Chapter 23
Parasitic Protozoa, Helminths, and Arthropod Vectors
Parasitic Diseases

• Protozoan and helminthic parasites are emerging as serious threats worldwide

• Parasitic infections often involve several hosts
  • Definitive host
    • Mature forms of the parasite are present and usually reproducing
  • Intermediate host
    • Immature parasites undergo various stages of maturation in these hosts
Routes of Infection

- **Contact and Penetration of Eyes**
  - Acanthamoeba

- **Inhalation**
  - Acanthamoeba
  - Enterobius
  - Naegleria

- **Vector-Borne**
  - Mosquito
  - Plasmodium
  - Wuchereria
  - Kissing bug
  - Trypanosoma
  - Tsetse fly
  - Trypanosoma
  - Sand fly
  - Leishmania

- **Fecal-Oral, Ingestion**
  - Ascaris
  - Balantidium
  - Cryptosporidium
  - Cyclospora
  - Echinococcus
  - Entamoeba
  - Enterobius
  - Fasciola
  - Giardia
  - Opisthorchis
  - Taenia
  - Toxoplasma

- **Sexual Contact**
  - Entamoeba
  - Giardia
  - Trichomonas

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1. Protozoan Parasites of Humans

- Most protozoa that enter the body via ingestion have two morphological forms
  - Trophozoite
    - Feeding and reproducing stage that lives within the host
  - Cyst
    - Dormant form that can survive in the environment and is infective to new hosts
- Cysts when ingested by a host develop into trophozoites
- Trophozoites undergo encystment
  - before leaving the host in the feces and becoming available to infect other hosts
Protozoan Parasites of Humans

• Parasites modes of locomotion
  • Cilia, pseudopodia, flagella, and the nonmotile (apicomplexans)
Acanthamoeba and Naegleria

• Cause rare and usually fatal brain infections

• Common inhabitants of natural waterways as well as artificial water systems

• Contact lenses wearers who use tap water to wash their lenses can become infected

• Acanthamoeba diseases
  • Infection occurs through cuts or scrapes, the conjunctiva, or through inhalation
  • Keratitis results from conjunctival inoculation
  • Amoebic encephalitis is the more common disease
Acanthamoeba and Naegleria

• Naegleria disease
  • Infection occurs when swimmers inhale contaminated water
  • Amoebic meningoencephalitis results when trophozoites migrate to the brain
• Prevention is difficult because these organisms are environmentally hardy
Acanthamoeba and Naegleria

- Acanthamoeba

Naegleria

A

B
Flagellates

- Protozoa that possess at least one flagellum

- Number and arrangement of the flagella are important to determining the species

- The flagellates include members of the genera *Trypanosoma, Leishmania, Giardi, Trichomonas*
Giardia intestinalis

• Causative agent of giardiasis

• Giardiasis - common gastrointestinal disease in U.S.

• *Giardia* are found in the intestinal tracts of animals and humans worldwide but also in the environment

• *Giardia* have a life cycle
  
  • Ingestion of cysts in contaminated drinking water
  
  • The trophozoites are released into the small intestines where they multiply
  
  • Trophozoites can either remain free in the lumen of the small intestine or attach to the intestinal mucosa
Giardia intestinalis

• Giardiasis can range from an asymptomatic infection to significant gastrointestinal disease

• Prevention of infections in endemic areas requires the use of filtered water

• Individuals recovering from infection must use good hygiene to prevent transmission
Trypanosoma brucei

- Causes African sleeping sickness
- The insect vector is the tsetse fly
- Humans are usually infected when bitten by tsetse flies infected while feeding on infected animals
Trypanosoma brucei
(African Sleeping Sickness)
African Sleeping Sickness

• Progresses through three stages if left untreated
  • Bite wound - becomes a chancre with necrotic tissue
  • Presence of the parasites in the blood generates fever, lymph node swelling, and headaches
  • Invasion of the central nervous system results in meningoencephalitis, coma and death
African Sleeping Sickness

- Infections are characterized by cyclical waves of parasitemia
  - *T. brucei* changes its surface glycoproteins with each wave of replication resulting in an ineffective immune response
- Clearing of tsetse fly habitats and use of insecticides help reduce the cases of disease
Figure 23.3

(a) Life cycle of *Trypanosoma brucei*

1. Epimastigotes transform into trypomastigotes in salivary gland of tsetse fly

2. Trypomastigotes injected by tsetse fly during blood meal

3. Trypomastigotes are carried via bloodstream to other sites

4. Trypomastigotes multiply by binary fission in body fluids, including blood, lymph, and spinal fluid

5. Trypomastigotes ingested by tsetse fly during blood meal

6. Trypomastigotes form epimastigotes by binary fission in midgut of tsetse fly; these migrate to salivary glands

*Glossina* (tsetse fly)
• *Trypanosoma gambiense* (African Sleeping Sickness)

![Tsetse Fly](image1)

• *Trypanosoma cruzi* (Chagas Disease)

![Kissing Bug](image2)
**Trypanosoma cruzi**

- Causes Chagas’ disease
- Endemic in Central and South America
- Opossums and armadillos are the primary reservoir
- Transmission occurs through the bite of insects in the genus *Triatoma*
  - The “kissing bugs”
  - Parasite-induced heart disease is one of the leading causes of death in Latin America
Figure 23.3: Life cycle of Trypanosoma cruzi.

1. Epimastigotes transform into trypomastigotes in hindgut of kissing bug (Triatoma).
2. Trypomastigotes deposited in feces of kissing bug at bite wound site.
3. Scratching introduces trypomastigotes into blood.
4. Trypomastigotes travel in blood, penetrate cells, and transform into amastigotes.
5. Amastigotes multiply by binary fission in cells and infected tissue.
6. Some amastigotes infect other cells.
7. Some amastigotes transform into trypomastigotes in blood.
8. Trypomastigotes ingested by kissing bug during blood meal.
9. Trypomastigotes form epimastigotes by binary fission in midgut of kissing bug.
Chagas’ Disease

• Progresses through four stages

  • Acute stage characterized by chagomas, which are swellings at the sites of each of the bites

  • A generalized stage characterized by fever, swollen lymph nodes, myocarditis, and enlargement of the spleen, esophagus, and colon

  • A chronic stage, which is asymptomatic and can last for years

  • A symptomatic stage characterized primarily by congestive heart failure following the formation of pseudocysts, which are clusters of amastigotes in heart muscle tissue
Trypanosoma cruzi
(Chagas Disease)
Chagas Disease Distribution
Protozoa whose infective forms are characterized by an ornate complex of organelles at their apical end

Parasites of animals

Life cycles involve at least two types of hosts

Schizogony is a major feature of apicomplexan life cycles

Asexual reproduction producing multinucleate schizonts before the cells divide

4 important apicomplexan parasites

Plasmodium, Toxoplasma, Cryptosporidium, Cyclospora
Plasmodium

• Causative agent of malaria

• 4 species cause malaria
  • *P. falciparum*, *P. vivax*, *P. ovale*, and *P. malariae*

• Malaria is endemic throughout the tropics and subtropics

• Mosquitoes act as the vector for *Plasmodium*

• The *Plasmodium* life cycle has three prominent stages
Figure 23.10

1. Sporozoites injected into host during blood meal
2. Sporozoites invade liver cells and undergo schizogony
3. Liver cell ruptures and releases numerous merozoites into blood
4. Merozoites become trophozoites
5. Some merozoites develop into gametocytes within erythrocytes
6. Mosquito ingests gametocytes during blood meal
7. Gametocytes become gametes that fuse to form zygote
8. Zygote differentiates into ookinete, which becomes an oocyst in gut wall
9. Oocyst forms sporozoites, ruptures, and sporozoites migrate to salivary glands of mosquito
Malaria

- General symptoms of malaria are associated with synchronous cycles of erythrocyte lysis
- Fever correlates with erythrocyte lysis and most likely due to the immune response
- *P. falciparum* can cause a malaria form called blackwater fever
  - Characterized by extreme fever, large-scale erythrocyte lysis, renal failure, and dark urine
- Cerebral malaria results when tissue death occurs in the brain
Plasmodium falciparum
Malaria

• Immunity gradually develops if the victim survives the acute stage of malaria
  • Periodic episodes become less severe over time
• Prevention requires limiting contact with the mosquitoes carrying *Plasmodium*
Plasmodium malariae (Malaria)
Malaria Distribution

Cases per 1,000 population
- Malaria free
- 0–4
- 5–49
- 50–200
- >200

2011
Resistance to Malaria

- Due to various genetic traits in endemic populations
  - Sickle-cell trait
    - Sickle-shaped cells somehow resist penetration by *Plasmodium*
  - Hemoglobin C
    - Humans with two genes for hemoglobin C are invulnerable to malaria
  - Glucose-6-phosphate-dehydrogenase deficiency
    - Needed by the trophozoites to synthesize DNA
  - Lack of Duffy antigens on erythrocytes
    - *P. vivax* requires Duffy antigen to bind & infect erythrocytes
Resistant Malaria Distribution
Cryptosporidium parvum

- Disease – cryptosporidiosis
  - severe diarrhea
  - can last up to 2 weeks
- Zoonotic disease
  - Once thought to only infect livestock and poultry
- Humans can carry the parasite asymptomatically
- Infection usually results from drinking contaminated water
  - Fecal-oral transmission can occur, especially in day care facilities
Cryptosporidium parvum

- Chronic cryptosporidiosis is an indicator disease for the clinical stages of AIDS
  - Infection of AIDS patients can be life threatening
- Oral rehydration is used to treat the disease as drugs are ineffective against the parasite
## Table 23.1: Key Features of Protozoan Parasites of Humans

<table>
<thead>
<tr>
<th>Organism</th>
<th>Primary Diseases</th>
<th>Geographical Distribution</th>
<th>Mode of Transmission</th>
<th>Host Organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ciliates</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Balantidium coli</em></td>
<td>Balantidiasis, dysentery</td>
<td>Worldwide</td>
<td>Fecal-oral</td>
<td>Pigs, rodents, primates, humans</td>
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<tr>
<td><strong>Amoebae</strong></td>
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<tr>
<td><em>Entamoeba histolytica</em></td>
<td>Luminal amoebiasis, amoebic dysentery, invasive extraintestinal amoebiasis</td>
<td>Worldwide</td>
<td>Fecal-oral</td>
<td>Humans</td>
</tr>
<tr>
<td><em>Acanthamoeba spp.</em></td>
<td>Ulcerative keratitis, amoebic encephalitis</td>
<td>Worldwide</td>
<td>Contact</td>
<td>Humans</td>
</tr>
<tr>
<td><em>Naegleria</em></td>
<td>Primary amoebic meningoencephalitis</td>
<td>Worldwide</td>
<td>Inhalation</td>
<td>Humans</td>
</tr>
<tr>
<td><strong>Flagellates</strong></td>
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<td></td>
</tr>
<tr>
<td><em>Trypanosoma brucei</em></td>
<td>African sleeping sickness</td>
<td>African subcontinent</td>
<td>Tsetse fly (<em>Glossina</em>)</td>
<td>Wild game, pigs, humans</td>
</tr>
<tr>
<td><em>Trypanosoma cruzi</em></td>
<td>Chagas’ disease</td>
<td>Central and South America</td>
<td>Kissing bugs (<em>Triatoma</em>)</td>
<td>Opossums, armadillos, humans</td>
</tr>
<tr>
<td><em>Leishmania spp.</em></td>
<td>Cutaneous, mucocutaneous, or visceral leishmaniasis</td>
<td>Tropics, subtropics</td>
<td>Sand flies (<em>Phlebotomus</em>)</td>
<td>Canines, rodents, humans</td>
</tr>
<tr>
<td><em>Giardia intestinalis (lamblia)</em></td>
<td>Giardiasis</td>
<td>Developed nations, tropics</td>
<td>Fecal-oral</td>
<td>Humans, wild animals</td>
</tr>
<tr>
<td><em>Trichomonas vaginalis</em></td>
<td>Vaginitis</td>
<td>Developed nations</td>
<td>Sexual contact</td>
<td>Humans</td>
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<td><strong>Apicomplexans</strong></td>
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<tr>
<td><em>Plasmodium spp.</em></td>
<td>Malaria</td>
<td>Tropics, subtropics</td>
<td>Mosquitoes (<em>Anopheles</em>)</td>
<td>Humans</td>
</tr>
<tr>
<td><em>Toxoplasma gondii</em></td>
<td>Toxoplasmosis</td>
<td>Worldwide</td>
<td>Fecal-oral</td>
<td>Cats, livestock, humans</td>
</tr>
<tr>
<td><em>Cryptosporidium parvum</em></td>
<td>Cryptosporidiosis</td>
<td>Worldwide</td>
<td>Fecal-oral</td>
<td>Livestock, poultry, humans</td>
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<tr>
<td><em>Cyclospora cayetanensis</em></td>
<td>Gastrointestinal disorders</td>
<td>North, Central, and South America</td>
<td>Fecal-oral</td>
<td>Humans</td>
</tr>
</tbody>
</table>
Arthropod Vectors

- Vectors are animals that carry microbial pathogens
- Arthropods are a common vector
- Some arthropods also serve as hosts for the pathogens they transmit
(a) tick  (b) flea  (c) louse

(d) Tsetse fly  (e) mosquitoes  (f) Kissing bug
Malaria Vectors

**Figure 1.** Global distribution (Robinson projection) of dominant or potentially important malaria vectors.
Chagas Vector

Triatoma protracta

Triatoma lecticularia
Tsetse Fly Distribution

Number and distribution of tsetse species in Africa

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