic pregnancies
- **disseminated gonococcal infections**
  - involvement of joints, heart, and throat

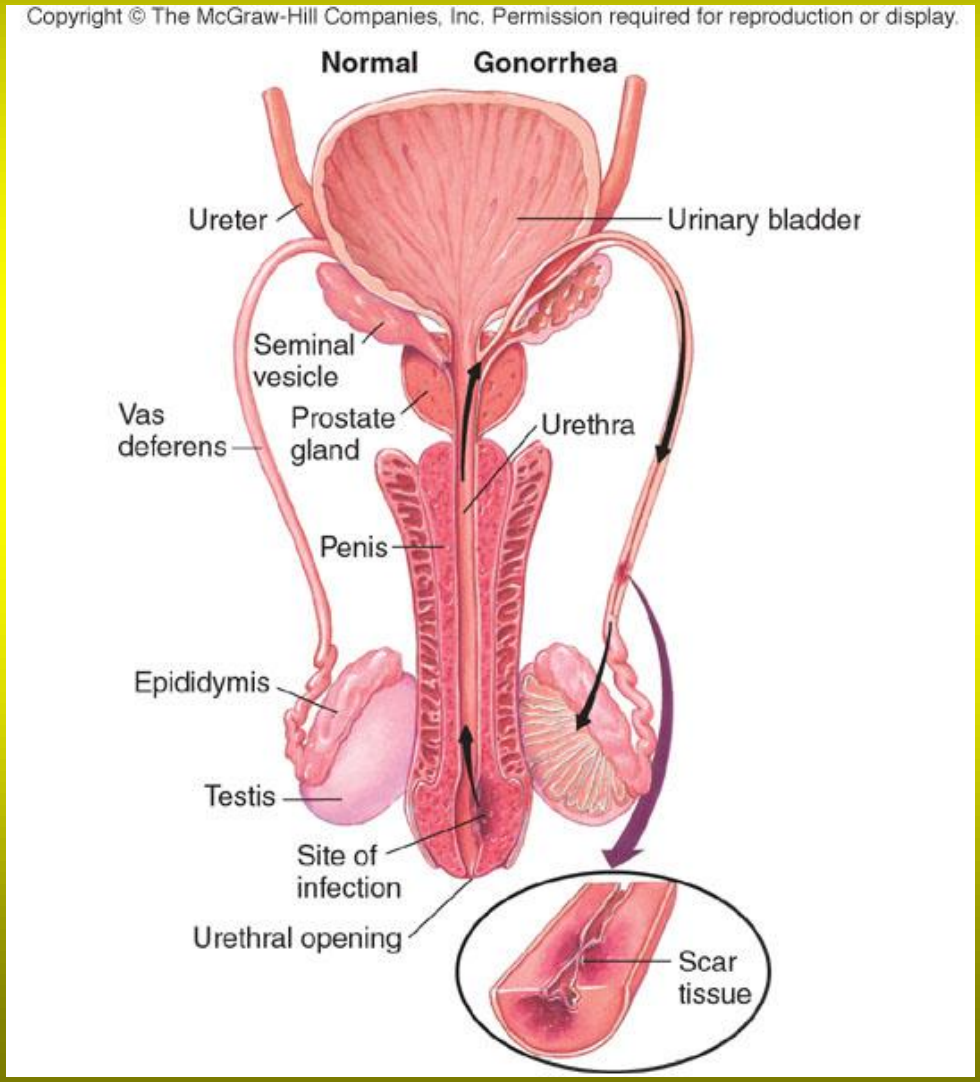
Gonorrhea…

- **diagnosis**
  - culture of bacterium followed by gram stain, oxidase test, and determination of cell and colony morphology; DNA probe test
- **treatment, prevention, and control**
  - antibiotic therapy
    - penicillin resistance common
  - public education, diagnosis and treatment of asymptomatic individuals, condom use, and quick diagnosis and treatment of infected individuals

gonorrhea

- Males – urethritis, yellowish discharge, scarring & infertility
- Females – vaginitis, urethritis, salpingitis (**PID**) mixed anaerobic abdominal infection, common cause of sterility & ectopic tubal pregnancies
- Extragenital infections – anal, pharygeal, conjunctivitis, septicemia, arthritis

gonorrhea



Gonorrhea

- caused by *Neisseria gonorrhoeae*
  - gram-negative, oxidase-positive diplococcus
  - referred to as gonococcus, (pl. gonococci)
  - attaches to microvilli and then phagocytosed by mucosal cells
- disease of mucous membranes of the genitourinary tract, eye, rectum and throat
- can also be transmitted from mother to child during birth, causing
  - ophthalmia neonatorum (conjunctivitis of the newborn)

Gonorrhea in newborns

- Infected as they pass through birth canal
- Eye inflammation, blindness
- Prevented by prophylaxis after birth

Gonorrhea in newborns

Gonorrhea…

- treatment, prevention, and control
  - culture of bacterium followed by Gram stain, oxidase test, and determination of cell and colony morphology; DNA probe test
  - antibiotic therapy
    - penicillin resistance common
  - public education, diagnosis and treatment of asymptomatic individuals, condom use, and quick diagnosis and treatment of infected individuals

Meningitis

- inflammation of meninges

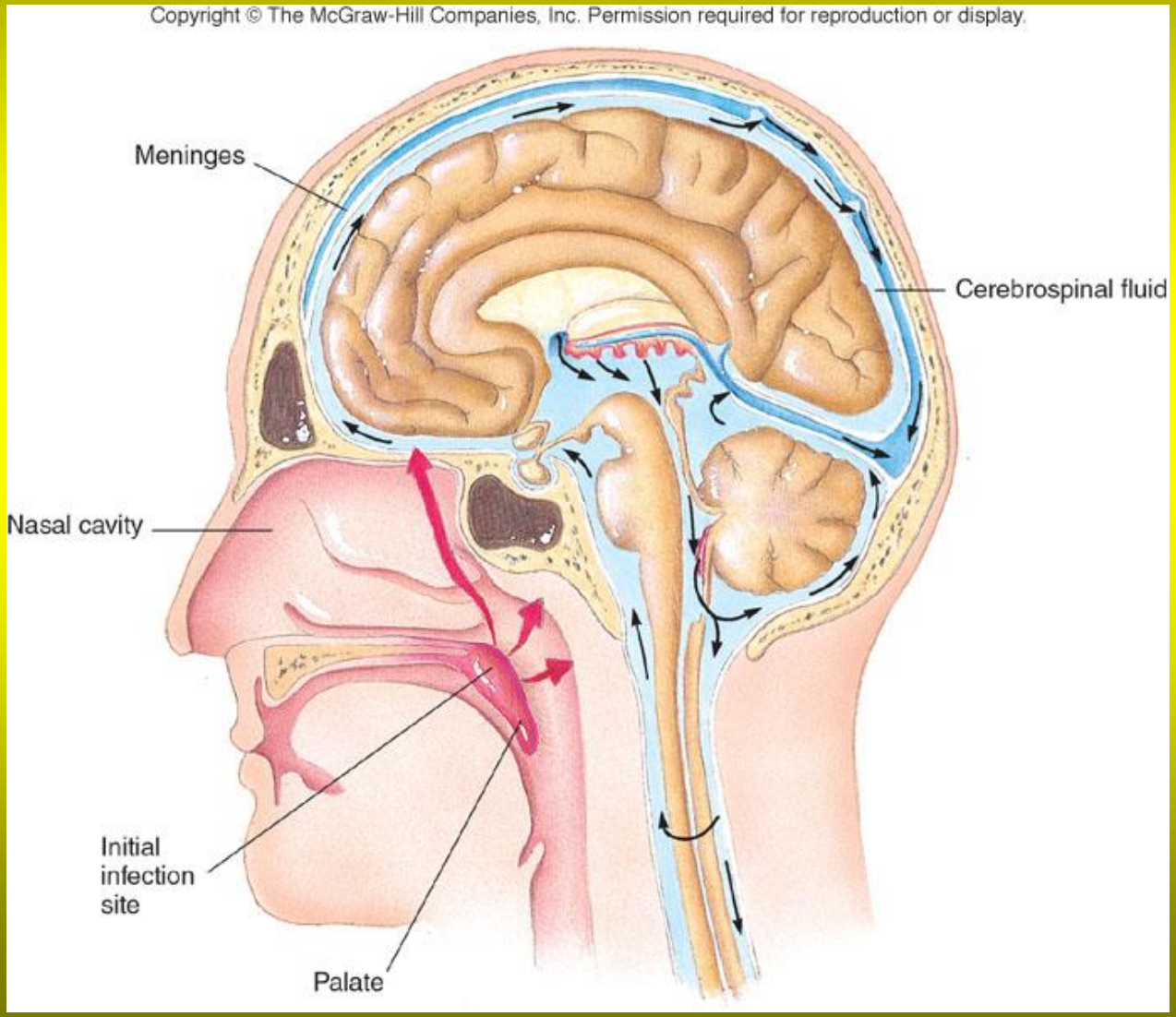
Table 39.2 Causative Agents of Meningitis by Diagnostic Category

Type of Meningitis	Causative Agent
Bacterial (Septic) Meningitis	*Streptococcus pneumoniae*
	Neisseria meningitidis
	Haemophilus influenzae type b
	Gram-negative bacilli
	Group B streptococci
	Listeria monocytogenes
	Mycobacterium tuberculosis
	Nocardia asteroides
	Staphylococcus aureus
	Staphylococcus epidermidis
Aseptic Meningitis Syndrome	
Agents Requiring Antimicrobials	Fungi
	Amoebae
	Syphilis
	Mycoplasmas
	Leptospires
Agents Requiring Other Treatments	Viruses
	Cancers
	Parasitic cysts
	Chemicals

Neisseria meningitidis

- Virulence factors – capsule, pili, IgA protease
- 12 strains; serotypes A, B, C, cause most cases
- Prevalent cause of meningitis
- Disease begins when bacteria enter bloodstream, pass into cranial circulation, multiply in meninges; very rapid onset; endotoxin causes hemorrhage and shock; can be fatal
- Treated with penicillin, chloramphenicol
- Vaccines exist for group A and C

Neisseria meningitidis



Neisseria meningitidis