**Pertussis** is an infection of the lower respiratory system caused by the Gram-negative bacterium, *Bordatella pertussis*

- *B. pertussis* colonizes the trachea, and an exotoxin it produces interferes with normal ciliary function, leading to accumulation of mucus (Tortora et al., Figure 24.8)

- Pertussis, which can be quite severe, develops through a characteristic sequence
  - The **cataarrhal stage**, in which the organism first infects the host, resembles a common cold
  - During the **paroxysmal stage**, when ciliary action is comprised and mucus accumulates, an infected person desparately attempts to cough up the mucus accumulations
    - This is where the common name for pertussis, *whooping cough*, arises
    - Most of us have never heard the sound of a patient in the paroxysmal stage of pertussis, but at one time it was known and greatly feared
  - The violence of the paroxysmal stage is adequate to result in broken ribs
  - Eventually, an adequate immune response leads to a long **convalescence stage**

- Today, vaccination is recommended for all children
  - Earlier pertussis vaccines were whole killed *B. pertussis* cells; however there is some concern about neurological sequelae
  - Whole cell pertussis vaccine is being replaced with “acellular” subunit vaccines

**Tuberculosis** is a lower respiratory system infection caused by the bacterium *Mycobacterium tuberculosis*

- Cells of *M. tuberculosis* are quite resistant to dessication (perhaps due to their acid-fast cell wall (remember?!)), and are usually acquired by inhalation of the bacteria

- Tuberculosis arises when cells of *M. tuberculosis* are ingested by alveolar macrophages (Tortora et al, Figure 24.10)
  - The macrophages may fail to kill the *M. tuberculosis* cells, which may actually multiply inside of the macrophages
  - A cell-mediated hypersensitivity response leads to formation of a **tubercle**, consisting of masses of tissue cells, leukocytes and *M. tuberculosis* cells
  - The tubercle may "wall off" the *M. tuberculosis* infection, leading to arrest of the infectious process

- The tissue damage resulting from tuberculosis is actually due to the hypersensitivity reaction; if this continues, the tubercle may actually promote multiplication of *M. tuberculosis*, leading eventually to systemic infection

- Even if the infection is arrested, changes in immune status of an infected person can lead to **reactivation** of tuberculosis

- The **tuberculin skin test**, which detects a CMI response to *M. tuberculosis* antigens, can identify persons previously exposed to *M. tuberculosis* and thus potential reservoirs of infection (Tortora et al. Figure 24.11)

- **Bovine tuberculosis**, caused by *Mycobacterium bovis* and transmitted from cattle via contaminated milk, is relatively rare today

- The **BCG vaccine** (the acronym is for "Bacillus of Calmette and Guerin") is fairly effective in preventing tuberculosis; it is not used universally since it precludes use of the tuberculin skin test to detect *M. tuberculosis* infection

- In the United States, tuberculosis remains largely a disease of poverty (hence malnutrition, hence inadequate immune response)
  - Prevelance of tuberculosis, though low, remains higher than it should be
  - Incidence of tuberculosis has tended, in recent years, to parallel the HIV epidemic; persons with HIV disease are susceptible to tuberculosis (due to severely impaired cell-mediated immunity) and can serve as reservoirs for transmission to others
Bacterial pneumonias, multiplication of bacteria in the lower respiratory tract, cause about 50,000 deaths annually in the United States.

- Most of the bacteria that cause pneumonias are members of the upper respiratory tract flora that cause opportunistic infections, including (here they are again!) *Haemophilus influenzae* and *Streptococcus pneumoniae*.

- The most common pneumonia in adults is pneumococcal pneumonia, caused by *S. pneumoniae*.
  - Cells of pathogenic strains of *S. pneumoniae* are invariably encapsulated (Tortora et al., Figure 24.12; and remember Griffith's experiments (Tortora et al., Figure 8.24)).

  - Pathogenesis of pneumococcal pneumonia varies with a person's resistance, which may be influenced by other disease states.
    - Many illnesses in the elderly terminate (too often, literally) with pneumococcal pneumonia.
    - Pneumococcal pneumonia is frequently a secondary infection of viral respiratory tract infections, especially influenza.

  - A vaccine, "PneumoVax", has been developed from pooled capsular material of different strains of *S. pneumoniae*; it is often administered along with influenza vaccine to susceptible populations.

- Pneumonia due to *Klebsiella pneumoniae* or *H. influenzae* are most commonly found in compromised hosts; interestingly, alcoholics are a susceptible group (probably related to malnutrition accompanying the addiction).

- *Primary atypical pneumonia*, so called since the "typical" bacteria cannot be isolated, is usually due to bacteria of the genus *Mycoplasma*.
  - Mycoplasmas lack cell walls and are usually found in close association with host cells (although they do not multiply intracellularly).
  - Because of their unusual biology, *Mycoplasma* species are difficult to grow on artificial media and are not typically isolated (Tortora et al. Figure 24.14).
  - Pathogenesis in primary atypical pneumonia is usually mild - hence the term "walking pneumonia" - and the disease is usually treated successfully with tetracycline.

- *Legionellosis*, caused by *Legionella pneumophila*, is a bacterial pneumonia identified only recently (OK, not that recently to you, but recently to me).
  - *L. pneumophila* is never transmitted person-to-person; rather, it is acquired from nonliving reservoirs, such as contaminated water.
  - *L. pneumophila* is rather difficult to grow in the laboratory, which explains why it took a long time to identify; in fact, legionellosis may be relatively common.

- Bacterial pneumonias may be caused by bacteria that multiply intracellularly.
  - *Psittacosis*, caused by *Chlamydia psittaci*, is transmitted from birds.
  - *Q fever*, caused by *Coxiella burnetii* (Tortora et al., Figure 24.15), is a rickettsial infection that can lead to pneumonia; like rickettsias, *C. burnetii* is transmitted by arthropod vectors.

- Not all pneumonias have bacterial etiologies; there are a number of agents of viral pneumonias, including respiratory syncytial virus, which is the most common cause of viral respiratory disease in infants.

Influenza is caused by an enveloped virus with a segmented RNA genome (Tortora et al., Figure 24.16).

- Virions of influenza virus display characteristic envelope proteins.
  - *Hemagglutinin* aids in attachment to host cells; the term refers to the agglutination that occurs when virions are mixed with erythrocytes.
  - *Neuraminidase* may be involved with release from host cells.
    - Both hemagglutinin and neuraminidase are strongly antigenic.

- Strains of influenza virus are distinguished by the antigenic nature of their hemagglutinin and neuraminidase spikes.

- One reason that influenza continues as an epidemic (indeed, pandemic) disease is that antigenic variation is common (Tortora et al. Table 24.1).
  - *Antigenic shift* refers to new combinations of hemagglutinins and neuraminidases.
  - *Antigenic drift* refers to periodic changes in antigen structure due to mutation.
As a result of these variations, a vaccine developed against one strain of influenza virus may not protect a person from a future influenza outbreak.
- Influenza vaccine development has become something of a competitive sport, with epidemiologists seeking to identify epidemic strains in time to allow vaccine production.
- Mortality due to influenza is usually a consequence of secondary bacterial pneumonia.

Fungal spores, brought to the lower respiratory system by inhalation, cause several infectious diseases; these often resemble tuberculosis in that type IV hypersensitivity is frequently involved in pathogenesis.
- **Histoplasmosis**, due to *Histoplasma capsulatum* (Tortora et al., Figure 24.17), is mostly limited in the United States to the Mississippi and Ohio river valleys (Tortora et al., Figure 24.18).
- **Coccidiomycosis**, due to *Coccidioides immitis* (Tortora et al., Figure 24.19) is most common in the Southwest U.S. (Tortora et al., Figure 24.20).
- **Aspergillosis**, due to *Aspergillus fumigatus*, is an occupational hazard of agricultural workers, who may be exposed to massive numbers of *Aspergillus* spores.
- Pneumonia due to *Pneumocystis carinii* has become well-known as a leading cause of mortality in AIDS patients.