Helminths (Parasitic worms)

Kingdom Animalia

Phylum Platyhelminthes
- Ascaridida
  - Roundworm
- Trichurida
  - Whipworm
- Rhabditida
- Strongylida
- Spirurida
- Strongylida

Phylum Nematoda
- Rhabditida
- Ascaridida
- Trichurida
- Strongylida
- Spirurida

Parasitic Nematodes of Humans

- Roundworm: Ascaris
- Pinworm: Enterobius
- Whipworm: Trichuris
- Trichinella
- Toxocara
- Hookworms: Necator & Ancylostoma
- Threadworm: Strongyloides
- Filarial nematodes: Wuchereria, Loa, Onchocerca
- Guinea worm: Dracunculus

Nematodes - General Properties

- Extremely abundant
- Debate - more insects or nematodes?
  - 90,000 worms in a single rotting apple
  - ~9 billion in 1 acre of farmland
  - Major are small predators or saprophytes
  - Nearly every insect is parasitized by a nematode
  - Plant and animals nematode parasites
  - Parasitic infections can be enormous
- Diverse habitats
  - Free-living marine, freshwater, soil species
  - Animal and plant tissue
Impact of Nematodes

- Human diseases
- Debilitating diseases
- Livestock and other domesticated animal diseases
- Impact on economic stability
- Huge industry for anti-helminths for our pets
- Plant diseases
- Turf grasses - big money (golf courses etc.)
- Model system for the study of development, aging, human diseases such as cancer

Nematodes - General Properties

- "White worms"
  - Not segmented
  - Covered with a cuticle (non-cellular)
  - Hides the internal organs
  - Secreted by hypodermis (epidermis)
  - Grows as worm grows
  - Shed during each molt (new cuticle beneath)
- Sexes are separate
  - Find each other via pheromones
  - Male sperm lack flagellum
  - Move by pseudopodia
- Most are slender with few distinguishing characteristics.
- Cause of some of the most debilitating the disfiguring diseases in humans

Nematode General Properties

- Pseudocoel
  - Fluid-filled cavity that forms hydrostatic skeleton
- Simple nervous system
  - May include sensory organs called phasmids
- Complete digestive system
- Four larval stages which all look similar (molting)
  - Called L1, L2, L3, L4 or J1, J2, J3, J4
  - Most larval stages are free-living
  - L3 is usually the stage that gets into the definitive host
Body Plan - roundworms

- Platyhelminth
- Nematode
- Annelid

- Bilateral symmetry
- Acoelomate
- Pseudocoelomate
- Coelomate

Body Plan

- Triradiate pharynx (esophagus)
- Cuticle
- Epidermis (hypodermis)
- Hemocoel - filled with fluid
- Exceptionally high hydrostatic pressure
- Tube within a tube

Nematode Anatomy

- Tapered body shape
- Unsegmented
- Separate sexes
  - Females are typically larger
- Anterior mouth opening
- Posterior anus
**Cuticle - complex outer covering**

- Epicuticle - thin layer of lipid and proteins
- Cortex - cross-linked cuticulin proteins and collagen
- Basal layer - closest to the hypodermis
  - Basal layers are put down at angles to form a lattice structure
  - Hypodermis secretes the cuticle (starting with the epicuticle - B)
  - The old cuticle separates from the newly synthesized one

**Neuromusculature**

- Possess only longitudinal muscles - no circular muscles
- Musculature is tightly attached to hypodermis (and therefore cuticle)
- Muscle cell extends out to the hypodermis and to the neuron.

**Nematode Locomotion**

- Turgid body - high pressure in pseudocoel
  - Contributes to muscle contractions - work against high pressure
- Undulating motion - wave-like
- The body’s contractions are according to dorsal/ventral contractions of the body
Reproduction

- Most nematodes are dioecious (meaning they have two sexes, male and female), but hermaphrodites occur as well.
- Males often have additional external features at the posterior end of the worm.
- Partners are attracted to each other by pheromones.
- The male inserts two sclerotized copulatory spicules.
- The sperm duct is muscular and sperm is transferred to the female against the pseudocoel pressure.
- Male cement glands can close vulva in some species.

Reproduction

- Female is held by male within the bursa.
- Bursa size and shape are diagnostic.

Amoeboid Sperm

- All nematode sperm lack flagella.
- Sperm actually crawl into uterus of the female.
- In many species the amoeboid sperm are highly sensitive to oxygen.
  - In vitro, sperm will die quickly when exposed to oxygen.
- Non-actin based motility!!!
- Major sperm protein (MSP)
  - ~16% of total protein in sperm.
  - Mainly localized to pseudopodia.
Most female nematodes have two ovaries. Structure is similar to the linear male system, oogonia are produced at the distal end and mature into oocytes while they move into the growth zone. As the oocytes enter the oviduct they are fertilized by sperm stored in the receptacle. Fertilization triggers the completion of meiosis.

6 life cycle stages
- Egg
- 4 larval stages
- Adults (dioecious)

Free-living and parasitic nematode undergo molts
- Increasing in size with each molt
- Usually the L3 larvae are infectious stage
- Infective stage can vary among the nematodes
Larval forms

- Feeding form
- Non-feeding form

Enlarged bulb at end of esophagus

Infective form

Parasitic Nematode Diversity

<table>
<thead>
<tr>
<th>Size of Nematodes</th>
<th>mm</th>
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<tbody>
<tr>
<td>Ascaris</td>
<td>12-40</td>
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<tr>
<td>Trichuris</td>
<td>3-5</td>
</tr>
<tr>
<td>Ancylostoma</td>
<td>16-14</td>
</tr>
<tr>
<td>Enterobius</td>
<td>6-13</td>
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<tr>
<td>hook worm</td>
<td>5-13</td>
</tr>
<tr>
<td>Trichostrongylus</td>
<td>4-8</td>
</tr>
<tr>
<td>Capillaria philippinensis</td>
<td>2-4</td>
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<tr>
<td>Strongyloides</td>
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<tr>
<td>Caparisomobilis</td>
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Helminth Lifespan

Maximum survival of helminths in Human Host

<table>
<thead>
<tr>
<th>Helminth</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascaris</td>
<td>1</td>
</tr>
<tr>
<td>Hook worm</td>
<td>6</td>
</tr>
<tr>
<td>Trichuris</td>
<td>3</td>
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<tr>
<td>Liver fluke</td>
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</tr>
<tr>
<td>Lung fluke</td>
<td>20</td>
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<tr>
<td>Schistosoma</td>
<td>40</td>
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<tr>
<td>Taenia</td>
<td>35</td>
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<tr>
<td>Strongyloides</td>
<td>70</td>
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</tbody>
</table>
**Helminths (Parasitic worms)**

- **Kingdom Animalia**
  - **Phylum Platyhelminthes**
  - **Phylum Nematoda**
    - **Ascaridida**
    - **Trichurida**
    - **Rhabditida**
    - **Strongylida**
    - **Spirurida**

**Ascaris**

- Largest of the nematode parasites
- Some are over a foot long
- Stout, big worms
- Mouth surrounded with large lips, usually 3
- Most are intestinal parasites
- Infections are usually very heavy

**Ascaris lumbricoides**

- **Definitive Host:** Humans
- **Intermediate Host:** None
- **Geographic Distribution:**
  - Cosmopolitan
  - 25% of world population is infected
  - Prevalence in southeastern U.S. can reach 60%
  - Has been known as human parasite for over 2000 years
    - Found in writing of ancient Greeks
- **Location:** small intestines
Ascaris lumbricoides, A. suum

A. lumbricoides transmission

- Ingestion of eggs in contaminated food or water.
  - Use of night soils on crops increases transmission
- Require shade and mild temperatures
- Eggs are very resistant
  - Eggs can embryonate in very strong chemicals
    - 2% formalin
    - Potassium dichromate
    - 50% hydrochloric, nitric, acetic, and sulfuric acid
- Very long life
  - At least 10-15 years

Embryonated egg containing L1

Ascaris eggs

Embryonated, abnormally layered
Unembryonated, normal layered
Fertilized, normal layered
Unfertilized, normal layered
A. lumbricoides transmission

- Eggs can splash up onto vegetables
  - One strawberry patch was still infective after six years
- Eggs can be picked up and transported by cockroaches.
- Wind borne dust may carry the eggs
  - Trapped on mucus membranes then swallowed
- Eggs have been found on German bank notes!
- Children are infected much more frequently than adults
  - Dig in soil and put fingers in mouth

Ascaris lumbricoides Life Cycle

A: Egg ingested
B: L1 in intest
C: L2 migration
D: L3 lungs
G: Adults

Ascaris infestation

- Ascariasis
- Depends on the number of worms
- Worms subsist on liquid content of small intestines
  - Do not suck blood or graze on mucosa.
- Small to medium infections are usually asymptomatic
  - May cause “sensitization phenomenon”
    - Allergic reaction to worm waste.
    - Rashes, eye pain, asthma, insomnia, restlessness
Pathology

- Wandering adults are dangerous.
  - Overcrowding can lead to wandering
  - Upstream to pancreatic or bile ducts
  - May cause liver damage
  - If reach stomach, causes vomiting of worms
  - Downstream to appendix or out anus
- Females like to crawl through small spaces
  - Looking for curly tail of male
  - She may crawl through nose, ear, or any other opening
  - Imagine the surprise as a 1.5 foot worm crawls out the nose or ear!
- Aspiration of worm can cause death

Diagnosis

- Diagnosis:
  - Eggs in feces
  - Juveniles in sputum
    - Difficult to identify to species.
  - Sticky Tape test
  - Dead adults may be found in feces

Deworming

- Treatment: Mebendazole will kill the adults but not the migrating larvae
  - May need to repeat treatment
  - Dead adults usually pass out through the anus