General Features of Nematode

- Have elongated, cylindrical, smooth, unsegmented, flesh-colored bodies.
- Body is usually a pointed posterior end, and to a rounded anterior end
- The body is covered by resistant coating “the cuticle”
- They have complete digestive system with mouth, oesophagus, midgut and anus.
- All are separate sexes; the female is usually larger than the male.
- They are classified into 2 main categories according to their primary location:
  - Intestinal nematodes
  - Tissue nematodes (filariae)

MAIN FEATURES OF NEMATODES

	Intestinal Nematodes	Tissue Nematodes
Shape	Large size, Cylindrical	Elongated, Slender (slim)
Habitat	Most adult worms live in the intestinal tract	Inhabit either lymph vessels; or skin and subcutaneous tissues
Diseases	Diseases are diagnosed by identifying their characteristic eggs in stool	Diseases are diagnosed by demonstrating microfilariae in blood, in tissue or tissue fluids

MEDICALLY IMPORTANT NEMATODES.

Intestinal Nematodes	Tissue (Filarial worms)
1. *Enterobius vermicularis*	**I. Lymphatic filariae:**
2. *Ascaris lumbricoides*	1. *Wuchereria bancrofti*
3. **Hookworms** **Ancylostoma duodenale* **Necator americanus* **Strongyloides sterocoralis*	**II. Cutaneous filariae:** 1. *Loa loa* 2. *Onchocerca volvulus*
4. *Trichuris trichiuria*	
5. *Trichinella spiralis*	

Terminology In Nematode

- **Filariform larvae -** the 3rd or infective stage; Long, thread-like; Designed for penetration.
- **Rhabditiform larvae -** characterized by the presence of a muscular esophagus and bulbular pharynx. The worms leaving the egg are termed “rhabditiform” larvae.
- **Egg -** characteristic of the genus. Size & shape are relatively consistent.
- **Larvae -** undergo several molts (third stage usually the infective stage).
- **Adult -** varies in size from genus to genus; Range from less than 1 mm to over one meter.

Intestinal Nematodes

Enterobius vermicularis , Ascaris lumbricoides

Enterobius vermicularis

A pinworm ("threadworm") is a small, thin, white ,called *Enterobius vermicularis* that sometimes lives in the colon and rectum of humans. While an infected person sleeps, female pinworms leave the intestine through the anus and deposit their eggs on the surrounding skin.

A second species, *Enterobius gregorii*, has been described and reported from Europe, Africa, and Asia. For all practical purposes, the morphology, life cycle, clinical presentation, and treatment of *E. gregorii* is identical to *E. vermicularis*.

Transmission

Pinworm infection is spread by the fecal-oral route,either directly by hand or indirectly through contaminated clothing, bedding, food, or other articles.

Eggs become infective within a few hours after being deposited on the skin around the anus and can survive for 2 to 3 weeks on clothing, bedding, or other objects. People become infected by swallowing (ingesting) infective pinworm eggs that are on fingers, under fingernails, or on clothing, bedding, and other contaminated objects and surfaces. Because of their small size,eggs sometimes can become airborne and ingested while breathing.

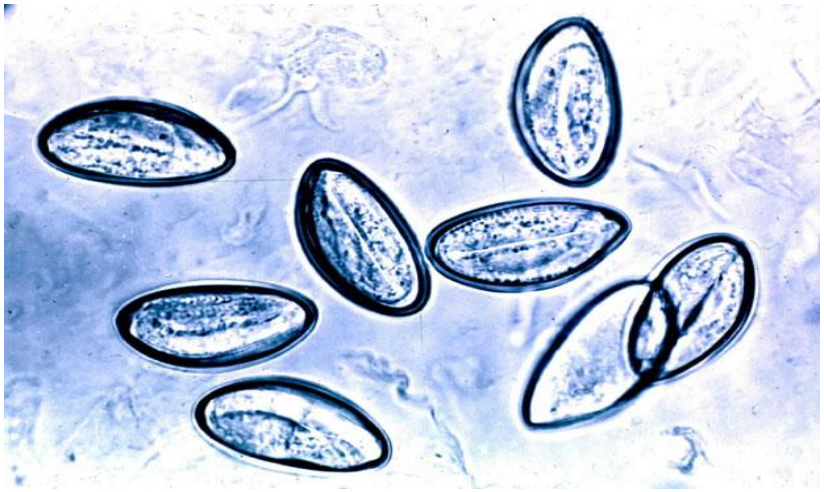
Epidemiology

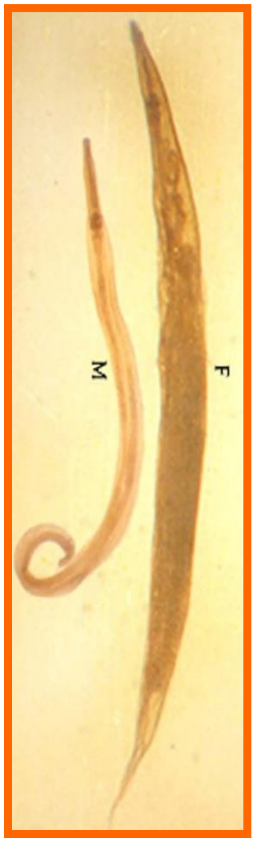
Pinworm infections are more common within families with school-aged children, in primary caregivers of infected children, and in institutionalized children.

These eggs are deposited around the anus by the worm and can be carried to common surfaces such as hands, toys, bedding, clothing, and toilet seats. By putting anyone's contaminated hands (including one's own) around the mouth area or putting one's mouth on common contaminated surfaces, a person can ingest pinworm eggs and become infected with the pinworm parasite. Since pinworm eggs are so small, it is possible to ingest them while breathing.

Once someone has ingested pinworm eggs, there is an incubation period of 1 to 2 months or longer for the adult gravid female to mature in the small intestine. Once mature, the adult female worm migrates to the colon and lays eggs around the anus at night,A person can also re-infect themselves, or be re-infected by eggs from another person.

- **Adults -** female: creamy white, ~ 8-13 mm long, with sharply pointed tails; Wing-like flaps (cervical alae) at head end; Male: small (2-5 mm) with strongly curved posterior.
- **Eggs -** 50 to 60 x 20 to 32 microns, broadly oval, and flattened on one side. Compressed laterally; Normally are embryonated (contain a larva).



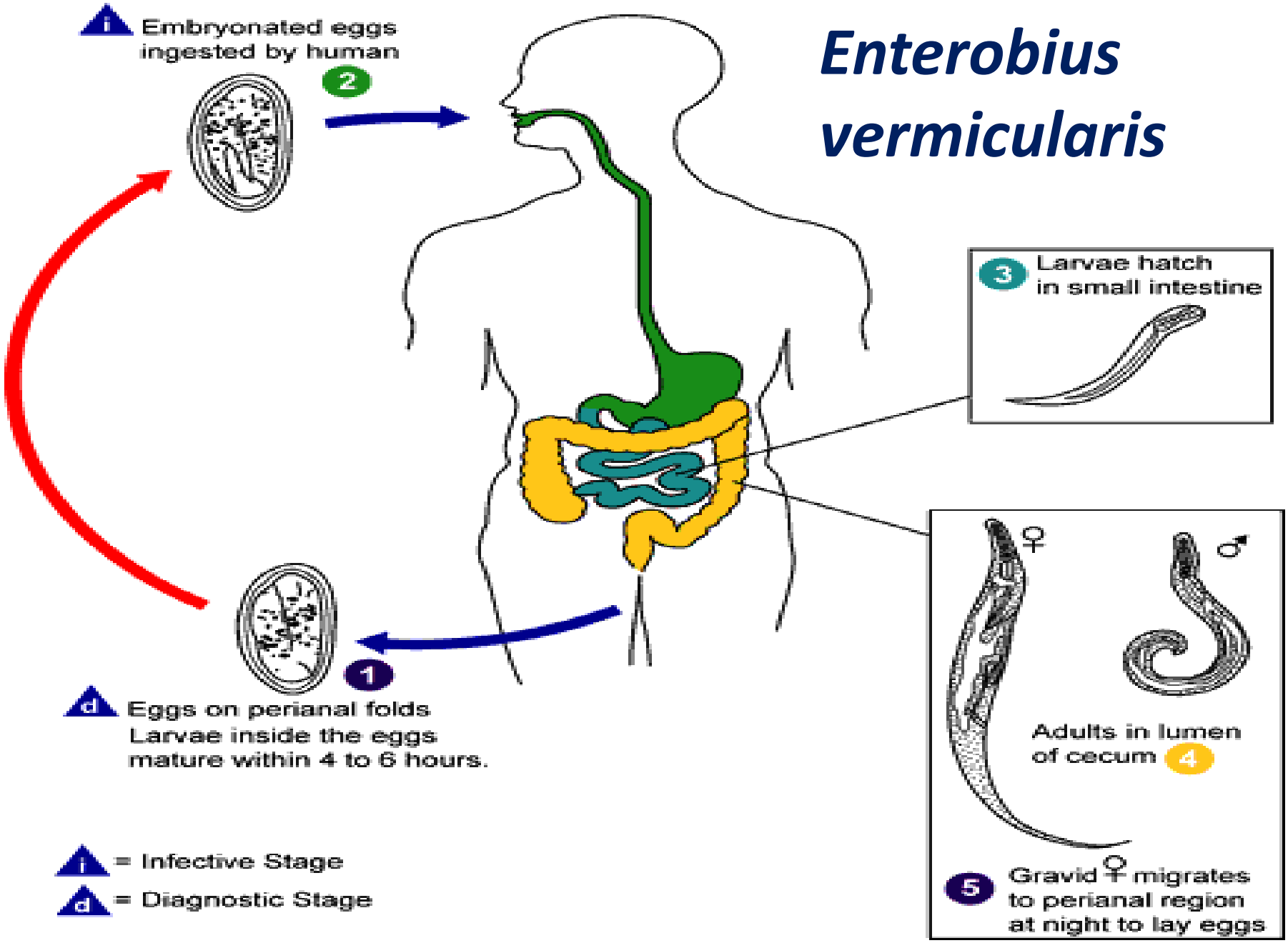


Life Cycle

Humans are considered to be the only hosts of *E. vermicularis*.

Eggs are deposited on perianal folds.Self-infection occurs by transferring infective eggs to the mouth with hands that have scratched the perianal area . Person-to-personcan occur transmission,contaminated clothes or bed linens. Enterobiasis may also be acquired through surfaces in the environment (e.g. , curtains, carpeting). Some small number of eggs may become airborne and inhaled. These would be swallowed and Following ingestion of infective eggs, the larvae hatch in the small intestine and the adults establish themselves in the colon . The time interval from ingestion of infective eggs to oviposition by the adult females is about one month. The life span of the adults is about two months. Gravid females migrate nocturnally outside the anus and oviposit while crawling on the skin of the perianal area . The larvae contained inside the eggs develop (the eggs become infective) in 4 to 6 hours under optimal conditions . Retroinfection, or the migration of newly hatched larvae from the anal skin back into the rectum, may occur but the frequency with which this happens is unknown .

Enterobius vermicularis



Clinical Signs

The most common clinical manifestation of a pinworm infection is an itchy anal region. When the infection is heavy, there can be a secondary bacterial infection due to the irritation and scratching of the anal area. Often the patient will complain of teeth grinding, and insomnia due to disturbed sleep, or even abdominal pain or appendicitis.

Sometimes, pinworm may migrate up the female reproductive tract, cause vaginitis, endometritis and granuloma in uterus and fallopian tubes. Occasionally, invasion of the female to the appendix, the peritoneal cavity or the urinary bladder may occur

Diagnosis

Diagnosis of pinworm can be reached from three simple techniques. The first option is to look for the worms in the perianal reqion 2 to 3 hours after the infected person is asleep. The second option is to touch the perianal skin with transparent tape to collect possible pinworm eggs around the anus first thing in the morning. If a person is infected, the eggs on the tape will be visible under a microscope. The tape method should be conducted on 3 consecutive mornings right after the infected person wakes up and before he/she does any washing. the third option for diagnosis is analyzing samples from under fingernails under a microscope.

Treatment

The medications used for the treatment of pinworm are mebendazole, pyrantel pamoate, and albendazole. All three of these drugs are to be given in 1 dose at first and then another single dose 2 weeks later. Pyrantel pamoate is available without prescription. the second dose is to prevent re-infection by adult worms that hatch from any eggs not killed by the first treatment.

Ascaris lumbricoides

Ascaris is an intestinal parasite of humans. The larvae and adult worms live in the small intestine and can cause intestinal disease.

Transmmision

Ascaris lives in the intestine and *Ascaris* eggs are passed in the feces of infected persons. or if the feces of an infected person are used as fertilizer, then eggs are deposited on the soil. They can then mature into a form that is infective. Ascariasis is caused by ingesting infective eggs. This can happen when hands or fingers that have contaminated dirt on them are put in the mouth or by consuming vegetables or fruits that have not been carefully cooked, washed or peeled.

Epidemiology

It is found in association with poor personal hygiene, poor sanitation, and in places where human feces are used as fertilizer.

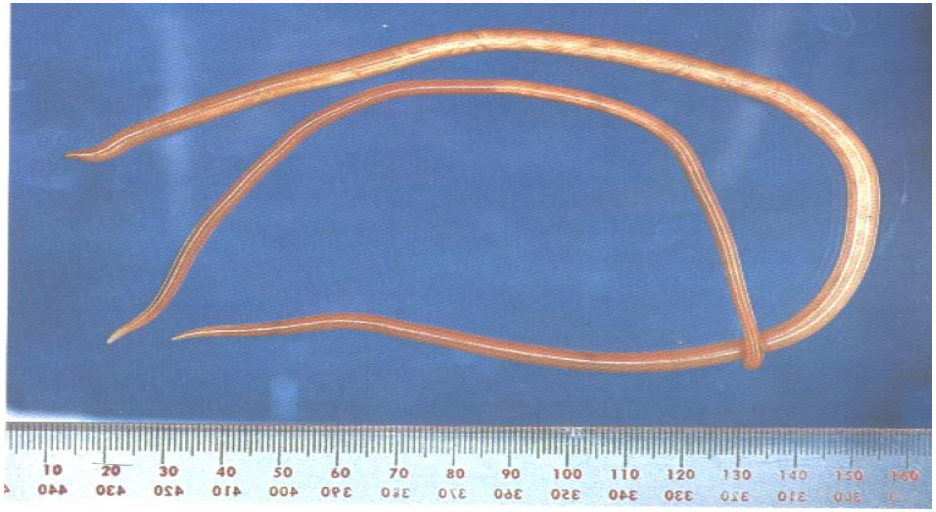
Geographic Distribution

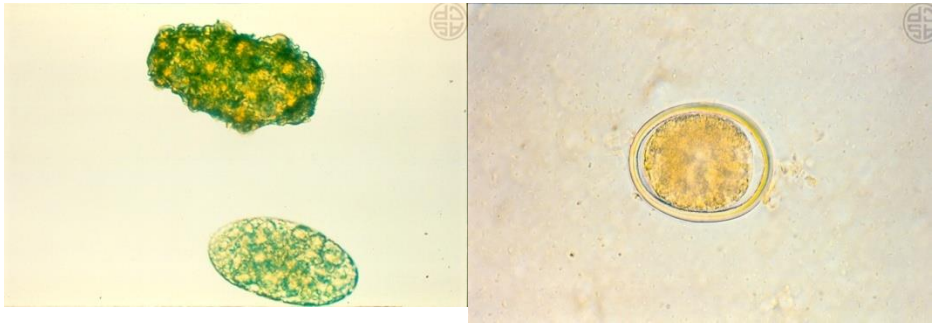
The geographic distributions of *Ascaris* are worldwide in areas with warm, moist climates and are widely overlapping. Infection occurs worldwide and is most common in tropical and subtropical areas where sanitation and hygiene are poor.

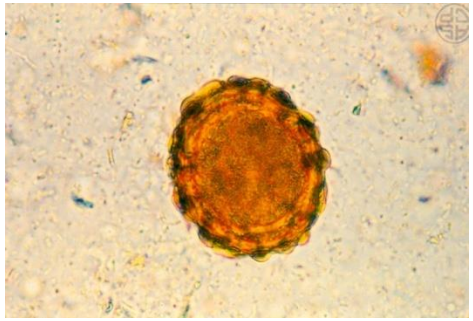
Ascaris lumbercoides

Morphology:

- **Adults -** males are 15 to 30 cm long, with strongly curved tails; females are 20 to 35 cm long, with straight tails.
- **Eggs -** one female produces 200,000 per day. The egg has an outer shell membrane which is heavily mamillated. This layer is sometimes rubbed off in passage down the fecal stream. Infertile eggs often appear longer, and thinner shelled.

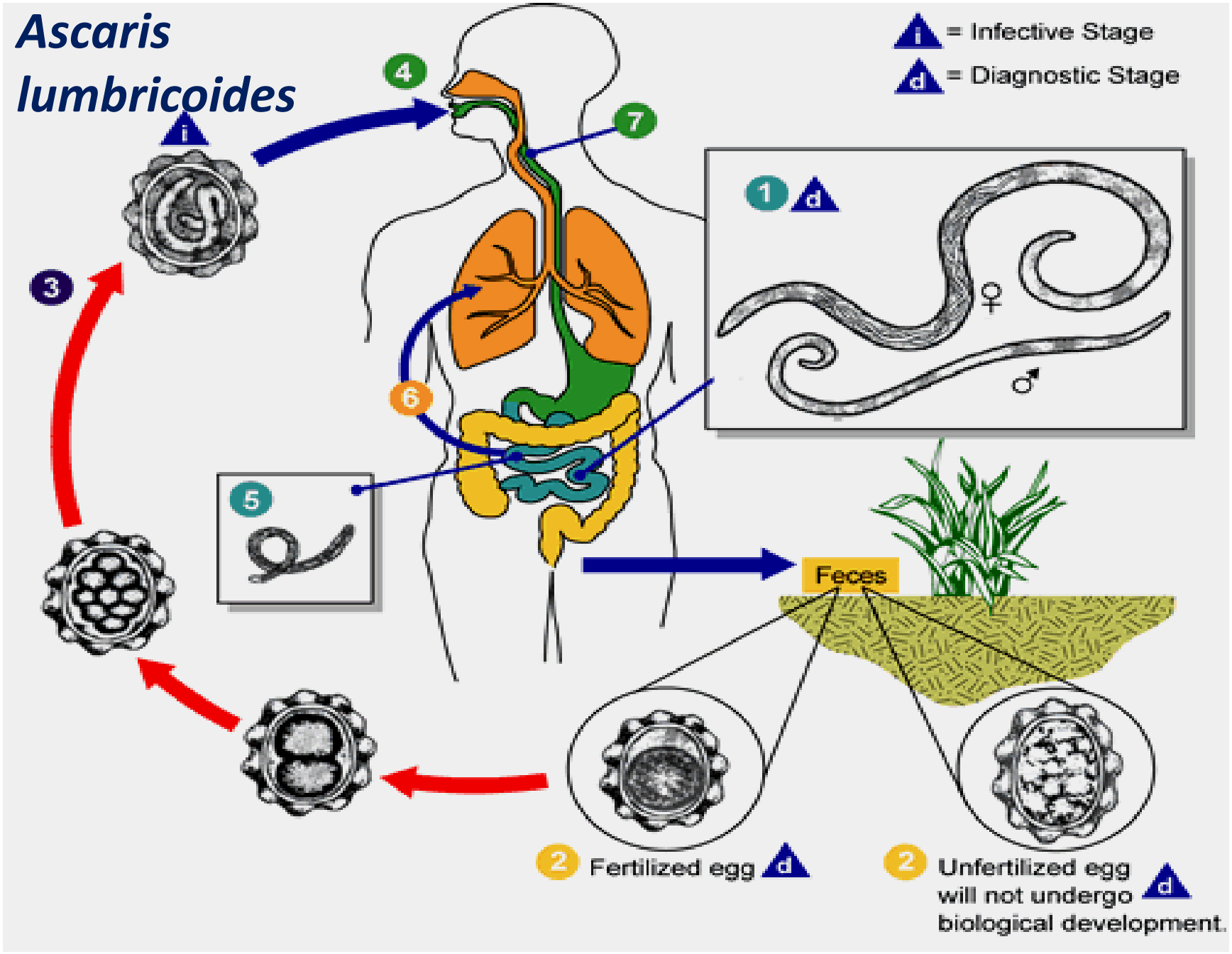






Life Cycle

Ascaris lumbricoides is the largest nematode (roundworm) parasitizing the human intestine. Adult worms live in the lumen of the small intestine. A female may produce approximately 200,000 eggs per day, which are passed with the feces . Unfertilized eggs may be ingested but are not infective. Fertile eggs embryonate and become infective after 18 days to several weeks , depending on the environmental conditions (optimum: moist, warm, shaded soil). After infective eggs are swallowed , the larvae hatch , invade the intestinal mucosa, and are carried via the portal, then systemic circulation to the lungs . The larvae mature further in the lungs (10 to 14 days), penetrate the alveolar walls, ascend the bronchial tree to the throat, and are swallowed . Upon reaching the small intestine, they develop into adult worms . Between 2 and 3 months are required from ingestion of the infective eggs to oviposition by the adult female. Adult worms can live 1 to 2 years.


Ascaris lumbricoides
i = Infective Stage
d = Diagnostic Stage
1 d
2 Fertilized egg d
2 Unfertilized egg will not undergo biological development. d
Feces

Symptoms

People infected with *Ascaris* often show no symptoms. If symptoms do occur they can be light and include abdominal discomfort. Heavy infections can cause intestinal blockage and impair growth in children. Other symptoms such as cough are due to migration of the worms through the body.

Diagnosis

The standard method for diagnosing ascariasis is by identifying *Ascaris* eggs in a stool sample using a microscope. Because eggs may be difficult to find in light infections, a concentration procedure is recommended.

Treatment

Antihelminthic medications (drugs that rid the body of parasitic worms), such as albendazole and mebendazole, are the drugs of choice for treatment of *Ascaris* infections. Infections are generally treated for 1-3 days. The drugs are effective and appear to have few side effects.

	Enterobius vermicularis	*Ascaris lumbricoides*
Name	**Pinworm, seat worm**	**Ascariasis, round worm**
Size	**Female 8-13 , male 2-5 mm**	**Female 20-35, male 15-30 cm**
Disease	**Enterobiasis**	**Ascariasis**
Geographical distribution	**Worldwide, most common in temperate regions and in crowded places**	**Worldwide; high prevalence in tropical and subtropical areas with inadequate sanitation, and where human feces are used as fertilizer**
Infective stage	**Embryonated egg**	**Embryonated egg**
Mode of infection	**Ingestion; or autoinfection via nails scratching the perianus**	**Ingestion of eggs in food contaminated with human feces**
Infection site	**Large intestine**	**Small intestine, lung**

	Enterobius vermicularis	*Ascaris lumbricoides*
Symptoms	**Perianal Pruritis, especially at night, appendicitis, abdominal pain, *invasion of girls' genital tract cause vaginitis, pelvic or peritoneal granulomas**	**Migrating worms cause occlusion of biliary tract or oral expulsion in lung it causes inflammation with pulmonary symptoms, e.g. cough, hemoptysis**
Identification	**Characteristic eggs collected mornings from perianal area using transparent adhesive tape adult worm may be found in perianal area or during vaginal examination**	**Characteristic eggs in feces, larvae identified in sputum or gastric aspirate adult worm may pass in stool.**
Treatment	**Pyrantel pamoate**	**Albendazole, Mebendazole, Pyrantel pamoate**

- The **hookworm** is a parasitic nematode worm that lives in the small intestine of its host, which may be infected to mammal such as a dog, cat, or human.
- Two species of hookworms commonly infect humans, ***Ancylostoma duodenale* and *Necator americanus*.**
- Hookworms are thought to infect 800 million people worldwide
- **Distribution:**
  A. duodenale - Europe and south America
  N. americanus - North America and Africa
  Moist, warm regions of the world where the skin frequently contacts the soil is optimal for infection, especially in areas of poor sanitation.

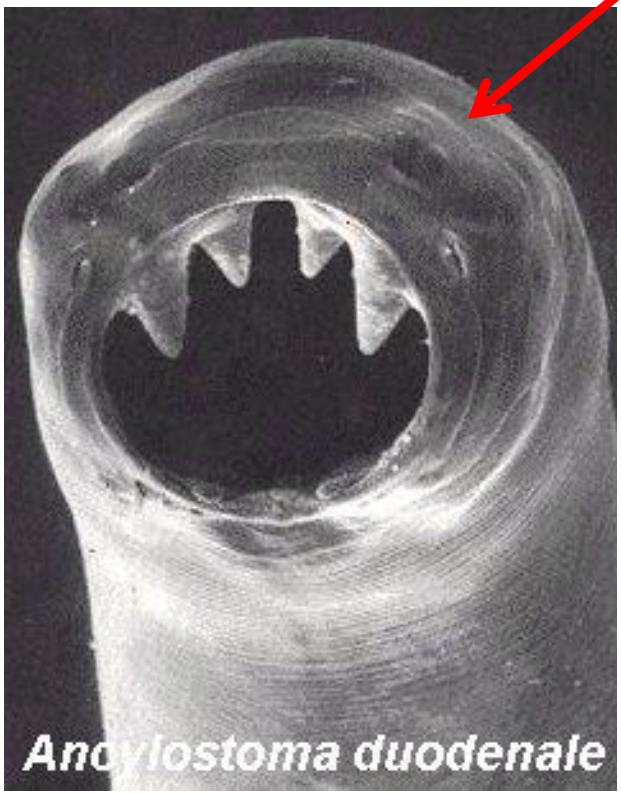
Transmission

Hookworm eggs are passed in the feces of an infected person. If an infected person defecates outside (near bushes, in a garden, or field) or if the feces from an infected person are used as fertilizer, eggs are deposited on soil. They can then mature and hatch, releasing larvae (immature worms). The larvae mature into a form that can penetrate the skin of humans. Hookworm infection is transmitted primarily by walking barefoot on contaminated soil.

Hookworms

Ancylostoma duodenale Old World hookworm

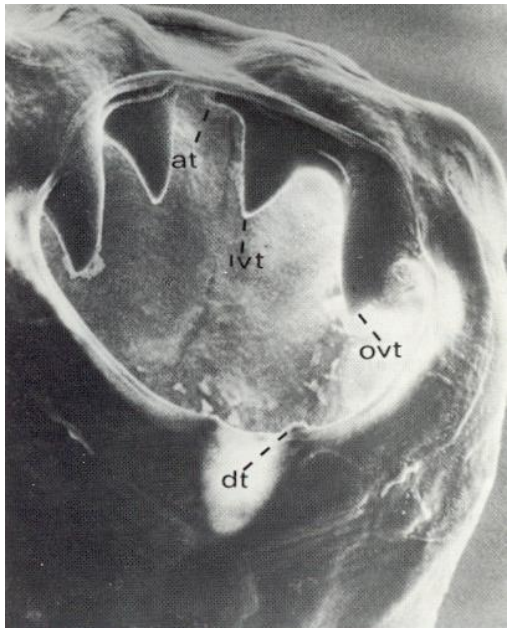
Necator americanus New world hookworm

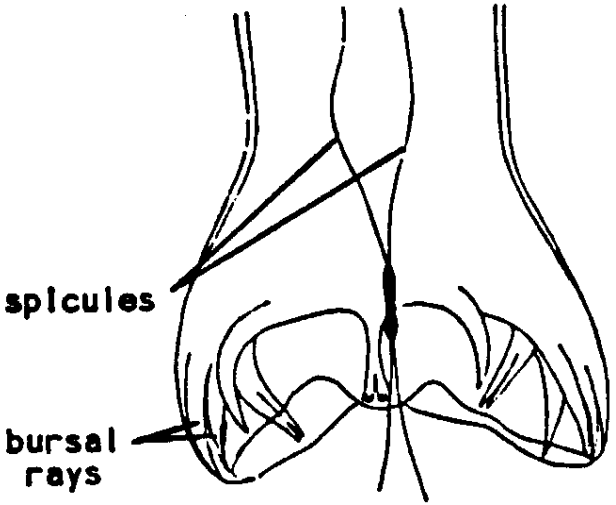


Morphology of *Ancylostoma duodenale*

Buccal capsule contains 2 pairs of large ventral (anterior) teeth

Copulatory bursa is at posterior end and contains 2 thin spicules that separate distally.

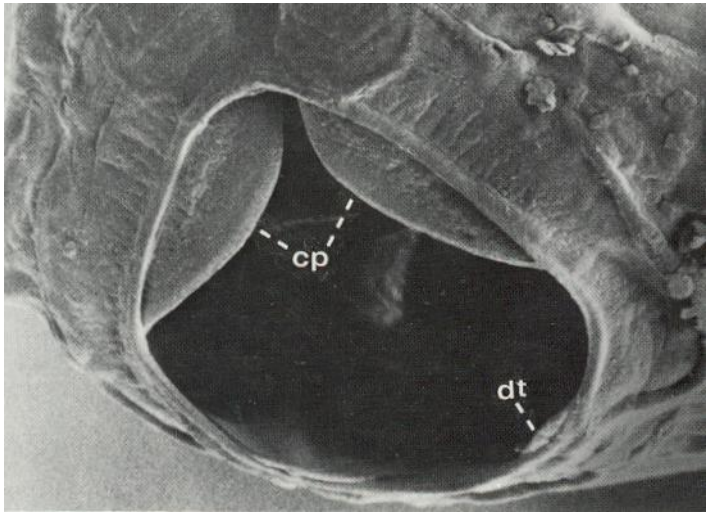


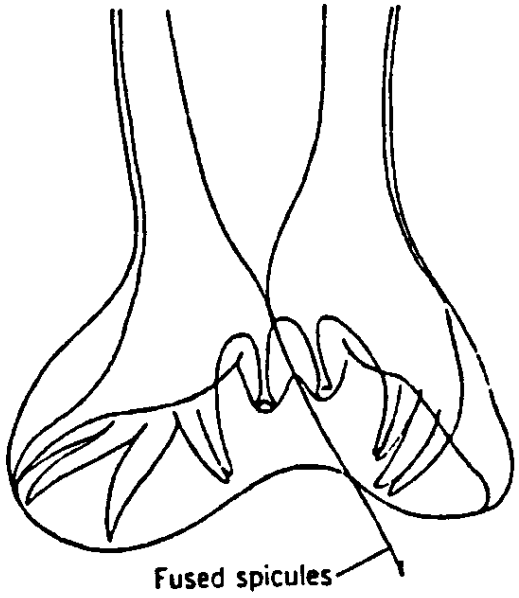


Morphology of *Necator americanus*

Buccal capsule contains a pair of ventral and dorsal cutting plates.

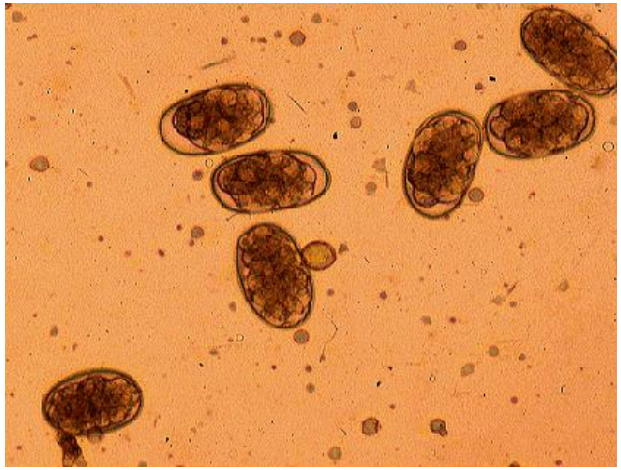
Copulatory bursa contains spicules that are fused distally.

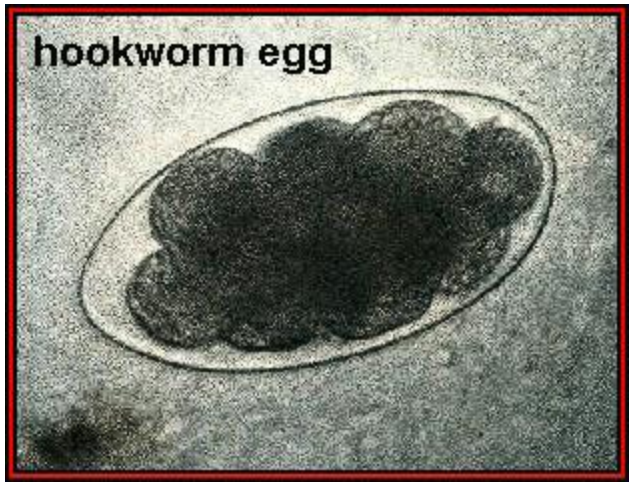


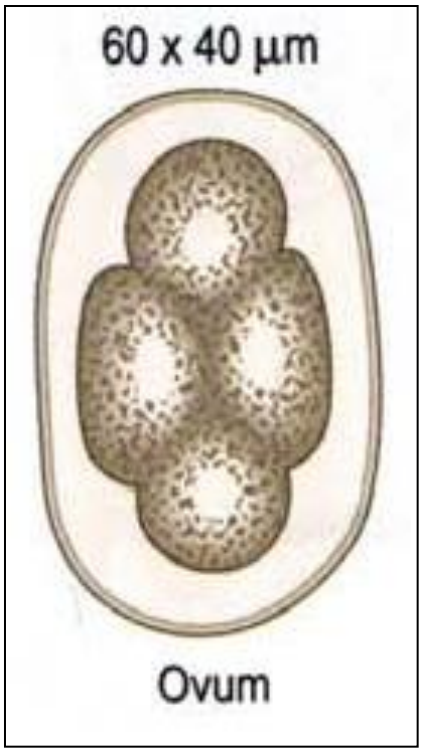


Egg

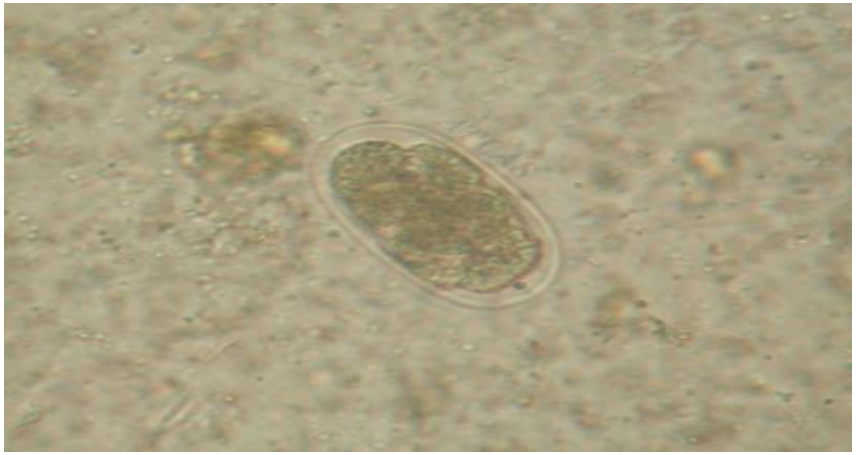
- **Shape** : oval with an empty space between the shell and content
- **Size**: 60 x 40 µm
- **Shell**: thin egg shell, and are almost indistinguish between the different species.
- **Color**: colorless and transparent
- **Content**: 4-8 cell unembryonated
- Immature eggs pass in feces (20,000 eggs / day).

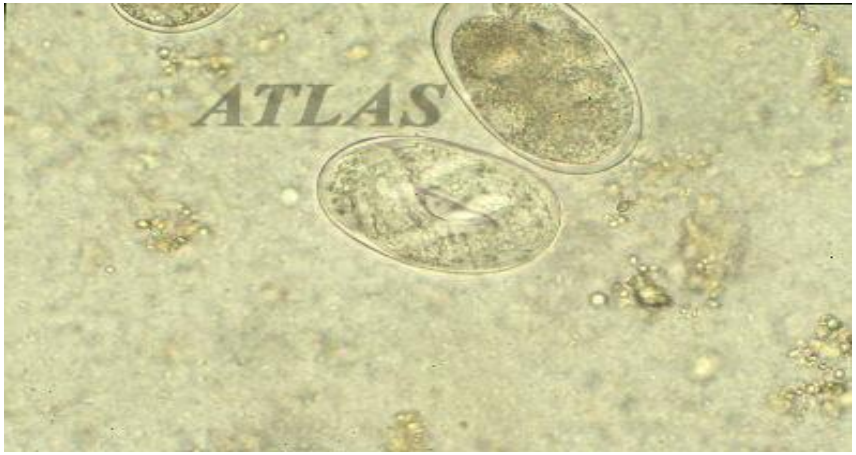






Hookworm eggs in the stool examination from the patient





Rhabditiform larva:

-thin

-size: 200-400µ

-long buccal cavity.

-rhabditiform oesophagus, very small genital

-pointed tail end.

Filariform larva:

-size: 600-700µ.

-cylindrical oesophagus(one third of the body length)

-sharply pointed tail

Filariform

Rhabditiform

The Morphological Differences between Two species of Hookworms

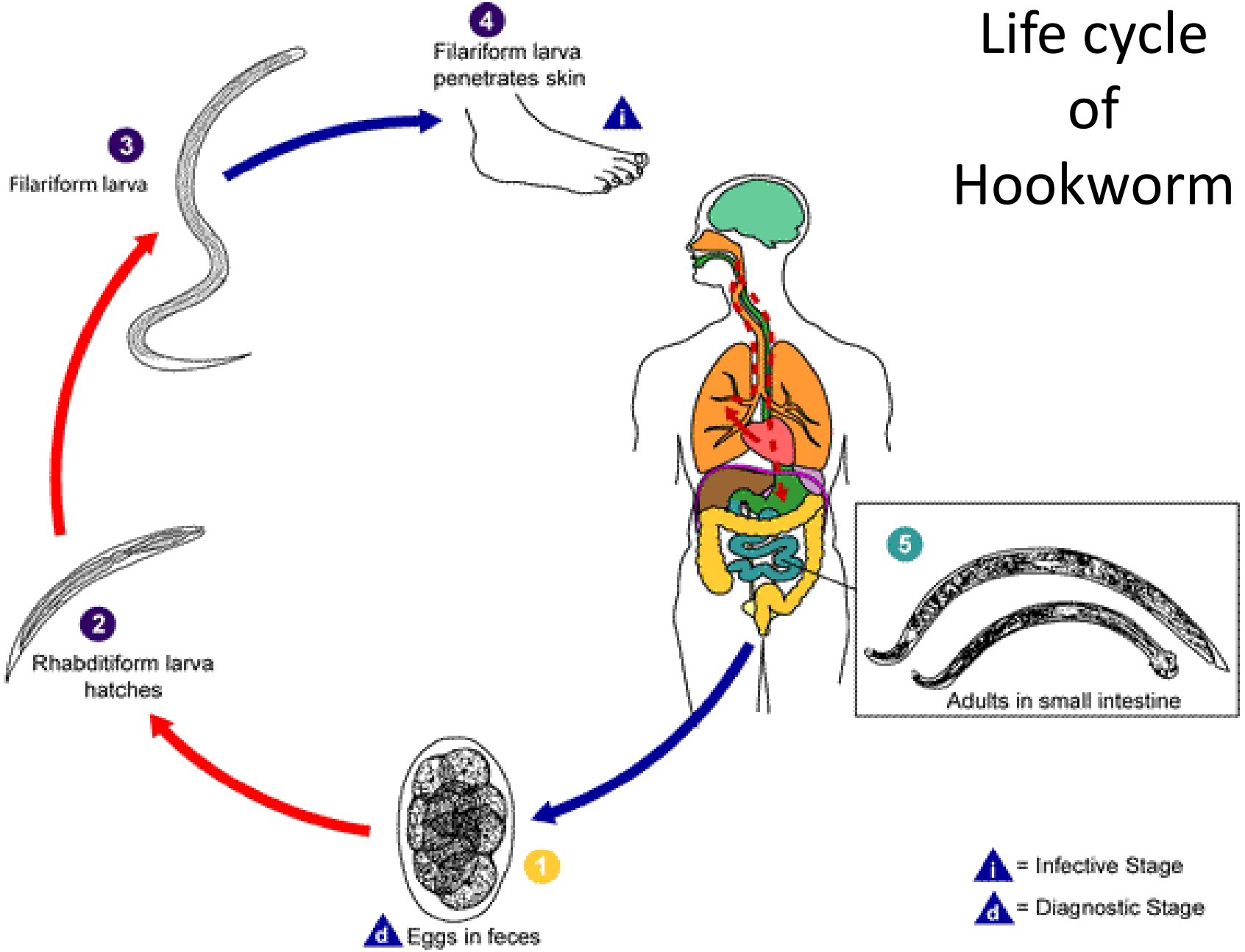
	A. duodenale	N. americanus
Size	larger	smaller
Shape	single curve, looks like C	double curves, looks like S
Mouth	2 pairs of ventral teeth	1peir of ventral cutting plates
Copulatory Bursa	circle in shape (a top view)	oval in shape (a top view)
Copulatory spicule	1pair with separate endings	1pair of which unite to form a terminal hooklet
caudal spine	present	no
vulva position	post-equatorial	pre-equatorial

Life Cycle

Eggs are passed in the stool , and under favorable conditions, larvae hatch in 1 to 2 days. The released rhabditiform larvae grow in the feces and/or the soil , and after 5 to 10 days (and two molts) they become filariform (third-stage) larvae that are infective . These infective larvae can survive 3 to 4 weeks in favorable environmental conditions. On contact with the human host, the larvae penetrate the skin and are carried through the blood vessels to the heart and then to the lungs. They penetrate into the pulmonary alveoli, to the pharynx, and are swallowed . The larvae reach the small intestine,Adult worms live in the lumen of the small intestine, where they attach to the intestinal wall with resultant blood loss by the host . Most adult worms are eliminated in 1 to 2 years, but the longevity may reach several years .

Some *A. duodenale* larvae, following penetration of the host skin, can become dormant (in the intestine or muscle). In addition, infection by *A. duodenale* may probably also occur by the oral and transmammary route. *N. americanus*, however, requires a transpulmonary migration phase.

Life cycle of Hookworm



Major pathology and symptoms:

- Serpent-like tunneling at site of penetration may occur (cutaneous larva migrans).
- During migration through the lungs, patients may experience a sore throat and / or bloody sputum.
- Heavy intestinal infections may result in enteritis, anemia, weakness, and loss of strength due to the anemia.
- Chronic infections may experience anemia, weakness, weight loss and gastro-intestinal symptoms.
- Nutritional and disease factors are commonly seen in endemic areas. Children may exhibit stunted growth and intellectual development.
- Blood loss can be up to 100 milliliters/day.

Diagnosis

The standard method for diagnosing the presence of hookworm is by identifying hookworm eggs in a stool sample using a microscope. Because eggs may be difficult to find in light infections, a concentration procedure is recommended.

Treatment

Anthelminthic medications such as albendazole and mebendazole, are the drugs of choice for treatment of hookworm infections. Infections are generally treated for 1-3 days. The recommended medications are effective and appear to have few side effects. Iron supplements may also be prescribed if the infected person has anemia.

Strongyloides stercoralis

Human parasitic disease caused by nematode S. Stercoralis,Mostly in tropical, subtropical area and temperate climate,has two unique life cycle: Free life cycle and Parasitic life cycle, Cause by direct contact with contaminated soil and recreational activities, Children highly affected to bad sanitation.

Epidemiology

Strongyloides most common in the tropics, subtropics, and in warm temperate regions. The global prevalence of *Strongyloides* is unknown, but experts estimate that there are between 30–100 million infected persons worldwide.

In the United States, a series of small studies in select populations have shown that between 0-6.1% of persons sampled were infected. Studies in immigrant populations have shown a much higher percentage of infected persons ranging from 0-46.1%.

Morphology

Egg:

Size : 55 x 30 um.

Shape: oval . Clear, thin shelled Similar to hookworm but are smaller.

Eggs are laid in the mucosa, hatch into rhabditiform larvae and pass into the lumen of the intestine and out the feces

Morphology

Parasitic female:

- 2.2 mm in length
- Cylindrical oesophagus (1/3 body length)
- Posterior end straight

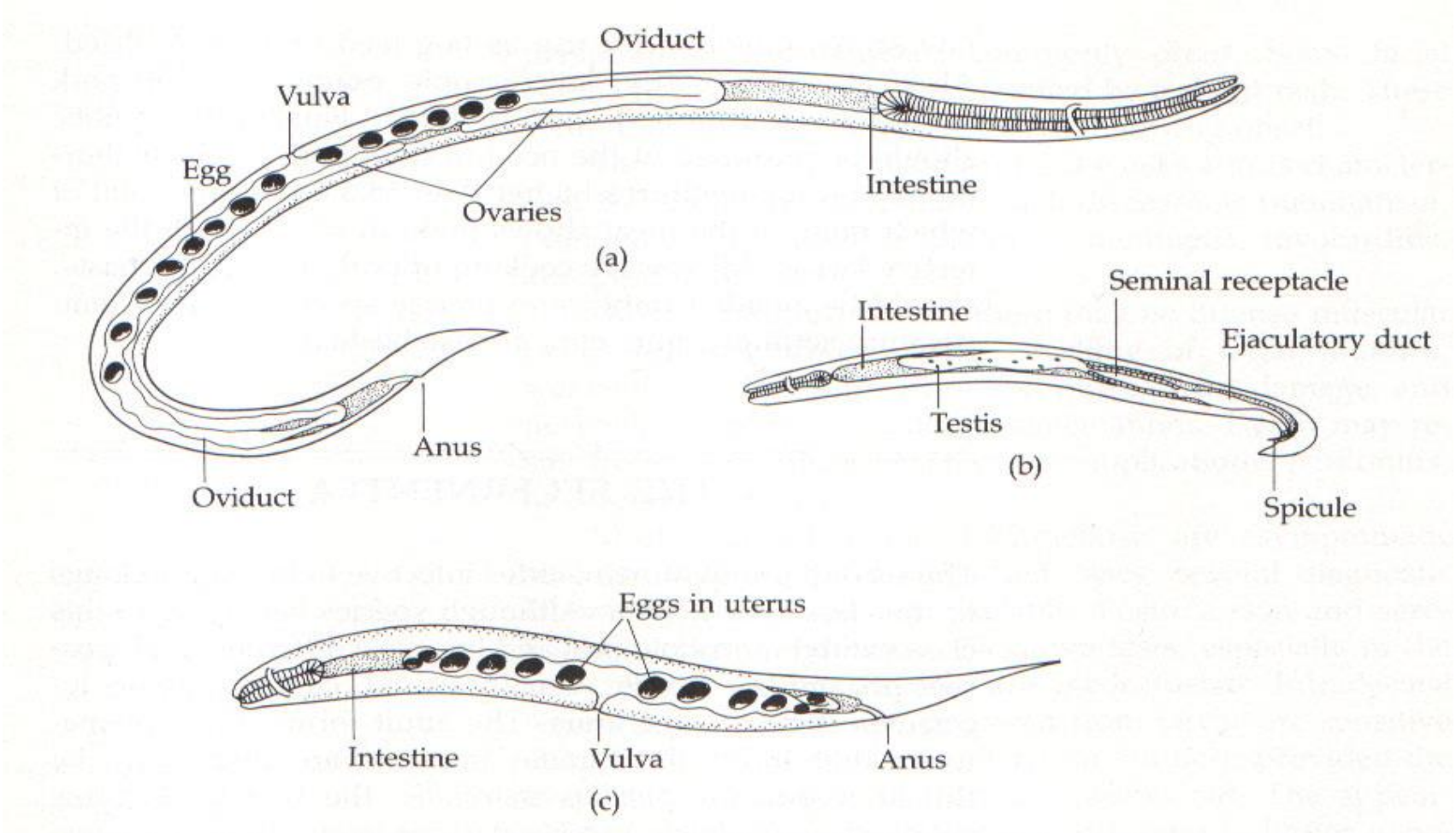
Free living female:

- 1 mm in length
- rhabditiform oesophagus
- posterior end straight

Adult: Male (parasitic or free-living):

- 0.7 mm in length
- Rhabditiform oesophagus
- Posterior end curved ventrally with Spicules

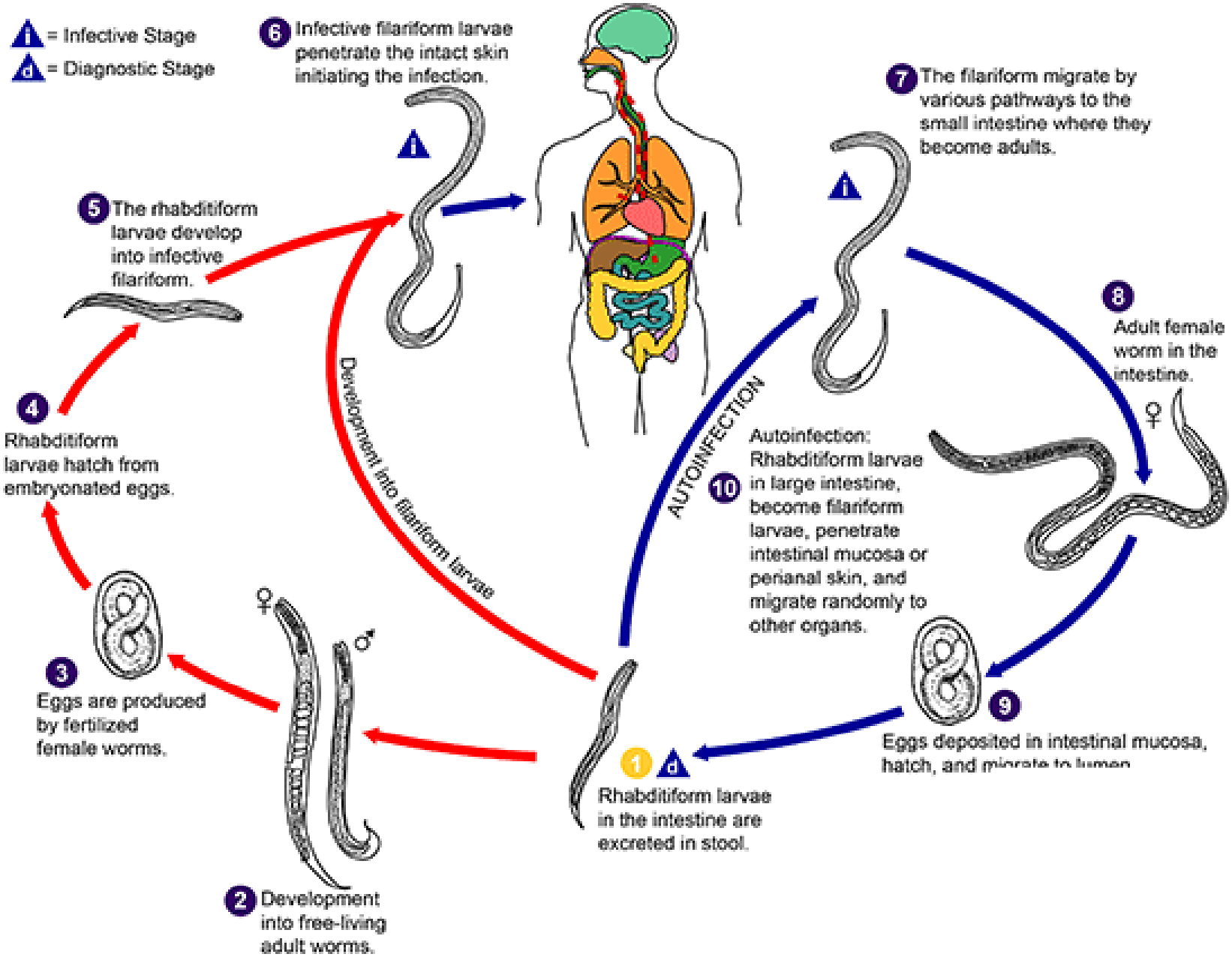
Morphology of *Strongyloides stercoralis*



a) parasitic female b) free-living male c)free-living female

Life Cycles

The *Strongyloides* life cycle is more complex than that of most nematodes with its alternation between free-living and parasitic cycles,. Two types of cycles exist: **Free-living cycle:** The rhabditiform larvae passed in the stool (see "Parasitic cycle" below) can either become infective filariform larvae (direct development) or free living adult males and females that mate and produce eggs from which rhabditiform larvae hatch . and become infective filariform larvae . The filariform larvae penetrate the human host skin to initiate the parasitic cycle (see below) . **Parasitic cycle:** Filariform larvae in contaminated soil penetrate the human skin , and by various, often random routes, migrate into the small intestine . it was believed that the L3 larvae migrate via the bloodstream to the lungs, where they are coughed up and swallowed. However, there is also evidence that L3 larvae can migrate directly to the intestine via connective tissues. In the small intestine they molt twice and become adult female worms . The females live threaded in the epithelium of the small intestine and by parthenogenesis produce eggs , which yield rhabditiform larvae. The rhabditiform larvae can either be passed in the stool (see "Free-living cycle" above), or can cause autoinfection . In autoinfection, the rhabditiform larvae become infective filariform larvae, which can penetrate either the intestinal mucosa (internal autoinfection) or the skin of the perianal area (external autoinfection); in either case, the filariform larvae may disseminate throughout the body .


i = Infective Stage
d = Diagnostic Stage
6 Infective filariform larvae penetrate the intact skin initiating the infection.
7 The filariform migrate by various pathways to the small intestine where they become adults.
5 The rhabditiform larvae develop into infective filariform.
8 Adult female worm in the intestine.
♀
4 Rhabditiform larvae hatch from embryonated eggs.
Development into filariform larvae
AUTOINFECTION
10 Autoinfection: Rhabditiform larvae in large intestine, become filariform larvae, penetrate intestinal mucosa or perianal skin, and migrate randomly to other organs.
3 Eggs are produced by fertilized female worms.
♀
♂
9 Eggs deposited in intestinal mucosa, hatch, and migrate to lumen
1 d Rhabditiform larvae in the intestine are excreted in stool.
2 Development into free-living adult worms.

Clinical Signs

Most people infected with *Strongyloides* do not know they're infected. If they do feel sick the most common complaints are the following:

- Abdominal

stomachache, bloating, and heartburn,intermittent episodes of diarrhea and constipation,nausea and loss of appetite

- Respiratory

dry cough,throat irritation

- Skin

an itchy, red rash that occurs where the worm entered the skin
recurrent raised red rash typically along the thighs and buttocks.
Rarely, severe life-threatening forms of the disease called hyperinfection syndrome and disseminated strongyloidiasis can occur.

Diagnosis

The gold standard for the diagnosis of *Strongyloides* is serial stool examination.Specialized stool exams include Baermann concentration, Horadi-Mori filter paper culture, quantitative acetate concentration technique, and nutrient agar plate cultures. Duodenal aspirate is more sensitive than stool examination, and duodenal biopsy may reveal parasites in the gastric crypts, in the duodenal glands, larvae can be seen by a simple wet-mount in fluid from a bronchoalveolar lavage (BAL).

Treatment

Treatment for strongyloidiasis is recommended for all persons found to be infected, whether symptomatic or not, due to the risk of developing hyperinfection syndrome and/or disseminated strongyloidiasis. **Ivermectin**, in a single dose, 200 µg/kg orally for 1-2 days.