INTESTINAL WORMS

GENERAL

Roundworms (Ascaris) kills 100,000 annually worldwide
Hookworm kills 65,000 annually world-wide

Intestinal nematodes are found where human feces are deposited indiscriminately or used for fertilizer.

Intestinal nematodes infect more than 25% human race.

Intestinal nematodes cause
- embarrassment
- discomfort
- malnutrition
- anemia
- occasional deaths

Six intestinal nematodes most commonly infect humans.

ORGANISM	BURDEN (million)
Enterobius vermicularis (pinworm)	200
Trichuris trichiura (whipworm)	800
Ascaris lumbricoides (large roundworm)	1200
Necator americanus & *Ancylostoma duodenale* (hookworms)	750
Strongyloides stercoralis	90

Immune responses in humans
- Can lead to the expulsion of the worms.
- Immunity is slow to develop and often incomplete.

The frequency and intensity of reinfection, rather than anti-parasite immune responses, determine worm burdens in humans.

CLINICAL FEATURES

Disease severity is related to the number of adult worms in the host.

The greater the worm load / burden, the more serious the consequences.

Small burdens may remain asymptomatic throughout the parasite's lifespan.

Repeated infections increase worm burdens & symptoms.

Adult nematode can survive for months or years within the gut.

Severity depends on the level of "adaptation" to the host the nematode has achieved.

Some species have a "simple" life cycle that completes without serious damage to the host.

Ascaris lumbricoides (large roundworm)

Clinical manifestations caused by
- Presence of adults in the intestinal lumen
- Migration of larvae through lungs
- Asymptomatic if worm load is small

Infection discovered when worms are vomited up or passed in stools
- Fevers stimulate worm's motility
- Worms can crawl out of mouth, nose, or ear

Gut involvement
- Heavier worm loads (50 to 2000 worms in a single child)
- Abdominal pain
- Worms can block appendix, bile duct, pancreatic duct (acute disease)
- Malabsorption of fat, protein, carbohydrates, and vitamins
- Growth retardation
- Intestinal obstruction
  - 2 per 1000 infected children per year
  - 3% mortality

Lung involvement
- Fever, cough, wheezing, and shortness of breath

Eosinophilia, oxygen desaturation, migratory pulmonary infiltrates
Occasional death from respiratory failure
Often seen in communities where transmission is seasonal
Symptoms related to previous infections
Degree of hypersensitivity to previous infections
Intensity of current exposure

Trichuris trichiura (whipworm)

Infection is most often asymptomatic
Gut involvement
Heavy infection can result in severe diarrhea or dysentery and rectal prolapse
Can also cause growth retardation

Necator americanus & Ancylostoma duodenale (hookworms)

Average blood loss in gut
Adult A. duodenale — extract 0.2 ml blood daily
Adult N. americanus — extracts 0.03 ml blood daily
Adult survives 2 to 14 years — accumulated blood loss enormous

In most individuals worm burden is small with asymptomatic infection

Skin involvement
Penetration by filariform larvae
Causes rash, itching, and local swelling — called “ground itch”
Usually occurs between toes — lasts several days

Lung involvement
Symptoms similar to Ascaris infections — often less frequent and severe

Gut involvement
Epigastric pain and abnormal peristalsis
Anemia — degree of anemia depends on iron intake
Hypoalbuminemia
Heart failure — due to severe anemia in children
Kwashiorkor
Retarded mental, sexual and physical development

EPIDEMIOLOGY

General Features

Human feces carries eggs outside the body / gastrointestinal tract.

Typically, eggs must incubate (embryonate) outside human hosts before becoming infectious to humans.

Embryonation

Process by which the agent becomes infective takes several weeks
eggs → embryo divides repeatedly → larva & adolescent forms

Site of embroynation depends on the species of nematode.
Sites include perineum, soil, and/or intestine.

Eggs must embryonate on the soil for weeks before becoming infectious.
The duration and site of embroynation differ with each worm species.
Determines the mechanism of transmission to the new host.

Infective Forms

Eggs / mouth cycle

Eggs ingested with contaminated food.

Filariform larvae / skin cycle

Larvae penetrate skin of persons who come into direct contact.

EPIDEMIOLOGY OF EACH ORGANISM

Enterobius vermicularis (pinworm)

Scope of infection

~200 million people infected worldwide
~30 to 40 million in United States

Prevalence decreasing in the USA?

Transmission

See Table

Life Cycle

Best adapted intestinal nematode
Simplest life cycle

Eggs are swallowed or inhaled → hatch in bowel lumen → copulates within the gut → molts through stages while traveling down the colon→ gravid females migrate nocturnally to anus → deposit eggs on skin

Eggs contain an embryo upon passage and become infective within 4-6 hours

Return to same host or new host via fingers or dust

Ingestion of infective eggs to oviposition by the adult females is about one month.

Trichuris trichiura (whipworm)

Scope of infection

~ 800 million people infected worldwide

~ 2 million in rural areas of southeastern United States

Transmission

See Table

Life Cycle

Similar to pinworm, except eggs must incubate in soil

Eggs embryonate for ~15-30 days (depends on soil, temperature, moisture)

Slight difference has profound epidemiologic ramifications

Climates must be suitable for maturation of eggs in the soil

Whipworm carried in populations with indiscriminate defecation

Eggs hatch in duodenum and migrate to cecum as adults → Adult worms (approximately 4 cm in length) live in the cecum and ascending colon, and are fixed in that location, with the anterior portions threaded into the mucosa

Female worms in the cecum shed between 3,000-20,000 eggs per day

Females begin to oviposit 60-70 days after infection

Ascaris lumbricoides (large roundworm)

Scope of infection

~1.2 billion people infected worldwide

~4 million Americans infected

Generate ~25,000 tons of Ascaris eggs annually

Transmission

Disease of warm climates and poor sanitation

Maintained by small children who defecate indiscriminately near home

Children pick up infectious eggs during play

Eating dirt “Geophagia” may cause massive worm loads

Eggs may become airborne, then inhaled and swallowed

Life Cycle

Eggs *must* incubate in soil, taking 18 days or more to embyronate, depending on soil conditions
Takes 2-3 months from ingestion of infective eggs to oviposition by females

Egg hatches in gut lumen → larvae penetrate bowel wall → migrate to liver → filter through liver → migrate to lung → maturation occurs in lungs (10-14 days) → trapped in lung → penetrate into alveolar space → ascend the bronchial tree to the throat → swallowed → return to small intestine → complete maturation and mate

Necator americanus & Ancylostoma duodenale (hookworms)

Scope of Infection

~ 750 million people infected worldwide
~ 700,000 in southeastern United States
~7 million liters blood extracted per day by these worms

Transmission

Found worldwide between 45N & 30S latitudes
Tropical Asia, Africa, Americas, Middle East, India, China, Japan
Larvae require shady areas, well-drained soil, rainfall, warm temperatures
Filariform larvae penetrate epidermis of skin

Life Cycle

Eggs hatch within 48 hours after passing in stool →
Rhabditiform larvae feed on bacteria and debris in soil →
After 5-10 days, larvae molt & become filariform larvae (infectious form) → In moist conditions, filariform larvae may survive 3-4 weeks →
On contact with human skin, filariform larvae penetrate epidermis →
Carried through the veins to the heart and then to the lungs →
Penetrate into pulmonary alveoli → ascend up bronchial tree → swallowed → Pass to small intestine and attach to intestinal wall → Complete maturation & mate

Strongyloides stercoralis

Scope of Infection

~90 million people infected worldwide

~400,000 people in Puerto Rico & southeastern United States

Transmission

See Table

Life Cycle

The most complex of the nematode lifecycles, with both a free-living and parasitic cycle

1. Soil (parasitic cycle)

Filariform larvae in soil penetrate the skin → transported to the lungs→penetrate the alveolar space→carried up the bronchial tree→swallowed→travel to the small intestine→mature and become adults female worms→females live threaded in the epithelium of the small intestine and through parthenogenesis produce eggs→rhabditiform larvae emerge→rhabditiform larvae can either

a. be passed in stool OR

b. cause autoinfection

1. rhabditiform larvae become infective filariform larvae which can penetrate the intestinal mucosa (internal autoinfection) or the skin of the perianal area (external autoinfection)

2. Free-living

Capable of surviving as a free-living soil organisms.

Rhabditiform larvae are passed in the stool and can either

a. molt twice and become infective filariform larvae (direct development) OR

b. molt four times and become free living adults that mate and produce eggs from which rhabditiform larvae hatch → these larvae can either

1. develop into a new generation of free living adults OR

2. develop into infective filariform larvae

Adaptation in Strongyloides is the least of the intestinal Nematodes Evolutionary history — likely to have invaded humans more recently.

SUMMARY TABLE

Parasite Name	Route of infection	Migration in body	Diagnostic form	Embroynation site	Infective form	Free living
Enterobius vermicularis (pinworm)	Mouth	Intestinal	Egg	Perineum	Egg	No
Trichuris trichiura (whipworm)	Mouth	Intestinal	Egg	Soil	Egg	No
Ascaris lumbricoides (roundworm)	Mouth	Pulmonary	Egg	Soil	Egg	No
Necator Americanus (hookworms)	Skin	Pulmonary	Egg	Soil	Filariform larvae	No
Strongyloides stercoralis	Skin	Pulmonary	Rhabditiform	Soil & gut	Filariform larvae	Yes

PATHOGEN'S FEATURES

General Anatomy

- Covered with tough, acellular cuticle
- Muscle, longitudinal nerve trunk, excretory system
- Tubular alimentary tract — mouth, esophagus, midgut, and anus
- Highly developed reproductive organs

Separate Sexes

- Male worm smaller than female worm
- Female produces thousands of offspring in the form of eggs

Ascaris lumbricoides (large roundworm)

- 150 - 350 mm length (largest intestinal helminth)
- Female passes 200,000 eggs daily, whether fertilized or not
- Eggs
  - Elliptic shape, 35 x 55 microns
  - Remain viable for up to 6 years in mild climates
- Shorter living adult worm (6 - 24 months)

Necator americanus & Ancylostoma duodenale (hookworms)

- 10 mm length
- Head curves away from body — hooked appearance
- The two species have different oral cavity morphologies
  - *Ancylostoma duodenale* — four sharp tooth like structures
  - *Necator americanus* — dorsal and ventral cutting plates
- Attach to mucosa of small bowel, lacerate the tissue and suck blood
- Female passes 10,000 to 20,000 eggs daily
- Longer living adult worm (2 - 14 years)

PREVENTION

Ascaris lumbricoides (large roundworm)

Immunity

- Infection induced a weakly protective immune response

Diagnosis

- Eggs in feces
- Larvae and eosinophils in sputum

Drug Therapies

- Mebendazole BID PO for 3 days
- Pyrantel pamoate PO once

Community-wide Control
- Mass therapy at 6 month intervals
- Adequate sanitation facilities
- Encourage handwashing and personal hygiene
- Eliminate the use of nightsoil

Necator americanus & Ancylostoma duodenale (hookworms)

Immunity
- No clear evidence that immune reactions alter worm burdens

Diagnosis
- Eggs in feces
- Quantitative egg counts correlate with worm loads
- Eggs may hatch if stool stands for 48 hours before examination

Drug Therapies
- Correct anemia with iron / blood transfusions
- Mebendazole BID PO for 3 days
- Pyrantel pamoate PO for 3 days

Community-wide Control
- Adequate sanitation facilities
- Prevent people from walking barefoot
- Stop the use of sand and soil to pack diapers

BOTTOM LINES

Control of intestinal nematodes requires adequate sanitation facilities.

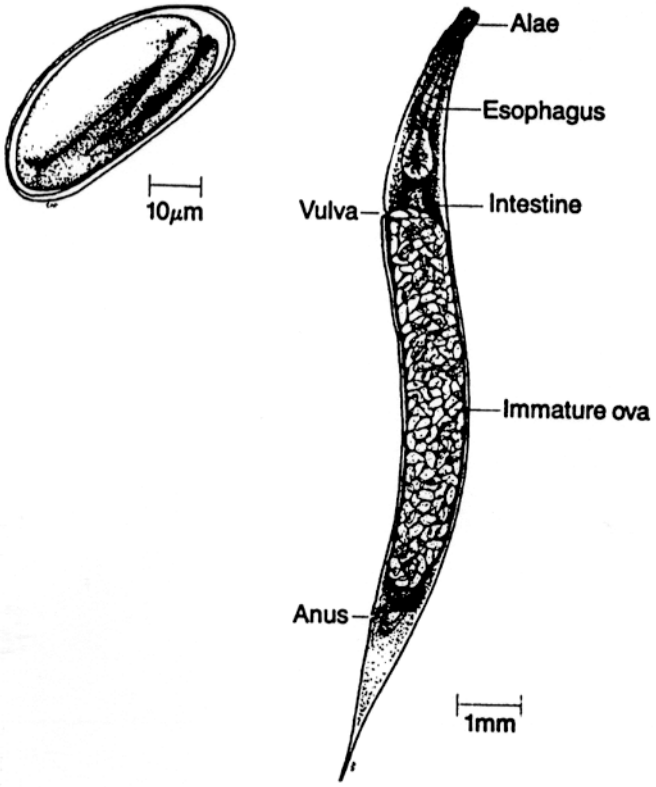
No vaccines are available but a few are under development (though they are not promising)

READING

• Chan MS. The Global Burden of Intestinal Nematode Infections – Fifty Years On. Parasitology Today 1997; 13: 438 - 443.

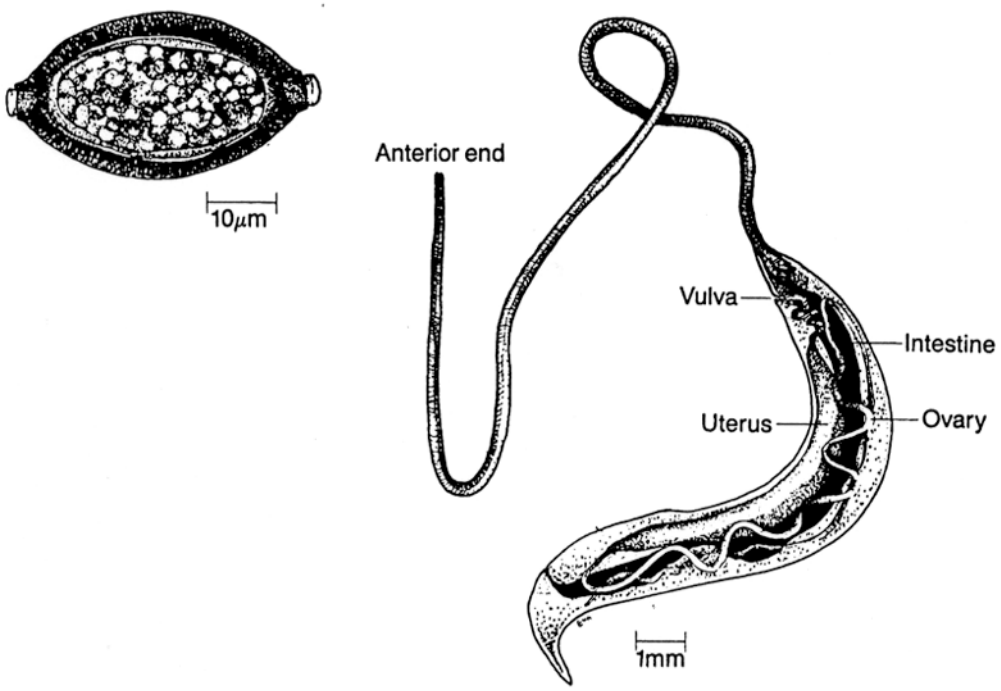
• Stepek G et al. Human gastrointestinal nematode infections: are new control methods required? International Journal of Experimental Parasitology 2006; 87: 325 - 341.

FIGURE 1



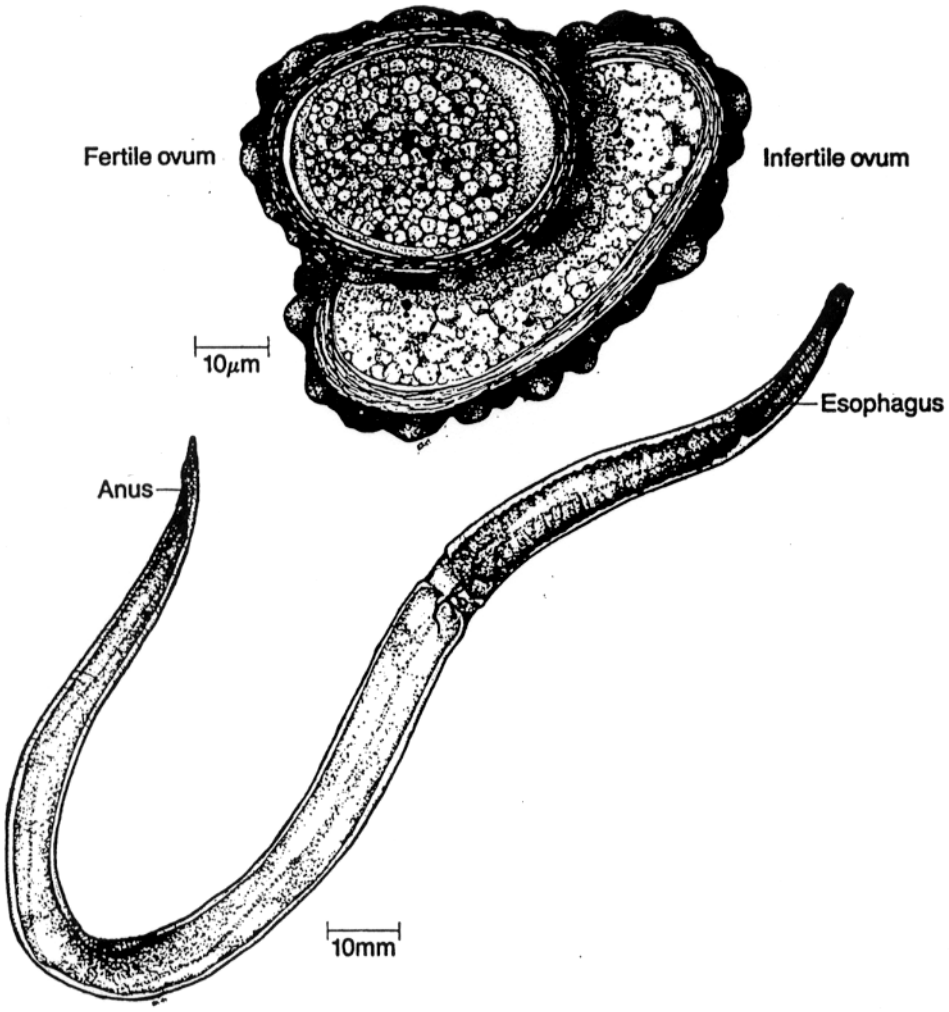
Female pinworm (*Enterobius vermicularis*) and embryonated egg.

FIGURE 2



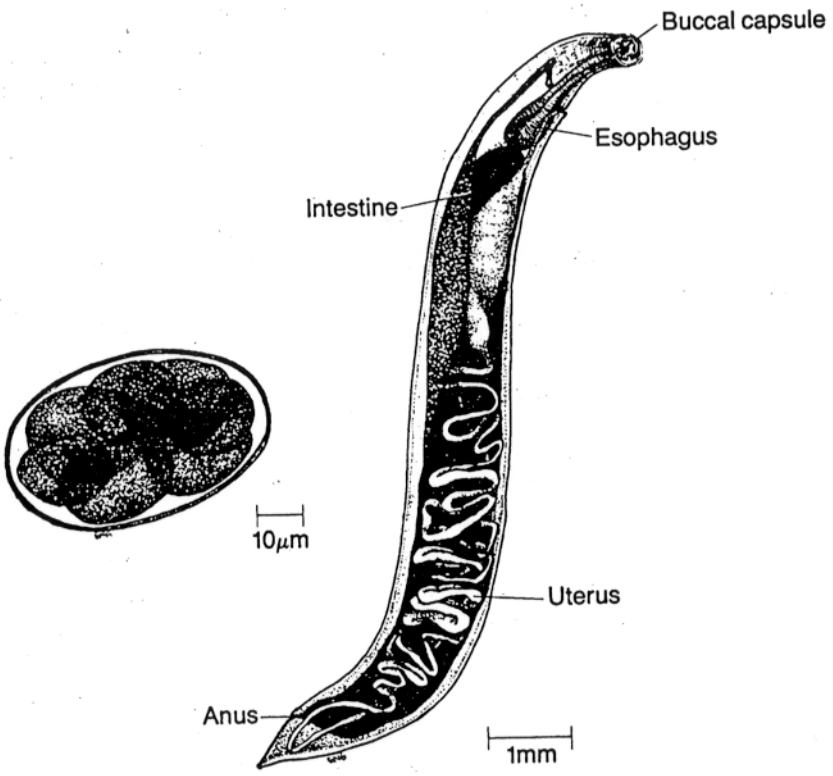
Female whipworm (*Trichuris trichuria*) and unembryonated egg.

FIGURE 3



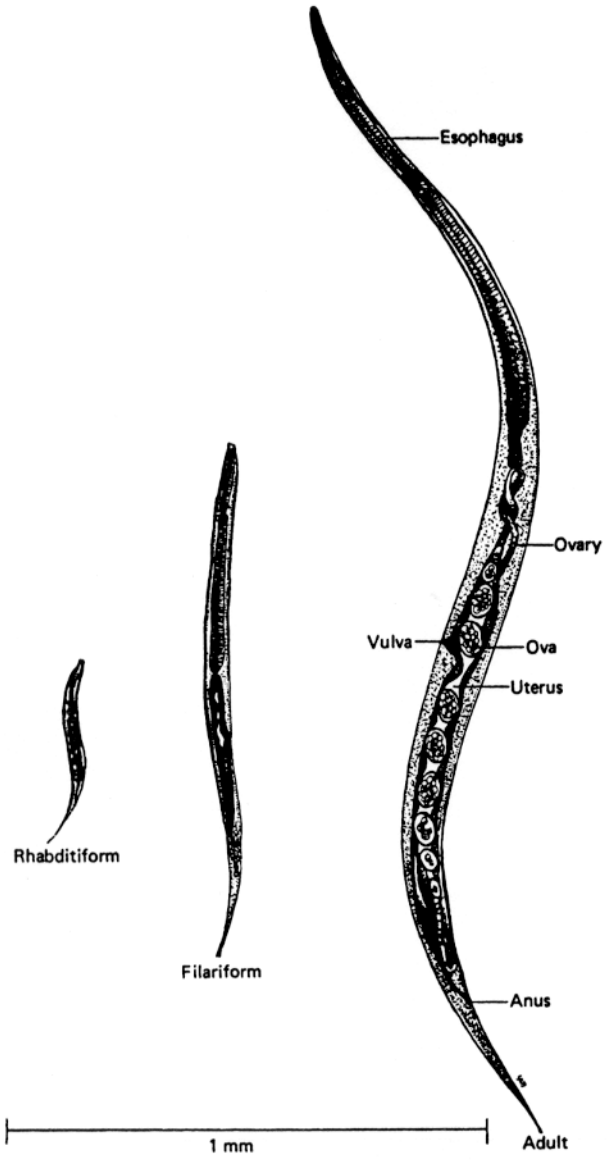
Female *Ascaris lumbricoides* worm and fertile and infertile egg.

FIGURE 4



Female hookworm (*Necator americanus*) and egg.

FIGURE 5



Strongyloides stercoralis worm and rhabditiform and filariform larvae.