Gastrointestinal parasitology 2

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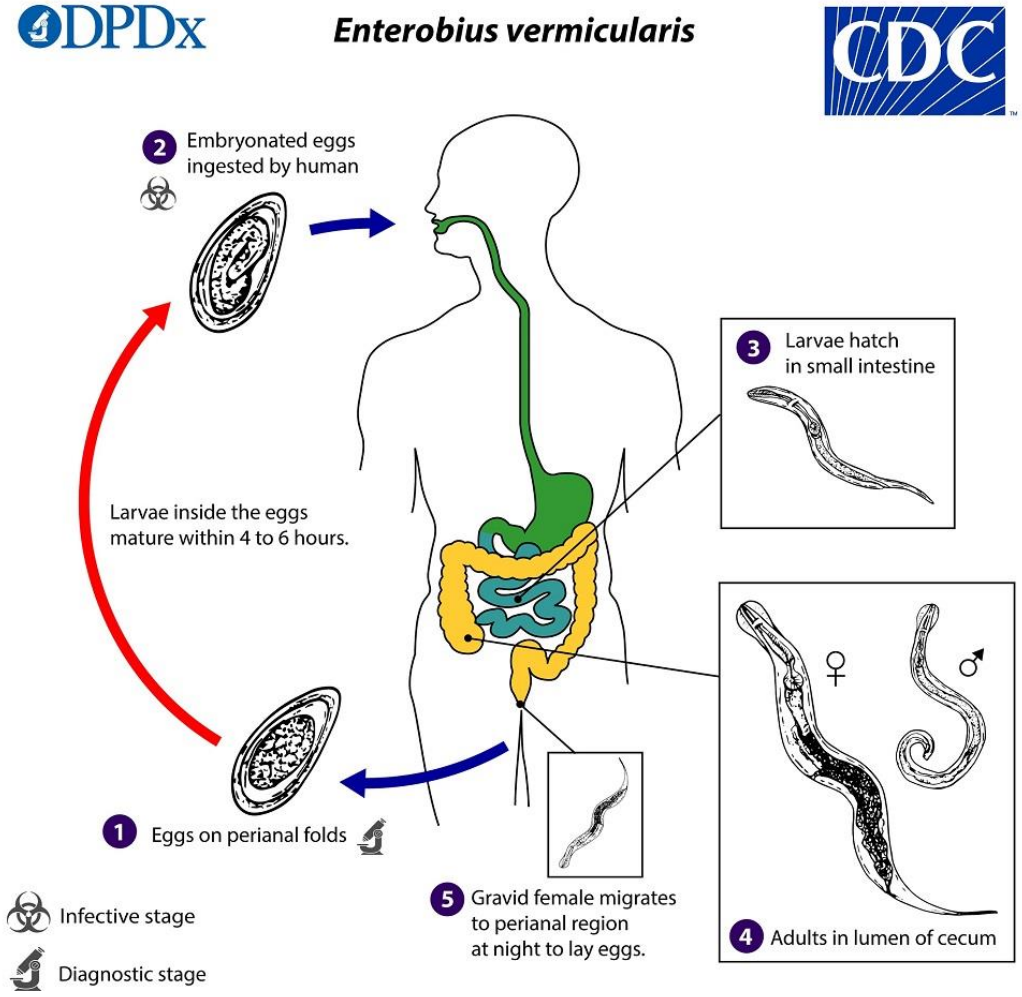
Intestinal Nematodes

- The nematodes are the most easily recognized form of intestinal parasite because of their **large size** and **cylindric, unsegmented bodies**; hence the common name **roundworms**.
- These parasites live primarily as **adult worms in the intestinal tract**.
- Nematode infections are most commonly confirmed by detecting the characteristic **eggs in feces**.
- Egg identification should take into account the **size and shape of the egg**, **thickness of the shell**, and structures such as **polar plugs, knobs, spines, and opercula**.

Enterobius vermicularis

- **E. vermicularis**, the **pinworm**, is a small, white worm found in the **perianal folds** or **vagina** of an infected child.
- Infection is initiated by ingestion of **embryonated eggs**.
- Larvae hatch in the **small intestine** and migrate to the **large intestine**, where they mature into adults in **2 to 6 weeks**.
- Fertilization produces characteristic **asymmetric eggs**, which are laid in the **perianal folds**.
- As many as **20,000 eggs** are deposited on the perianal skin, and the eggs rapidly mature and are **infectious within hours**.



Epidemiology and Clinical Disease

- Person-to-person spread is greatest in crowded conditions, such as **day-care centers, schools, and mental institutions**.
- Eggs may be transmitted from **hand to mouth** by children scratching the **perianal folds**.
- Egg-laden dust can be inhaled and swallowed to produce infestation.
- **Autoinfection ("retrofection")** can occur, in which eggs hatch in the **perianal folds** and the larval worms migrate into the **rectum and large intestine**.
- Many children and adults show **no symptoms** and serve only as carriers.
- Allergic response to migrating worms causes **severe pruritus**, **loss of sleep**, and **fatigue**.

Figure A: Adult male of *E. vermicularis* from a formalin-ethyl acetate (FEA) concentrated stool smear. The worm measured 1.4 mm in length. Image contributed by the Centre for Tropical Medicine and Imported Infectious Diseases, Bergen, Norway.

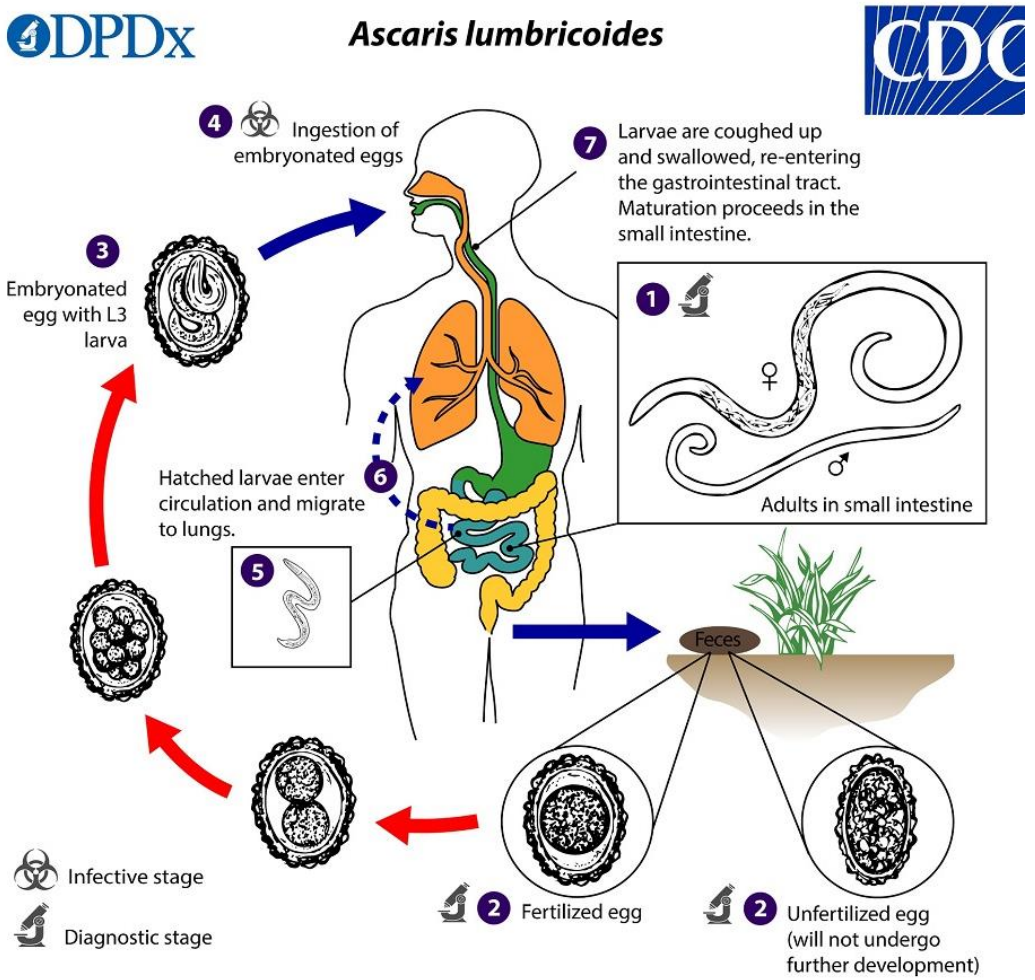
Diagnosis and Treatment

- Diagnosis is confirmed by detection of characteristic eggs on the **anal mucosa**.
- The method of choice is an **anal swab with a sticky surface** collected before **bathing or defecation, or** "Scotch test", using cellulose tape slide test.
- The eggs are rarely seen in **fecal specimens**.
- The drug of choice is **albendazole** or **mebendazole**.
- **Pyrantel pamoate** and **piperazine** are effective, but reinfection is common.
- The **entire family** is usually treated simultaneously; repeat treatment after **2 weeks** may help prevent reinfection.
- **Personal hygiene**, clipping of fingernails, and washing of bed clothes contribute to control.

Figure A: Eggs of *E. vermicularis* in a cellulose-tape preparation.

Ascaris lumbricoides

- ***A. lumbricoides*** are large **20 to 35 cm in length**, pink worms.
- The ingested infective egg releases a larval worm that penetrates the **duodenal wall**, enters the bloodstream, and is carried to the **liver and heart** and then the **pulmonary circulation**.
- Larvae break free in the **alveoli of the lungs**, grow and molt, then are coughed up, swallowed, and returned to the **small intestine**.
- Adult worms mature mainly in the **jejunum**.
- Egg production may amount to **200,000 eggs per day**.
- Eggs are found in feces **60 to 75 days** after the initial infection.



Epidemiology and Disease

- ***A. lumbricoides*** is prevalent where **sanitation is poor** and human feces are used as fertilizer.
- **Ascariasis** is the most common helminthic infection worldwide, with an estimated **1 billion people infected**.
- Mild infection may produce **no symptoms**.
- Migration to the lungs can cause **pneumonitis resembling an asthmatic attack**.
- Mature worms may cause **obstruction**, **perforation**, **occlusion of the appendix**, or migration into the **bile duct**, **gallbladder**, and **liver**.

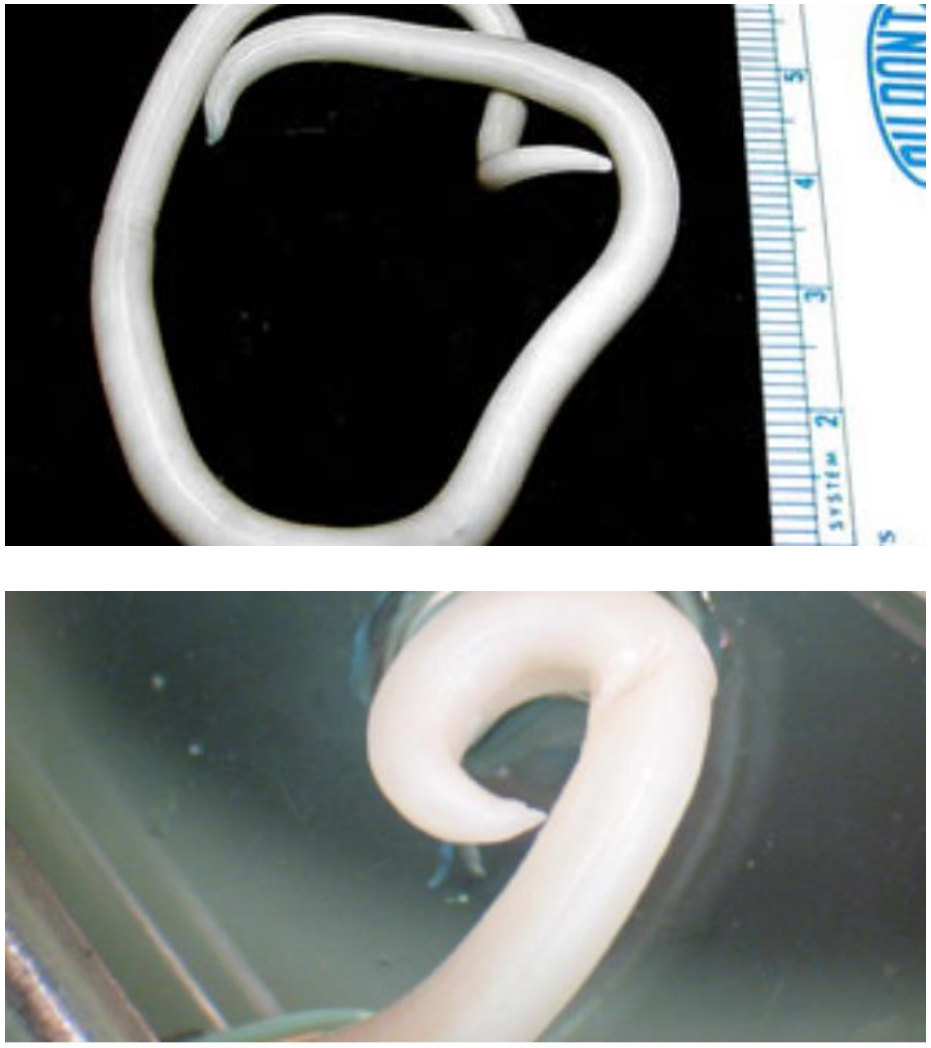


Figure D: Posterior end of a male *A. lumbricoides*, showing the curled tail.

Diagnosis and Treatment

- Diagnosis is by finding **knobby-coated**, **bile-stained**, fertilized and unfertilized eggs in concentrated stool.
- Drug of choice: **albendazole** or **mebendazole**; alternatives are **pyrantel pamoate** and **piperazine**.
- **Education, improved sanitation, and avoidance of human feces as fertilizer** are critical.

Figure B: Unfertilized egg of *A. lumbricoides* in an unstained wet mount, 200x magnification.

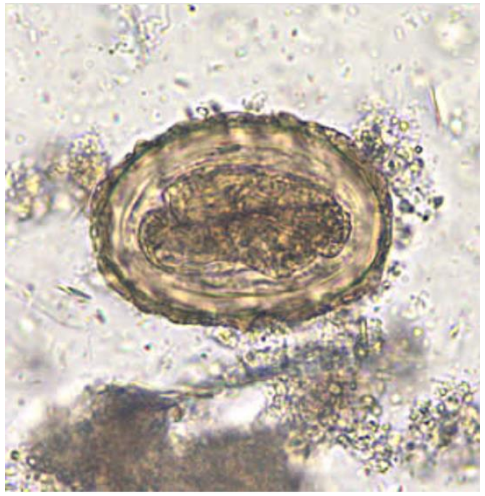
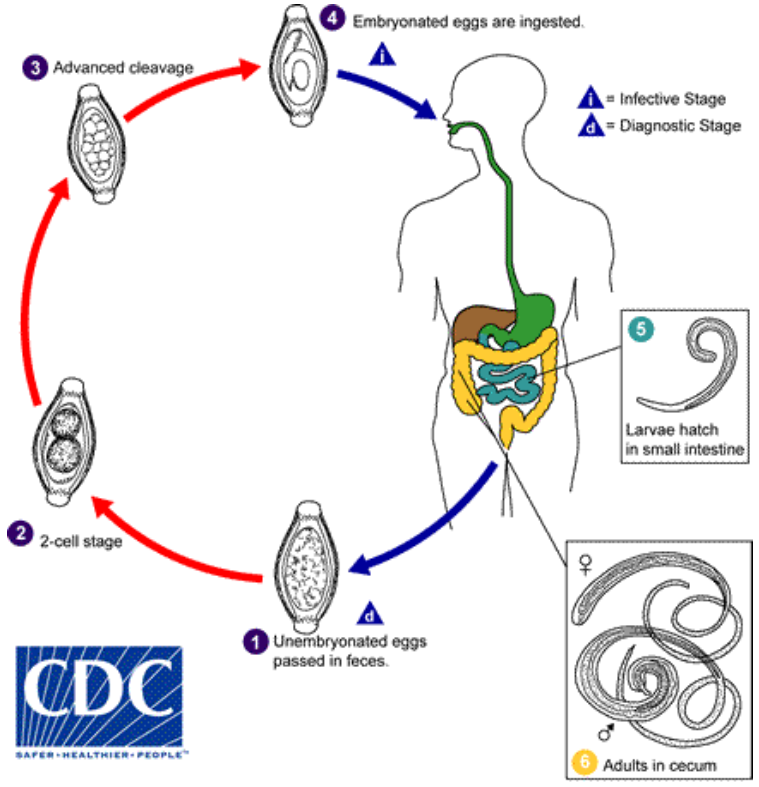


Figure E: Fertilized egg of *A. lumbricoides* in an unstained wet mount of stool, 200x magnification. A larva is visible in the egg.

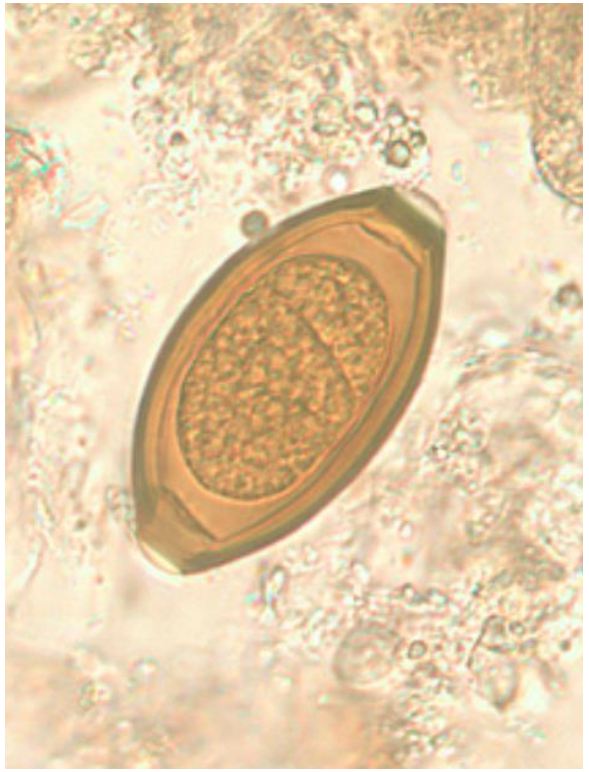
Trichuris trichiura: Physiology, Structure, and Epidemiology

- Commonly called **whipworm** because it resembles the handle and lash of a whip.
- Ingested eggs hatch into a larval worm in the **small intestine** and then migrate to the **cecum**, in which they penetrate the mucosa and mature to adults.
- About **3 months** after the initial infection, the fertilized female worm starts laying eggs and may produce **3000 to 10,000 eggs per day**.
- Female worms can live for as long as **8 years**.
- Eggs passed into the soil mature and become infectious in **3 weeks**.
- **T. trichiura** eggs are distinctive, with **dark bile staining**, a **barrel shape**, and the presence of **polar plugs** in the egg shell.
- Like ***A. lumbricoides***, ***T. trichiura*** has worldwide distribution, and its prevalence is directly correlated with **poor sanitation** and the use of **human feces as fertilizer**.



Clinical Syndromes, Diagnosis, and Treatment

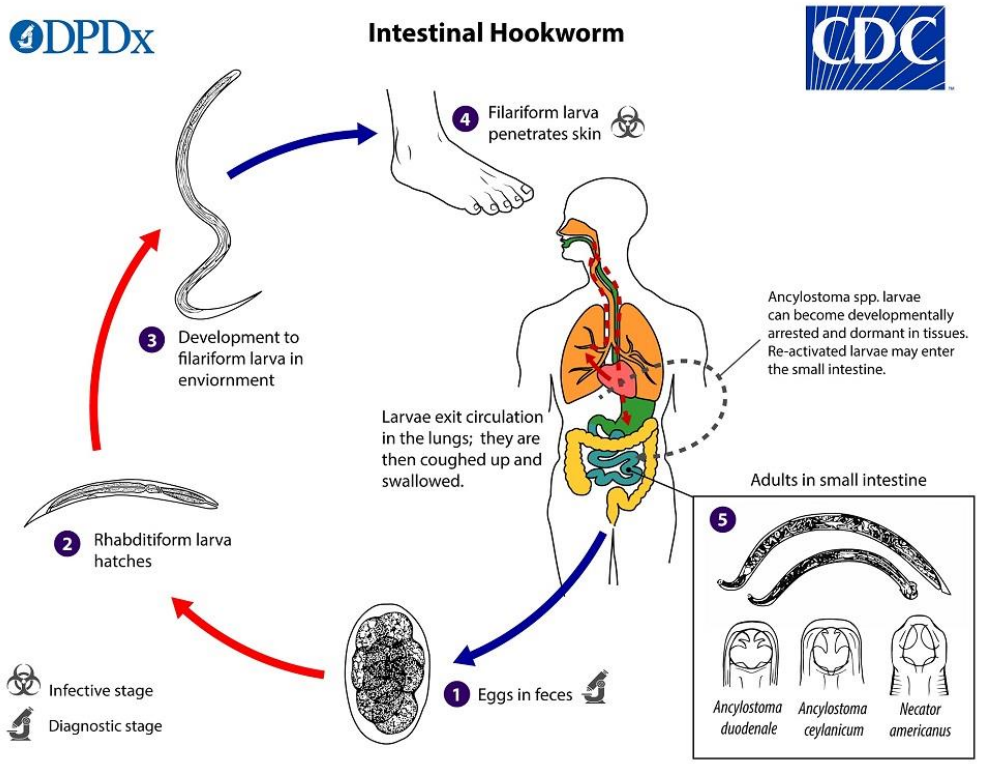
- The clinical manifestations of **trichuriasis** are generally related to the intensity of the worm burden.
- Most infections are with small numbers of **Trichuris** organisms and are usually **asymptomatic**.
- Infections with many larvae may produce **abdominal pain and distention, bloody diarrhea, weakness, and weight loss**.
- **Appendicitis** may occur as worms fill the lumen.
- **Prolapse of the rectum** is seen in children because of the irritation and straining during defecation.
- **Anemia** and **eosinophilia** also are seen in severe infections.
- Stool examination reveals the characteristic **bile-stained eggs with polar plugs**.
- The drug of choice is **albendazole** or **mebendazole**; combination chemotherapies have showed the highest efficacy, such as **albendazole plus oxantel pamoate**.



ure A: Egg of *T. trichiura* in an iodine-stained wet mount.

Hookworms

- The two human hookworms are ***A. duodenale*** (**Old World hookworm**) and ***N. americanus*** (**New World hookworm**).
- The human phase of the hookworm life cycle is initiated when a **filariform** (**infective form**) larva penetrates intact skin.
- The larva then enters the circulation, is carried to the lungs, is coughed up, swallowed, and develops to adulthood in the **small intestine**.
- Egg laying is initiated **4 to 8 weeks** after the initial exposure and can persist for as long as **5 years (10,000 to 20,000 eggs per day**,).
- On contact with soil, the **rhabditiform** (**noninfective**) larvae are released from the eggs and within **2 weeks** develop into **filariform larvae**.
- Both species have mouthparts designed for **sucking blood** from injured intestinal tissue.
- Transmission requires deposition of egg-containing feces on **shady, well-drained soil** and is favored by **warm, humid tropical conditions**.



Clinical Syndromes

- Skin-penetrating larvae may produce an **allergic reaction and rash** at sites of entry.
- Larvae migrating in the lungs can cause **pneumonitis and eosinophilia**.
- Adult worms produce gastrointestinal symptoms of **nausea, vomiting, and diarrhea**.
- As blood is lost from feeding worms, a **microcytic hypochromic anemia** develops.
- In severe, chronic infections, **emaciation** and **mental and physical retardation** may occur related to anemia from blood loss and nutritional deficiencies.

Figure B: Adult worm of *Necator americanus*. Anterior end showing mouth parts with cutting plates.

Diagnosis, Treatment, and Control

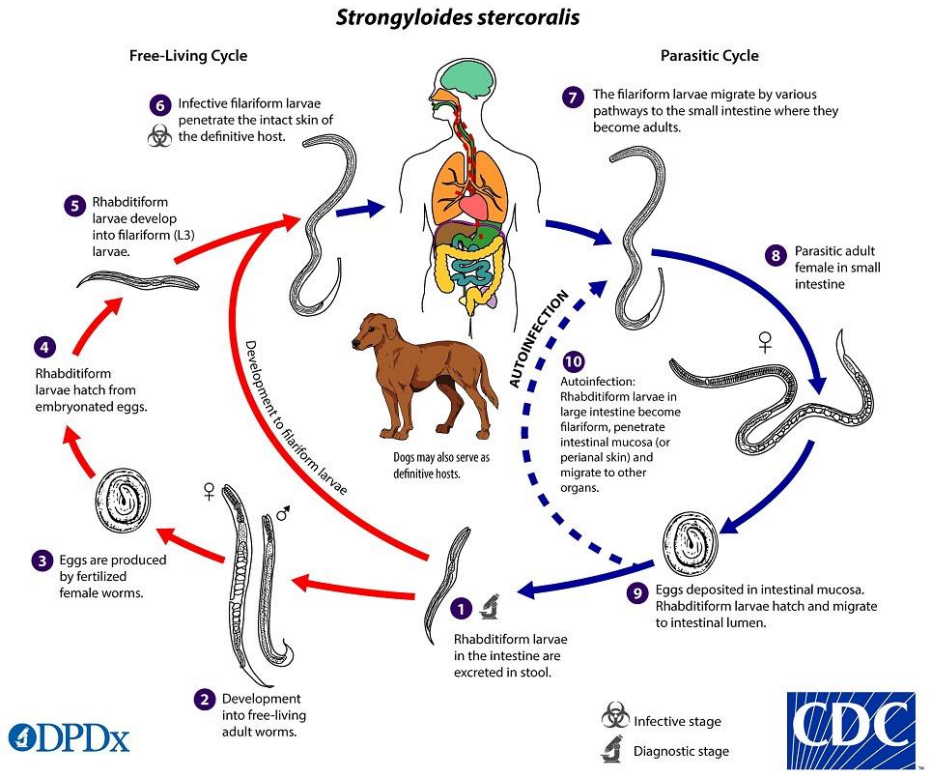
- Stool examination reveals the characteristic **non–bile-stained segmented eggs**.
- The eggs of **A. duodenale** and **N. americanus** cannot be distinguished.
- The drug of choice is **albendazole** or **mebendazole**; **pyrantel pamoate** is an alternative.
- **Iron therapy** is indicated to raise hemoglobin levels to normal, and **blood transfusion** may be necessary in severe cases of anemia.
- **Education, improved sanitation, and controlled disposal of human feces** are critical preventive measures; wearing shoes in endemic areas helps reduce infection.

Figure A: Hookworm rhabditiform larva (wet preparation).

Figure A: Filariform (L3) hookworm larva.

Strongyloides stercoralis

- The life cycle of ***S. stercoralis*** differs from hookworm in three aspects:
  eggs hatch into larvae in the intestine, larvae can mature into **filariforms** in the intestine and cause **autoinfection**, and a **free-living, nonparasitic cycle** can be established outside the human host.
- A skin-penetrating ***S. stercoralis*** larva enters the circulation and follows the **pulmonary course**.
- It is coughed up and swallowed, and adults develop in the **small intestine**.
- Adult females burrow into the mucosa of the **duodenum** and reproduce **parthenogenetically**.
- Eggs hatch within the mucosa and release **rhabditiform larvae** into the lumen of the bowel.
- In **autoinfection**, rhabditiform larvae become **filariform larvae**, penetrate the intestinal mucosa or perianal skin, and repeat the circulation–lung–intestine cycle.
- This cycle can persist for years and can lead to **hyperinfection** and massive or disseminated, often fatal infection.



Epidemiology and Clinical Syndromes

- ***S. stercoralis*** requires **warm temperatures and moisture**.
- It has low prevalence but broader geographic distribution, including parts of the northern United States and Canada.
- **Sexual transmission** also occurs, and animal reservoirs such as **domestic pets** are recognized.
- Infected individuals frequently have **pneumonitis from migrating larvae.**
- Heavy worm loads may involve the **biliary and pancreatic ducts**, the entire small bowel, and the colon, causing **inflammation and ulceration**.
- Symptoms may include **epigastric pain and tenderness, vomiting, diarrhea**, occasionally bloody, and **malabsorption**.
- **Hyperinfection syndrome** is most common in immunocompromised patients, especially those with malignancies, **corticosteroid therapy**, solid organ transplantation, or malnutrition.
- Hyperinfection may cause dissemination to the **lung, abdominal lymph nodes, liver, spleen, kidneys, pancreas, thyroid, heart, brain, and meninges**.

Laboratory Diagnosis, Treatment, Prevention, and Control

- Diagnosis may be difficult because of the intermittent passage of low numbers of **first-stage larvae in stool**.
- Examination of concentrated stool sediment reveals the **larval worms**; eggs are generally **not seen**.
- Collecting samples from **three stools, one per day for 3 days**, is recommended because larvae may occur in **"showers."**
- Larvae may be detected in **duodenal aspirates** or in **sputum** in massive infection.
- Demonstration of **anti-Strongyloides antibodies** in blood may be useful as a screening test or adjunct for diagnosis.
- Diagnosis by **nucleic acid amplification tests** for stool and urine is available in many reference laboratories.
- Infection should be treated to prevent **autoinfection** and dissemination.
- The drug of choice is **ivermectin; albendazole** or **mebendazole** as alternatives.
- Control requires **education, proper sanitation, and prompt treatment** of existing infections.

Figure B: L2 rhabditiform larva of *S. stercoralis* in unstained wet mounts of stool. Note the short buccal canal and the genital primordium (red arrows), but longer intestinal tract than seen in an L1.

Figure A: L1 rhabditiform larva of *S. stercoralis* in unstained wet mounts of stool. Note the short buccal canal and the genital primordium (red arrow).

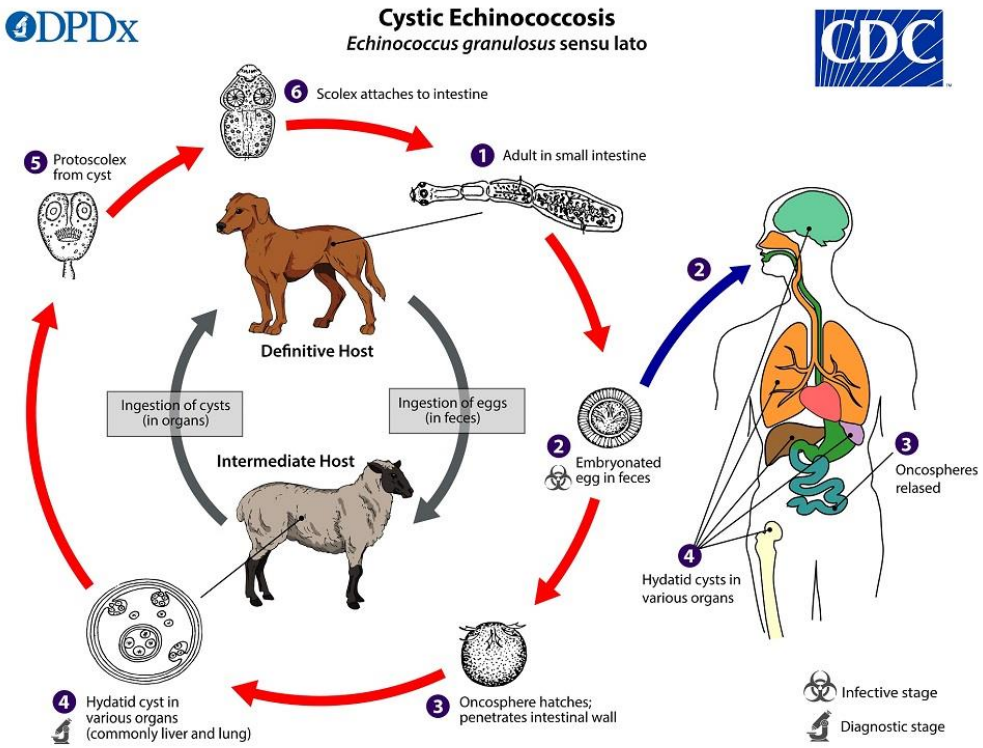
Cestodes

TABLE 76.1 Medically Important Cestodes

Cestode	Common Name	Reservoir for Larvae	Reservoir for Adults
Taenia solium	Pork tapeworm	Hogs	Humans
	Cysticercosis	Humans	—
Taenia saginata	Beef tapeworm	Cattle	Humans
Diphyllobothrium latum	Fish tapeworm	Freshwater crustaceans and fish	Humans, dogs, cats, bears
Echinococcus granulosus	Unilocular hydatid cyst	Herbivores, humans	Canines
E. multilocularis	Alveolar hydatid cyst	Herbivores, humans	Foxes, wolves, dogs, cats
Hymenolepis nana	Dwarf tapeworm	Rodents, humans	Rodents, humans
H. diminuta	Dwarf tapeworm	Insects	Rodents, humans
Dipylidium caninum	Pumpkin seed tapeworm	Fleas	Dogs, cats

Echinococcus granulosus: Physiology and Life Cycle

- Infection with **E. granulosus** is another example of accidental human infection, with humans serving as **dead-end intermediate hosts**.
- Adult tapeworms are found in the intestines of **canines**: dog, fox, wolf, coyote, jackal, and dingo.
- The larval cyst stage is present in the viscera of **herbivores**: sheep, cattle, swine, deer, moose, and elk.
- Adult tapeworms in the canine intestine produce **infective eggs** that pass in feces.
- When eggs are ingested by humans, a six-hooked larval stage called an **oncosphere** hatches.
- The oncosphere penetrates the human intestinal wall and enters the circulation to be carried primarily to the **liver and lungs**, but also the **central nervous system and bone**.



Hydatid Cyst Structure and Pathogenesis

- In humans, the larvae form a **unilocular hydatid cyst**, which is a slow-growing, tumor-like, space-occupying structure.
- The cyst is enclosed by a **laminated germinative membrane**.
- The membrane produces **brood capsules**, where tapeworm heads, called **protoscolices**, develop.
- **Daughter cysts** may develop in the original mother cyst and also produce brood capsules and protoscolices.
- The cyst fluid is potentially toxic; if spilled into body cavities, **anaphylactic shock and death** can result.
- Spillage and escape of protoscolices can lead to development of cysts in other sites.
- Liberated protoscolices become known as **hydatid sand**.

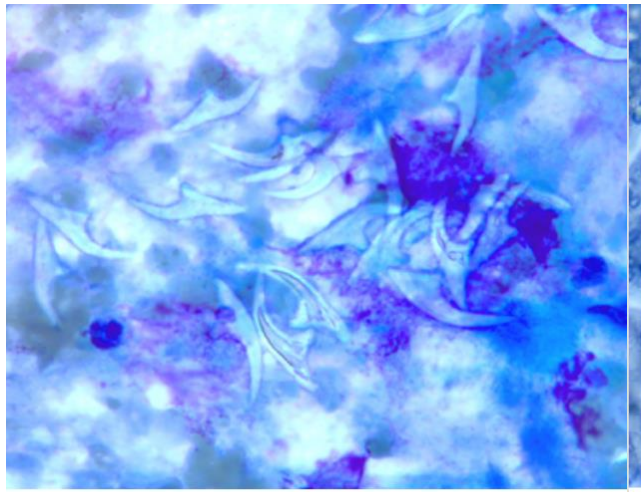


Figure F: Free hooklets in 'hydatid sand' from the aspirate of a liver cyst, stained with PAP.

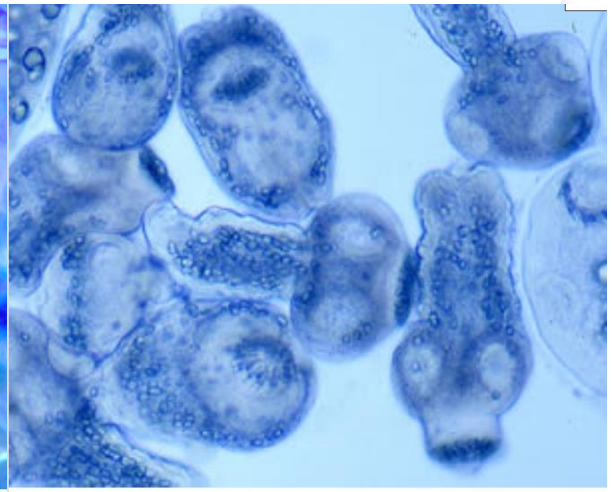


Figure C: Protoscolices liberated from a hydatid cyst. The two protoscolices on the right side of the image are evaginated.

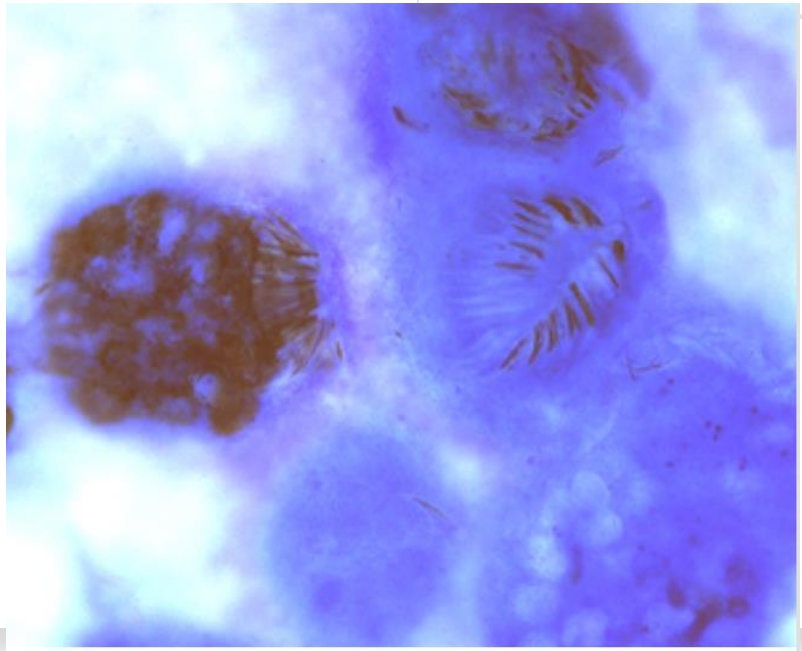


Figure A: Protoscolices in a hydatid cyst removed a liver cyst, stained with PAP.

Epidemiology, Clinical Disease, Diagnosis, and Treatment

- Human infection is directly correlated with **raising sheep** in many countries.
- Human infection follows ingestion of contaminated **water or vegetation**, or hand-to-mouth transmission of canine feces carrying infective eggs.
- Because the unilocular cyst grows slowly, **5 to 20 years** may pass before symptoms appear.
- In most cases, cysts are located in the **liver or lung**.
- In the liver, the cyst may cause pressure on **bile ducts and blood vessels**, producing pain and biliary rupture.
- In the lungs, cysts may produce **cough, dyspnea, and chest pains**.
- Diagnosis depends primarily on **clinical, radiographic, and serologic findings**.
- **Surgical resection of the cyst** is the treatment of choice; if inoperable, high-dose **albendazole, mebendazole, or praziquantel** may be considered.

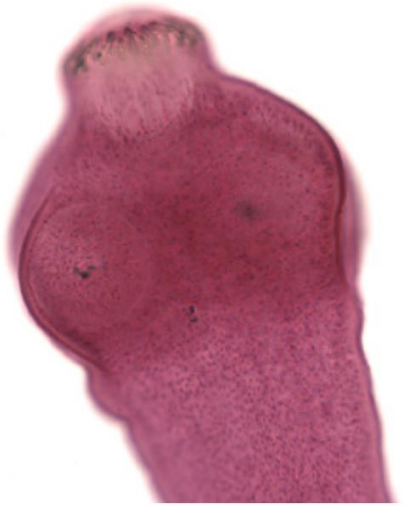


Figure B: Close-up of the scolex of *E. granulosus*. In this focal plane, one of the suckers is clearly visible, as is the ring of rostellar hooks.

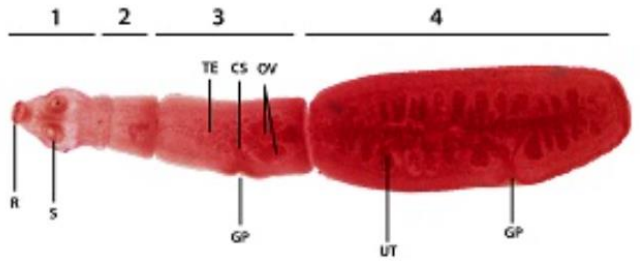


Figure A: *Echinococcus granulosus* adult, stained with carmine. This specimen has four segments (1: scolex; 2: immature proglottid; 3: mature proglottid; 4: gravid proglottid). Features highlighted are the armed rostellum (R) and suckers (S) of the scolex, and reproductive structures including the testes (TE), cirrus sac (CS), ovaries (OV), branched uterus containing eggs (UT), and genital pores on the mature and gravid proglottids (GP).

Hymenolepis nana and *Hymenolepis diminuta*

- ***H. nana***, the **dwarf tapeworm**, is only **2 to 4 cm** in length
- Infection begins when **embryonated eggs are ingested** from contaminated food and water and develop in the intestinal villi into a **larval cysticercoid stage**.
- Eggs passing in the feces are **immediately and directly infective**, initiating another cycle.
- ***H. nana*** also can cause **autoinfection**, leading to **hyperinfection** .
- Few worms cause **no symptoms**; heavy infections may cause **diarrhea, abdominal pain, headache, anorexia**, and vague complaints.
- Stool examination reveals the characteristic ***H. nana* egg** with its **six-hooked embryo and polar filaments**.
- Treatment: drug of choice is **praziquantel.**
- ***H. diminuta*** is primarily a tapeworm of **rats and mice** but is also found in humans; it measures **20 to 60 cm**.
- Diagnosis: stool examination shows a **bile-stained egg that lacks polar filaments**.
- Treatment: drug of choice is **niclosamide**, with **praziquantel** as an alternative.

Figure A: Egg of *H. diminuta* in a wet mount stained with iodine. Four of the hooks are visible at this level of focus. Image courtesy of the Georgia Department of Public Health.

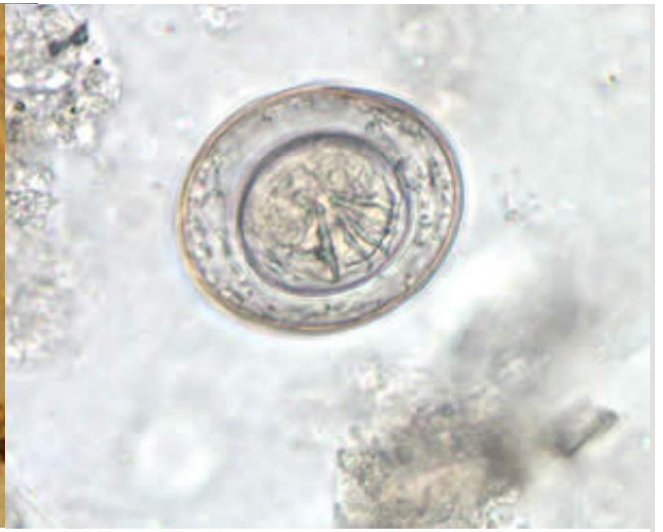
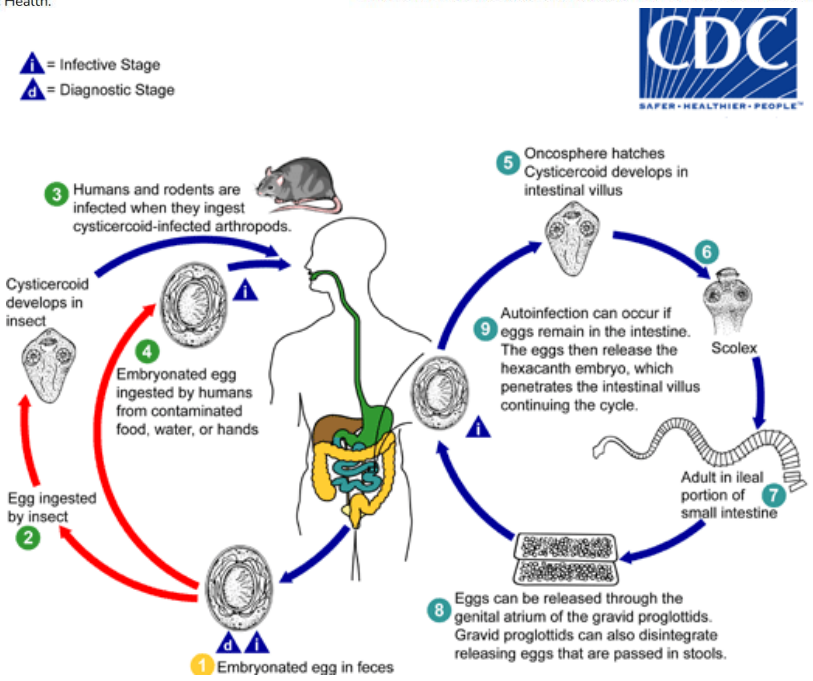


Figure A: Egg of *H. nana* in an unstained wet mount. Note the presence of hooks in the oncosphere and polar filaments within the space between the



Trematodes

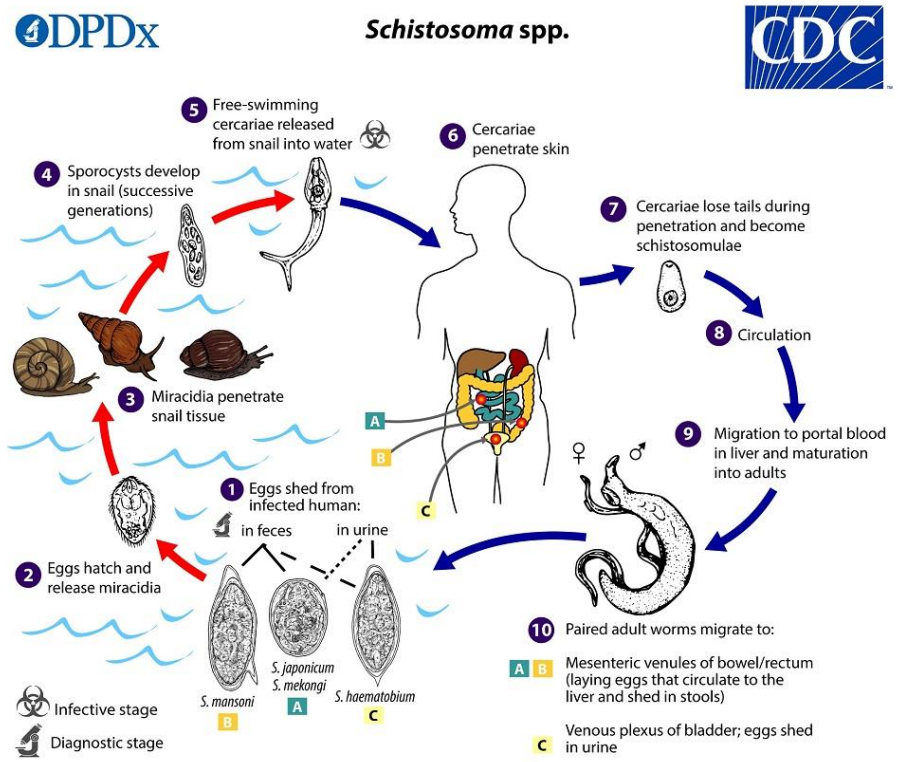
- **Trematodes**, or **flukes**, are **flat, fleshy, leaf-shaped Platyhelminthes**.
- They have an **oral sucker** and a **ventral sucker** for feeding/attachment.
- Most flukes are **hermaphroditic**; **schistosomes** are the exception with separate male and female worms.
- All flukes require **intermediate hosts**; the first host is always a **mollusk**, such as a snail or clam.
- Many fluke eggs have an **operculum**, a lid-like structure that releases the larva.
- **Schistosome eggs do not have an operculum**; the eggshell splits to release the larva.

Schistosomes

- **Schistosomiasis** is a major parasitic infection of tropical areas, with some **230 million infections worldwide**.
- The three schistosomes most frequently associated with human disease are ***Schistosoma mansoni, S. japonicum, and S. haematobium***.
- They collectively produce **schistosomiasis**, also known as **bilharziasis** or **snail fever**.
- Schistosomes differ from other flukes: they are **male and female rather than hermaphroditic**, and their eggs **do not have an operculum**.
- They are **obligate intravascular parasites**.
- The infective forms are **skin-penetrating cercariae** liberated from snails.
- Infection is initiated by **ciliated, free-swimming, freshwater cercariae** that penetrate intact skin and enter the circulation.

Pathogenesis and Early Clinical Disease

- ***S. mansoni*** *and* ***S. japonicum*** develop in the **intrahepatic portal circulation**.
- ***S. mansoni*** *and* ***S. japonicum*** are found in **mesenteric veins** and produce **intestinal schistosomiasis**.
- The host inflammatory response to adult worms is minimal, but the **eggs elicit an intense inflammatory reaction** with cellular infiltrates and **microabscesses**.
- Disease results primarily from the host's **immune response to the eggs**.
- Cercarial penetration may cause an intensely **pruritic papular skin rash**.
- The onset of oviposition may cause **Katayama syndrome**, marked by **fever, chills, cough, urticaria, arthralgias, lymphadenopathy, splenomegaly, and abdominal pain**.



Schistosoma mansoni

- ***S. mansoni*** usually resides in the small branches of the **inferior mesenteric vein near the lower colon**.
- The eggs are **oval**, possess a **sharp lateral spine**, and measure **115 to 175 µm × 45 to 70 µm**.
- ***S. mansoni*** is the most widespread of the schistosomes and is endemic in **Africa, Saudi Arabia, and Madagascar**.
- Infections may produce **hepatic and intestinal abnormalities**.
- Deposition of eggs in the bowel mucosa results in **inflammation and thickening of the bowel wall** with **abdominal pain, diarrhea, and blood in the stool**.
- Eggs carried to the liver may lead to **periportal fibrosis**, **portal hypertension**, **hepatosplenomegaly**, and ascitic fluid.

Diagnosis, Treatment, and Control

- Stool examination reveals the large golden eggs with a **sharp lateral spine**.
- **Concentration techniques** may be necessary in light infections.
- **Rectal biopsy** can show egg tracks laid by the worms in rectal vessels.
- Quantitation of egg output in stool is useful in estimating severity and following response to therapy.
- The drug of choice is **praziquantel**, and the alternative is **oxamniquine**.
- Schistosomal dermatitis and **Katayama syndrome** may be treated with **antihistamines and corticosteroids**.
- Prevention and control require **education**, molluscicide control of snails, improved sanitation, and control of **human fecal deposits**.

Schistosoma japonicum

- ***S. japonicum*** resides in branches of the **superior mesenteric vein** around the small intestine and in the **inferior mesenteric vessels**.
- ***S. japonicum*** eggs are smaller, almost **spheric**, and possess a **tiny spine**.
- Eggs are carried to more sites in the body, including **liver, lungs, and brain, and are produced in greater numbers.**
- This Oriental blood fluke is found only in **China, the Philippines, and Sulawesi, Indonesia**.
- The initial stages are similar to ***S. mansoni***, with **dermatitis, allergic reactions, fever, and malaise**, followed by **abdominal discomfort and diarrhea**.
- **Katayama syndrome** is observed more commonly with ***S. japonicum*** than with ***S. mansoni***.

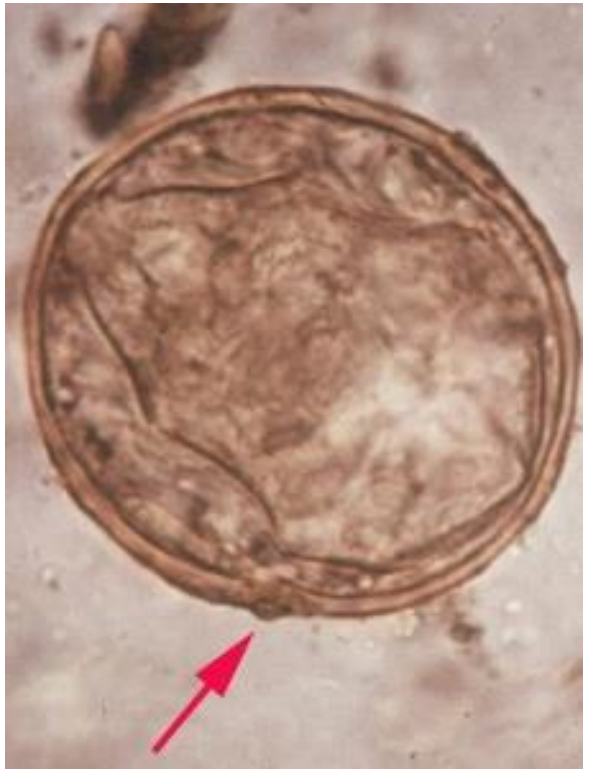


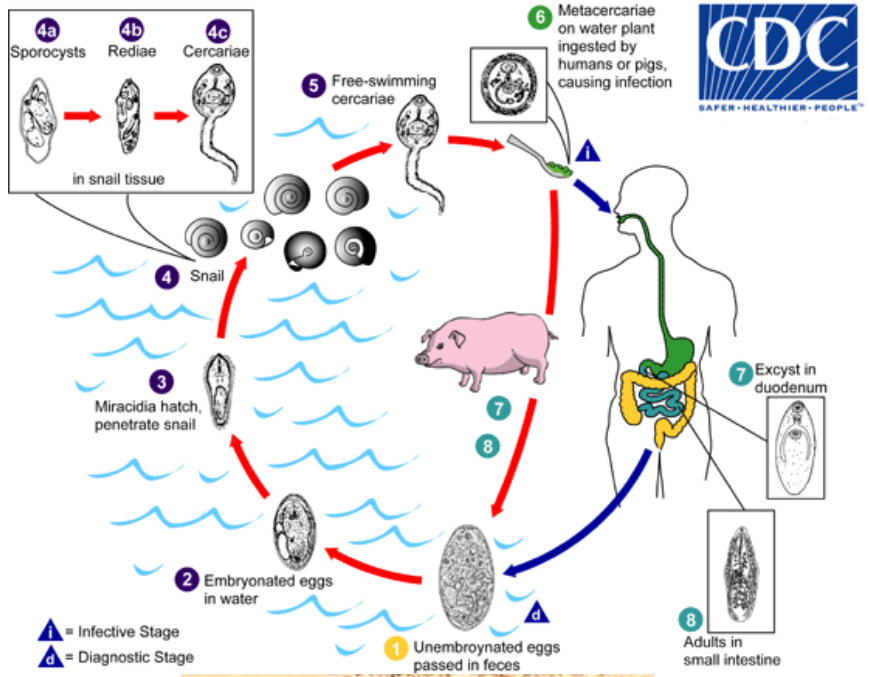
Figure B: Egg of *S. japonicum* in an unstained wet mount. Note the s
inconspicuous spines (red arrows).

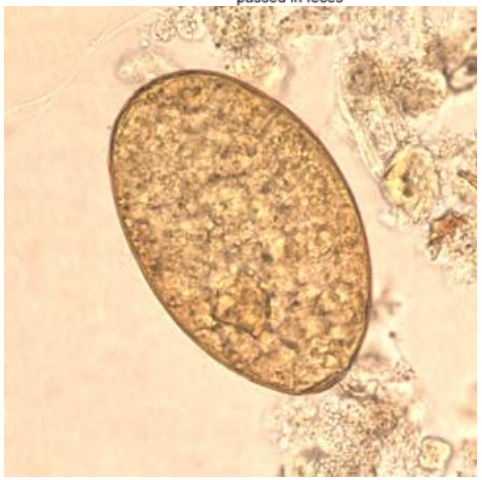
Chronic Disease, Diagnosis, Treatment, and Control

- In chronic ***S. japonicum*** infection, **hepatosplenic disease, portal hypertension, bleeding esophageal varices, and accumulation of ascitic fluid** are commonly seen.
- ***S. japonicum*** frequently involves cerebral structures when eggs reach the brain and granulomas develop around them.
- Neurologic manifestations include **lethargy, speech impairment, visual defects, and seizures**.
- Stool examination demonstrates the small, golden eggs with **tiny spines**.
- Rectal biopsy is similarly revealing, and serologic tests are available.
- The drug of choice is **praziquantel**.
- Prevention and control are similar to those *for* ***S. mansoni***, especially **education**, proper water purification, sanitation, and control of **human fecal deposits**.

Fasciolopsis buski

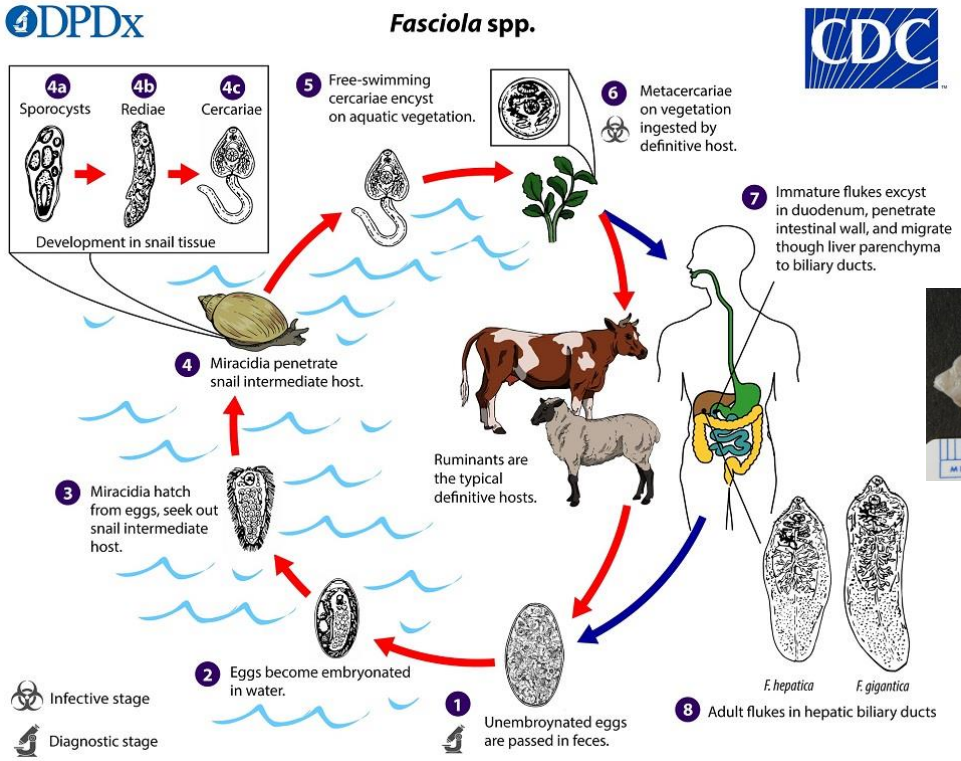
- ***F. buski*** is the **largest, most prevalent, and most important intestinal fluke**.
- Humans ingest the encysted larval stage, **metacercaria**, from aquatic vegetation, such as **water chestnuts**.
- The metacercariae develop into immature flukes in the **duodenum; adult forms in small intestine and undergoe self fertilization.**
- Egg production starts about **3 months** after infection.
- Endemic areas include **China, Vietnam, Thailand, parts of Indonesia, Malaysia, and India**; **pigs, dogs, and rabbits** serve as reservoir hosts.
- Attachment may cause **inflammation, ulceration, and hemorrhage**.
- Severe infection causes **abdominal discomfort**, **diarrhea**, **malabsorption syndrome**, intestinal obstruction, and marked **eosinophilia**.
- Stool examination shows large, golden, **bile-stained eggs with an operculum**.
- Treatment: **praziquantel** is the drug of choice; **mebendazole** is an alternative.





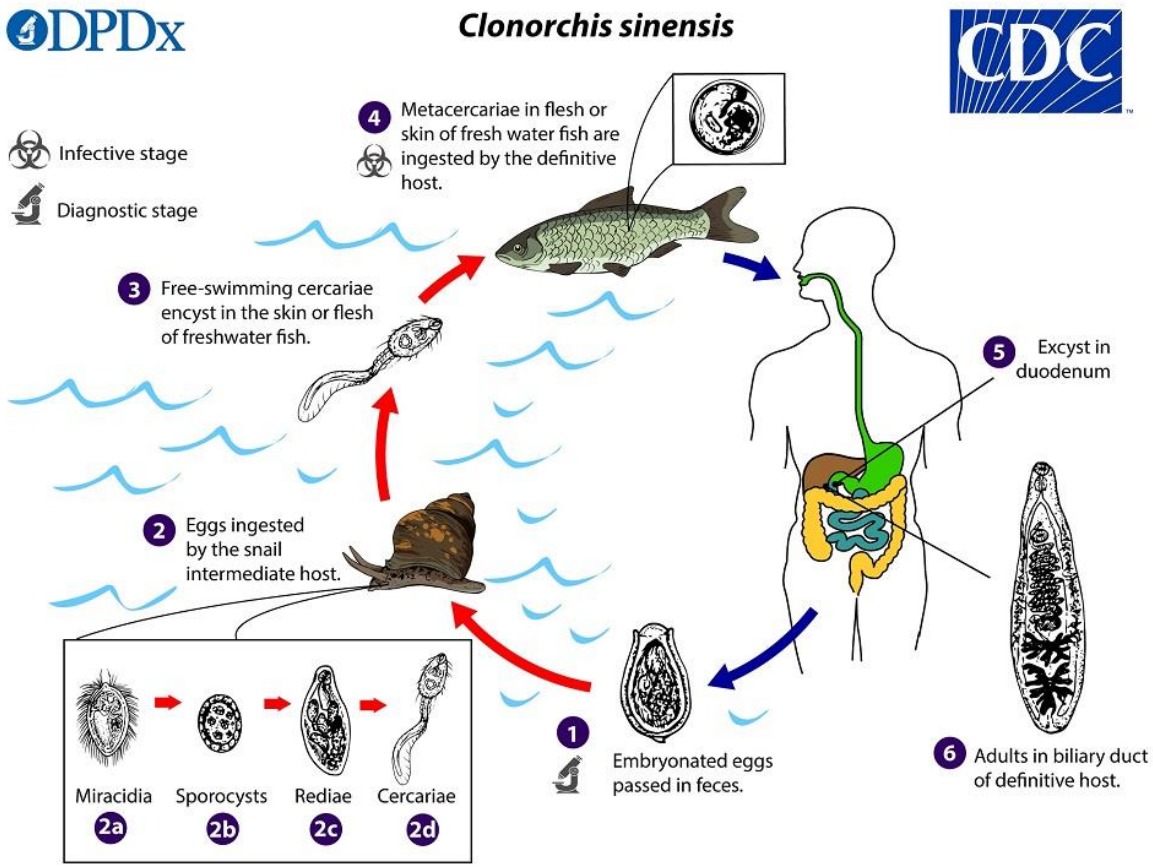
Fasciola hepatica: Sheep Liver Fluke

- Aparasite of **herbivores**, especially **sheep and cattle**, and humans. Human infection results from ingestion of **watercress** harboring encysted **metacercariae**.
- Larval flukes migrate through the **duodenal wall**, penetrate the **liver capsule**, and enter the **bile ducts** to become adult worms.
- Operculated eggs are produced after 3-4 months.
- **Right upper quadrant pain, fever, hepatomegaly**, and marked **eosinophilia; hepatitis and biliary obstruction also result.**
- Stool shows **operculated eggs**; bile examination confirms ***F. hepatica*** because ***F. buski*** is limited to the small intestine.
- Serologic diagnosis is valuable.
- Treatment: **triclabendazole.**



Clonorchis (Opisthorchis) sinensis: Chinese Liver Fluke

- **Two intermediate hosts**: a **snail** and a **freshwater fish**. Infection occurs when **uncooked freshwater fish** harboring **metacercariae** are eaten.
- Flukes develop first in the **duodenum** , migrate to the **bile ducts**, where they become adults.
- Most infections are **mild and asymptomatic; diarrhea, hepatomegaly**, and **biliary obstruction in sever infections.**
- Chronic infection can result in **adenocarcinoma of the bile ducts**.
- Stool exam reveal operculated eggs (**27 to 35 µm × 12 to 19 µm), with tiny posterior knob.**
- **Treatment: praziquantel.**
- Avoid **uncooked fish** and ensure proper disposal of **human, dog, and cat feces** to prevent contamination of water supplies.



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