## Classification of Helminth Parasites

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<tr>
<th>Class</th>
<th>Roundworm (Nematode)</th>
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Helminths: Nematodes

· Intestinal
  - *Enterobius vermicularis* (pinworm)*
  - *Trichuris trichiura* (whipworm)
  - *Ascaris lumbricoides* (large roundworm)
  - *Ancylostoma duodenale* (hookworm)
  - *Necator americanus* (hookworm)
  - *Strongyloides stercoralis*
Enterobius vermicularis (pinworm)

1. Embryonated eggs ingested by human
2. Eggs on perianal folds
   Larvae inside the eggs mature within 4 to 6 hours.
3. Larvae hatch in small intestine
4. Adults in lumen of cecum
5. Gravid ♀ migrates to perianal region at night to lay eggs

= Infective Stage
= Diagnostic Stage
Helminths/ Nematodes

**Enterobius vermicularis Eggs**

Diagnostic Features
- Oval with flat side
- 60 x 30 μm
- Smooth thick, colorless shell

Iodine 1000x
Helminths/ Nematodes

**Enterobius vermicularis** Eggs

- Immature
- Mature

Iodine 1000x

Iodine 1000x
Helminths/ Nematodes

Cellulose Tape Method

Pinworm Paddle
Helminths / Nematodes

*Enterobius vermicularis* (pinworm)
Enterobius vermicularis Female Adult

1 mm
**Trichuris trichuria** (Whipworm)

**Diagnostic Features**
- Barrel shaped
- 55 x 25 μm
- Yellow-brown thick shell
- Translucent knobs at ends

**Immature Egg**

Iodine 1000x
Helminths/ Nematodes

*Trichuris trichuria* (Whipworm)
Helminths/ Nematodes

*Trichuris trichuria* (Whipworm)
Ascaris lumbricoides
Helminths/ Nematodes

**Ascaris lumbricoides**

- Oval
- Fertile 75x50 μm, Infertile 95x50 μm
- Yellow-brown thick shell
- ± Rough mamillated layer

Fertile Egg

![Fertile Egg](image1)

Infertile Egg

![Infertile Egg](image2)
Helminths/ Nematodes

Adult female

Diagnostic Features
- Smooth creamy cuticle
- No radial ridges

Earthworm
Helminths/ Nematodes

Ascaris lumbricoides
Mystery meningitis

- *Baylisascaris procyonis*; raccoon roundworm, causes larval migrans.

Embryonated, infective stage from raccoon feces
Helminths/ Nematodes

Ancylostoma duodenale & Necator americanus (Hookworms)

Diagnostic Features
- Oval
- 75x40 μm
- Thin shell wall
- 4-8 cell stage
- Clear space

Iodine 1000x
Helminths/ Nematodes

*Ancylostoma duodenale* & *Necator americanus* (Hookworms)
Helminths/ Nematodes

*Ancylostoma duodenale* (Hookworms)

**Ancylostoma duodenale**  
**Necator americanus**

Diagnostic Features:
- Bucal capsule (teeth vs cutting plates)
Helminths/ Nematodes

Ancylostoma duodenale (Hookworms)
Helminths/ Nematodes

*Ancylostoma duodenale* & *Necator americanus* (Hookworms)

- Embryonated Egg
- Rhabditiform larvae

Iodine 1000x  
Iodine 400x
Strongyloides stercoralis

1. Infective Stage
2. Diagnostic Stage
3. Infective filariform larvae penetrate the intact skin initiating the infection.
4. The rhabditiform larvae develop into infective filariform larvae.
5. Eggs are produced by fertilized female worms.
6. Development into rhabditiform larvae.
7. The filariform larvae enter the circulatory system, are transported to the lungs, and penetrate the alveolar spaces. They are carried to the trachea and pharynx, swallowed, and reach the small intestine where they become adults.
8. Adult female worm in the intestine.
9. Rhabditiform larvae hatch in the intestine and migrate to the lumen.
10. Autoinfection: Rhabditiform larvae in the large intestine become filariform larvae, penetrate intestinal mucosa or perianal skin, and follow the normal infective cycle.

CDC
http://www.dpd.cdc.gov/dpdfx
Strongyloides stercoralis Rhabditoid Larva

Diagnostic Features
- 200-400 μm
- Short buccal canal
- Prominent genital primordium
- Esophagus:Intestine 1:4
Helminths/ Nematodes

**HOOKWORM AND STRONGYLOIDES**

**Comparison of Larvae**

- *Strongyloides stercoralis*
  - rhabditiform larva
  - short buccal cavity
  - distinct genital primordium

- *Hookworm*
  - rhabditiform larva
  - long buccal cavity
  - genital primordium cannot be distinguished
**Strongyloides stercoralis** Serology

**Focus Lab**
- Commercial ELISA
- Cross reacts with other round worms

**CDC**
- “Home-brew“ EIA
- Chaffee extract of 3rd larval stage
- 95% sens and 99% spec.
Microfilariae
Loa loa

Wuchereria
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## Types of Tape Worms

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<tr>
<th>Fish</th>
<th>Cattle</th>
<th>Pig</th>
<th>Insects</th>
<th>Herbivores</th>
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| *Diphylllo bothrium* | *Taenia saginata* | *Taenia solium* | *Hymenolepis nana*  
|               |                  |                | *H. diminuta*              | *Echinococcus granulosus*  
|               |                  |                |                             | *E. multilocularis*            |
Adult Tapeworms

1. Scolex
2. Neck
3. Strobila
Helminths/ Cestodes

Scolex of Tapeworms

Diphyllobothrium latum

T. Solium
H. nana
Echinococcus spp.

T. saginata
H. diminuta
Helminths/ Cestodes

Life Cycle of Tape Worms

Intermediate Host

Definitive Host
Helminths / Cestodes

Life Cycle of Tapeworms

- Intermediate Host
- Cestode
- Definitive Host
- T. solium

Diagram showing the life cycle of a tapeworm with intermediate hosts and definitive hosts.
Taenia life cycle

1. Eggs passed in feces
2. Ingested by an arthropod intermediate host
3. Oncospheres hatch and penetrate intestinal wall
4. Cysticerci in body cavity of insect ingested by rodent or human
5. Scolex
6. Adults in small intestine
7. Gravid proglottids
Cysticercosis
(Taenia spp.)

1. Eggs or gravid proglottids in feces and passed into environment
2. Embryonated eggs and/or gravid proglottids ingested by pigs or humans
3. Oncospheres hatch, penetrate intestinal wall, and circulate to musculature in pigs or humans
4. Humans acquire the infection by ingesting raw or undercooked meat from infected animal host
5. Scolex attaches to intestine
6. Adults in small intestine

Cysticerci may develop in any organ, being more common in subcutaneous tissues as well as in the brain and eyes.
Cysticercosis

Slaughtered pig in Papua-Indonesia
Dr. Sukwan Handali 2006

Brain CT of a patient in Lima
Helminths/ Cestodes

Embryonated Tapeworm Eggs

- **H. nana**
  - Oval ~45μm
  - Bipolar inner membrane
  - 4-8 polar filaments
  - 6 hooks

- **H. diminuta**
  - Round ~70μm
  - Striated outer shell
  - Thin inner membrane
  - Interspace smooth

- **T. solium & saginata**
  - Round ~40μm
  - Thick, radial striation
  - Brown shell
  - 6 hooks
Helminths/ Cestodes

**D. latum Eggs**

Dx Features:
- Oval
- 60 x 40 μm
- Operculated
- Terminal knob
- Cleavage fills entire shell
Diphyllobothrium latum during Colonoscopy
Helminths/ Cestodes

Proglottid of Tapeworms

D. latum

T. solium

T. saginata

Dx Features:
- 3 x 11 mm
- central uterus
- 11 x 5 mm
- 7-13 lateral
- 20 x 5
- 15-30 lateral
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### Types of Flukes

<table>
<thead>
<tr>
<th>Fluke</th>
<th>Common name</th>
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<tbody>
<tr>
<td><em>Paragonimus westermani</em></td>
<td>Oriental lung fluke</td>
</tr>
<tr>
<td><em>Clonorchis sinensis</em></td>
<td>Chinese or oriental fluke</td>
</tr>
<tr>
<td><em>Fasciola hepatica</em></td>
<td>Sheep liver fluke</td>
</tr>
<tr>
<td><em>Schistosoma spp.</em></td>
<td>-</td>
</tr>
</tbody>
</table>
Types of Flukes

The life cycle of *Schistosoma mansoni*

- Man
- Cercaria
- Snail
- Miracidium
- Schistosome egg
Schistosoma Adult Worm

“The 1-2 cm long male possess a deep ventral groove or canal in which it carries the longer more slender female in life-long copulatory embrace.”
Life cycle of *Schistosomas*
Schistosoma Eggs

S. mansoni
Oval ~180 μm
Lateral spine

S. haematobium
Oval ~ 180 μm
Terminal spine
Helminths/ Trematodes

**Schistosoma Eggs**

*S. japonicum*
- Oval ~100 μm
- Vestigial spine

*S. mekongi*
- Oval ~80 μm
- Vestigial spine
- Mekong River area
Helminths/ Trematodes

**Schistosoma Eggs in Tissue**

*S. mansoni*
- Intestinal wall
- Liver

*S. spp*
- Liver
Parasite Diagnostic Assays

- Nucleic acid test
  - Syndromic GI PCR:

  (1) axTAG GPP, Luminex xTag gastrointestinal pathogen panel (Luminex Corporation, Toronto, Canada)

  (2) FilmArray, FilmArrayTM Gastrointestinal Panel (BioFire Diagnostics, Salt Lake City, UT)
# FilmArray™ Gastrointestinal Panel

**1 Test. 22 Targets. All in about an hour.**

<table>
<thead>
<tr>
<th><strong>Bacteria</strong></th>
<th><strong>Parasites</strong></th>
<th><strong>Viruses</strong></th>
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<tr>
<td>Campylobacter (jejuni, coli and upsaliensis)</td>
<td>Cryptosporidium</td>
<td>Adenovirus F 40/41</td>
</tr>
<tr>
<td>Clostridium difficile (toxin A/B)</td>
<td>Cyclospora caytanensis</td>
<td>Astrovirus</td>
</tr>
<tr>
<td>Plesiomonas shigelloides</td>
<td>Entamoeba histolytica</td>
<td>Norovirus GI/GII</td>
</tr>
<tr>
<td>Salmonella</td>
<td>Giardia lamblia</td>
<td>Rotavirus A</td>
</tr>
<tr>
<td>Yersinia enterocolitica</td>
<td></td>
<td>Sapovirus (I, II, IV and V)</td>
</tr>
<tr>
<td><em>Vibrio</em> (parahaemolyticus, vulnificus and cholerae)</td>
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<td><em>Vibrio cholerae</em></td>
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<tr>
<td><strong>Diarrhoeagenic E. coli/Shigella</strong></td>
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<td>Enteroaggregative <em>E. coli</em> (EAEC)</td>
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<td>Enteropathogenic <em>E. coli</em> (EPEC)</td>
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<td>Enterotoxigenic <em>E. coli</em> (ETEC) lt/st</td>
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<td>Shiga-like toxin-producing <em>E. coli</em> (STEC) stx1/stx2</td>
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<td><em>E. coli</em> O157</td>
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<td><em>Shigella/Enteroinvasive E. coli</em> (EIEC)</td>
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Syndromic GI Assays

· Accuracy
  · Sensitivities and specificities are superior or comparable to conventional and molecular methods

· Advantages
  · Comprehensive coverage of etiologies
  · Allow consolidation of multiple laboratory tests

· Disadvantages
  · Cost

· Future needs
  · Larger studies to determine sensitivity and specificity of all targets
  · Significance of multiple positive targets (30% of positives)

Khare et al JCM 2014
Buss et al JCM 2015
Case 1:
61 year old sushi lover was referred for upper endoscopy to evaluate typical longstanding dyspepsia and reflux type symptoms. What is the diagnosis?
Click to view video of removal of anisakis worm found in stomach during an endoscopy. 5Mb Flash file.
Case 2:
Pt with hepatic abscess? Which amoeba is seen in stool?
Case 3:
Biopsy from a 27 y/o woman who complained of belching, flatulence and diarrhea. What can be seen in the lumen?
Case 4:
60 y/o with CGD with profuse diarrhea
Concentrated stool, Modified AFB stain
Concentrated stool, Cryptosporidium DFA
Case 6:
50 y/o man with HTLV infection and respiratory failure
Bronchial aspirate, Bacterial culture on blood agar
Case 7:
Oncology patient on chemotherapy with pneumonitis.
Stool: direct mount with iodine 100X
Case 8:  
7 y/o with anal itching. What does cellulose tape preparation show?
Case1x:
48 year old Filipino with portal vein thrombosis/portal HTN presented with massive upper GI bleed.