Overview

ML Medicine Learning

GI, Biliary, & Vaginal				Skin/Hair
PROTOZOA	HELMINTHS			Ectoparasites
	Roundworms (Nematodes)	Tapeworms (Cestodes)	Flukes (Trematodes)	*Sarcoptes* (Scabies)
Entamoeba histolytica	Enterobius	*Taenia saginata*	*Clonorchis*	*Pediculosis* (Lice)
Giardia	Trichuris	*Taenia solium*		*Cimex* (Bed Bugs)
Trichomonas	*Ascaris*	*Diphyllobothrium*		Demodex mite
Cryptosporidium	*Ankylostoma & Necator*			Myiasis
	Strongyloides			*Tunga penetrans* (Tungiasis)

Blood & Tissue				
Protozoa		HELMINTHS		
Blood	Tissue	Nematodes	Cestodes	Flukes
Plasmodium	*Toxoplasma*	*Wuchereria & Brugia*	*Taenia solium*	*Schistosoma hematobium*
Babesia	*Trypanosoma brucei*	*Onchocerca*	Echinococcosis	*Schistosoma mansoni/japonicum*
	Trypanosoma cruzi	*Toxocara*		Paragonimiasis
	Leishmania	Dog & cat hookworm		
	Naegleria	*Trichinella*		

Protozoa

ML Medicine Learning

Amoeba

About the size of WBCs, but move by pseudopodia

Entamoeba histolytica (Amebiasis)

Obligate human parasite that are transmitted to humans by ingestion of the cysts shed in asymptomatic carriers' stool.

Cysts form trophozoites in intestine where they can eat RBCs and invade the colonic mucosa. Clinical disease includes acute dysenteric colitis (fever, blood and mucous in stool) and later liver abscess (hole in liver). Anal and penile disease have been described in MSM patients.

Dx: stool wet mount/O&P, or stool or serum E. histolytica Ag test (depending on stage GI or extraintestinal disease).

Rx with metronidazole (or tinidazole), etc.

Entamoeba coli

One of many non-pathogenic amoeba and may be confused with E. histolytica on wet mount

Acanthamoeba

Found in freshwater lakes and soil. Keratitis in contact lens wearers. Also can cause amebic meningoencephalitis which is associated with devastating morbidity/mortality.

Naegleria

Free living amoeba in pools and freshwater lakes and soil. Causes acute and usually fatal meningoencephalitis.

Flagellates

Motile

GI/Vaginal

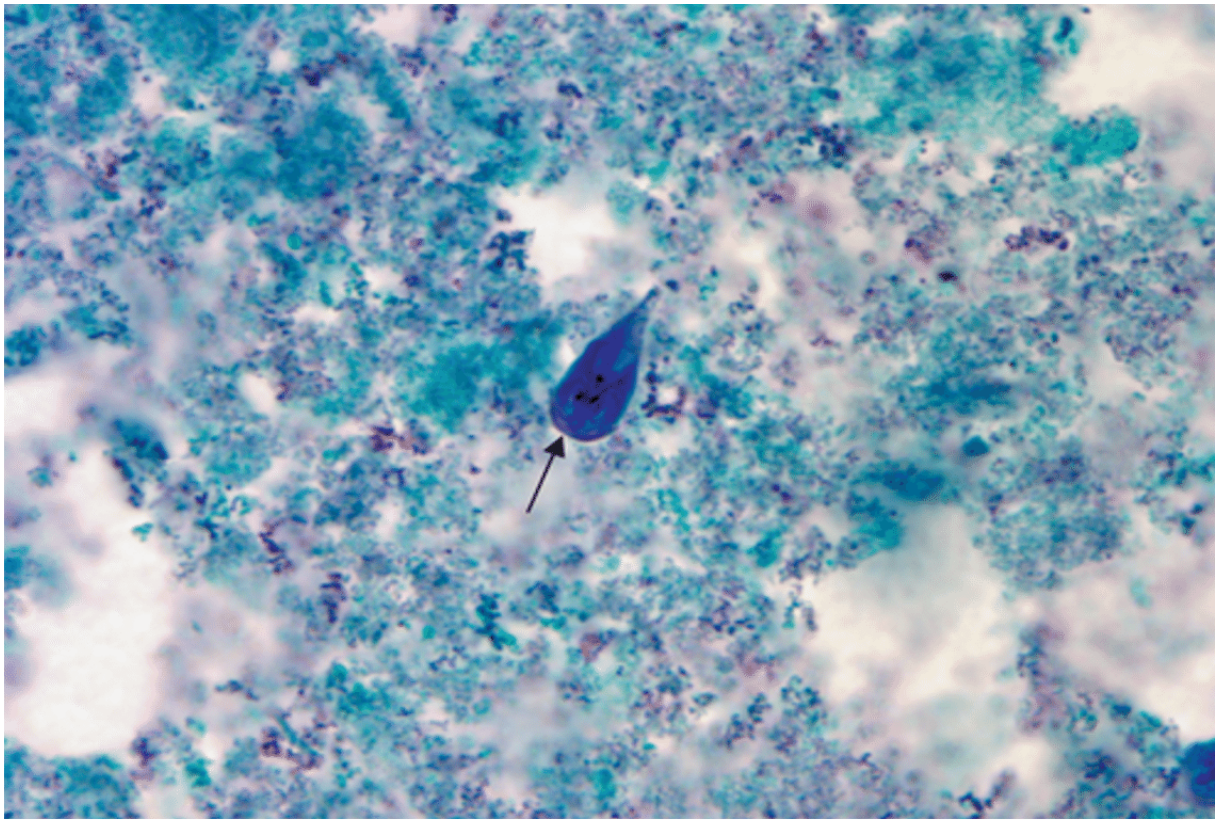
Giardia

Intestinal pear-shaped flagellated protozoan

Occurs worldwide in humans and animal hosts. Fecal oral spread when cysts are ingested in contaminated water. Organism is harbored by many rodents and beaver, so campers drinking stream water are at special risk. Clinical disease is characterized by watery diarrhea, with bloating and foul smell (malabsorption), without fever. Increased risk in IgA deficiency.

Dx with Giardia antigen or cysts in stool.

Rx with metronidazole or tinidazole.



Arrow points to a pear-shaped trophozoite of G. lamblia.

Intestinal & Urogenital—Protozoa, Levinson W, Chin-Hong P, Joyce EA, Nussbaum J, Schwartz B. *Review of Medical Microbiology & Immunology: A Guide to Clinical Infectious Diseases, 15e;* 2018

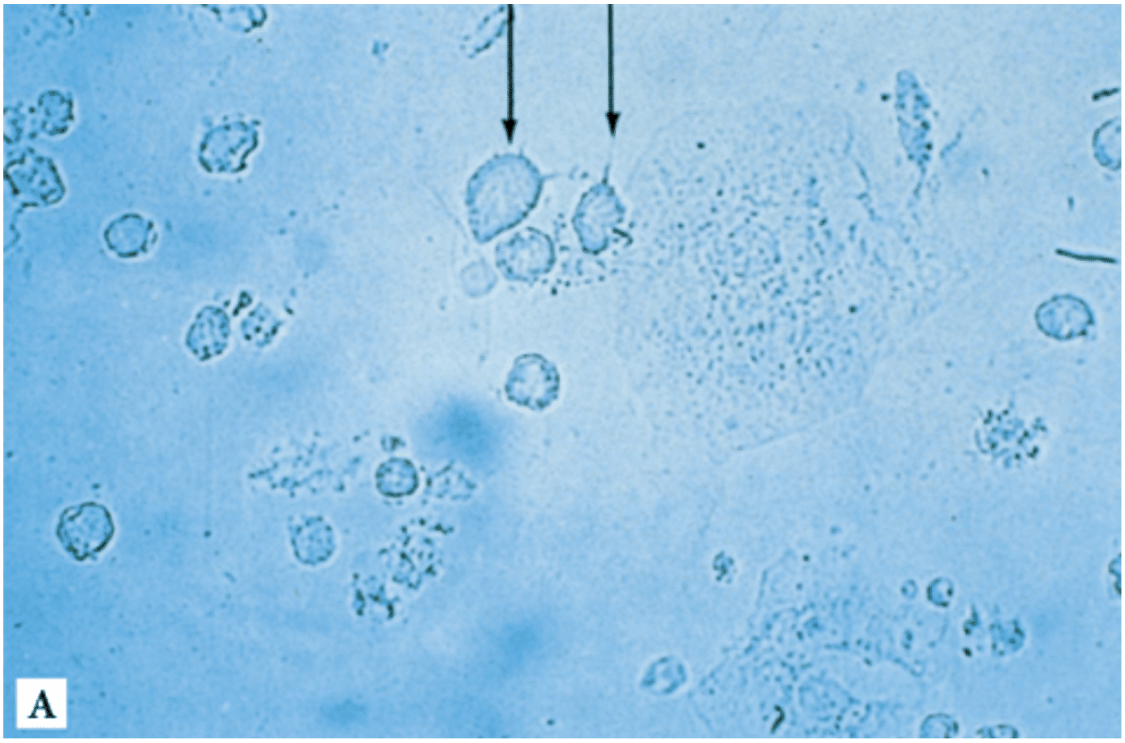
Trichomonas

Urogenital pear-shaped flagellated protozoan

Trophozoites attach to mucosa of female genital tract and cause inflammation. Clinical disease characterized by homogeneous watery discharge and strawberry cervix. Urethritis in men is usually asymptomatic. Sexual transmission.

Dx: High vaginal pH=5-6 (normal vaginal pH=3.8-4.5) and highly motile cells about the size of WBCs but with flagellum on wet mount.

Rx with metronidazole (or tinidazole).



Trichomonas. Saline wet mount demonstrating oval-bodied, flagellated trichomonads. They are similar in size to leukocytes and can be distinguished from them by their motility and presence of flagella

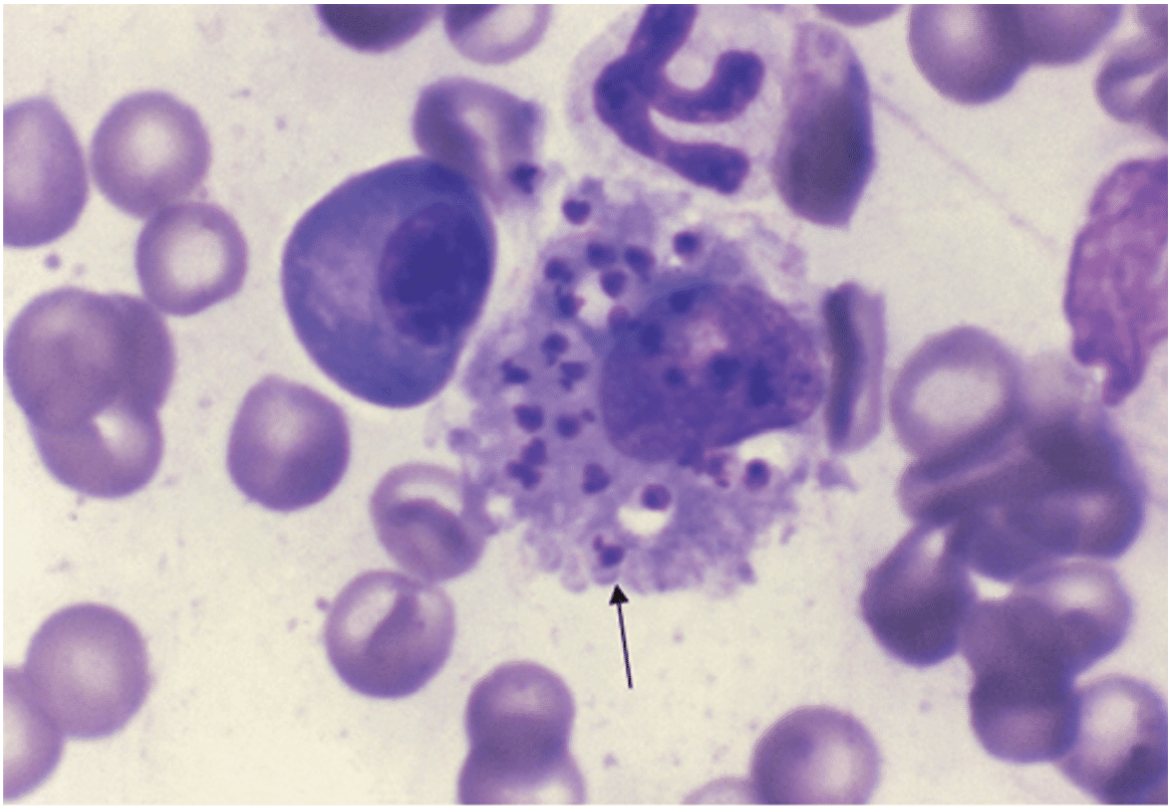
MICROSCOPIC FINDINGS, Knoop KJ, Stack LB, Storrow AB, Thurman R. *The Atlas of Emergency Medicine, 4e;* 2016.

Blood and Tissue

Leishmaniasis

Blood and tissue protozoan

Transmitted by phlebotomine sandfly bite. After bite, promastigotes enter blood macrophages and form amastigotes that infect other cells within reticuloendothelial system. Association with travel to many tropical countries and the Middle East but found widely.



Leishmania donovani—Arrow points to an amastigote (nonflagellated form) in cytoplasm of bone marrow cell. (Source: Dr. Francis Chandler, Public Health Image Library, Centers for Disease Control and Prevention.)

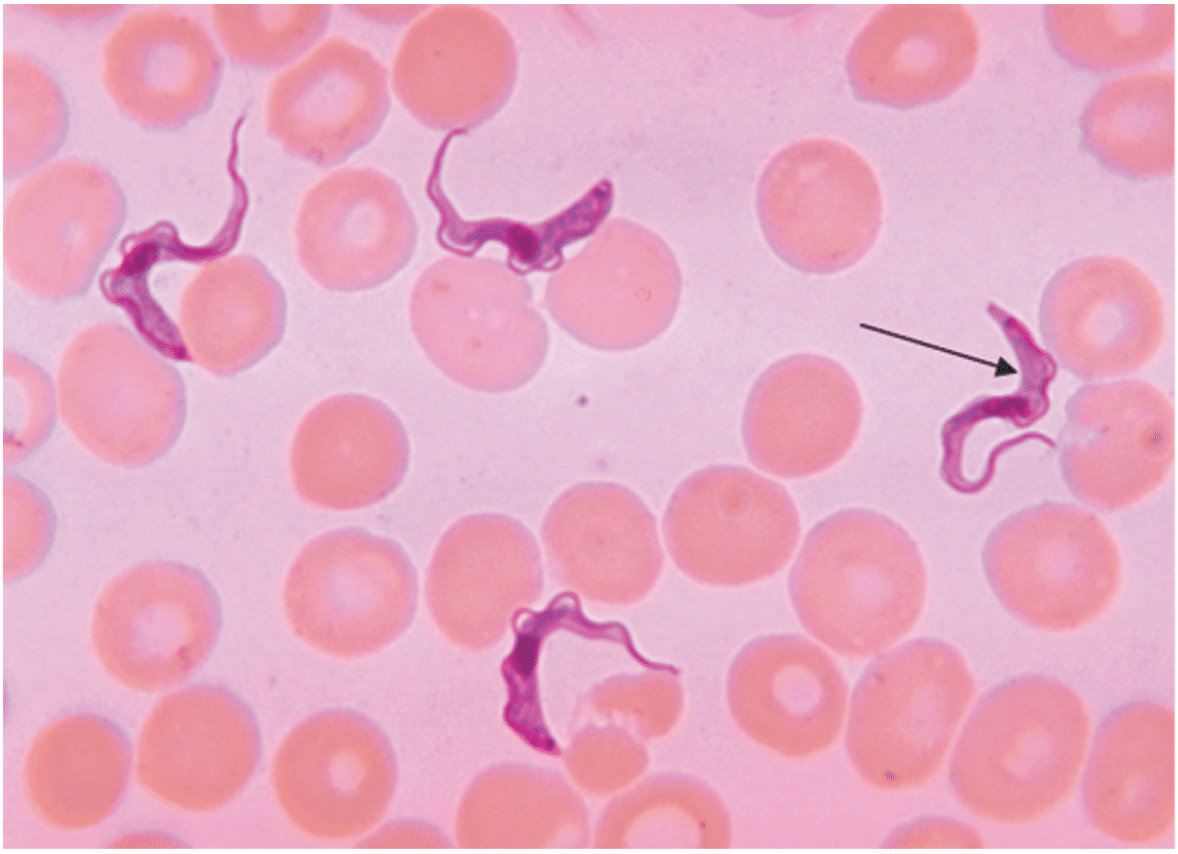
Cutaneous and mucocutaneous leishmaniasis ("new world")

Leishmania braziliensis, etc. Nonhealing nodules and skin ulcers after travel. Diagnosis is based on seeing asmastigotes in macrophages from skin smear at edge of lesion.
Treatment: Sodium stibogluconate.

Visceral leishmaniasis (kala azar, "old world")

Usually *L. donovani*.
Fever, weight loss, hepatosplenomegaly and pancytopenia. Spleen aspirate shows macrophages filled with organisms (reproducing intracellularly).
Other forms like diffuse cutaneous leishmaniasis (less common)
Treatment: Pentavalent antimony, Amphotericin B

Trypanosomiasis



Trypanosoma brucei—Arrow points to a trypomastigote (the flagellated form) in the blood. (Source: Dr. M. Schultz, Public Health Image Library, Centers for Disease Control and Prevention.)

Trypanosoma brucei

African sleeping sickness is blood and tissue protozoan with East African and West African forms
Transmission is from bite of Tsetse fly, when trypomastigotes enter blood stream. Repeated variation of surface antigens (like borrelia) allow immune evasion. Clinical disease is characterized first by painful chancre at bite site, then enlarged nodes. Progression to encephalitis and coma is part of late manifestations and is 100% fatal.

Dx by finding flagellated protozoa in blood smear (NOT inside RBCs like malaria and Babesia, but in serum like Borrelia)
Tx: pentamidine, suramin, eflornithine, nifurtimox.

Trypanosoma cruzi

Chagas disease. Blood and tissue protozoan that is transmitted by the bite of reduviid/triatome bug

Geographically more prevalent in central and south America. Insects feed at night and the face/eyes are common available locations. Localized inflammation occurs (Romaña's sign on the eye). Transmission by reduviid bug (triatomine/kissing bug) bites at night causing swollen lesion especially around eye (Romaña's sign). Acute infection nmay be asymptomatic. Chronic infection leads to late manifestations: megacolon, megaesophagus, and megacardia (megacardia is not a real clinical term, but useful here to describe cardiomyopathy/CHF/arrhythmia).

Dx with serology in appropriate clinical setting. Flagellated protozoa in blood smear (similar to other trypanosomes but somewhat more C-shaped) are rare and hard to find. Classical xenodiagnosis by infecting reduviid bugs after biting patient with suspected Chagas.
Tx: Nifutimox, Benznidazole. Late manifestations are often irreversible.

Ciliates

Few of medical significance to humans.

Balantidium coli

Colitis and watery diarrhea especially in AIDS patients

Sporozoa

Non-motile protozoa

GI

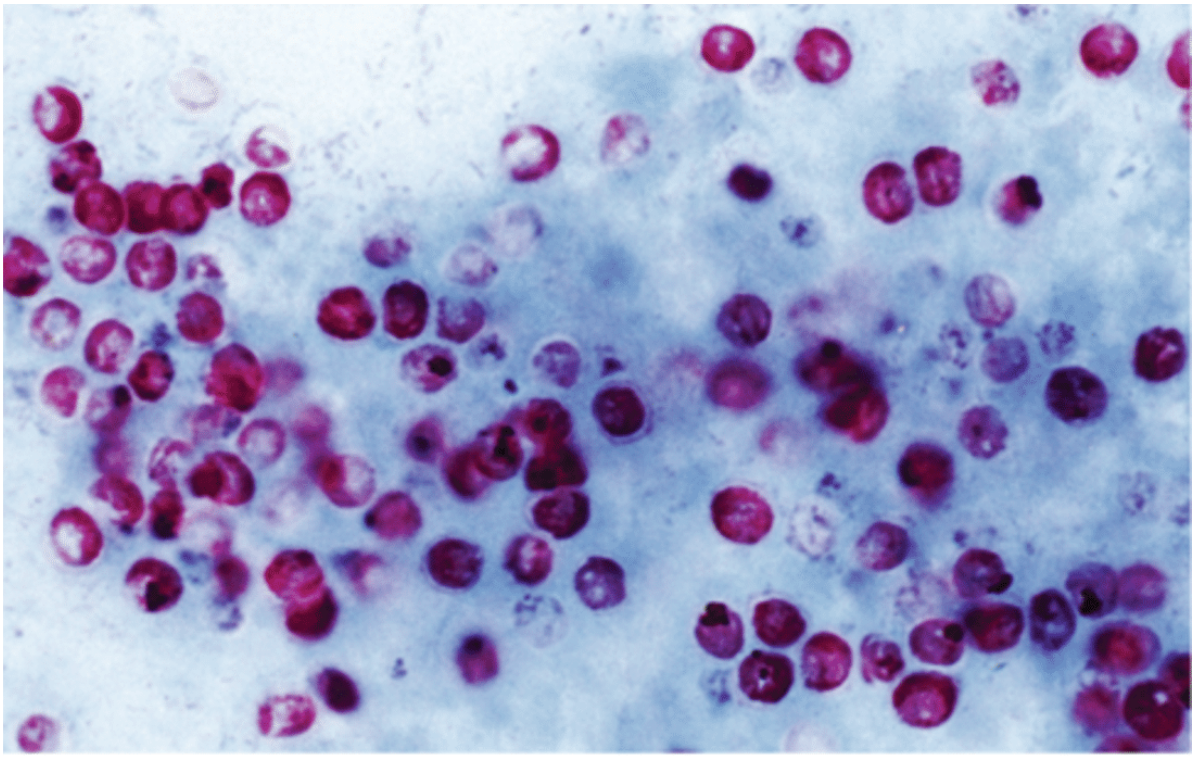
Cryptosporidium

Obligate intracellular parasite of intestinal epithelial cells

Causes watery diarrhea, worse in AIDS patients where it can cause chronic wasting and malnutrition. Fecal oral spread (person to person or animal to person) especially from public swimming areas.

Dx: Not seen on regular O&P study, but stains with modified acid-fast stain.

Tx: supportive, immune reconstitution, paromomycin



Cryptosporidium parvum. This acid-fast stain demonstrates oocysts in the feces of a diarrheal patient.

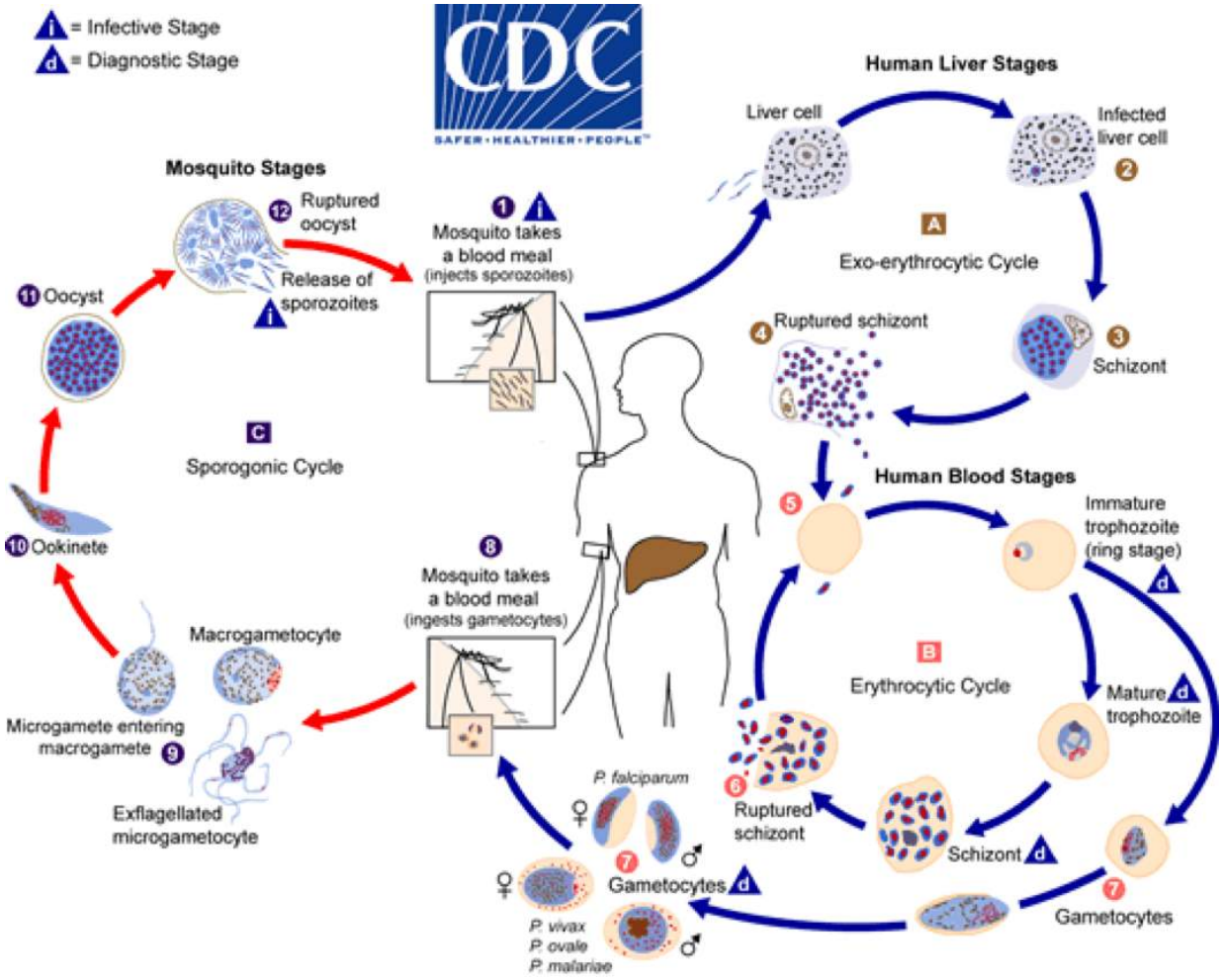
Blood and Tissue

Malaria/*Plasmodium*

One of the major causes of mortality due to infectious diseases worldwide

Transmitted by female anopheles mosquitoes (or blood transfusion). There is geographic distribution of species types and geographic variation in pharmacologic susceptibilities. In US, persons that travel to visit friends and family are highest risk group. Clinical disease is typically manifested by high fever usually related to international travel. Paroxysmal episodes of fevers are classically described and represent the blood phase of parasitic replication. In 'real world' paroxysms are not always well defined. Complications of malaria occur from species that have chronic/latent forms and from P. falciparum which has potential to cause severe multisystem.

Diagnosis is made on thick and thin smears where parasite morphology and quantity can be distinguished. Molecular and rapid tests are of increasing importance in regions with limited resources and/or limited experience (i.e. USA)

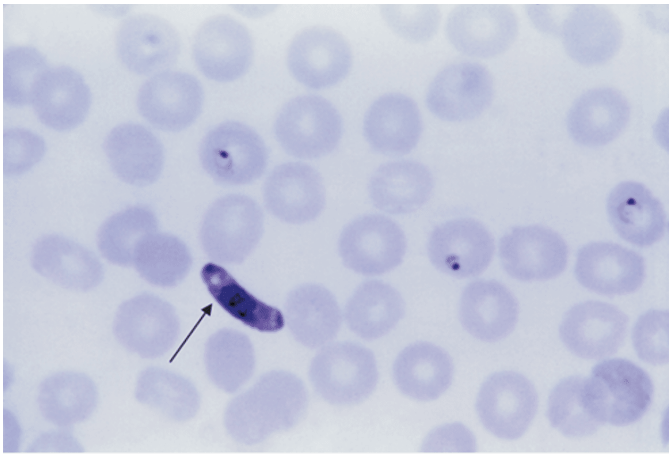


Plasmodium falciparum

Causes most fatal cases, cerebral malaria, parasites inside RBCs cause hemolysis

Banana gametocytes. Increased resistance to chloroquine and other antiparasitic drugs except in Central America and Caribbean areas (such as Haiti). No hepatic latent stage, so no relapsing form. Prevention with atovaquone-proguanil (expensive), mefloquine (side effects psychiatric and cardiac), or doxycycline.

Therapy with artemether combination drugs (e.g. artemether-lumefantrine), especially for severe malaria. Other options atovaquone-proguanil, quinine, mefloquine. Chloroquine rarely appropriate.



Plasmodium falciparum—Arrow points to a “banana-shaped” gametocyte. Ring forms visible with RBCs.

Blood & Tissue Protozoa, Levinson W, Chin-Hong P, Joyce EA, Nussbaum J, Schwartz B. *Review of Medical Microbiology & Immunology: A Guide to Clinical Infectious Diseases, 15e;* 2018.

P. vivax and P. ovale

Relapsing forms due to hypnozoites in the liver. P. vivax infects younger RBCs (larger size). P. ovale is only in West Africa. Erythrocyte stage is usually sensitive to chloroquine, but liver stage for these two species requires primaquine Rx after treatment of the erythrocytic stage. Check for G6PD deficiency, especially before using primaquine.

P. malariae

Infects older RBCs (smaller size)

P. knowlesi

Malaria variant seen in South Pacific region (from monkeys)

Babesiosis

Looks like malaria with trophozoites in RBCS, but transmitted by ticks and regional disease (esp. N.E. USA, Minnesota, Wisconsin). “Maltese cross” in RBCs.

Toxoplasmosis

Transmitted by cysts from cat feces and poorly cooked meat

Primary infection in a pregnant woman is a major risk for the fetus (congenital toxoplasmosis) causing mental retardation, chorioretinitis and other birth defects. In normal host, it causes fever and mononucleosis-like syndrome, adenopathy, hepatosplenomegaly. Retinitis (blindness that can flair in second and third decade or in immune suppressed. Toxoplasmosis is a common cause of encephalitis with brain cysts especially in AIDS patients. Presents as confusion or seizures, and CT/MRI show ring-shaped brain lesions which enhance with contrast. Serology helpful in dx. Bx shows crescent-shaped trophozoites in macrophages. Rx with sulfadiazine/pyrimethamine.

Pneumocystis

P. jiroveci (previously *P. carinii*) now classified as fungus (previously protozoan).

Classic cause of pneumonia (PCP) in opportunistic host, especially AIDS patients. Presents with fever, SOB and severe hypoxia. No person-to-person transmission. Early in clinical course may have minimal infiltrates on CXR.

Dx: biopsy of lung tissue or occasionally sputum may show the oval shaped organism seen with silver stain or immunofluorescent stain. Rx with trimethoprim-sulfamethoxazole or pentamidine. Give prophylaxis for AIDS patients with CD4<200.

See Fungi Dendritic

FUNGI

Nematodes

ML Medicine Learning

Round Worms

GI

Grouped together as intestinal worms primarily based on the adult worm that causes infection and disease. Some of these have life cycles entirely limited to GI tract, but some have a tissue migration phase, though these are temporary phases.

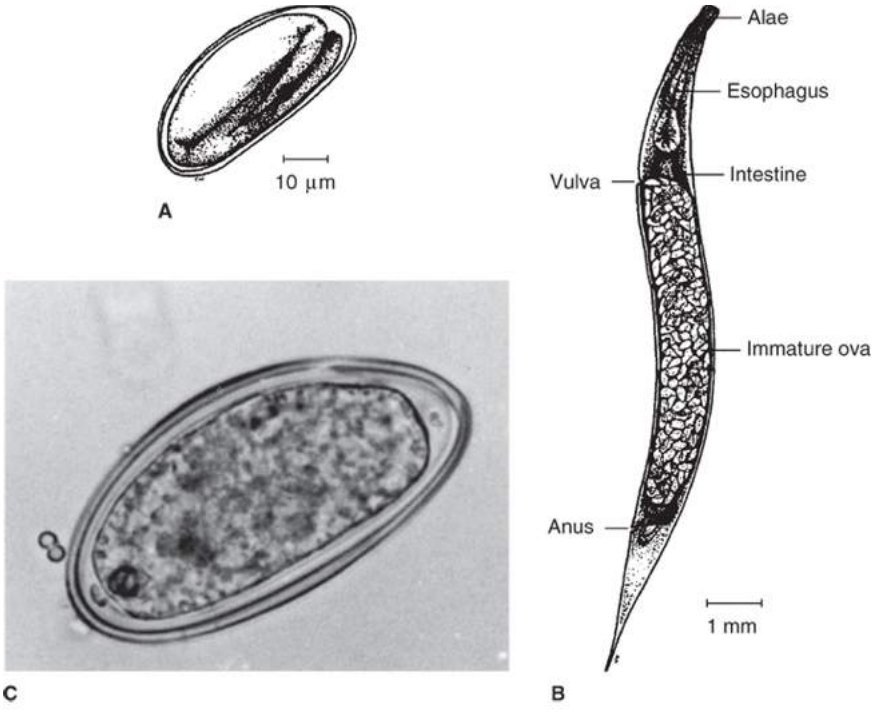
Enterobius (Pin Worm)

Transmitted by ingestion of eggs which develop into adults within the gut

Females migrate to rectum/anus to lay eggs on skin. Symptoms are associated with this migration and lead to intense anal pruritis (itchy butt). Re-infection is common when hands are used to scratch the pruritic area, carrying eggs that are then incidentally ingested.

Dx: Scotch-tape test for eggs on anus.

Tx: Albendazole



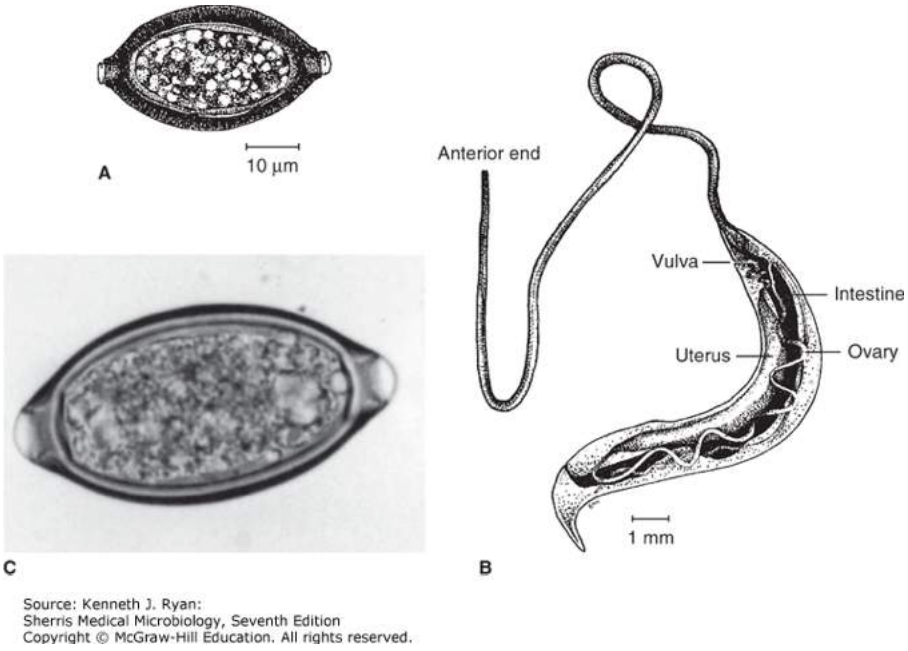
Trichuris (Whip Worm)

Intestinal nematode transmitted to humans by ingestion of eggs which develop into adults in gut

The thin 'whip' end embeds in the GI mucosa. Eggs are shed into soil where they embryonate and become infectious. With heavy egg burden, anemia from occult blood loss and rectal prolapse can occur. Adult worms can often be seen embedded in the prolapsed mucosa.

Dx: Stool microscopy for eggs

Tx: Albendazole



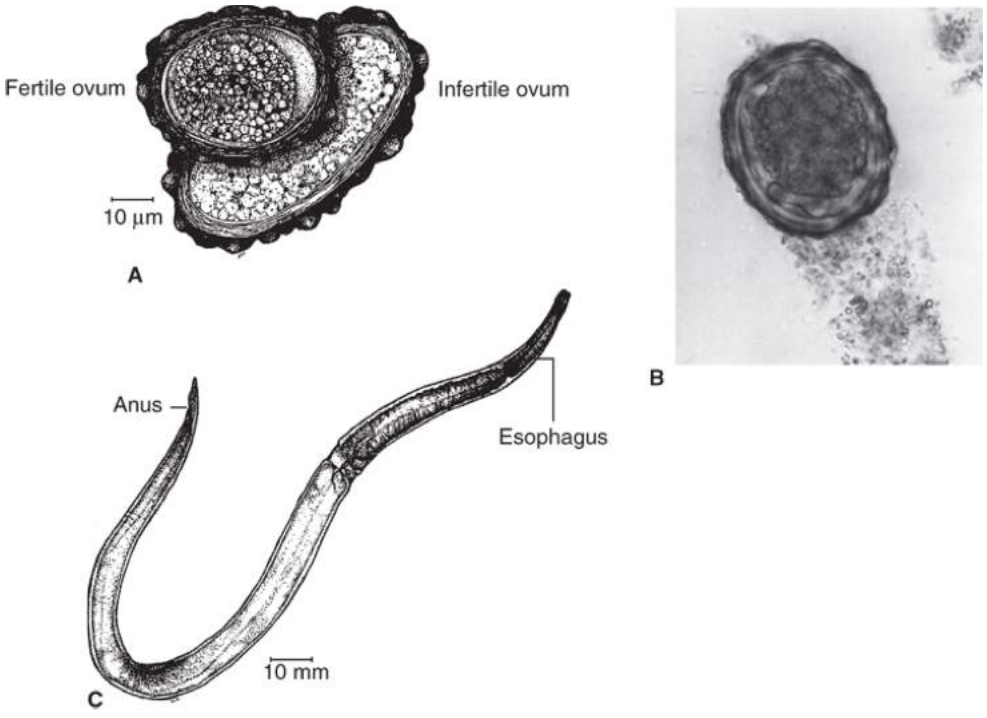
Ascaris Lumbricoides (Round Worm)

Intestinal nematode transmitted to humans by ingestion of eggs which develop into larvae in gut

Larvae penetrate the gut to the blood where they migrate to the lungs, are coughed up and swallowed, then develop into adult worms in the gut. Adults are big round worm (30 cm) and very common worldwide. Causes intestinal obstruction with worm balls. Also invade appendix or biliary tree. Pulmonary migration stage can cause transient asthma like symtpoms, or eosinophilic pneumonia (Loeffler's syndrome)

Dx: eggs found in stool or worms seen after

Rx: Albendazole



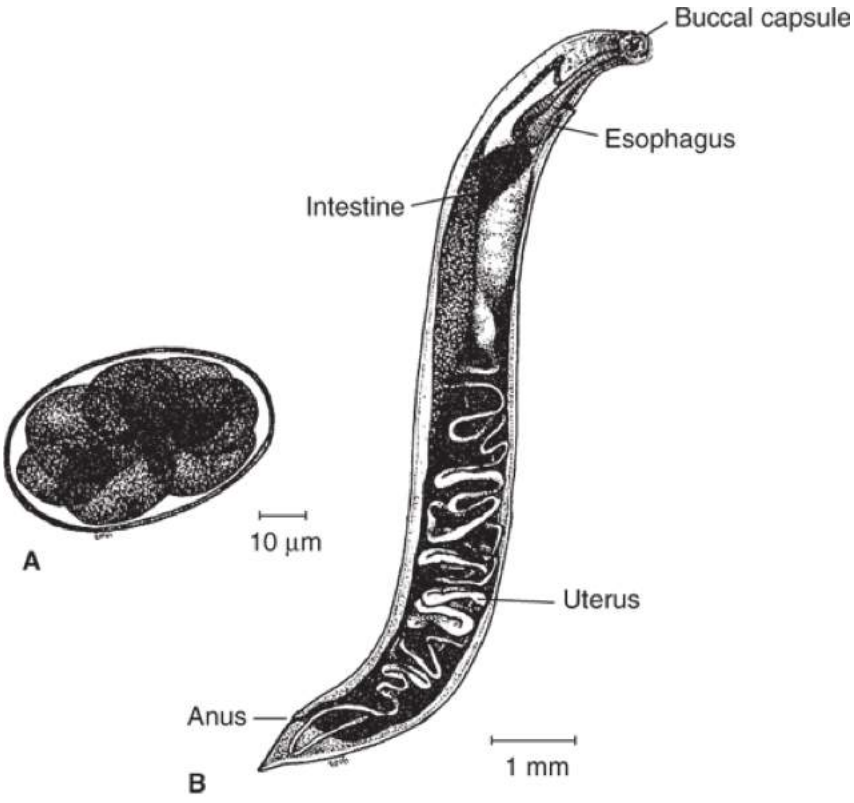
Hookworm *(Ancylostoma* and *Necator)*

Filarial form penetrates intact skin then enters the blood and eventually migrates to the lung. After entering alveoli, larvae pass up trachea and are swallowed. They mature into adult worms in the GI tract. Adult worms attach to the walls of the small intestine via teeth and cutting plates. Clinical disease includes cutaneous larvae migrans, a pruritic serpentine rash that occurs during the cutaneous phase, known as “ground itch. ” Pulmonary migration can lead to eosinophilic pneumonia and Loeffler’s syndrome. And adult worms lead to chronic iron deficiency anemia due to microscopic blood loss. The iron-deficiency anemia has been linked with poor cognitive development in children and perpetuation of chronic impoverished states.

Dx: eggs in stool.

Prevention: wear shoes, improve sanitation.

Tx: Albendazole



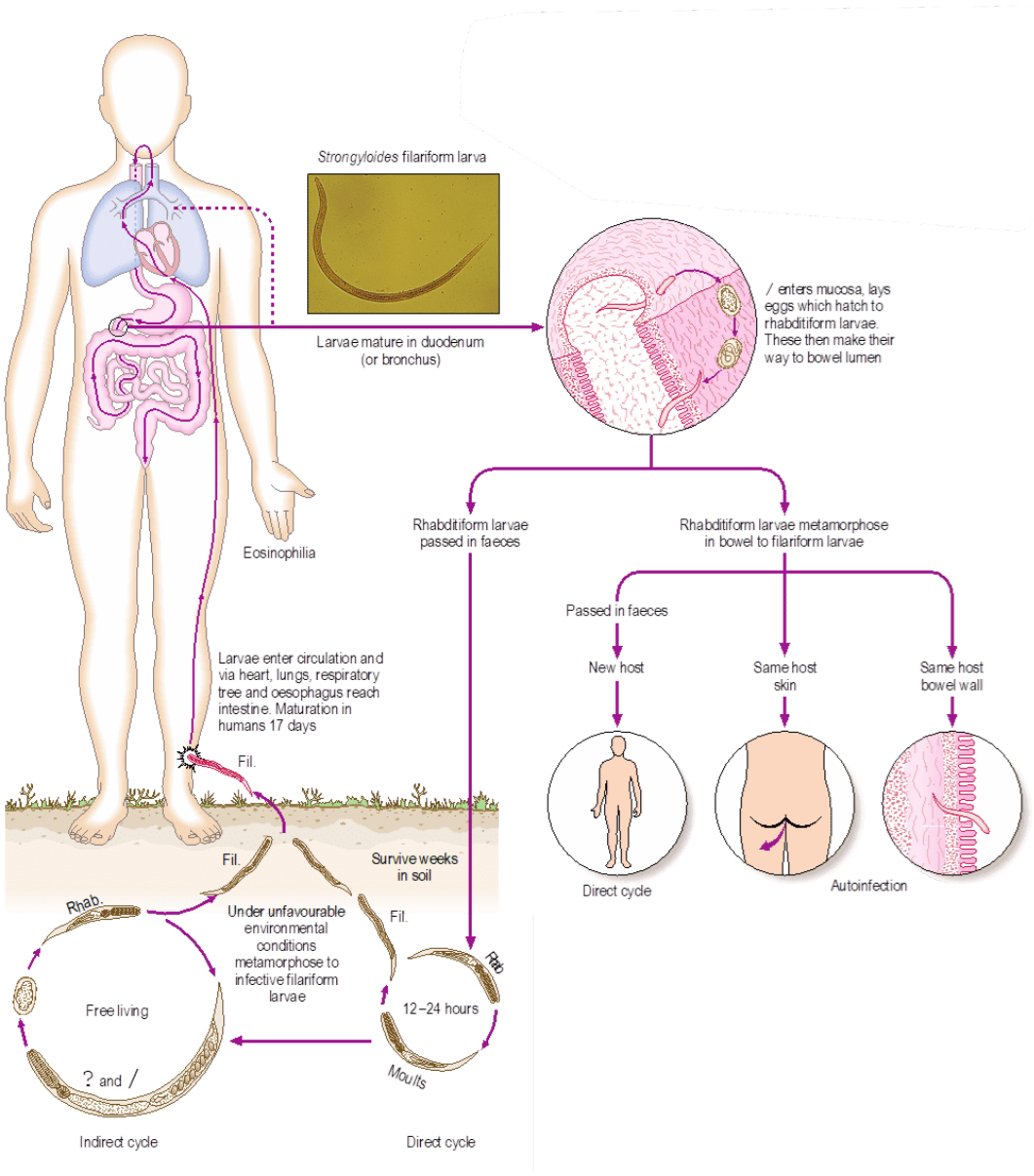
Strongyloides

Filarial form penetrates intact skin then enters the blood and eventually migrates to the lung. After entering alveoli, larvae pass up trachea and are swallowed. They mature into adult worms in the GI tract. Adults produce eggs that hatch in colon to rhabditiform larvae (non-infectious). Rhabditiform larvae can molt in the gut forming infectious filariform larvae that can directly reenter the blood stream – autoinfection. Autoinfection can allow persistence of infection for decades. Rhabditiform larvae that are passed into the soil can mature into adults and have several free-living cycles.

Clinical manifestations include asthma like pulmonary disease and eosinophilia during migration. Autoinfection allows for high worm burden leading to hyperinfection which is more common with immunosuppression. Hyperinfection can cause polymicrobial bacteremia when bacteria translocate across bowel with larvae. Hyperinfection can be fatal.

Dx: Look for larvae in stool or dx by serology. Larvae hatch before reaching the anus, so no eggs in stool.

Tx: Ivermectin



Blood and Tissue

Cause disease through their presence in tissues and lymphohematogenous system. Some migrate through the human GI tract, but that is temporary part of the life cycle.

Trichinosis (*Trichinella spiralis*)

Transmission to humans when ingesting undercooked meat that contains encysted larvae which mature into adult worm in small intestine. The adult worms release larvae that enter blood and migrate to tissues, they are able to encyst in skeletal muscle and brain. Reservoir in pigs. Clinical manifestations include severe myalgia/myositis. Late stages result in calcified cysts in muscle.

Dx by serology or biopsy.

Decreased incidence in US because of prohibition of feeding pigs uncooked garbage, plus meat inspection.

Tx: Thiabendazole, Mebendazole +/- steroids for inflammatory reaction

Filaria

Wuchereria bancrofti (or Brugia malayi in Malaysia and SE Asia)

Transmitted to humans through the bite of mosquito which deposits larvae into skin where they develop into microfilariae that migrate to lymphatic where they develop into adult worm. Adult worm lies coiled in lymphatic for the entirety of decade long-lives. Clinical disease is filariasis which results from long-term lymphatic obstruction . Tropical pulmonary eosinophilia can occur.

Dx by finding microfilaria in night-time blood smear. Serology also helpful.

Tx: Diethylcarbamazine for microfilariae. There is no treatment for adult worms.

Onchocerciasis (Onchocerca volvulus)

Transmitted by Simulium black flies that live near rivers ("River blindness"). Larvae are deposited into skin where they mature to adult worms within skin nodules. Females produce microfilariae that migrate in interstitial fluid. Microfilariae in the eye ultimately causes blindness. Affected skin is described as "lizard-like", itchy and hyperpigmented.

Dx: Skin snip reveals microfilaria.

Tx: Ivermectin for microfilariae. Suramin for adult worms.

Toxocara (Dog and Cat Ascarids)

Visceral larva migrans. Transmitted by ingestion of eggs in soil or food contaminated with dog feces. Eggs hatch into larvae in small intestine then enter blood and migrate to organs – brain, liver, eyes – where they are trapped and die. Clinical manifestations include fever, eosinophilia, hepatitis, and chorioretinitis. Exudative endophthalmitis mimics retinoblastoma.

Dx with serology. Biopsy demonstrate granulomas around dead larvae.

Tx: Albendazole

Cestodes

ML Medicine Learning

Tapeworms

Segmented flat worms

Taenia saginata (Beef Tapeworm)

Humans ingest undercooked beef containing cystercerci, larvae attach to bowel wall and mature to adult worms that eventually shed proglottids into feces that are eaten by cattle. Humans are the definitive host, and cows the intermediate host. Clinically, infection is usually asymptomatic except mild abdominal discomfort, as with most other adult tapeworms. Cystercercosis in humans does not occur.

Dx: Find proglottids or longer segment of the worm in stool. Find eggs in stool O&P (same appearance as T. solium)

Tx: Raziquantel

Taenia solium (Pork Tapeworm)

Humans develop disease depending on what stage of the organism is ingested. When ingesting undercooked pork containining cysteicreci larvae attach to bowel wall and mature to adult worms that eventually shed proglottids into feces that are eaten by pork or other humans – this is taeniasis, or tapeworm, similar to beef tapeworm and is relatively asymptomatic.

When humans ingest eggs (fecal-oral route), oncospheres burrow into blood vessels in the gut lumen then disseminate to organs – causing cystercercosis. CNS and eyes are common locations. Humans are the definitive host in taeniasis and are the intermediate host in cystercercosis.

Dx: Intestinal tapeworm = gravid proglottids in stool. Cystercercosis is diagnosed with combination of serology, radiographic findings, +/- biopsy.

Tx: Praziquantel

Diphyllobothrium latum (Fish Tapeworm)

Humans develop infection when ingesting raw, pickled, or undercooked freshwater fish containing larvae. Larvae attach to gut wall and become adults, passing gravid proglottids and eggs into feces. Humans and fish-eating mammals are the definitive host with small crustaceans and fish as the intermediate hosts. Generally asymptomatic, but associated with B12 deficiency due to competition for the nutrient with the worm (one of the causes of a macrocytic anemia).

Dx: gravid proglottids in stool have centrally positioned, rosette-shaped uterus

Tx: Praziquantel

Echinococcus/Hydatid disease

(E. granulosus = dog tapeworm, E. multilocularis = arctic/subarctic) – Dogs and foxes are the definitive host when they ingest entrails of sheep (intermediate hosts) containing hydatid cysts. Adult worms develop in gut of dogs and shed eggs into feces. Humans are intermediate hosts when eggs are ingested. Eggs hatch in gut and migrate through blood to various organs, with liver and lung most common. Larvae form large, unilocular hydatid cysts containing many protoscoleces and daughter cysts. Cysts can cause symptoms from mass-effect. Ruptured cyst can cause acute anaphylaxis due to overwhelming antigen exposure.

Dx: Imaging that shows cysts with "daughter cysts" or "hydatid sand" is diagnostic.

Prevention: don't feed sheep viscera to dogs. Food handling hygiene

Tx: Albendazole +/- Local injection of cyst with ethanol. Careful surgical excision.

Trematodes

ML Medicine Learning

Flukes

Non-segmented flat worms

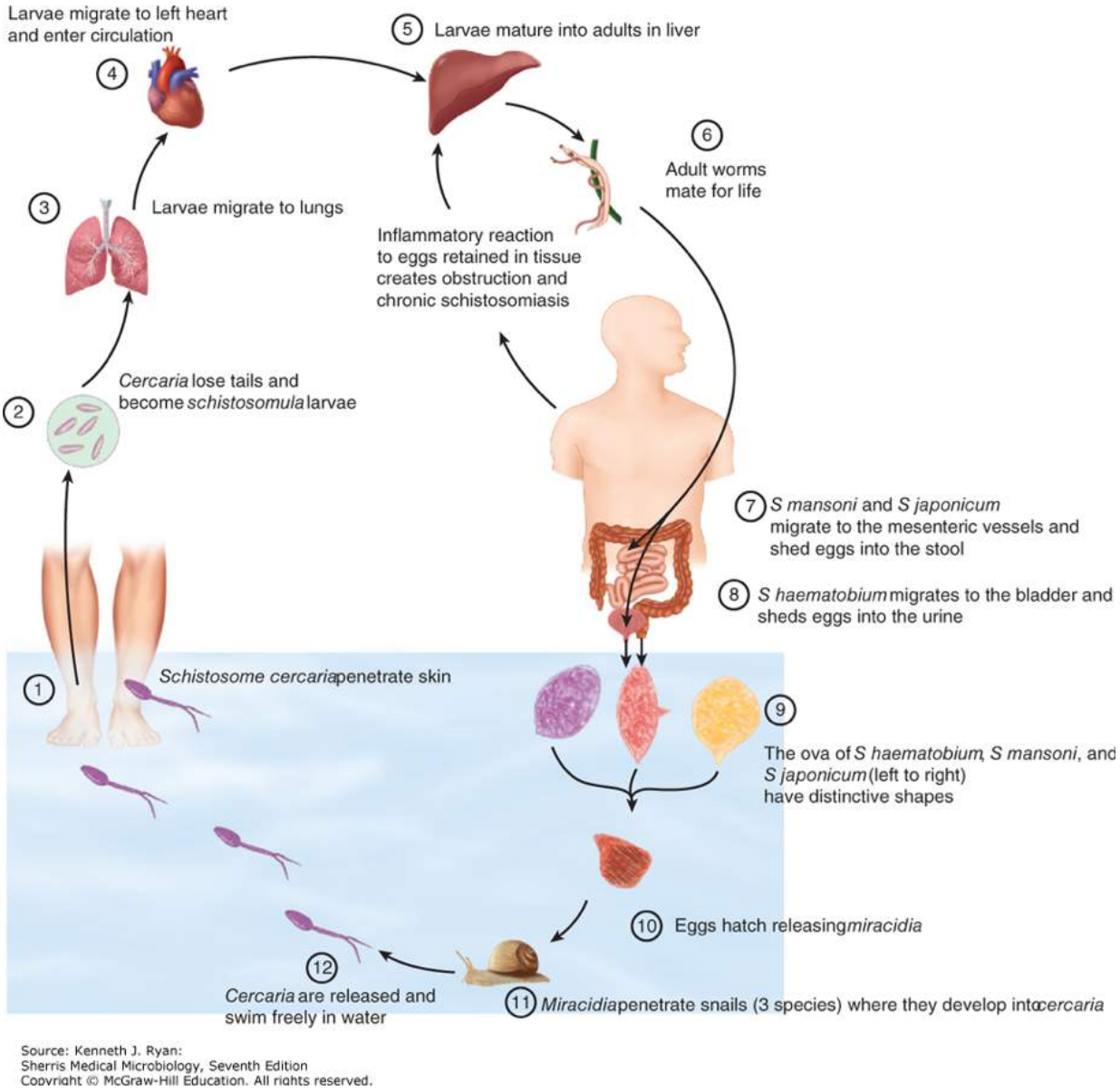
Schistosomiasis (Blood Fluke)

A very common parasitic disease with significant morbidity and mortality

Human reservoir (or animal reservoir for some species) with snails in life cycle. Infection occurs when humans are in water and schistosomal cercariae (from snails) penetrate human skin. Cercariae form larvae that penetrate blood vessels and are carried to the liver where they become adults. The adults then migrate through portal vein to either mesenteric or urinary venules depending on the species. Adults lay eggs that penetrate mucosa and are passed into gut or urine respectively. Early symptoms with itchy rash after swimming, and later fever, lymphadenopathy and allergic phenomenon related to migrating larvae (Katayama Fever). Eventually a few adult worms live in abdominal venous system for decades, laying eggs that cause liver, colon, or bladder disease. Eggs and adult worms induce localized inflammatory response that leads to the long-term sequelae: portal hypertension without cirrhosis, ileitis, colitis, bladder cancer.

Dx: Stool and urine O&P are not sensitive tests for dx. Serology or biopsy helpful.

Rx: praziquantel.



Life Cycle of Schistosomes

Schistosoma hematobium

(Africa, Middle East)

Man is reservoir, presents with hematuria. Find eggs with terminal barb in a terminal urine sample. Fibrosis and calcifications of the bladder can lead to urinary obstruction and bladder cancer.

S. mansoni

(Africa, Middle East, South America), *S. japonicum* (Asia)
Adult blood flukes live in the portal veins and lay eggs that travel to liver or lung causing inflammation and ultimately fibrosis (hepatic schistosomiasis). Children and adolescents present with hepatosplenomegaly related to the egg burden. Chronic hepatic schistosomiasis develops years later with portal hypertension, ascites, splenomegaly, esophageal varices and upper GI bleeding, and sometimes pulmonary hypertension. Liver function is preserved. Association with Salmonella bacteremia from bowel.

Swimmer's Itch

From bird schistosomes penetrating skin. No further disease (similar pathogenesis to cutaneous larva migrans from dog hookworm).

Paragonimus (Lung Fluke)

Humans ingest undercooked freshwater crab meat containing encysted larvae (metacercariae). In gut, immature flukes enter peritoneal cavity, burrow through diaphragm into lung parenchyma, and become adults. Eggs enter bronchioles and are coughed up or swallowed. Clinical symptoms include hemoptysis and clinical picture like TB, but with eosinophilia.

Dx: Eggs visualized in sputum or feces

Tx: Praziquantel

Clonorchis sinensis/Opisthorchis sinensis (Chinese Liver Fluke)

Life cycle with man/animals, snails and fish. Human infection from eating freshwater fish (second intermediate host). Adult flukes live up to 25 years in biliary tree and is generally asymptomatic, but can cause inflammation, and biliary obstruction with jaundice and ascending cholangitis (fever, chills, right upper quadrant abdominal pain). Up to 15 x increased risk for cholangiocarcinoma (biliary tract cancer). In Thailand, nearly all cholangiocarcinomas develop in persons infected with Opisthorchis, usually by age 40-50.

Dx by elevated serum alkaline phosphatase, biliary imaging showing obstruction, eggs in stool, and peripheral eosinophilia in 10-20%.

Prevention: Thorough cooking or freezing of freshwater fish.

Rx: praziquantel.

Ectoparasites

ML Medicine Learning

Scabies/*Sarcoptes*

Human to human spread. Clinical: intensely itchy papular rash (hands, wrists, elbows, webbing between fingers, penis, scrotum), or occasionally diffuse non-pruritic rash in immune suppressed patients (crusted scabies). Secondary bacterial infection is common.

Dx: skin scraping or adhesive tape (look for mites, eggs or feces).

Rx: lindane, etc.

Lice/Pediculosis

Three types:

1. *Head louse*
2. *Body louse*
3. *Pubic louse/"crab louse"* (also found in eyebrows)

Frequent secondary infection.

Dx: find nits (eggs) firmly attached to hair.

Rx: topical agents and combing nits out.

Bed bugs/*Culex*

Itchy rash. No proven transmission of diseases (although some speculation). Bites may be grouped or in lines (breakfast, lunch and dinner).

Insect Bites

Chiggers, biting midges (no-see-ums), flea bites – often cause very itchy papular rashes or urticaria.

Myiasis

Invasive fly larva from eggs lain on clothing etc. Lesions look like folliculitis or scattered small abscesses.