Airborne bacterial diseases

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Airborne Bacterial Diseases

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- **Most airborne diseases caused by bacteria involve the respiratory system**
  - **Diphtheria**
  - **Legionnaires disease**
  - **Pontiac fever**
  - **Tuberculosis infections**
  - **Pertussis**
  - **Streptococcal diseases**
  - **Pneumonia**
- **Other airborne bacteria can cause skin diseases**
  - **Cellulitis**
  - **Erysipelas**
- **Some may cause systemic or visceral damage**
  - **Meningitis**
  - **Glomerulonephritis**
  - **Rheumatic fever**

Diphtheria

- Diphtheria mainly affects poor people living in crowded conditions.

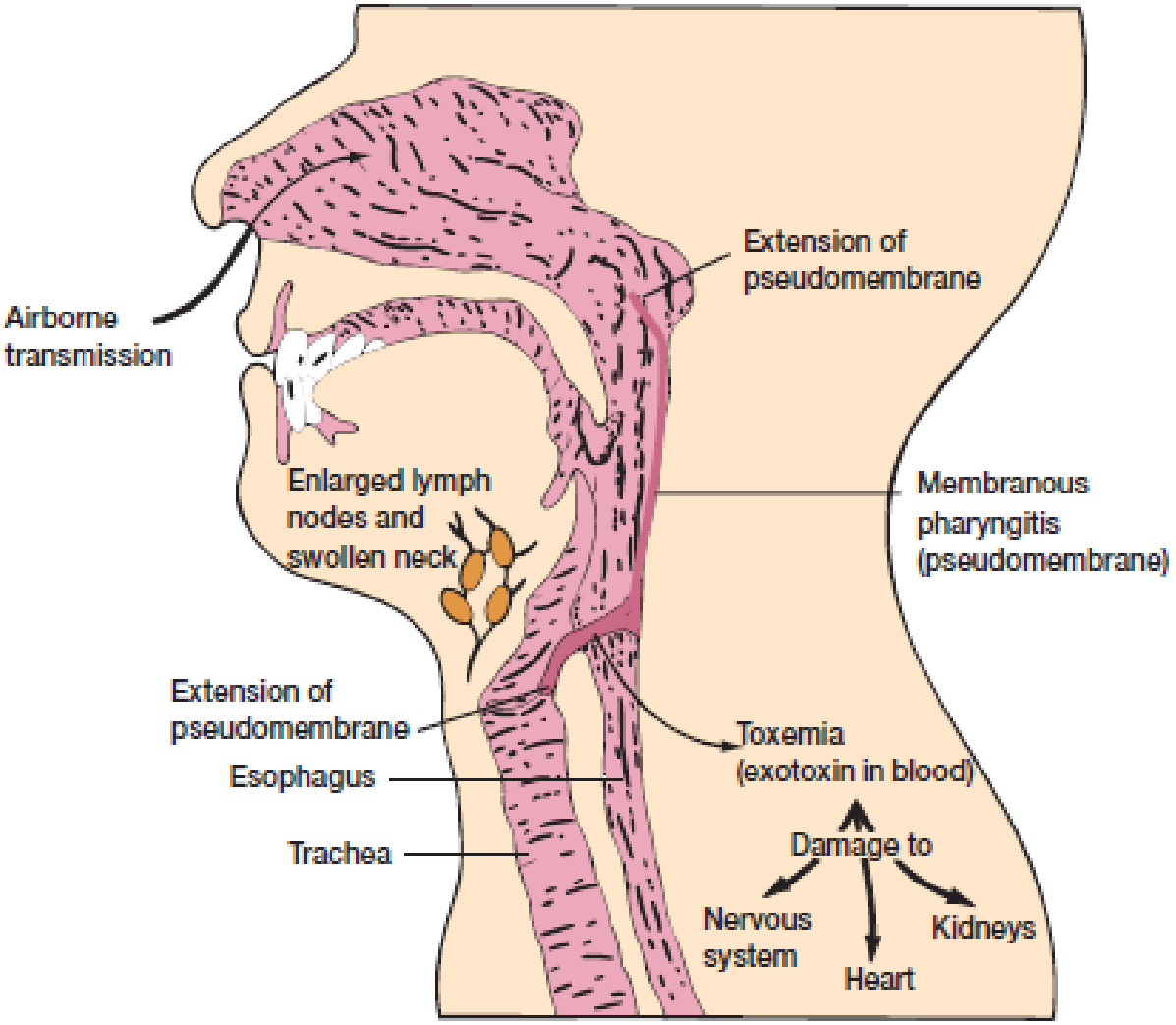
Caused by: the Gram-positive *Corynebacterium diphtheriae*

Transmission: airborne transmission by way of nasopharyngeal secretions and is very resistant to drying.

Pathogenesis: Once within the respiratory system, bacteria that carry the prophage containing the *tox gene* produce diphtheria toxin, an exotoxin that causes an inflammatory response and the formation of a grayish pseudomembrane on the respiratory mucosa

- The pseudomembrane consists of dead host cells and cells of *C. diphtheriae.*
- *The exotoxin is also absorbed* into the circulatory system and distributed throughout the body, where it may cause destruction of cardiac, kidney, and nervous tissues by inhibiting protein synthesis

Diphtheria Pathogenesis



...Diphtheria

Typical symptoms of diphtheria include a thick mucopurulent (containing both mucus and pus) nasal discharge, fever, and cough.

Diagnosis is made by observation of the pseudomembrane in the throat and by bacterial culture.

Treatment: Diphtheria antitoxin is given to neutralize any unabsorbed exotoxin in the patient's tissues

- Penicillin and erythromycin are used to treat the infection.
- Prevention is by active immunization with the DPT (diphtheriapertussis-
- tetanus) vaccine

Cutaneous diphtheria

- *C. diphtheriae can also infect the skin, usually at a wound or* skin lesion, causing a slow-healing ulceration termed cutaneous diphtheria.
- Most cases involve people over 30 years of age who have a weakened immunity to the diphtheria toxin and live in tropical areas.

Legionnaires'Disease/ legionellosis

- **Caused by:** *Legionella pneumophila*, a nutritionally fastidious aerobic Gram negative rod
- It is now known that this bacterium is part of the natural microbial community of soil and aquatic ecosystems, and it has been found in large numbers in air conditioning systems and shower stalls.
- A variety of free-living amoebae and ciliated protozoa that contain *Legionella* spp. have been isolated from water sites suspected as sources of *Legionella* infections.
- *Legionella* spp. multiply intracellularly within the amoebae, just as they do within human monocytes and macrophages.
- This might explain why there is no human-to-human spread of legionellosis

… Legionellosis

Transmission: Infection with *L. pneumophila* results from the airborne spread of bacteria from an environmental reservoir to the human respiratory system.

- Males over 50 years of age most commonly contract the disease, especially if their immune system is compromised by heavy smoking, alcoholism, or chronic illness.
- The bacteria reside within the phagosomes of alveolar macrophages, where they multiply and produce localized tissue destruction through export of a cytotoxic exoprotease.

Symptoms: include a high fever, nonproductive cough (respiratory secretions are not brought up during coughing), headache, neurological manifestations, and severe bronchopneumonia.

Diagnosis: depends on isolation of the bacterium, documentation of a rise in antibody titer over time, or a rapid test kit using urine to detect antigens.

Treatment: begins with supportive measures and the administration of erythromycin or rifampin.

Pontiac fever

Caused by: *Legionella pneumophila* also causes an illness called **Pontiac fever.**

Symptoms: This disease, which resembles an allergic disease more than an infection, is characterized by an abrupt onset of fever, headache, dizziness, and muscle pains.

- It is indistinguishable clinically from the various respiratory syndromes caused by viruses.
- Pneumonia does not occur.
- The disease resolves spontaneously within 2 to 5 days.
- No deaths from Pontiac fever have been reported.
- Pontiac fever was first described from an outbreak in a county health department in Pontiac, Michigan. Ninety-five percent of the employees became ill and eventually showed elevated serum titers against *L. pneumophila.*
- *These bacteria were later isolated from* the lungs of guinea pigs exposed to the air of the building. The likely source was water from a defective air conditioner.

Tuberculosis

Caused by: Over a century ago Robert Koch identified *Mycobacterium tuberculosis* (MTB) as the causative agent of tuberculosis (TBM).

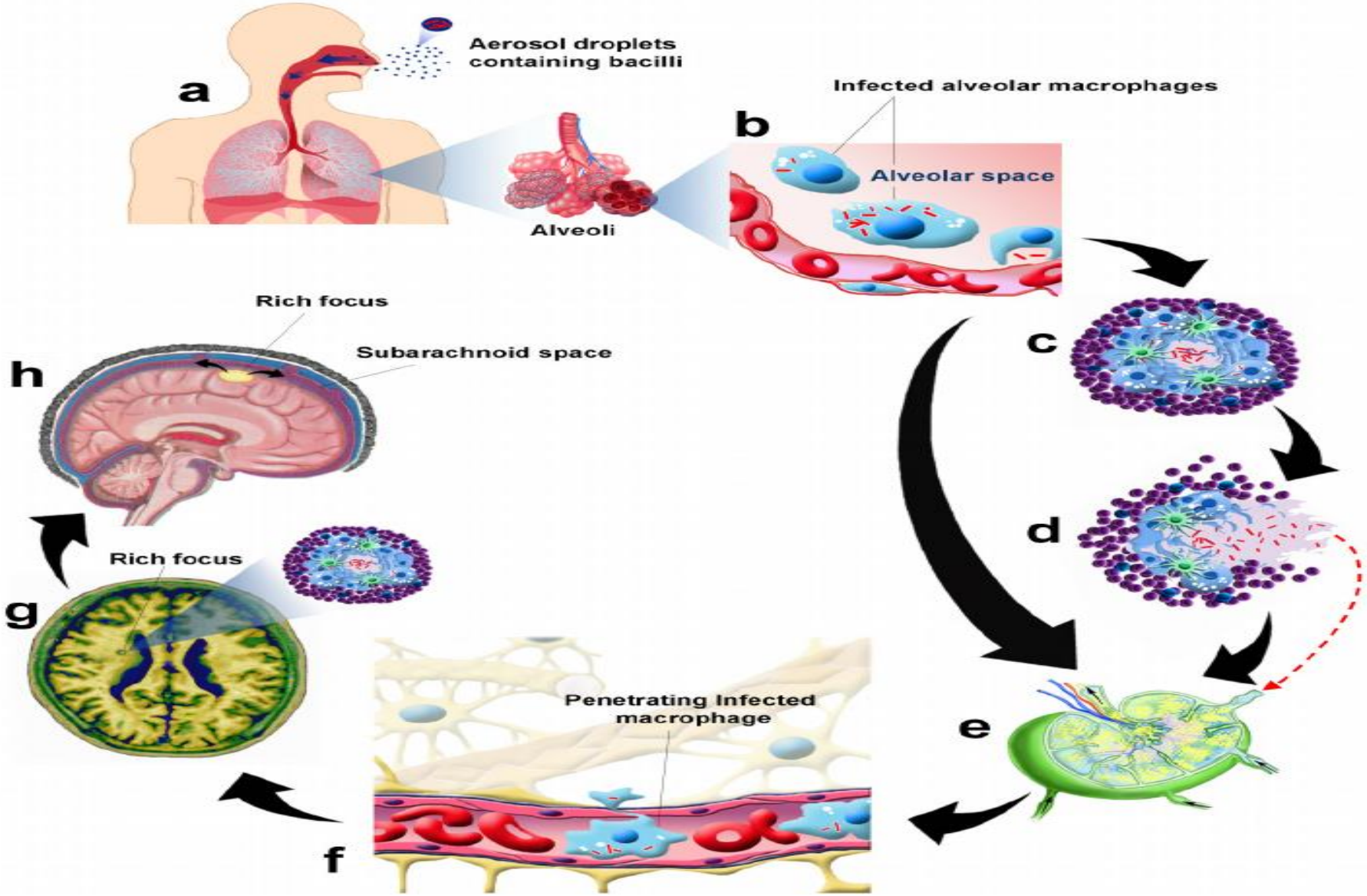
- Worldwide, *M. bovis and M. africanum* also cause TB.

Transmission: acquired from other humans through droplet nuclei and the respiratory route

- Available statistics indicate that a close association exists between AIDS and TB.
- Therefore further spread of HIV infection among the population with a high prevalence of TB infection is resulting in dramatic increases in TB.

Tuberculosis Pathogenesis

- Once in the lungs the bacteria are phagocytosed by macrophages and a hypersensitivity response forms small, hard nodules called **tubercles, which are characteristic of tuberculosis and give** the disease its name.
- The disease process usually stops at this stage, but the bacteria often remain alive within macrophage phagosomes.
- Resistance to oxidative killing, inhibition of phagosome lysosome fusion, and inhibition of diffusion of lysosomal enzymes are some of the mechanisms that may explain the survival of *M. tuberculosis* inside macrophages.
- In time the tubercle may change to a cheeselike consistency and is then called a **caseous lesion.**
- **If such lesions calcify, they are termed Ghon complexes,** which show up prominently in a chest X ray.
- Sometimes the tubercle lesions liquefy and form air-filled **tuberculous cavities** from there bacteria can spread to new foci of infections throughout the body.
- This spreading is often called **miliary tuberculosis due to the many tubercles the size of millet** seeds that are formed in the infected tissue.
- It also may be called **reactivation tuberculosis because the bacteria have been reactivated** in the initial site of infection.



Pathogenesis of TBM and postulation of the formation of Rich foci. (a) Aerosol transmission of MTB (b) Phagocytosis of MTB by alveolar macrophages inside alveoli. (c) Granuloma formation in the lung, which subsequently occurs due to cellular and cytokine network responses; 90% of hosts with granulomas maintain them stably over the course of their lives. (d) MTB escapes from the granuloma, which occurs in 10% of latent TB patients. (e) MTB can cause TBM by escalating from the lung or by secondary reactivation from a "leaked granuloma", which is then filtered into a regional lymph node. (f) After spreading through the blood circulation, MTB can enter the CNS through the BBB, likely by a Trojan horse mechanism. (g) Bacilli seed to the meninges or the brain parenchyma, forming subpial or sub-ependymal primary complexes, termed "Rich foci". (h) Rich foci increase in size, rupture and discharge into the subarachnoid space, which indicates the onset of TBM. (Faksri et al. 2012)

...Tuberculosis

Symptoms: The incubation period is about 4 to 12 weeks, and the diseasedevelops slowly. The symptoms of tuberculosis are fever, fatigue, and weight loss. A cough, which is characteristic of pulmonary involvement, may result in expectoration of bloody sputum.

Diagnosis: Laboratory diagnosis of tuberculosis is by isolation of the acid-fast bacterium, chest X ray, commercially available DNA probes, the BACTEC NAP test, and the Mantoux or tuberculin skin test.

Treatment: Both chemotherapy and chemoprophylaxis are carried out by administering isoniazid (INH), plus rifampin, ethambutol, and pyrazinamide.

- These drugs are administered simultaneously for 12 to 24 months as a way of decreasing the possibility that the patient develops drug resistance.
- In many countries individuals, especially infants and children, are vaccinated with **bacille Calmette-Guérin (BCG) vaccine to prevent** complications such as meningitis.

Pertussis/ Whooping cough

Caused by: Gram-negative bacterium *Bordetella pertussis (B. parapertussis* is a closely related species that causes a milder form of the disease)

Transmission: Pertussis is a highly contagious disease that primarily affects children. Transmission occurs by inhalation of the bacterium in droplets released from an infectious person.

Pathogenesis: The incubation period is 7 to 14 days.

- Once inside the upper respiratory tract, the bacteria attach to the ciliated epithelial cells
- After attachment, the bacteria synthesize several toxins that are responsible for the symptoms. The most important toxin is pertussis toxin, which causes increased tissue susceptibility to histamine and serotonin, and an increased lymphocyte response.
- *B. pertussis* also produces an extracytoplasmic invasive adenylate cyclase, and tracheal cytotoxin and dermonecrotic toxin, which destroy epithelial tissue.
- In addition, the secretion of a thick mucus impedes ciliary action, and often, ciliated epithelial cells die.

...Pertussis

Symptoms: Pertussis is divided into three stages.

- The catarrhal stage-characterize the mucous membrane inflammation.
- Paroxysmal stage –characterize by prolonged coughing sieges followed by the characteristic whoop—a hurried deep inspiration.
- Convalescent stage - Final recovery may take several months.

Diagnosis: by culture of the bacterium, fluorescent antibody staining of smears from nasopharyngeal swabs, and serological tests

Treatment: with erythromycin, tetracycline, or chloramphenicol

Prevention: with the DPT vaccine; vaccination of children is recommended when they are 2 to 3 months old

Streptococcal Pneumonia

Caused by the gram-positive *Streptococcus pneumoniae*, found in the upper respiratory tract**.**

- However, disease usually occurs only in those individuals with predisposing factors such as viral infections of the respiratory tract, physical injury to the tract, alcoholism, or diabetes.
- About 60 to 80% of all respiratory diseases known as pneumonia are caused by *S. pneumoniae.*

Pathogenesis is due to the rapid multiplication of the bacteria in alveolar spaces.

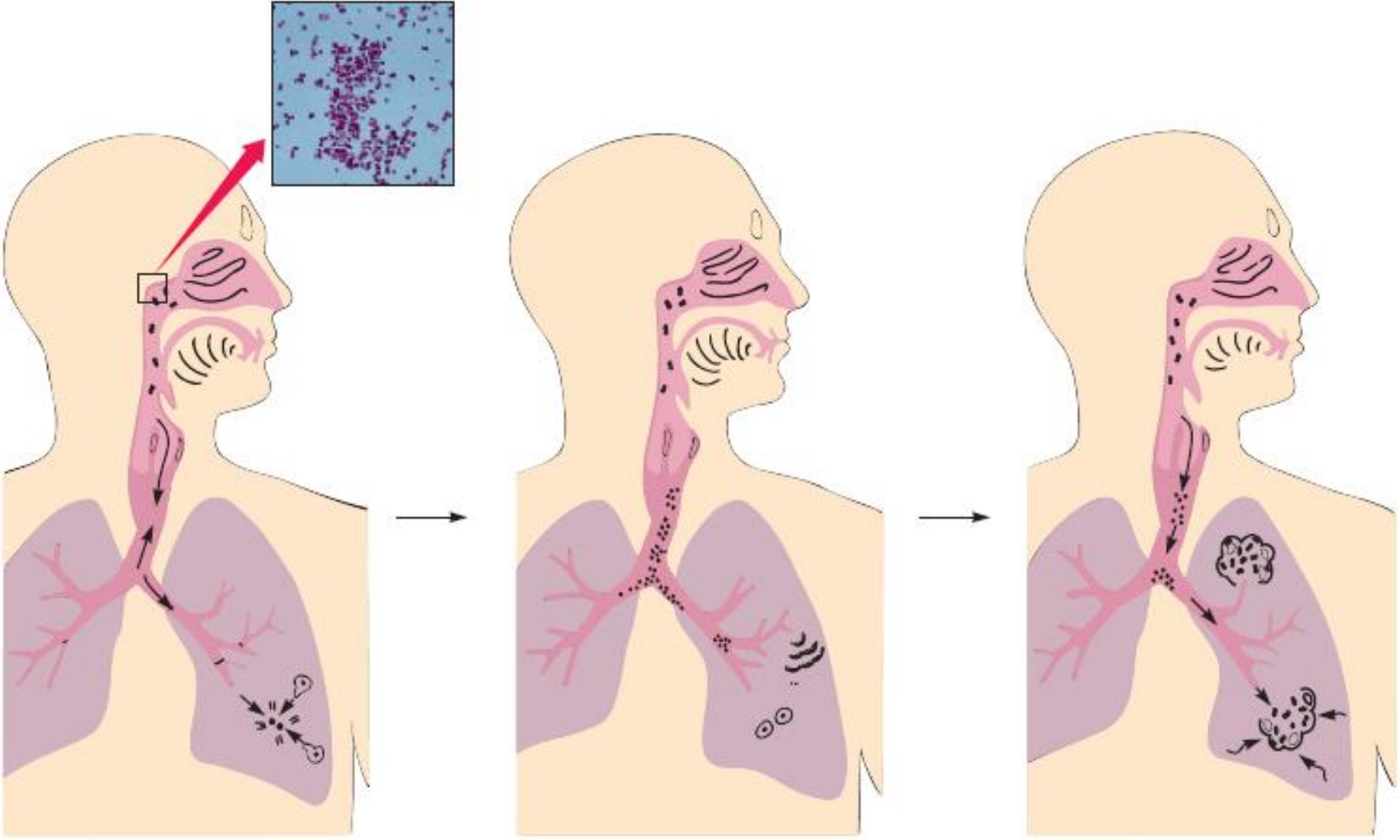
- The bacteria also produce the toxin pneumolysin that destroys host cells. The alveoli fill with blood cells and fluid and become inflamed.
- The sputum is often rust colored because of blood coughed up from the lungs.

Symptoms: The onset of clinical symptoms is usually abrupt, with chills, hard labored breathing, and chest pain.

Diagnosis is by chest X ray, biochemical tests, and culture.

Treatment: Penicillin G, cefotaxime, ofloxacin, and ceftriaxone have contributed to a greatly reduced mortality rate.

- Pneumococcal vaccines (Pneumovax 23, Pnu-Imune 23) are available



Normal condition

1 Periodic colonization with streptococci
2 Some penetration into lower respiratory tract
3 Streptococci trapped by mucus and removed by ciliary action
4 Phagocytosed by macrophages

Predisposing factors

5 Ciliated epithelium damaged by viruses, toxins, smoking, chemicals
6 Fluid accumulation
7 Decreased activity of macrophages

Development of pneumonia

8 Growth of streptococci on damaged ciliated epithelium
9 Growth in fluids and in alveoli, both of which stimulate increased fluid accumulation

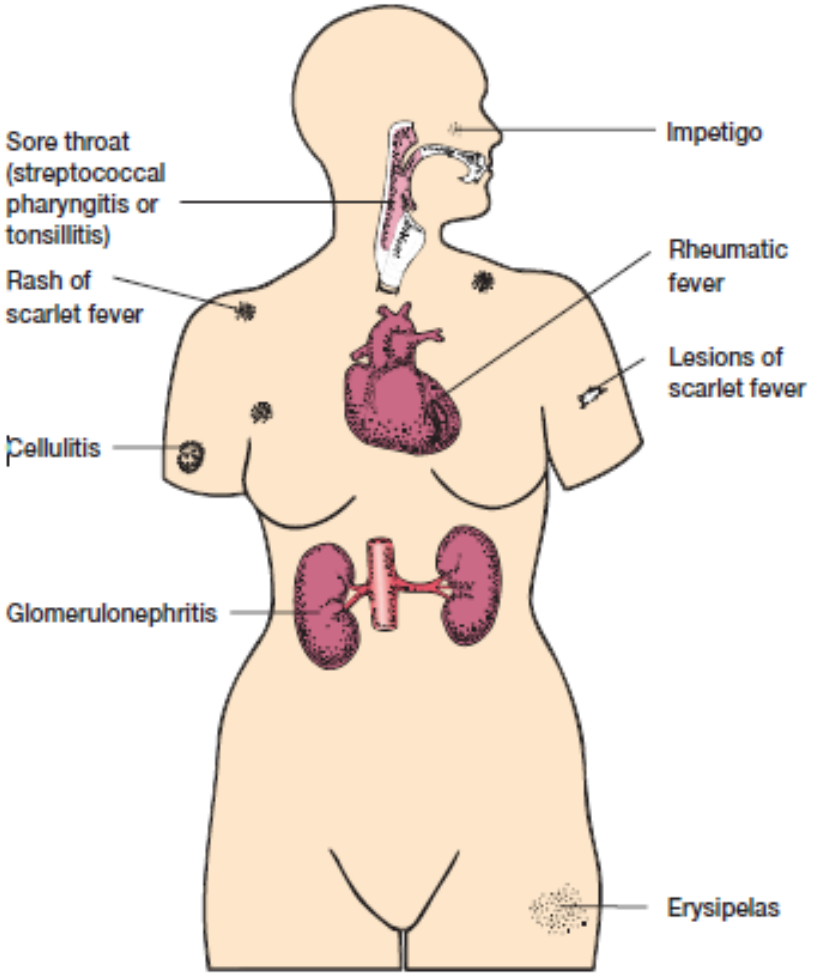
Streptococcal Diseases

- Streptococci, commonly called strep, are a heterogeneous group of Gram-positive bacteria.
- In this group ***Streptococcus pyogenes*** (group A -hemolytic streptococci) is one of the most important bacterial pathogens.
- The different serotypes produce:
  - (1) extracellular enzymes that break down host molecules;
  - (2) streptokinases, enzymes that activate a host-blood factor that dissolves blood clots;
  - (3) the cytolysins streptolysin O and streptolysin S, which kill host leukocytes;
  - (4) capsules and M protein that help retard phagocytosis
- **Transmission:** Individuals with acute infections may spread the pathogen, and transmission can occur through respiratory droplets, direct, or indirect contact.
- **Symptoms:** When highly virulent strains appear in schools, they can cause sharp outbreaks of sore throats and scarlet fever. Due to the cumulative buildup of antibodies to many different *S. pyogenes* serotypes over the years, outbreaks among adults are less frequent

… Streptococcal Diseases

- **Diagnosis** of a streptococcal infection is based on both clinical and laboratory findings.
- Several rapid tests are available

- **Treatment** is with penicillin or erythromycin.
- Vaccines are not available for streptococcal diseases other than streptococcal pneumonia because of the large number of serotypes.



Most prominent streptococcal diseases associated with group A streptococcal infections, and the body sites affected.

… Streptococcal Diseases

Cellulitis: is a diffuse, spreading infection of subcutaneous skin tissue.

- The resulting inflammation is characterized by a defined area of redness (erythema) and the accumulation of fluid (edema).

Erysipelas: an acute infection and inflammation of the dermal layer of the skin.

- It occurs primarily in infants and people over 30 years of age with a history of streptococcal sore throat.
- The skin often develops painful reddish patches that enlarge and thicken with a sharply defined edge.
- Recovery usually takes a week or longer if no treatment is given.
- The drugs of choice for the treatment of erysipelas are erythromycin and penicillin.
- Erysipelas may recur periodically at the same body site for years.

Invasive Streptococcus A Infections: A life-threatening infection begins when invasive strep A strains penetrate a mucous membrane or take up residence in a skin lesion such as a bruise.

- This infection can quickly lead either to **necrotizing fasciitis** that destroys the sheath covering skeletal muscles or to **myositis** the inflammation and destruction of skeletal muscle and fat tissue.
- Because necrotizing fasciitis and myositis arise and spread so quickly, they have been colloquially called “galloping gangrene.”

Poststreptococcal Diseases

<u>Glomerulonephritis or Bright's disease</u> is an inflammatory disease of the renal glomeruli, membranous structures within the kidney where blood is filtered.

- Damage probably results from the deposition of antigen-antibody complexes, possibly involving the streptococcal M protein, in the glomeruli.
- The complexes cause destruction of the glomerular membrane, allowing proteins and blood to leak into the urine.
- **Symptoms:** Clinically the affected person exhibits edema, fever, hypertension, and hematuria (blood in the urine).
- Diagnosis is based on the clinical history, physical findings, and confirmatory evidence of prior streptococcal infection.
- **Treatment:** Penicillin G or erythromycin can be given for any residual streptococci.
- However, there is no specific therapy once kidney damage has occurred.

Poststreptococcal Diseases

Rheumatic fever is an autoimmune disease characterized by inflammatory lesions involving the heart valves, joints, subcutaneous tissues, central nervous system.

- It usually results from a prior streptococcal sore throat infection.
- The exact mechanism of rheumatic fever development remains unknown.
- The disease occurs most frequently among children 6 to 15 years of age
- Therapy: decreasing the inflammation, fever and controlling cardiac failure.
- Salicylates and corticosteroids are the mainstays of treatment.

Scarlet fever (scarlatina) results from a throat infection with astrain of *S. pyogenes that carries a lysogenic bacteriophage.*

- Scarlet fever is a communicable disease spread by inhalation of infective respiratory droplets.
- After a 2-day incubation period, a scarlatinal rash appears on the upper chest and then spreads to the remainder of the body.
- This rash represents the skin's generalized reaction to the circulating toxin.
- Along with the rash, the infected individual experiences a sore throat, chills, fever, headache, and a strawberry colored tongue**.**
- Treatment is with penicillin.

Meningitis

- **Meningitis** is an inflammation of the brain or spinal cord meninges (membranes).
- Based on the specific cause, it can be divided into **bacterial (septic) meningitis and the aseptic meningitis syndrome**
- The immediate sources of the bacteria responsible for meningitis are respiratory secretions from carriers or active cases.
- The bacteria initially colonize the nasopharynx after which they cross the mucosal barrier and enter the bloodstream and cerebrospinal fluid, where they produce inflammation of the meninges.

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

...Meningitis

- **Symptoms:** The usual symptoms of meningitis include an initial respiratory illness or sore throat interrupted by one of the meningeal syndromes:
  - vomiting, headache, lethargy, confusion, and stiffness in the neck and back.
- **Diagnosis:**
  - Gram stain and culture of the bacteria from cerebrospinal fluid or rapid tests.
- **Treatment:**
  - Specific antibiotics (penicillin, chloramphenicol, cefotaxime, ceftriaxone, ofloxacin) are administered immediately.

Questions

- Discuss in detail about common airborne bacterial diseases, and their treatments.
- Write an essay on common airborne diseases caused by bacteria involve the respiratory system.
- Write short note on:
  - airborne bacterial skin diseases
  - Airborne diseases causing systemic or visceral damage