Microbial Diseases: Cardiovascular and Systemic

Microbiology

CCV

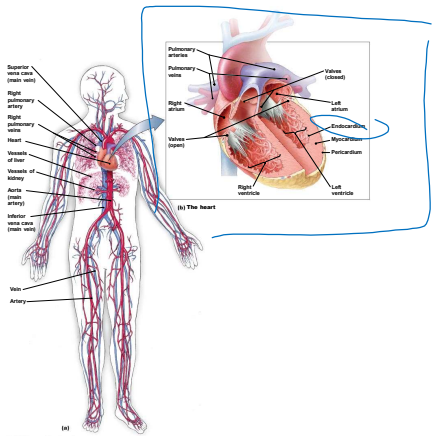
1

Structures of the Cardiovascular System

- Cardiovascular system is composed of heart, blood, and blood vessels
- Heart pumps blood into arteries connected via capillaries to veins
  - Arteries carry blood away from the heart
  - Veins carry blood to the heart
- Blood composition
  - Serum: liquid part of blood
  - Formed elements: erythrocytes, leukocytes, platelets

2

Figure 21.1 The cardiovascular system.



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Structures of the Cardiovascular System

- **Movement of Blood and Lymph**
  - The right ventricle pumps blood to the lungs
    - Oxygen enters blood, and carbon dioxide diffuses out
  - Oxygenated blood returns to the heart through the left ventricle
  - Blood then moves to the arteries and capillaries
    - Capillaries carry blood to the surrounding tissues
    - Leaked fluid is picked up by the lymphatic vessels

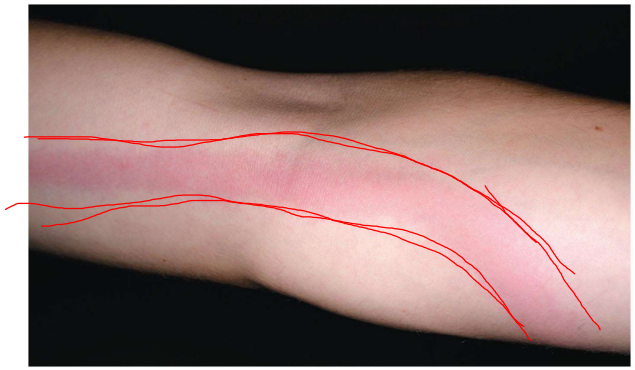
4

Bacterial Cardiovascular and Systemic Diseases

- **Septicemia, Bacteremia, and Toxemia**
  - Septicemia
    - Any microbial infection of the blood that produces illness
  - Bacteremia
    - Bacterial septicemia
  - Toxemia
    - Release of bacterial toxins into the blood
  - Lymphangitis
    - Infection and inflammation of the lymphatic vessels

5

Figure 21.2 Lymphangitis, a sign of septicemia.



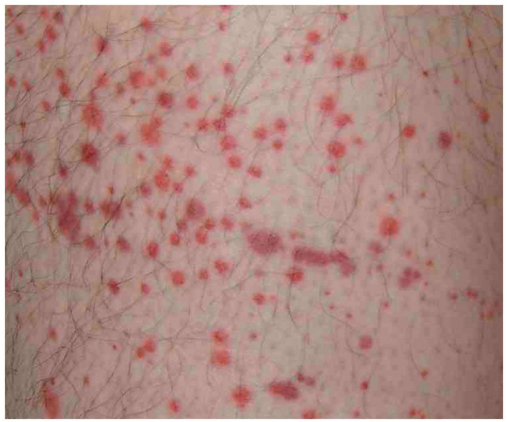
6

Bacterial Cardiovascular and Systemic Diseases

- **Septicemia, Bacteremia, and Toxemia**
  - Signs and symptoms
    - Fever, chills, nausea, vomiting, diarrhea, malaise
    - Septic shock can develop rapidly
    - Small hemorrhagic lesions called *petechiae* can develop
    - Osteomyelitis occurs if bacteria invade the bones
    - Toxemia symptoms vary depending on the toxin
      - Exotoxins: released from living microorganisms
      - Endotoxin: released from Gram-negative bacteria

7

Figure 21.3 Petechiae, a sign of bacteremia.



8

Bacterial Cardiovascular and Systemic Diseases

- **Septicemia, Bacteremia, and Toxemia**
  - Pathogens and virulence factors
    - Septicemia and toxemia are caused by various bacteria
    - Often opportunistic or healthcare associated infections
    - Septicemia is caused more often by Gram-negative bacteria
    - Bacteria that produce capsule may resist phagocytosis
    - Use siderophores to acquire iron needed for bacterial metabolism
    - Endotoxin is produced by Gram-negative bacteria

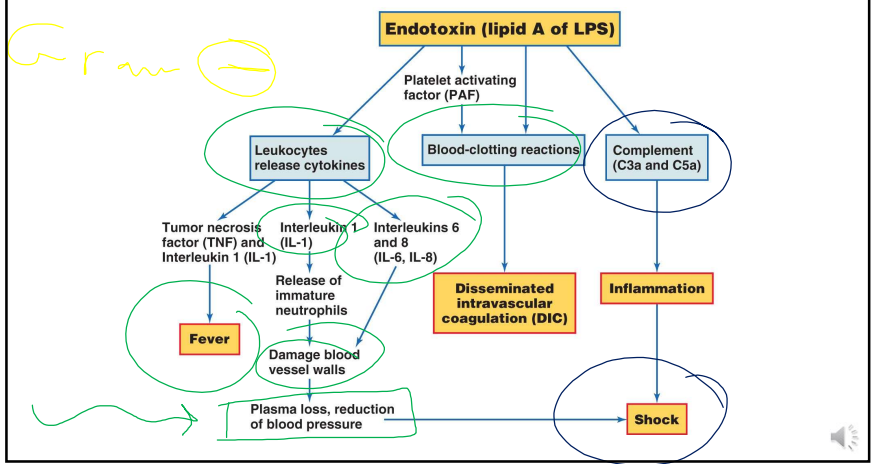
9

Bacterial Cardiovascular and Systemic Diseases

- **Septicemia, Bacteremia, and Toxemia**
  - Pathogenesis and epidemiology
    - Septicemia is due to direct inoculation of bacteria into the blood
    - Immunocompetent individuals rarely have septicemia
      - Bacterial infections self-limited in these people
    - Gram-negative bacteria more often produce severe septicemia
      - Due to release of endotoxin as the bacteria die
        - Activates various defensive reactions by the body

10

Figure 21.4 Potential effects of endotoxin.



11

Bacterial Cardiovascular and Systemic Diseases

- **Septicemia, Bacteremia, and Toxemia**
  - Diagnosis, treatment, and prevention
    - Signs and symptoms are usually diagnostic
    - Treated with prompt diagnosis and administration of antimicrobial drugs
    - Prevention includes immediate treatment of infections
      - Important in individuals with compromised immune systems

12

Bacterial Cardiovascular and Systemic Diseases

- **Endocarditis**
  - Signs and symptoms
    - Inflammation of the endocardium
    - Fever, fatigue, malaise, and difficulty breathing
    - Tachycardia may be detected
  - Pathogens
    - Normal microbiota are usually responsible
    - Viridans streptococci cause almost half the cases
  - Pathogenesis and epidemiology
    - Patients usually have obvious source of infection
    - Patients with abnormal heart have increased risk
    - Embolus can block blood vessels in other organs

13

Bacterial Cardiovascular and Systemic Diseases

- **Endocarditis**
  - Diagnosis, treatment, and prevention
    - Diagnosis is based on symptoms
    - Vegetations visualized by echocardiogram
    - Treated with intravenous antibacterial drugs
    - Prophylactic antibiotics for high-risk patients when needed

14

Bacterial Cardiovascular and Systemic Diseases

- Systemic diseases are diseases that are carried throughout the body
- Pathogens are carried by the blood and lymph

15

Bacterial Cardiovascular and Systemic Diseases

- **Brucellosis**
  - Signs and symptoms
    - Fluctuating fever that spikes every afternoon
  - Pathogen and virulence factors
    - Caused by *Brucella melitensis* strains
    - Endotoxin causes some of the signs and symptoms
  - Pathogenesis and epidemiology
    - Consumption of contaminated dairy products
    - Contact with animal blood, urine, or placentas
  - Diagnosis, treatment, and prevention
    - Diagnosed by serological tests and presence of fever
    - Usually requires no treatment
    - Attenuated vaccine exists for animals

16

Bacterial Cardiovascular and Systemic Diseases

- **Tularemia**
  - Signs and symptoms
    - Skin lesions and swollen lymph nodes at infection site
    - Ascending lymphangitis
  - Pathogen and virulence factors
    - Caused by *Francisella tularensis*
      - Diverse host range includes mammals, birds, fish, ticks, and insects
    - *F. tularensis* can survive within infected cells
    - Endotoxin causes many signs and symptoms

17

Bacterial Cardiovascular and Systemic Diseases

- **Tularemia**
  - Pathogenesis and epidemiology
    - Transmitted via bite of infected tick or contact with infected animal
    - Small size of bacteria allows entry through seemingly unbroken skin
    - Individuals in contact with dead animals at highest risk
  - Diagnosis, treatment, and prevention
    - Diagnosis is difficult and requires serological confirmation
    - Treated with antimicrobials
    - Vaccine available for people at risk for exposure

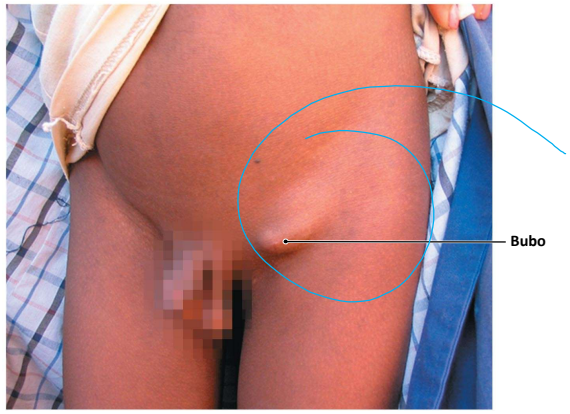
18

Bacterial Cardiovascular and Systemic Diseases

- **Plague**
  - Signs and symptoms
    - Bubonic plague
      - Characterized by enlarged lymph nodes called *buboes*
    - Pneumonic plague
      - Occurs when the bacterium spreads to the lungs
      - Difficulty breathing can develop rapidly
  - Pathogen and virulence factors
    - Caused by *Yersinia pestis*
    - Various virulence factors
      - Adhesins, type III secretion systems, capsules, and antiphagocytic proteins

19

Figure 21.5 Bubo.



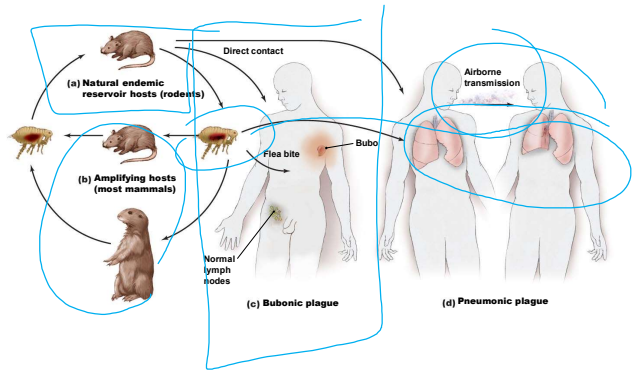
20

Bacterial Cardiovascular and Systemic Diseases

- **Plague**
  - Pathogenesis and epidemiology
    - Transmitted by contact with infected animal or flea feces
    - Bubonic plague fatal in 50% of cases if untreated
    - Pneumonic plague fatal in 100% of cases if untreated
  - Diagnosis, treatment, and prevention
    - Diagnosis is based on characteristic symptoms
    - Must be diagnosed and treated immediately
    - Treated with various antimicrobial drugs
    - Prevented with rodent and flea control and good hygiene

21

Figure 21.6 The natural history and transmission of *Yersinia pestis*, the bacterium that causes plague.



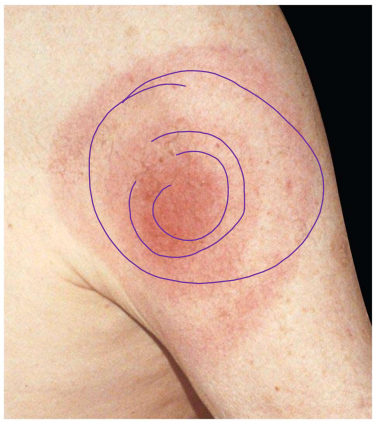
22

Bacterial Cardiovascular and Systemic Diseases

- **Lyme Disease**
  - Signs and symptoms
    - Three phases in untreated patients
      - Bull's-eye rash at infection site
      - Neurological symptoms
      - Severe arthritis
  - Pathogen and virulence factors
    - Caused by the spirochete *Borrelia burgdorferi*
    - Use of manganese instead of iron circumvents host defense
    - Avoids immune detection by altering membrane proteins

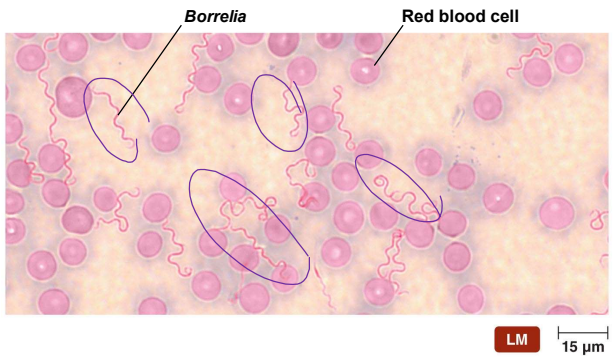
23

Figure 21.7 Distinctive "bull's-eye" rash of Lyme disease.



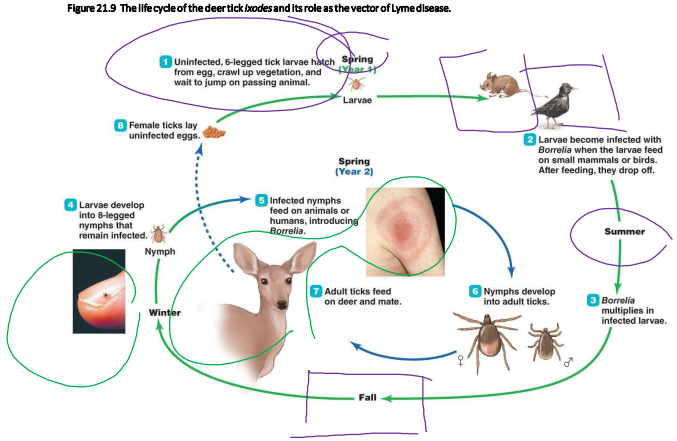
24

Figure 21.8 *Borrelia burgdorferi*.



25

Figure 21.9 The life cycle of the deer tick *Ixodes* and its role as the vector of Lyme disease.



26

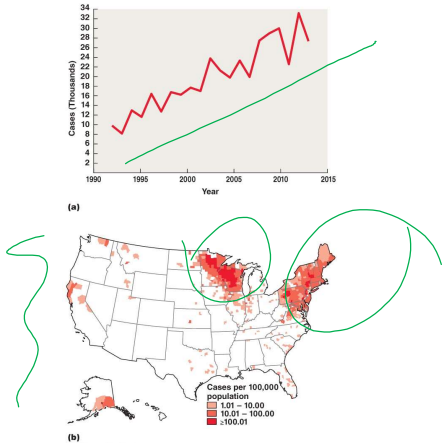
Bacterial Cardiovascular and Systemic Diseases

- **Lyme Disease**
  - Epidemiology
    - One of the most reported vector-borne diseases in United States
    - Three events contributed to an increase in Lyme disease
      - Movement of human populations into woodland areas
      - Protection of the deer population
      - Coyotes have displaced the foxes that help control the mouse population

[tinfoil hat]

27

Figure 21.10 The occurrence of Lyme disease in the United States.



28

Bacterial Cardiovascular and Systemic Diseases

- **Lyme Disease**
  - Diagnosis, treatment, and prevention
    - Diagnosis is based on the signs and symptoms of the disease
      - Bacterium is rarely detected in the blood
    - Antimicrobial drugs are used in the early phases
    - Treatment of later phases is difficult
      - Symptoms often caused by the immune system
    - Prevented with repellents containing DEET and with protective clothing

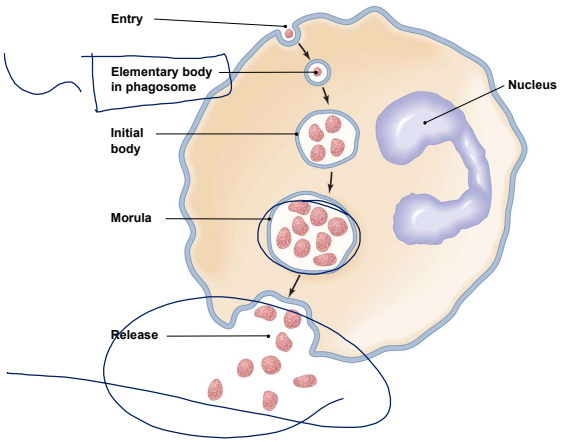
29

Bacterial Cardiovascular and Systemic Diseases

- **Ehrlichiosis and Anaplasmosis**
  - Signs and symptoms
    - Resemble the flu
    - Leukopenia and thrombocytopenia also occur
  - Pathogen and virulence factors
    - *Ehrlichia chaffeensis* causes ehrlichiosis
    - *Anaplasma phagocytophilum* causes anaplasmosis
    - Both bacteria live inside infected cells
  - Pathogenesis
    - Ticks transmit bacteria to humans

30

Figure 21.11 The growth and reproduction of *Ehrlichia* and *Anaplasma* in an infected leukocyte.



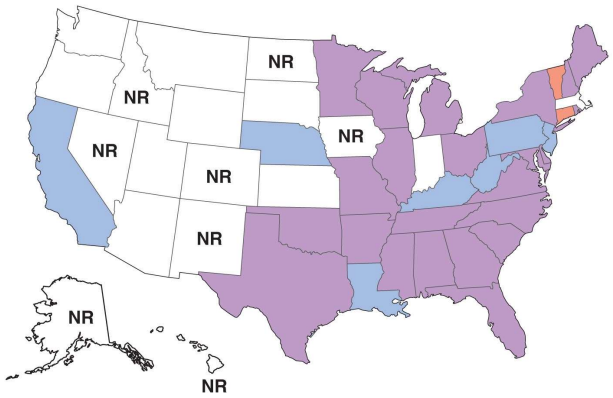
31

Bacterial Cardiovascular and Systemic Diseases

- **Ehrlichiosis and Anaplasmosis**
  - Epidemiology
    - Both considered emerging diseases
  - Diagnosis, treatment, and prevention
    - Diagnosis difficult since symptoms resemble other diseases
    - Antimicrobials effective against both bacteria
    - Prevention involves avoiding tick-infested areas

32

Figure 21.12 The geographical distribution of ehrlichiosis and anaplasmosis in the contiguous United States (2010).



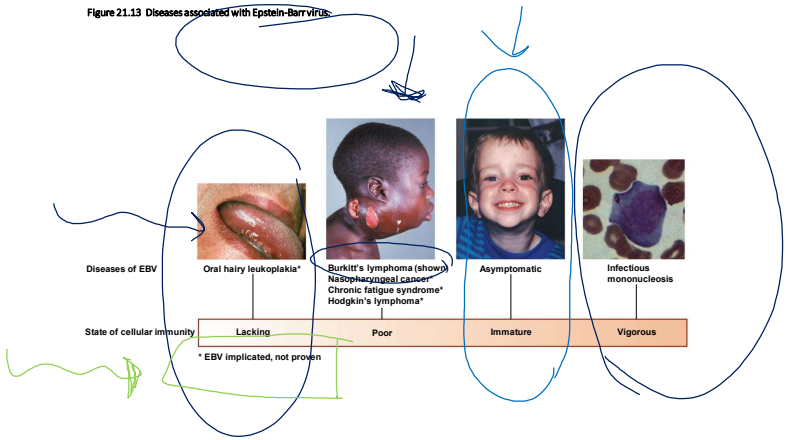
33

Viral Cardiovascular and Systemic Diseases

- **Infectious Mononucleosis**
  - Signs and symptoms
    - Severe sore throat and fever occur initially
    - Followed by swollen lymph nodes, fatigue, appetite loss, and a skin rash
  - Pathogen and virulence factors
    - Epstein-Barr virus (EBV or HHV-4) is the causative agent
    - EBV establishes latent infection in host
      - Suppresses apoptosis of infected B cells
    - EBV is implicated in a number of other diseases

34

Figure 21.13 Diseases associated with Epstein-Barr virus.



35

Viral Cardiovascular and Systemic Diseases

- **Infectious Mononucleosis**
  - Pathogenesis and epidemiology
    - Transmission occurs via saliva
    - EBV infects B lymphocytes
    - Majority of adults have antibodies against EBV
  - Diagnosis, treatment, and prevention
    - Diagnosed by presence of large, lobed B lymphocytes and neutropenia
    - Treatment focuses on relieving symptoms
    - Prevention is difficult since EBV occurrence is widespread

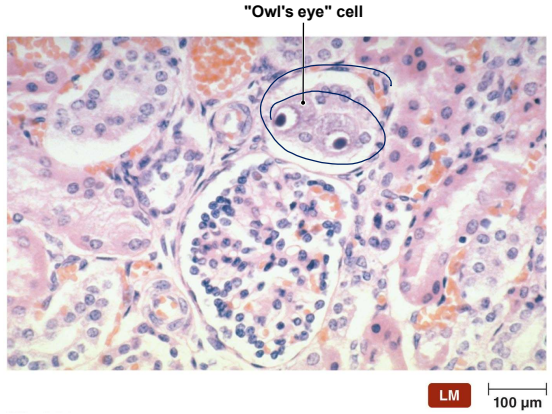
36

Viral Cardiovascular and Systemic Diseases

- **Cytomegalovirus Disease**
  - Signs and symptoms
    - Asymptomatic in most cases
    - Complications in neonates and the immunocompromised
  - Pathogen and virulence factors
    - Caused by *Cytomegalovirus*
  - Pathogenesis and epidemiology
    - Transmit by direct contact with bodily fluids or transplacentally
    - One of the most common infections of humans
  - Diagnosis, treatment, and prevention
    - Diagnosed by identifying enlarged cells with inclusions
    - Fomivirsen is administered for eye infections
    - No vaccine is available

37

Figure 21.14 An abnormally enlarged "owl's eye" cell indicates *Cytomegalovirus* (CMV) infection.



38

Viral Cardiovascular and Systemic Diseases

- **Yellow Fever**
  - Signs and symptoms
    - First stage: fever, headache, muscle aches
    - Second stage: period of remission
    - Third stage: delirium, seizures, coma, hemorrhaging
  - Pathogen and virulence factors
    - Caused by yellow fever virus

39

Figure 21.15 *Aedes aegypti*, the vector of yellow fever and dengue.

40

Viral Cardiovascular and Systemic Diseases

- **Yellow Fever**
  - Pathogenesis and epidemiology
    - Transmitted via the bite of an infected *Aedes* mosquito
    - Virus travels to the liver, where it replicates
    - Yellow fever cases occur today in South America and Africa
  - Diagnosis, treatment, and prevention
    - Diagnosed by detecting viral antigens in the blood
    - Treatment is supportive
    - Vaccine is available

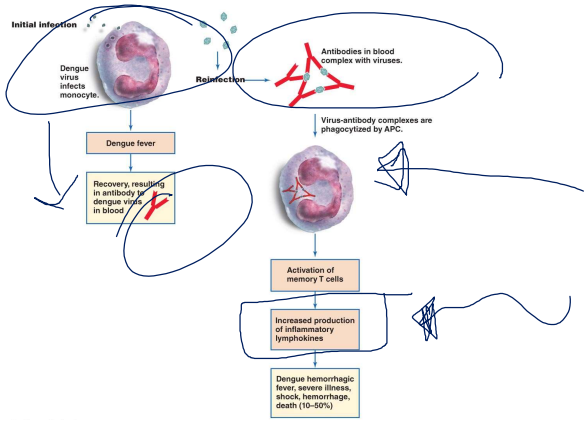
41

Viral Cardiovascular and Systemic Diseases

- **Dengue Fever and Dengue Hemorrhagic Fever**
  - Signs and symptoms
    - Dengue fever
      - First phase: fever, edema, head and muscle pain
      - Second phase: return of fever and red rash
    - Dengue hemorrhagic fever
      - Internal bleeding, shock, and possibly death
  - Pathogens and virulence factors
    - Caused by four strains of dengue viruses
    - *Aedes* mosquitoes are the vector

42

Figure 21.16 Pathogenesis of dengue hemorrhagic fever (DHF).



43

Viral Cardiovascular and Systemic Diseases

- **Dengue Fever and Dengue Hemorrhagic Fever**
  - Pathogenesis and epidemiology
    - Dengue fever is usually a mild disease
    - Dengue hemorrhagic fever is more severe and can be fatal
    - Distribution of dengue diseases has expanded
  - Diagnosis, treatment, and prevention
    - Diagnosis is based on signs and symptoms in people who have traveled to endemic regions
    - No specific treatment is available
    - Prevention requires control of mosquitoes

44

Viral Cardiovascular and Systemic Diseases

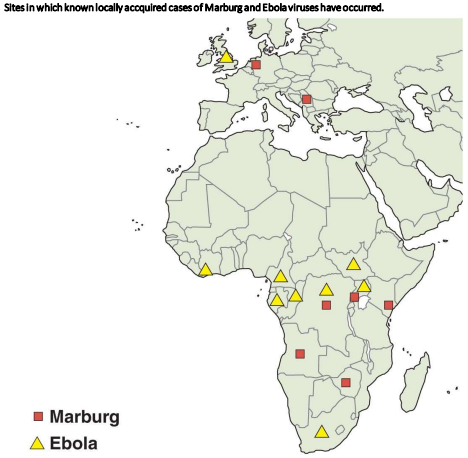
- **African Viral Hemorrhagic Fever**
  - Signs and symptoms
    - Fever and fatigue
    - Minor petechiae progress to severe internal hemorrhaging
  - Pathogens and virulence factors
    - Caused by *Ebolavirus* or *Marburgvirus*
  - Pathogenesis and epidemiology
    - Malfunctioning blood clotting causes hemorrhaging
    - Occurs primarily in Africa
    - Transmitted via contact with bodily fluids of infected individual

45

Figure 21.17 Filamentous *Ebolavirus*.

46

Figure 21.18 Sites in which known locally accquired cases of Marburg and Ebola viruses have occurred.



47

Viral Cardiovascular and Systemic Diseases

- **African Viral Hemorrhagic Fever**
  - Diagnosis, treatment, and prevention
    - Diagnosis is based on characteristic symptoms and presence of virus in the blood
    - Treatment involves fluid and electrolyte replacement
    - Vaccines are being studied for their effectiveness in humans

48

TABLE 21.1 Characteristics of Some Viral Hemorrhagic Fevers

Disease	Viral Genus (Family)	Natural Host(s)	Vector	Geographic Distribution
Yellow fever	*Flavivirus (Flaviviridae)*	Humans, monkeys	*Aedes aegypti* mosquito	Africa, South America
Dengue, dengue hemorrhagic fever	*Flavivirus (Flaviviridae)*	Humans, monkeys	*Aedes aegypti* mosquito	Worldwide, especially tropics
Ebola hemorrhagic fever	*Ebolavirus (Filoviridae)*	Probably bats	None	Central Africa, research facility in the United States
Marburg hemorrhagic fever	*Marburgvirus (Filoviridae)*	Probably bats	None	Central Africa, research facility in Europe

49

Protozoan and Helminthic Cardiovascular and Systemic Diseases

- **Malaria**
  - Signs and symptoms
    - Associated with parasite's life in erythrocytes
      - Fever, chills, diarrhea, headache
      - Anemia, weakness, and fatigue gradually occur
  - Pathogen and pathogenesis
    - At least four *Plasmodium* species cause malaria
    - Disease severity depends on the species
    - *P. falciparum* causes the most severe malaria
    - Children are particularly vulnerable to infection

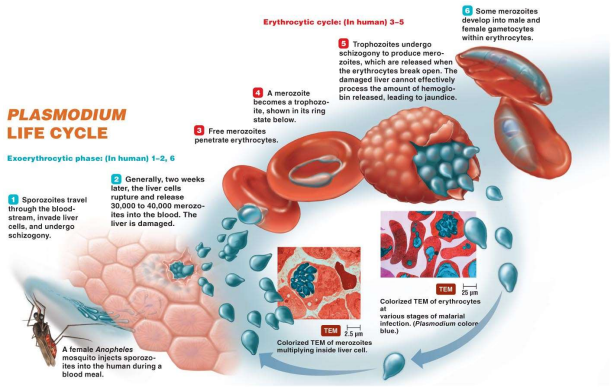
50

Protozoan and Helminthic Cardiovascular and Systemic Diseases

- **Malaria**
  - Pathogen and pathogenesis
    - Certain genetic traits increase resistance to malaria
      - Presence of the sickle-cell gene
      - Presence of two genes for hemoglobin C
      - Genetic deficiency of glucose-6-phosphate dehydrogenase
      - Lack of Duffy antigens on erythrocytes

51

Figure Disease in Depth: The life cycle of *Plasmodium*.



52

Protozoan and Helminthic Cardiovascular and Systemic Diseases

- **Malaria**
  - Virulence factors
    - Reproductive cycle hides parasite from immune surveillance
    - Malaria secretome injects toxins into host cells
    - Adhesins allow red blood cells to adhere to certain tissues
    - Merozoites form within vesicles and avoid detection
    - Changes in body chemistry attract other mosquitoes

53

Protozoan and Helminthic Cardiovascular and Systemic Diseases

- **Malaria**
  - Epidemiology
    - Endemic throughout tropics and subtropics
    - Malaria causes more than 1 million deaths annually
  - Diagnosis, treatment, and prevention
    - Diagnosis made by identifying *Plasmodium* in blood
    - Treated with various antimalarial drugs
    - Some *Plasmodium* strains are resistant to antimalarial drugs
    - Prevention requires control of mosquitoes
      - Use of mosquito nets is important way to reduce contact

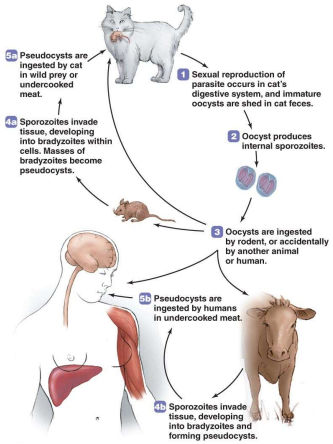
54

Protozoan and Helminthic Cardiovascular and Systemic Diseases

- **Toxoplasmosis**
  - Signs and symptoms
    - Majority of cases have no symptoms
    - Symptoms in individuals with poor immunity
      - Fever, malaise, and inflammation of the lungs, liver, and heart
    - Fetal infections can cause numerous conditions, including spontaneous abortion or stillbirth
  - Pathogen and virulence factors
    - *Toxoplasma gondii* is the causative agent
      - Cats are the definitive host
    - *Toxoplasma* infects and lives in many cell types

55

Figure 21.19 The life cycle of *Toxoplasma gondii*.



56

Protozoan and Helminthic Cardiovascular and Systemic Diseases

- **Toxoplasmosis**
  - Pathogenesis and epidemiology
    - Consumed in undercooked meat containing the parasite
    - Transmission across the placenta can also occur
    - Specific mechanism of disease is not yet known
  - Diagnosis, treatment, and prevention
    - Diagnosed mainly by detection of organisms in tissues
    - Treatment needed only in AIDS patients, pregnant women, and newborns
    - Prevention is difficult because *T.gondii* has numerous hosts

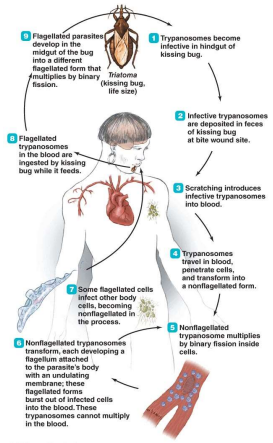
57

Protozoan and Helminthic Cardiovascular and Systemic Diseases

- **Chagas' Disease**
  - Signs and symptoms
    - Swelling at infection site and nonspecific symptoms
    - Chronic manifestations can occur years after infection
  - Pathogen and virulence factors
    - Caused by *Trypanosoma cruzi*
    - Endemic throughout Central and South America
    - Most mammals can harbor *T. cruzi*
    - *T. cruzi* evades the immune system in several ways
      - Lives inside host cells
      - Changes its surface antigens
      - Suppresses production of immune cytokines

58

Figure 21.20 The life cycle of *Trypanosoma cruzi* in a South American.



59

Protozoan and Helminthic Cardiovascular and Systemic Diseases

- **Chagas' Disease**
  - Pathogenesis and epidemiology
    - Transmitted through the bite of infected *Triatoma* or transfusion with infected blood
    - Progresses through four stages over several months
  - Diagnosis, treatment, and prevention
    - Diagnosed by microscopic identification of *T. cruzi* or xenodiagnosis
    - Most patients show no early symptoms, and late stages of the disease cannot be treated
    - Prevention involves avoidance of *Triatoma* bugs

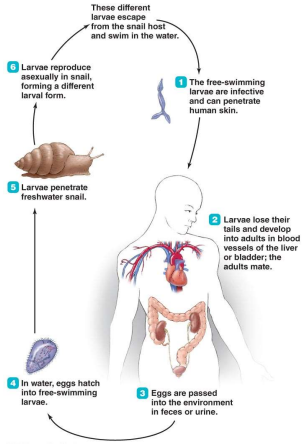
60

Protozoan and Helminthic Cardiovascular and Systemic Diseases

- **Schistosomiasis**
  - Signs and symptoms
    - Swimmer's itch may occur at infection site
    - Eggs deposited throughout body can cause other symptoms
  - Pathogens and virulence factors
    - Caused by three species of *Schistosoma*
      - Each species is geographically limited

61

Figure 21.21 The life cycle of *Schistosoma*, a blood fluke.



62

Protozoan and Helminthic Cardiovascular and Systemic Diseases

- **Schistosomiasis**
  - Pathogenesis and epidemiology
    - Humans are principal host for most *Schistosoma* species
    - Schistosomiasis is not found in the U.S.
  - Diagnosis, treatment, and prevention
    - Diagnosed by identifying eggs in stool or urine sample
    - Treated with praziquantel
    - Prevention requires avoiding potentially contaminated water

63