PARASITES

Kenneth Alonso, MD, FACP

Protozoa

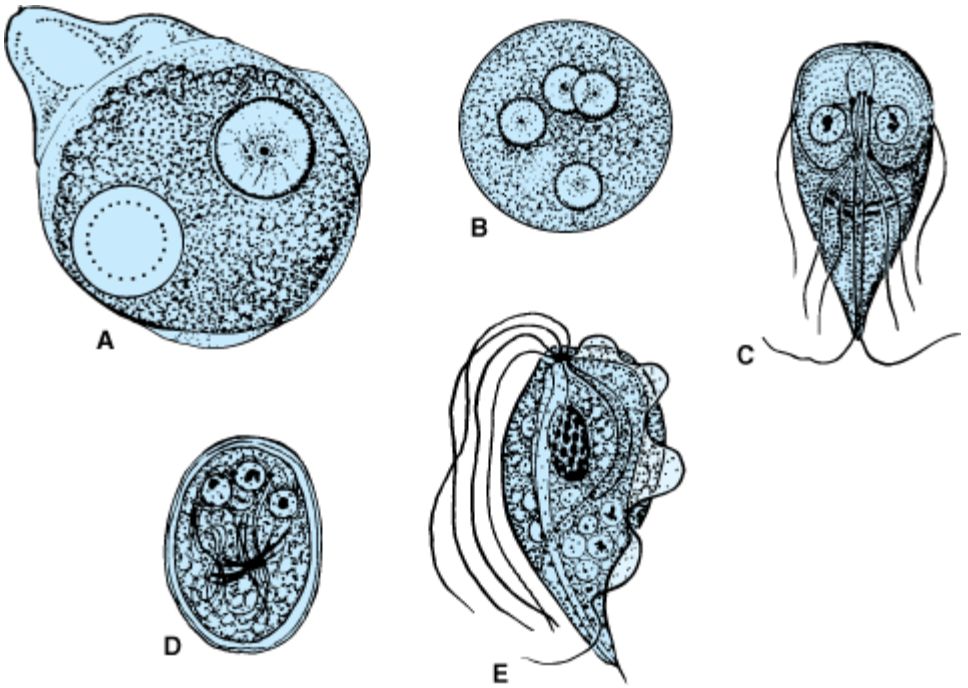
Location	Species	Disease	Transmission	Diagnosis
Intestine	Entamoeba histolytica	Amebiasis	Ingestion of: cysts	Smear
	Giardia Lamblia	Giardiasis	cysts	Smear
	Cryptosporidium parvum	Cryptosporidiosis	oocysts	Smear
	Balantidium coli	Dysentery	cysts	Smear
Urogenital tract	Trichomonas vaginalis	Trichomoniasis	Intercourse (trophozoite)	Smear
CNS	Acanthamoeba spp.	Meningitis	Amoebae in pond water	Smear
	Nagleria fowlerii	Meningitis		Smear
Blood	Plasmodium spp.	Malaria	Sporozoite from: Anopheles mosquito	Smear
	Babesiosis microti	Babesiosis	Ixodes tick	Smear

Protozoa

Location	Species	Disease	Transimssion	Diagnosis
Blood	Trypanosoma Cruzi	Chagas	trypo-mastigotes in bite of: Reduuvid bug	Smear
	Trypanosoma gambiense, rhodesiense	Sleeping sickness	Tsetse Fly	Smear
	Leishmania mexicana, braziliensis L. donovani	Leishmaniasis (cutaneous) (visceral)	Amastigotes in bite of Sand Fly	Biopsy
Tissue	Pneumocystis (fungus)		Inhalation	Smear
	Toxoplasma	Toxoplasmosis	Ingestion of oocysts	

Flagellates

- A. Entamoeba histolytica trophozoite with one nucleus and one ingested red cell B. Entamoeba histolytica cyst with four nuclei C. Giardia lamblia trophozoite D. Giardia lamblia cyst E. Trichomonas vaginalis



Source: Levinson W: *Review of Medical Microbiology and Immunology*, 10th Edition: http://www.accessmedicine.com

Fig. 51-1 Accessed 08/01/2010

Entamoeba histolytica

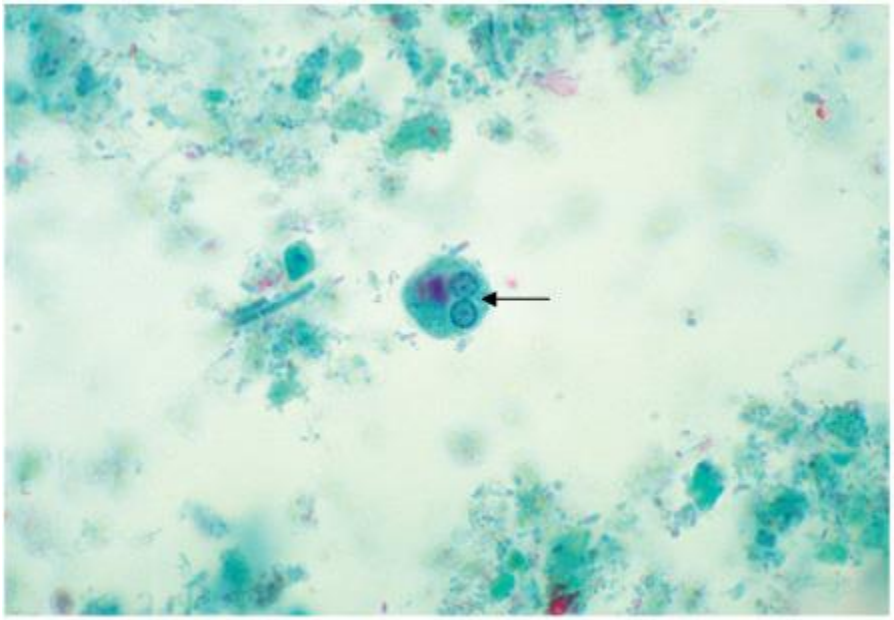
- Obligate fermenters of ethanol.
- Lack mitochondria.
- Cysts have chitin wall.
- Resistant to gastric acid.
- Principally in cecum.
- Colonize epithelial surface (parasite lectin).
- Release trophozoites
- Reproduce under anerobic conditions without harming host

Entamoeba histolytica

- Cause epithelial cell apoptosis (amebapore channel forming protein), invade colonic gland crypts, and burrow into lamina propria (by releasing cysteine proteases that break down extracellular matrix), creating a flask like ulcer.
- 40% of cases show penetration of splanchinc vessels and liver abscesses.
- Treat with metronidazole.

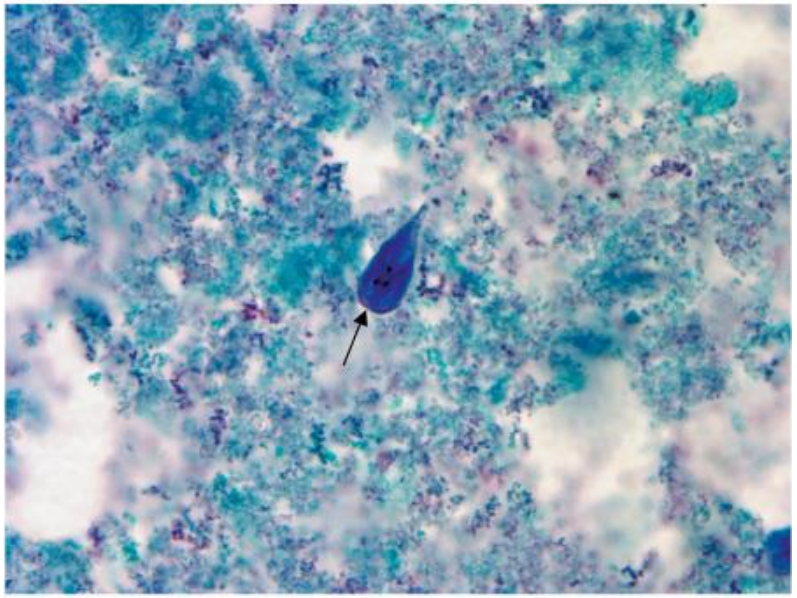
Flagellates

- Entamoeba histolytica cyst



Source: Levinson W: *Review of Medical Microbiology and Immunology*, 10th Edition: http://www.accessmedicine.com

Giardia lambia trophozoite



Source: Levinson W: *Review of Medical Microbiology and Immunology*, 10th Edition: http://www.accessmedicine.com

Provider: CDC with Giardia lambia from Dr. M. Mosher.

Color plates 42 and 43
Accessed 08/01/2010

Giardia lambia

- Ferments glucose
- Lacks mitochondria.
- Acid activates cyst transformation to trophozoites.
- Lack of cholesterol as organism moves from duodenum to jejunum leads to transformation to cyst.
- Ventral cuticles permit mucosal attachment.
- Adhere to surface epithelium through activation of parasite lectin.

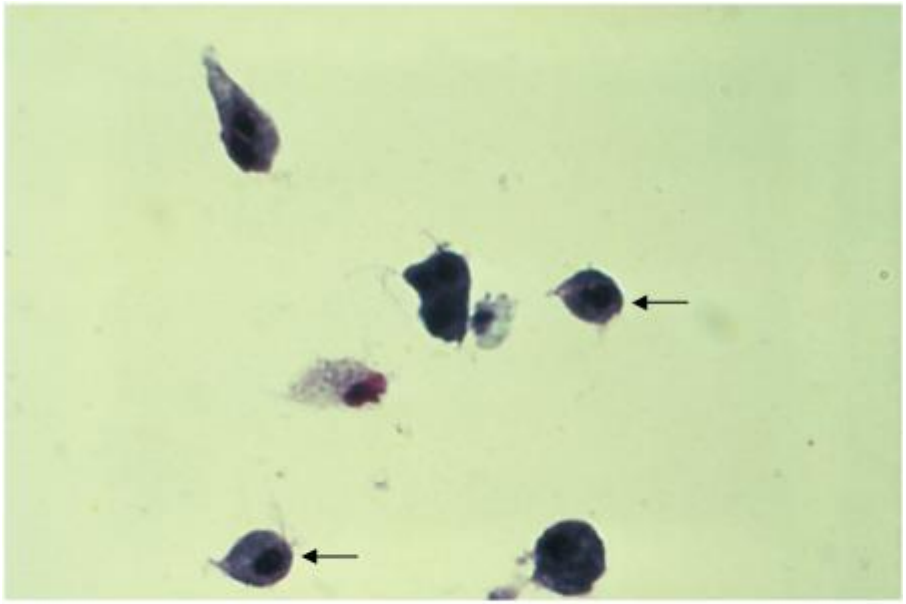
Giardia lambia

- Cysteine rich surface protein resembles a diarrhea producing snake venom
- Chloride pump affected
- 20-40% of chronic cases have disaccharidase deficiency.
- IgA mediated immunity.
- Respond to metronidazole.

Trichomoniasis

- Frothy green or gray vaginal discharge (women)
- Urethral itch with frothy discharge (men)
- Men may be asymptomatic
- Visualization of T. vaginalis on wet mount preparation
- Responds to single dose of metronidazole (given orally or rectally or vaginally)
- Should treat sexual partner as well.

Trichomonas vaginalis



Source: Levinson W: *Review of Medical Microbiology and Immunology*, 10th Edition: http://www.accessmedicine.com

Arrows point to two trophozoites.

Provider: CDC

Color plate 44
Accessed 08/01/2010

Plasmodium spp.

- Sporozoites transmitted via bite of female Anopheles mosquito
- Between dusk and dawn, generally
- Sporozoites invade hepatocytes and divide until mature tissue schizonts (containing merozoites).
- Asymptomatic.
- Merozoites released into bloodstream with rupture of schizonts.
- In the red cell, mature successively from ring forms to trophozoites to schizonts.
- Fever cycle related to maturation time and release of daughter merozoites that can infect new cells.

Plasmodium spp.

- Parasite antigens expressed on MHC I molecules on hepatocytes.
- Diminished frequency of those with HLAB53 or HLADRB1*1302 (Gambia) seen with those progressing to cerebral malaria in childhood.
- Merozoites infect red cells using glycophorin A receptor (falciparum) or Fy^a or Fy^b (vivax).
- GPI-linked proteins including merozoite surface antigens are released from infected red cells and induce cytokine production and induce PfEMP1 expression

Plasmodium spp.

- Plasmodium falciparum induces red cell clumping and adhesion to endothelial cells lining small blood vessels.
- PfEMP1 forms knobs on the surface of red cells; binds to ligands on endothelial cells, including CD36, thrombospondin, VCAM-1, ICAM-1 and E-selectin.
- TNF-α, IFN-γ, and IL-1 production marked.
- IFN-γ activates macrophages, leading to production of TNF-α and IL-1, increasing ICAM-1 on cerebral blood vessels
- CD8+ cells damage cerebral vasculature.
- TNF-α stimulates nitric oxide production (and tissue damage).

Plasmodium spp.

- Plasmodium vivax and Plasmodium ovale have regular 48 hour fever spikes. (Benign tertian fever)
- Plasmodium malariae has a regular 72 hour fever spike. (Quartan fever)
- May recrudesce
- Plasmodium falciparum has irregular fever spikes but may show a 48 hour pattern. (Malignant tertian fever).
- Can invade red cells of all ages.
- Causes cerebral malaria (related to level of parasitemia.).

Plasmodium spp.

- A few merozoites differentiate into sexual forms (gametocytes).
- These complete their life cycle in the midgut of an anopheline mosquito.
- Asymptomatic.

Plasmodium spp.

- All species digest red cell proteins and hemoglobin.
- Alter the cell membrane, making it less deformable, resulting in hemolysis and accelerated splenic clearance.
- Heme is polymerized, rendering it non-toxic to parasite.
- More effective utilization of glucose than red cell.
- As red cell forced to derive energy from anerobic glycolysis, infection may precipitate hypoglycemia with lactic acidosis.
- Red cell lysis stimulates release of TNF-α (which also suppresses hematopoiesis).

Plasmodium spp.

- Plasmodium falciparum PfEMP1induces the formation of sticky knobs on red cell surface.
- Bind to receptors on endothelial cells, leading to sequestration and obstruction of blood flow.
- Plasmodium falciparum infected red cells express membrane protein 1 which interacts with complement receptor 1 of uninfected cells, leading to rosetting and clogging of the microcirculation.
- Mechanism of damage in cerebral form.

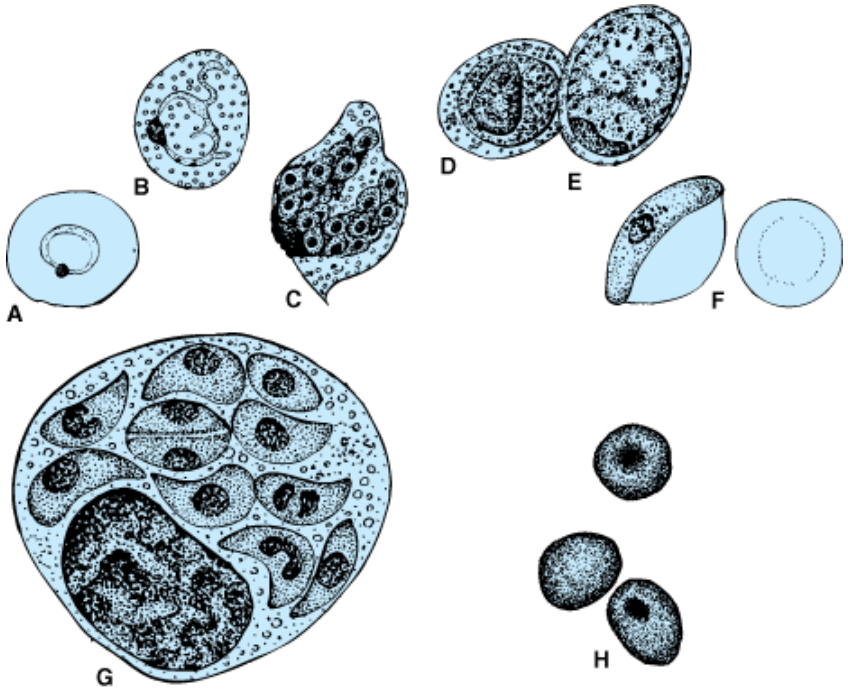
Plasmodium spp.

- Protective against Plasmodium vivax is the absence of Fy (Duffy) antigen from red cells.
- Sickle trait is also associated with lower risk of P. falciparum infection as well as lower parasite densities.
- Parasite multiplication is reduced in β-thalassemia
- Hb F is resistant to malarial hemoglobinases
- Parasite multiplication is reduced as well in α-thalassemia

Plasmodium spp.

- Cytoadeherence diminished in ovalocytes (elliptocytosis).
- Pyruvate kinase deficiency appears to be protective against Plasmodium falciparum.

Plasmodium species

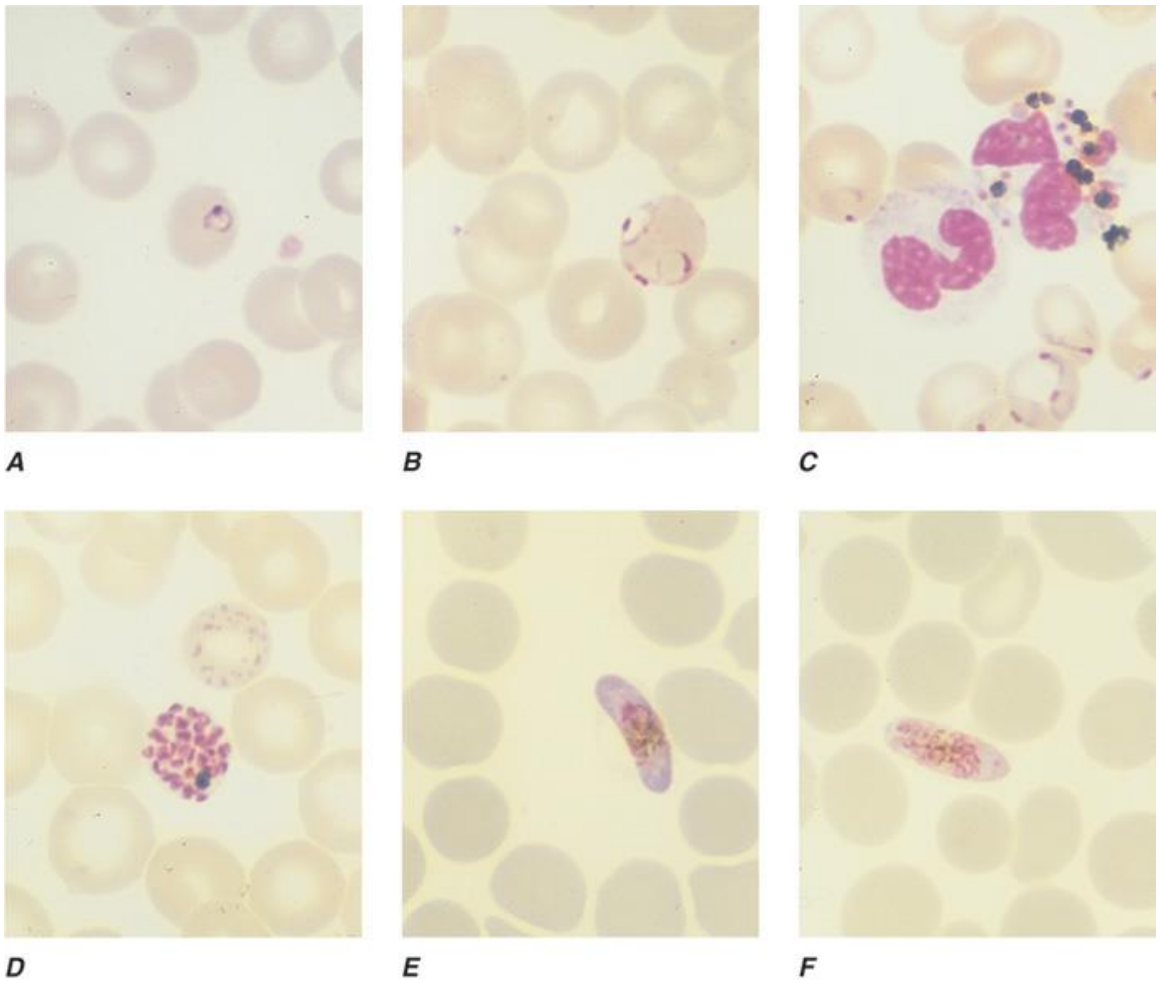


Source: Levinson W: *Review of Medical Microbiology and Immunology*, 10th Edition: http://www.accessmedicine.com

A:*Plasmodium vivax* signet-ring trophozoite within a red blood cell. B:*Plasmodium vivax* ameboid trophozoite within a red blood cell, showing Schüffner's dots. C:*Plasmodium vivax* mature schizont with merozoites inside. D:*Plasmodium vivax* microgametocyte. E:*Plasmodium vivax* macrogametocyte. F:*Plasmodium falciparum* "banana-shaped" gametocyte with attached red cell ghost. G:*Toxoplasma gondii* trophozoites within macrophage. H:*Pneumocystis carinii* cysts. (A–G, 1200 x; H, 800 x.)

Fig. 52-1 Accessed 08/01/2010

Plasmodium falciparum

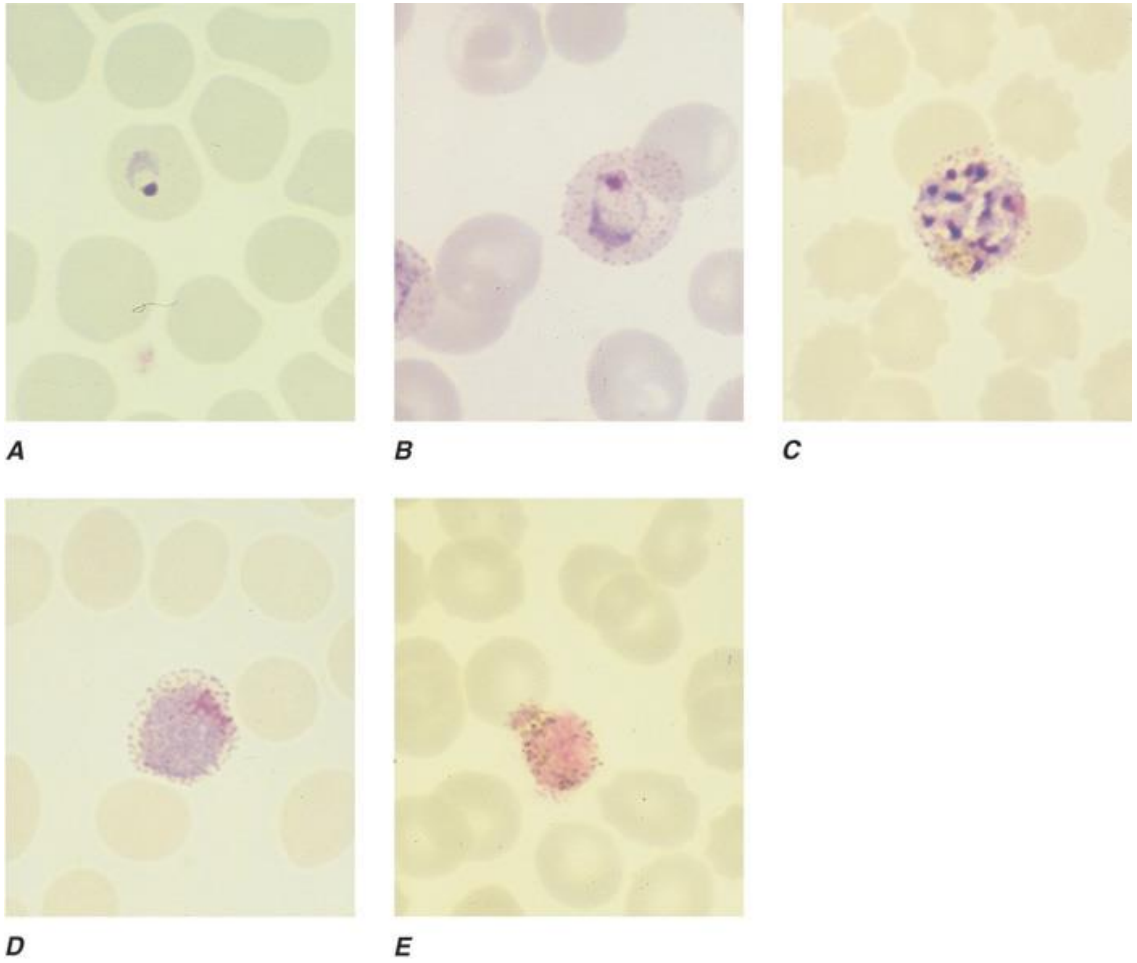


A. Young trophozoites.
B. Old trophozoites.
C. Pigment in polymorphonuclear cells and trophozoites.
D. Mature schizonts.
E. Female gametocytes.
F. Male gametocytes.

(Reproduced from Bench Aids for the Diagnosis of Malaria Infections, 2d ed, with the permission of the World Health Organization.)

Fig. e18-2 Acessed 07/01/2010

Plasmodium vivax



A. Young trophozoites.
B. Old trophozoites.
C. Mature schizonts.
D. Female gametocytes.
E. Male gametocytes.

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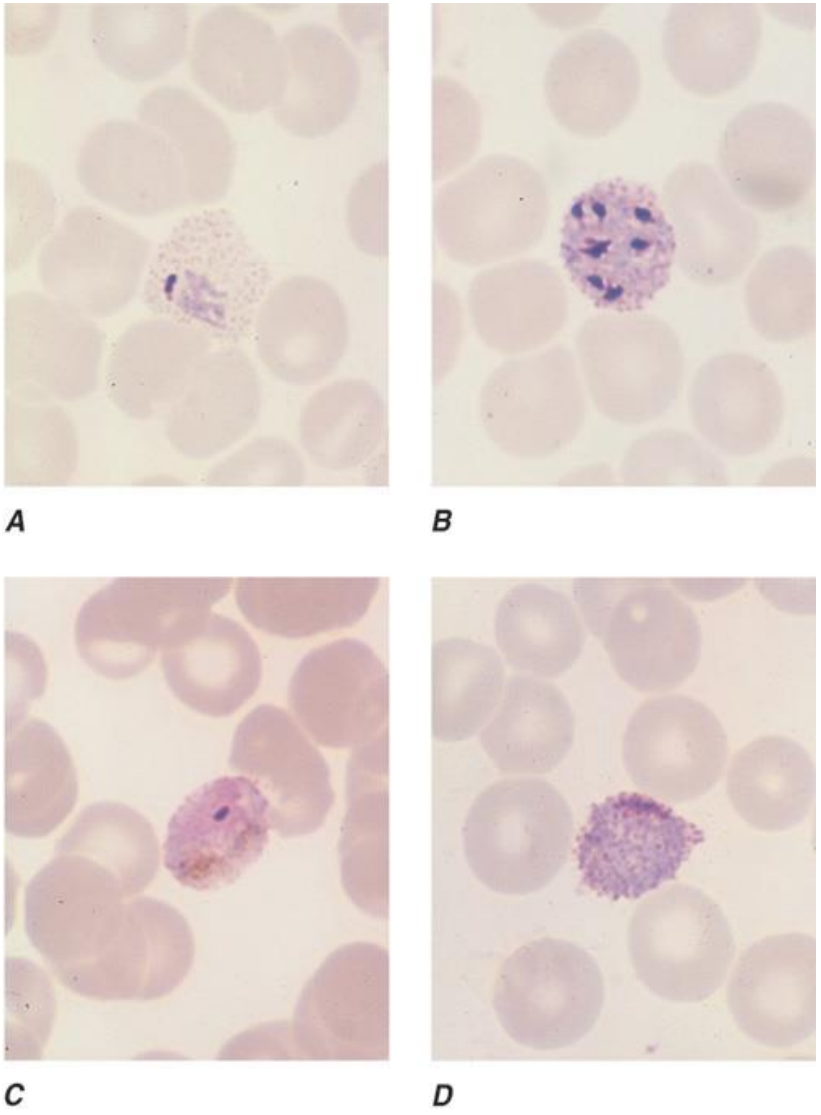
Fig. e18-1 Assessed 07/01/2010

Plasmodium ovale



A. Old trophozoites.
B. Mature schizonts.
C. Male gametocytes.
D. Female gametocytes.

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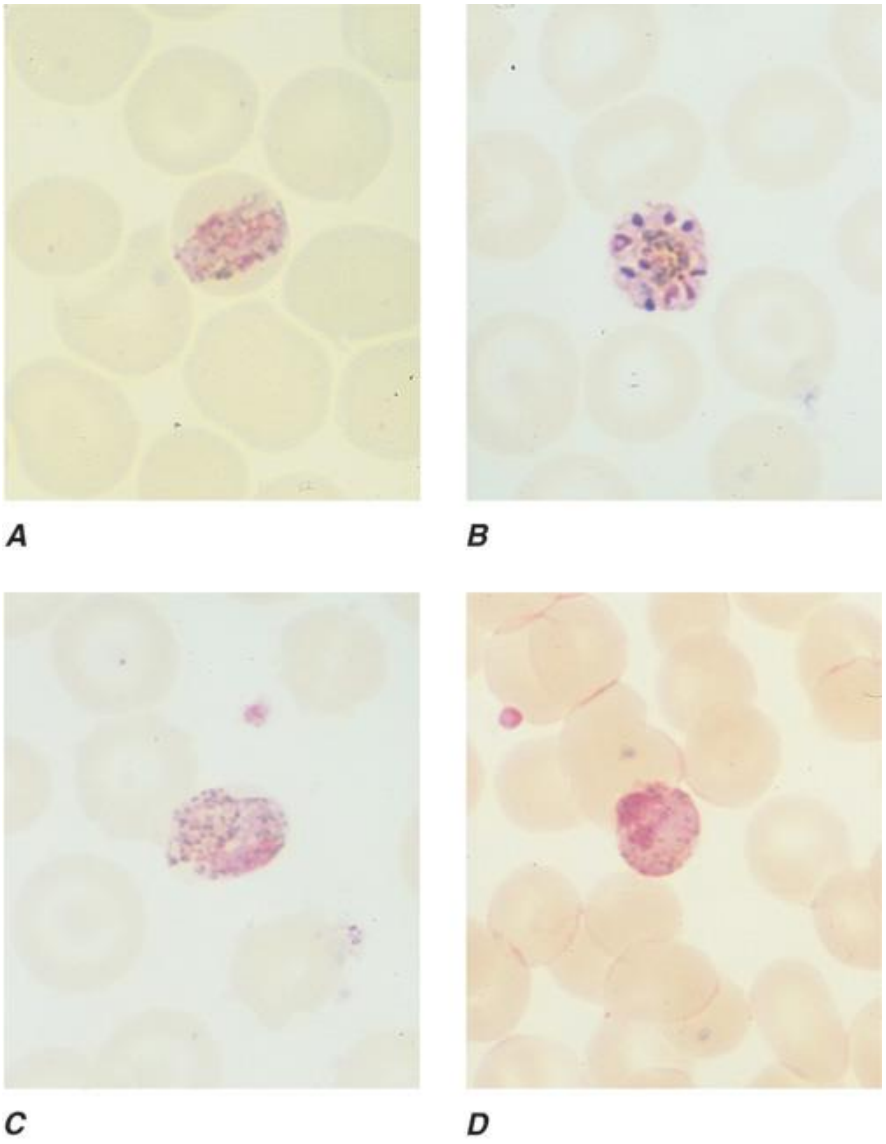
Fig. e18-3
Accessed 07/01/2010

Plasmodium malariae



A. Old trophozoites.
B. Mature schizonts.
C. Male gametocytes.
D. Female gametocytes.

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Fig. e18-4
Accessed 07/01/2010

Therapy

- Plasmodium falciparum infections can cause rapidly progressive severe illness or death
- Plasmodium vivax, Plasmodium ovale, or Plasmodium malariae species rarely cause severe manifestations
- Plasmodium vivax and Plasmodium ovale infections require treatment for the hypnozoite forms that remain dormant in the liver and can cause a relapsing infection

Therapy

- Patients diagnosed with uncomplicated malaria can be effectively treated with oral antimalarials.
- Plasmodium falciparum and Plamsodium vivax species have different drug resistance patterns in differing geographic regions.
- For Plasmodium falciparum infections, the urgent initiation of appropriate therapy is especially critical.

Therapy

- Patients who have one or more of the following clinical criteria require aggressive parenteral therapy:
- Impaired consciousness/coma
- Severe normocytic anemia
- Renal failure
- Pulmonary edema
- Acute respiratory distress syndrome
- Circulatory shock
- Disseminated intravascular coagulation
-

Therapy

- Acidosis
- Hemoglobinuria
- Jaundice
- Repeated generalized convulsions
- Parasitemia of > 5%).

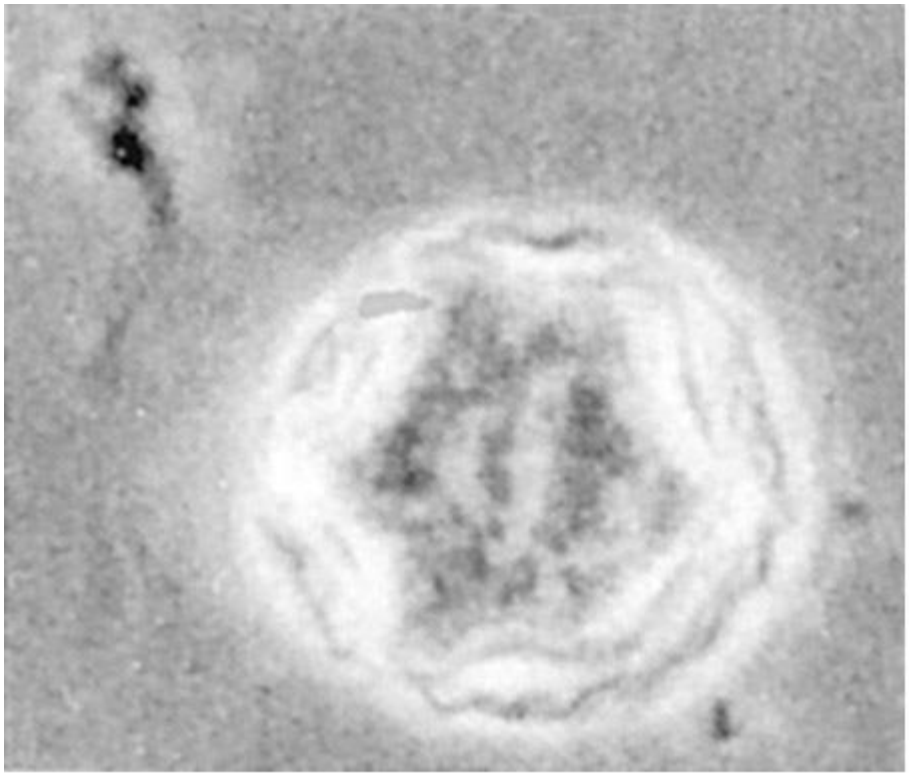
Therapy

- Oral choloroquine therapy is preferred for the treatment of Plasmodium falciparum.
- Infection acquired in Central America or the Middle East is associated with chloroquine resistance
- If chloroquine resistance, quinine plus doxycyline is preferred.
- Atovaquone-proguanil is an excellent alternative.
- Chloroquine is the drug of choice for all other Plasmodium spp.
- Plasmodium vivax resistance noted in Papua New Guinea and Indonesia

Therapy

- Primaquine added to chloroquine to eradicate hypnozoites of Plasmodium vivax and Plasmodium ovale.
- Not administered if patient G6PD deficient.
- Quinidine for intravenous use (may prolong QT interval).
- Doxycyline good for malarial prophylaxis in all areas.
- Primaquine prophylaxis only for short visits to areas with high risk of Plasmodium vivax and Plasmodium ovale infections.
- Neither doxycycline, primaquine, or atovaquone-proguanil is indicated for pregnant women.
- Clindamycin employed.

Acanthamoeba



Phase-contrast microscopy. Free-living amoeba (Acanthamoeba castellani). Double walled cyst resistant to chlorine. Causes keratitis, granumomatous encephalitis.

Consider Naegleria fowlerii if fulminant memingitis without bacterial findings.

[From DJ Krogstad et al, in A Balows et al (eds): Manual of Clinical Microbiology, 5th ed. Washington, DC, American Society for Microbiology, 1991.]

Fig. 202-5 Accessed 07/01/2010

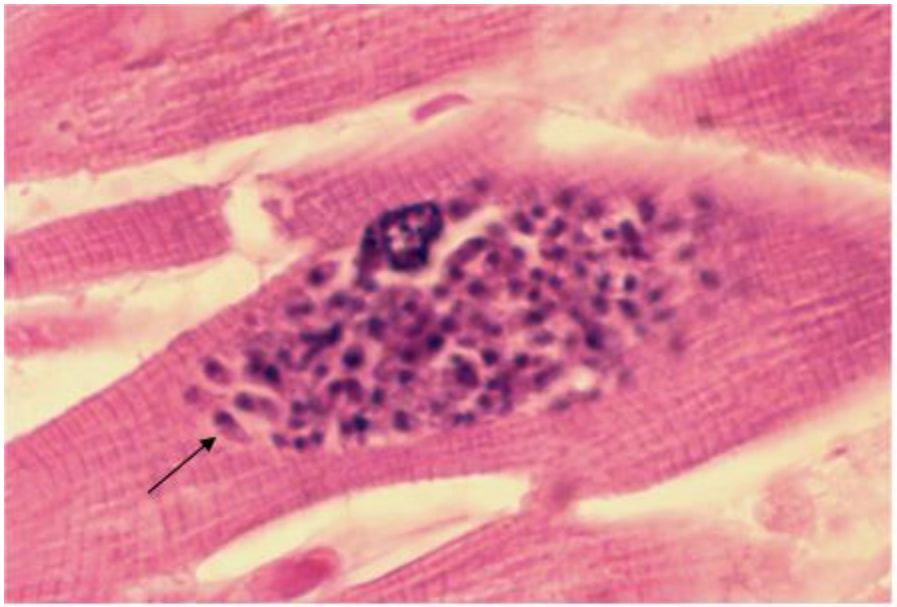
Toxoplasma gondii

- Felines are the only animals in which Toxoplasma gondii can complete its reproductive cycle.
- Cysts ingested.
- The organisms invade intestinal epithelium and disseminate throughout the body.
- They then encyst in any type of nucleated cell and can lie dormant within tissues for the life of the host.
- When symptomatic infection does occur, the most common manifestation is bilateral, symmetrical, non-tender cervical adenopathy (small, non-fluctuant).
- Generally resolves within weeks.
- Constitutional symptoms mild.

Toxoplasma gondii

- Toxoplasma gondii is one of the most common pathogens to cause chorioretinitis in immunocompetent hosts.
- May be mistaken for acute Epstein-Barr virus or cytomegalovirus infection, especially since mild atypical lymphocytosis can be seen with toxoplasmosis.
- Serologic diagnosis.
- Pyrimethamine plus sulfadiazine.
- Leucovorin is given to all patietns receiving pyrimethamine.
- When Toxoplasma gondii reactivates in the immunocompromised, it most commonly does so in the CNS leading to cerebral abscesses.

Toxoplasma cyst



Arrow points to a tachyzoite of *Toxoplasma gondii* in cardiac muscle.

Provider: CDC/Dr. E. Ewing, Jr.

Color plate 47 Accessed 08/08/10

Pneumocystis jirovecii

- Pneumocystis jiroveci (PCP).
- Colonizes airway.
- Primary mode of transmission unknown.
- Variation of expression of the major surface glycoprotein allows evasion of immuno-surveillance.
- In HIV-infected patients, PCP is generally gradual in onset and characterized by fever (79 to 100 percent), non-productive cough (95 percent), and progressive dyspnea (95 percent)
- Specific diagnosis requires documentation of the organism in respiratory specimens.

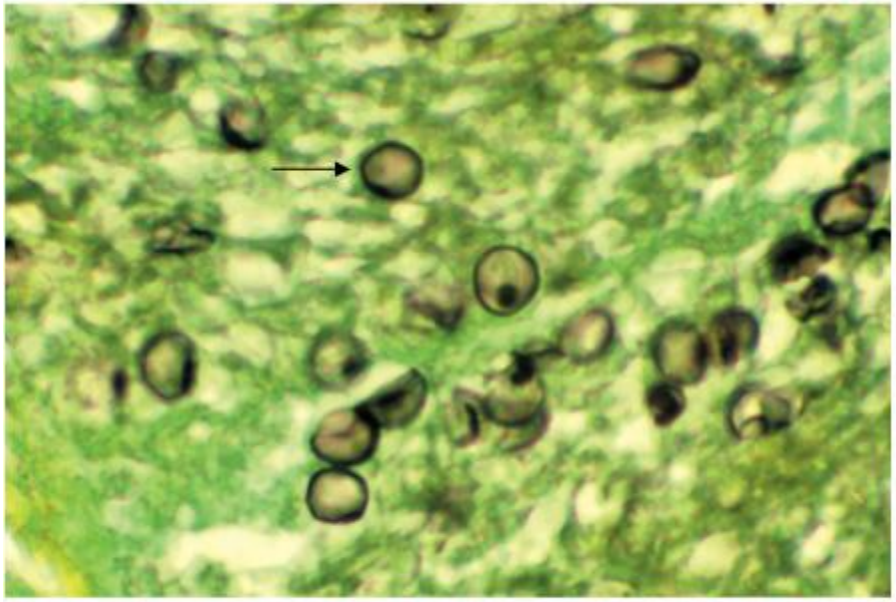
Pneumocystis jirovecii

- Chest radiographs are initially normal in up to one-fourth of patients with PCP.
- The most common radiographic abnormalities are diffuse, bilateral, interstitial, or alveolar infiltrates,
- Although upper lobe infiltrates can be seen de novo, a higher incidence of predominantly apical infiltrates is reported in patients using aerosolized prophylaxis.
- If sputum induction is nondiagnostic or cannot be performed, then fiberoptic bronchoscopy with bronchoalveolar lavage is recommended, with or without transbronchial biopsy.

Pneumocystis jirovecii

- Antibiotic therapy may worsen hypoxemia.
- Trimethoprim-sulfisoxazole drug of choice.
- Glucocorticoid therapy if pO_2 <70 torr.

Pneumocystis pneumonia



Arrow points to a cyst of Pneumocystis jeroveci in lung tissue. Gomori methenamine silver stain.

Provider: CDC/Dr. E. Ewing, Jr.

Color plate 48
Accessed 08/01/2010

Leishmania

- Obligate intracellular kinetoplast-containing protozoan parasites
- Sandfly vector
- Promastigote lives extracellularly
- Promastigote has lipophosphoglycan surface that leads to C3b deposition on its surface but prevents membrane attack complex insertion on its surface.
- Rather, it binds Mac-1 and CR1 on macrophage surface for phagocytosis.
- Glycolax protects the parasite in the phagosome.
- Also present on the promastigote is a zinc dependent proteinase (gp63) that promotes adhesion.

Leishmania

- Flagellated promastigote alters conformation in acid environment (phagocyte) and are transformed into rounded amastigotes without flagella but with a single mitochondrion and with its DNA massed into the sub-organelle, kinetoplast.
- Expresses a proton transporting ATPase to maintain intracellular pH.
- Proliferate in macrophages and are released as cell dies.
- T_{H1} Response protective

Leishmaniasis

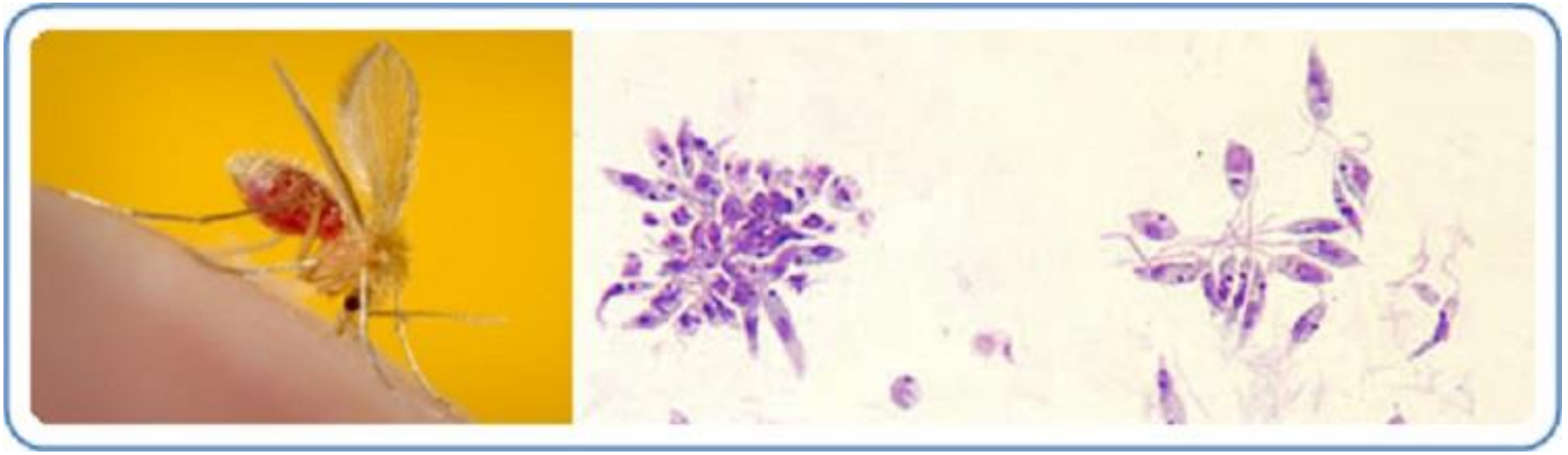
- Cutaneous leishmainisis characterized by ulcers on exposed skin.
- Mild.
- Granulomatous lesion with few parasites.
- Diffuse cutaneous form begins as a single nodule and spreads until the entire body is covered by nodules.
- Foamy macrophages stuffed with parasite.

Leishmaniasis

- Mucocutaneous form only seen with Leishmania brasiliensis.
- Ulcerating and non-ulcerating lesions in nasopharyngeal area.
- Progressive and highly destructive.

Leishmaniasis

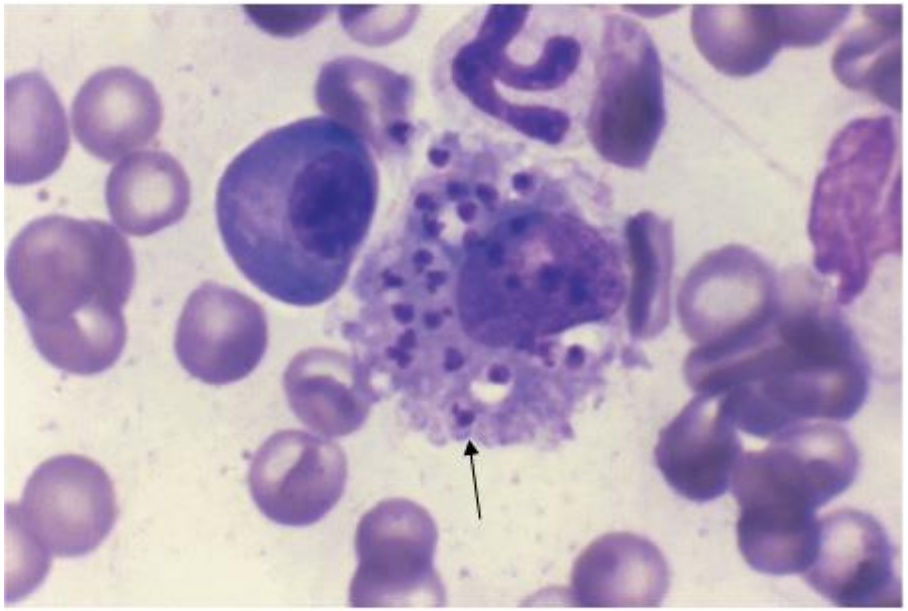
- Visceral form seen with Leishmania donovani or chagasi.
- Involves macrophages through out the body.
- Hepatosplenomegaly.
- May see skin hyper-pigmentation (kala-azar), mesangioproliferative glomerulonephritis, amyloidosis.
- Macrophages contain parasites.
- Plasma cell response also noted.



On average, the sand flies that transmit the parasite are only about one fourth the size of mosquitoes or even smaller. On the left, an example of a vector sand fly (Phlebotomus papatasi) is shown; its blood meal is visible in its distended transparent abdomen. On the right, Leishmania promastigotes from a culture are shown. The flagellated promastigote stage of the parasite is found in sand flies and in cultures.

Cdc.gov

Leishmania donovani

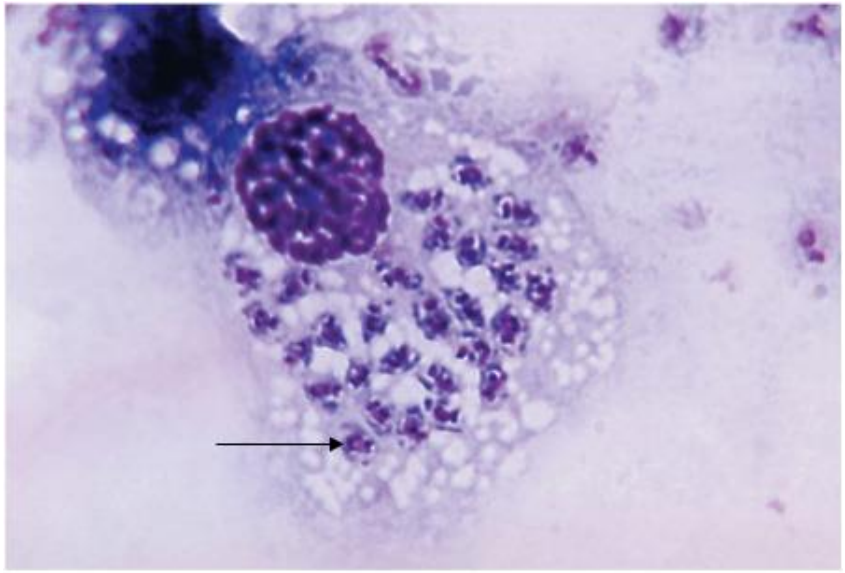


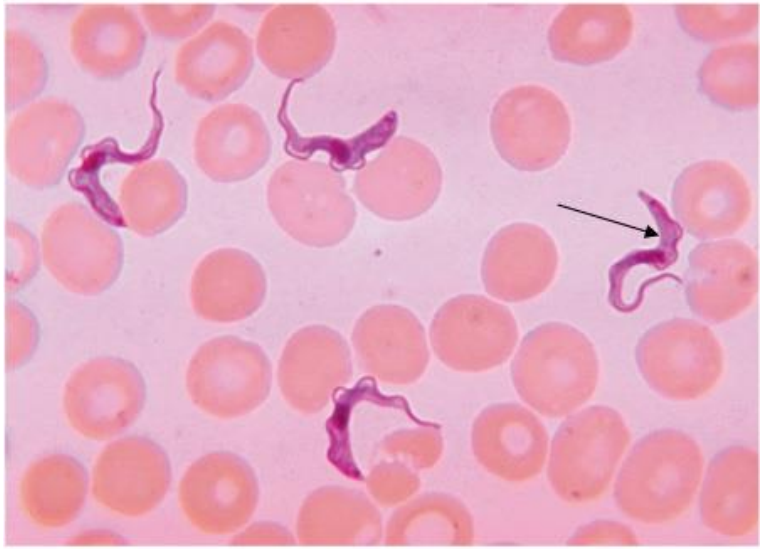
Arrow points to an amastigote (non-flagellated from) in cytoplasm of bone marrow cell.

Provider: CDC/Dr. Francis Chandler.

Color plate 51 Accessed 08/01/2010

Trympanosomes





Left. Trypansoma cruzeii. Arrow points to an amastigote (non-flagellated form) in cytoplasm. Right: Arrow points to a trypomastigote (the flagellated form) in the blood.

Provider: CDC/Dr. A. J. Sulzer (T. cruzeii) and D. M. Schultz.
Color plates 49 and 50 Accessed 08/01/2010

Trypanosomiasis

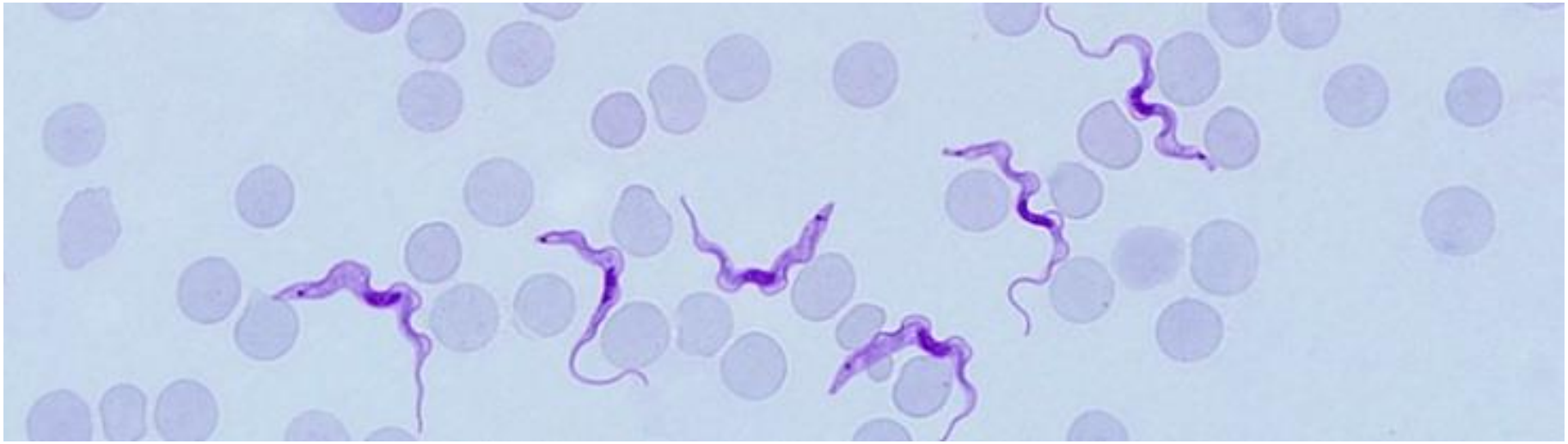
- Tsetse fly bite transmits a flagellated metacyclic trypomastigote form of the parasite.
- Chancre can develop at the site of inoculation.
- Parasites enter regional lymphatics and then disseminate widely in the bloodstream.
- Metacyclic trypomastigotes differentiate to long, slender forms (trypomastigotes).
- These forms can be found in blood smears and are characterized by a flagella and a kinetoplast, which is an organelle that is associated with the mitochondrion, and contains extranuclear DNA.
- Trypomastigotes can cross through walls of blood and lymphatic vessels, and enter the CSF and brain.

Trypanosomiasis

- Innate immunity against Trypanosoma brucei is due to the trypanolytic activity of apolipoprotein L-I, which is bound to high-density lipoproteins in human serum.
- This protein, which is taken up in the parasite by endocytosis, triggers osmotic swelling of the lysosomal compartment and subsequent cell death.
- Evades surveillance by antigenic switching (glycolipid-anchored variant surface glycoprotein), by their ability to grow in the presence of high levels of IFN-γ and to avoid complement-mediated destruction.

Trypanosomiasis

- During infection, massive nonspecific polyclonal B cell activation occurs, and large amounts of IgM are produced.
- Large numbers of immune complexes form, and secondary hyperplasia of the reticuloendothelial system occurs, particularly involving the spleen and lymph nodes.
- In addition, generalized suppression of humoral and cellular immune responses is also seen.
- Mott cells are eosinophilic cells with large amounts of unsecreted immunoglobulin



Trypanosoma brucei rhodesiense in a Giemsa-stained blood smear.
Cdc.gov

Trympanosomiasis

- Trypanosoma b. gambiense
- Slowly progressive infection
- Asymptomatic phase can last for months or years.
- Trypanosoma b. rhodesiense
- Tends to progress rapidly
- CNS involvement is often detectable within weeks of infection.
- Both infections are fatal if untreated.

Trympanosomiasis

- The first sign of infection with either type of African trypanosome may be the trypanosomal chancre
- Typically appears approximately one week after the bite of an infected tsetse fly.
- A well-circumscribed, rubbery, painful, indurated, red papule 2 to 5 cm in diameter.
- The chancre usually resolves spontaneously after several weeks, but it can ulcerate.
- It is seen more frequently with Trypanosoma b. rhodesiense than Trypansosoma b. gambiense.

Trympanosomiasis

- Patients can also present with transient, erythematous, urticarial, or macular rashes six to eight weeks after the onset of illness .
- Lesions can manifest as poorly defined, centrally pale, evanescent, annular, or blotchy erythematous macules on the trunk (trypanids).

Trypanosomiasis

- Trypansoma b. gambiense
- Soft, painless, mobile posterior cervical nodes ("Winterbottom's sign“).
- Lymphadenopathy can develop at any site.
- Lymph node enlargement is found less frequently with Trypanosoma b. rhodesiense.
- However, when lymphadenopathy is present, nodes in the submandibular, axillary or inguinal region are more often involved rather than cervical.

Trypanosomiasis

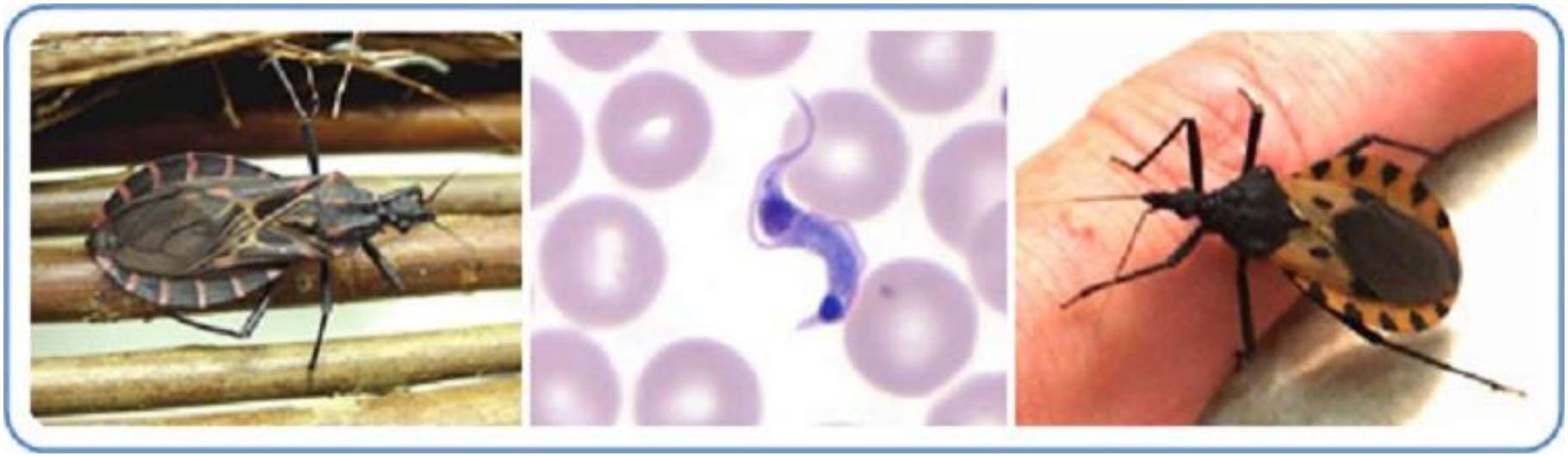
- Early symptoms include intermittent headache, fevers, malaise and arthralgias.
- These symptoms are frequently intermittent, corresponding with successive waves of parasitemia and antibody production.
- Organomegaly, in particularly splenomegaly, is a common finding.
- Generalized lymphadenopathy is also often present.
- Pancarditis occasionally develops, leading to arrhythmias and/or cardiac failure.
- This presumably arises from perivascular infiltration by trypanosomes and lymphocytes, resulting in endarteritis and secondary fibrosis.

Trypanosomiasis

- Symptoms include: headache, difficulty concentrating, personality changes, psychosis, sensory disorders, tremor and ataxia.
- Meningismus and focal neurologic signs may occur but are unusual.
- An alteration of the circadian sleep/wake cycle leading to daytime somnolence also frequently develops.
- Convulsions may occur, especially in children.
- Progressive deterioration occurs until the patient is in a stuporous state.

Trypanosomiasis

- Other nonspecific symptoms may be present, including pruritus, rash, weight loss and facial swelling.
- Neuroendocrine disturbances leading to amenorrhea in women or impotence in men may also be seen.
- In later stages, progressive diffuse meningoencephalitis and parenchymal edema of the brain develop.
- Perivascular and meningeal inflammatory infiltrates, cerebral hemorrhages, and widespread multifocal white matter demyelination occur.



Left and Right: Various species of triatomine bugs, which if infected can transmit T. cruzi. Center: T. cruzi trypomastigote in a thin blood smear stained with Giemsa.

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Chagas disease

- Trypanosoma cruzi
- Transmitted by Reduuvid bug
- Armadillo reservoir
- Found in Mexico and South America.
- Transient erythematous nodule (chagoma).
- Stimulates intracellular Ca^{2+} concentration in host cell to promote fusion of phagosome and lysosome.
- Requires brief exposure to acid environment of phagolysosome to stimulate amastigote development.
- Damage due to direct invasion of cardiac myocytes

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- Damage due to direct invasion of cardiac myocytes

Trypanosomiasis

- For management of early Trypanosoma b. gambiense infection, pentamidine is preferred; suramin is an alternative agent.
- Melarsoprol is effective but it should be reserved for treatment in the setting of CNS disease because of its toxicity.
- For management of late Trypanosoma b. gambiense infection, eflornithine is the treatment of choice

Trypanosomiasis

- Following treatment, patients should be monitored for two years with twice yearly lumbar punctures.
- A rise in CSF WBC or demonstration of trypanosomes in CSF, blood, or lymph node aspirate is evidence of relapse.
- Relapses should be treated based upon the stage of initial disease.
- Relapse after early Trypanosoma b. gambiense should be treated with eflornithine or melarsoprol.

Trypanosomiasis

- Relapse after an initial course of melarsoprol for late Trypansomiasis b. gambiense should be treated with eflornithine.
- Cure rates in this situation are 98 percent with seven days of eflornithine; two weeks of eflornithine used initially only result in a 90 percent cure rate.
- Relapse in a patient with late stage infection treated initially with eflornithine should be managed with melarsoprol.
- For a patient who relapses after a course of each drug has been tried, a combination of the nifurtimox with eflornithine can be used.

Trypanosomiasis

- For patients with early Trypanosomiasis b. rhodesiense, suramin should be used.
- For late Trypanosomiasis b. rhodesiense, melarsoprol is the only effective drug.
- Patients should have lumbar punctures performed every three months for the first year after therapy.
- Patients who relapse after suramin or melarsoprol should be treated with melarsoprol.

Pentasomidia

- Primitive, worm like parasites found in lungs of reptiles
- Humans infected in larval stage
- Usually self-limiting

Helminth infections

- Helminths do not multiply within the human host.
- Inflammatory changes result from local tissue invasion.
- Eosinophilia is a local allergic reaction.
- Cell mediated immunity operative against cysts.
- Nematode and Trematode zoonoses are transmitted through ingestion of the egg stage of the organism
- Generally nematode eggs hatch into infective larval stage in 24 hours

Nematodes

Location	Species	Common name	Transmission	Diagnosis
Intestine	Enterobius	Pinworm	Ingestion of eggs	Eggs on skin
	Trichuris	Whipworm	Ingestion of eggs	Eggs in stool
	Ascaris	Ascaris	Ingestion of eggs	Eggs in stool
	Ancylostoma Necator	Hookworm	Larval penetration of skin	Larvae in stools
	Strongyloides	Strongylodiasis	Larval penetration of skin	Larvae in stools
	Trichinella	Trichinosis	Larvae in meat	Biopsy
	Asinakis	Anisakiasis	Larvae in fish	

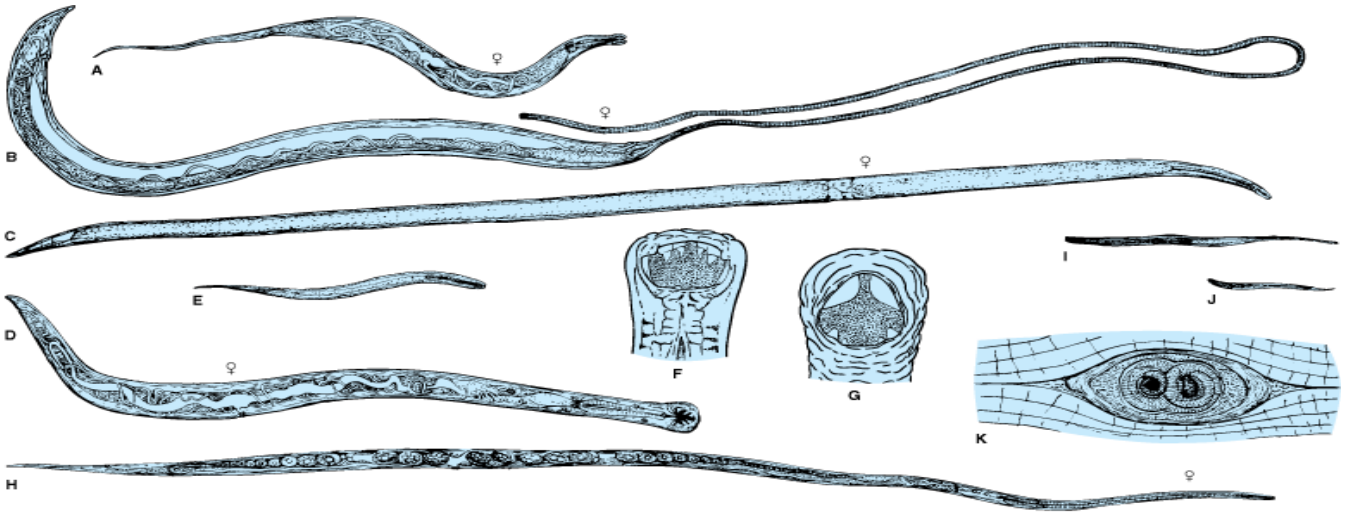
Nematodes

Location	Species	Common name	Transmission	Diagnosis
Tissue	Wucheria	Filariasis	Aedes, Culex, Anopheles, Mansoni Mosquito	Blood smear
	Onchocerca	Onchocerciasis	Black fly	Biopsy
	Loa	Loaisis	Deer fly	Blood smear
	Dracunculus	Guinea worm	Ingestion of copepods	
	Toxocara larvae	Visceral larva migrans	Ingestion of eggs	Serologic
	Ancylostoma larvae	Cutaneous larva migrans	Penetration of skin	

Intestinal nematodes (roundworms)

A:Enterobius vermicularis female adult (6 x). B:Trichuris trichiura female adult. Note the thin anterior (whiplike) end (6 x). C:Ascaris lumbricoides female adult (0.6 x). D:Ancylostoma duodenale female adult (6 x). E:Ancylostoma duodenale filariform larva (60 x). F:Ancylostoma duodenale head with teeth (25 x). G:Necator americanus head with cutting plates (25 x). H:Strongyloides stercoralis female adult (60 x). I:Strongyloides stercoralis filariform larva (60 x). J:Strongyloides stercoralis rhabditiform larva (60 x). K:Trichinella spiralis cyst containing two larvae in muscle (60 x).

Fig. 56-1
Accessed
07/01/2010



Soil transmitted helminth infections

- Ascariasis lumbricoides, hookworm, whipworm
- Major cause of parasitic disease worldwide
- Mild symptoms
- Heavy infections can cause a range of health problems, including abdominal pain, diarrhea, blood and protein loss, rectal prolapse

Ascaris lumbricoides

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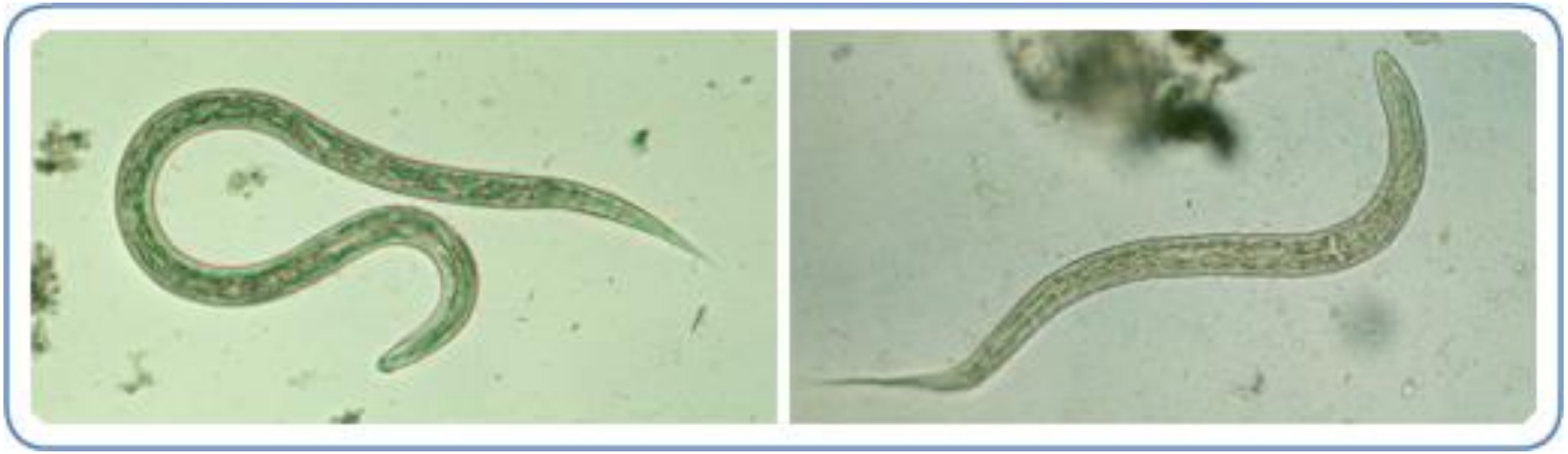
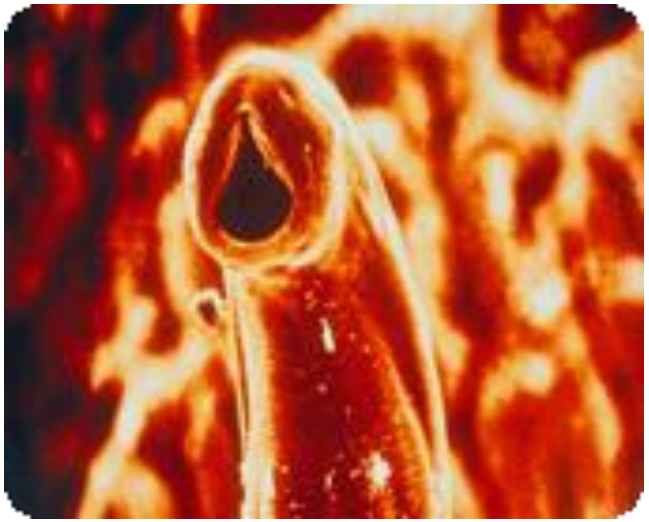
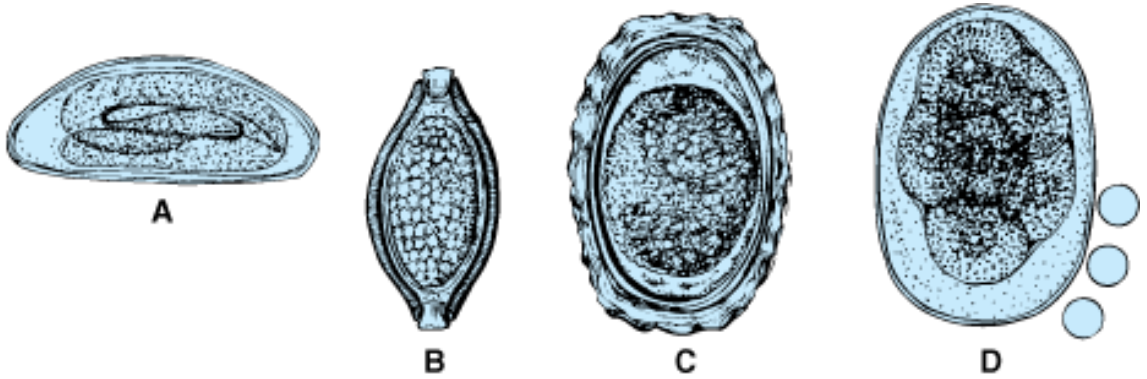




Ancylostoma duodenale
Hookworm
Cdc.gov

Intestinal nematode eggs



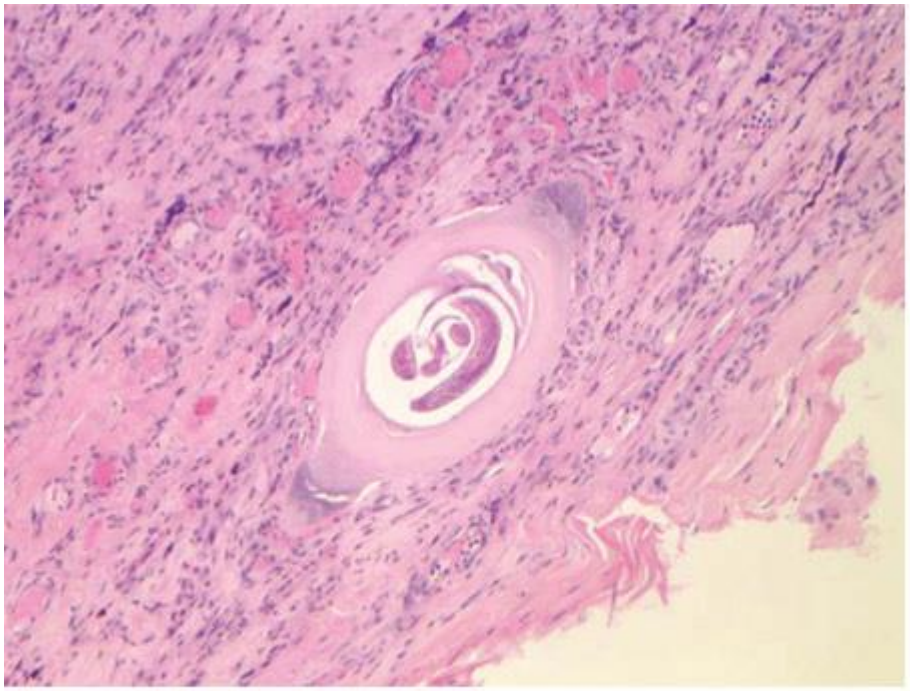
Source: Levinson W: *Review of Medical Microbiology and Immunology*, 10th Edition: http://www.accessmedicine.com

A:Enterobius vermicularis ovum. B:Trichuris trichiura ovum. C:Ascaris lumbricoides ovum. D:Ancylostoma duodenale or Necator americanus ovum (300 x). (Circles represent red blood cells.)

Fig. 56-2 Accessed 07/01/2010

Left: Egg of T. trichiura in an iodine-stained wet mount.
Right: Egg of T. trichiura in an unstained wet mount.
Center: Micrograph of an adult female Trichuris human whipworm that is approximately 4cm long
Cdc.gov

Trichinella spiralis



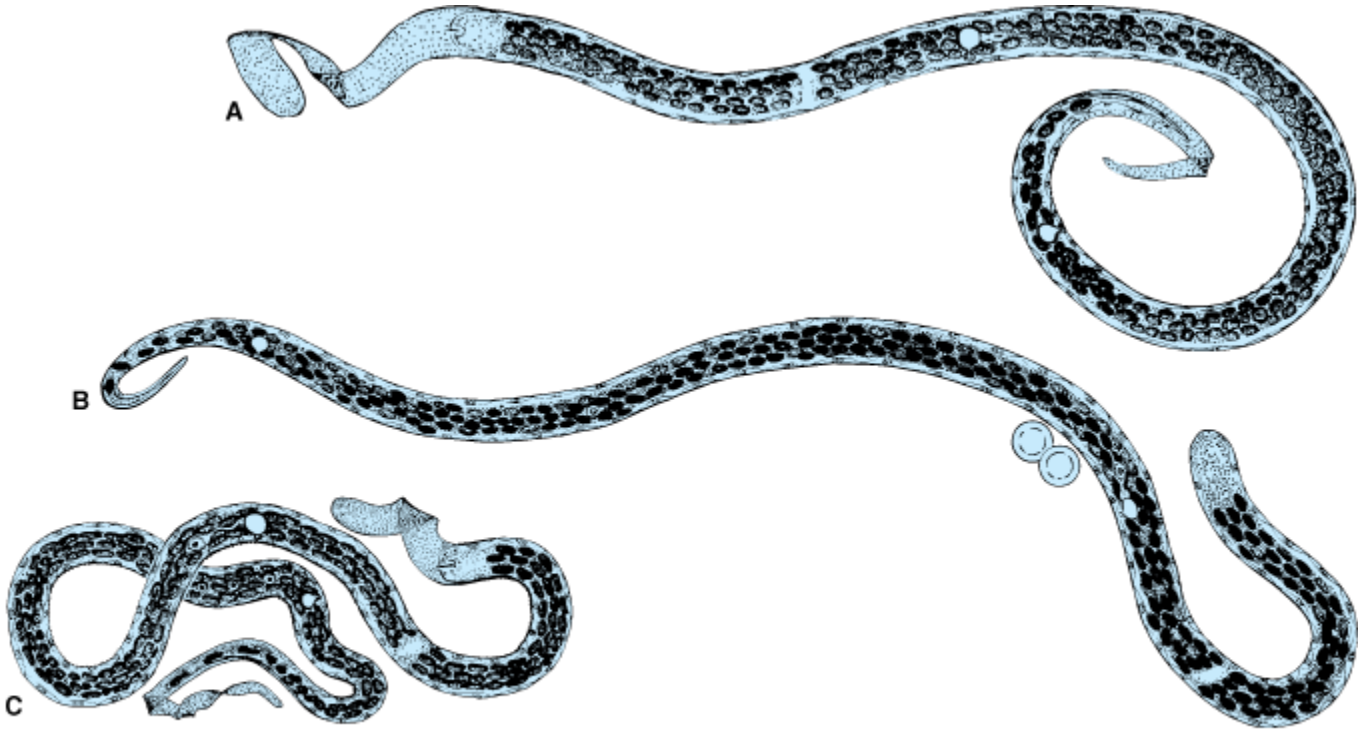
Trichinella larva encysted in a characteristic hyalinized capsule in striated muscle tissue. Stimulate T_{H2} response. May present with periorbital dedma, muscle aches, splinter hemorrnages.

(Photo/Wadsworth Center, New York State Department of Health. Reprinted from CDC MMWR 53:606, 2004; public domain.)

Fig. 209-2 Accessed 07/01/2010

Tissue nematodes

- A. Wucheria bancrofti. The tail is free of nuclei. B. Onchocerca volvulus. Rare to see these in blood. C. Loa Loa. The tail contains nuclei.



Source: Levinson W: *Review of Medical Microbiology and Immunology*, 10th Edition: http://www.accessmedicine.com

Fig. 56-3 Accessed 07/01/2010

Left: Microfilaria of Wuchereria bancrofti in thick blood smear stained with Giemsa. Right: Microfilaria of Brugia malayi in a thick blood smear, stained with Giemsa. Center: Photograph of a female Aedes aegypti mosquito as she was in the process of obtaining a “blood meal.”
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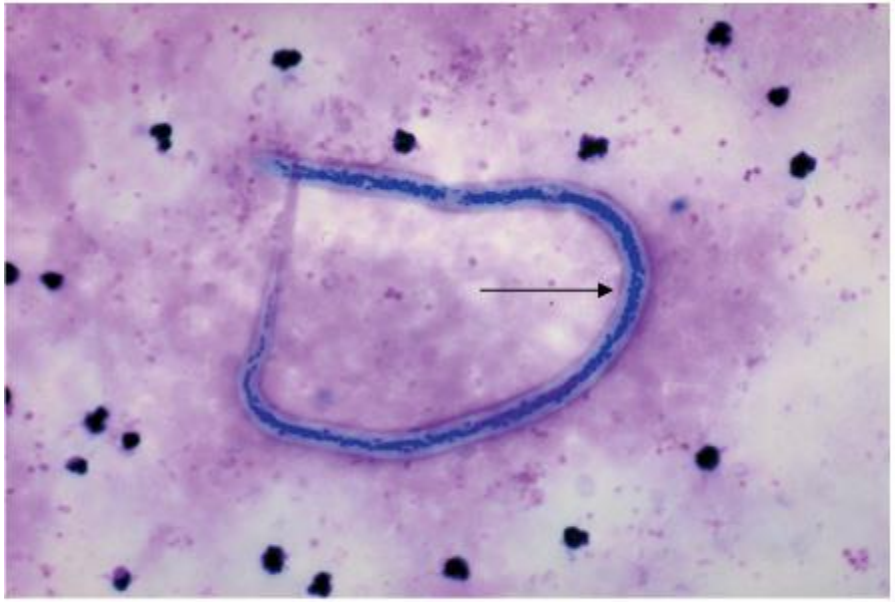
Microfilaria



Wucheria bancroftii. Filarial worm in blood. Arrow points to filarial worm in blood smear.

Provider: CDC/Dr. M. Melvin.
Color plate 67 Accessed 07/01/2010

Filaria

- Wucheria bancrofti
- Lymphatic filariasis (elephantiasis).
- Culex, Anopheles, Mansoni, Aedes mosquitoes as vectors.
- Tropical and sub-tropical climates.
- Surface glycoproteins have antioxidant function
- Cystatin homologues impair MHC class II antigen processing pathway
- TGF-β homologues downregulate inflammatory response
- Serine protease inhibitors block inflammation

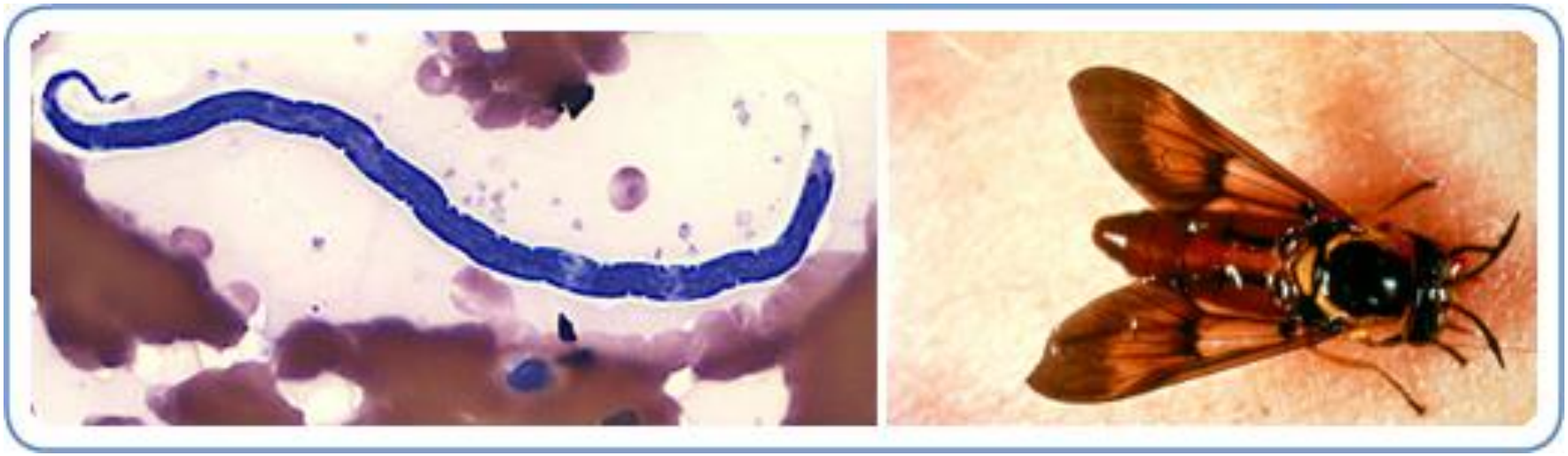
Lymphatic filiariasis

Elephantiasis associated with Wucheria bancroftii infection.

Fig. 211-2
Accessed 07/01/2010

Filaria

- Loa loa
- Repeated bites of deerflies (also known as mango flies or mangrove flies)
- Repeated episodes of itchy swellings of the body ("Calabar swellings").
- Subconjunctival migration of adult worm.
- Rain forest and swamp forest of West Africa.
- Often co-infection with Onchocerca volvulus.
- Brugia malayi
- Pulmonary tropical eosinophilia syndrome.
- South and Southeast Asia.



L: Microfilaria of L. loa in a thin blood smear, stained with Giemsa.
R: Picture of Chrysops silacea feeding on a volunteer.
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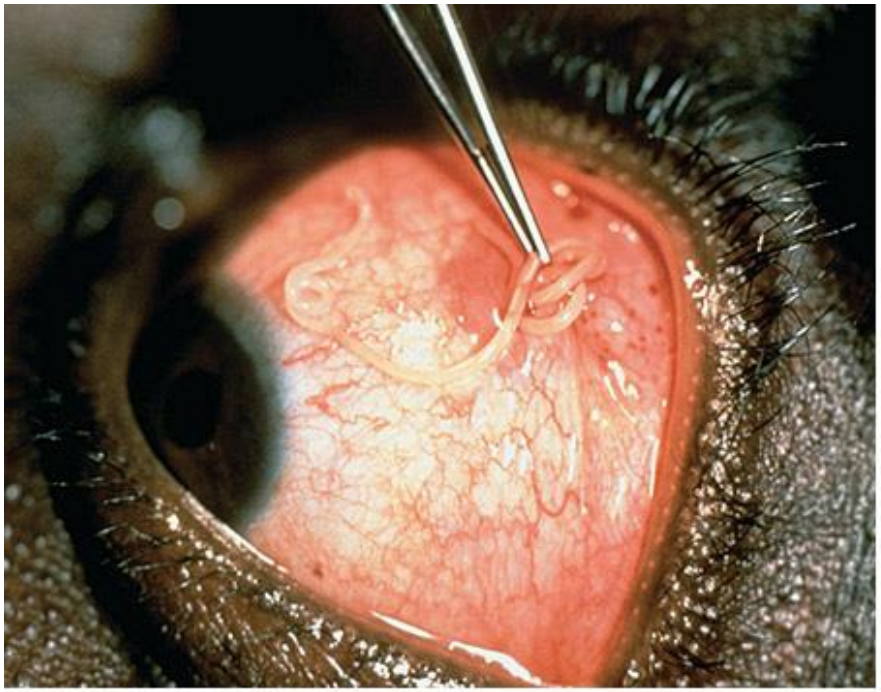
Loa Loa

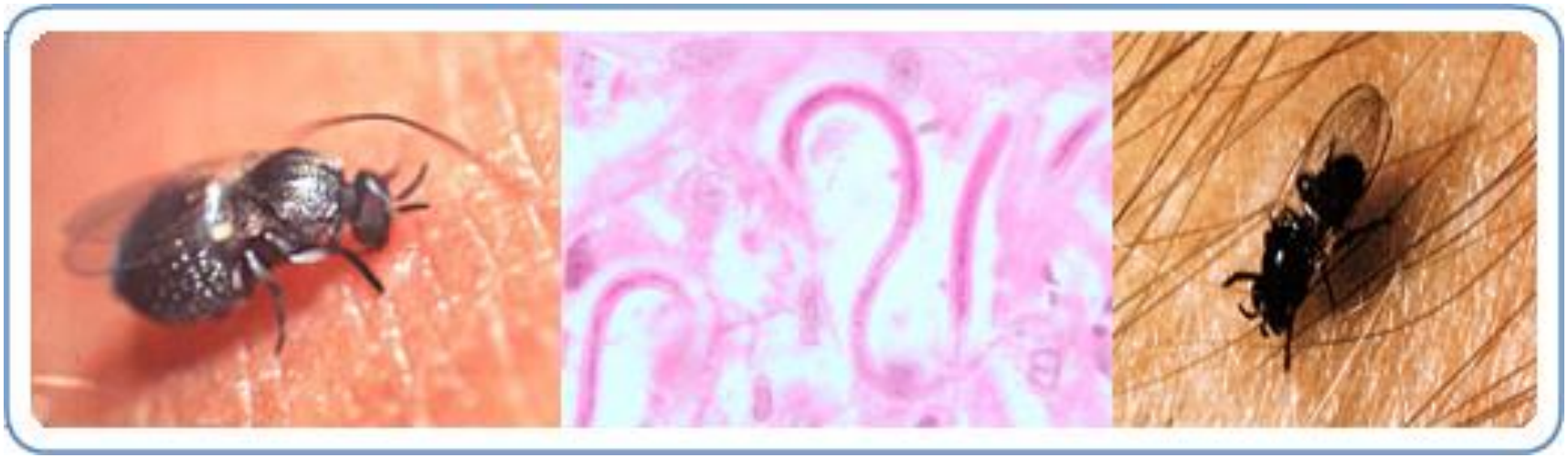
Adult Loa loa being surgically removed after its subconjunctival migration.

Fig. 211-4
Accessed 07/01/2010



Dracunculus medinensis

- Copepods ("water fleas") swallow Guinea worm larvae
- Copepods die and release the larvae, which penetrate the host stomach and intestinal wall and move to the connective tissues of the abdomen where they mate.
- During the next 10–14 months, the male worm dies and the pregnant female worm grows
- The worm moves to a spot just beneath the skin prior to releasing larvae.
- A blister then forms on the skin where the worm will eventually emerge.
- Secondary bacterial infection follows



Left/Right: Blackflies, the vector of onchocerciasis. Center: Microfilariae of O. volvulus from a skin nodule of a patient from Zambia, stained with H&E. Image taken at 1000x oil magnification

Cdc.gov

Onchocerciasis

- Onchocerca volvulus
- River blindness
- Repeated bites of black fly (daytime)
- Nodules form around the worms as part of the interaction between the parasite and its human host. Inside the nodules the worms are relatively safe from the human immune response.
- As adults, female worms produce thousands of new larvae daily.
- The larvae become detectable in the skin 12–18 months after the initial infection.
- May live 10-15 years

Onchocerciasis

- Persons with heavy infections will usually have one or more of three conditions:
- (1) Skin rash (usually itchy)
- Skin inflammation can result in long-term damage to the skin.
- Cause changes in the color of the skin (“leopard skin)”
- Cause thinning of the skin with loss of elasticity (“cigarette-paper” appearance)
- Can contribute to conditions such as “hanging groin.”

Onchocerciasis

- (2) Nodules under the skin.
- (3) Eye signs
- The inflammation caused by larvae that die in the eye results initially in reversible lesions on the cornea that without treatment progress to permanent clouding of the cornea, resulting in blindness.
- There can also be inflammation of the optic nerve resulting in vision loss, particularly peripheral vision, and eventually blindness.

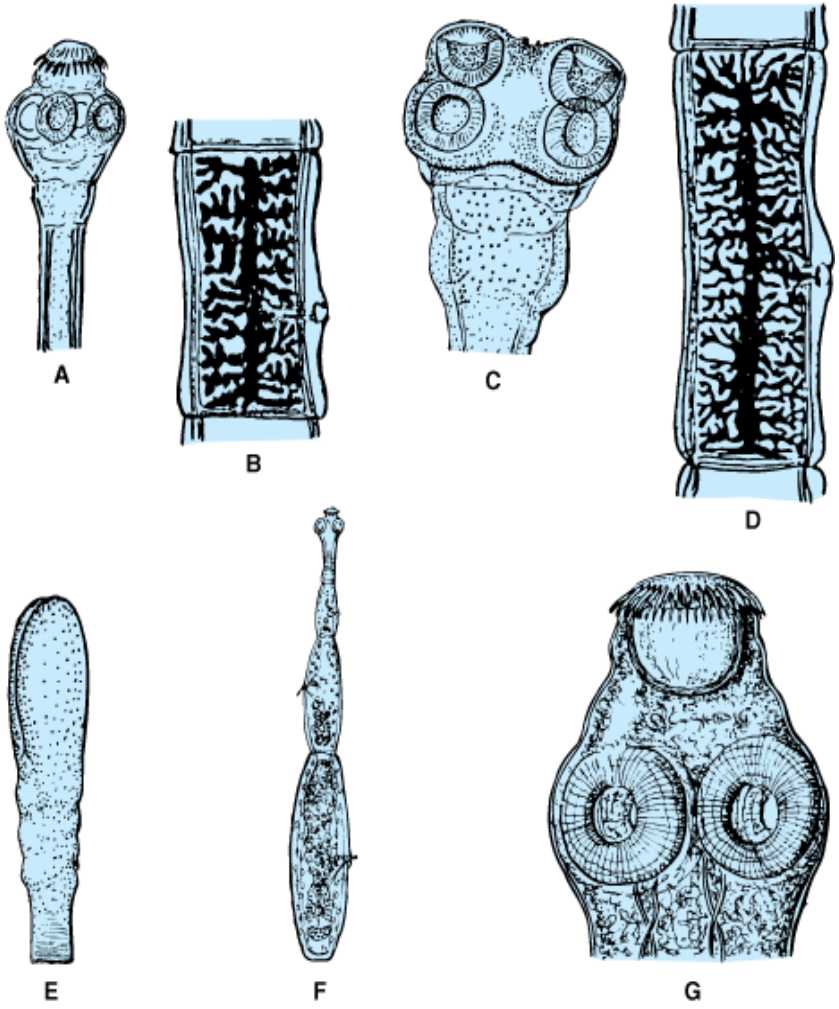
Cestodes

Cestode	Mode of Transmission	Host	Infected Site
Taenia solium	Larvae Eggs	Pigs	Proglottids in stool Biopsy
Taenia saginata	Larvae	Cattle	Proglottids in stool
Diphyllobothrium latum	Eggs	Fish or copepods	Operculated eggs in stool
Echinococcus granulosa	Eggs	Sheep	Biopsy

Little eosinophilia noted as do not invade mucosa. Single worm infection.

Cestodes (tapeworms)

- Tenia solium: A. with scolex and hooks; B. with gravid proglottid.
- Tenia saginata: C. with scolex and hooks; D. with gravid proglottid (and more uterine branches than T. solium).
- E. Diphyllobothrium latum with scolex and sucking grooves
- F. Echinoccus granulosus, entire worm; G: adult scolex



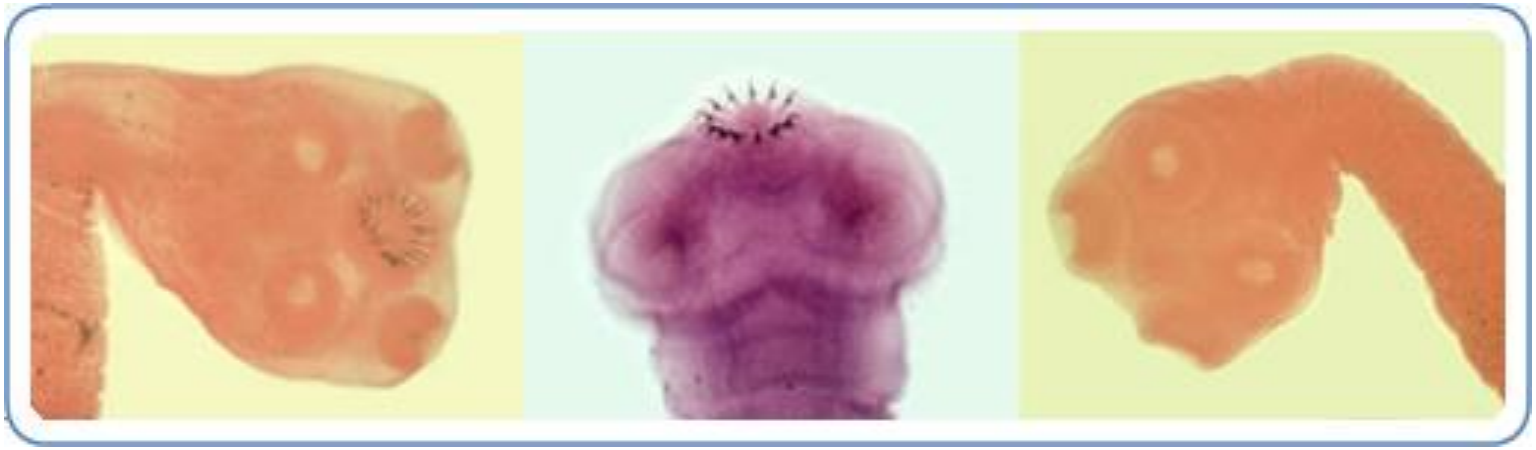
Source: Levinson W: *Review of Medical Microbiology and Immunology*, 10th Edition: http://www.accessmedicine.com

Fig. 54-1 Accessed 07/01/2010

Cestodes

- A. Tenia solium egg containing oncosphere embryo. Four hooklets are visible. Tenia saginata and Echinococcus granulosa eggs are similar to Tenia solium but do not have hooklets. B. Diphyllobothrium latum operculated egg.

Fig. 54-2 Accessed 07/01/2010



Tenia solium

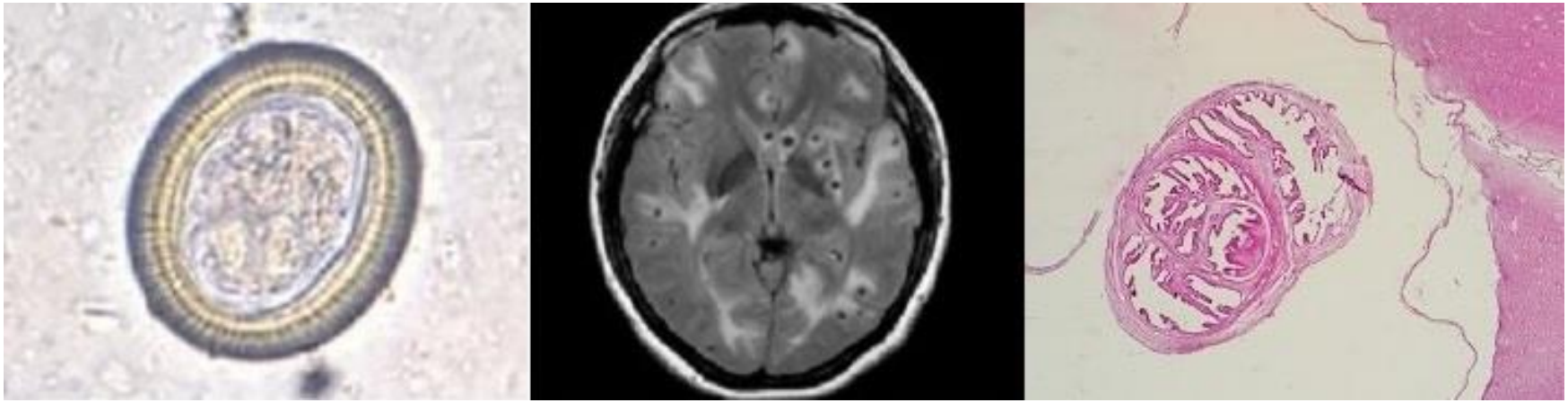
Scolex and several proglottids. Long arrow points to one of the four suckers on the scolex of *Taenia solium*. Short arrow points to the circle of hooklets. Proglottids can be seen extending from the scolex toward the left side of the image.

Provider: CDC/Dr. M. Melvin.

Color plate 54 Accessed 07/01/2010

Taeniasis

- Taenia saginata (beef tapeworm), Taenia solium (pork tapeworm), and Taenia asiatica (Asian tapeworm).
- Mild symptoms.
- Abdominal pain, loss of appetite, weight loss, and upset stomach.
- Patients with T. saginata taeniasis often experience more symptoms that those with the other infections as the T saginata tapeworm is much larger in size (up to 10 meters in length)
- T. solium produces cysticercosis
- Larval cysts encyst in muscles and brain



Left: *Taenia* egg at a high magnification of 400x. When consumed by humans, *Taenia solium* eggs can lead to cysticercosis, including a serious condition known as neurocysticercosis. Center: A radiographic image of the brain of a patient who has neurocysticercosis; the small dark spots within the brain are larval cysts of *T. solium*. Right: A cross-section through a *T. solium* cyst from a human brain tissue specimen, stained with hematoxylin and eosin (H&E).

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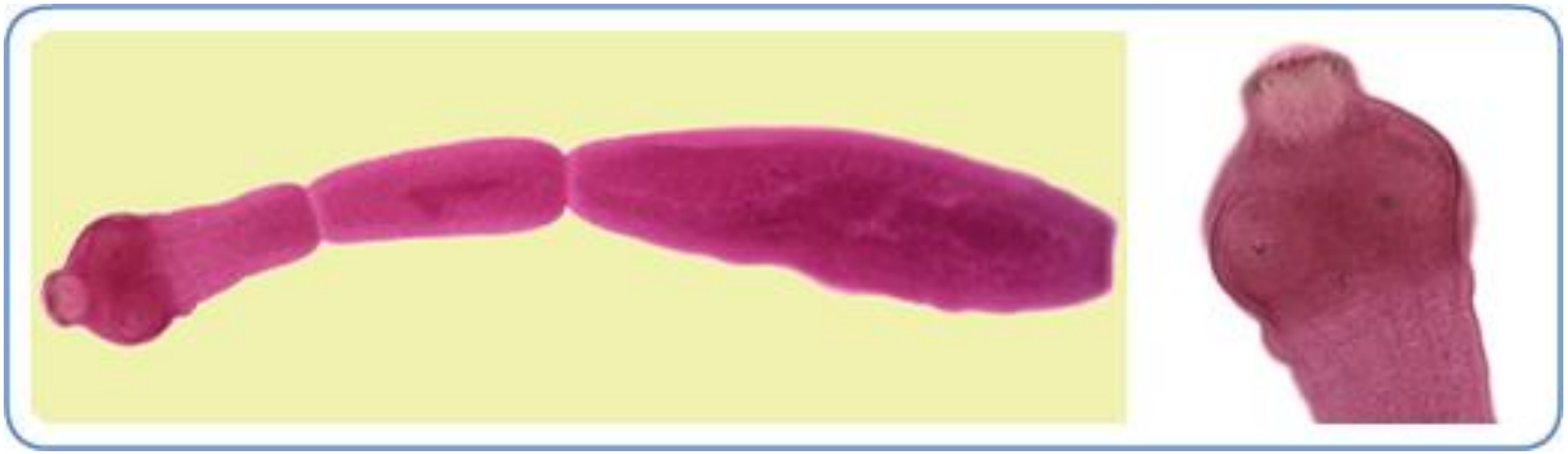


L to R: Echinococcus granulosus adult, stained with carmine. Close-up of the scolex of E. granulosus. In this focal plane, one of the suckers is clearly visible, as is the ring of rostellar hooks.
Cdc.gov

Echinococcus

- Cystic echinocccosis (CE)
- Hydatid disease
- Tapeworm found in dogs (definitive host) and sheep, cattle, goats, and pigs (intermediate hosts).
- Often asymptomatic
- Causes harmful, slowly enlarging cysts in the liver, lungs, and other organs that often grow unnoticed and neglected for years.

Echinococcus

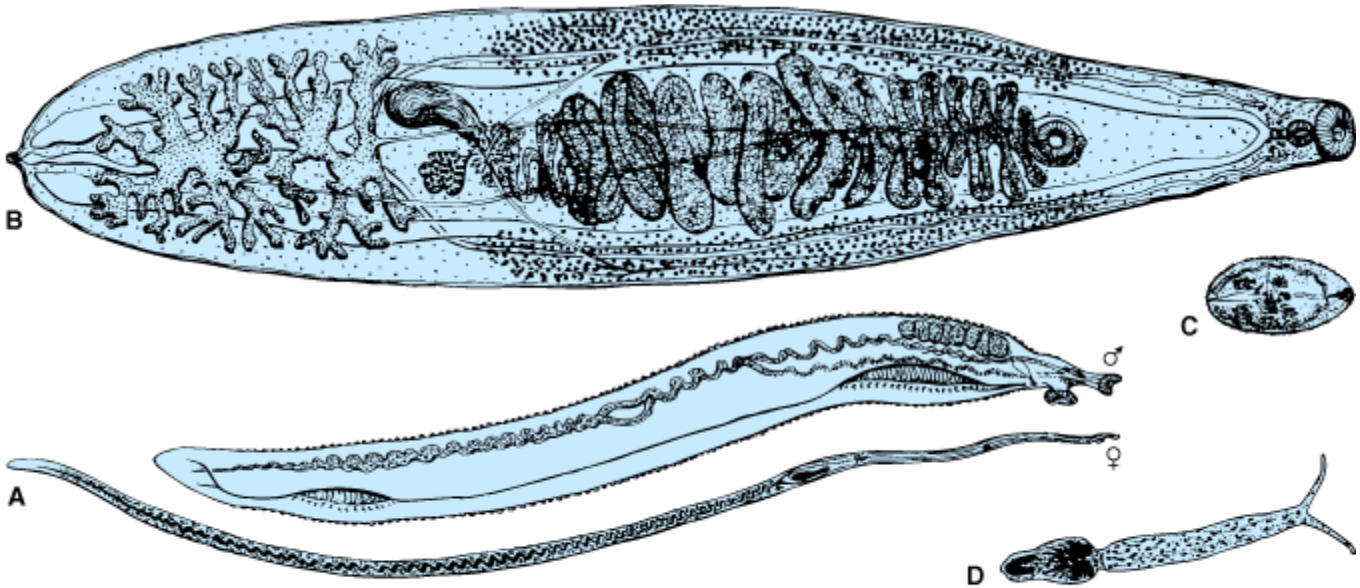
- Alveolar echinococcosis (AE) disease
- Infection with the larval stage of Echinococcus multilocularis
- Tapeworm found in foxes, coyotes, and dogs (definitive hosts).
- Small rodents are intermediate hosts for E. multilocularis.
- May cause parasitic tumors that can form in the liver, lungs, brain, and other organs. If left untreated, AE can be fatal.

Trematodes

Trematode	Transmission (Ingestion)	Site Affected	Host	Egg Features
Schistosoma mansonii	Cercaraie penetrate skin	Veins of colon	Snail	Large lateral spine
Schistosoma japonicum	Cercaraie penetrate skin	Veins of small intestine, liver	Snail	Large terminal spine
Schistosoma hematobium Fasciola spp.	Cercaraie penetrate skin Ingest aquatic plants	Veins of bladder	Snail	Small lateral spine Operculated
Clonorchis sinensis	raw fish	Liver	Snail and fish	Operculated
Paragominus westermanii	raw crab	Lung	Snail and crab	operculated

Trematodes (flukes)

- A. Male and female Schistosoma mansonii adults. The female lives in the male schist (shown here as a ventral opening). B. Clonorchis sinensis adult C. Paragominus westermanii adult D. Schistosoma mansonii cercaria (Only Schistosoma that is not hermaphroditic)
- All are transmitted by freshwater snails



Source: Levinson W: *Review of Medical Microbiology and Immunology*, 10th Edition: http://www.accessmedicine.com

Fig. 55-1 Accessed 07/01/2010

Trematode eggs

- A. Schistosoma mansonii with lateral spine B. Schistosoma hematobium with terminal spine C. Clornchis sinensis operculated egg D. Paragominus westermanii with operculum

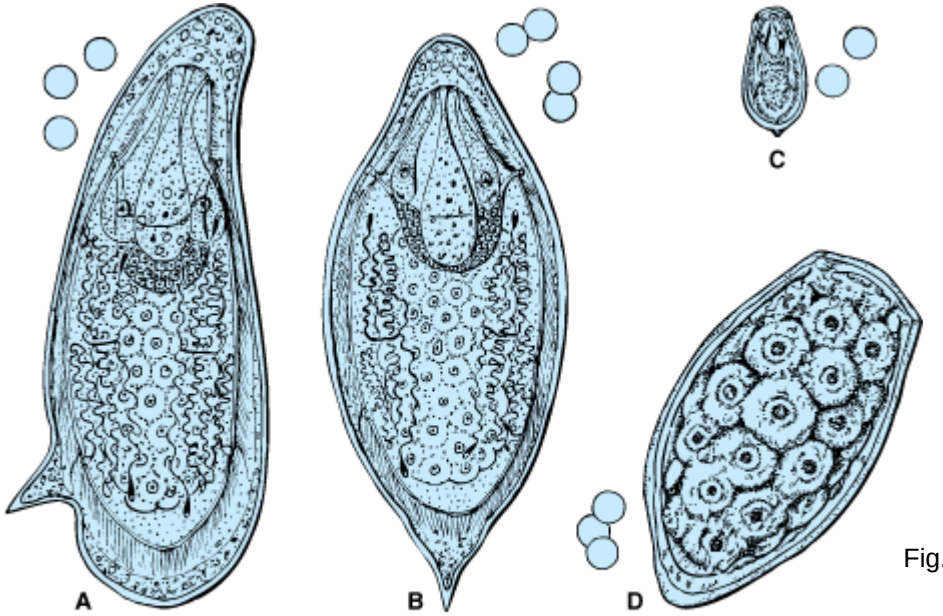


Fig. 55-2 Accessed 07/01/2010

Trematode eggs

- Egg. Long arrow points to an egg of Schistosoma mansoni. Short arrow points to its large lateral spine.

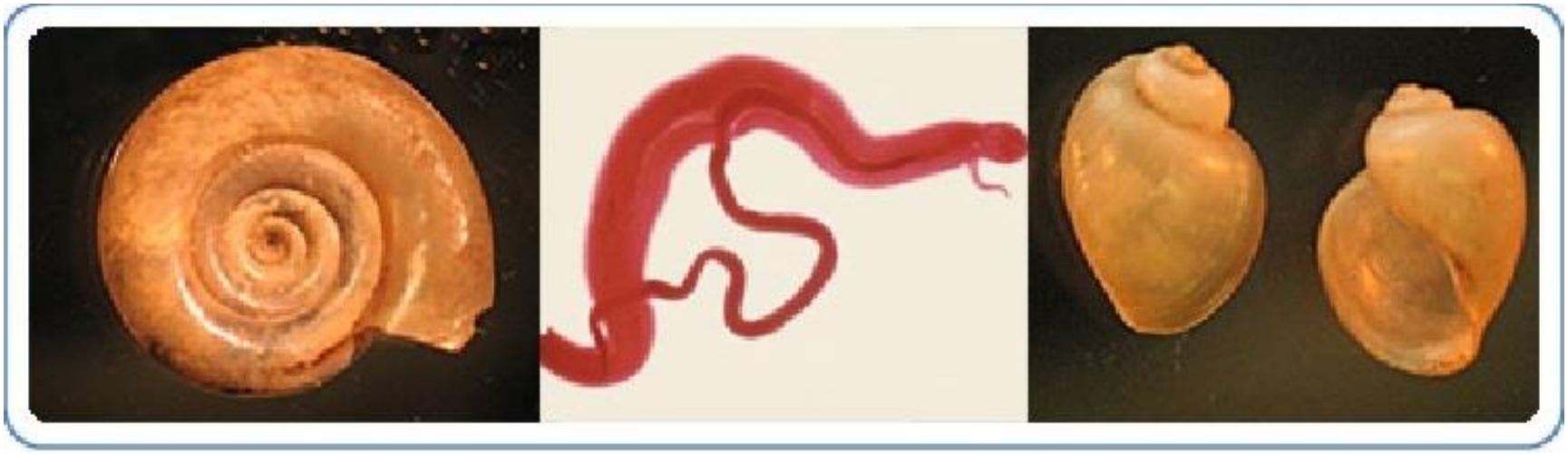
Source: Levinson W: *Review of Medical Microbiology and Immunology*, 10th Edition: http://www.accessmedicine.com

- Egg. Long arrow points to an egg of Schistosoma hematobium. Short arrow points to its terminal spine.

Source: Levinson W: *Review of Medical Microbiology and Immunology*, 10th Edition: http://www.accessmedicine.com

Provider: CDC.

Color plates 58 and 59 Accessed 07/01/2010



Left: Biomphalaria sp., the intermediate host for S. mansoni. Right: Bulinus sp., the intermediate host for S. haematobium and S. intercalatum. Center: Adults of S. mansoni. The thin female resides in the gynecophoral canal of the thicker male.

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Schistosomiasis

- Intermediate host is freshwater snail.
- Leaves the snail and enters the water where it can survive for about 48 hours.
- Penetrate the skin of persons who are wading, swimming, bathing, or washing in contaminated water.
- Most are asymptomatic.
- May have rash or itchy skin.

Schistosomiasis

- Fever, chills, cough, and muscle aches can begin within 1-2 months of infection as the parasites mature into adult worms and live in the blood vessels of the body where the females produce eggs.
- Some of the eggs travel to the bladder or intestine and are passed into the urine or stool.