

Bacterial diseases

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Airborne Bacterial Diseases

(Source Book: “Microbiology” by- Prescott (ISBN: 0-07-282905-2))

- **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.

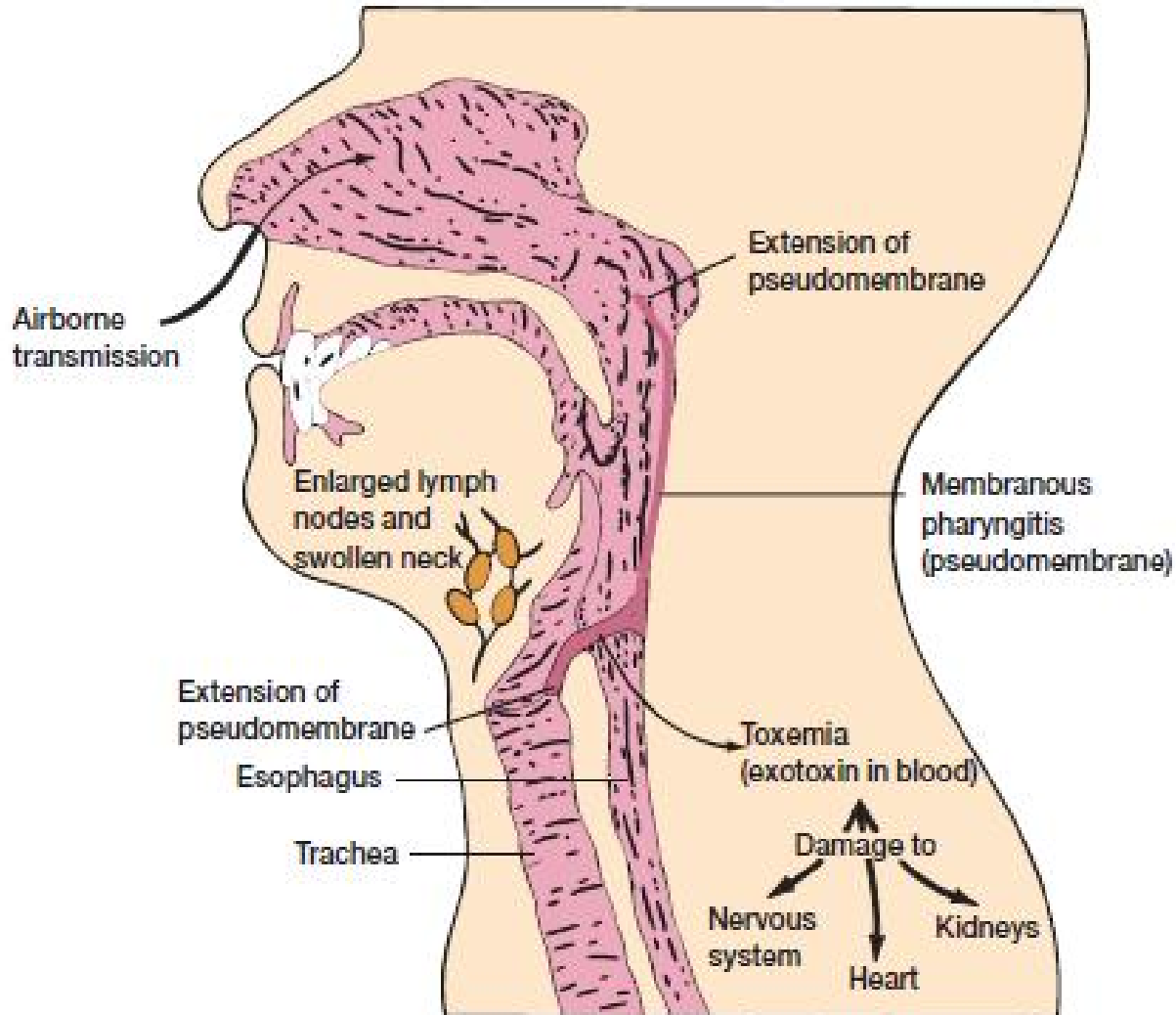
Caused by: the Gram-positive *Corynebacterium diphtheriae*

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.

Tuberculosis

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

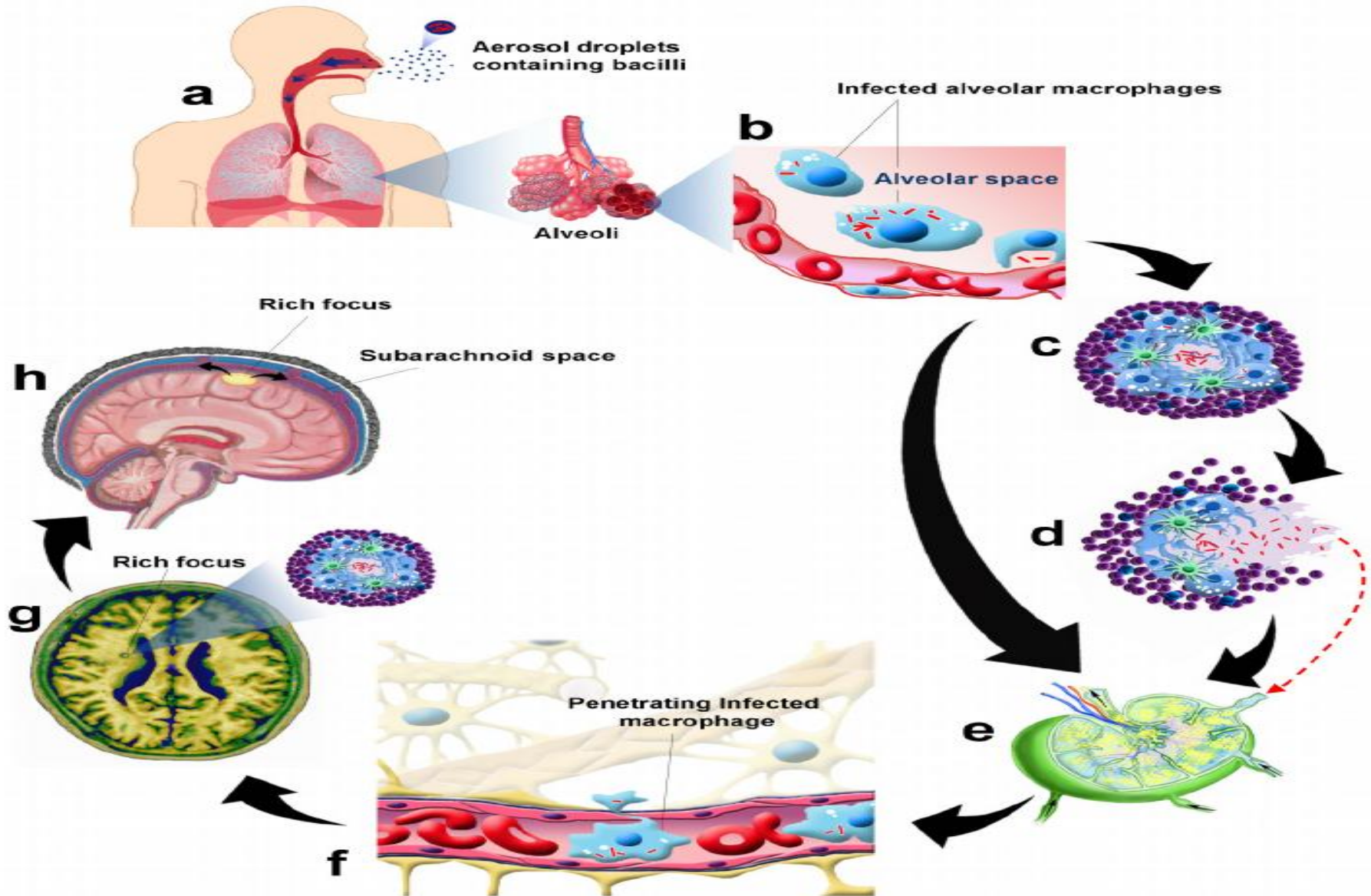
- Worldwide, *M. bovis* and *M. africanum* also cause TB.

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 disease develops 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.**

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.

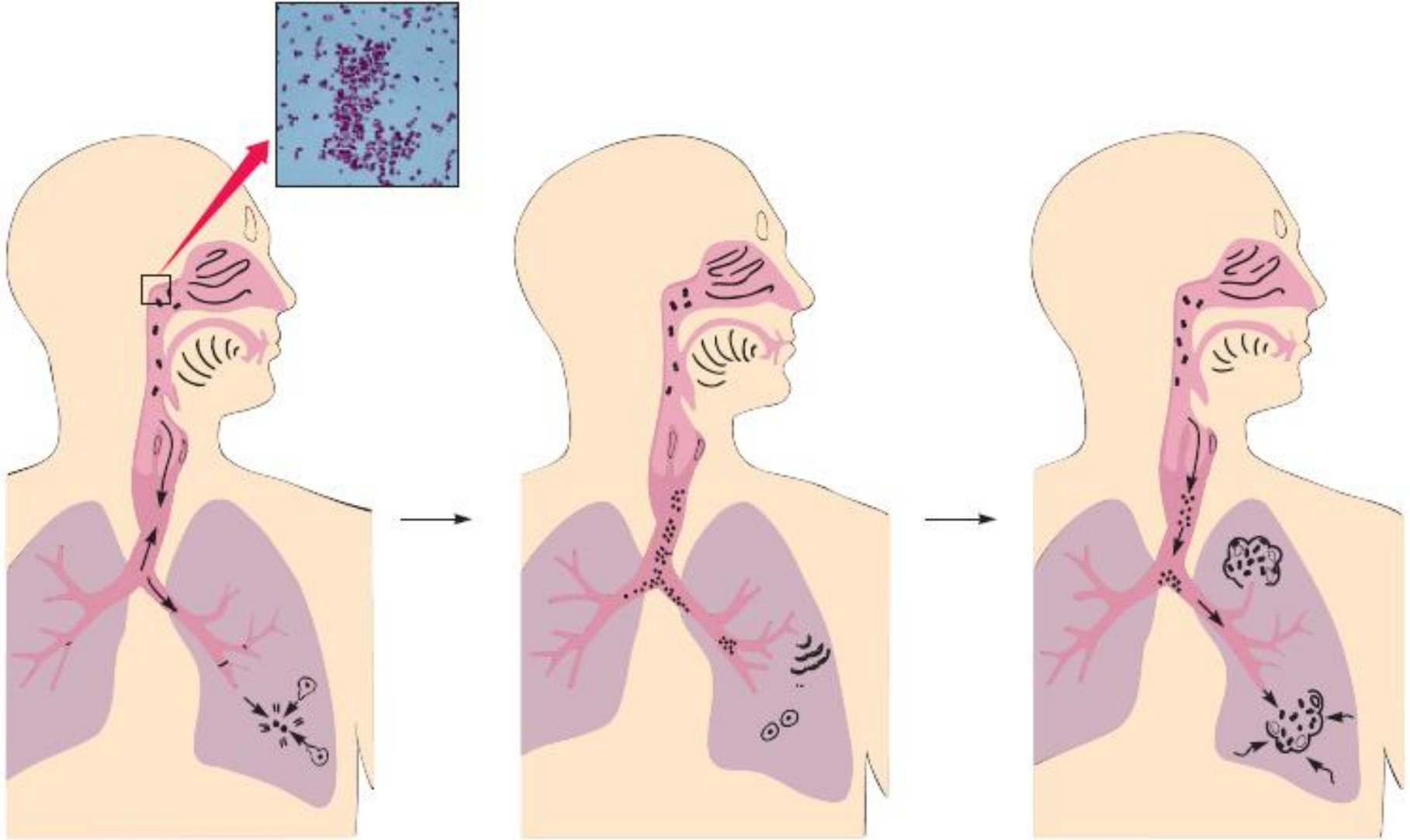
- The bacteria also produce the **toxin pneumolysin** that destroys host cells. The alveoli fill with blood cells and fluid and become inflamed.
- The sputum is often rust colored because of blood coughed up from the lungs.

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.
- **Transmission:** Individuals with acute infections may spread the pathogen, and transmission can occur through respiratory droplets, direct, or indirect contact.

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.

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	<i>Streptococcus pneumoniae</i> <i>Neisseria meningitidis</i> <i>Haemophilus influenzae</i> type b Gram-negative bacilli Group B streptococci <i>Listeria monocytogenes</i> <i>Mycobacterium tuberculosis</i> <i>Nocardia asteroides</i> <i>Staphylococcus aureus</i> <i>Staphylococcus epidermidis</i>
Aseptic Meningitis Syndrome	
Agents Requiring Antimicrobials	Fungi Amoebae Syphilis Mycoplasmas Leptospire
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.

Waterborne Diseases

- Many microorganisms contaminating food and water can cause acute gastroenteritis or inflammation of the stomach and intestinal lining.
- Worldwide, diarrheal diseases are second only to respiratory diseases as a cause of adult death; they are the leading cause of childhood death.

Cholera

- **Caused by:** the gram-negative *Vibrio cholerae* bacterium of the family Vibrionaceae.
- **Transmission:** Cholera is acquired by ingesting food or water contaminated by fecal material from patients or carriers. (Shellfish and copepods are natural reservoirs.)
- In 1961 the El Tor biotype emerged as an important cause of cholera pandemics, and in 1992 the strain *V. cholerae* O139 emerged in Asia.
- **Pathogenesis:** Once the bacteria enter the body, the incubation period is from 24 to 72 h.
- The bacteria adhere to the intestinal mucosa of the small intestine, where they are not invasive but secrete **cholera toxin**.
- Cholera toxin is a protein composed of two functional units, an enzymatic A subunit and an intestinal receptor-binding B subunit.
- The A subunit enters the intestinal epithelial cells and activates the enzyme adenylate cyclase by the addition of an ADP-ribosyl group in a way similar to that employed by diphtheria toxin.
- As a result cholera toxin stimulates hypersecretion of water and chloride ions while inhibiting absorption of sodium ions.
- There is now evidence that the cholera toxin gene is carried by the CTX filamentous bacteriophage.
- The phage binds to the pilus used to colonize the host's gut, enters the bacterium, and incorporates its genes into the bacterial chromosome.

...Cholera

- **Symptoms:** The patient loses massive quantities of fluid and electrolytes, which is associated with abdominal muscle cramps, vomiting, fever, and watery diarrhea.
- The diarrhea can be so profuse that a person can lose 10 to 15 liters of fluid during the infection.
- Death may result from the elevated concentration of blood proteins, caused by reduced fluid levels, which leads to circulatory shock and collapse.
- **Diagnosis:** by culture of the bacterium from feces and subsequent identification by agglutination reactions with specific antisera.
- **Treatment:** is by oral rehydration therapy with NaCl plus glucose to stimulate water uptake by the intestine
- The antibiotics of choice are a tetracycline, trimethoprim-sulfamethoxazole, or ciprofloxacin.
- The most reliable control methods are based on proper sanitation, especially of water supplies.

Typhoid Fever

- **Caused by:** several virulent serovars of *Salmonella typhi*
- **Transmission:** by ingestion of food or water contaminated by feces of infected humans or animals.
- **Pathogenesis:** Once in the small intestine the incubation period is about 10 to 14 days.
- The bacteria colonize the small intestine, penetrate the epithelium, and spread to the lymphoid tissue, blood, liver, and gallbladder.
- After approximately 3 months, most individuals stop shedding bacteria in their feces.
- However, a few individuals continue to shed *S. typhi* for extended periods but show no symptoms.
- In these carriers, the bacteria continue to grow in the gallbladder and reach the intestine through the bile duct.

...Typhoid Fever

- **Symptoms:** Symptoms include fever, headache, abdominal pain, anorexia, and malaise, which last several weeks.
- **Diagnosis:** by demonstration of typhoid bacilli in the blood, urine, or stools and serology (the Widal test).
- **Treatments:** Treatment with ceftriaxone, trimethoprim-sulfamethoxazole, or ampicillin has reduced the mortality rate to less than 1%.
- Recovery from typhoid confers a permanent immunity.
- Purification of drinking water, milk pasteurization, prevention of food handling by carriers, and complete isolation of patients are the most successful prophylactic measures.
- There is a vaccine for high-risk individuals.
 - Ty21a: 1 capsule by mouth at minimum age of 6 years.
 - ViCPS: injection at minimum age of 2 years.

Salmonellosis (*Salmonella gastroenteritis*)

- **Caused by:** over 2,000 *Salmonella* serovars (strains; a subspecies category).
- The most frequently reported one from humans is *S. typhimurium*.
- *This* bacterium is a gram-negative, motile, non-spore-forming rod.
- **Transmission:** The initial source of the bacterium is the intestinal tracts of birds and other animals.
- Humans acquire the bacteria from contaminated foods such as beef products, poultry, eggs, egg products, or water.
- **Pathogenesis:** Once the bacteria are in the body, the incubation time is only about 8 to 48 hours.
- The disease results because the bacteria multiply and invade the intestinal mucosa where they produce an enterotoxin and cytotoxin that destroy the epithelial cells.

...Salmonellosis (*Salmonella gastroenteritis*)

- **Symptoms:** Abdominal pain, cramps, diarrhea, nausea, vomiting, and fever are the most prominent symptoms, which usually persist for 2 to 5 days but can last for several weeks.
- Most adult patients recover, but the loss of fluids can cause problems for children and elderly people.
- **Diagnosis:** by isolation of the bacterium from food or patients' stools.
- **Treatments:** is with fluid and electrolyte replacement.
- Prevention depends on good food-processing practices, proper refrigeration, and adequate cooking.

Traveler's Diarrhea and *Escherichia coli* Infections

- Millions of people travel yearly from country to country.
- Unfortunately a large percentage of these travelers acquire a rapidly acting, dehydrating condition called traveler's diarrhea.
- **Caused by:** certain viruses, bacteria, or protozoa usually absent from the traveler's environment.
- One of the major causative agents is *E. coli*.
- **Transmission:** This bacterium circulates in the resident population, typically without causing symptoms due to the immunity afforded by previous exposure.
- Because many of these bacteria are needed to initiate infection, contaminated food and water are the major means by which the bacteria are spread.
- This is the basis for the popular warnings to international travelers: "Don't drink the local water" and "Boil it, peel it, cook it, or forget it."

... Traveler's Diarrhea and *Escherichia coli* Infections

- *E. coli* may cause diarrheal disease by several mechanisms, and six categories or strains of diarrheagenic *E. coli* are now recognized:
 - Enterotoxigenic *E. coli* (ETEC),
 - Enteroinvasive *E. Coli* (EIEC),
 - Enterohaemorrhagic *E. coli* (EHEC),
 - Enteropathogenic *E. coli* (EPEC),
 - Enteroaggregative *E. coli* (EAaggEC),
 - Diffusely adhering *E. coli* (DAEC)