Welcome to *Parasitic Diseases*

Fall 2006
Parasite
Any organism that takes metabolic advantage of another organism

Viruses
Rickettsiae
bacteria
Fungi
Protozoa*
Helminths*

Nematodes - round worms
Cestodes - segmented flat worms
Trematodes - non-segmented flat worms

Arthropods* - six and eight-legged critters

* Covered in Parasitic Diseases
Required textbook:
Available at bookstore.
$69.95
Helminths (Worms)

Nematodes - non-segmented round worms

Cestodes - segmented flat worms

Trematodes - non-segmented flat worms
Nematodes - round worms

1. All are eukaryotes - *Caenorhabditis elegans* is the best known example and is free-living in soil.

2. Most nematodes are non-parasitic.

3. Almost 4 billion people harbor at least one species of parasitic nematode. Many have more than one.
Geohelminths

*Enterobius vermicularis* (Pinworm)

*Trichuris trichiura* (Whipworm)

*Ascaris lumbricoides* (Giant intestinal worm)

*Toxocara canis and T. cati* (*Visceral larva migrans*)

Hookworms

*Ancylostoma duodenale*

*Necator americanus*

*Strongyloides stercoralis* (Cochin China diarrhea)
## Disability-Adjusted Life Years - DALY (WHO)

<table>
<thead>
<tr>
<th>Disease / Parasite</th>
<th>Population at risk (millions)</th>
<th>No. of endemic countries</th>
<th>No. of infected (millions)</th>
<th>Estimated deaths (humans × 1000)</th>
<th>DALYs female</th>
<th>DALYs male</th>
<th>Total DALYS</th>
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<tbody>
<tr>
<td>Malaria</td>
<td>2 000</td>
<td>90</td>
<td>300–500</td>
<td>1 080</td>
<td>182.3</td>
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<td>357.3</td>
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<td>Leishmaniasis</td>
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<td>82</td>
<td>12</td>
<td>41</td>
<td>12</td>
<td>8.6</td>
<td>20.6</td>
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<tr>
<td>Lymphatic filariasis</td>
<td>750</td>
<td>65</td>
<td>119</td>
<td>No direct mortality</td>
<td>5.6</td>
<td>2.9</td>
<td>7.5</td>
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<tr>
<td>Guinea worm disease</td>
<td>140</td>
<td>18</td>
<td>c. 0.12</td>
<td>No direct mortality</td>
<td>3.7</td>
<td>2.7</td>
<td>6.4</td>
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<td>Onchocerciasis</td>
<td>122</td>
<td>34</td>
<td>17.6</td>
<td>No direct mortality</td>
<td>3.7</td>
<td>2.7</td>
<td>6.4</td>
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<td>African trypanosomiasis</td>
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<td>36</td>
<td>0.02–0.30</td>
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<td>9</td>
<td>8.8</td>
<td>17.8</td>
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<td>Chagas disease</td>
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<td>19</td>
<td>16</td>
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<td>Schistosomiasis</td>
<td>500–600</td>
<td>74</td>
<td>200</td>
<td>11</td>
<td>29.9</td>
<td>15.4</td>
<td>45.3</td>
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<td><em>Ascaris</em> infection</td>
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<td></td>
<td></td>
<td>1 000</td>
<td>53.8</td>
<td>51.4</td>
<td>105.2</td>
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<td><em>Trichuris</em> infection</td>
<td>500</td>
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<td></td>
<td>32.2</td>
<td>30.9</td>
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<td>63.1</td>
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<tr>
<td>Hookworm infection</td>
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<td>5.8</td>
<td>5.6</td>
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<td>11.4</td>
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<td>Giardiasis</td>
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<td>Taeniasis</td>
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<td>15</td>
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<td>Neurocystocercosis</td>
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<td>Food-borne trematodes</td>
<td>500</td>
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<td>Fascioliasis</td>
<td>180.25</td>
<td>8</td>
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<td>Clonorchiasis</td>
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<td>6</td>
<td>7</td>
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<tr>
<td>Opisthorchiasis</td>
<td>63.60</td>
<td>5</td>
<td>10.30</td>
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<tr>
<td>Paragonimiasis</td>
<td>194.80</td>
<td>5</td>
<td>20.60</td>
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<tr>
<td>Other intestinal flukes</td>
<td>6</td>
<td></td>
<td>1.28m</td>
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</table>
Anatomic Site In The Host

<table>
<thead>
<tr>
<th>Anatomical Site</th>
<th>Species Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alimentary tract</td>
<td>197 species</td>
</tr>
<tr>
<td>Cavities, organs, and tissues</td>
<td>107 species</td>
</tr>
<tr>
<td>Circulatory system</td>
<td>21 species</td>
</tr>
<tr>
<td>Skin and tissues</td>
<td>56 species</td>
</tr>
</tbody>
</table>
Helminths that routinely infect humans

<table>
<thead>
<tr>
<th>Group</th>
<th>Species Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acanthocephala</td>
<td>7 species</td>
</tr>
<tr>
<td>Nematoda</td>
<td>138 species</td>
</tr>
<tr>
<td>Nematomorpha</td>
<td>24 species</td>
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<tr>
<td>Platyhelminthes</td>
<td>173 species</td>
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<tr>
<td>Digenea</td>
<td>113 species</td>
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<tr>
<td>Eucestoda</td>
<td>57 species</td>
</tr>
<tr>
<td>Turbellaria</td>
<td>3 species</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>342 species</strong></td>
</tr>
</tbody>
</table>
Why so many parasite species??
We live everywhere.
We eat everything.
In fact,...........
All living things eat, so
Everybody Poops
Night Soil
What will it be today?
Reality Check
Immunity and Parasitism

Parasite antigen

Worm infections elicit Th2 protective immune responses. Protozoan infections elicit Th1 protective immune responses.
## Cytokines and Immunity to Parasites

<table>
<thead>
<tr>
<th>Th1 cytokines</th>
<th>Th2 cytokines</th>
<th>Pro-inflammatory cytokines</th>
<th>Counter-inflammatory cytokines</th>
<th>Cytokines that can lead to pathology (e.g. increased vascular permeability, tissue damage, circulatory collapse, multi-organ failure etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IFN-γ*</td>
<td>IL-4*</td>
<td>IL-12</td>
<td>IL-4</td>
<td>IL-1</td>
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<tr>
<td>IL-2</td>
<td>IL-5*</td>
<td>IL-15</td>
<td>IL-10</td>
<td>IL-6</td>
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<tr>
<td>IL-3</td>
<td>IL-3</td>
<td>IL-18</td>
<td>TGF-β</td>
<td>IL-8</td>
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<td>TNF-α</td>
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<td>TNF-β</td>
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<td>TGF-β</td>
<td>TNF-α</td>
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<tr>
<td>GM-CSF</td>
<td>IL-10</td>
<td></td>
<td>TGF-β</td>
<td>MIF</td>
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</tbody>
</table>

*most important in immune expulsion of protozoa and worms
Helminths:
Nematoda

*Enterobius vermicularis*
(Pinworm)
Adult Female *Enterobius vermicularis*
Enterobius vermicularis

- Eggs are ingested
- Eggs contaminate fingers
- Larvae hatch in small intestine
- Larvae migrate to colony
- Eggs embryonate on perianum
- Adults mature in colon
- Gravid adults migrate out of anus
- Adults lay eggs on perianum
Heavy Infection of *Enterobius vermicularis*

Photo: Martin Weber, MD, Children’s Hospital; Hannover Medical School; Hannover, Germany
Eggs of *Enterobius vermicularis*

Unembryonated

Embryonated

Larva
Enterobius vermicularis in appendix
Clinical Disease:

None
Diagnosis:
Eggs found on microscopic examination of clear sticky tape.
Drug of Choice:

Mebendazole

Mode of Action:
De-polymerizes all species of invertebrate tubulins; not vertebrate tubulins.
Prevention and Control:

Prevention is difficult among children, especially those attending day care facilities and lower grades in school. We “out-grow” our pinworm infections once we reach puberty.
Helminths: Nematoda

*Trichuris trichiura*  
(Whipworm)
Female adult *Trichuris trichiura*
Adult male *Trichuris trichiura*
Trichuris trichiura

1. Eggs are ingested
2. Larvae hatch in small intestine
3. Larvae migrate to colon
4. Unembryonated eggs pass out in feces
5. Eggs embryonate in soil
6. Adults mature in colon
7. PATHOLOGY
8. Prolapsed rectum
9. Adult female
Adult *Trichuris muris* in situ (SEM)
Pathogenesis:

*Trichuris spp.* secrete a pore-forming protein that may play a role in anemia and diarrhea. Adult worms *do not* feed directly on blood or other host tissues. Mechanism of anemia still unknown.
Prolapsed rectum with adult *Trichuris trichiura*
Clinical Disease:

1. Diarrhea

2. Anemia

3. Malnutrition (protein calorie deficiency?)
Diagnosis:
Microscopic examination of feces for eggs
Drug of choice: Mebendazole

Mode of Action:
De-polymerizes invertebrate microtubules, only
Prevention and Control:
Sanitary disposal of feces
Helminths:
Nematoda

Ascaris lumbricoides
(Giant intestinal worm)
Adult *Ascaris lumbricoides*
"Jar-O-Worms"
Collected from one rural village in Bangladesh in a single day!
Ascaris lumbricoides

PATHOLOGY

Eggs are ingested

Larvae hatch in small intestine, enter bloodstream, go to liver

Larvae migrate to heart

Larvae reach lung capillaries

Larvae migrate up trachea, are swallowed

Larvae enter alveolar spaces

Eggs pass out in feces, embryonate in soil

Adults mature in small intestine

Obstruction
Cross section of adult *Ascaris lumbricoides*
Larvae of *Ascaris lumbricoides* in liver
Larva of *Ascaris lumbricoides* in lung
Pathogenesis:

1. “Verminous” pneumonia, lung tissue damage due to migratory larvae.

2. Bowel obstruction - too many adult worms.

3. Parasite secretes trypsin inhibitor, prevents host from digesting proteins.

4. Aberrant migration of “irritated” adult worms to:
   a. Ampulla of Vater
   b. Common duct
   c. Liver
   d. Pharynx
   e. Peritoneum
Clinical Disease:

1. Light infections are asymptomatic as long as the adult worms do not migrate.

2. Heavy infection leads to:
   a. protein calorie malnutrition - “failure to thrive” syndrome.
   b. bowel obstruction.
   c. aberrant migratory events.
Child with heavy *Ascaris lumbricoides* infection
Infant with heavy Ascaris infection
Bolus of *Ascaris lumbricoides* in small intestine
Ascaris lumbricoides adult in appendix
Ascaris adults in liver (fatal case)
Bolus of *Ascaris lumbricoides* (fatal case)
Diagnosis:
Microscopic examination of feces for eggs

30 µm

Fertilized, unembryonated egg
Drug of choice: 
Mebendazole

Mode of Action:
De-polymerizes invertebrate microtubules, only
Medical Ecology

ASCARIS : KOREA

NUMBER OF CASES

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15+
Prevention and Control:
Sanitary disposal of feces
Helminths: Nematoda

Toxocara canis
Toxocara cati
Visceral and ocular larva migrans
Adult *Toxocara canis*
Street scene in Paro, Bhutan
Toxocara canis and Toxocara cati

Animals eat embryonated eggs, acquires adults

Adults live in dog and cat small intestine

Eggs pass in feces and embryonate in soil

Eggs are ingested

Larvae migrate to all organs via bloodstream

Larvae hatch in small intestine, and penetrate wall

CNS

Liver

Eye

PATHOLOGY
Embryonated egg of *Toxocara canis*
Pathogenesis:

Tissue damage (systemic) due to migratory 3rd stage larva
Clinical Disease:

1. Fever

2. Loss of visual acuity

3. Blindness

4. Learning disabilities
Granuloma in retina due to *Toxocara canis*
Larvae of *Toxocara canis* in mouse brain
Diagnosis:
Serological tests (ELISA-based)
Drugs of choice:

Mebendazole

Steroids

Prednisolone
Prevention and Control:
Sanitary disposal of dog and cat feces

Not practical

Pooper-scooper

Potty-trained cat!
Prevention and Control (cont’d):

2. Periodically de-worm pets.
3. Cover public sand boxes at night.