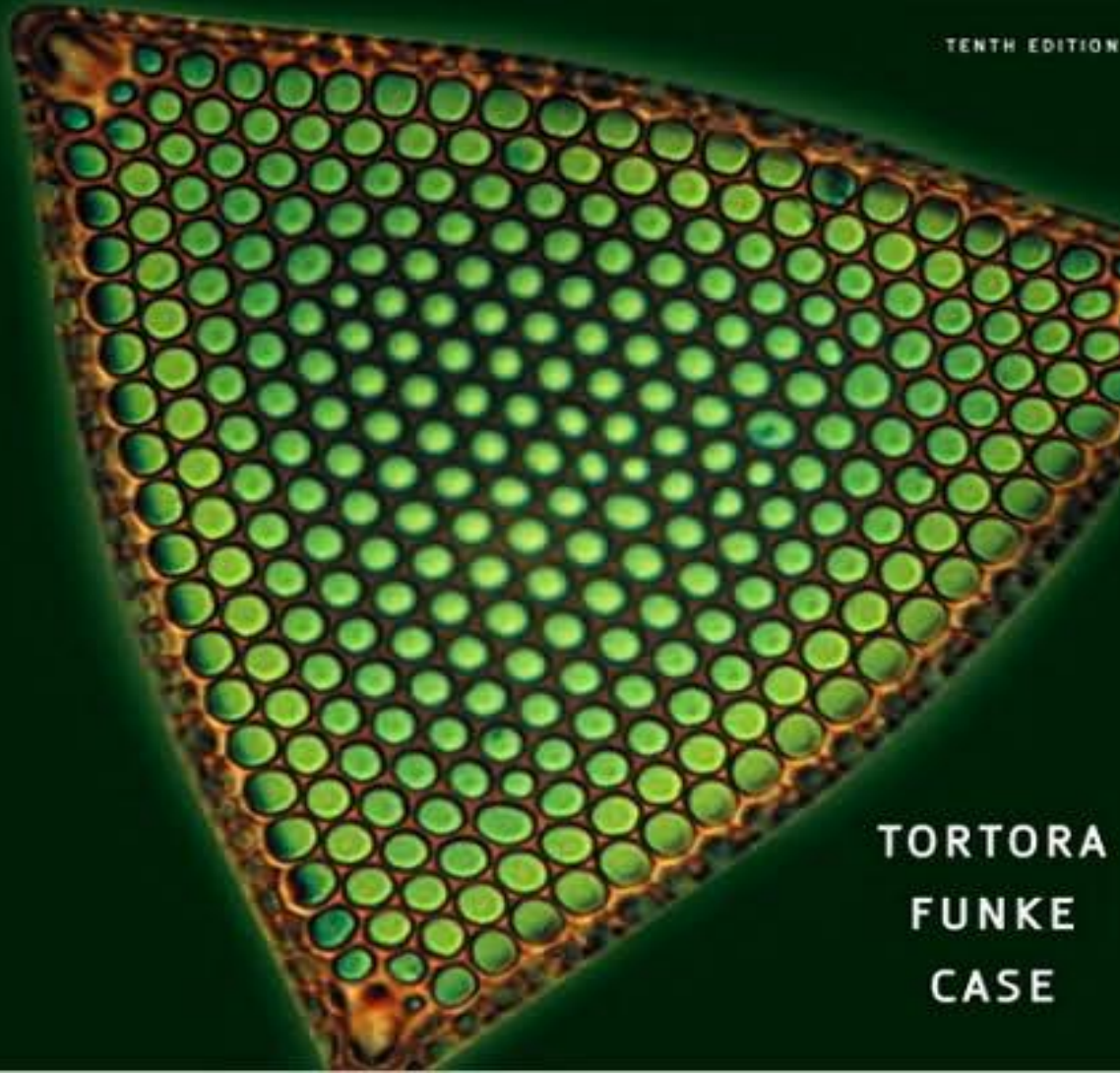


MICROBIOLOGY

AN INTRODUCTION

TENTH EDITION



TORTORA
FUNKE
CASE

Ch 24

Microbial Diseases of the Respiratory System

LEARNING OBJECTIVES

Describe how microorganisms are prevented from entering the respiratory system

Characterize the normal microbiota of the upper and lower respiratory systems

Differentiate among pharyngitis, laryngitis, tonsillitis, and sinusitis

List the causative agent, symptoms, prevention, preferred treatment, and laboratory identification tests for streptococcal pharyngitis, diphtheria, and otitis media.

List the causative agents and treatments for the common cold.

List the causative agent, symptoms, prevention, preferred treatment, and laboratory identification tests for pertussis and tuberculosis.

Compare and contrast the seven bacterial pneumonias discussed in this chapter.

List the causative agent, symptoms, prevention, and preferred treatment for viral pneumonia and influenza.

List causative agent, mode of transmission, preferred treatment, and laboratory identification tests for two fungal respiratory system diseases.

Normal Respiratory Tract Flora

- can include pathogens.
- Lower respiratory system is usually sterile because of muco-ciliary escalator action.

Genus	Characteristics
<i>Staphylococcus</i>	Gram-positive cocci in clusters
<i>Corynebacterium</i>	Pleomorphic, Gram-positive rods; nonmotile; non-spore-forming genera
<i>Moraxella</i>	Gram-negative diplococci and diplobacilli
<i>Haemophilus</i>	Small, Gram-negative rods
<i>Bacteroides</i>	Small, pleomorphic, Gram-negative rods
<i>Streptococcus</i>	Gram-positive cocci in chains

Microbial Diseases of the Upper Respiratory System

Specific areas of the upper respiratory system can become infected

The infections may be caused by several bacteria and viruses, often in combination

Most respiratory tract infections are self-limiting

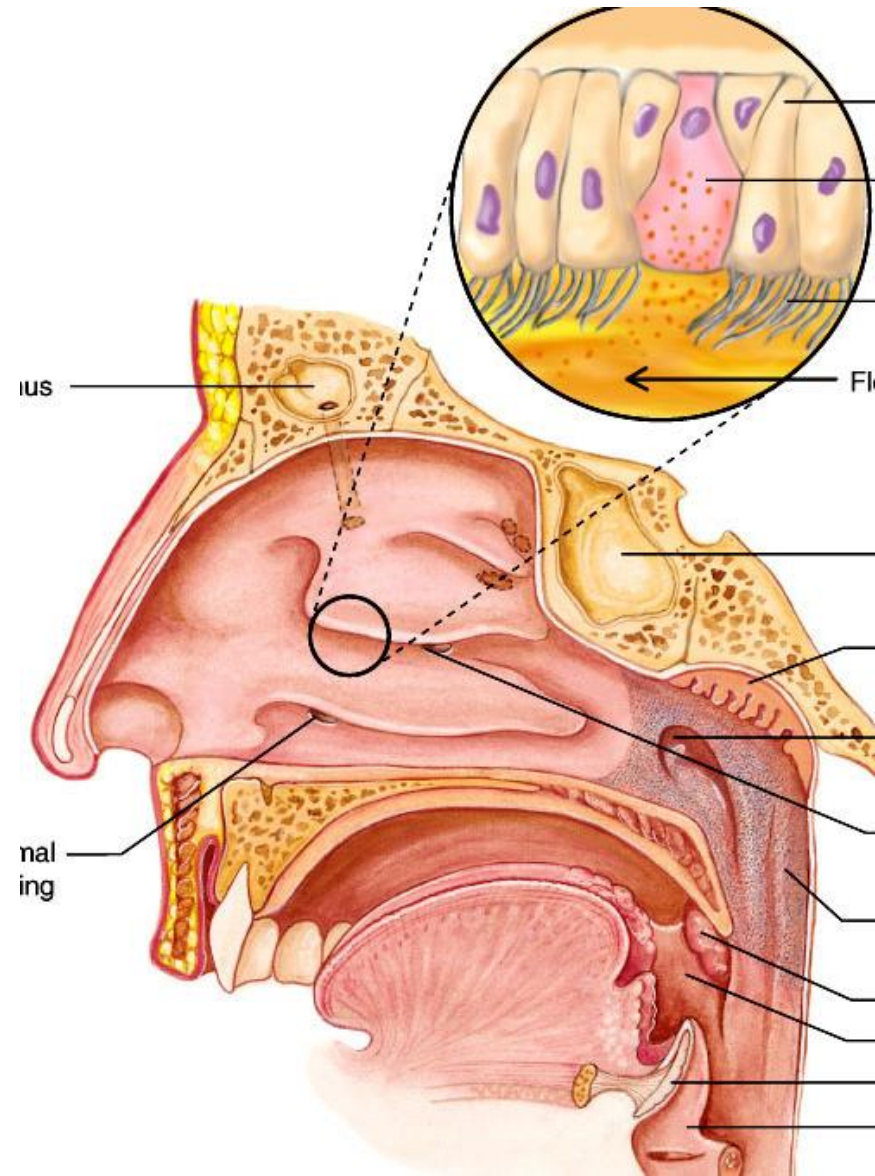
Laryngitis:

- *S. pneumoniae*
- *S. pyogenes*
- viruses

Tonsillitis:

- *S. pneumoniae*
- *S. pyogenes*
- viruses

Sinusitis: Bacteria



Strep throat

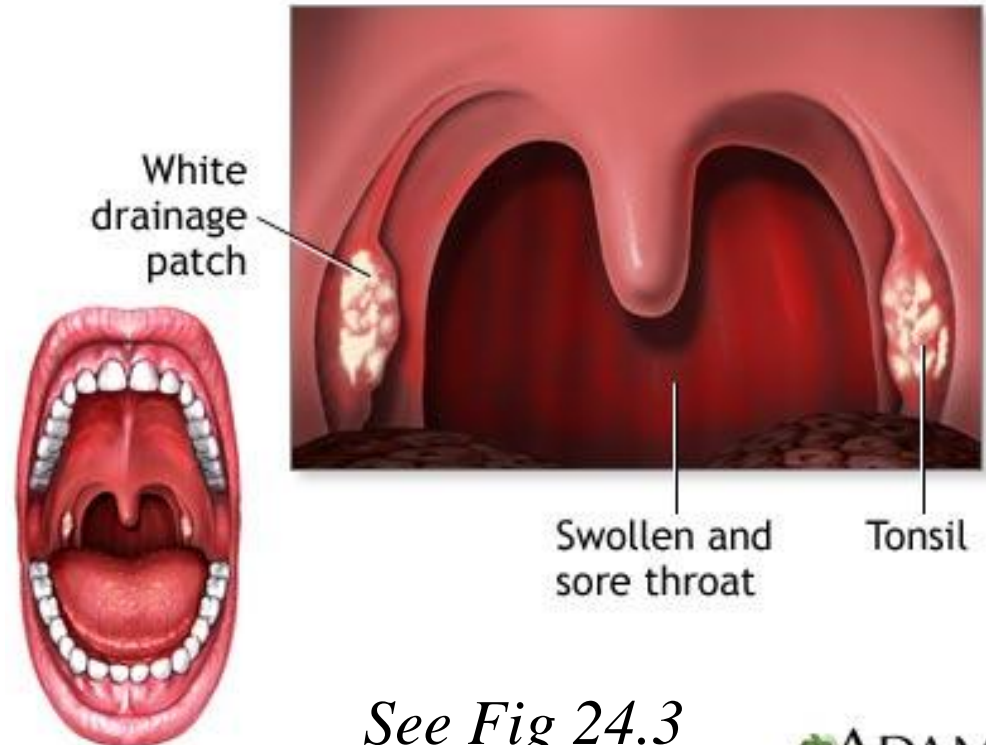
β - hemolytic - **Group A** (GAS) streptococci: *S. pyogenes*

Droplet Transmission

Symptoms: Sore throat, high fever, coughing, swollen LN, otitis media may also occur

The **Rapid Strep Test** detects presence of a unique Group A Streptococcus ag.

Penicillin is used to treat streptococcal pharyngitis.



See Fig 24.3

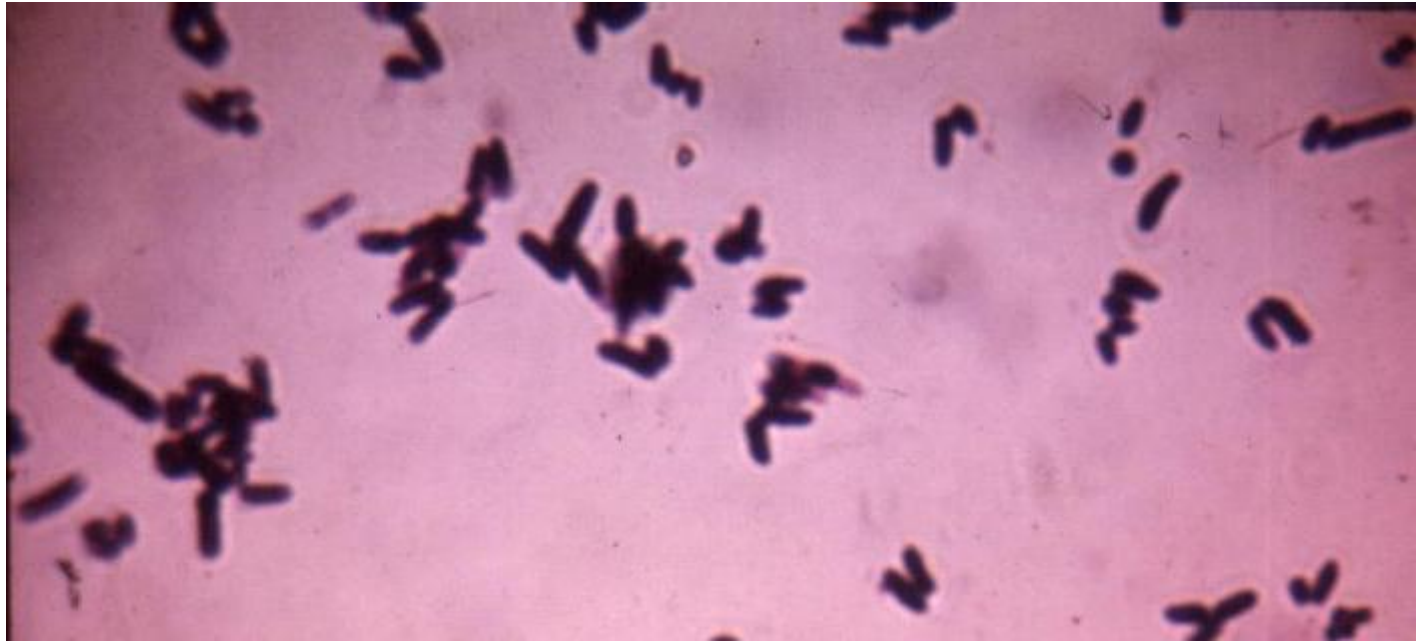
Complications of Strep Throat

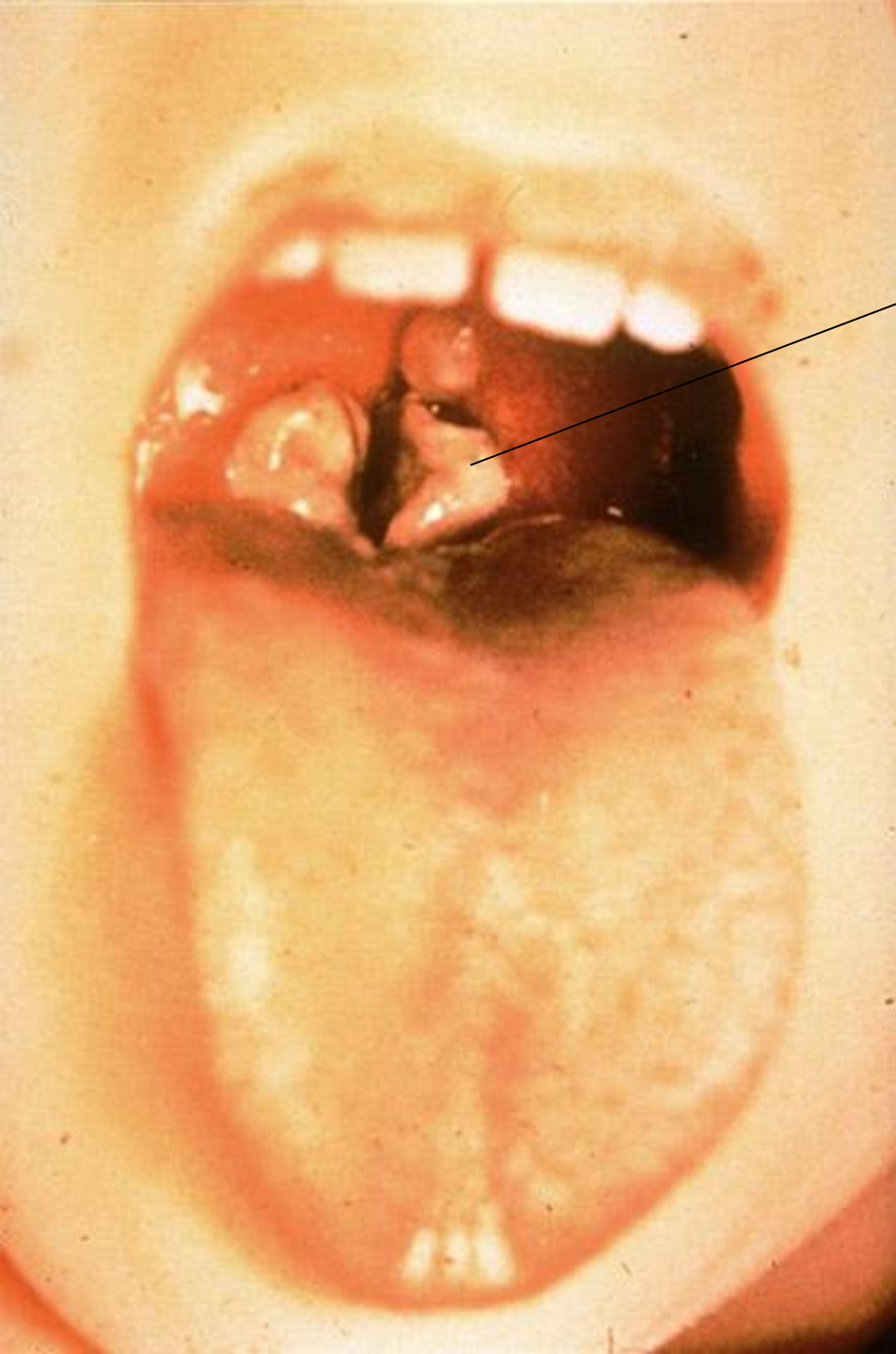
***S. pyogenes* causes two major nonsuppurative autoimmune complications (antibodies cross-react)**

- 1. Acute rheumatic fever** (*read page 676*):
Short period of arthritis and fever followed in ~
50% of affected by **rheumatic heart disease**
⇒ heart valve damage ⇒ chronic valvular disease
(stenosis and/or incompetence) ⇒ heart failure
and/or subacute bacterial endocarditis
- 2. Acute poststreptococcal glomerulonephritis**

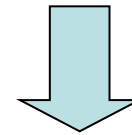
Diphtheria

- *Corynebacterium diphtheriae*
- Pseudomembrane formation (fibrin, dead tissue and bacteria)
- Not very invasive, but prophage encoded exotoxin inhibits protein synthesis ⇒ absorbed into blood ⇒ heart, nerve and kidney damage
- DTaP
- Boosters every 10 years





**Pseudomembrane
on tonsils**



**can lead to
respiratory
blockage.**

See Fig 24.5

Otitis Media

Complication of nose and throat infections

Pus accumulation causes pressure on the eardrum

Bacterial causes include

- *S. pneumoniae* (35%)
- *H. influenzae* (20-30%)
- *M. catarrhalis* (10-15%)
- *S. pyogenes* (8-10%)
- *S. aureus* (1-2%)
- Treated with broad-spectrum antibiotics
- Incidence of *S. pneumoniae* reduced by vaccine

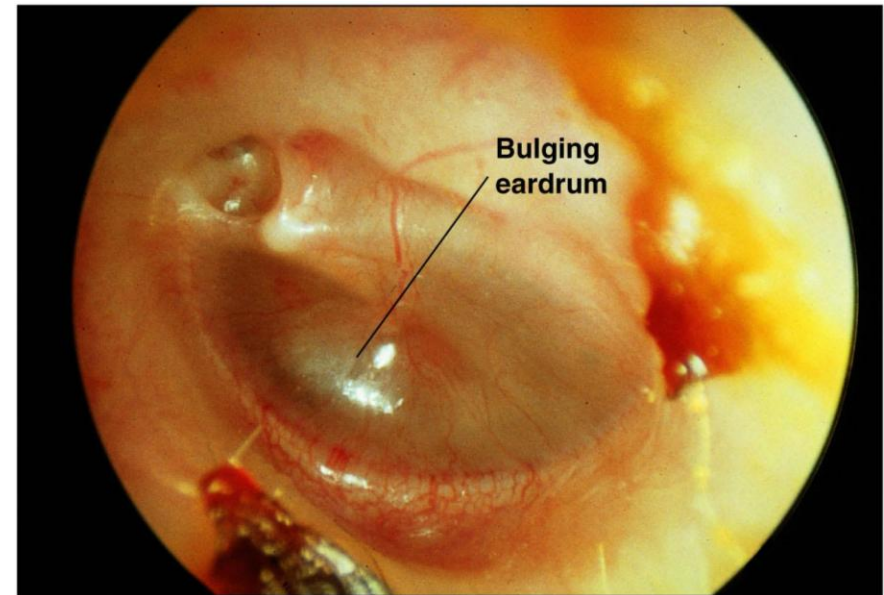


Fig 24.6

Common Cold

About 200 different viruses can cause the common cold:

- ❖ ~ 50% of cases caused by **rhinoviruses** (>100 types)
- ❖ ~ 15-20% caused by **coronaviruses**

Many additional cold viruses (Parainfluenza *Paramyxoviridae*
Corona-, Coxsackie-, Echo-, Reovirus)

Symptoms: Sneezing, nasal secretions and congestion

Possible complications: Sinus infections, lower respiratory tract infections, laryngitis, otitis media

In some children: **Croup** (breathing difficulty accompanied by a "barking" cough)

Why no Vaccine for common cold?

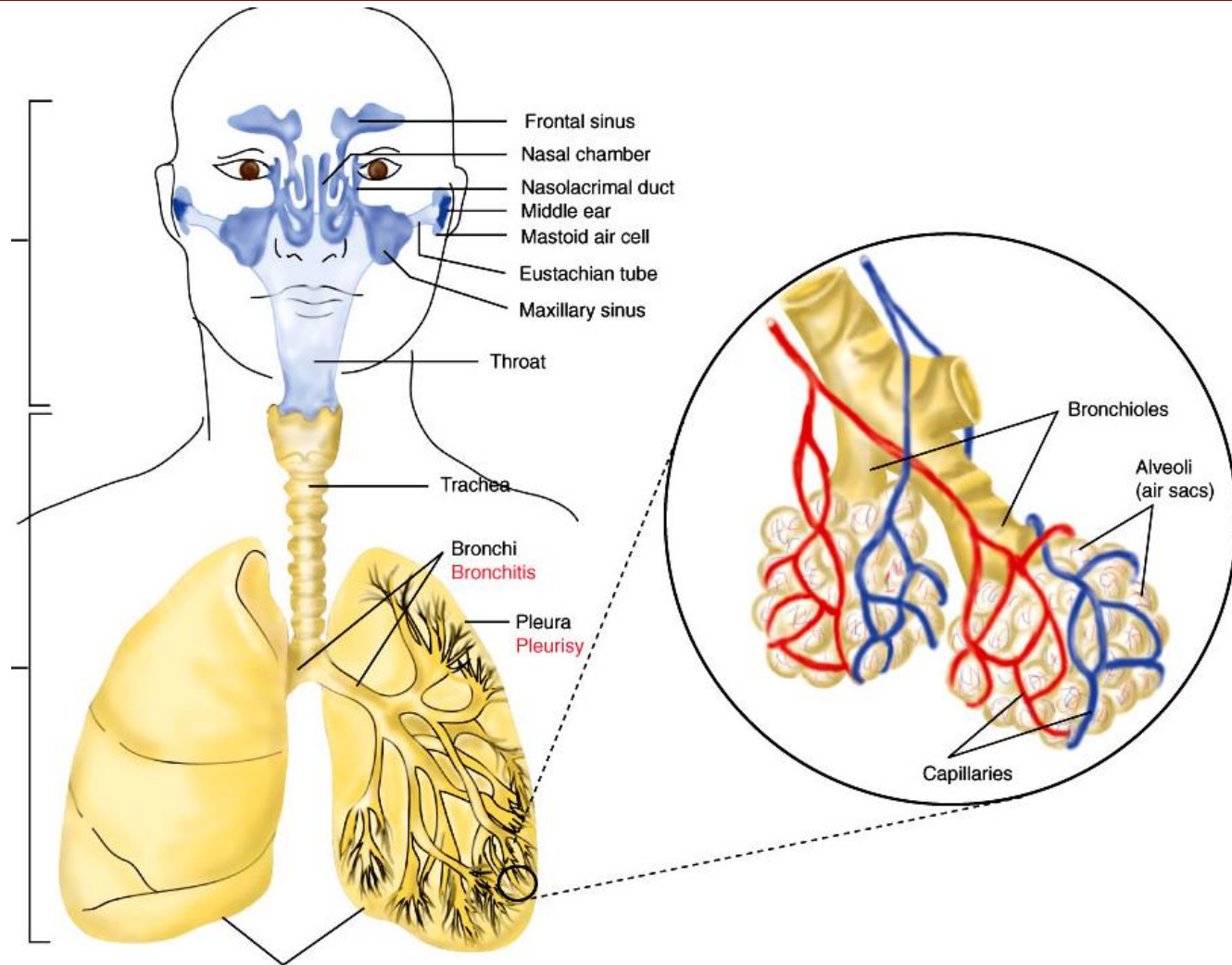
Incidence of colds ↑ during cold weather, due to increased interpersonal indoor contact and/or physiological changes

Antibodies are produced against the specific viruses

Bacterial Diseases of the Lower Respiratory System (LRS)

Bacteria, viruses, and fungi cause

- Bronchitis
- Bronchiolitis
- Pneumonia



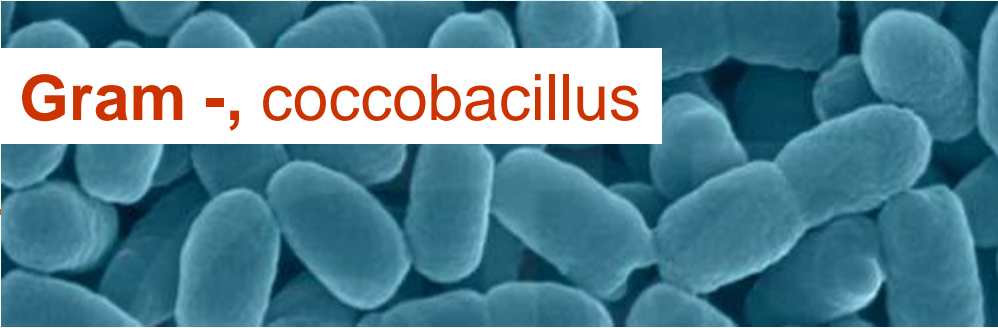
What keeps LRS sterile?

- | | |
|-------------------------------|-----------------------|
| Lungs | Legionnaires' disease |
| Bronchiolitis | Pleurisy |
| Bronchitis | Pneumonia |
| Coccidioidomycosis | RSV infections |
| Hantavirus pulmonary syndrome | Tuberculosis |
| Histoplasmosis | Whooping cough |
| Influenza | |

Compare to Fig 24.2

Bacterial Diseases of the LRS

- **Pertussis** (*Bordetella pertussis*)
 - **Tuberculosis** (*Mycobacterium tuberculosis*)
 - **Common Bacterial pneumonias:**
 - ***S. pneumoniae***, typical pneumonia
 - *H. influenza*
 - ***Mycoplasma pneumoniae***
 - ***Legionella pneumophila***
 - *Chlamydophila psittaci*
- } *Atypical pneumoniae*



Gram -, coccobacillus

Whooping Cough

Clinical presentation



Bordetella pertussis, highly contagious

Various toxins:

- **Tracheal cytotoxin** damaged ciliated cells
- **Pertussis toxin** enters blood → systemic symptoms

Three stages of disease

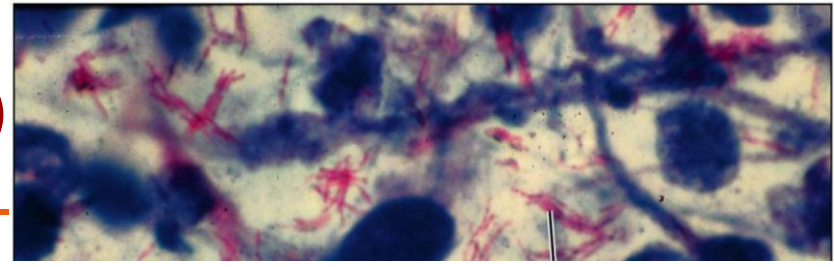
1. **Catarrhal stage** resembles a cold
2. **Paroxysmal stage** due to accumulation of mucus in trachea and bronchi ⇒ deep paroxysmal coughs (brain and eye hemorrhage)
3. **Convalescence stage** can last for months

Laboratory diagnosis based on isolation of bacteria on enrichment and selective media, followed by serological tests

Vaccination available: DPT and new acellular DTaP

*Comments by
Dr. Marcus*

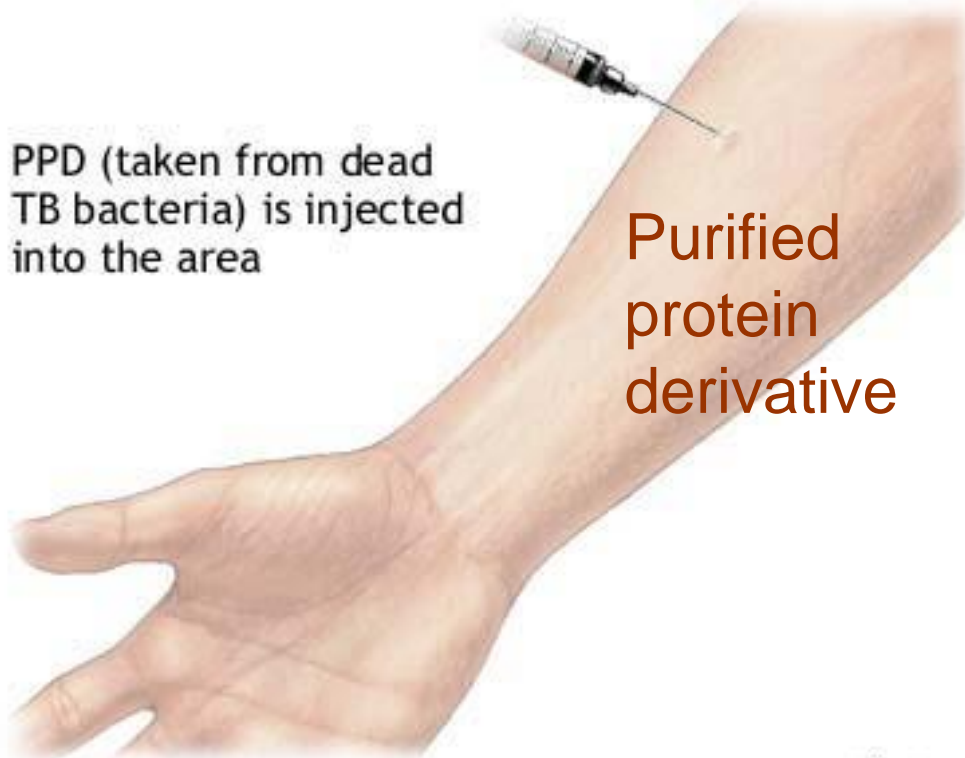
Tuberculosis (Consumption)



- ***Mycobacterium tuberculosis***: transmitted from human to human via aerosol
- ***M. bovis***: <1% U.S. cases, usually extrapulmonary, affecting bones or lymphatic system (Pott disease)
- ***M. avium-intracellulare*** complex infects people with late stage HIV
- Mycobacteria → resistant to drying and disinfectants
- **BCG vaccine**: live, avirulent *M. bovis*
- **Tuberculin (Mantoux) test**: inject PPD and wait for delayed hypersensitivity reaction (problem: BCG vaccination!)

Tuberculin test

Diagnostic tool for pre-symptomatic Tuberculosis



PPD (taken from dead TB bacteria) is injected into the area

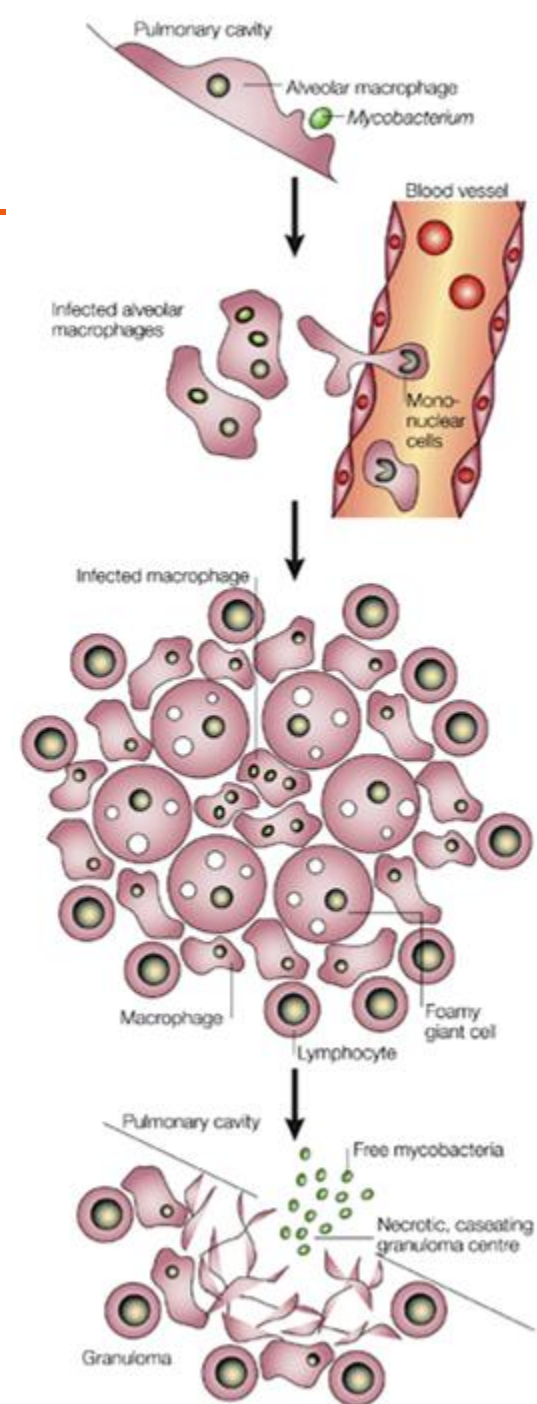
Purified protein derivative

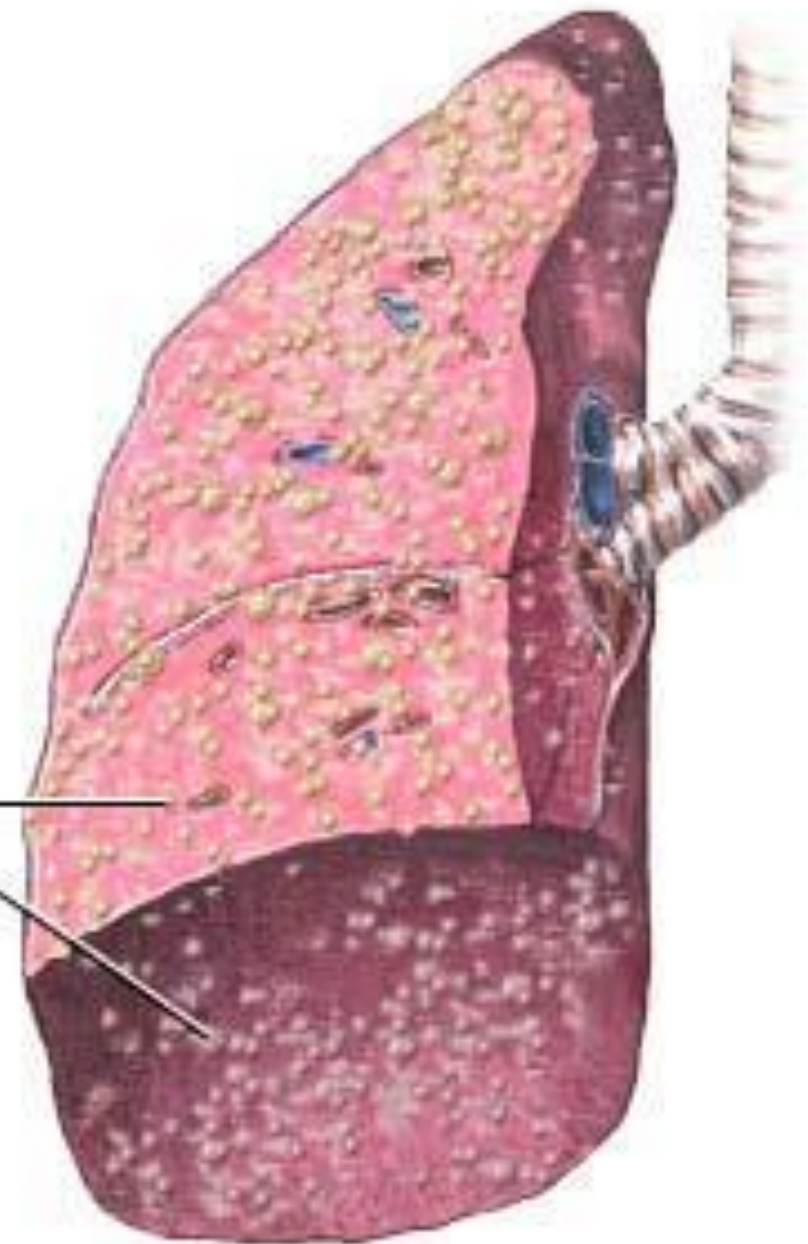


TB Pathogenesis

Review Fig 24.10!

- *M. tuberculosis* may reproduce in MΦ
- Lesions formed = tubercles
- **Caseous lesions:** Dead MΦ and bacteria; might calcify and appear in an X ray as a Ghon's complex
- **Liquefaction** of the caseous lesion results in a tuberculous cavity in which *M. tuberculosis* can grow
- ruptures of caseous lesion ⇒ bacteria released into blood or lymph vessels ⇒ **miliary tuberculosis**
- Miliary tuberculosis ⇒ weight loss, coughing of blood, loss of vigor





Granulomas from
Mycobacterium
tuberculosis

Miliary Tuberculosis

Chemotherapy

- 3 or 4 drugs taken for at least 6 months

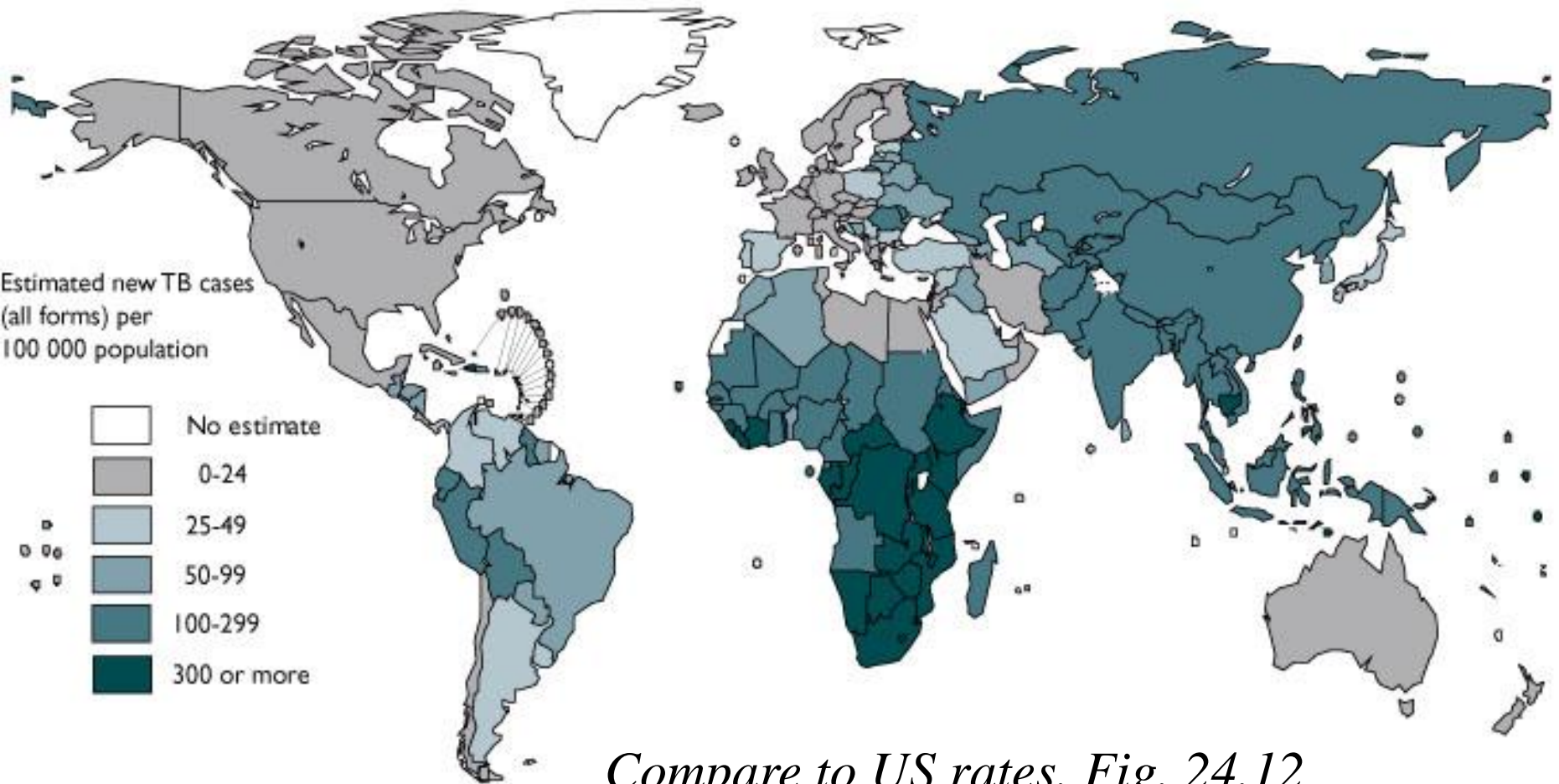
MDR-TB becoming prevalent!



DOTS has **FIVE** key components:

- 1. Political commitment**
- 2. Good quality diagnosis** (sputum-smear microscopy)
- 3. Good quality drugs** (2 most powerful: rifampin, isoniazide)
- 4. 6-8 month chemotherapy given under direct observation**
- 5. Systematic monitoring and accountability**

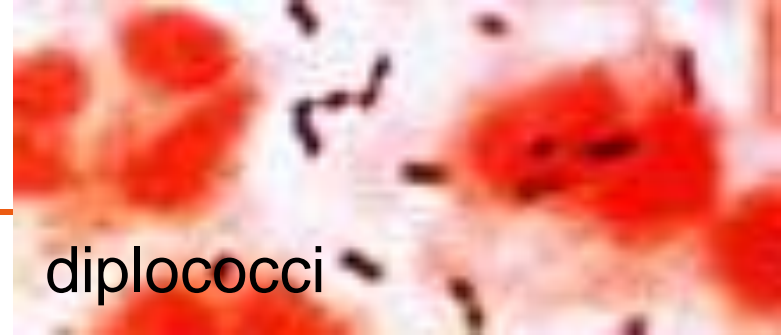
Tuberculosis, 2005



Source: ©WHO, 2008. All rights reserved.

Each year, 1% of the global population is infected.
5-10% of infected get sick or infectious. 1.6 Mio died in 2005
Populations infected:
Africa: 35%; Americas: 18%; Europe: 15%; South-east Asia: 44%

Typical pneumonia: **Pneumococcal Pneumonia**

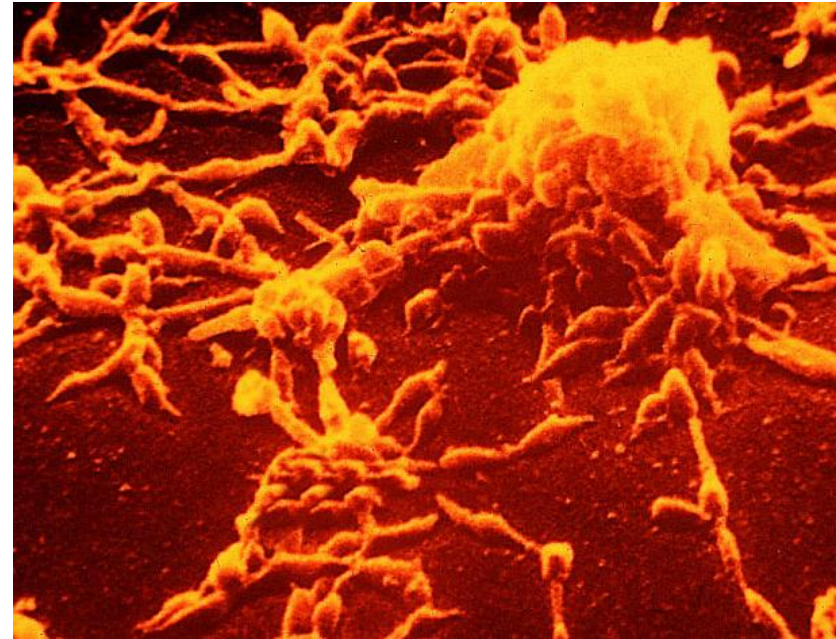
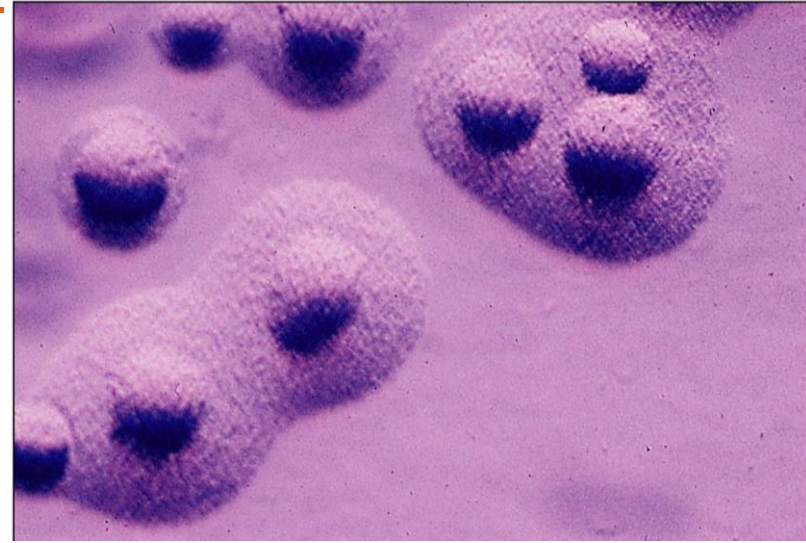


diplococci

- Encapsulated *S. pneumoniae*
- Can be identified by production of alpha-hemolysins, inhibition by optochin, bile solubility, and through serological tests
- Aerosol inhalation from asymptomatic carriers → illness due to immune suppression, smoking, viral infection *etc.*
- Symptoms: fever, breathing difficulty, chest pain, rust-colored sputum
- 80% of bacterial pneumoniae (esp. elderly)
- Penicillin, but multi drug resistance increasing
- Vaccine for 23 most common (of > 90) strains

Mycoplasmal Pneumonia – also known as **Primary Atypical Pneumonia** or **Walking Pneumonia**

- ***Mycoplasma pneumoniae***, pleomorphic, wall-less
- *Mycoplasma* produce small “fried-egg” colonies after two weeks’ incubation on enriched media containing horse serum and yeast extract
- Common in children and young adults – often mild enough to go undiagnosed for long periods of time
- Diagnosis: PCR or serological tests (IgM antibodies)



Legionellosis or Legionnaires' disease

- *Legionella pneumophila*, Gram– rod
- First discovered in 1976 among a group of elderly men attending an American Legion Convention in Philadelphia
- The bacteria grow in water (pools, lakes, water systems of buildings, air conditioning units, etc.) then disseminated in the air
- Transmission by inhaling aerosols; no person to person transmission
- Diagnosis: Bacterial culture, FA tests, DNA probes
- Pneumonia and pleurisy (15 - 20% mortality rate when hospitalized)
- Treatment: Erythromycin

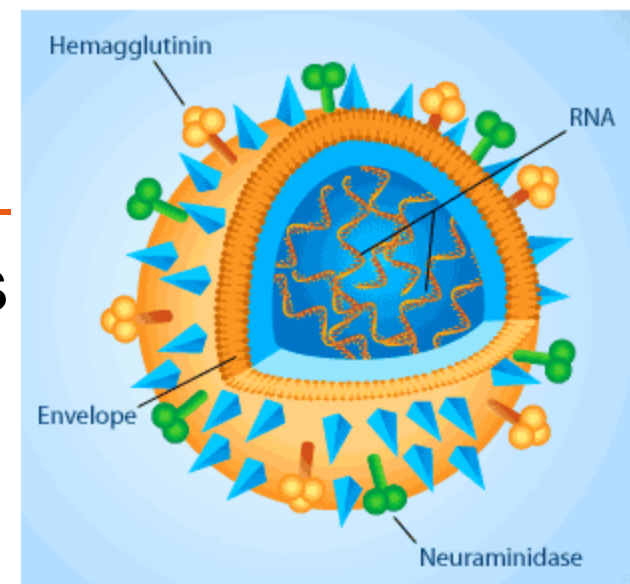
Viral Diseases of the Lower Respiratory System (LRS)

- ❖ Several viruses can cause pneumonia as a complication of infections such as influenza, measles, or chickenpox
- ❖ Etiologies are not usually identified in a clinical laboratory because of the difficulty in isolating and identifying viruses.
- ❖ Viral etiology suspected if no cause determined.

Respiratory Syncytial Virus:

- Most common cause of pneumonia in infants – 4,500 deaths annually
- Causes cell fusion (syncytium) in cell culture
- Symptoms: Coughing
- Diagnosis by serologic test for viruses and antibodies
- Treatment: Ribavirin

Influenza



- *Influenzavirus*, ssRNA, 8 segments
- Symptoms: Chills, fever, headache, muscle aches (no intestinal symptoms)
- Viral strains identified by antigenic differences in the H and N spikes
- Also divided by antigenic differences in protein coats:
 - Type **A** → mammals and birds (most severe and extensive); currently most common antigenic variants of influenza A virus: H1N1 and H3N2
 - Types **B** and **C** → humans only
- Viral isolates identified by HI and IF testing with monoclonal antibodies

Hemagglutinin and Neuraminidase

Hemagglutinin (H) spikes
used for attachment to host
cells

Neuraminidase (N) spikes
used to release virus from
cell

H and N are virulence factors
and antigens

Mutations in H and N leads to
antigenic shifts (major
changes only for type A) or
antigenic drifts (minor
changes for all types)
⇒ natural immunity and
vaccination obsolete

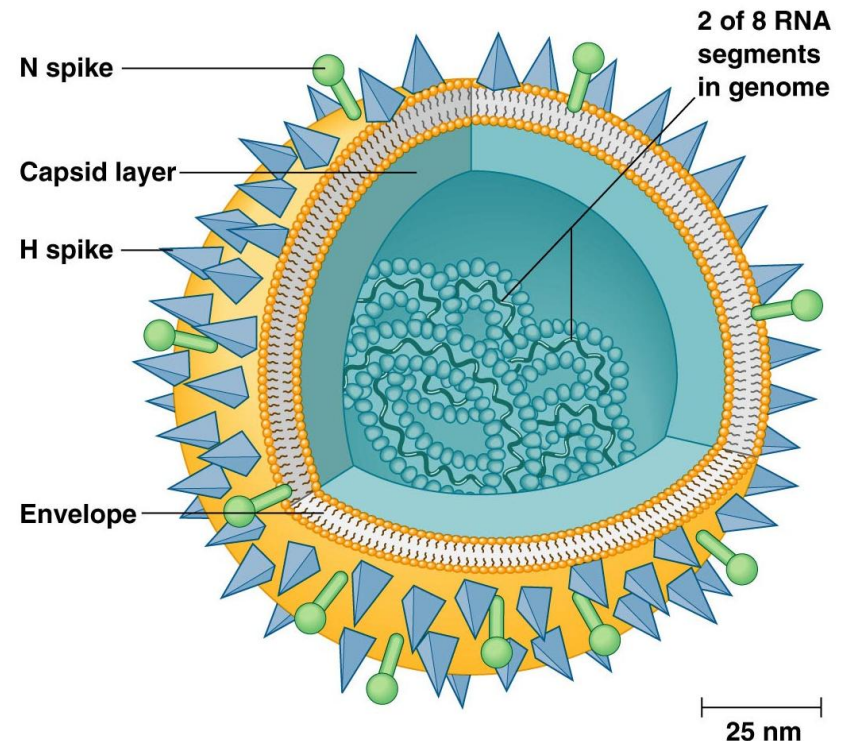
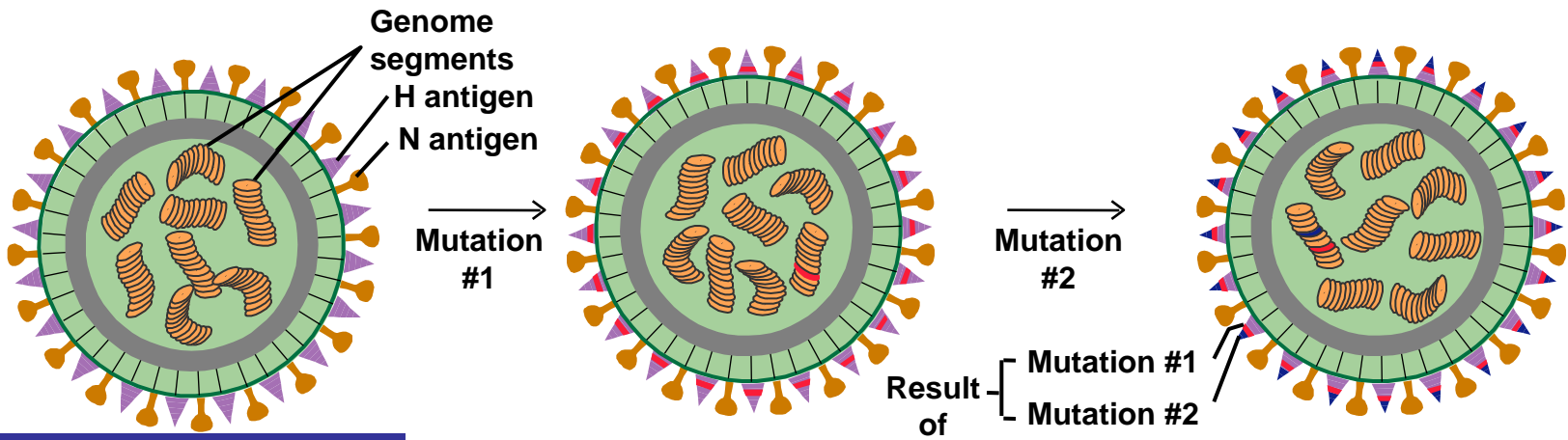
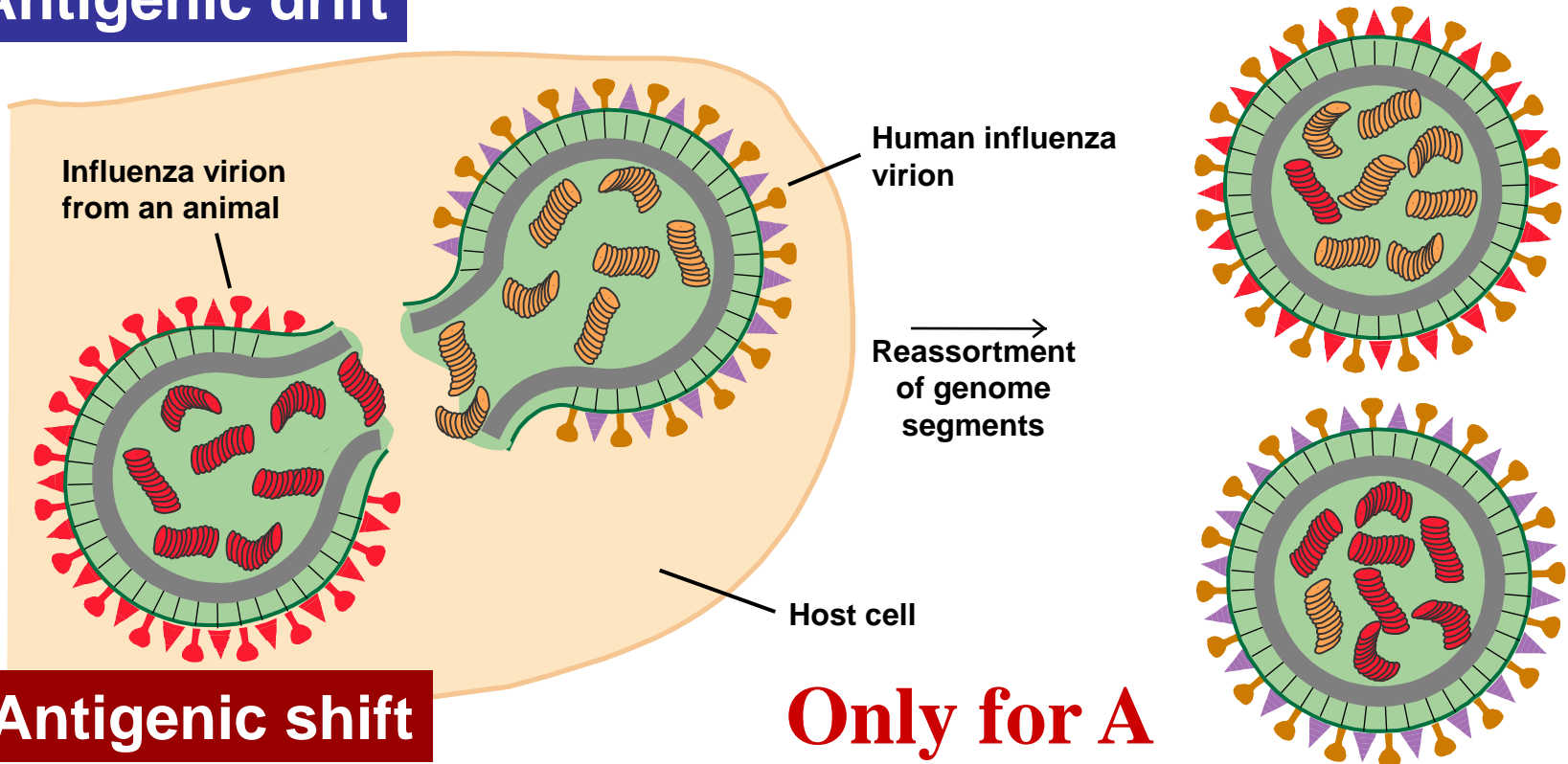


Fig 24.15



Antigenic drift

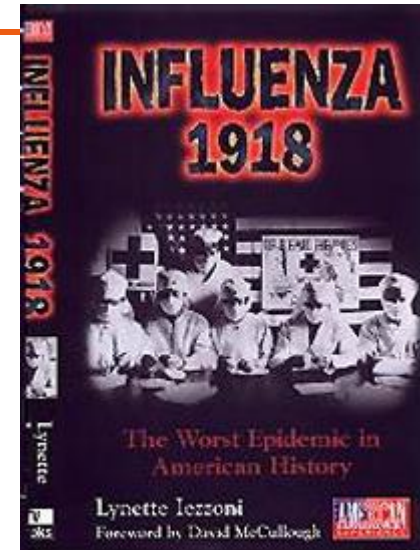


Antigenic shift

Only for A

Prevention and Treatment

- Wide spread epidemics due to antigenic shifts → **Pandemics**
- Symptoms and Diagnosis
- Complications often due to bacterial secondary infections (??) ~ 50,000 – 70,000 deaths/year in US - also Guillain-Barré and Reye's syndrome
- Vaccine produced in chicken embryos: flu shot and nasal spray (LAIV)
- Four antiviral drugs currently approved by FDA to treat acute, uncomplicated influenza



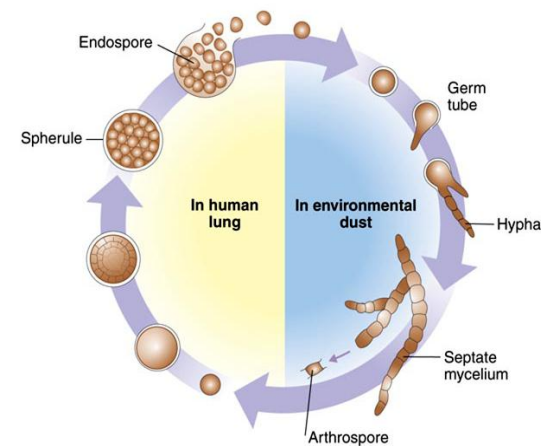
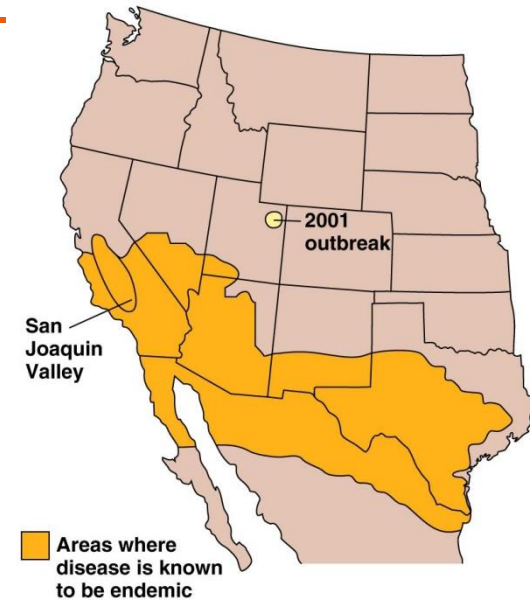
CDC

Fungal Diseases of the Lower Respiratory System (LRS)

- Fungal spores are easily inhaled; they may germinate in the lower respiratory tract
- The incidence of fungal diseases has been increasing in recent years
- Mycoses in the sections below can be treated with amphotericin B
 - ***Coccidioidomycosis***
 - ***Pneumocystis Pneumonia***

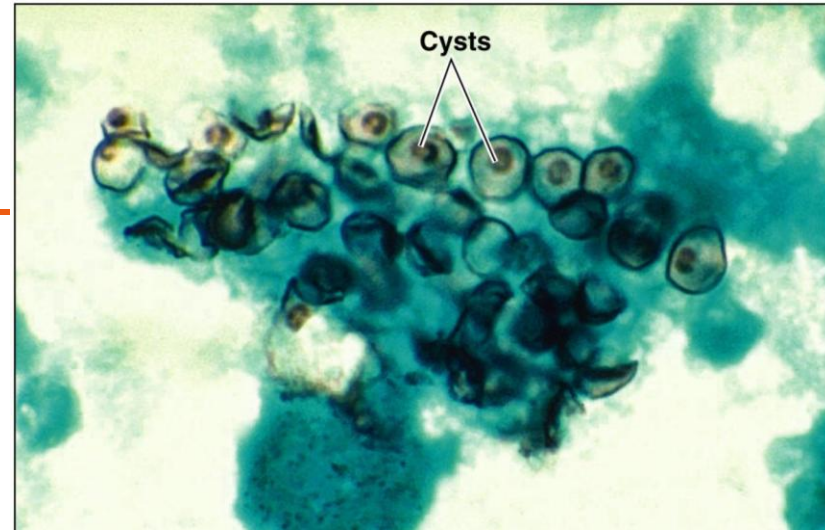
Coccidioidomycosis = Valley Fever

- *Coccidioides immitis*,
- Airborne transmission
- Most cases are subclinical, some get respiratory infection with flu-like symptoms
- In < 1% of cases (due to predisposing factors, such as fatigue, poor nutrition, *etc.*): progressive, disseminated disease form resembling TB
- Diagnosis: serological tests
- 97% of reported cases are from California and Arizona



Pneumocystis Pneumonia (PCP)

Pneumocystis jiroveci
(*P. carinii*), tiny fungus



Commonly found in nature,
healthy human lungs and animals → Aerosol
transmission

Illness and death in newly infected infants and
immunosuppressed individuals

Used to be leading cause of death in AIDS patients –
now preventive drug therapy

Diagnosis: detection of cysts in sputum samples

The end