

# Microbial Diseases of the Respiratory System

Microbiology  
CCV

1

## Structures of the Respiratory System

- Respiratory system exchanges gases between the atmosphere and the blood
- Divided into two main parts
  - Upper respiratory system
  - Lower respiratory system

2

## Structures of the Respiratory System

- **Structures of the Upper Respiratory System, Sinuses, and Ears**
  - Components of the upper respiratory system
    - Nose
    - Nasal cavity
    - Pharynx
    - Tonsils
    - Mucus

3

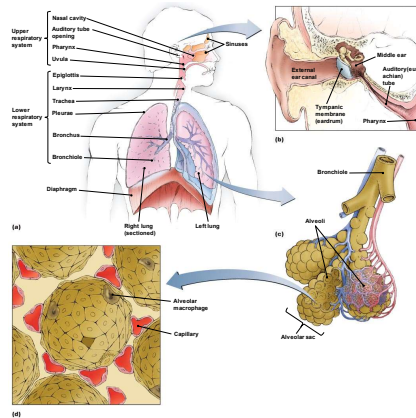
## Structures of the Respiratory System

### • Structures of the Lower Respiratory System

- Components of the lower respiratory system
  - Larynx
  - Trachea
  - Bronchi
  - Alveoli
  - Diaphragm
  - Various protective components
    - Ciliated mucous membrane, alveolar macrophages, and secretory antibodies

4

Figure 22.1 Structures of the respiratory system.



5

## Structure of the Respiratory System

### • Normal Microbiota of the Respiratory System

- Lower respiratory system
  - Typically microorganisms are not present
- Upper respiratory system
  - Colonized by many microorganisms
  - Normal microbiota limit growth of pathogens
  - Normal microbiota may be opportunistic pathogens

6

## Bacterial Diseases of the Upper Respiratory System, Sinuses, and Ears

### • Streptococcal Respiratory Diseases

- Signs and symptoms
  - Pharyngitis
    - Sore throat and difficulty swallowing
  - Often accompanied by fever, malaise, and headache
  - Laryngitis and bronchitis can occur if infection spreads to lower respiratory tract
  - May progress to scarlet or rheumatic fever
  - Acute glomerulonephritis occurs in some untreated cases

7

## Bacterial Diseases of the Upper Respiratory System, Sinuses, and Ears

### • Streptococcal Respiratory Diseases

- Signs and symptoms
- Pathogen and virulence factors
  - Caused by group A streptococci (*S. pyogenes*)
  - Variety of virulence factors
    - M proteins
    - Hyaluronic acid capsule
    - Streptokinases
    - C5a peptidase
    - Pyrogenic toxins
    - Streptolysins

8

## Bacterial Diseases of the Upper Respiratory System, Sinuses, and Ears

### • Streptococcal Respiratory Diseases

- Pathogenesis
  - Occurs when normal microbiota are depleted, large inoculum is introduced, or adaptive immunity is impaired
- Epidemiology
  - Spread via respiratory droplets
  - Occurs most often in winter and spring
- Diagnosis, treatment, and prevention
  - Often confused with viral pharyngitis
  - Oral penicillin is an effective treatment

9

**TABLE 22.1** Manifestations of Some Respiratory Diseases

| Ailment                                        | Manifestations                                                                                  |
|------------------------------------------------|-------------------------------------------------------------------------------------------------|
| Common cold (viral)                            | Sneezing, rhinorrhea, congestion, sore throat, headache, malaise, cough                         |
| Influenza (viral)                              | Fever, rhinorrhea, headache, body aches, fatigue, dry cough, pharyngitis, congestion            |
| "Strep" throat (bacterial)                     | Fever, red and sore throat, swollen lymph nodes in neck                                         |
| Viral pneumonia                                | Fever, chills, mucus-producing cough, headache, body aches, fatigue                             |
| Bacterial pneumonia                            | Fever, chills, congestion, cough, chest pain, rapid breathing, and possible nausea and vomiting |
| Bronchitis (viral or bacterial)                | Mucus-producing cough, wheezing                                                                 |
| Inhalation anthrax (bacterial)                 | Fever, malaise, cough, chest discomfort, vomiting                                               |
| Coronavirus respiratory syndromes (SARS, MERS) | High fever (>38°C), cough, shortness of breath                                                  |

10

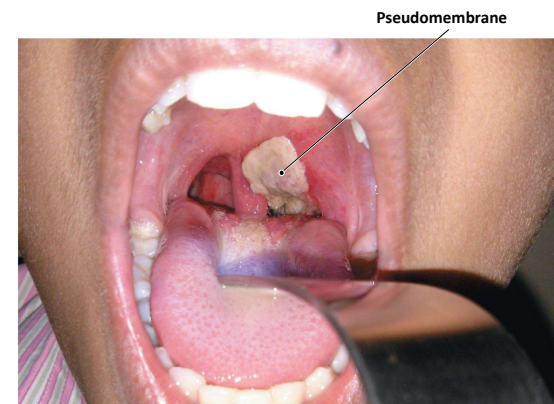
## Bacterial Diseases of the Upper Respiratory System, Sinuses, and Ears

### • Diphtheria

- Signs and symptoms
  - Sore throat, localized pain, fever
  - Presence of a pseudomembrane that can obstruct airways
- Pathogen and virulence factors
  - Caused by *Corynebacterium diphtheriae*
    - Ubiquitous in animals and humans
  - Virulence factors
    - *C. diphtheriae* produces diphtheria toxin
      - Prevents polypeptide synthesis and causes cell death

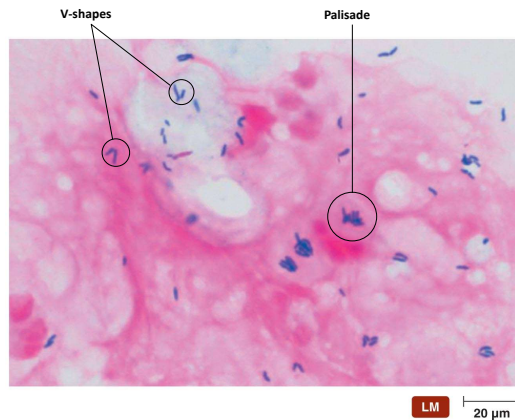
11

Figure 22.2 A pseudomembrane, characteristic of diphtheria.



12

Figure 22.3 Characteristic arrangements of Gram-stained cells of *Corynebacterium diphtheriae*.



13

## Bacterial Diseases of the Upper Respiratory System, Sinuses, and Ears

### • Diphtheria

- Pathogenesis and epidemiology
  - Spread via respiratory droplets or skin contact
  - Symptomatic in immunocompromised or nonimmune individuals
  - Leading cause of death among unimmunized children
- Diagnosis, treatment, and prevention
  - Diagnosis is based on presence of a pseudomembrane
  - Treated with antitoxin and antibiotics
  - Immunization is an effective prevention

14

## Bacterial Diseases of the Upper Respiratory System, Sinuses, and Ears

### • Rhinosinusitis and Otitis Media

- Signs and symptoms
  - Malaise accompanied by headache and inflamed nasal passages
  - Otitis media results in severe pain in the ears
- Pathogen and virulence factors
  - Caused by various respiratory microbiota
    - May be due to damage to upper respiratory system and auditory tube

15

## Bacterial Diseases of the Upper Respiratory System, Sinuses, and Ears

### • Sinusitis and Otitis Media

- Pathogenesis and epidemiology
  - Bacteria in the pharynx spread to the sinuses via the throat
  - Rhinosinusitis is more common in adults
  - Otitis media is more common in children
- Diagnosis, treatment, and prevention
  - Symptoms are often diagnostic
  - No known way to prevent rhinosinusitis
  - Flushing nasal and sinus cavities with saline solution can reduce duration of symptoms

16

Figure 22.4 Neti pot.



17

## Viral Diseases of the Upper Respiratory System

### • Common Cold

- Signs and symptoms
  - Sneezing, runny nose, congestion, sore throat, malaise, and cough
- Pathogens and virulence factors
  - Enteroviruses (rhinoviruses) are the most common cause
  - Numerous other viruses cause colds
  - Cold viruses replicate at the lower temperature of the nasal cavity
- Pathogenesis
  - Cold viruses replicate in and kill infected cells

18

Figure 22.5 Rhinoviruses, the most common cause of colds.



19

## Viral Diseases of the Upper Respiratory System

### • Common Cold

- Epidemiology
  - Rhinoviruses are highly infective
  - Spread by coughing/sneezing, fomites, or person-to-person contact
  - Develop some immunity to serotypes over time
- Diagnosis, treatment, and prevention
  - Signs and symptoms are usually diagnostic
  - Pleconaril can reduce duration of symptoms
  - Hand antisepsis is important preventive measure

20

## Bacterial Diseases of the Lower Respiratory System

- Lower respiratory organs are usually axenic
- Bacterial infection of the lower respiratory system can cause life-threatening illness

21

## Bacterial Diseases of the Lower Respiratory System

### • Bacterial Pneumonias

- Lung inflammation accompanied by fluid-filled alveoli and bronchioles
- Described by affected region or organism causing the disease
  - Lobar pneumonia
  - Mycoplasmal pneumonia
  - Healthcare associated pneumonia
- Bacterial pneumonias are the most serious and the most frequent in adults

22

## Bacterial Diseases of the Lower Respiratory System

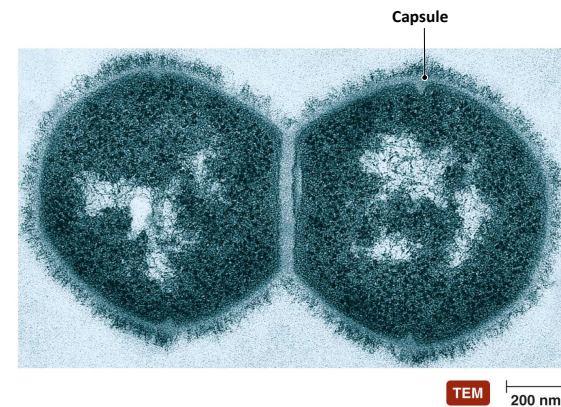
### • Bacterial Pneumonias

#### • Pneumococcal Pneumonia

- Signs and symptoms
  - Fever, chills, congestion, cough, chest pain
    - Results in short, rapid breathing
  - Blood enters the lungs, causing rust-colored sputum
- Pathogen and virulence factors
  - Caused by *Streptococcus pneumoniae*
  - Virulence factors
    - Adhesins
    - Capsule
    - Pneumolysin

23

Figure 22.6 *Streptococcus pneumoniae*, the most common cause of bacterial pneumonia.



24

## Bacterial Diseases of the Lower Respiratory System

### • Bacterial Pneumonias

#### • Pneumococcal Pneumonia

- Pathogenesis and epidemiology
  - Infection occurs by inhalation of bacteria
  - Bacterial replication causes damage to the lungs
  - Host secretory IgA destroyed by secretion of pneumococcal IgA protease
  - Pneumococcal pneumonia account for most cases of bacterial pneumonia
- Diagnosis, treatment, and prevention
  - Diagnosed by identifying diplococci in sputum smears
  - Penicillin is drug of choice for treatment
    - Some strains are now penicillin resistant
  - Vaccination is method of prevention

25

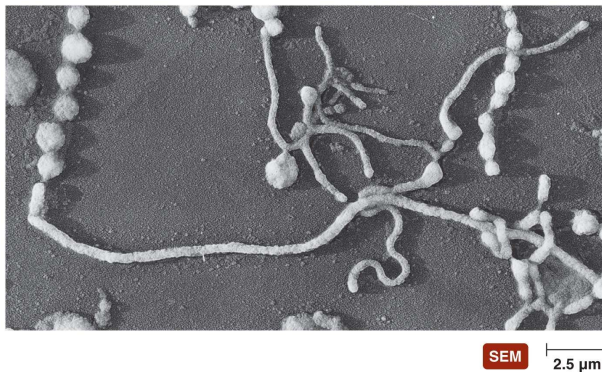
## Bacterial Diseases of the Lower Respiratory System

### • Primary Atypical (Mycoplasmal) Pneumonia

- Signs and symptoms
  - Include fever, malaise, sore throat, excessive sweating
  - Symptoms may last for weeks
- Pathogen and virulence factors
  - Caused by *Mycoplasma pneumoniae*
  - Virulence factors include an adhesion protein
- Pathogenesis
  - Bacteria colonize and kill epithelial cells
    - Causes mucus buildup and colonization by other bacteria

26

Figure 22.7 Pleomorphic forms of *Mycoplasma*.



SEM 2.5 μm

27

## Bacterial Diseases of the Lower Respiratory System

### • Primary Atypical (Mycoplasmal) Pneumonia

- Epidemiology
  - Bacteria spread by nasal secretions
  - Most common form of pneumonia in teenagers and young adults
- Diagnosis, treatment, and prevention
  - Difficult to diagnose
  - Treated with erythromycin or doxycycline
  - Prevention difficult since infected individuals may be asymptomatic

28

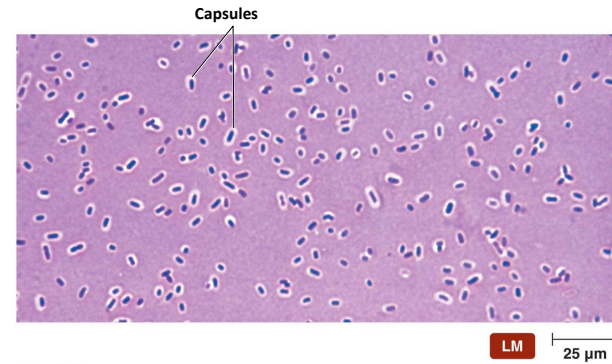
## Bacterial Diseases of the Lower Respiratory System

### • *Klebsiella Pneumonia*

- Signs and symptoms
  - Pneumonia symptoms with a thick, bloody sputum
- Pathogen and virulence factors
  - Caused by *Klebsiella pneumoniae*
  - Virulence factors include a capsule
- Pathogenesis and epidemiology
  - Immunocompromised individuals at greatest risk for infection
- Diagnosis, treatment, and prevention
  - Diagnosed by identifying *Klebsiella* in sputum samples
  - Treated with antimicrobials
  - Prevention involves good aseptic technique by health care workers

29

Figure 22.8 The prominent capsule of *Klebsiella pneumoniae*.



30

## Bacterial Diseases of the Lower Respiratory System

### • Other Bacterial Pneumonias

- *Haemophilus influenzae* and *Staphylococcus aureus*
  - Disease similar to pneumococcal pneumonia
- *Yersinia pestis*
  - Causes pneumonia, called pneumonic plague
- *Chlamydophila psittaci*
  - Causative agent of ornithosis
    - Disease of birds that can be transmitted to humans
- *Chlamydophila pneumoniae*
  - Causes pneumonia, bronchitis, and rhinosinusitis

31

## Bacterial Diseases of the Lower Respiratory System

### • Legionnaires' Disease

- Signs and symptoms
  - Typical pneumonia symptoms
  - Pulmonary function can rapidly decrease
- Pathogen and virulence factors
  - Most cases caused by *Legionella pneumophila*
- Pathogenesis
  - *L. pneumophila* kills human cells
    - Causes tissue damage and inflammation

32

Figure 22.9 *Legionella pneumophila* growing on buffered charcoal yeast extract agar.



33

## Bacterial Diseases of the Lower Respiratory System

### • Legionnaires' Disease

- Epidemiology
  - *Legionella* survives in domestic water sources
  - The elderly, smokers, and immunocompromised individuals are at increased risk for infection
- Diagnosis, treatment, and prevention
  - Diagnosed with fluorescent antibody staining or serology
  - Quinolones or macrolides are the preferred treatment
  - Controlled by reducing bacterial presence in water

34

## Bacterial Diseases of the Lower Respiratory System

### • Tuberculosis

- The leading disease killer in the world
- Incidence has declined in the industrialized world
- Signs and symptoms
  - Initially limited to minor cough and mild fever
  - Symptoms are not always apparent
- Pathogen and virulence factors
  - Caused by *Mycobacterium tuberculosis*
  - Presence of mycolic acid gives bacteria unique features
    - Slow growth
    - Protection from phagocytic lysis
    - Intracellular growth
    - Resistance to many antimicrobial drugs

35

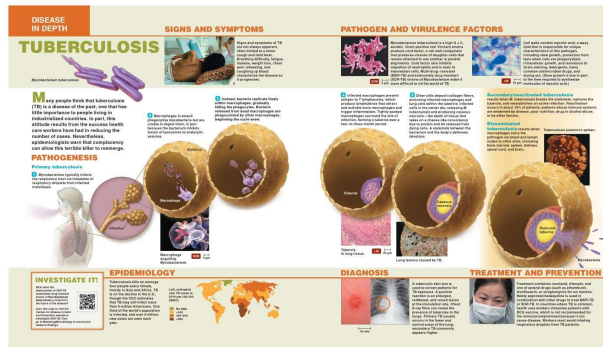
## Bacterial Diseases of the Lower Respiratory System

### • Tuberculosis

- Pathogenesis
  - Spread via inhalation of respiratory drops
- Three types of tuberculosis
  - Primary tuberculosis
  - Secondary tuberculosis
  - Disseminated tuberculosis

36

Disease in Depth: Tuberculosis, Pathogenesis



37

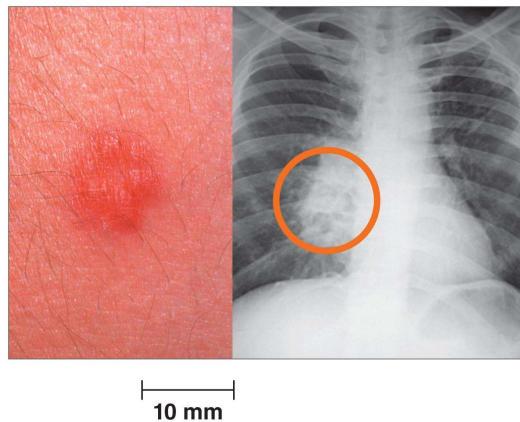
## Bacterial Diseases of the Lower Respiratory System

### • Tuberculosis

- Epidemiology
  - One-third of the world's population is infected
  - Most deaths occur in Asia and Africa
- Diagnosis, treatment, and prevention
  - Tuberculin skin test identifies exposure to tuberculosis
  - Chest X-ray images can identify tubercles in the lungs
  - Treatment requires combination of drugs
  - Drug-resistant strains of *M. tuberculosis* have emerged
  - BCG vaccine is available where tuberculosis is common

38

Figure Disease at a Glance: Diagnosis of tuberculosis—overview.



39

## Bacterial Diseases of the Lower Respiratory System

### • Pertussis (Whooping Cough)

- Signs and symptoms
  - Initially coldlike, then characteristic cough develops
- Pathogen and virulence factors
  - *Bordetella pertussis* is the causative agent
  - Produces numerous virulence factors
    - Includes adhesins and several toxins
- Pathogenesis
  - Pertussis progresses through four phases
    - Incubation, catarrhal, paroxysmal, and convalescent

40

## Bacterial Diseases of the Lower Respiratory System

### • **Pertussis (Whooping Cough)**

- Epidemiology
  - Highly contagious
  - Bacteria spread through airborne droplets in air
  - Bacteria does not survive long outside the body
- Diagnosis, treatment, and prevention
  - Symptoms are usually diagnostic
  - Treatment is primarily supportive
  - Prevention is with the DTaP vaccine

41

## Bacterial Diseases of the Lower Respiratory System

### • **Inhalational Anthrax**

- Signs and symptoms
  - Initially resembles a cold or flu
  - Progresses to severe coughing, lethargy, shock, and death
- Pathogen and virulence factors
  - *Bacillus anthracis* is the causative agent
  - Virulence factors include a capsule and anthrax toxin
- Pathogenesis and epidemiology
  - Anthrax not spread from person to person
  - Acquired by contact or inhalation of endospores

42

## Bacterial Diseases of the Lower Respiratory System

### • **Inhalation Anthrax**

- Diagnosis, treatment, and prevention
  - Diagnosis based on identification of bacteria in sputum
  - Early and aggressive antimicrobial treatment is necessary
  - Anthrax vaccine is available to select individuals

43

Figure 22.10 A scene from the flu pandemic of 1918–19.



44

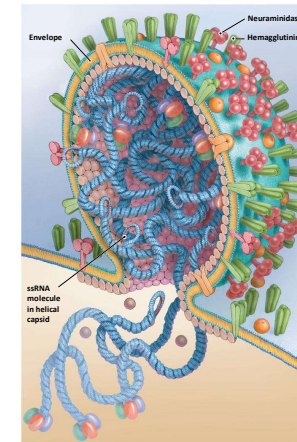
## Viral Diseases of the Lower Respiratory System

### • Influenza

- Signs and symptoms
  - Pharyngitis, congestion, cough, myalgia
  - Sudden fever distinguishes flu from a common cold
- Pathogens and virulence factors
  - Influenza virus types A and B are the causative agents
  - Mutations in hemagglutinin and neuraminidase produce new strains
    - Occurs via antigenic drift and antigenic shift
  - Concern about the fatality associated with strains similar to those of past pandemics

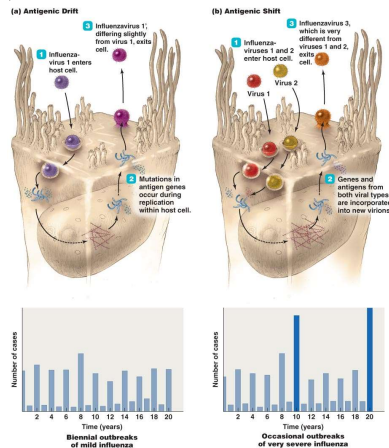
45

Figure 22.11 Artist's rendition of a cross-sectioned influenzavirus budding from a cell.



46

Figure 22.12 The development of new strains of flu viruses.



47

## Viral Diseases of the Lower Respiratory System

### • Influenza

- Pathogenesis
  - Symptoms produced by the immune response to the virus
  - Flu patients are susceptible to secondary bacterial infections
    - Virus causes damage to the lung epithelium
- Epidemiology
  - Transmitted via inhalation of viruses or by self-inoculation
  - Complications occur most often in the elderly, children, and individuals with chronic diseases

48

## Viral Diseases of the Lower Respiratory System

### • Influenza

- Diagnosis, treatment, and prevention
  - Signs and symptoms during a community-wide outbreak are often diagnostic
  - Treatment involves supportive care to relieve symptoms
  - Oseltamivir and zanamivir can be administered early in infection
  - Prevented by immunization with a multivalent vaccine

49

## Viral Diseases of the Lower Respiratory System

### • Coronavirus Respiratory Syndromes

- Two recently emerging diseases
  - Severe acute respiratory syndrome (SARS)
  - Middle East respiratory syndrome (MERS)
- Signs and symptoms
  - High fever, shortness of breath, difficulty breathing
  - Later, patients develop dry cough and pneumonia
- Pathogen and virulence factors
  - Coronaviruses are the causative agent
  - Most diseases are usually mild
    - SARS and MERS have higher fatalities

50

Figure 22.13 The face of coronavirus respiratory syndromes.



51

## Viral Diseases of the Lower Respiratory System

### • Coronavirus Respiratory Syndromes

- Pathogenesis and epidemiology
  - Coronaviruses spread via respiratory droplets
  - Virus spreads from the lungs to the heart and kidneys
- Diagnosis, treatment, and prevention
  - Diagnosis is based on signs and symptoms
  - Confirmed by isolating the virus or antibodies against the virus
  - Treatment is supportive

52

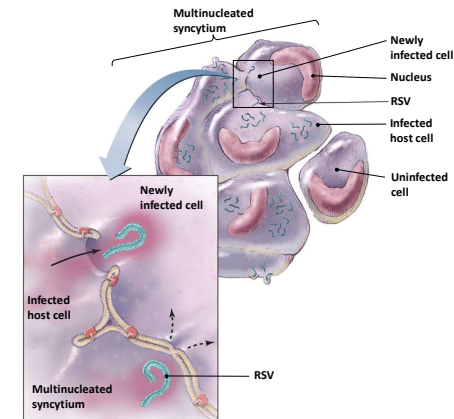
## Viral Diseases of the Lower Respiratory System

### • Respiratory Syncytial Virus Infection

- Most common childhood respiratory disease
- Signs and symptoms
  - Fever, runny nose, and coughing in babies or immunocompromised individuals
  - Mild coldlike symptoms in older children and adults
- Pathogen
  - Respiratory syncytial virus (RSV)
- Pathogenesis
  - Virus causes syncytia to form in the lungs
  - Immune response to RSV further damages the lungs

53

Figure 22.14 A syncytium forms when RSV triggers infected cells to fuse with uninfected cells.



54

## Viral Diseases of the Lower Respiratory System

### • Respiratory Syncytial Virus Infection

- Epidemiology
  - Transmission occurs via close contact with infected persons
- Diagnosis, treatment, and prevention
  - Diagnosis is made by immunoassay
  - Supportive treatment for young children
  - Prevention includes aseptic technique of health care and day care employees

55

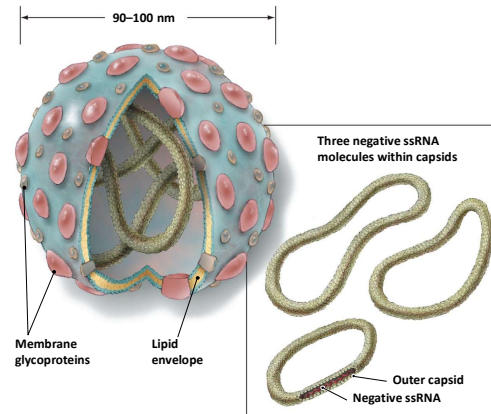
## Viral Diseases of the Lower Respiratory System

### • Hantavirus Pulmonary Syndrome (HPS)

- Signs and symptoms
  - Symptoms progress to cough, shock, and labored breathing
- Pathogen
  - Caused by *Hantavirus*
  - Transmitted from mice via inhalation
- Pathogenesis
  - *Hantavirus* travels throughout body via the blood
  - Infection causes widespread inflammation leading to shock

56

Figure 22.15 *Hantavirus* is an enveloped, segmented, -ssRNA bunyavirus.



57

## Viral Diseases of the Lower Respiratory System

### • *Hantavirus* Pulmonary Syndrome (HPS)

- Epidemiology
  - Human disease more likely as mouse population increases
  - Person-to-person contact does not occur
- Diagnosis, treatment, and prevention
  - Diagnosis is based on characteristic symptoms
  - No pharmacological treatment is available
  - Prevention requires control of rodents

58

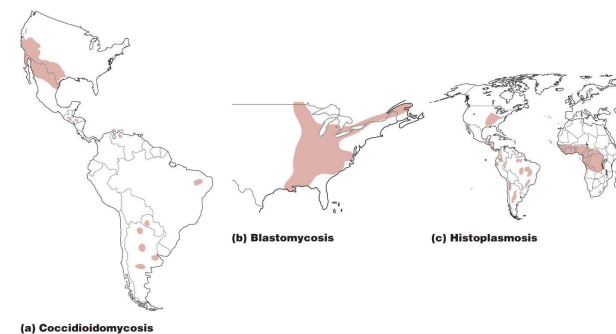
## Viral Diseases of the Lower Respiratory System

### • Other Viral Respiratory Diseases

- Other viruses cause respiratory disease in children, the elderly, or immunocompromised individuals
  - Cytomegalovirus
  - Metapneumovirus
    - Estimated to be the second most common cause of viral respiratory disease
  - Parainfluenza viruses
    - Three strains cause croup and viral pneumonia
    - Occur primarily in young children

59

Figure 22.16 The geographic distributions of three systemic fungal diseases endemic to North America.



60

## Mycoses of the Lower Respiratory System

### • **Coccidioidomycosis**

- Signs and symptoms
  - Resembles pneumonia or tuberculosis
  - Can become systemic in immunocompromised persons
- Pathogen and virulence factors
  - Caused by *Coccidioides immitis*
  - Pathogen assumes yeast form at human body temperature
- Pathogenesis
  - Arthroconidia from the soil enter the body through inhalation

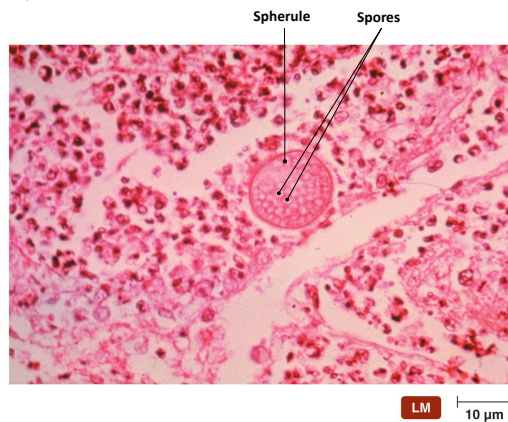
61

Figure 22.17 Coccidioidomycosis lesions in subcutaneous tissue.



62

Figure 22.18 Spherules of *Coccidioides immitis*.



63

## Mycoses of the Lower Respiratory System

### • **Coccidioidomycosis**

- Epidemiology
  - Almost exclusively in southwestern U.S. and northern Mexico
- Diagnosis, treatment, and prevention
  - Diagnosed by presence of spherules in clinical specimens
  - Treated with amphotericin B
  - Protective masks can prevent exposure to arthroconidia

64

## Mycoses of the Lower Respiratory System

### • Blastomycosis

- Signs and symptoms
  - Flulike symptoms
  - Systemic infections can produce lesions on the face and upper body or purulent lesions on various organs
- Pathogen
  - Caused by *Blastomyces dermatitidis*
  - Pathogenic yeast form at human body temperature

65

Figure 22.19 Cutaneous blastomycosis in an American woman.



66

## Mycoses of the Lower Respiratory System

### • Blastomycosis

- Pathogenesis and epidemiology
  - Enters body through inhalation of dust carrying fungal spores
  - Incidence of human infection is increasing
- Diagnosis, treatment, and prevention
  - Diagnosis is based on identifying fungus in clinical samples
  - Treated with amphotericin B
  - Relapse common in AIDS patients

67

## Mycoses of the Lower Respiratory System

### • Histoplasmosis

- Signs and symptoms
  - Asymptomatic in most cases
  - Symptomatic infection causes coughing with bloody sputum or skin lesions
- Pathogen
  - Caused by *Histoplasma capsulatum*
  - Pathogenic yeast form at human body temperature
  - *Histoplasma* produces several proteins that inhibit macrophage activation and other host defenses

68

## Mycoses of the Lower Respiratory System

### • Histoplasmosis

- Pathogenesis and epidemiology
  - Humans inhale airborne spores from the soil
  - Prevalent in the eastern U.S.
- Diagnosis, treatment, and prevention
  - Diagnosis is based on identifying fungus in clinical samples
  - Infections in immunocompetent individuals typically resolve without treatment

69

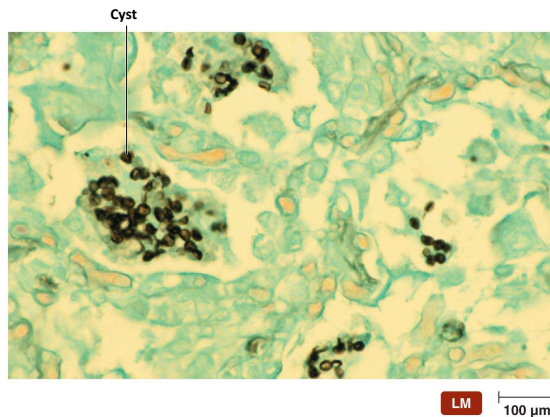
## Mycoses of the Lower Respiratory System

### • *Pneumocystis Pneumonia (PCP)*

- Signs and symptoms
  - Difficulty breathing, anemia, hypoxia, and fever
- Pathogen
  - Caused by *Pneumocystis jirovecii*
- Pathogenesis and epidemiology
  - Transmitted by inhalation of droplets containing the fungus
  - Common disease in AIDS patients
- Diagnosis, treatment, and prevention
  - Diagnosis is based on clinical and microscopic findings
  - Treated with trimethoprim and sulfamethoxazole
  - Impossible to prevent infection with *P. jirovecii*

70

Figure 22.20 Cysts of *Pneumocystis jirovecii* in lung tissue.



71