Microbial diseases of the cardiovascular system include those in which a pathogen invades and is distributed through tissues of the cardiovascular system and/or the lymphatic system
- The cardiovascular system consists of the heart, blood and blood vessels
- The lymphatic system consists of lymph, lymph vessels, and lymphatic tissues
  = Because lymphatic vessels are relatively permeable and drain the interstitial fluid (which becomes lymph) from tissues throughout the body, they readily pick up microorganisms and their products
  = At various points, lymph flows through lymph nodes (Tortora et al., Figure 23.2, inset B), where microorganisms and their products are phagocytosed by macrophages, which present antigens to lymphocytes
  = On occasion, the accumulation of microbial material and the proliferation of lymphocytes leads to enlargement of the lymph nodes, a classic infectious disease symptom.

**Septicemia** is the proliferation of bacteria in blood
- The organisms most often associated with septicemia are Gram-negative bacteria, such as *Escherichia coli*, *Serratia marcescens* and *Pseudomonas aeruginosa*
- A potentially lethal consequence of septicemia is *septic shock* resulting from release of endotoxin from the invading bacteria
- Many cases of septicemia are of nosocomial origin, where bacteria that are normally incapable of invading the cardiovascular system are introduced by medical procedures
- **Puerperal sepsis**, or "childbirth fever", results from septicemia associated with childbirth or abortion
  = The most frequent pathogen associated with puerperal sepsis is *Streptococcus pyogenes*, a ß-hemolytic streptococcus
  = Infection of the uterus progresses to peritonitis and then to septicemia
  = Once quite common, the incidence of puerperal sepsis was reduced dramatically by adoption of antiseptic techniques in delivery

**Bacterial endocarditis** involves bacterial infection of the endocardium, a layer of epithelium lining the heart and its valves
- **Subacute bacterial endocarditis**, usually caused by ß-hemolytic streptococci, leads to progressive damage of endocardial tissue and functional impairment of the heart (Tortora et al., Figure 23.3)
  = The bacteria causing the infection probably migrate to the heart from some other locus of infection
  = Susceptibility to subacute endocarditis is greatly enhanced by preexisting damage caused by congenital defects or previous infection
- **Acute bacterial endocarditis**, often due to *Staphylococcus aureus* (see, there they are again!) or *Streptococcus pneumoniae*, can lead to rapid destruction of heart valves
- Because of their increased risk for bacterial endocarditis, persons with preexisting heart damage are often treated prophylactically with antibiotics prior to routine medical procedures such as tooth extraction or PAP tests (both of which release small numbers of bacteria into the blood)
- **Rheumatic fever**, which may also damage the heart valves, is a hypersensitivity complication of infections caused by *Streptococcus pyogenes*, including "strep throat"
  = Rheumatic fever may be an immune complex disorder in which streptococcal antigens deposited in the heart and joints complex with antibodies, leading to inflammatory damage
  = It is also possible that streptococcal antigens similar to components of heart muscle invoke an autoimmune response
Because of its association with an immune response to streptococcal infection, persons who have suffered rheumatic fever must be careful to avoid subsequent infection.

*Tularemia* and *brucellosis* are bacterial infections transmitted from animal reservoirs; both are relatively uncommon in the United States.

- The agent of tularemia, *Francisella tularensis*, is usually acquired from an infected animal through minor skin breaks.
  - Tularemia can also be obtained from ingestion of inadequately cooked game, from aerosols and by vector transmission.
  - Probably 90% of US cases of tularemia are acquired from rabbits.
  - Although infrequently encountered, *F. tularensis* is quite virulent, complicating its handling in the clinical laboratory.

- Brucellosis is caused by infection with bacteria belonging to the genus *Brucella*; most infections in this country are by *Brucella abortus* (so-named because fetal infection in cattle causes miscarriage) acquired from inadequately pasteurized milk.
- Both *Francisella tularensis* and *Brucella* species are able to multiply in phagocytes (see Tortora et al., Figure 23.6).

**Anthrax** is a serious infection in livestock that occasionally occurs in humans.

- The agent of anthrax is *Bacillus anthracis*; *B. anthracis* endospores can be ingested by grazing animals.
- Robert Koch's identification of *B. anthracis* as the agent of anthrax led to elucidation of "Koch's postulates".
- There are only a handful of U.S. anthrax cases each year, mostly associated with handling of animal products.
- Because they are so resilient, *B. anthracis* endospores have an interesting history (hopefully past) as potential biological warfare agents.

**Gangrene** results from multiplication of anaerobic bacteria, especially *Clostridium perfringens*, in necrotic tissue.

- Necrotic tissue is "dead" tissue from which the blood supply has been cut off (a condition known as *ischemia*).
- Substances released from necrotic tissue can provide nutrients for anaerobic bacteria.
- Once established, the bacteria may produce toxins that destroy surrounding tissue, facilitating spread of the gangrene.
- Treatment of gangrene usually requires surgical removal of the necrotic tissue.

Animal bites can cause systemic bacterial infections; especially significant are infection of deep wounds by anaerobes, transmission of *Pasteurella multicoda*, and "cat scratch disease" infection with *Bartonella henselae*.

Arthropod vectors can transmit a number of bacterial infectious diseases.

- **Plague** is perhaps the best-known, due to its history as a devastating epidemic disease in Europe.
  - The agent of plague is *Yersinia pestis*, which normally infects rats.
  - Fleas can transmit *Y. pestis* from rats to other mammals, including humans.
  - *Y. pestis* can survive and proliferate inside of phagocytes, which carry the bacteria to lymphoid tissues.
  - *Bubonic plague* is characterized by *buboes*, inflamed lymph nodes (Tortora et al., Figure 23.10).
  - Involvement of the lower respiratory tract leads to *pneumonic plague*, which is rapidly lethal and contagious.
- **Relapsing fever** and **Lyme disease** are caused by spirochetes belonging to the genus *Borrelia*, transmitted by ticks (Tortora et al. Figure 23.13).
Acquisition of Lyme disease is frequently indicated by a characteristic "bull's-eye rash" (Tortora et al., Figure 23.14). Lyme disease may progress from acute fever to neurological symptoms to severe arthritis; in its early stages, it can be effectively treated with antibiotics.

A variety of arthropod-transmitted diseases are caused by bacteria of the genus *Rickettsia*:

- Rickettsias are obligate intracellular parasites which typically multiply in endothelial cells of the cardiovascular system.
- *Epidemic typhus*, typically transmitted by human body lice, can occur in widespread outbreaks in crowded communities.
- *Endemic typhus*, which occurs sporadically, is usually transmitted by fleas from infected rodents.
- The agent of *Rocky Mountain spotted fever* (which is more common in the Southeast than in the Rocky Mountains! (Tortora et al., Figure 23.15)), *Rickettsia rickettsii*, multiplies in ticks and can be passed to the ticks' progeny by transovarian passage (Tortora et al., Figure 23.16).