Helminths (worms)

- **Nematodes**: Round worms, “thread”, bisexual, intestinal, outside

- **Cestodes**: Tape worms, Flat worms, segmented, hermaphrodites, intestinal (larva extraintestinal)

- **Trematodes**: Flukes, “leaf-shaped”, suckers, hermaphrodites except blood flukes (bisexual). Snail as intermediate host
Helminths
Nematoda - general morphology - female
Transmission
3 types according to life cycle

• Type 1: DIRECT TRANSMISSION:
  – Embryonated eggs in stools hatch and re-infect within 2-3 hours by anus to mouth (DO NOT REACH SOIL). E.g. *Enterobius vermicularis* (threadworm)
    *Trichuris trichiura* (whipworm)

• Type 2: MODIFIED DIRECT

• Type 3: PENETRATION OF THE SKIN
Transmission- Ctd

• Type 2: MODIFIED DIRECT
  – Eggs in stools ➔ develop in soil ➔ ingestion ➔ hatching ➔ Larvae penetrate mucous membrane of stomach ➔ circulation ➔ lungs ➔ esophagus ➔ intestine where they become adults

E.g. *Ascaris lumbricoïdes* (roundworm)  
*Toxocara* spp.
Transmission- Ctd

• Type 3: PENETRATION OF THE SKIN
  – Eggs in stools → soil → hatching → larvae → penetrate the skin → circulation → lungs → esophagus → small intestine → adults

E.g. Ancylostoma spp (hookworm)  
  *Strongyloïdes stercoralis*

  Autoinfection can also occur at the anal margin & can exist in soil without developing in humans!
Enterobius - adults
Enterobius - male
Enterobius – adults
Enterobius - adults
Enterobius - egg
Enterobius – Cycle

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 female migrates to perianal region at night to lay eggs

- i = Infective Stage
- d = Diagnostic Stage

http://www.dpd.cdc.gov/dpdx
**Trichuris - cycle**

1. Unembryonated eggs passed in feces.
2. 2-cell stage
3. Advanced cleavage
4. Embryonated eggs are ingested.
5. Larvae hatch in small intestine
6. Adults in cecum

Life Cycle of *Trichuris trichiura*
Trichuris - adults

Trichuris trichuria

(female)  (male)
Trichuris
Trichuris – prolapse of rectum
Trichuris – prolapse of rectum
Trichuris – prolapse of rectum
Clubbing of fingers
Transmission
3 types according to life cycle

• Type 1: DIRECT TRANSMISSION

• Type 2: MODIFIED DIRECT

• Type 3: PENETRATION OF THE SKIN
Type 2: MODIFIED DIRECT TRANSMISSION

Ascariasis \( (Ascaris\ lumbricoides) \)

- Most common, most widespread human infection
- 1.2 million people infected worldwide
- Estimated 12 million cases of acute illness & 10,000 deaths annually
- Similar global distribution than \( Trichuris \)
- Large worm
  - Female \( \mathcal{O} \): 20-25 x 3-6 cm
  - Male \( \mathcal{M} \): 15-31 x 2-4 cm
- Eggs (60 x 45 \( \mu \text{m} \)), surrounded by mamillated shell
- Live in small intestine
A. lumbricoides- Adult female
Ascaris - Cycle

1. Infective Stage
2. Fertilized egg → Feces
3. Unfertilized egg will not undergo biological development.
4. Ingestion of infectious eggs
5. Migration through the body
6. Maturation in the intestine
7. Egg production by adult worms

CDC
http://www.dpd.cdc.gov/dpdx
Ascaris - cycle

**Infective Stage Embryonated Egg**
- Larval worm released, penetrates duodenal wall, moves to blood

**Circulation to Internal Organs**
- Enters pulmonary circulation

**Lungs 10-14 Days**
- Larvae release in alveoli

**Adults Develop in Small Intestine Lumen**
- Fertilization of female promotes egg production

**Egg Production 60-75 Days into Infection**

**Eggs in Faeces - Diagnostic Stage**
- 200,000/day for up to a year

**Egg Development Externally 10-14 Days**
- Eggs now infectious

**Ingestion Humans**

**Advanced Cleavage**

**2 Cell Stage**

**Unfertilised Eggs**
- Produced in absence of male

**Fertilised Eggs**
• From eggs ingested to larvae in intestine: 10-14 days
• From infection to eggs in stools: 60-70 days
• Transmission via accidental ingestion of eggs in contaminated soil (usually children)
• Geophagia
A. lumbricoides - egg
Ascaris - Aggregate masses of worms
Ascaris – adults
Ascaris – Differential Diagnosis

- Pulmonary symptoms, lung infiltration & hypereosinophilia are common to several helminths and other infections (toxocariasis, hookworm, Strongyloides, schistosomes, TPE, aspergillosis)

- Larval ascariasis is short-term (2-3 w) with rapidly falling eosinophilia

- Toxocara spp also cause the visceral larva migrans (VML) syndrome but last many months with high eosinophilia

- Hookworms invasive stage lasts 2-3 m (specif. serol.)

- Schistosomes invasive stage (Katayama syndrome) lasts 2-3 m with splenomegaly (specif. serol.)

- TPE is mainly in adult, longer duration, filarial tests + and responds to diethylcarbamazine

- Aspergillosis and drug reactions are more chronic
Type 2: MODIFIED DIRECT TRANSMISSION

Toxocariasis (Toxocara canis & T cati)

• Dogs & cats ascarids
• Man abnormal host and development stops at larval stage which causes toxocariasis, visceral larva migrans (VLM), ocular and covert toxocariasis
• Worldwide (2% to 86% prevalence in humans)
• Same morphology as Ascaris
• Large worm
  – Female ♀: 6.5 – 10 cm long
  – Male ♂: 4 – 6 cm long
• Eggs (85 x 75 μm), pitted superficially. In dogs, cats faeces and soil
• Transmission: Mostly children playing in contaminated soil or eating earth
Toxocara canis - adults
Toxocara canis - egg
Toxocara - Cycle

In dog/cat:

• Ingestion of eggs from soil and cycle similar to Ascaris but transplacental infection is possible

In humans:

• Eggs ingested hatch in stomach → L₂ which penetrates mucosa → circulation via mesenteric vessels → intestinal viscera & liver (held up by capillaries). They may pass into general circulation via lungs to brain, eyes, etc. causing granulomatous reaction (pathology)

• Larvae do not mould but can live up to 11 years
Toxocara canis - Cycle
Toxocara - Pathology

• Depends on intensity of infection
  ➢ VLM (heavy infected children)
  ➢ Toxocariasis (lighter infections, later in life)

• VLM:
  ❑ L₂ (450 length x 20 μm φ) are arrested mostly in liver and cause granuloma
  ❑ Also in lungs, kidneys, heart, striated muscles, brain, eye
Toxocara - Pathology

• VLM:
  ❑ Granuloma:
    ❑ Centre of packed eosinophils & histiocytes
    ❑ Surrounded by large histiocytes (palisade)
    ❑ Maybe giant cells
    ❑ L₂ remains sometimes

• Ocular toxocariasis:
  ❑ Granulomatous reaction in eye sub retinal mass with patch of choroiditis
    Resembles retinoblastoma.
Toxocara - Immunity

• Larvae provoke humoral response
• Rise in IgG, IgM, IgE
• Rise in peripheral eosinophils
• Cellular response: cell-mediated granuloma response around the larvae
Toxocara – Clinical features

• In most cases, larvae are destroyed without trouble
• In some cases, larvae survive for years and cause lesions
• Only trouble is with heavy infection and VLM. This can be self-limiting or fatal (rare)
• In eye: loss of vision, loss of sight
Toxocara – Symptoms & signs

VLM

• Mostly in younger children
• Enlarged liver, fever, asthma
• Hypereosinophilia & hyperγglobulinaemia
• Sometimes pulmonary signs, cardiac dysfunction, nephrosis
• Severe: neurological lesions (fits, paresis, transverse myelitis)
Toxocara – Symptoms & signs

• Most VLM cases recover after 2 years but some fatal

• Retinal lesions (at/near macula) lead to vitritis, cystoid macular oedema & traction retinal detachment

• Strabismus due to damage is often the symptom

• L₂ may rarely be seen in anterior chamber of eye

COVERT TOXOCARIASIS: cough, sleep disturbance, headache, abdominal pain
Toxocara – Diagnosis

• VLM : - Stable eosinophilia
  - Leukocytosis
  - Decrease of albumin:globulin ratio
  - Increase of IgG, IgH, anti A or B iso-haemagglutinin titres
  - Hypoechoic area in liver by US
Toxocara – Diagnosis (Ctd)

• Serology:
  – ELISA using excretory – secretory (ES) antigens from L₂ in vitro but some cross reactions. Improved if based on specific IgE & IgG subclasses
  – Cannot differentiate between past and present infection

• Ocular toxocariasis:
  Ophtalmologic examination. Serum antibodies detection, fluorescein angiography, computed tomography to differentiate from ocular larva migrans
Toxocara – Differential diagnosis

• VLM: See ascariasis.

• Ocular toxocariasis must be distinguished from retinal tumour (retinoblastoma) and other causes of choroiditis (toxoplasmosis)

• Exclude toxocariasis in all cases of retinoblastoma in children (ELISA)
Toxocara – Management

• Albendazole & Mebendazole (2xd for 5d)
• Thiabendazole
• Diethylcarbamazine not recommended
• In VLM, high eosinophilia may persist but relapses do not occur
• In severe ocular toxocariasis, corticosteroids may be needed
Toxocara – Epidemiology

• Common in adult dogs and cats
• In tropical areas, often associated with *Ascaris* and *Trichuris*
• Seroprevalence increases throughout early childhood and stabilizes around 2.5 years
• Uncommon after 5 years of age, except ocular form
Toxocara – Control

- Control in dogs/cats by treatment
- Health education
- Prevent soil contamination by animals faeces
- Hand washing
Transmission
3 types according to life cycle

• Type 1: DIRECT TRANSMISSION

• Type 2: MODIFIED DIRECT

• Type 3: PENETRATION OF THE SKIN
Transmission- Ctd

• Type 3: PENETRATION OF THE SKIN
  – Eggs in stools $\rightarrow$ soil $\rightarrow$ hatching $\rightarrow$ larvae
    $\rightarrow$ penetrate the skin $\rightarrow$ circulation $\rightarrow$ lungs
    $\rightarrow$ esophagus $\rightarrow$ small intestine $\rightarrow$ adults

E.g. *Ancylostoma* spp (hookworm)  
*Strongyloïdes stercoralis*

Autoinfection can also occur at the anal margin & can exist in soil without developing in humans!
Type 2: PENETRATION OF THE SKIN

Ancylostomiasis  
*hookworm disease*

- Caused by 2 hookworms: *Ancylostoma duodenale* and *Necator americanus*
- 740 million people infected in tropics/subtropics
- Causes more morbidity than other geohelminths
- Often in huge number attached causing hookworm anemia, iron deficiency anaemia
- *N.americanus* is the predominant hookworm of Sub-Saharan Africa, Southern Asia, Caribbean America
- *A. duodenale* is predominant in EU, North Africa, China, Japan, Latin America, Northern India
## Hookworm - Aetiology

<table>
<thead>
<tr>
<th></th>
<th>A. duodenale</th>
<th>N. americanus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aetiology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>♂ and ♀ have buccal capsule with teeth</td>
<td></td>
<td>Same but smaller with cutting plates</td>
</tr>
<tr>
<td>♂ 1 x 0.5 cm</td>
<td></td>
<td>♂ smaller, more slender</td>
</tr>
<tr>
<td>♀ 1.2 x 0.6 cm</td>
<td></td>
<td>♀ smaller</td>
</tr>
<tr>
<td>25-35.000 eggs/d</td>
<td></td>
<td>6-20.000 eggs/d</td>
</tr>
<tr>
<td>Egg: 50x35 μm, elliptical, transparent shell</td>
<td>Egg: 70x40 μm</td>
<td></td>
</tr>
<tr>
<td>Average stay in host : 1y</td>
<td></td>
<td>Life duration: 3-5 y</td>
</tr>
<tr>
<td>♂ with copulatory bursa</td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

- Egg: 50x35 μm, elliptical, transparent shell
- Egg: 70x40 μm
- Average stay in host: 1 year
- Life duration: 3-5 years
Anterior end of an adult of *Ancylostoma caninum*
Hookworm egg in unstained wet mount
Hookworms - Cycle

1. Eggs in feces
2. Rhabditiform larva hatches
3. Filariform larva penetrates skin
4. Filariform larva
5. Adults in small intestine

$\text{CDC}$

http://www.dpd.cdc.gov/dpdx

$\text{i = Infective Stage}$

$\text{d = Diagnostic Stage}$
## A. duodenale & N. americanus

### Differences in life cycle

<table>
<thead>
<tr>
<th>A. duodenale</th>
<th>N. americanus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live 1 to 3 years</td>
<td>Live 3 to 10 years</td>
</tr>
<tr>
<td>Can also infect by ingestion</td>
<td>Infects only through skin</td>
</tr>
<tr>
<td>No larval development in lungs</td>
<td>Larvae grow and develop in lungs</td>
</tr>
<tr>
<td>Can remain as L in host for months before developing to adult</td>
<td></td>
</tr>
</tbody>
</table>
Ancylostoma – anterior end with teeth
Hookworms - Cutaneous larva migrans
Hookworms - Diagnostic

• Microscopic identification of eggs in the stools
• Concentrate using the formalin–ethyl acetate sedimentation technique
• Kato-Katz can be used for quantitative assessments of infection

[link to Parasitology_Methods_PDF/8_S Tool_Kato-Katz.pdf]

• Examination of the eggs cannot distinguish between *N. americanus* and *A. duodenale*. Filariform larvae of the 2 species can be differentiated in a fecal smear on a moist filter paper strip
Life Cycle (cutaneous larval migrans)

*A. braziliense* and *A. caninum*
Type 2: PENETRATION OF THE SKIN

Strongyloidiasis  
*(Strongyloides stercoralis)*

- Tropical and subtropical areas, but cases also occur in temperate areas.
- More frequently found in rural areas, institutional settings, and lower socioeconomic groups
- Males grow to only about 0.9 mm in length
- Females can be anywhere from 2.0 to 2.5 mm
- Both genders also possess a tiny buccal capsule and cylindrical esophagus without a posterior bulb
- It has become a serious problem in individuals receiving immunosuppressive treatment, or immuno-compromised
- Three developmental forms: adult, rhabditiform larva & filariform (infective) larva
**S. stercoralis – Life cycle**

1. Eggs are produced by fertilized female worms.
2. Development into free-living adult worms.
3. Eggs are produced by fertilized female worms.
4. Rhabditiform larvae hatch from embryonated eggs.
5. The rhabditiform larvae develop into infective filariform.
6. Infective filariform larvae penetrate the intact skin initiating the infection.
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. Eggs deposited in intestinal mucosa, hatch, and migrate to lumen.
10. Autoinfection: Rhabditiform larvae in large intestine, become filariform larvae, penetrate intestinal mucosa or perianal skin, and follow the normal infective cycle.
S. stercoralis – Egg
S. stercoralis – rhabditiform larva
Longitudinal-section of a larva of *S. stercoralis* from an intestinal biopsy specimen
**S. stercoralis – Diagnosis**

- Diagnosis rests on the microscopic identification of larvae (rhabditiform and occasionally filariform) in the stool or duodenal fluid.

- **For stools:**
  - directly
  - after concentration (formalin-ethyl acetate)
  - after recovery of the larvae by the Baermann funnel technique
  - after culture by the Harada-Mori filter paper technique
  - after culture in agar plates

- Examination of serial samples may be necessary, and not always sufficient, because stool examination is relatively insensitive.

- The duodenal fluid can be examined using techniques such as the Enterotest string or duodenal aspiration.

- Larvae may be detected in sputum from patients with disseminated strongyloidiasis.
$L_1$ larva (rhabditiform) 250-300 $\mu$m
L₃ larva (filariform) 500-600 µm
**S. stercoralis** – Management

- The drug of choice for the treatment of uncomplicated strongyloidiasis is Ivermectin
- Albendazole, Mebendazole are alternatives
- All patients who are at risk of disseminated strongyloidiasis should be treated
- There is often a decrease in the efficacy of treatment in persons co-infected with HTLV-1