Chapter 23
Parasitic Protozoa, Helminths, and Arthropod Vectors
Helminthic Parasites of Humans

- Helminths are macroscopic, multicellular, eukaryotic worms
- Lack digestive system (or greatly reduced)
- Lacking or reduced locomotion
- Reduced nervous system
- Reproductive systems and life cycles are complex
- Intermediate hosts are often needed to support larval stages
Helminthic Parasites of Humans

- 3 groups of helminthes
  - Cestodes-tapeworms
  - Trematodes-flukes
  - Nematodes-roundworms
Cestodes (Tapeworms)

- All tapeworms lack digestive systems
- All possess the same general body plan
Taenia

- *Taenia saginata* is the beef tapeworm
- *Taenia solium* is the pork tapeworm
- Cattle and swine serve as the intermediate hosts
- Humans living in close proximity to livestock have the highest incidence of infection
- Cattle and swine become infected by eating contaminated vegetation
- Humans ingest cysticerci in raw or undercooked meat
- Adults attach to the intestinal epithelium
**Taenia**

- Adults attach to the intestinal epithelium
- Most individuals shed proglottids without experiencing symptoms
- Blockage of the intestine can occur if the tapeworm is large
- Thoroughly cooking or freezing meat is the easiest method of prevention
Generalized Life Cycle for Cestodes

1. Eggs and egg-filled proglottids are passed into the environment in feces.
2. Intermediate (secondary) hosts ingest eggs on contaminated food.
3. Eggs hatch into larvae that penetrate the intestinal wall and migrate to other tissues.
4. Larva develops into a cysticercus in muscle.
5. Human, the definitive (primary) host, ingests cysticercus in undercooked contaminated meat.
6. Cysticercus excysts to become a scolex that attaches to intestinal wall and matures.
7. Adult worm forms new proglottids.
Echinococcus granulosus

1. Adult tapeworm releases eggs, which are excreted by definitive host.
2. Intermediate host ingests eggs.
3. Eggs hatch, and larvae migrate to liver or lungs.
4. Larvae develop into hydatid cysts.
5. Definitive host eats intermediate host, ingesting cysts.
6. Scoleces from cyst attach to intestine and grow into adults.
• Hydatid cyst
Termatodes

- Flukes are flat, leaf-shaped worms
- Lack complete digestive systems
- Oral and ventral suckers enable attachment to host tissues to obtain nutrients
- Geographical distribution is limited because the intermediate host is limited
- Grouped according to the site in the body they parasitize
Figure 23.17

1. Eggs are passed into the environment in feces or urine
2. In water, eggs hatch into free-swimming larvae (miracidia)
3. Miracidia penetrate freshwater snail
4. Miracidia reproduce asexually in snail forming cercariae
5. Cercariae of blood flukes penetrate human skin
6. Cercariae of some intestinal liver flukes settle on plants and become metacercariae
7. Cercariae of lung and some intestinal liver flukes penetrate mollusks, fish, or crustaceans and become encysted metacercariae in muscle
8. Metacercariae in undercooked plants or fish are ingested by humans
9. Adults develop in definitive human

Swimming cercariae escape from snail host
Blood Flukes: *Schistosoma*

- Causative agent of schistosomiasis
- Humans are the principal definitive host
- 3 geographically limited species infect humans
  - *S. mansoni*-found in the Carribean, Venezuela, Brazil, Arabia, and Africa
  - *S. haemotobium*-found only in Africa and India
  - *S. japonicum*-found in China, Taiwan, the Phillippines, and rarely in Japan
Blood Flukes: *Schistosoma*

- Cercariae burrow through the skin of humans who contact contaminated water
- Larvae mature and mate in the circulatory system
- Eggs move to the lumen of the intestines or of the urinary bladder and ureters
- Dermatitis may occur at the site where the cercariae entered
- Infections can become chronic and can be fatal
- Prevention depends on improved sanitation and avoiding contact with contaminated water
(a) Male and female schistosomes. The female lives in a groove on the ventral surface of the male schistosome ("split-body"), is continuously fertilized, and continuously lays eggs. The sucker is used by the male to attach to the host.

(b) Life cycle of *Schistosoma*, cause of schistosomiasis.
Life Cycle of Roundworms - Nematodes

- Parasites of almost all vertebrate animals
- Have a number of reproduction strategies
  - Most intestinal nematodes shed their eggs into the lumen of the intestine
    - Eggs are eliminated in feces
    - Eggs are consumed in contaminated food or water
  - Some intestinal nematodes release their eggs into the soil
    - Larvae actively penetrate the skin of a host
    - Inside the body, they travel to the intestine
Feature of the Life Cycle of Roundworms

- Other nematodes encyst in muscle tissue and are consumed in raw or undercooked meat
- Mosquitoes transmit a few species of nematodes
- Adult sexually mature stages are found only in definitive hosts
Hookworms

- *Ancylostoma duodeneale* and *Necator americanus*
- Larvae in soil hatched from eggs shed in feces
- Larvae bore through skin
- Migrate to small intestine
- Mucosal damage and anemia
- In children – intellectual, cognitive & growth retardation
- 600 million people infected/year
- Treated with mebendazole
Hookworms
Ascaris lumbricoides

- Ascariasis
- Transmitted by ingesting *Ascaris* eggs in contaminated food or water
- Larval worm penetrates the duodenum and enters bloodstream
- Travels to the liver and heart
- Enters pulmonary circulation & breaks into alveoli, where it grows and molts.
Ascaris lumbricoides

- 3 weeks later - larvae are coughed up & swallowed
- Returned to the small intestine & mature to adult male and female worms
- A female produces as many as 200,000 eggs per day for a year.
- Fertilized eggs passed in feces & become infectious after 2 weeks in soil
- Can persist in soil for 10 centuries or more.
- Treated with mebendazole
Trichinella spiralis

1. Adult *Trichinella spiralis* develop, invade intestinal wall of pig, and produce larvae that invade muscles.

2. Section showing *T. spiralis* larvae encysted in pig's muscle tissue (capsule is 0.25 to 0.5 mm in length).

3. Human eats undercooked pork containing cysts.

4. In human intestine, cyst walls are removed, and *T. spiralis* adults develop. Adults produce larvae that encyst in muscles.

(a) Life cycle of *Trichinella spiralis*, the causative agent of trichinosis

(b) *T. spiralis* adult
Enterobius vermicularis

- Commonly known as the **pinworm**
- Most common parasitic worm in US
- Humans are the only host for *Enterobius*
- Female pinworms deposit their eggs in the anus
- Infections can often be asymptomatic
- Intense perianal itching is the main symptom when they do occur
- Preventing fecal-oral spread from infected individuals can help limit the disease
- Treatment mebendazole
Wuchereria bancrofti

- Filarial nematodes
- Causative agent of filariasis
- Infests the lymphatic system or subcutaneous tissue
- Transmitted by various genera of female mosquitoes
  - Mosquitoes ingest the immature forms, or microfilariae, when taking blood meals from infected human hosts
  - Mosquitoes then transmit the parasite back to humans at their next meal
**Wuchereria bancrofti**

- Lymphatic filariasis is asymptomatic for years
  - Acute symptoms, when they develop, are due to lymphatic dysfunction
- Elephantiasis is the end result
  - Cutaneous and subcutaneous tissue enlarge and harden in areas where lymph has accumulated
  - Usually occurs in the lower extremities
- Prevention relies on avoiding infected mosquitoes
# Key Features of Helminthic Parasites of Humans

<table>
<thead>
<tr>
<th>Organism</th>
<th>Primary Infection or Disease</th>
<th>Geographical Distribution</th>
<th>Mode of Transmission</th>
<th>Length of Adult Worms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cestodes (Tapeworms)</strong></td>
<td></td>
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<tr>
<td><em>Taenia saginata</em>;</td>
<td>Beef tapeworm infection;</td>
<td>Worldwide with local endemic areas</td>
<td>Consumption of undercooked meat</td>
<td><em>T. saginata</em>: 5–20 m;</td>
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<tr>
<td><em>Taenia solium</em></td>
<td>pork tapeworm infection</td>
<td></td>
<td></td>
<td><em>T. solium</em>: 2–8 m</td>
</tr>
<tr>
<td><em>Echinococcus granulosus</em></td>
<td>Hydatid disease</td>
<td></td>
<td>Contact with feces</td>
<td>2–8 mm, depending on species</td>
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<tr>
<td><strong>Trematodes (Flukes)</strong></td>
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<tr>
<td><em>Fasciola hepatica</em></td>
<td>Fasciolias</td>
<td><em>F. hepatica</em>: Europe, Middle East, Asia; <em>F. gigantica</em>: Asia, Africa, Hawaii</td>
<td>Consumption of watercress or lettuce</td>
<td>30–75 mm</td>
</tr>
<tr>
<td><em>Schistosoma spp.</em></td>
<td>Schistosomiasis</td>
<td><em>S. mansoni</em>: Caribbean, S. America, Arabia, Africa; <em>S. haematobium</em>: Africa, India; <em>S. japonicum</em>: East Asia</td>
<td>Direct penetration of the skin</td>
<td>7–20 mm</td>
</tr>
<tr>
<td><strong>Nematodes (Roundworms)</strong></td>
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<tr>
<td><em>Ascaris lumbricoides</em></td>
<td>Ascariasis</td>
<td>Tropics and subtropics worldwide</td>
<td>Fecal-oral</td>
<td>Females: 20–35 cm; males: 15–30 cm</td>
</tr>
<tr>
<td><em>Ancylostoma duodenale,</em></td>
<td>Hookworm disease</td>
<td><em>Ancylostoma</em>: Africa, Asia, the Americas, Middle East, North Africa, southern Europe; <em>Necator</em>: the Americas, Australia, Asia, Africa</td>
<td>Direct penetration of the skin</td>
<td><em>Ancylostoma</em> females: 10–13 mm, males: 8–11 mm; <em>Necator</em> females: 9–11 mm, males: 7–9 mm</td>
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<td><em>Necator americanus</em></td>
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<tr>
<td><em>Enterobius vermicularis</em></td>
<td>Pinworm</td>
<td>Worldwide</td>
<td>Anal-oral and fecal-oral, inhalation</td>
<td>Females: 10 mm; males: 3 mm</td>
</tr>
<tr>
<td><em>Wuchereria bancrofti</em></td>
<td>Filariasis, elephantiasis</td>
<td>Worldwide, tropics</td>
<td>Mosquitoes</td>
<td>Females: 100 mm; males: 40 mm</td>
</tr>
</tbody>
</table>