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Infection vs. disease

- Successful parasites live in, but do not kill their hosts.
- Protozoa multiply within hosts. Expression of disease depends on host factors.
- Helminths do not multiply within hosts. Severity of disease depends on parasite burden and immunologic response to parasites.
Helminth forms

- Egg
- Larva
- Cyst
- Adults

C. Engleberg/V. Carruthers
Helminth modes of entry

• Ingestion (eggs or cysts)
• Arthropod bites (larvae)
• Penetration of intact skin or mucous membranes (larvae)
Spread and tropisms

• Some parasites must migrate to certain locations within the host in order to complete their life cycle

• Non-human parasites, in humans, often fail to migrate properly and become “dead-end infections”
Mechanisms for evading the host response

- **antigenic variation** - trypanosomases, malaria, giardia
- **intracellular infection** - malaria, toxoplasma
- **encystation** - Toxoplasma, cestodes
- **camouflage** - schistosomes
- **cleavage of ABs or C’ components** - amoebae, leishmania
- **suppression/redirection of the cellular immune response** - malaria, leishmania, schistosomes

*“cyst” has multiple meanings*
Tissue damage and host response

• direct destruction of tissue
• hypersensitivity reactions
• eosinophilia
  —occurs with helminths, not protozoa
  —results from tissue migration
Classification of helminths

Nematodes (roundworms)

Platyhelminthes (flatworms)

Trematodes (“flukes”)

Cestodes (“tapeworms”)
Helmintic diseases

• Intestinal
  — Others
  — Strongyloides (autoinfection cycle)

• Invasive
  — Trichinosis (muscle pain, uncooked carnivores)
  — Filaria (worms in lymphatics or under skin)
  — Schistosomiasis (liver or urinary tract granulomas and fibrosis)
  — Cysticercosis (cysts in brain, seizures)
  — Echinococcus (massive cysts in liver or lung)
Intestinal nematodes

- Eggs ingested
  - Eggs
  - Larvae hatch from eggs
  - Larvae penetrate through intact skin
    - strongyloides
    - hookworm
  - Larvae enter bloodstream
    - ascaris
  - Larvae pass through lungs
    - Trichuris (whipworm)
    - Enterobius (pinworm)
  - Adult worms in the intestine

C. Engleberg/V. Carruthers
Strongyloides life cycle

- Adult worms in the intestine
- Eggs
- 1st stage larvae hatch from eggs
- Larvae enter bloodstream
- Larvae pass through lungs
- Larvae penetrate through intact skin
- Larvae molt twice to form filariform larvae (infectious)

Autoinfection
Strongyloides - clinical features

• uncomplicated
  — GI upset

• autoinfection

• hyperinfection
  — rash
  — bronchospasm, chest X-ray infiltrates
  — diarrhea
  — profound eosinophilia
  — recurrent Gram-negative bacteremia
Trichinosis
Trichinella spiralis - life cycle

- "cycle of carnivorism" among hogs and rats
- humans ingest encysted larvae in infected, undercooked pork
- larvae exist in stomach and burrow into small intestinal mucosa
- adult males and female reemerge and produce larvae which penetrate intestine and circulate in bloodstream
- larvae enter skeletal muscle cells and encyst
<table>
<thead>
<tr>
<th>Source of Infection</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pork products</td>
<td></td>
</tr>
<tr>
<td>sausage</td>
<td>93</td>
</tr>
<tr>
<td>other</td>
<td>44</td>
</tr>
<tr>
<td>unspecified</td>
<td>9</td>
</tr>
<tr>
<td>Non-pork products</td>
<td></td>
</tr>
<tr>
<td>hamburger</td>
<td>18</td>
</tr>
<tr>
<td>bear</td>
<td>10</td>
</tr>
<tr>
<td>other wild animals</td>
<td>7</td>
</tr>
<tr>
<td>Unknown</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>188</td>
</tr>
</tbody>
</table>
Clinical features of trichinosis

- Most common sx:
  - muscle pain and tenderness
  - fever +/- chills
  - edema (often periorbital)
- >10% eosinophilia (often ~50%)
- Elevated creatine phosphokinase (CPK)
- +/- chronic neurologic/myocardial sx
- Self-limited (2% mortality)
Treatment of trichinosis

- antihelmintic (albendazole) to kill any intestinal adults
- steroids to relieve inflammatory reactions
- antipyretics
Filaria
Life cycles of two types of filaria

<table>
<thead>
<tr>
<th>Arthropod vector</th>
<th>Adult worm pairs</th>
<th>Larvae (microfilariae)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lymph-dwelling</td>
<td>mosquitoes</td>
<td>circulate in bloodstream</td>
</tr>
<tr>
<td>(e.g, <em>Wuchereria bancroftii</em>)</td>
<td>peripheral lymphatics</td>
<td></td>
</tr>
<tr>
<td>Skin-dwelling</td>
<td>biting flies</td>
<td>skin nodules or migratory</td>
</tr>
<tr>
<td></td>
<td>skin nodules or migratory</td>
<td>migrate through dermis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23</td>
</tr>
</tbody>
</table>
Microfiliaria found in the blood of lymph dwelling species
Long-term consequences of persistent lymph-dwelling filarial infection:

Blockage of lymph drainage with chronic lymphedema (elephantiasis)
### Life cycles of two types of filaria

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</tr>
<tr>
<td>Skin-dwelling (e.g., <em>Onchocerca volvulus</em> &amp; <em>Loa loa</em>)</td>
<td>biting flies</td>
<td>skin nodules or migratory</td>
</tr>
</tbody>
</table>
Black fly: vector of Onchocerciasis
*O. volvulus* microfilaria (a skin-dwelling species) in skin snip

Depigmentation due to chronic microfilarial production, degradation, and allergic host responses in the skin
*O. volvulus* skin nodule removed and sectioned, showing cross-sections of male and female adult worms (source of microfiliariiae)
Onchocerciasis ("River blindness")
Role of endosymbiont *Wohlbachia* sp. in filariasis infection

- Rickettsia-like organisms required for fecundity and viability of filaria
- *Wohlbachia*-free worms produce less inflammation in tissue (? LPS)
- Implications for rx:
  - ivermectin kills microfilaria only
  - tetracycline may destroy adult worms
Schistosomiasis
Geographic distribution of schistosomiasis

- **S. mansoni**
- **S. hematobium**
- **S. japonicum**
Schistosomiasis - life cycle

Cercaria

Eggs

S.m.  S.h.  S.j.

(snail) Pearson Scott Foresman, wikimedia commons
Cary Engleberg (All other images)
S. mansoni  S. haematobium  S. japonicum
Events following cercarial penetration

1. Larva migrate to lungs and develop as “schistosomulae” (this may trigger a self-limited febrile illness).
2. Male and female schistomulae migrate to the abdominal venules:
   I. Superior mesenteric (S. japonicum)
   II. Inferior mesenteric (S. mansoni)
   III. Bladder plexus (S. hematobium)
3. Males and females pair off and egg production begins
4. Eggs migrate out of the body through visceral organs or become trapped and die in tissues.
Immune response to schistosoma infection

Source Undetermined
“pipestem” fibrosis
Schistosomiasis - pathogenesis

- egg granuloma (type IV reaction) --> fibrosis
- morbidity ~ worm (egg) burden
- concomitant immunity to schistosomula
- adult worms: invisible to the immune system (survive for years)
Schistosomiasis - clinical features

- Cercarial dermatitis
- Intestinal schistosomiasis (granulomas -> polyps, protein loss, malabsorption, strictures)
- Hepatosplenic schistosomiasis (portal hypertension -> ascites, varices, splenomegaly, normal hepatic function)
- Urinary schistosomiasis (hematuria, chronic infection, obstruction)
- Other (cardiopulmonary, CNS, etc.)
Drug treatment of schistosomiasis

- Praziquantel increases permeability of adult parasite to Ca\(^{++}\).
- Tetanospasm --> death
Cestode infections
Tapeworms

- **Definitive hosts**: harbor adult worms
- **Intermediate hosts**: harbor tissue cysts (containing worm heads)
- Humans acquire infection two ways:
  - ingestion of eggs from feces (to acquire tissue cysts) = Intermediate host
  - ingestion of tissue cysts in undercooked meat (to acquire a tapeworm) = Definitive host
Taeniasis

ingestion of undercooked pork

poor hygiene

poor sanitation

Tapeworm

Cysticercosis

(pig) Martin von Nathusius, wikimedia commons
Cary Engleberg (All other images)
Cysticerci

Hydatid Cyst
Isolated cysticerci

Hydatid cyst

Source Undetermined
Echinococcosis

Cystic Hydatid Disease

ingestion of eggs in pastures

contact with dogs

ingestion of entrails
Treatment of cysticercosis and echinococcosis

- Antihelminthnic therapy (e.g., albendazole, praziquantel)
- (Echinococcus only)
  - Surgical removal
  - Irrigation-evacuation of cysts
Comparison of *pork tapeworm* and *Echinococcus* life cycles

Definitive hosts (adult tapeworms):
- Dog

Intermediate hosts (tissue cysts):
- Human
- Sheep
- Pig

Dead-end hosts:
- Human
- Human