Intestinal Nematodes

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SYSTEMIC CLASSIFICATION

Characteristics	*Class Adenophorea*	*Class Secernentea*
Sensory structure (phasmids)	Absent	Present
Esophagus	Modified with presence of: • Gland cells (stichocytes) or • Reserve organ (trophosome)	Normal appearance
Excretory organs	Without lateral canals	Lateral canals present
Caudal papillae	Absent	Present
Infective form to the definitive host	First stage larva (*Trichinella*) or embryonated eggs (*Trichuris, Capillaria*)	Third stage larva or embryonated eggs (e.g. all other nematodes)

SYSTEMIC CLASSIFICATION (cont..)

Superfamily	*Family*	*Genus*
Class: Adenophorea		
Trichinelloidea	Trichinellidae	*Trichinella*
	Trichuridae	*Trichuris, Capillaria*

Superfamily	*Family*	*Genus*
Class: Secernenatea		
Oxyuroidea	Oxyuridae	*Enterobius*
Ascaridoidea	Ascarididae	*Ascaris, Toxocara, Baylisascaris, Lagochilascaris*
	Anisakidae	*Anisakis*
Ancylostomatoidea	Ancylostomatidae	*Ancylostoma, Necator*
Rhabditoidea	Strongyloididae	*Strongyloides*
Strongyloidea	Chabertiidae	*Oesophagostomum, Ternidens*
	Syngamidae	*Mammomonogamus*
Gnathostomatoidea	Gnathostomatidae	*Gnathostoma*
Metastrongyloidea	Angiostrongylidae	*Angiostrongylus*
Trichostrongyloidea	Trichostrongylidae	*Trichostrongylus*
Filarioidea	Onchocercidae	*Wuchereria, Brugia, Loa loa, Onchocerca, Mansonella, Dirofilaria*
Dracunculoidea	Dracunculidae	*Dracunculus*
Thelazioidea	Thelaziidae	*Thelazia*
Dioctophymatoidea	Dioctophymatidae	*Dioctophyme*

Classification based on habitat

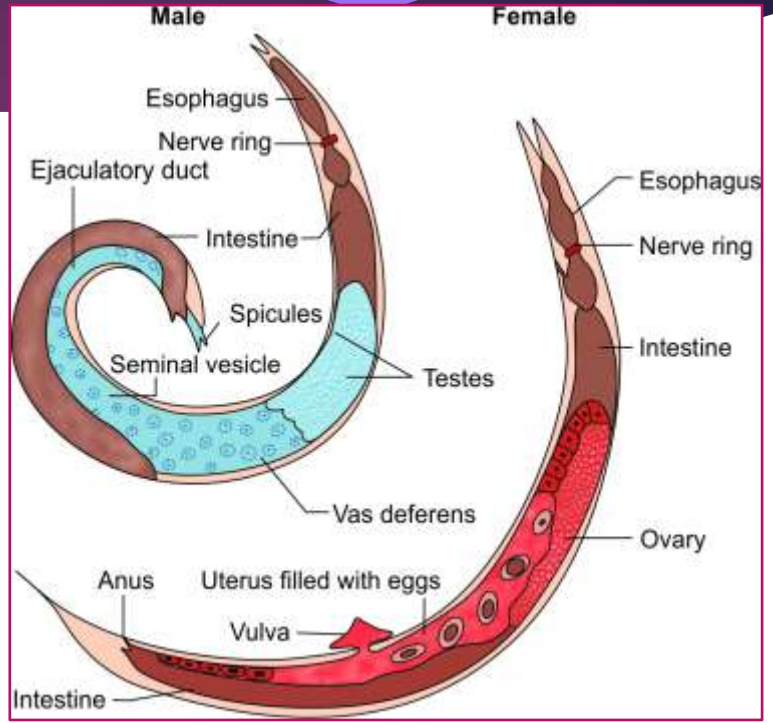
Intestinal human nematodes	*Somatic human nematodes*	*Animal nematodes that rarely infect man*	
		Larva migrans	*Other animal nematodes*
Small intestine *Ascaris lumbricoides* (common roundworm) *Ancylostoma duodenale* (old world Hookworm) *Necator americanus* (American or new world Hookworm) **Large intestine** *Trichuris trichiura* (whipworm) *Enterobius vermicularis* (threadworm or pinworm)	**Filarial worm** (1) ***Lymphatics*** *Wuchereria bancrofti* *Brugia malayi* *Brugia timori* (2) ***Skin*** *Loa loa* (also eye) *Onchocerca* (also eye) *Mansonella streptocerca* *Mansonella ozzardi* (Serous cavity) (3) ***Serous cavity*** *Mansonella perstans* **Other human somatic nematodes** *Trichinella spiralis* *Dracunculus medinensis* (Guinea worm)	**Visceral larva migrans** *Toxocara* (Liver) *Angiostrongylus cantonensis* (CNS) *Angiostrongylus costaricensis* (abdomen) *Anisakis* *Gnathostoma* *Baylisascaris* **Cutaneous larva migrans** *Ancylostoma braziliensis* *Ancylostoma caninum* *Ancylostoma ceylanicum* *Gnathostoma* species *Uncinaria stenocephala* *Bunostomum* species	**Zoonotic filariasis** *Dirofilaria* **Intestine** *Capillaria philippinensis* *Trichostrongylus* species *Strongyloides fuelleborni* *Oesophagostomum* *Ternidens* species **Conjunctiva** *Thelazia* species **Liver** *Capillaria hepatica* **Kidney** *Dioctophyma* species **Respiratory tract/lungs** *Mammomonogammus* *Capillaria aerophila* *Ascaris suum*

Classification based on they lay egg or larva

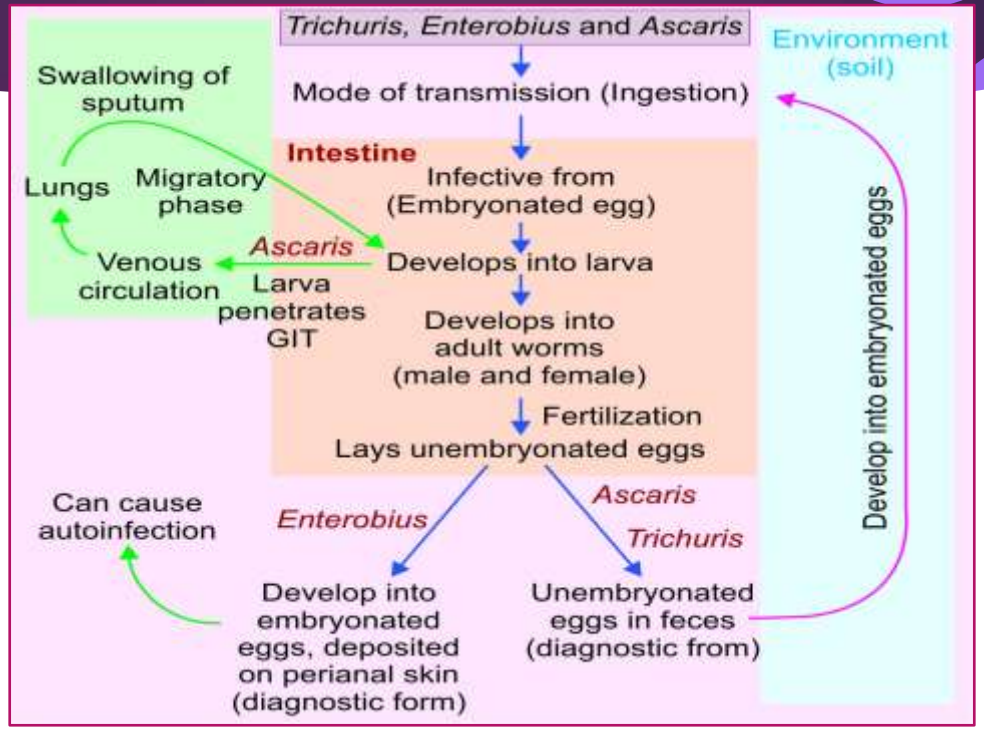
- **Oviparous:** Most of the intestinal nematodes are oviparous except *Strongyloides*. Examples include hookworm, *Ascaris, Trichuris, Enterobius, etc.*
- **Viviparous:** Most of the somatic nematodes are viviparous. Examples include filarial worm, *Trichinella and Dracunculus*
- **Ovoviviparous:** Example includes *Strongyloides species*

MORPHOLOGY

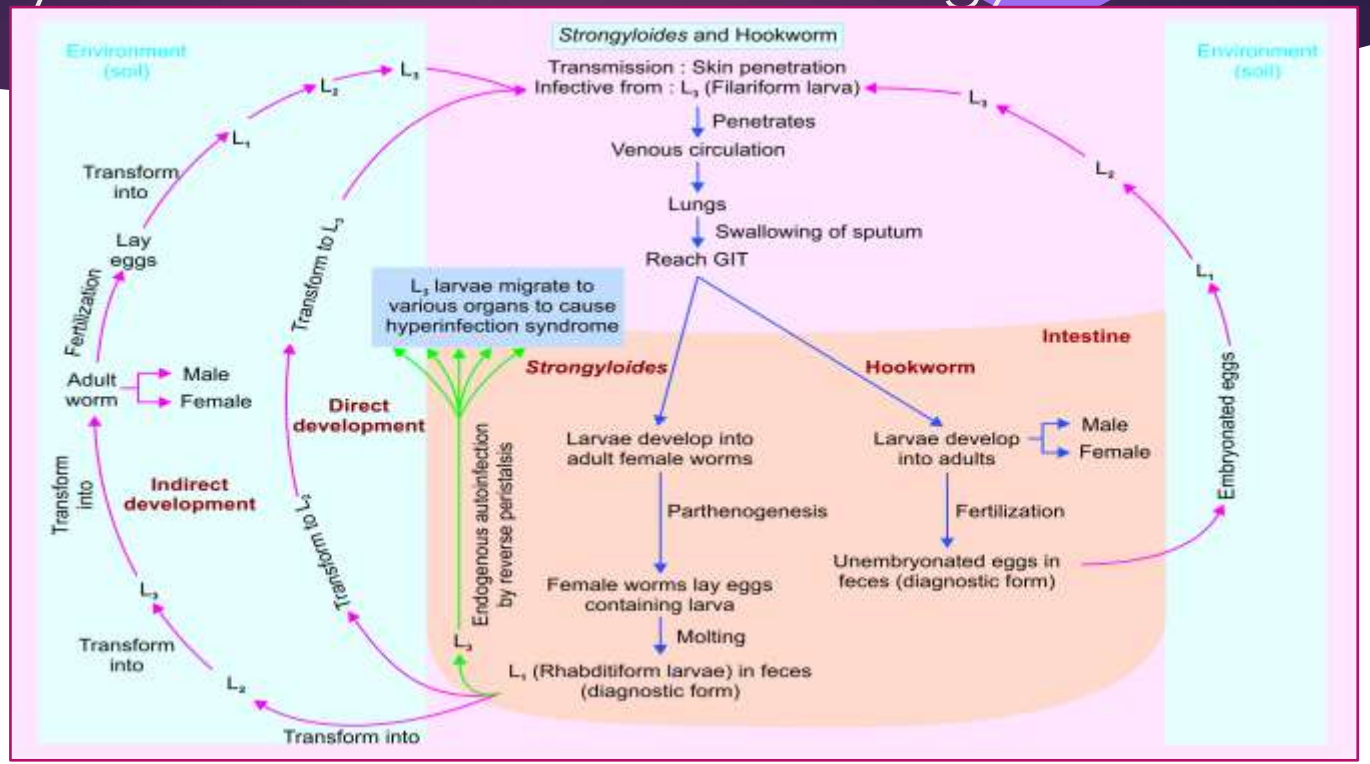
- Adult male and female nematode



Life cycles of Trichuris, Enterobius and Ascaris



Life cycles of Hook worm and *Strongyloides*



LARGE INTESTINAL NEMATODES TRICHURIS TRICHIURA

- **Whipworm**
- One of the soil-transmitted helminth

TRICHURIS TRICHIURA

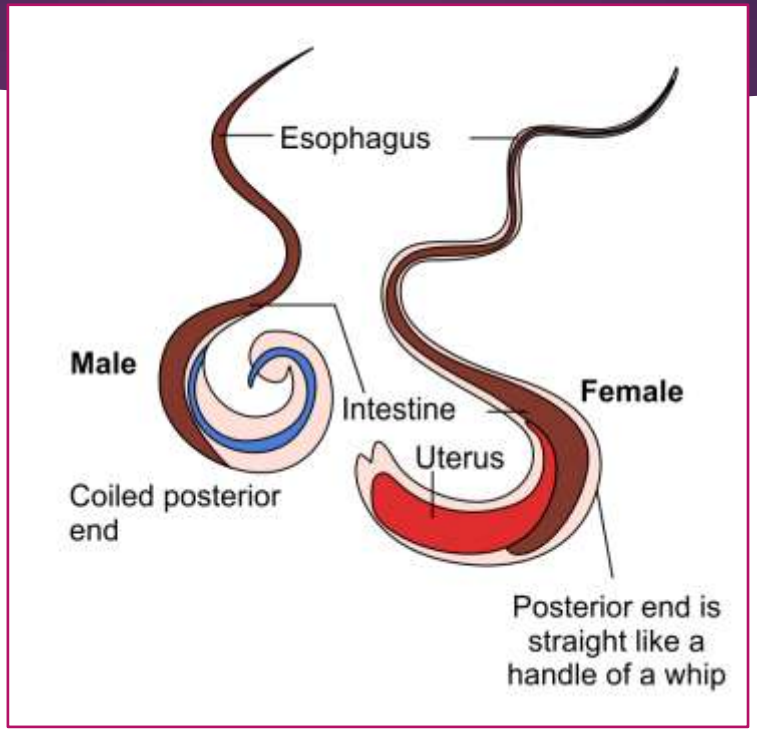
Habitat:

- *T. trichiura resides in the large intestine of man (mainly cecum and appendix).*

Epidemiology

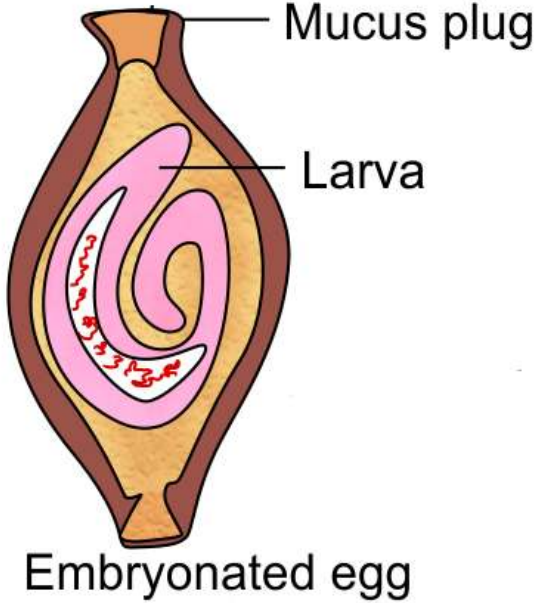
- Trichuriasis is worldwide in distribution, mainly in warm and moist climate similar to ascariasis.
- Children are commonly affected
- Global prevalence in humans is approximately 604 million.

Morphology
Adult worm

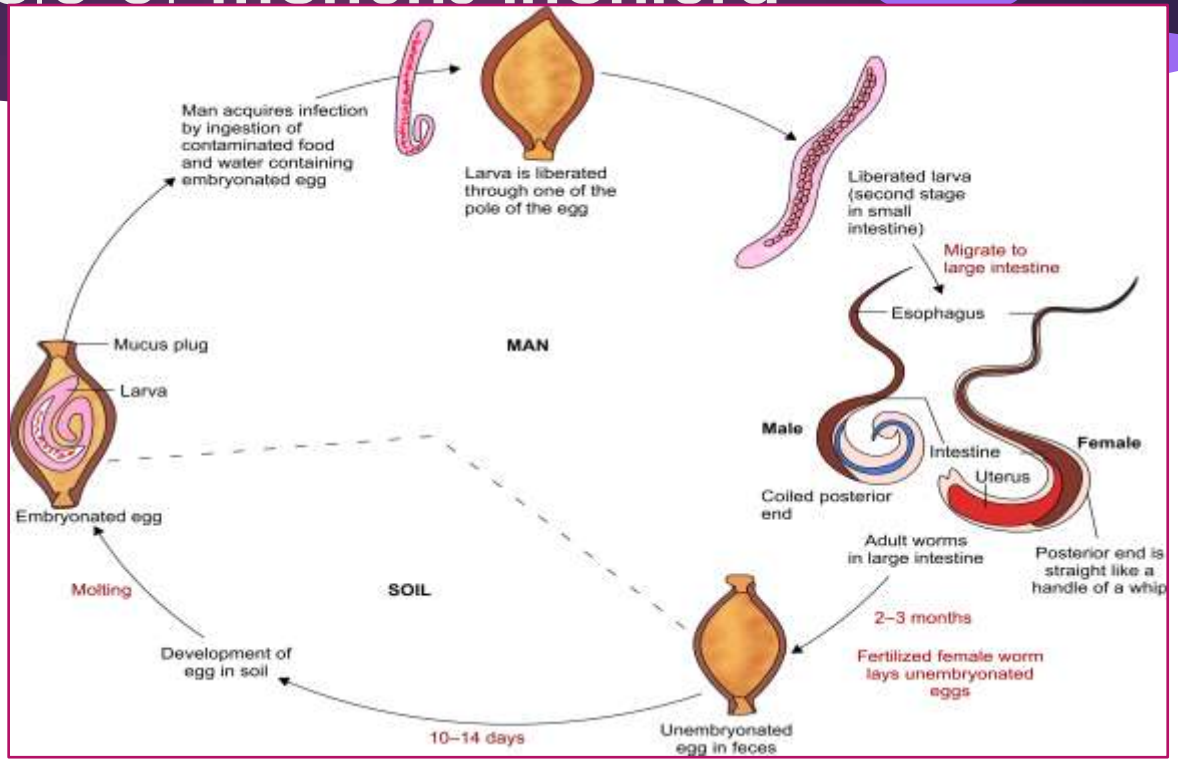


Morphology
EGG

- Barrel-shaped, surrounded by a shell, bear mucus plug at both the poles.
- 50–54 µm long and 22–23 µm wide
- Bile stained
- Float in saturated salt solution.



Life cycle of **Trichuris trichiura**



Pathogenicity and Clinical feature

- Incubation period varies from 70 to 90 days.
- Most infected individuals are asymptomatic, with or without having eosinophilia.
- **In people with heavy infections:** Mechanical distortion: leading to inflamed, edematous, and friable mucosa
- Allergic response by the host

Pathogenicity and Clinical feature

- **Common manifestations include:**
- Abdominal pain, anorexia, etc.
- *Trichuris dysentery syndrome*
- Iron deficiency anemia
- Recurrent rectal prolapse
- Growth retardation and impaired cognitive function

Laboratory diagnosis

- **Stool Examination -** Because the level of egg output is high (approximately 200 eggs/g of feces per worm pair), microscopic examination of a single fecal smear is sufficient for diagnosis of symptomatic cases

Trichuris trichiura (A) Egg in saline mount; (B) Adult female

Laboratory diagnosis

Other Findings:

- Peripheral blood eosinophilia (<15%)
- Increased serum IgE level.

Treatment

- Mebendazole (500 mg once) or albendazole (400 mg daily for three doses) is safe and moderately effective for treatment, with cure rates of 70%
- Ivermectin (200 mg/kg daily for three doses) is also safe but is less effective.

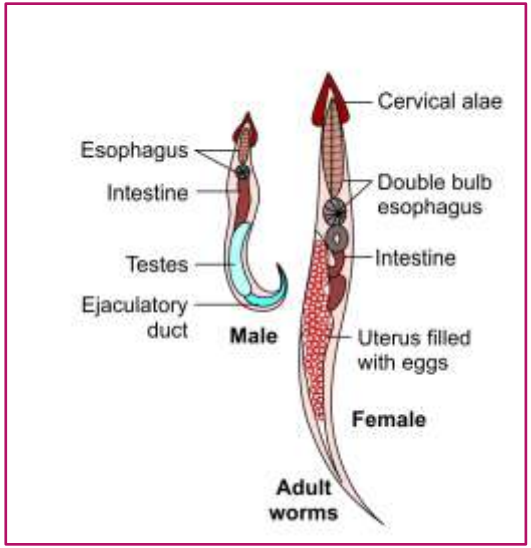
ENTEROBIUS VERMICULARIS

- *Enterobius vermicularis is also called as* ***pinworm or threadworm.***
- **Habitat - A**dult worm remains attached to the large intestine (cecum, appendix and adjacent portion of colon) by their mouth end.

Epidemiology

- The prevalence is maximum in school children between
- the age of 5 and 14 years
- People carry the infection for years together due to auto infective cycles
- **Factors promoting infection: Overcrowding and** impaired hygiene, poor personal care

Morphology- Adult worm



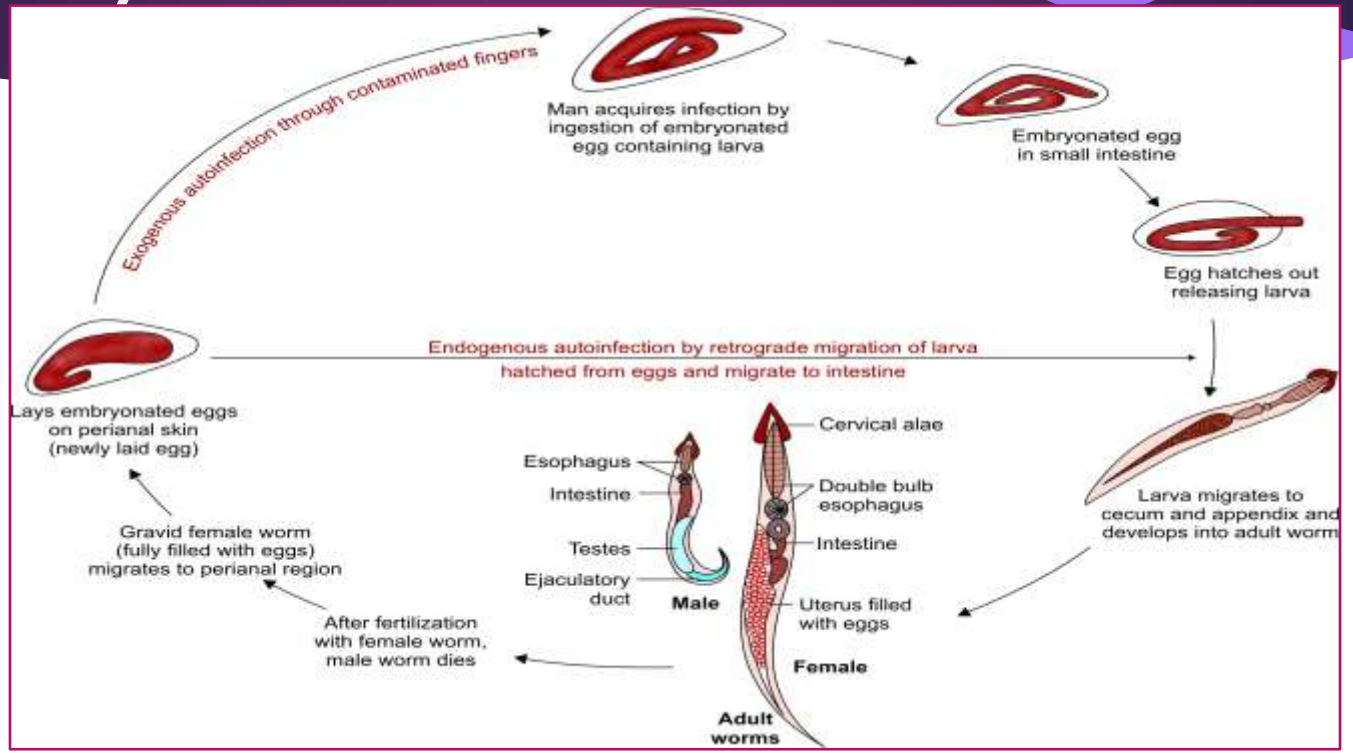
Morphology- Eggs

- Oval or spindle convex
- 50–60 µm long × 20–30 µm wide
- Double layered egg shell
- Non bile-stained, colorless in saline mount
- Embryonated egg - tadpole shaped larva inside
- Floats in saturated salt solution.

Life Cycle

- **Host: Humans are the only host.**
- **Infective form: Embryonated eggs are infec tive to man.**
- **Mode of transmission: Man (usually children) acquires** infection by:
  - Ingestion of eggs contaminated with fingers due to
  - inadequate hand washing or nail biting habit
  - **Autoinfection:** Endogenous autoinfection or Exogenous autoinfection

Life Cycle



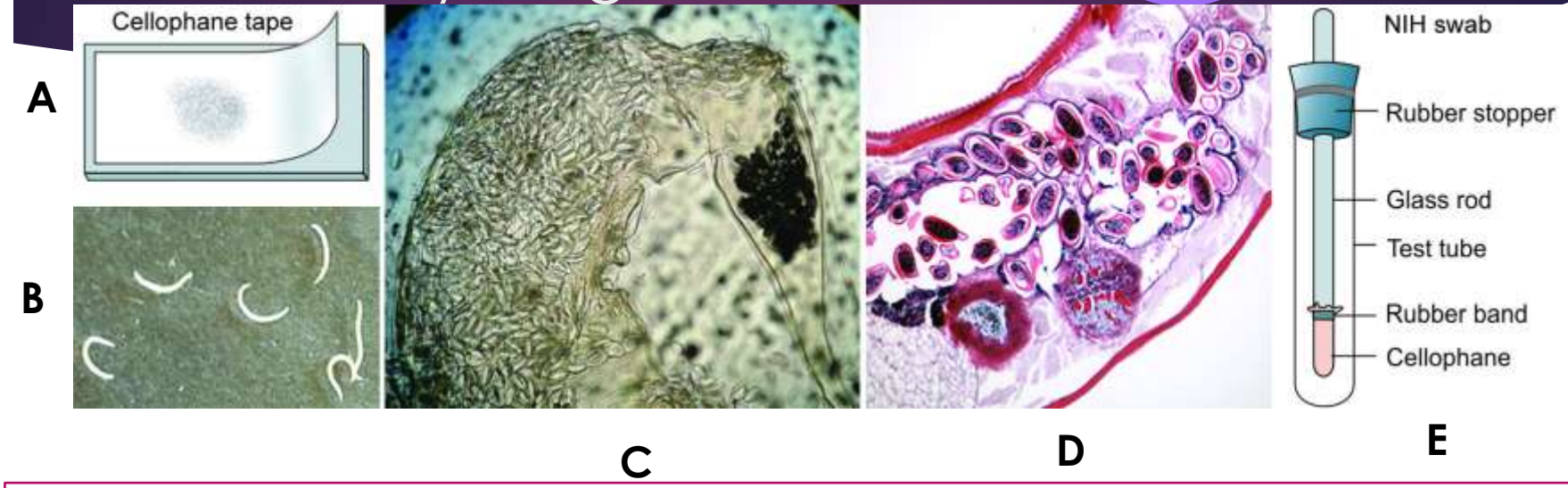
Pathogenicity and Clinical features

- **Asymptomatic: Most of the infections are asymptomatic**
- **Symptomatic patients: Perianal pruritus often worse** at night; Repeated scratching is the main reason of
- contaminated finger; which causes autoinfection.
- Excoriation of the perianal skin and bacterial superinfection
- Abdominal pain and weight loss

Laboratory diagnosis

- Eggs are rarely detected by stool examination; around 5% of cases.
- The eggs deposited in the perianal skin are collected by applying cellophane tape or its modification called, NIH swab.
- Eggs are non bile-stained, plancoconvex
- **Number of specimens: A series of 4–6 consecutive** tapes
- **Timing: Samples should be collected when the chance** of egg deposition is more such as late in the evening,

Laboratory diagnosis



(A) Cellophane tape; (B) Adult worms (actual size); (C) Adult female worm containing numerous eggs; (D) Longitudinal section of an adult female worm shows many planoconvex eggs; (E) NIH swab method (schematic)

Treatment

- Mebendazole (100 mg once)
- Albendazole (400 mg once) or
- Pyrantel pamoate (11 mg/kg once; maximum, 1 g)
- The same treatment should be repeated after 2 weeks
- Treatment of household members is advocated to eliminate asymptomatic reservoirs of potential reinfection.

SMALL INTESTINAL NEMATODES HOOKWORM

Classification

- Human parasite:
  - *A. duodenale or old world hookworm*
  - *N. americanus or new world hookworm or American* hookworm.
- Animal parasites that rarely infect man, causing cutaneous larva migrans:
  - *Ancylostoma braziliensis*
  - *Ancylostoma caninum*
  - *Ancylostoma ceylanicum*
  - *Uncinaria stenocephala.*

Epidemiology

India

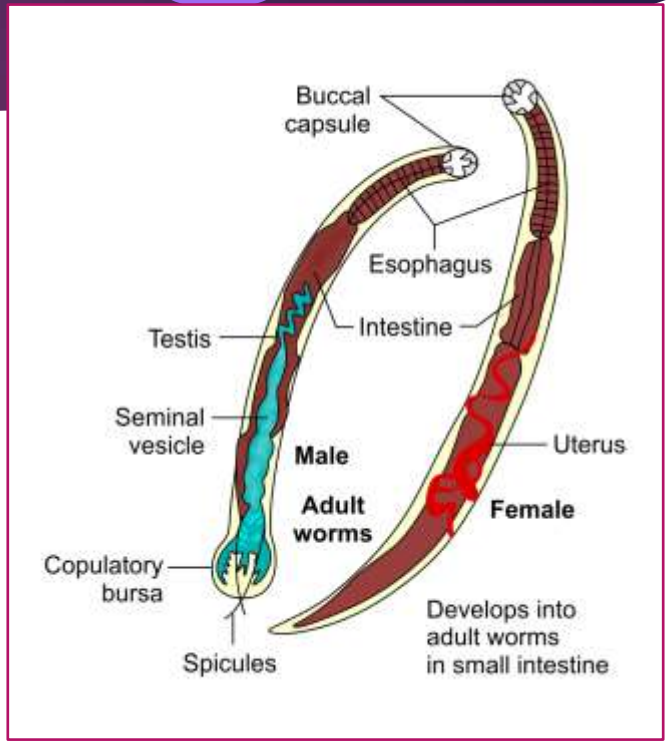
- Hookworm infection is widely prevalent in India.
- More than 200 million people are estimated to be infected in India.
- *N. americanus is predominant in South India and A.duodenale in North India*
- *Necator is seen in all the states except in Punjab and* Uttar Pradesh

Endemic Index

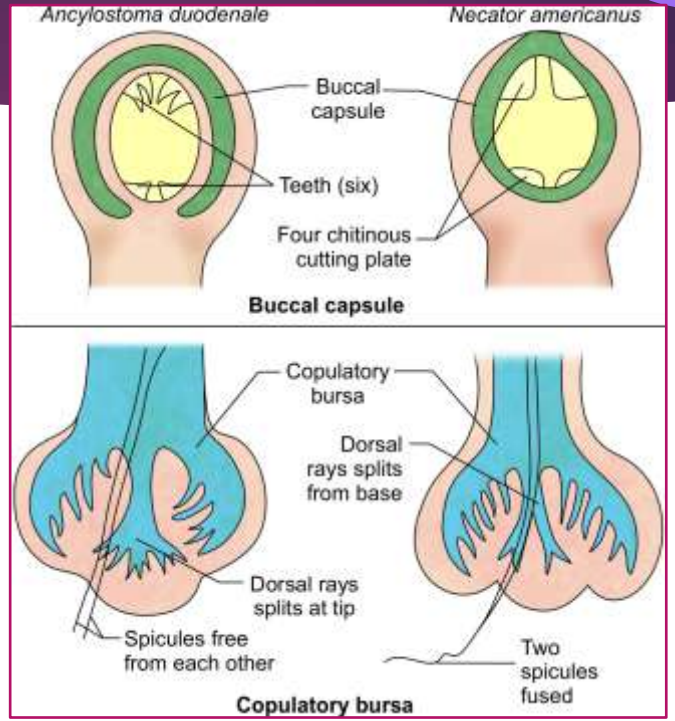
- **Chandler's index is used in the epidemiological studies of** hookworm disease.
- To estimate the morbidity and mortality in the community due to hookworm infection (whichdepends much upon the worm load).

Morphology

- Adult worm (A. duodenale)



Buccal capsule and Copulatory bursa of Ancylostoma duodenale and Necator americanus

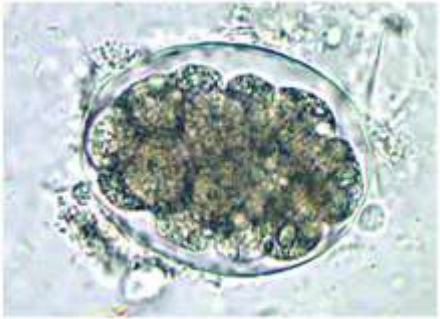


ences between male and female worms of ostoma duodenale

Features	*Male worm*	*Female worm*
Size	Smaller (5–11 mm)	Longer (9–13 mm)
Copulatory bursa	Present posteriorly	Absent
Posterior end	Expanded due to copulatory bursa	Tapering and straight pointed tail
Genital opening	Opens in cloaca along with anus	Opens separately in the middle

MORPHOLOGY
EGG

- Oval-shaped
- Measures 60 × 40 µm
- Not bile stained, appear colorless in saline mount
- Egg shell
- Ovum (embryo) is segmented; comprises of 4 to 32 blastomeres
- Floats on saturated salt solution
- Eggs of both *A. duodenale and N. americanus are* morphologically indistinguishable.



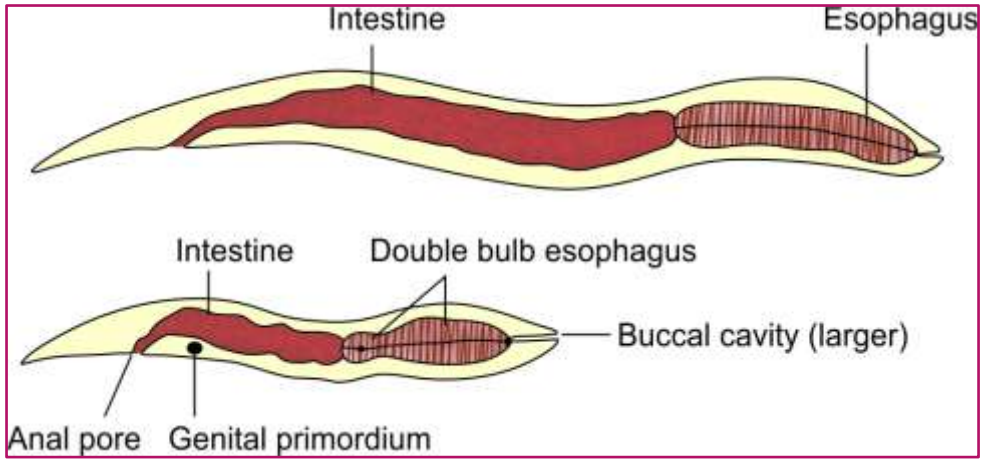
MORPHOLOGY-LARVA

- First stage larva is called as rhabditiform larva
- L3 larva is called as filariform larva and is the infective form to man

A

Hookworm (*Acylostoma duodenale*)
(A) Filariform larva;
(B) Rhabditiform larva

B



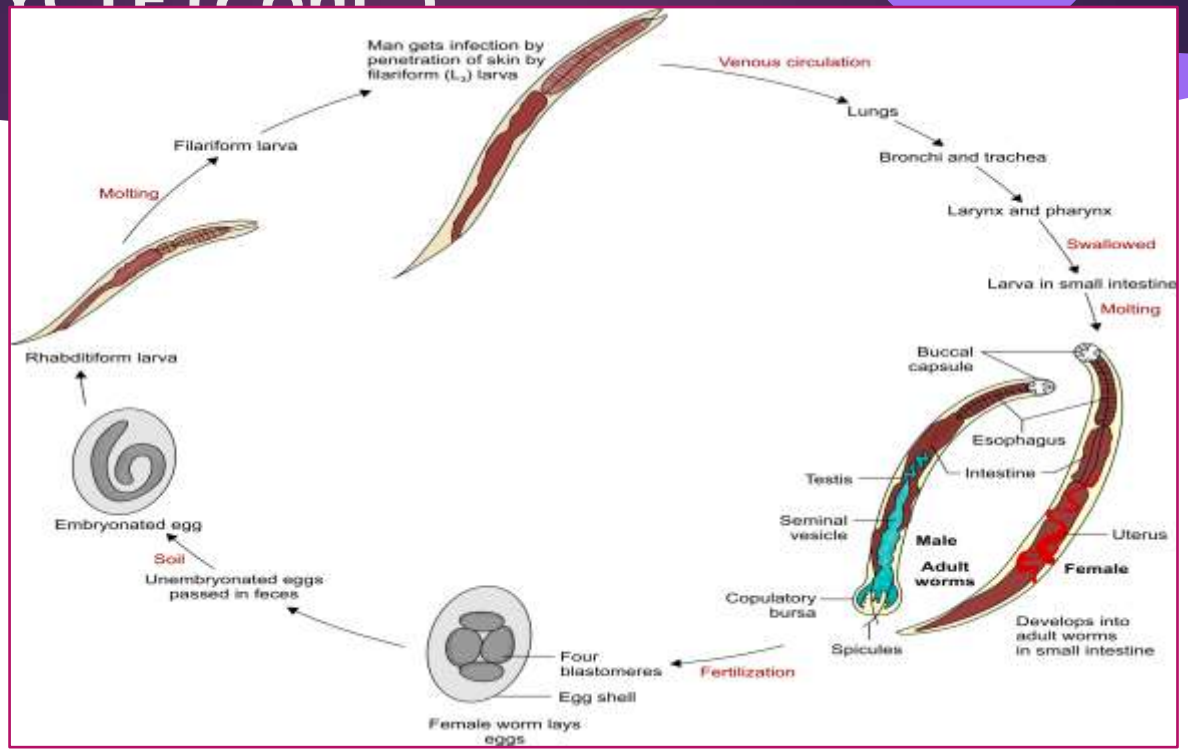
Differences between filariform (L3) larva of *Ancylostoma duodenale* and *Necator americanus*

Filariform (L_3) larva	*Ancylostoma duodenale*	*Necator americanus*
Size	720 µm	660 µm
Shape	Head end is blunt and tail is pointed	Same as *Ancylostoma*
Cuticle	Bears faint transverse striations	Bears prominent transverse striations
Buccal capsule	Shorter (10 µm), lumen larger and bound by two thin chitinous wall	Larger (15 µm), lumen short and bound by two thick chitinous wall
Esophagus-intestinal junction	No gap between esophagus and intestine	Gap between esophagus and intestine due to prominent anterior dilatation of intestinal lumen
Intestine	Posterior end of intestine has a refractile body	Refractile body absent

LIFE CYCLE

- **Host: Hookworm involves only one host (man).**
- **Infective stage: Third stage filariform** larva acts as the infective form.
- **Mode of transmission: Through penetration of skin by** the third stage larva (by walking bare foot in dampen soil).
- Other routes of transmission of the larva has been reported through oral, in utero and transmammary routes.

LIFE CYCLE (cont..)



Pathogenicity

Hookworm has ability to suck blood from the intestinal vessels by:

- Attaching and making cuts in the intestinal wall
- Secreting hydrolytic enzymes
- Releasing anticoagulants like factor Xa or VIIa/tissue factor inhibitor,
- Habitual blood-sucker; produces active suction impulses 120–200 times/min.
- Can also penetrate the skin which is facilitated

Clinical features

- Affect due to Migrating Larva - ("ground itch") at the site of skin penetration and serpiginous tracks may be formed due to subcutaneous migration of the larva
- Mild transient pneumonitis

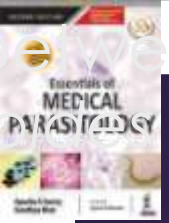
Clinical features (cont..)

Clinical spectrum produced by adult hookworm depends upon the worm load.

- **Asymptomatic** : Most hookworm infections are asymptomatic
- **Early intestinal phase *(less worm load):*** epigastric pain, inflammatory diarrhea, or other abdominal symptoms, accompanied by eosinophilia
- **Late intestinal phase *(chronic hookworm infection*** with heavy worm load): *Patients develop iron deficiency* anemia and protein energy
- **Wakana disease**

Laboratory diagnosis

- **Stool microscopy**—detects non bile stained oval segmented and non bile-stained eggs with 4–32 blastomeres. Eggs of *Acylostoma* and *Necator* are indistinguishable.
- **Stool culture**—eggs develop into filariform larvae, which help in differentiating *Acylostoma* from *Necator*
  - Harada-Mori filter paper tube method
  - Petri dish (slant culture) technique
  - Baermann funnel technique
  - Charcoal culture method
  - Agar plate technique (more sensitive)
- **Molecular method**—detects genes such as mitochondrial cytochrome oxidase I gene, ITS-1 and ITS-2 regions of ribosomal DNA
- **Other findings**— hypochromic microcytic anemia.



ween rhabditiform larva of hookworm *stercoralis*

Table 12.7: Differences between rhabditiform larva of hookworm and *Strongyloides stercoralis*

Rhabditiform larva	*Hookworm*	*Strongyloides*
Size	100–150 µm long × 16 µm width	108–380 µm long × 14–20 µm width
Mouth (buccal cavity)	Three times longer	Shorter
Genital primordium	Less prominent and small	Prominent and large
Anal pore (subterminal)	80 µm from the posterior end	50 µm from the posterior end

Classification of intensity of infection based on WHO guidelines (eggs per gram of stool)

Table 12.8: Classification of intensity of infection based on WHO guidelines (eggs per gram of stool)

	Light	*Moderate*	*Heavy*
Trichuris	1–999	1000–9999	≥10000
Ascaris	1–4999	5000–49999	≥50000
Hookworm	1–1999	2000–3999	≥4000

Treatment

Treatment	Hookworm

Antiparasitic

- Antiparasitic drugs like albendazole (400 mg once), mebendazole (500 mg once), and pyrantel pamoate (11 mg/kg for 3 days) can be given
- However, due to the widespread use of the drugs, their efficacy is decreased compared to the past. Resistance to albendazole and mebendazole has also been reported

Symptomatic treatment

- Mild iron-deficiency anemia can often be treated with oral iron with folic acid
- Severe hookworm disease with protein loss and malabsorption warrants nutritional support and oral or parenteral iron replacement

Prevention

General preventive measures include:

- Improved personal hygiene
- Proper disposal of feces
- Improved nutrition with dietary iron
- Treatment of infected persons.

Vaccine

- No vaccine has been licensed yet for hookworm infection;
- Vaccine trials:
  - *N. americanus 24 kDa glutathione-S-transferase* (Na-GST-1)
  - *N.americanus aspartic protease recombinant* (Na-APR)-1
  - Alhydrogel combined with an glucopyranosyl lipid A (GLA).

STRONGYLOIDES STERCORALIS

- **Classification -** *Strongyloides belongs to superfamily Rhab ditoidea and* family Strongyloididae.

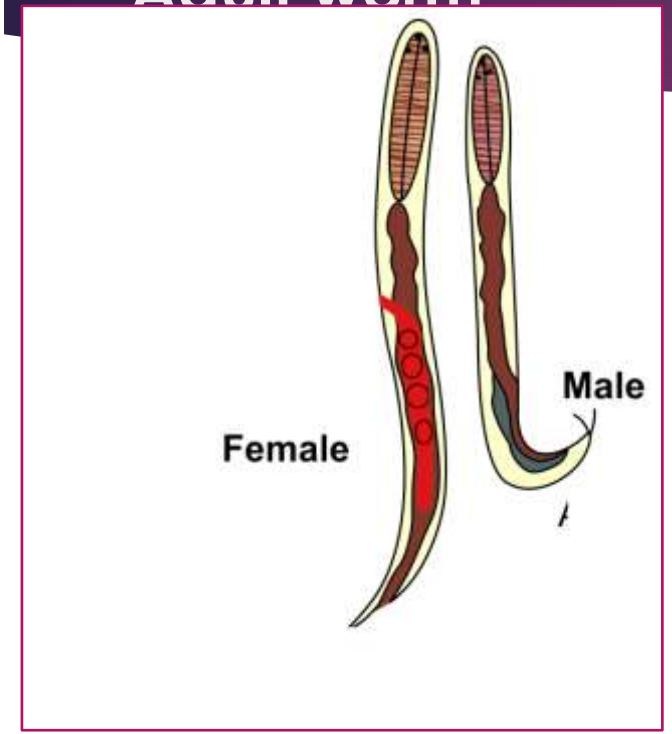
Epidemiology

- *S. stercoralis is distributed in hot, humid tropical areas.*
- Particularly common in South-east Asia (including India), Sub-Saharan Africa, and South America (Brazil)

Habitat

- Parasitic female worms reside in the human intestine (duodenum and upper jejunum)
- Free-living female worms multiply in the environment.

Morphology- Adult worm

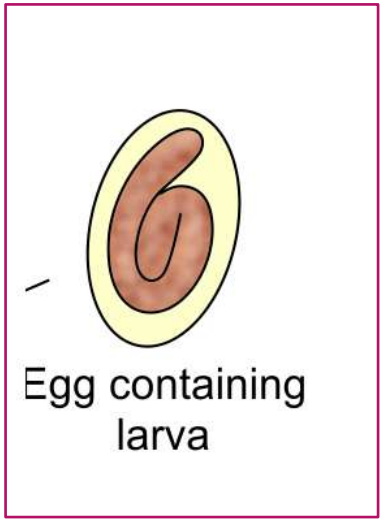


Adult male (arrow shows spicules)

Adult female (containing single row of eggs);

Morphology- Eggs

- Oval and measure 50–58 × 30-34 µm in size

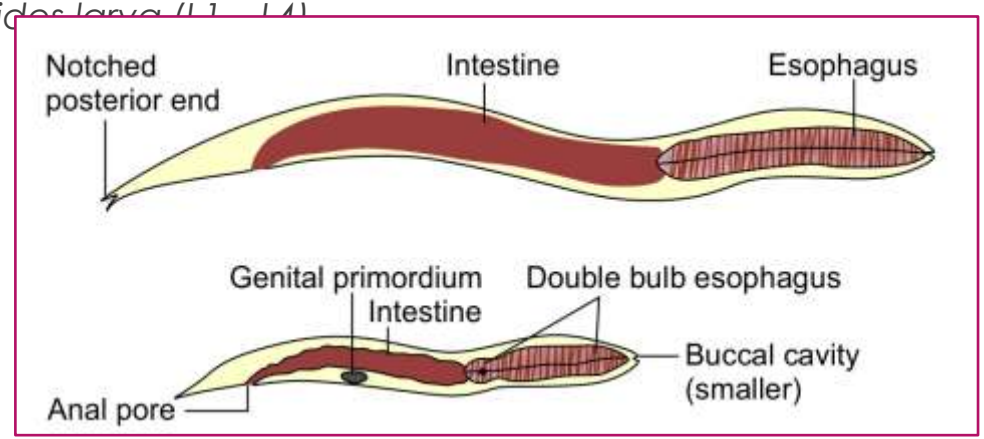


Morphology- Larva

- There are four stages of *Strongyloides larva (L1 – L4)*

Filariform larva

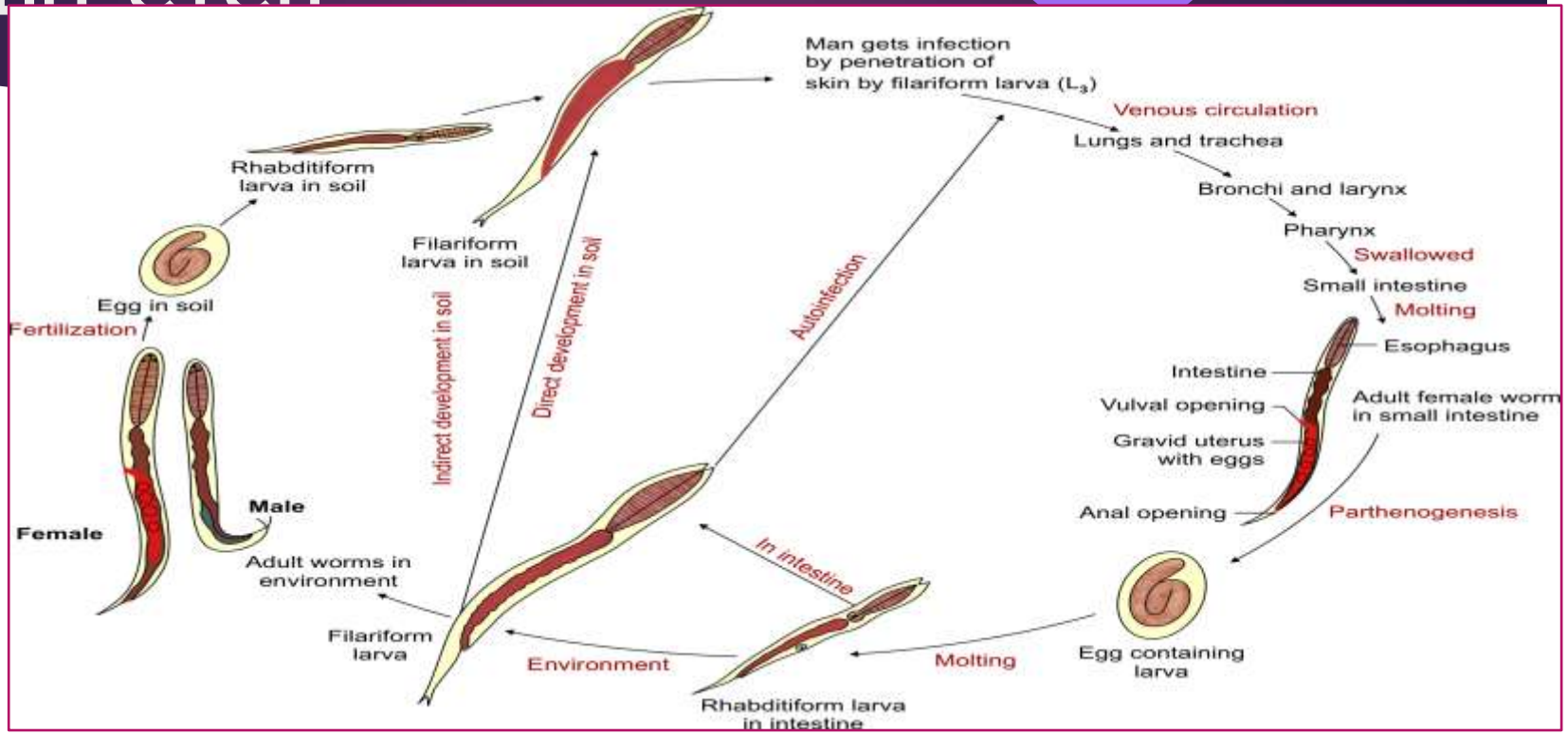
Rhabditiform larva



Life Cycle

- **Host: *S. stercoralis involves only one host (man). Rarely,*** domestic pets are recognized as reservoir of infection.
- **Infective stage: L3** larva (filariform).
- **Mode of transmission:** Penetration of skin by the L3 larva and Autoinfection (internal autoinfection)

LIFE CYCLE



Pathogenesis and Clinical feature

Effect due to Migrating Larva

- Asymptomatic infection
- Rashes
- Cutaneous larva migrans
- Pulmonary symptoms

Pathogenesis and Clinical feature (cont..)

Effect due to Adult worm and Filariform Larva

- **Mild to moderate worm load:** Epigastric pain (resembling peptic ulcer), nausea, diarrhea, constipation, and blood loss
- **Heavy larva load:** Hyperinfection syndrome and disseminated strongyloidiasis

LABORATORY DIAGNOSIS

Laboratory Diagnosis	*Strongyloides stercoralis*

- **Microscopy** [stool or duodenal aspirate (by Entero-test), rarely sputum]—detects rhabditiform larvae
- **Stool culture**—
  - Harada-Mori filter paper tube method
  - Petri dish (slant culture) technique
  - Baermann funnel technique
  - Charcoal culture method
  - Agar plate technique (more sensitive)
- **Antibody detection**—ELISA (CrAg-ELISA), luciferase immunoprecipitation assay
- **Coproantigen** in stool—capture ELISA detecting excretory/secretory (E/S) antigen
- **Molecular diagnosis**—real time PCR detecting cytochrome C oxidase subunit I gene, 18S rRNA, or 28S RNA gene sequences.

Complications of strongyloidiasis

Hyperinfection syndrome

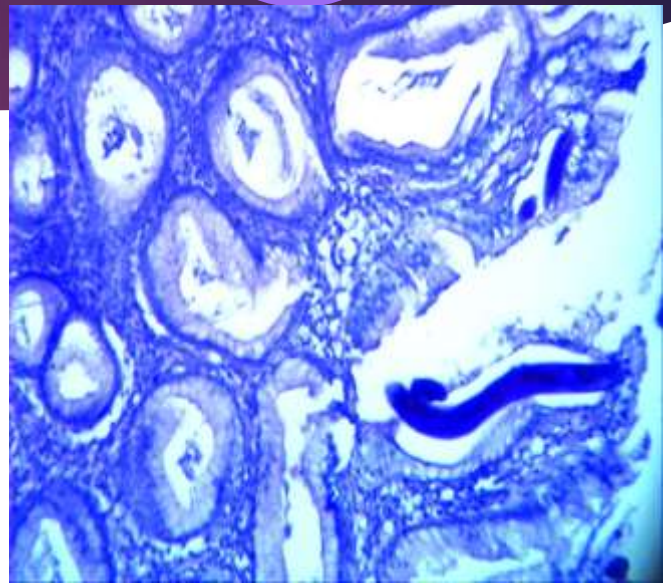
The underlying cause of hyperinfection syndrome is the repeated autoinfection cycles; which leads to generation of large number of filariform larvae. The larvae penetrate the GIT and migrate to various organs.

- **Risk factors:** Impaired host immunity favors larva multiplication
  - Glucocorticoid therapy is the main risk factor
  - Other risk factors include immunosuppressive conditions such as transplant recipients, hematologic malignancies, and intake of immunosuppressive drugs
  - Hyperinfection syndrome is common in patients coinfected with human T cell lymphotropic virus type (HTLV-1)
  - Coinfection of *Strongyloides* with HIV is common. However, it is not associated with disseminated strongyloidiasis.
- **Features:** Colitis, enteritis, or malabsorption, and in severe cases disseminated strongyloidiasis may develop
- **Disseminated strongyloidiasis:**
  - Larvae may invade the GIT and migrate to various organs including CNS, peritoneum, liver, and kidneys
  - Moreover, the passage of enteric flora through disrupted mucosa lead to gram-negative bacterial sepsis, pneumonia, or meningitis which may dominate the clinical course
  - CNS invasion, brain abscess and meningitis are common. Larvae can be seen in the CSF occasionally. CSF examination shows pleocytosis, elevated protein, normal glucose and negative for bacterial culture.
- Eosinophilia is often absent in severely infected patients
- The mortality rate in untreated patients approaches 100% and even with treatment it may exceed 25%.

Filariform larva	*Hookworm*	*Strongyloides*
Size	720 µm long	630 µm long × 16 µm width
Esophagus	Shorter	Long and cylindrical
Tail	Long pointed tail	Blunt and notched

Rhabditiform larva

Rhabditiform larva of **Strongyloides stercoralis** (A) **Iodine mount**



Histopathology from Intestinal biopsy (hematoxylin and eosin stain)

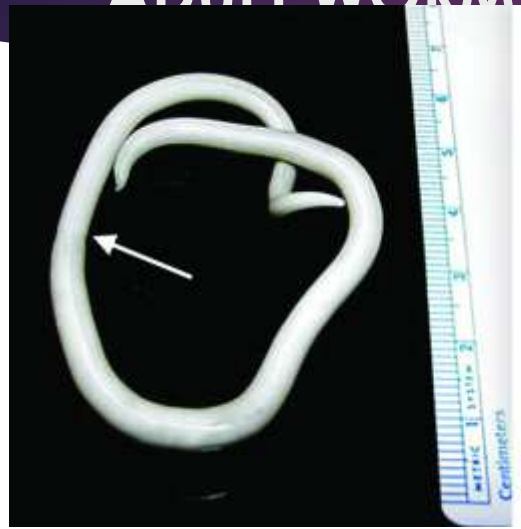
Treatment

- Even in the asymptomatic stage, strongyloidiasis must be treated because of the potential for subsequent fatal hyper infection
  - Ivermectin (200 mg/kg daily for 2 days) is more effective than albendazole (400 mg daily for 3 days)
  - For disseminated strongyloidiasis: Prolon ged course of Ivermectin should be given at least 5 days or until the parasites are eradicated.

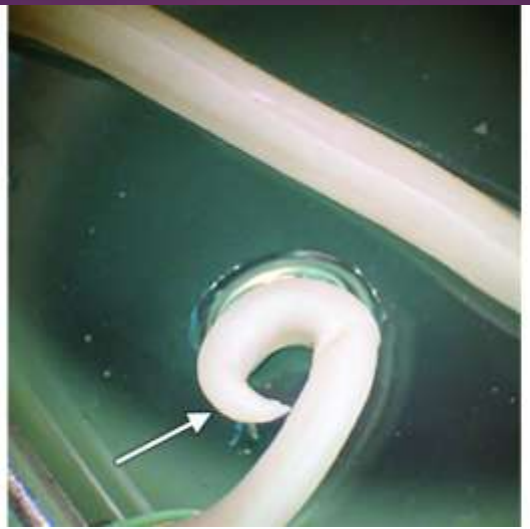
ASCARIS LUMBRICOIDES

- Commonly called as round- worm.
- Soil-transmitted helminth
- **Epidemiology -** *A. lumbricoides is cosmopolitan in distribution, mainly affecting tropical countries including India.*
-

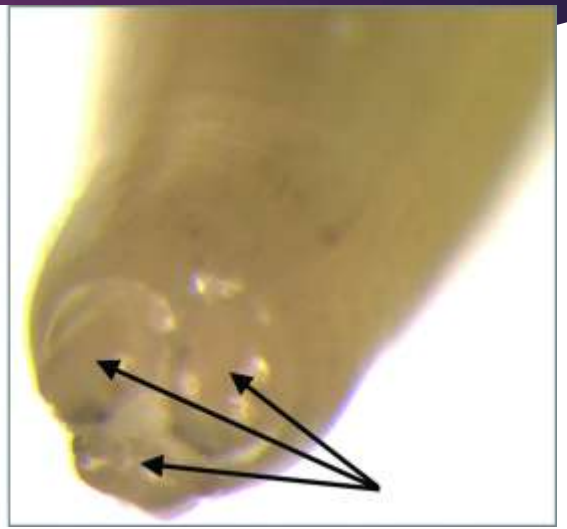
MORPHOLOGY – ADULT WORM



Adult female with vulvar waist



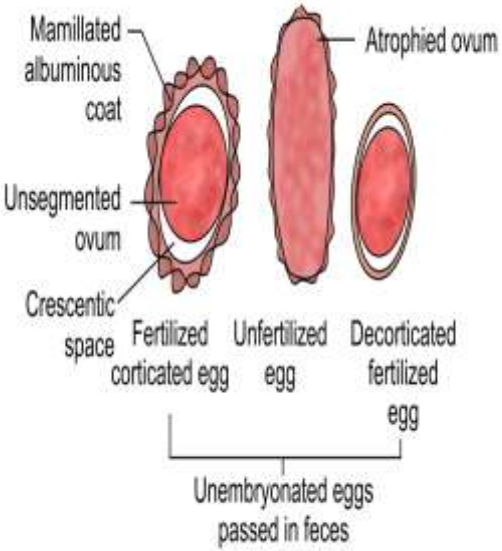
Posterior end of adult male showing the curled tail



Close-up of the anterior end of an adult showing the characteristic three lips

MORPHOLOGY – EGGS

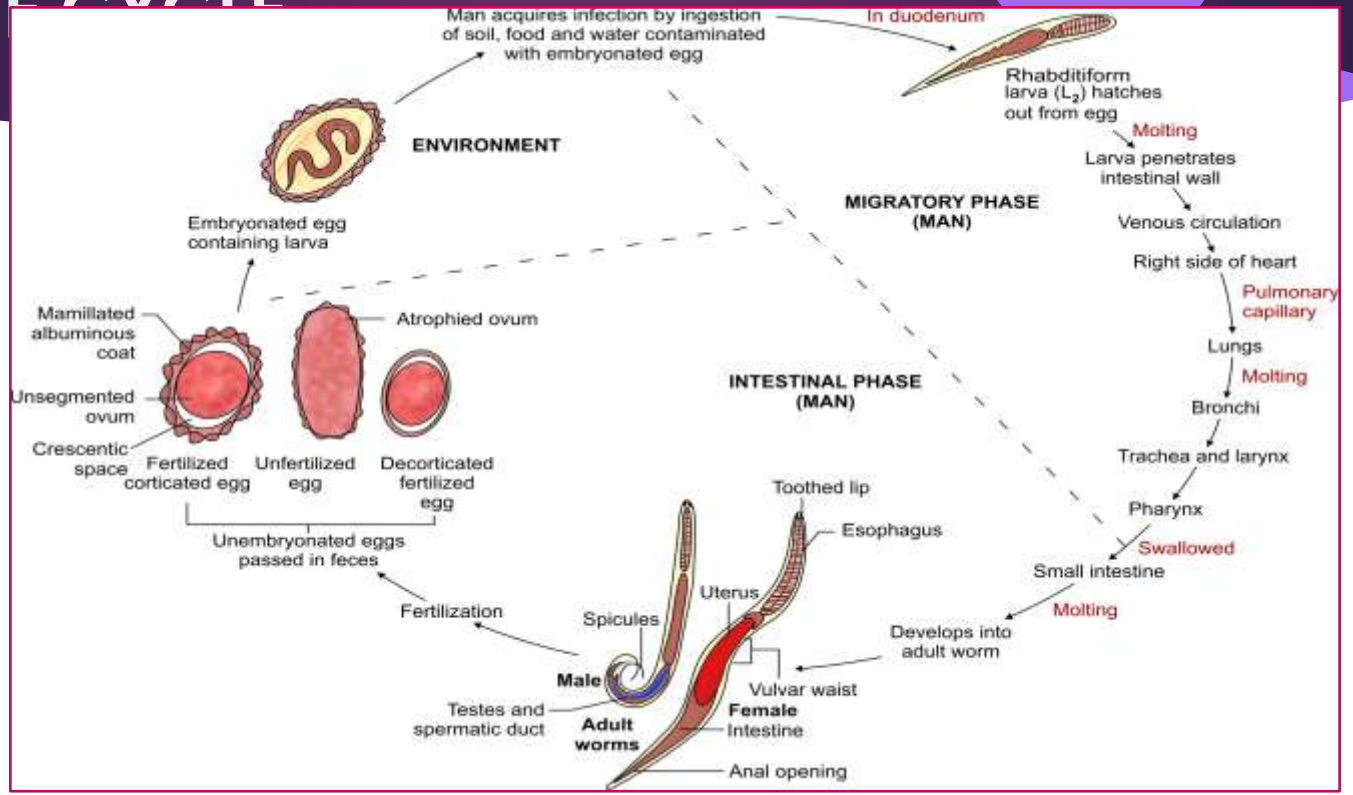
	Fertilized eggs	*Unfertilized eggs*
Shape	Round to oval	Elongated
Size	45–75 µm x 35–50 µm	85–95 µm x 43–47 µm
Covering (egg shell)	Surrounded by a thick mamillated, albuminous coat	Albuminous coat is thin, distorted and scanty
Crescentic space at poles	Present	Absent
Bile staining	Yes, golden brown in saline mount	Yes, golden brown in saline mount
Saturated salt solution	Floats	Does not float
Ovum	Egg contains a large unsegmented ovum of granular mass with clear space at both the end	Egg contains an unsegmented, small atrophied ovum with a mass of disorganized highly refractile granules



MORPHOLOGY – LARVA

- Four stages of *Ascaris larvae (L*1 - L4).

LIFE CYCLE



Pathogenesis and Clinical feature

Effect due to Migrating Larva

- Pulmonary symptoms
- Eosinophilic pneumonia (Loeffler's syndrome)

Effect due to Adult worm

- Asymptomatic
- Malnutrition and growth retardation
- Intestinal complications - acute pain abdomen due to small- bowel obstruction, rarely perforation, intussusception
- Extraintestinal complications: Larger worms can enter and occlude the biliary tree, causing biliary colic, cholecystitis, pancreatitis, or (rarely) intrahepatic abscesses.

Laboratory diagnosis

- **Stool examination** (saline and iodine mount)—detects three types of eggs
  - Fertilized egg—round to oval with outer thick albumin coat
  - Unfertlized eggs—rectangular and elongated, surrounded by thin albumin coat
  - Decorticated eggs—it is a fertilized egg with albumin coat lost
- **Adult worm detection**—X-ray (Trolley car lines), USG and Barium meal of GIT
- **Larva detection** (sputum/gastric aspirate)
- **Serology** (antibody detection)—ELISA, IFA, IHA test
- **Other findings** such as eosinophilia and Charcot-Leyden crystals in sputum and stool.

Treatment

Antiparasitic drugs - Ascariasis should always be treated early to prevent potentially serious complications.

- Albendazole (400 mg once), meben dazole (100 g twice daily for 3 days or 500 mg once) is recommended.
- Alternate drugs like ivermectin (150 ▪ 00 mg/kg once) and nitazoxanide are also effective
- In pregnancy, pyrantel pamoate is safe

Soil-transmitted helminths

- Soil-transmitted helminths (STH) refer to the intestinal worms infecting humans that are transmitted through contaminated soil such as Ascaris, Trichuris and hookworm.