

Microbiology & Parasitology Notes: Helminths and Protozoa



Helminths

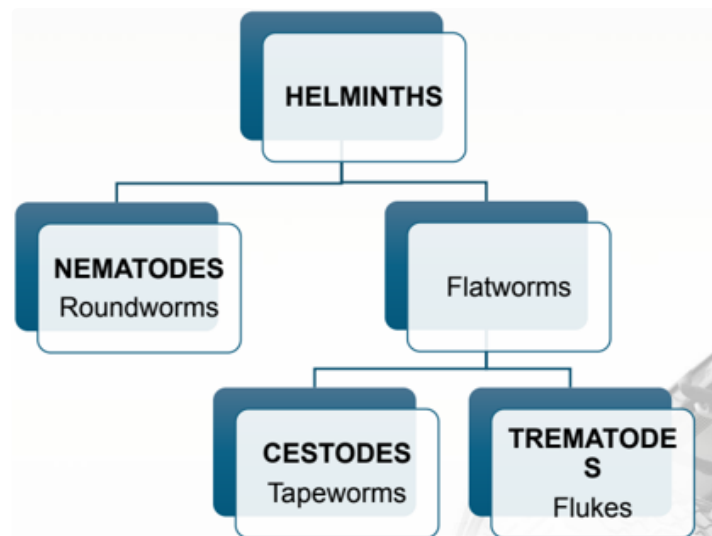
Helminths are parasitic worms. Their typical life cycle includes three stages: **egg**, **larva**, and **adult worm** (male or female, or hermaphrodite). Diagnosis is made by observing any of these three stages in a fecal specimen.

Typical hosts:

- **Intermediate host** – harbors the larval stage
- **Definitive host** – harbors the adult worm

Some helminths can have more than one intermediate or definitive host.

Classification of helminths:

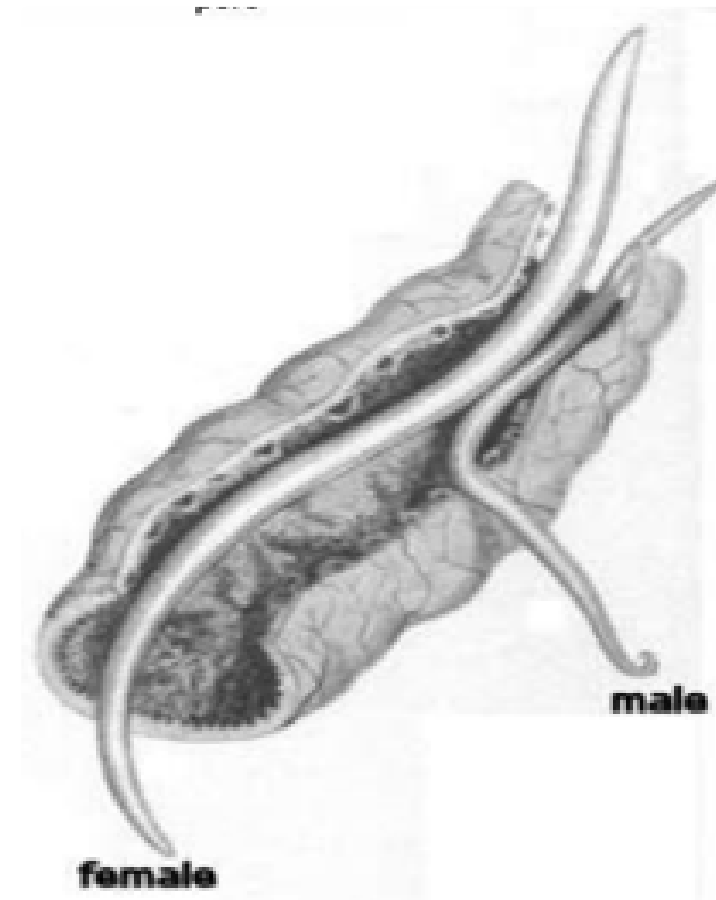


1. Nematodes

Nematodes are roundworms. They have a separate orifice for food intake (mouth) and waste excretion (anus), a pseudocoelom, and a cuticle. Reproduction is usually sexual; males are smaller than females and often have a characteristically bent tail for holding the female during copulation. **Eggs** may be embryonated or unembryonated.

Infection occurs by eating uncooked meat with larvae, entry through cuts in the skin or directly through the skin, via arthropod vectors, etc. **Diagnosis** is by microscopic identification of eggs in stool or of the adult form.

Important nematodes parasitic on humans: whipworms, hookworms, pinworms, ascarids, filarids.



Nematodes are divided into:

- **Intestinal Nematodes:** *Ascaris lumbricoides*, *Trichuris trichiura*, *Ancylostoma duodenale*, *Necator americanus*, *Strongyloides stercoralis*, *Enterobius vermicularis*, *Capillaria philippinensis*
- **Blood and Tissue Nematodes:** *Wuchereria bancrofti*, *Brugia malayi*, *Trichinella spiralis*, *Parastrongylus cantonensis*, *Onchocerca volvulus*, *Loa loa*, *Anisakis* species, *Toxocara canis*, *Toxocara cati*, *Dracunculus medinensis*

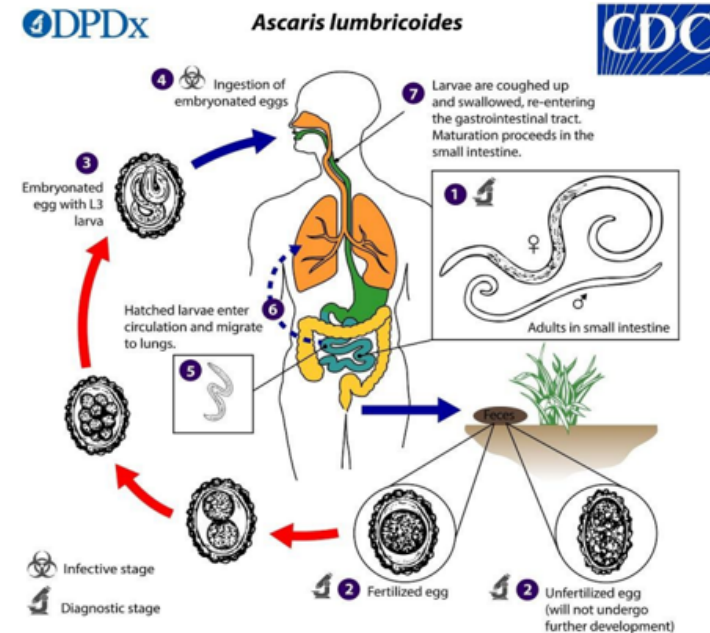
Intestinal Nematodes

Ascaris lumbricoides (Giant roundworm)

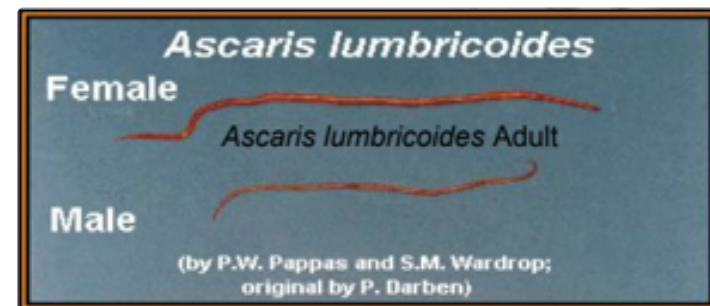
- Most common human helminthic infection globally
- Highest burden in tropical and subtropical regions with inadequate sanitation
- **Clinical presentation:** Heavy infections in children may cause stunted growth via malnutrition; high worm burdens cause abdominal pain and intestinal obstruction; migrating adult worms can cause symptomatic occlusion of the biliary tract, appendicitis; nasopharyngeal expulsion
- **Treatment:** Albendazole

Egg morphology:

- **Fertilized egg** – thick shell that appears lumpy (mamillated); some eggs may be 'decorticated' and lack this mamillated layer
- **Unembryonated egg**
- **Embryonated with L1 larva**
- **Embryonated with L2 larva**



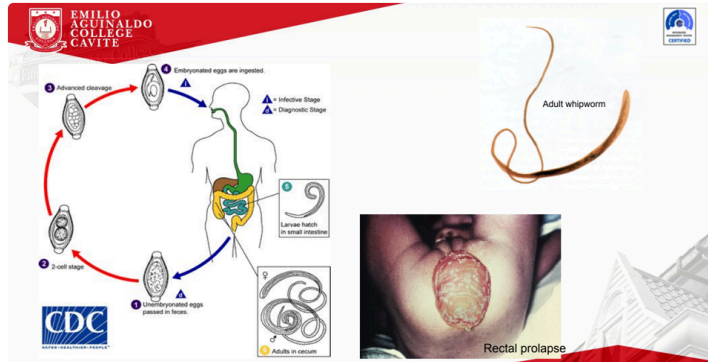
The adult worm has 'three lips' on its anterior end.



Trichuris trichiura (Whipworm)

- Third most common roundworm infection in humans
- **Clinical presentation:** Often asymptomatic; heavy infections in small children can cause gastrointestinal problems (abdominal pain, diarrhea, **rectal prolapse**) and growth retardation
- **Treatment:** Mebendazole

Egg morphology: Barrel-shaped, thick-shelled, with a pair of **polar plugs** at each end ('bipolar plugs'). Eggs are unembryonated when passed in stool.



Hookworms: *Ancylostoma duodenale* (Old World hookworm) and *Necator americanus* (New World hookworm)

- Considered the two primary intestinal hookworm species worldwide
- **Blood-sucking nematodes** that attach to the mucosa of the small intestines
- *A. duodenale*: blood loss of 0.15–0.26 mL/day per worm
- *N. americanus*: blood loss of 0.03 mL/day per worm
- **Clinical presentation:** Commonly asymptomatic; abdominal pain, nausea, anorexia; symptoms related to blood loss (anemia)
- **Treatment:** Albendazole

Egg morphology: Eggs of *Ancylostoma* and *Necator* cannot be differentiated microscopically. They are thin-shelled, colorless, and in the two- to eight-cell stage of division when passed in fresh feces.

Difference in buccal capsules:

- *Necator americanus* – two ventral semilunar **cutting plates**
- *Ancylostoma duodenale* – four ventral **teeth**



Strongyloides stercoralis (Threadworm)

- Major causative agent of strongyloidiasis in humans (other *Strongyloides* spp. do not cause true strongyloidiasis)
- **Facultative parasites** – can have a free-living cycle
- **Autoinfection** may occur (larval migration)
- **Unexplained eosinophilia** may be a clue

Acute strongyloidiasis has three phases:

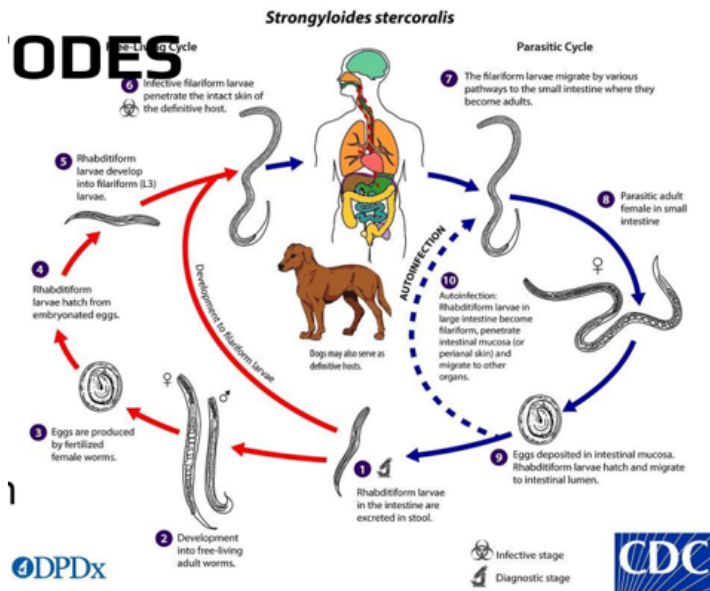
1. **Invasion of the skin** by filariform larvae
2. **Migration of larvae** through the body
3. **Penetration of intestinal mucosa** by adult female

Chronic strongyloidiasis is often asymptomatic.

Treatment: Albendazole, Thiabendazole, Ivermectin, or a combination.

Stages:

- **L1 Rhabditiform larvae** – diagnostic stage
- **L3 Filariform larvae** – infective stage

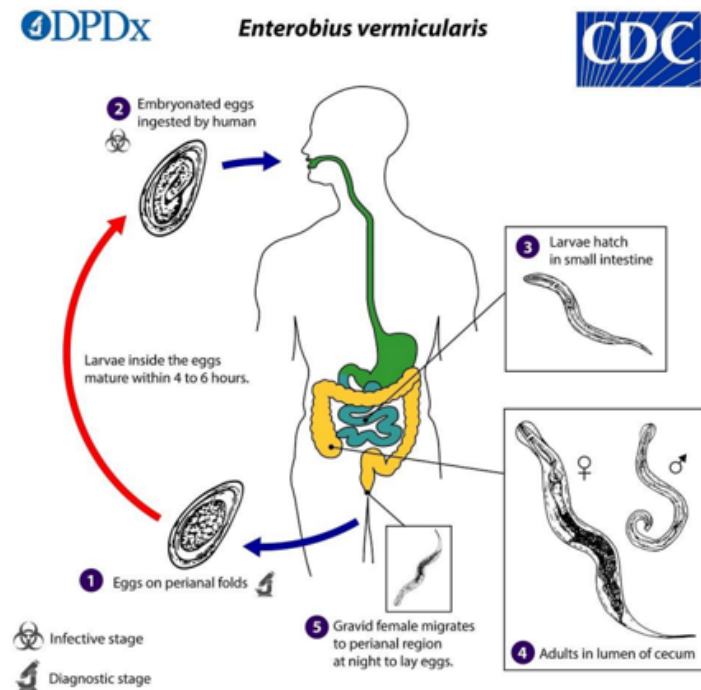


Clinical phases:

- **Cutaneous phase:** L3 skin penetration
- **Lung phase:** L3 lung migration
- **Intestinal phase:** Mild watery diarrhea to duodenitis
- **Disseminated strongyloidiasis:** hyperinfection syndrome in immunocompromised (especially in AIDS patients)

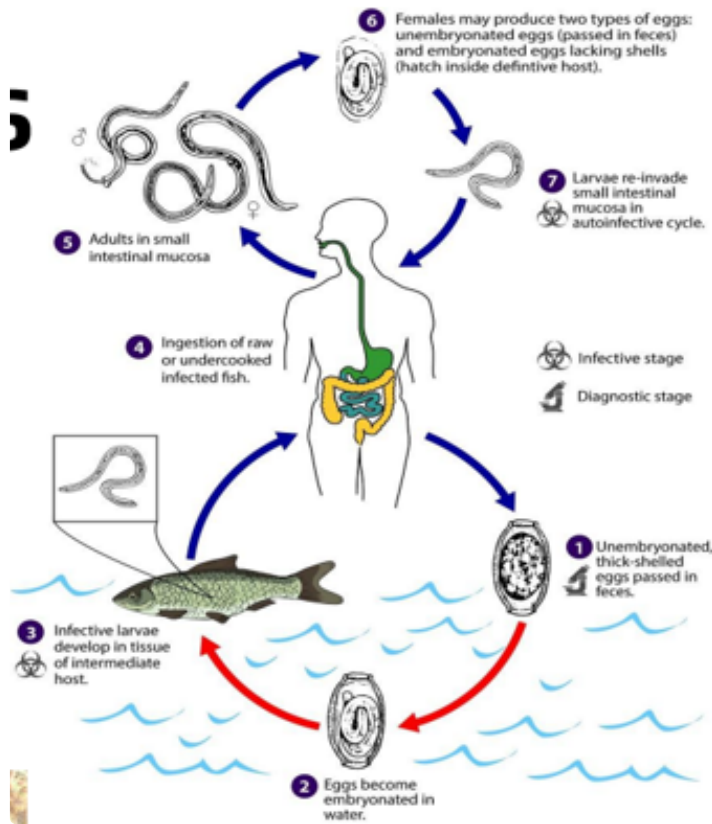
Enterobius vermicularis (Pinworm, Seatworm)

- Causes enterobiasis or oxyuriasis
- **Transmission:** ingestion of embryonated eggs, or inhalation of eggs
- **Clinical presentation:** **Perianal itching** (pruritus ani); can migrate to cause enterocolitis, vulvovaginitis, salpingitis, appendicitis
- **Diagnostic test:** **Graham's scotch/cellulose tape test** → **D-shaped ovum**
- **Treatment:** 1st line – Mebendazole; 2nd line – Pyrantel pamoate



Capillaria philippinensis (Pudoc worm)

- Transmitted via ingestion of improperly cooked fish
- Endemic in the Philippines, with epidemics in Northern Luzon
- **Clinical presentation:** Fever, abdominal pain, chronic watery diarrhea, edema, wasting (**protein-losing enteropathy**)
- **Diagnostic test:** Direct fecal smear → **peanut-shaped eggs** with flattened bipolar plugs
- **Treatment:** Albendazole; severe cases require electrolyte replacement and high protein diet



- **Pathogenesis:** Adult worms invade lymph nodes → inflammation → lymphatic obstruction → lymphedema
- **Clinical feature:** Severe lymphedema of the limbs (**elephantiasis**) and occasionally genitalia (**hydrocele**)
- **Treatment:** Diethylcarbamazine (DEC)



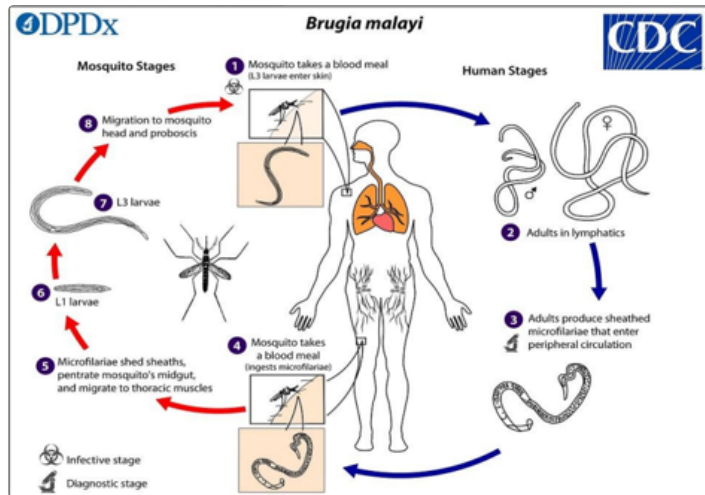
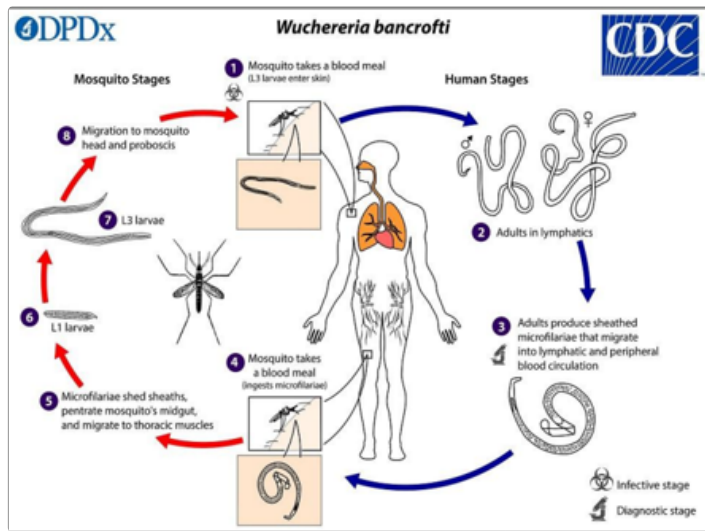
Blood and Tissue Nematodes

Filariasis – *Wuchereria bancrofti* (Bancroft's filaria) and *Brugia malayi* (Brugian filariasis)

- Most debilitating nematode infection
- **Transmission:** mosquito bite
- **Infective stage:** L3 larvae
- **Diagnostic stage:** L1 microfilariae (circulate in blood)

Microfilariae morphology:

- *W. bancrofti*: gently curved body, tail tapered to a point; nuclear column loosely packed, cells do not extend to tip of tail
- *B. malayi*: tail tapered with a significant gap between terminal and subterminal nuclei

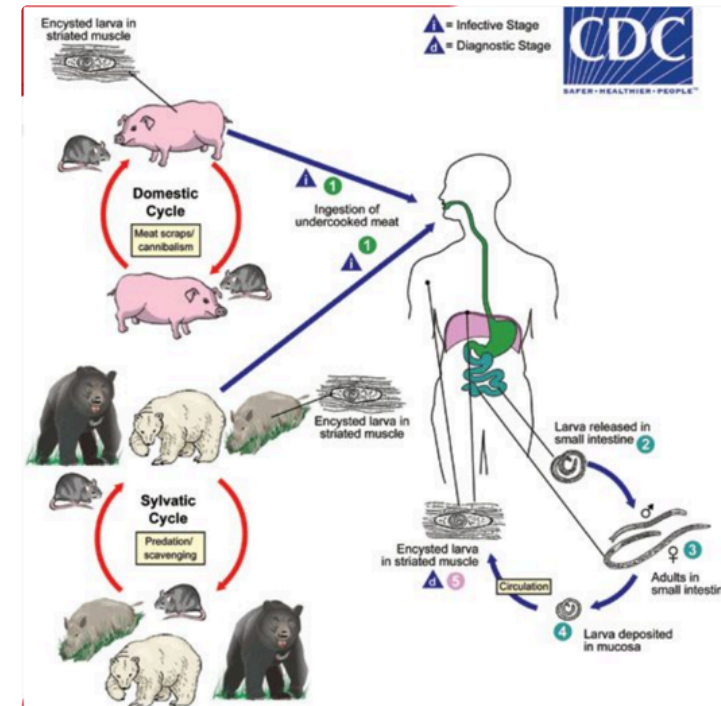


Pathogenesis:

- **Intestinal stage:** Larvae liberated from pork by gastric juices
- **Muscle stage:** Disseminated via blood to skeletal muscle → encysted within a host-derived cell (**nurse cell**)

Cardinal signs of trichinellosis: severe myalgia, periorbital edema, eosinophilia

- Intestinal invasion may cause diarrhea, abdominal pain, vomiting
- Severe disease: myocarditis, respiratory myositis
- **Treatment:** Mebendazole



Trichinella spiralis (Pork worm)

- **Intermediate host:** pigs
- **Transmission:** undercooked pork
- **Infective and diagnostic stage:** encysted larvae
- **Diagnostic test:** muscle biopsy (most definitive – larvae within striated muscles); 0.2–0.5 g of muscle tissue

Nematodes of Minor Importance

- **Onchocerca volvulus** ('Blinding worm') – transmitted by blackfly (*Simulium*); causes pruritus, dermatitis, onchocercomata (subcutaneous nodules), lymphadenopathies; most serious: ocular lesions leading to blindness.

- **Loa loa** ('Eye worm') – transmitted by deer fly or mango fly (*Chrysops*).
- **Dracunculus medinensis** ('Guinea worm') – transmitted when copepods (small crustaceans) are swallowed in water; live worm emerges from skin ulcer.
- **Anisakis** species ('Herring worm')
- **Toxocara canis** ('Dog roundworm')
- **Toxocara cati** ('Cat roundworm')
- **Parastongylus cantonensis** ('Rat lung worm')



2. Cestodes

Cestodes are tapeworms.

Morphology:

- **Pseudophyllideans** – have multiple proglottids, two **bothria** (grooves); first intermediate host: crustaceans; second intermediate host: fish
- **Cyclophyllideans** – possess cup-like suckers called **acetabula**

Treatment: **Niclosamide**, **Praziquantel** (except for *Echinococcus* spp., for which Albendazole is the drug of choice)

Classification of cestodes:

- **Pseudophyllidean cestodes:** *Diphyllobothrium latum*
- **Cyclophyllidean cestodes:** *Taenia saginata*, *Taenia solium*, *Taenia asiatica*, *Hymenolepis nana*, *Hymenolepis diminuta*, *Dipylidium caninum*
- **Extraintestinal cestodes:** *Echinococcus granulosus*, *Echinococcus multilocularis*

Pseudophyllidean Cestodes

Diphyllobothrium latum (Broad fish tapeworm)

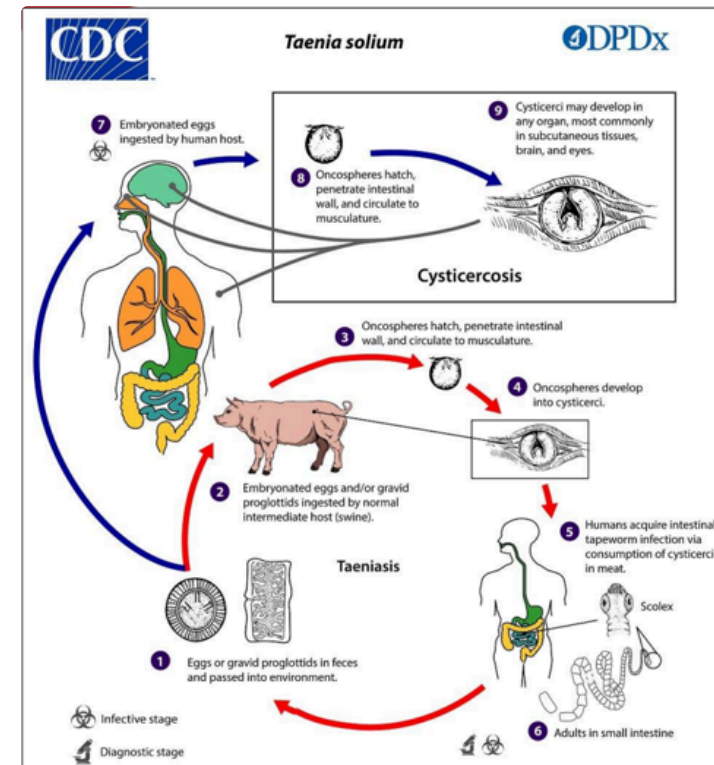
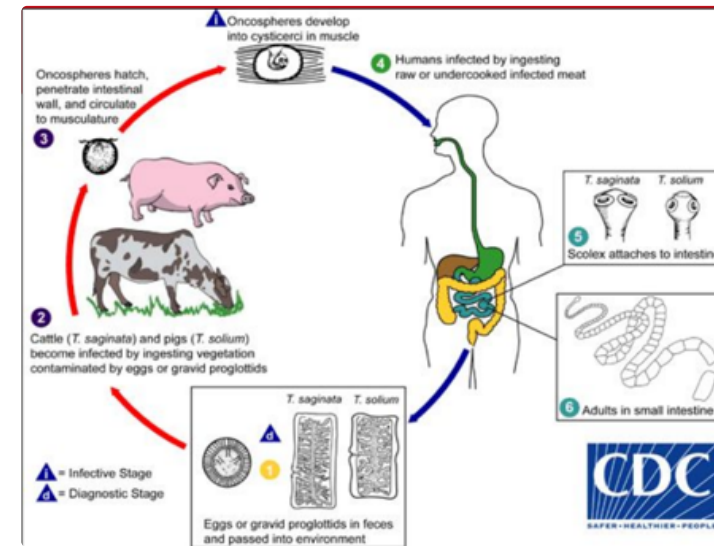
- **Longest of the tapeworms**
- **Diagnosis:** identification of eggs from fecal sample
- **Eggs:** oval or ellipsoidal; an **operculum** at one end and a small knob (**abopercular knob**) at the opposite end
- **Clinical presentation:** Can be long-lasting (up to 25 years); most asymptomatic; gastrointestinal symptoms; aberrant migration of proglottids can cause cholecystitis or cholangitis; rarely, massive infections cause intestinal obstruction

Cyclophyllidean Cestodes

Taenia spp.

Feature	<i>Taenia solium</i>	<i>Taenia saginata</i>	<i>Taenia asiatica</i>
Common name	Pork tapeworm	Beef tapeworm	Asian tapeworm
Scolex	Four suckers, circle of hooks around a rostellum	Four suckers, no hooks, no rostellum	No hooks but with rostellum
Gravid proglottid	5–10 primary uterine branches	15–25 primary uterine branches	11–32 primary uterine branches
Intermediate host	PIG	CATTLE	PIGS > cattle/goat/wild boar/monkey
Infective stage	Larvae (undercooked pork)	Larvae (undercooked beef)	Larvae (undercooked meat)
Clinical presentation (intestinal)	Mild intestinal symptoms	Abdominal pain, weight loss, pruritus ani	Similar
Additional disease	Neurocysticercosis (brain: headache, vomiting, seizure; eyes: uveitis/retinitis)	Does not cause cysticercosis in humans	Does not cause cysticercosis

The **eggs** of *Taenia* spp. are indistinguishable from each other and from other Taeniidae. They measure 30–35 µm in diameter and are **radially striated**.

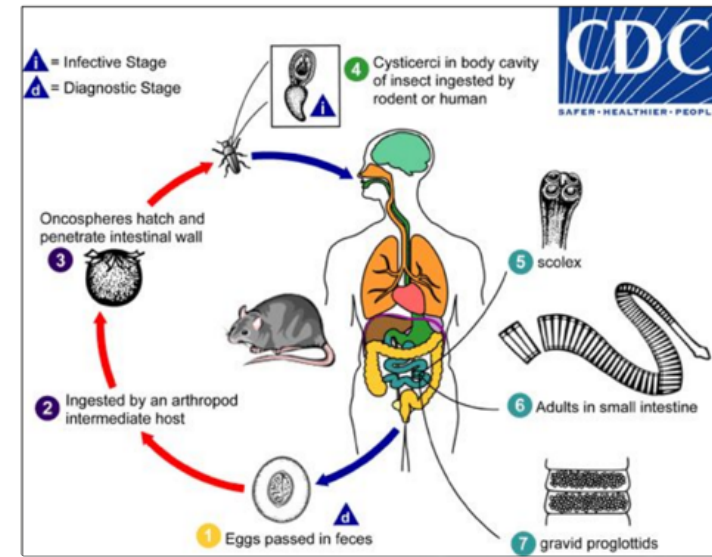
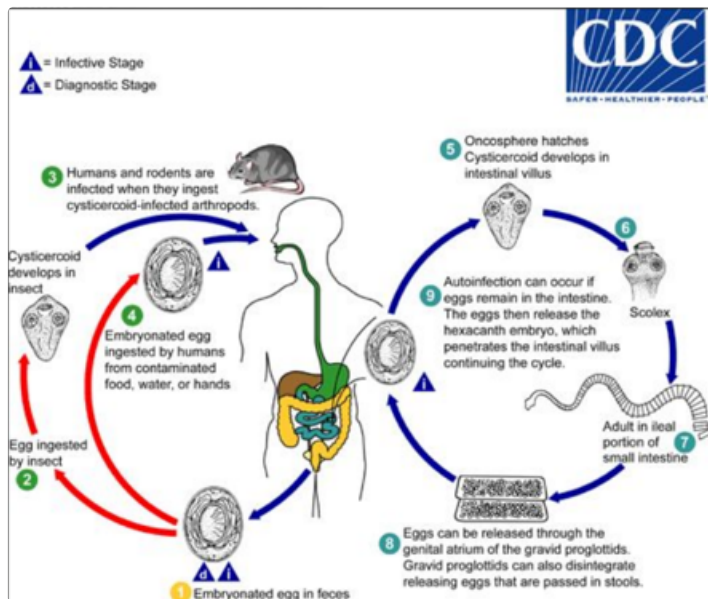


Hymenolepis nana (Dwarf tapeworm) and *Hymenolepis diminuta* (Rat tapeworm)

- *H. nana* is the most frequently found tapeworm in developed countries; *H. diminuta* is an accidental parasite
- **Transmission:**
 - *H. nana*: ingestion of cysticercoid larvae from infected rice or flour beetles; also direct ingestion of eggs (autoinfection possible)
 - *H. diminuta*: ingestion of rat flea cysticercoid larvae
- Most infections are asymptomatic; heavy *H. nana* infection can cause weakness, headaches, anorexia, abdominal pain, diarrhea

Egg morphology:

- *H. nana*: oval, 30–50 µm; inner membrane has two poles from which 4–8 **polar filaments** spread between the membranes
- *H. diminuta*: round to slightly oval, 70–85 x 60–80 µm; striated outer membrane, thin inner membrane; space between membranes is smooth or faintly granular



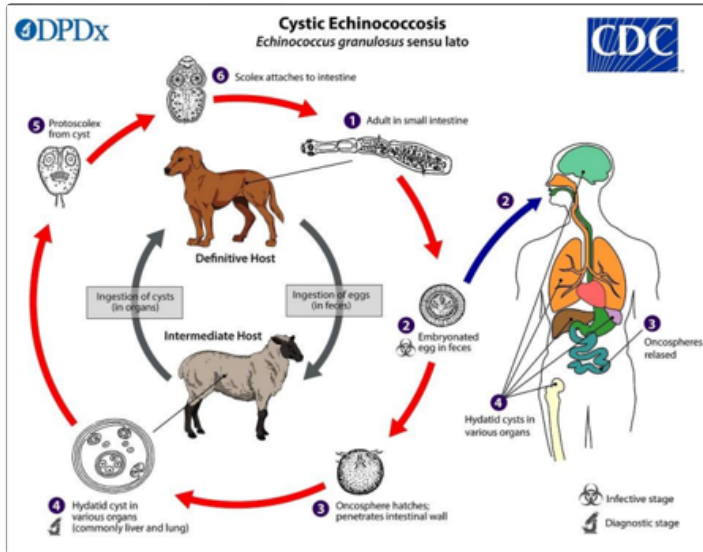
Dipylidium caninum

- Most common tapeworm of dogs or cats
- **Transmission:** dog or cat flea carrying cysticerci
- **Diagnosis:** barrel-shaped proglottids in stool; eggs are round to oval (31–50 x 27–48 µm) with an oncosphere containing 6 hooklets; proglottids contain characteristic **egg packets** (5–15 or more eggs each)

Echinococcus granulosus and *Echinococcus multilocularis*

- **E. granulosus:** scolex with four suckers and circle of hooks; only three proglottids (one of the smallest tapeworms). **Transmission:** ingestion of egg in food contaminated with dog feces. Causes **unilocular hydatid cyst** (liver, lungs, brain). **Definitive host:** dogs. **Intermediate host:** sheep/cattle/humans.
- **E. multilocularis:** definitive host – foxes; intermediate host – rodents; transmission by accidental ingestion of fox feces. Causes **multiloculated cysts** (alveolar cysts, 'honeycomb vesicles').

- **Treatment:** Albendazole; surgical resection if >10 cm liver cyst.



3. Trematodes

Trematodes are flukes.

Morphology: flattened, leaf-shaped (except *Schistosoma*, which are cylindrical). All flukes are **unsegmented** (unlike cestodes). **Reproduction:** hermaphroditic/monoecious (except *Schistosoma*). **Eggs:** all fluke eggs are **operculated** except *Schistosoma*. **Transmission:** all flukes via ingestion of **metacercaria** (except *Schistosoma* via penetration of **cercaria**).

Classification of trematodes:

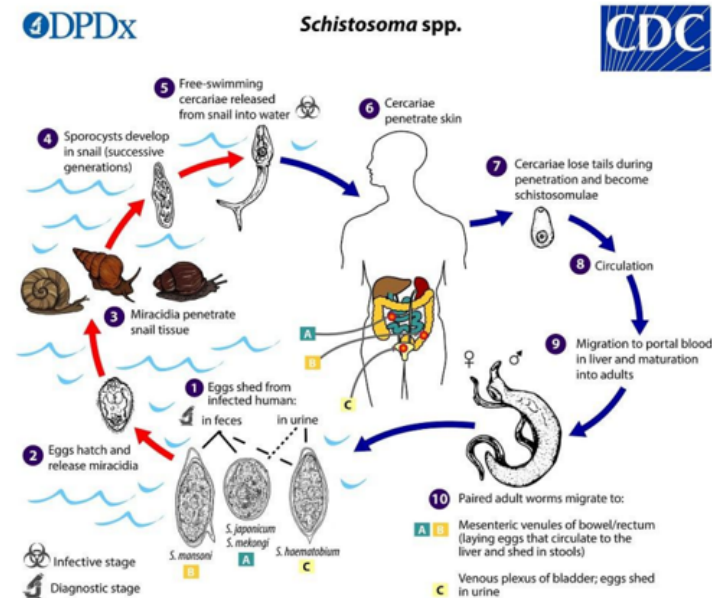
- **Blood flukes:** *Schistosoma mansoni*, *S. japonicum*, *S. mekongi*, *S. haematobium*, *S. intercalatum*, *S. incognitum*
- **Intestinal flukes:** *Fasciolopsis buski*, *Metagonimus yokogawai*, *Heterophyes heterophyes*, *Echinostoma ilocanum*, *Gastroduiscoides hominis*
- **Liver flukes:** *Fasciola hepatica*, *Fasciola gigantica*, *Clonorchis sinensis*, *Opisthorchis felinus*
- **Lung fluke:** *Paragonimus westermani*

Blood Flukes – *Schistosoma* spp.

General features: Oriental flukes; adult schistosomes exist as **separate sexes** (unlike other trematodes). Disease: **Schistosomiasis** ('snail fever'). **Infective stage:** **CERCARIAE**. **Transmission:** **skin penetration by cercariae**. Cercarial dermatitis = Swimmer's Itch; Katayama Fever = systemic hypersensitivity.

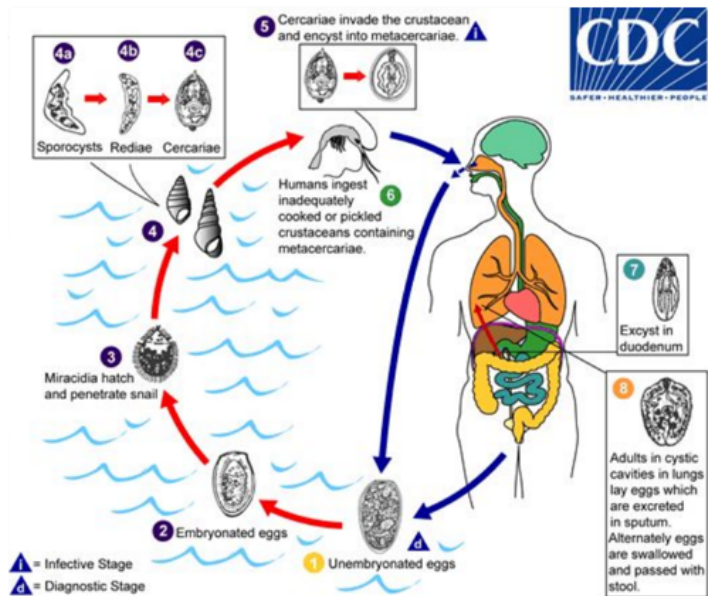
Species differences:

- ***S. japonicum*:** intermediate snail – *Oncomelania hupensis quadrasi*; disease – intestinal schistosomiasis; manifestations – liver granulomas, portal hypertension, pseudopolyps in colon, esophageal varices (bleeding may lead to death). Eggs: small, **lateral spine** ('knob').
- ***S. mansoni*:** intermediate snail – *Biomphalaria glabrata*; disease – intestinal schistosomiasis; same manifestations. Eggs: **large, prominent lateral spine**.
- ***S. haematobium*:** intermediate snail – *Bulinus truncatus*; disease – **urinary schistosomiasis**; manifestations – painless hematuria, associated with **squamous cell carcinoma of the urinary bladder**. Eggs: large, **terminal spine**.



Lung Fluke – *Paragonimus westermani* (Japanese lung fluke)

- **Transmission:** ingestion of raw crabmeat/crayfish
- **Intermediate hosts:** snail (*Antemelania asperata*), mountain crab (*Sundathelphusa philippina*)
- **Disease:** Paragonimiasis (closely resembles tuberculosis)
- **Diagnosis:** operculated/unembryonated egg in sputum or feces
- **Eggs:** yellow-brown, ovoid or elongate, thick shell, often asymmetrical; operculum at large end; abopercular end thickened; unembryonated when passed.

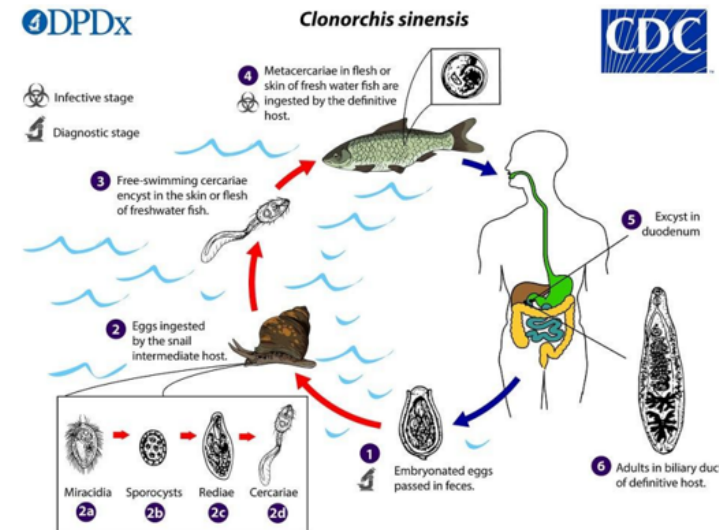


Liver Flukes

Clonorchis sinensis (Chinese/Oriental liver fluke)

- **Intermediate hosts:** snail (*Parafossarulus*), fish (Cyprinidae)

- **Transmission:** ingestion of undercooked fish
- **Disease:** Clonorchiasis – affects liver, especially common bile duct
- **Manifestations:** fever, lymphadenopathy, hepatomegaly; chronic disease: hepatobiliary disease, pancreatitis, **cholangiocarcinoma**
- **Diagnosis:** operculated/unembryonated egg in stool
- **Eggs:** oval with convex operculum on visible 'shoulders' at smaller end; abopercular end often has small knob/hook; miracidium visible inside. Morphologically similar to *Opisthorchis* spp.



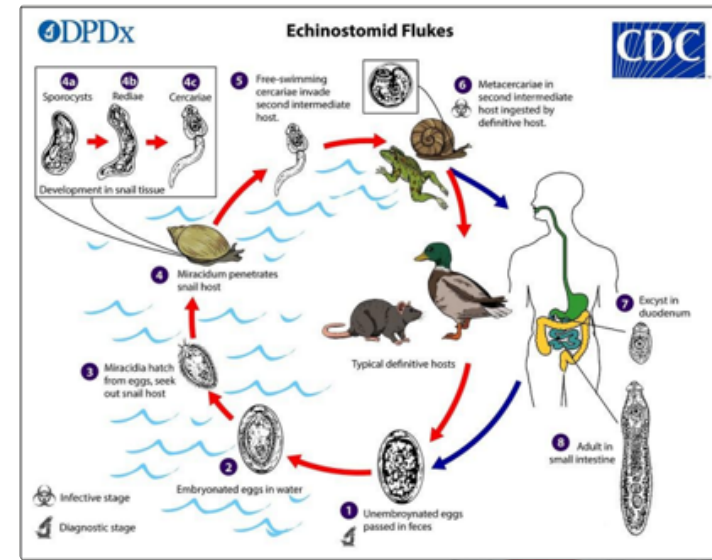
Fasciola hepatica (Temperate/sheep liver fluke) and *Fasciola gigantica* (Tropical liver fluke)

- *F. hepatica*: sheep-liver fluke; transmission by ingestion of watercress (or other aquatic plants). Symptoms due to adult worms in biliary tract (RUQ pain, fever, mostly asymptomatic). Can cause **Halzoun** (painful pharyngitis).
- *F. gigantica*: adult worms and eggs larger than *F. hepatica*. In the Philippines, snail hosts are *Lymnaea philippinensis* and *Lymnaea auricularia rubiginosa*.
- Eggs: broadly ellipsoidal, operculated.

Intestinal Flukes

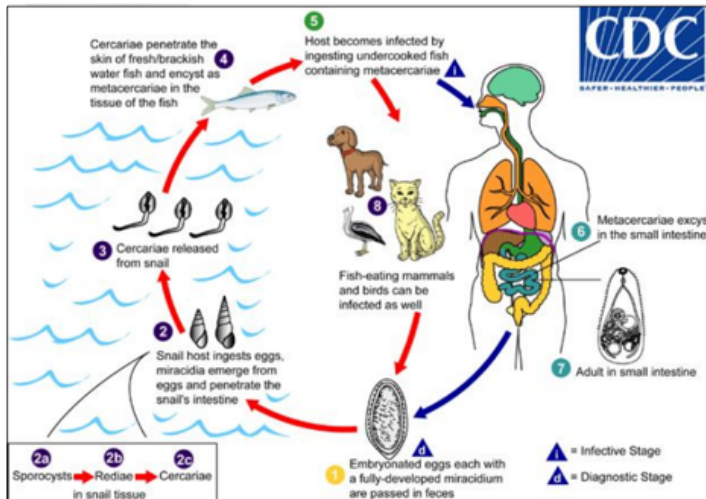
***Fasciolopsis buski* (Giant intestinal fluke)**

- Intestinal parasite of pigs and humans
- **Transmission:** ingestion of encysted metacercariae from aquatic plants
- **Intermediate hosts:** small planorbid snails (*Hippeutis* and *Segmentina*)
- **Manifestations:** most asymptomatic; heavy infections: diarrhea, abdominal pain, fever, ascites, anasarca, intestinal obstruction
- **Diagnosis:** microscopic identification of eggs (indistinguishable from *Fasciola hepatica* eggs) or adult flukes in stool/vomit
- **Eggs:** broadly ellipsoidal, operculated; abopercular end often has roughened/irregular area



Other Intestinal Flukes

- **Heterophyes heterophyes**: ingestion of raw fish containing cysts; mimics peptic ulcer disease
- **Echinostoma spp.**: incidence highest in areas where undercooked freshwater snails, clams, fish, or amphibians are eaten; catarrhal inflammation from sharp-spined collar penetrating intestinal mucosa



Protozoa

Protozoa are unicellular organisms (Kingdom Protista). Their mode of reproduction is **asexual** (binary fission, multiple fission, budding) and **sexual** (conjugation). They are classified according to their **locomotory organelle** or form of locomotion.

Classification of protozoan species:

Group	Examples
Amoebas (Sarcodina)	Pathogenic: <i>Entamoeba histolytica</i> ; Commensal: <i>E. dispar</i> , <i>E. coli</i> , <i>Endolimax nana</i> ; Free-living: <i>Naegleria fowleri</i> , <i>Acanthamoeba</i> spp.
Flagellates (Mastigophora)	Lumen-dwelling: <i>Giardia lamblia</i> , <i>Trichomonas vaginalis</i> ; Blood/tissue: <i>Leishmania</i> spp., <i>Trypanosoma cruzi</i> , <i>Trypanosoma brucei</i> complex
Ciliates (Ciliophora)	<i>Balantidium coli</i> (only ciliate that causes disease in humans)
Sporozoans (Apicomplexa)	<i>Plasmodium</i> spp., <i>Toxoplasma gondii</i> , <i>Cryptosporidium</i> spp.

Amoebas

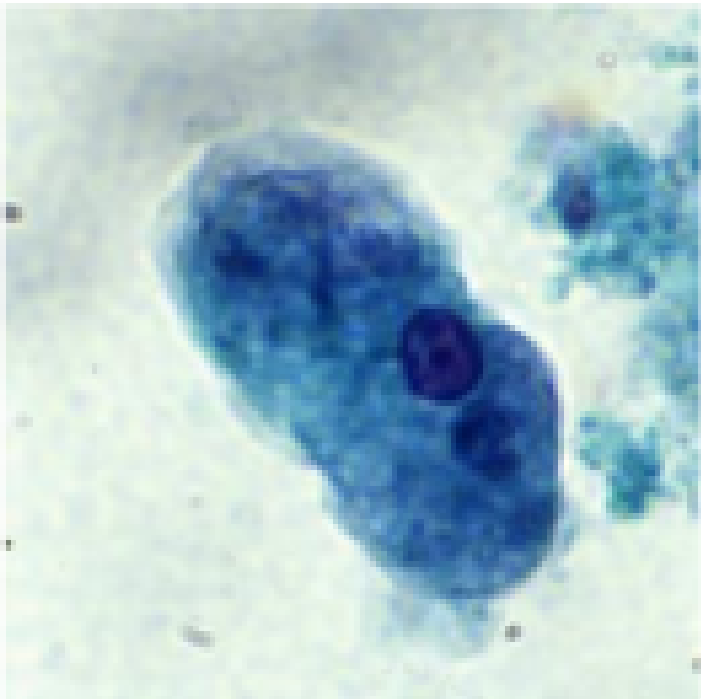
Entamoeba histolytica

- Pathologic, intestinal amoeba
- Erythrophagocytic – ingests RBCs
- Causes dysentery (severe bloody diarrhea)
- Treatment: Metronidazole

Life cycle stages:

Trophozoite	Cyst
- Motile, feeding, reproducing form (vegetative stage)	- Non-motile, non-metabolizing form
- Surrounded by flexible cell membrane	- Surrounded by thick wall
- Found in diarrheal stool (diagnostic stage)	- Survives environment; involved in transmission (infective stage)
	- Found in non-diarrheal stool (diagnostic stage)

- Mode of transmission: Fecal-oral route
- Infective stage: Mature cyst (normally has 4 nuclei, a chromatoid body)
- Diagnostic stage: Trophozoite (diarrheal stool), Cyst (non-diarrheal stool)



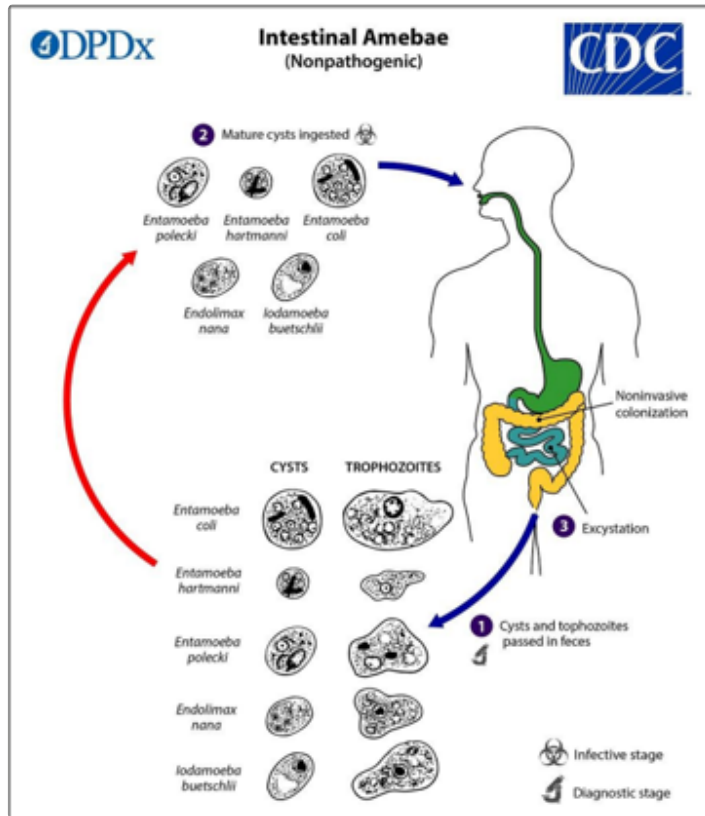
Spectrum of disease:

- Intestinal:
 1. Asymptomatic carrier
 2. Amebic colitis → dysentery without fever; flask-shaped ulcer in colon
 3. Ameboma → lesions in colon; dysentery
- Extraintestinal:
 4. Amebic liver abscess

Commensal Amoebas

- Non-invasive, do not cause disease, but important because they may be confused with E. histolytica in diagnosis.
- Entamoeba dispar: morphologically similar to E. histolytica but genetically different.
- Entamoeba coli: harmless inhabitant of colon; larger cyst than E. histolytica and greater number of nuclei.

- **Endolimax nana**: small size; four nuclei in cyst but lacks chromatoid body vs *E. histolytica* cyst.



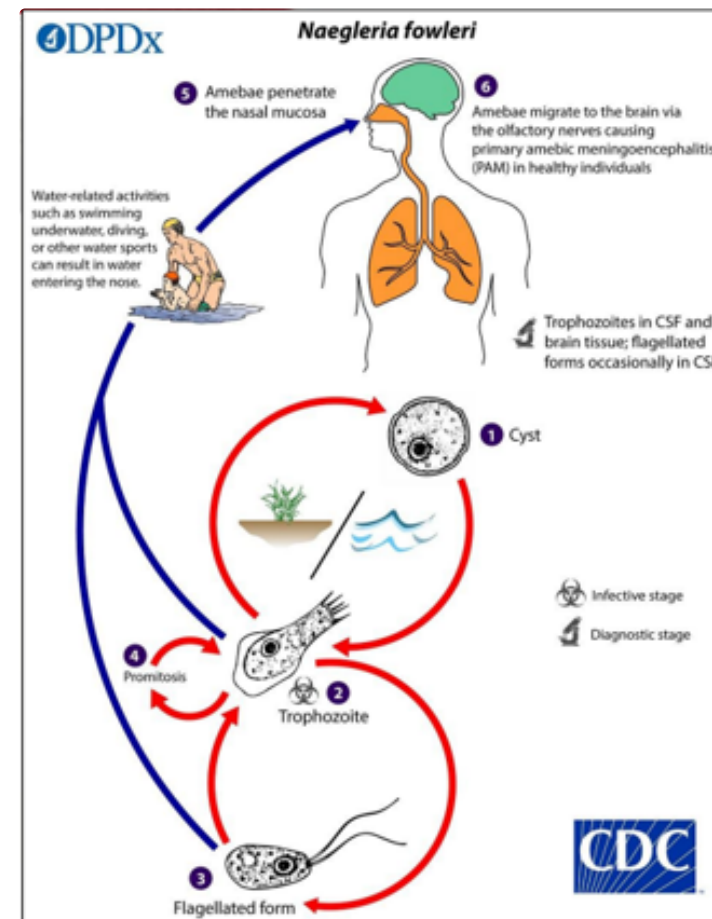
Free-Living Amoebas

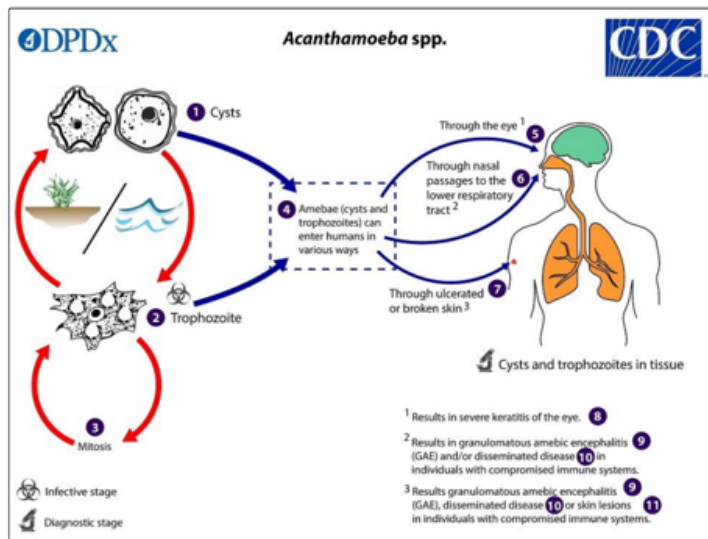
Naegleria fowleri

- **Disease: Primary Amoebic Meningoencephalitis (PAM)** – trophozoites reach nasal mucosa (during swimming or sinus irrigation) → migrate to brain via olfactory nerves
- **Transmission:** found in fresh water, soil, thermal discharges, poorly-chlorinated water
- **Infective and diagnostic stage:** Trophozoite

Acanthamoeba spp.

- **Diseases:**
 - Severe **keratitis** among contact lens wearers
 - Cutaneous lesions in immunocompromised
 - **Granulomatous amebic encephalitis (GAE)**
- **Transmission:** contaminated soil/water in contact with eyes, nose, respiratory tract, skin (seawater, contact lenses, swimming pools, tap water, dialysis machines)
- **Infective stage:** Trophozoite
- **Diagnostic stage:** Cyst and trophozoite





Flagellates

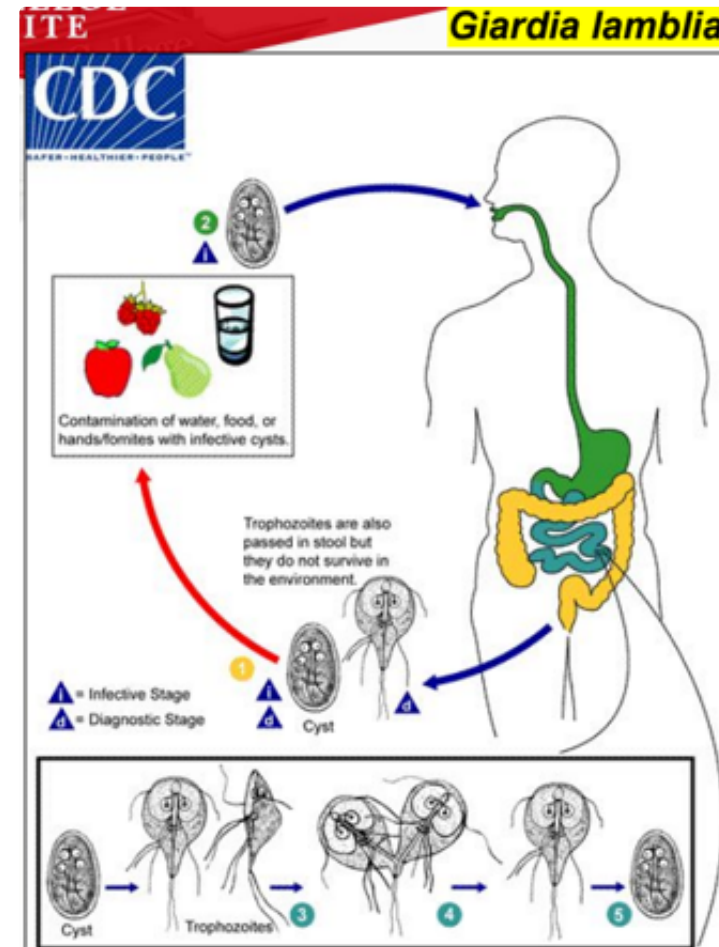
Lumen-Dwelling Flagellates

Giardia lamblia (also *G. intestinalis*, *G. duodenale*)

- Resides in small intestine up to upper ileum
- **Motility**: falling leaf motility
- **Pathogenesis**: invasion of duodenum → malabsorption of protein and fat; death of enterocytes
- **Transmission**: fecal-oral route (cysts)
- **Infective stage**: Cyst (mature cyst has 4 nuclei; immature has 2)
- **Diagnostic stage**: Trophozoite in diarrheal stool; cyst in formed stool
- **Morphology**: pear-shaped, two nuclei, four pairs of flagella, suction disk
- **Treatment**: Metronidazole

Spectrum of disease (Giardiasis):

- **Acute**: abdominal pain, watery foul-smelling diarrhea (smells like rotten eggs), excessive flatus; **no fever, non-bloody**
- **Chronic**: **steatorrhea** (fats in stool)



Trichomonas vaginalis

- **Urogenital flagellate**
- Exists only as **trophozoite** (no cyst stage)
- **Motility**: jerky motion
- **Morphology**: one large nucleus, 4 flagella

- **Transmission:** sexual intercourse
- **Infective stage:** Trophozoite
- **Diagnostic stage:** Trophozoite in wet mount of vaginal discharge
- **Treatment:** Metronidazole 2g single dose (treat both patient and sexual partner)

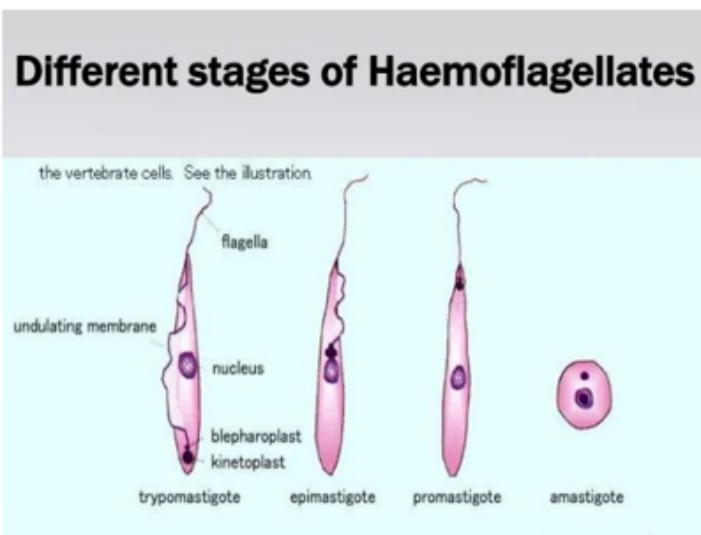
Spectrum of disease (Trichomoniasis):

- In men: frequently asymptomatic; occasionally urethritis, epididymitis, prostatitis
- In women: **strawberry cervix**, watery foul-smelling greenish discharge, vaginitis with itching and burning

Blood and Tissue Flagellates

Blood and tissue flagellates contain only **one flagellum** (vs. lumen-dwelling species with numerous flagella). They have different morphological stages:

- **Amastigote:** no flagellum (intracellular form)
- **Promastigote:** flagellated stage (in vector)
- **Trypomastigote:** has an undulating membrane and flagellum; small kinetoplast at posterior end, centrally located nucleus
- **Epimastigote:** subterminal undulating membrane and flagellum

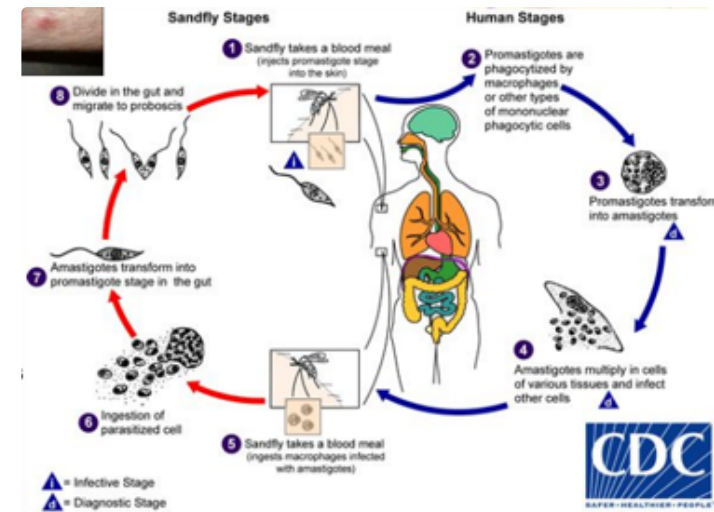


Leishmania spp.

- **Obligate intracellular protozoa**
- Invade skin (cutaneous), nose/mouth (mucocutaneous), or internal organs (visceral – **Kala Azar**, 'black fever', most severe, high fatality)
- **Transmission:** bite of female sandfly (*Phlebotomus*)
- **Infective stage:** **Promastigote**
- **Diagnostic stage:** **Amastigote** (in tissue)
- **Treatment:** Sodium stibogluconate

Species:

- *L. tropica* and *L. mexicana* → cutaneous
- *L. braziliensis* → mucocutaneous
- *L. donovani* → visceral (Kala Azar)

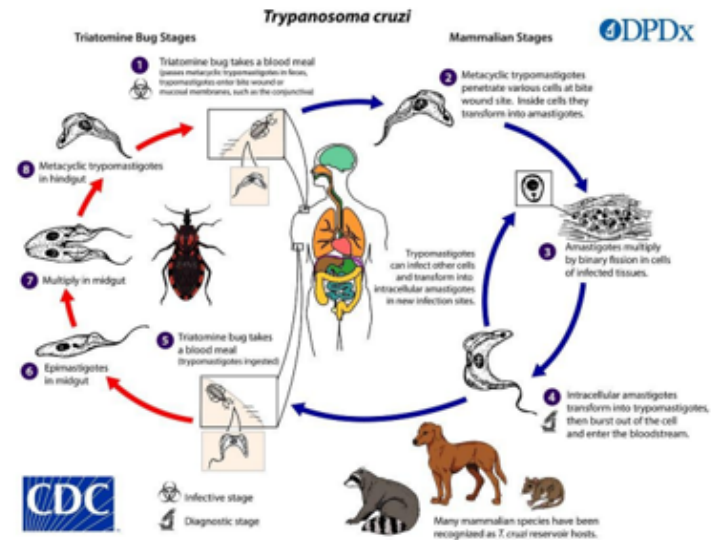




Amastigote

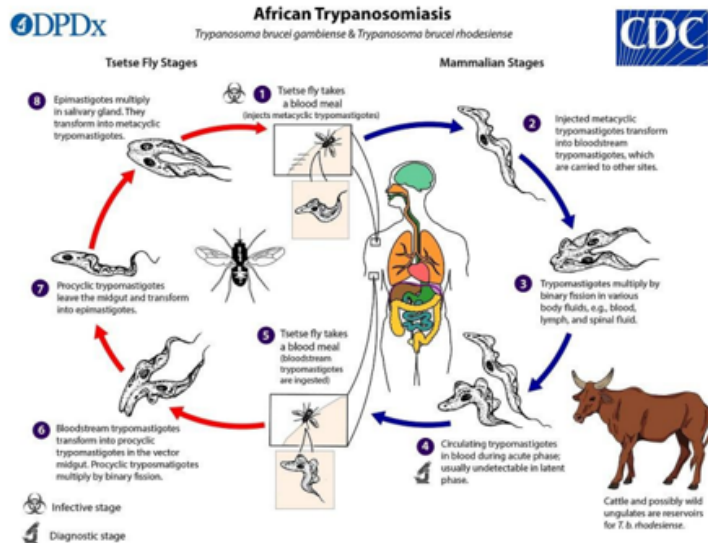
Trypanosoma cruzi

- **Disease:** American trypanosomiasis (Chagas disease)
- Affects cells of the **heart** (most frequently and severely), brain, bone marrow
- **Transmission:** feces of **Reduviid bug** ('kissing bug', *Triatoma*) – after biting (painless), fecal material deposited on skin
- **Infective and diagnostic stage:** Trypomastigote
- **Disease:**
 - **Acute:** facial edema, **chagoma** (bitten area), **Romana's sign** (unilateral palpebral swelling); resolves in 2 months
 - **Chronic:** heart enlargement, megacolon, CNS involvement → death



Trypanosoma brucei complex

- **T. b. gambiense** (West Africa) and **T. b. rhodesiense** (East Africa)
- **Disease:** African sleeping sickness
- **Acute form:** cyclical fever spike every 2 weeks
- **Sleeping sickness:** trypomastigotes enter skin → blood → lymph nodes → brain → demyelinating encephalitis (ARAS, brainstem) → somnolence → coma
- **Transmission:** painful bite of **Tsetse fly** (*Glossina* spp.)
- **Infective and diagnostic stage:** Trypomastigote
- **Treatment:** Blood stage → Suramin; CNS stage → Melarsoprol



Ciliates

Balantidium coli

- **Largest protozoan parasite of humans**
- Primary reservoir host: pigs (diarrhea among slaughterhouse workers)
- **Transmission:** fecal-oral route
- **Infective stage:** Cysts
- **Diagnostic stage:** Ciliated trophozoite in stool, or large cyst (with characteristic **V-shaped nucleus**) in stool
- **Disease: Balantidiasis/Balantidial dysentery** – colonic ulcers; no extraintestinal lesions (unlike *E. histolytica*)
- **Treatment:** Metronidazole



Sporozoans

Cryptosporidium spp. (*C. parvum*, *C. hominis*)

- **Opportunistic infection**
- **Acid-fast organism**
- **Transmission:** fecal-oral route
- **Infective stage:** Thick-walled oocysts
- **Diagnostic stage:** Thick-walled oocysts
- **Disease (Cryptosporidiosis):**
 - In healthy individuals: self-limiting, non-bloody diarrhea
 - In immunocompromised: chronic diarrhea

Toxoplasma gondii

- **Definitive host:** cats
- **Intermediate hosts:** humans and other mammals
- **Transmission:** fecal-oral route (oocysts); also **congenital toxoplasmosis** – can result in stillbirth, abortion, hydrocephalus in neonate
- **Infective stage:** Oocysts
- **Diagnostic stage:** Trophozoites
- **Disease (Toxoplasmosis):**
 - In healthy: usually asymptomatic; resembles infectious mononucleosis
 - In immunocompromised: **encephalitis**, brain abscesses

Species	Malarial Dots
<i>P. falciparum</i>	Maurer's
<i>P. vivax</i>	Schüffner's
<i>P. ovale</i>	Schüffner's
<i>P. malariae</i>	Ziemman's

Plasmodium spp.

- Species: *P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae*
- **Disease:** Malaria
- Pathologic findings are related to **destruction of RBCs**
- **Paroxysmal fever** with malaise and bone pains
- *P. falciparum*: malignant; causes **cerebral malaria**
- **Transmission:** bite of infected female **Anopheles** mosquito
- **Diagnostic stage:** Trophozoites (ring forms) in thin and thick blood smears; characteristic dots on RBC cytoplasm (Maurer's dots for *P. falciparum*, Schüffner's for *P. vivax* and *P. ovale*, Ziemman's for *P. malariae*)
- **Protective factors:** G6PD deficiency, sickle cell disease
- **Treatment and prophylaxis:** Chloroquine, Doxycycline, Primaquine, Atovaquone

