

Introduction to Parasitology

The basics are just the beginning

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Objectives for Learning

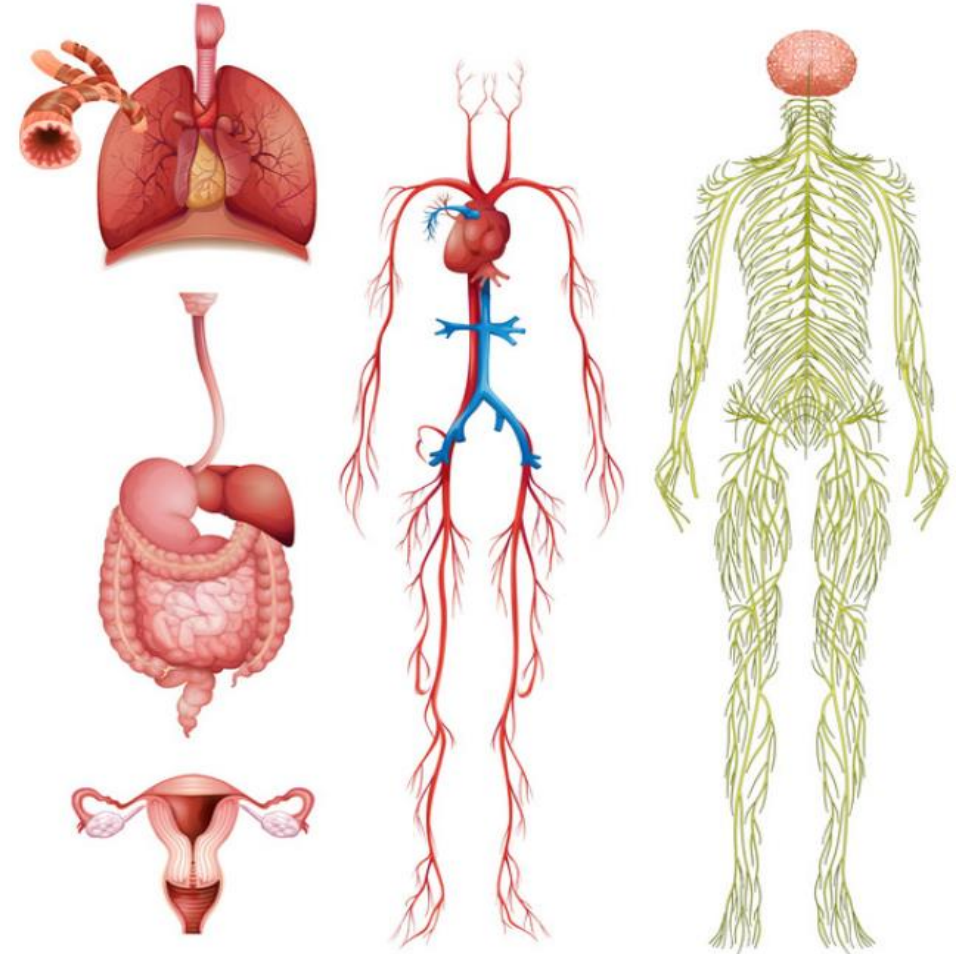
Understand parasite diversity/taxonomy


Recognize clinically relevant parasites found in humans and how to test for them

Understand the impact and role of parasites in human health

Parasitology Structure

- Basic overview of all sites
- Focus on:
 - » Brain/Central nervous system
 - » Skin/Soft tissue
 - » Lungs
 - » Liver
 - » GU
 - » Blood (See separate video)



A blurred background image of a laboratory setting, showing various pieces of equipment and glassware.

■ What is a parasite?

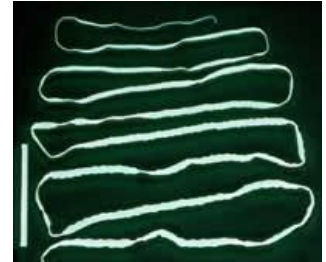
An organism that derives a survival benefit from a host at the expense of the host.

Key Concepts in Parasitism

- **Definitive Host** – where sexual maturity and reproduction occur for completion of transmission cycles
- **Intermediate Host** – where asexual or developmental stages occur (e.g. larvae development, excystation, etc). Not competent for development to final lifecycle stages
- **Paratenic Host** – a host which harbors an immature stage but no further development of the parasite occurs; used for further transmission
- **Reservoir Host** – a primary host that maintains a parasite in nature
- **Dead-end or Accidental Host** – where various levels of parasite life cycle can occur, but the parasite cannot complete the entire life cycle and fails to perpetuate gametes/fully mature.

Broad (Medical) Classification of Parasites

- Helminth – worm
 - » Flatworms – Platyhelminths (only 2 parasitic classes)
 - Cestoda – tapeworms
 - Trematoda – flukes
 - » Roundworms – Nematoda



Taenia



Paragonimus

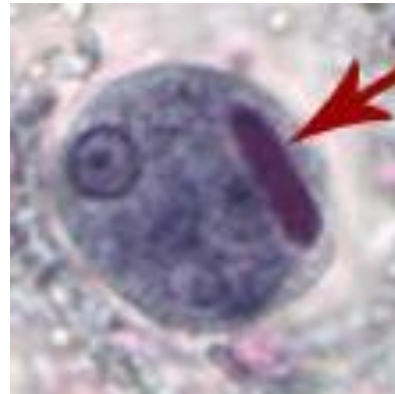


Ascaris

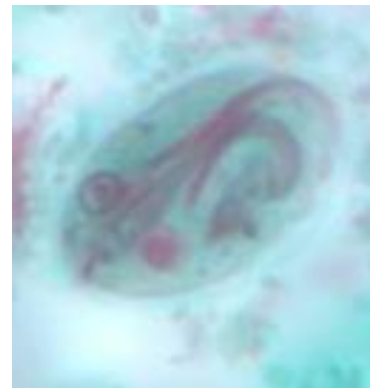
Broad (Medical) Classification of Parasites

- **Protozoa** – unicellular eukaryotic free-living or parasitic organisms

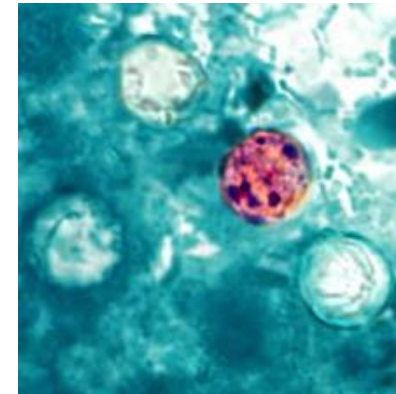
- » Ameba
- » Coccidia
- » Flagellates
- » Ciliates
- » Stramenopiles
- » Microsporidia*



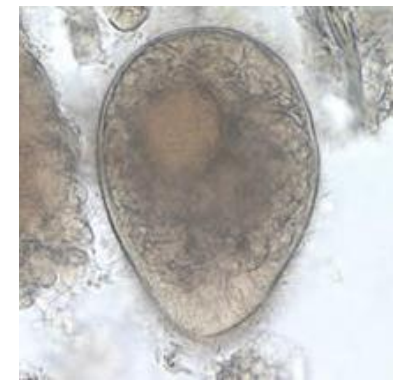
Entamoeba



Giardia



Cyclospora

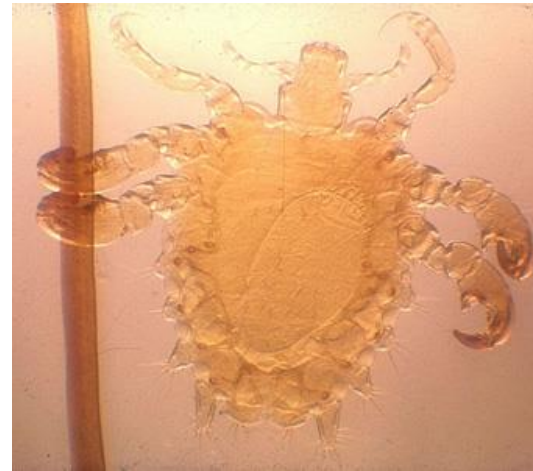


Balantioides

* Fungi, not protozoa

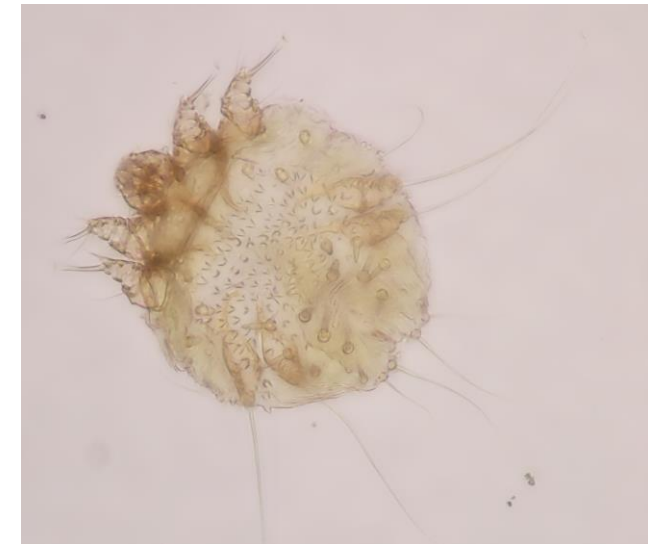
Broad (Medical) Classification of Parasites

- **Arthropods** –eukaryotic free-living or parasitic organisms
 - » Mites
 - » Lice
 - » Fleas
 - » Ticks
 - » Fly larvae (myiasis)
 - » True bugs



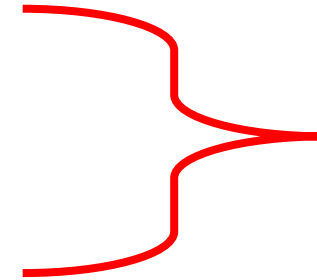
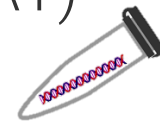
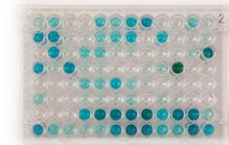
Pubic louse

Scabies mites



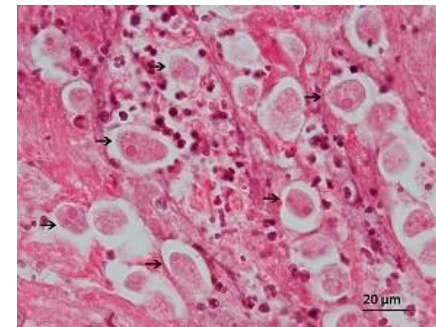
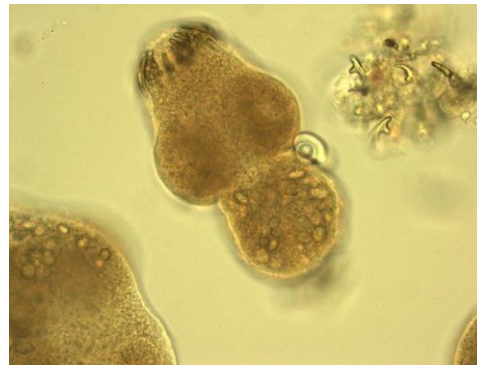
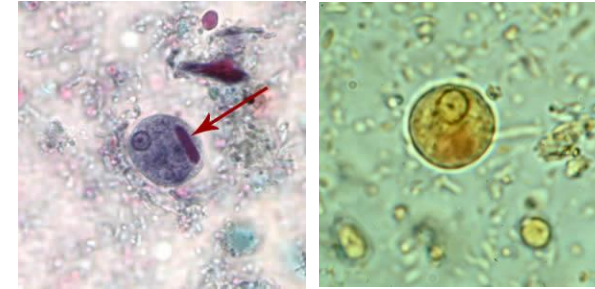
Diagnostics

- Specimen dependent/organism dependent
 - » Each organism discussed in more detail within body systems
- Broad types of tests include:
 - » Stool parasite examinations
 - » Body fluid parasite examinations and cytology
 - » Histopathology of tissue
 - » Antigen detection
 - » Antibody detection (serology)
 - » Nucleic acid amplification tests (NAAT)
 - » Culture (very limited use)



Diagnostics - Microscopy

- Stool examination
 - » Wet mount and permanent stain (trichrome)
 - » Other special stains
- Body fluid examination
 - » Aspirates
- Tissue
 - » H&E stains

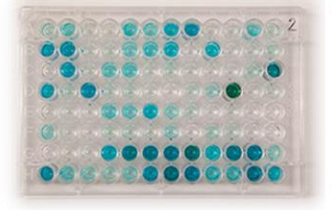


Diagnostics – Antigen detection



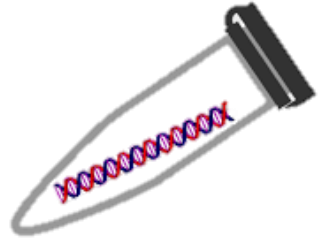
- Detection of antigen (immuno-stimulatory component) from a parasite in a patient specimen
- Variable in performance and specimen types
 - » Blood & stool
- Rapid time to result

Diagnostics – Antibody detection



- Detection of antibody from a patient that recognizes antigen(s) from a parasite
- Variable in performance and specimen types
 - » Serum and CSF
- Moderate time to result, limited availability

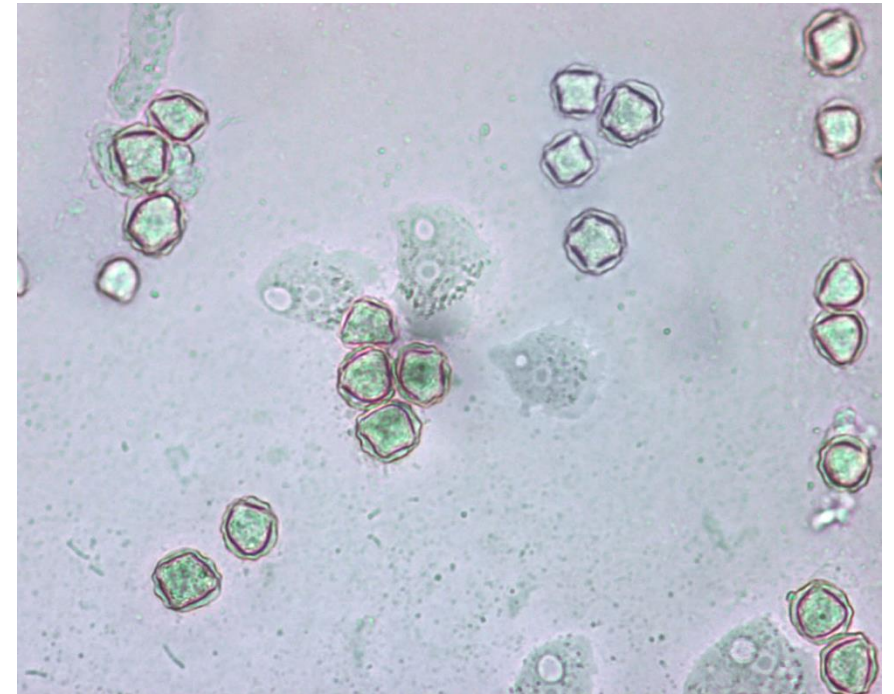
Diagnostics – NAAT



- Detection of nucleic acid from a parasite in a patient specimen
- Variable in specimen types, excellent specificity
 - » Sensitivity depends on organism and biology
- Long time to result for rare parasites, limited availability
 - » Stool parasites can be faster and readily available

Diagnostics – Culture

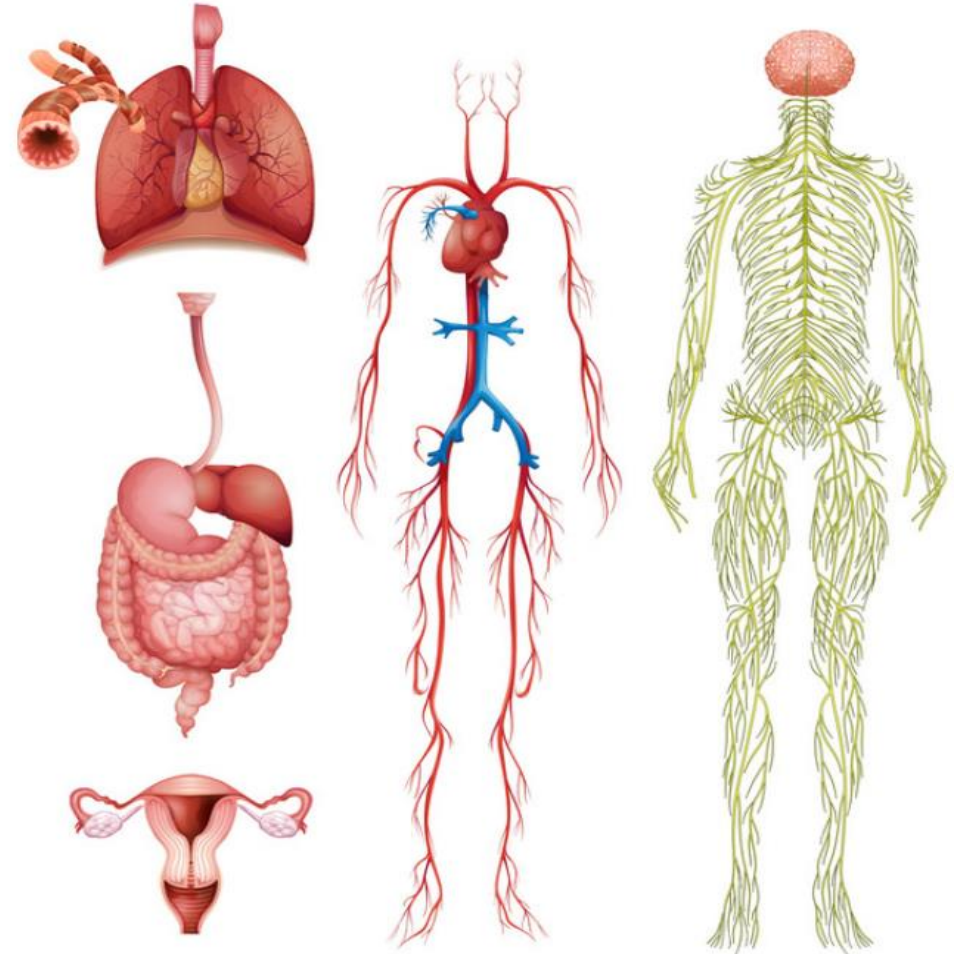
- Limited utility in parasitology
- Insensitive
- Not routinely performed in most labs
- Can be biosafety risk



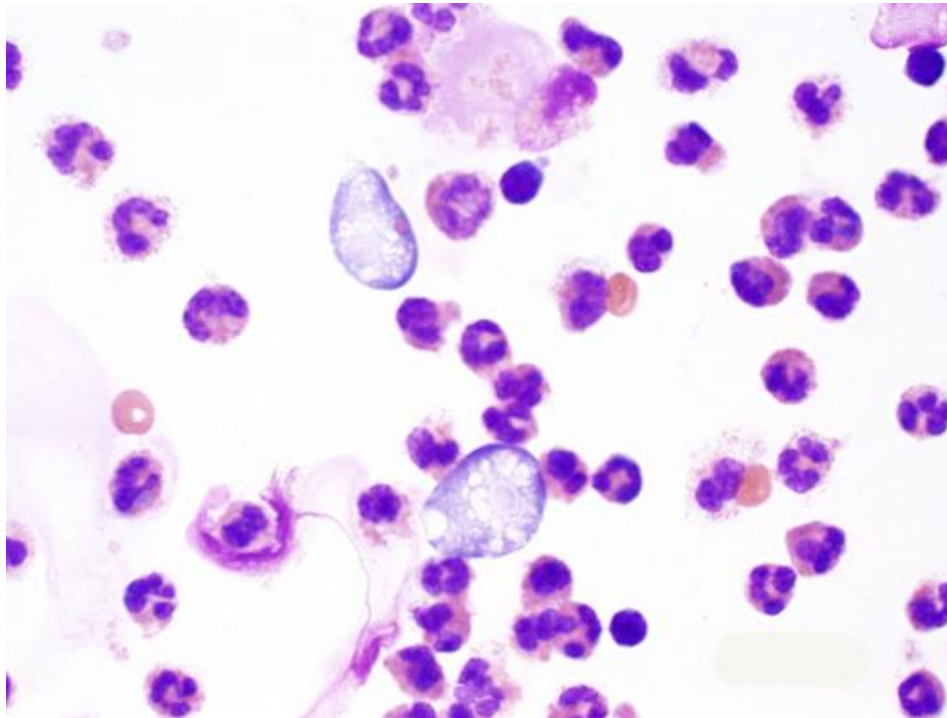
Acanthamoeba in culture

Organ Systems

- Brain/Central nervous system
- Skin/Soft tissue
- Lungs
- Liver
- GU



Parasites of the Brain/Central Nervous System

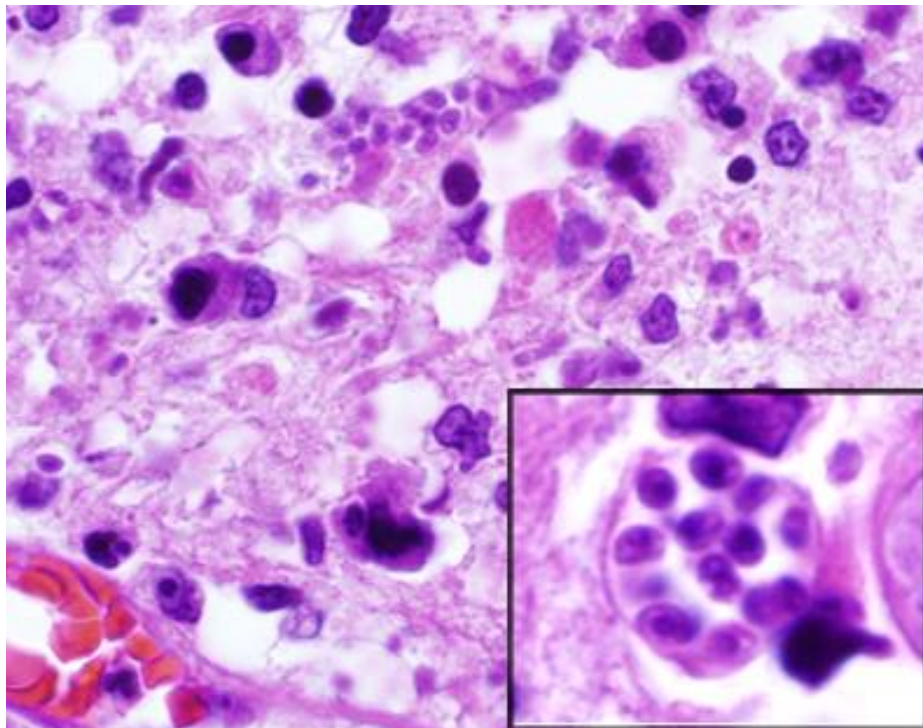


Toxoplasmosis (*Toxoplasma gondii*)

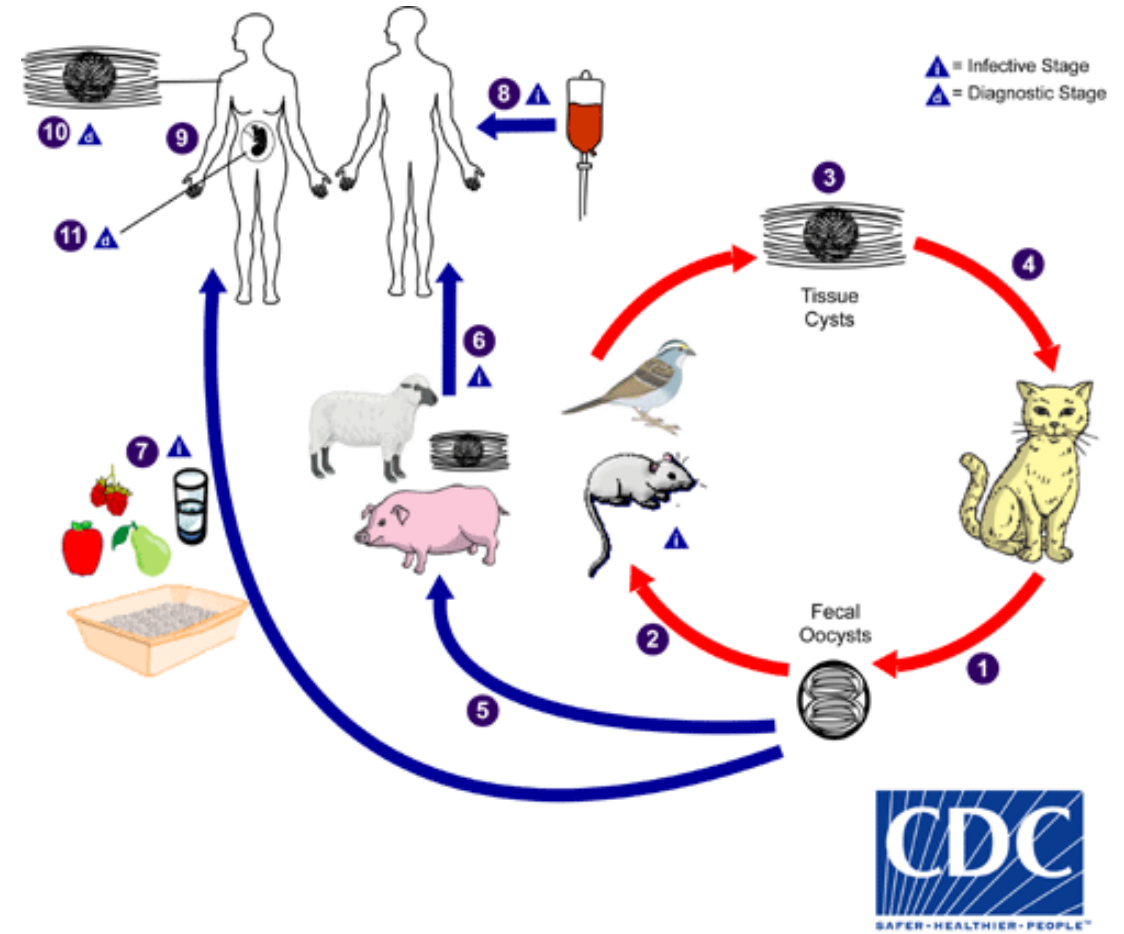
- Caused by apicomplexan parasite, *Toxoplasma gondii*
- Transmission occurs via:
 - » Eating undercooked meat of animals harboring tissue cysts
 - » Food, water, fomites contaminated with cat feces containing infectious oocysts
 - Contaminated soil or **changing cat litter box**
 - » Blood transfusion
 - » Organ transplantation
 - » Transplacentally from mother to fetus.

Toxoplasmosis (*Toxoplasma gondii*)

- Cats are definitive hosts
- Humans are dead-end hosts



Tachyzoites in brain tissue



Toxoplasmosis (*Toxoplasma gondii*)

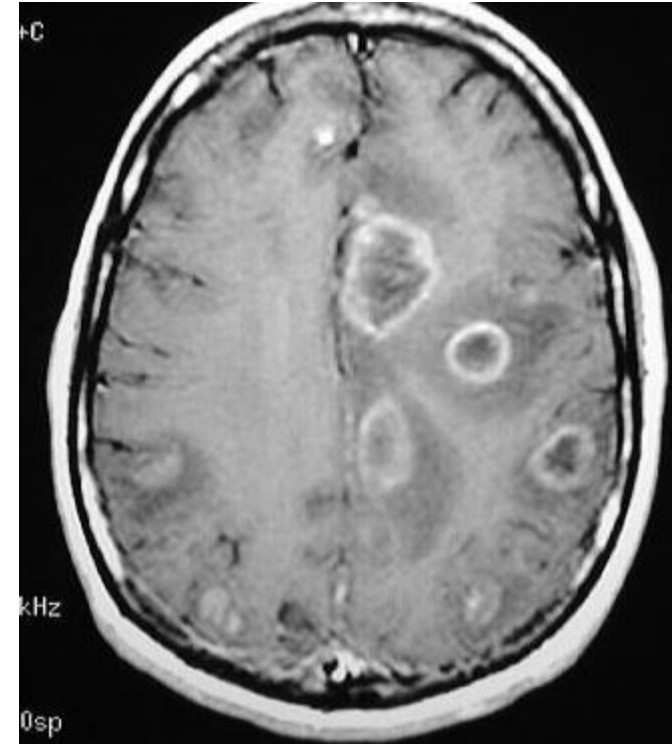
- Common sites of human infection are skeletal muscle, myocardium, brain, eyes.
- Symptoms
 - » Acute disease often asymptomatic; cervical lymphadenopathy and flu-like illness
 - » Immunodeficient patients will have localized symptoms based on body site
 - » Ocular disease: vision loss
 - » AIDS patients: toxoplasmic encephalitis.



Peripheral
retinochoroiditis

Toxoplasmosis (*Toxoplasma gondii*)

- Diagnosis is primarily by serology (IFA, IgG/IgM EIA); PCR of aspirates; tissue cysts & tachyzoites may be observed in biopsy specimens & aspirates.
 - » Radiologic findings of: “ring enhancing lesions”
 - Not specific to toxoplasmosis, but supports serology
- Treatment: pyrimethamine, folinic acid (leucovorin), & sulfadiazine in immunocompromised patients & congenitally-infected newborns.



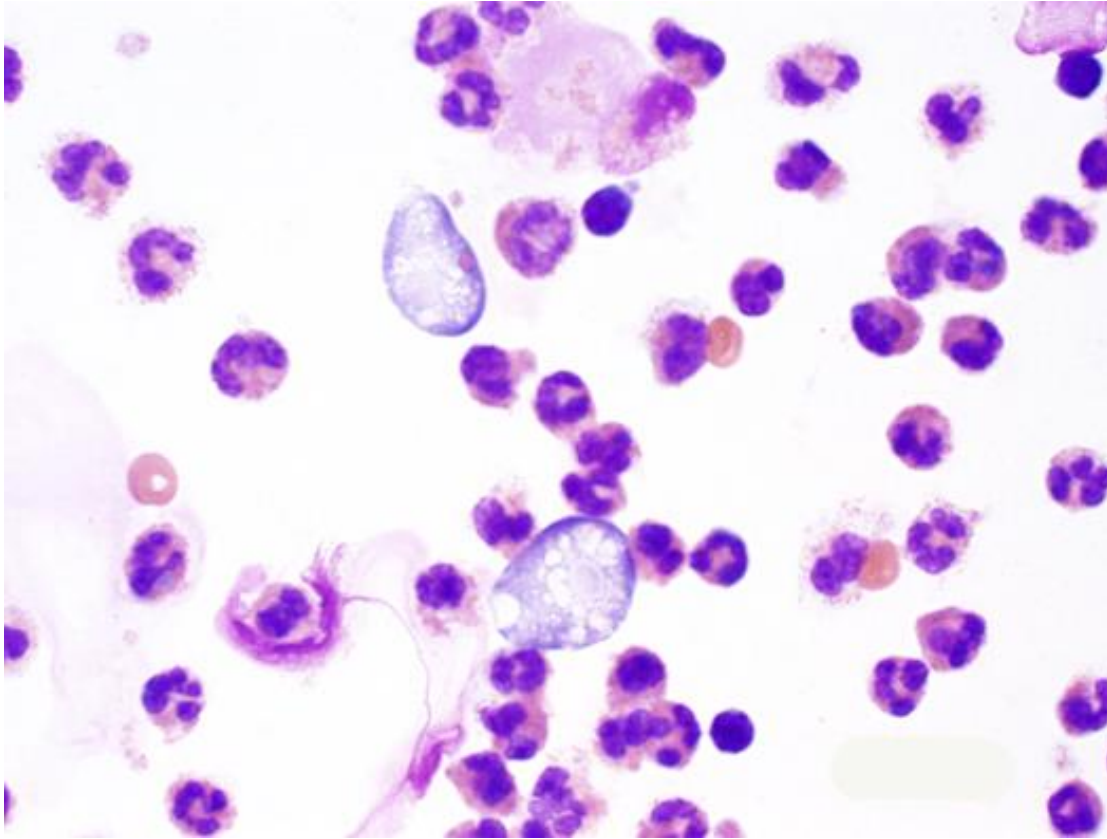
CT Scan showing ring enhancing lesions

Primary Amebic Meningoencephalitis (PAM)

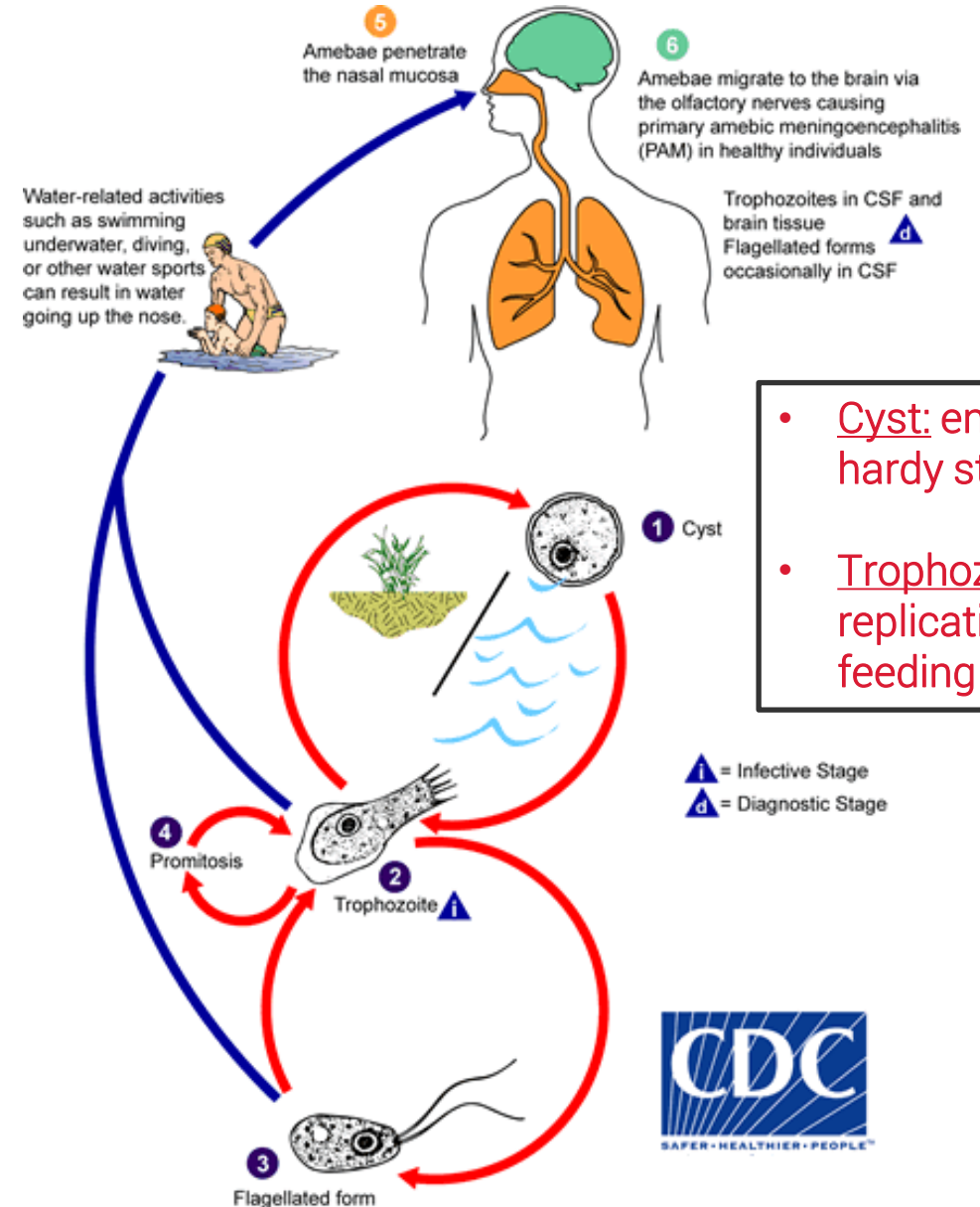
- Caused by the free-living ameba, *Naegleria fowleri*
- Not a “true parasite”: human infection is incidental & most cases fatal. Part of natural fauna of warm, fresh water.
- Route of infection is through the nasal mucosa
- Typically in children, teens, and young adults
- Symptoms
 - » Hemorrhagic-necrotizing meningoencephalitis
 - > severe CNS dysfunction
 - » Rapid onset
 - » High case-fatality rate



Life Cycle of *Naegleria fowleri*



Trophozoites in CSF



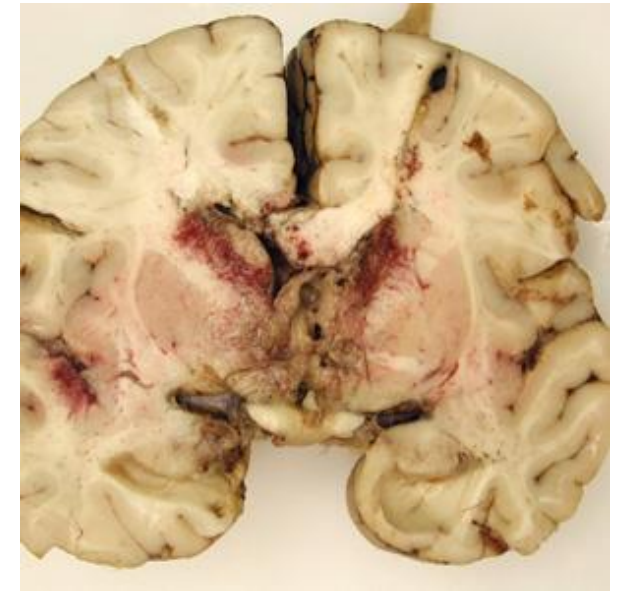
- Cyst: environmentally hardy stage
- Trophozoite: replication and feeding

Primary Amebic Meningoencephalitis (PAM)

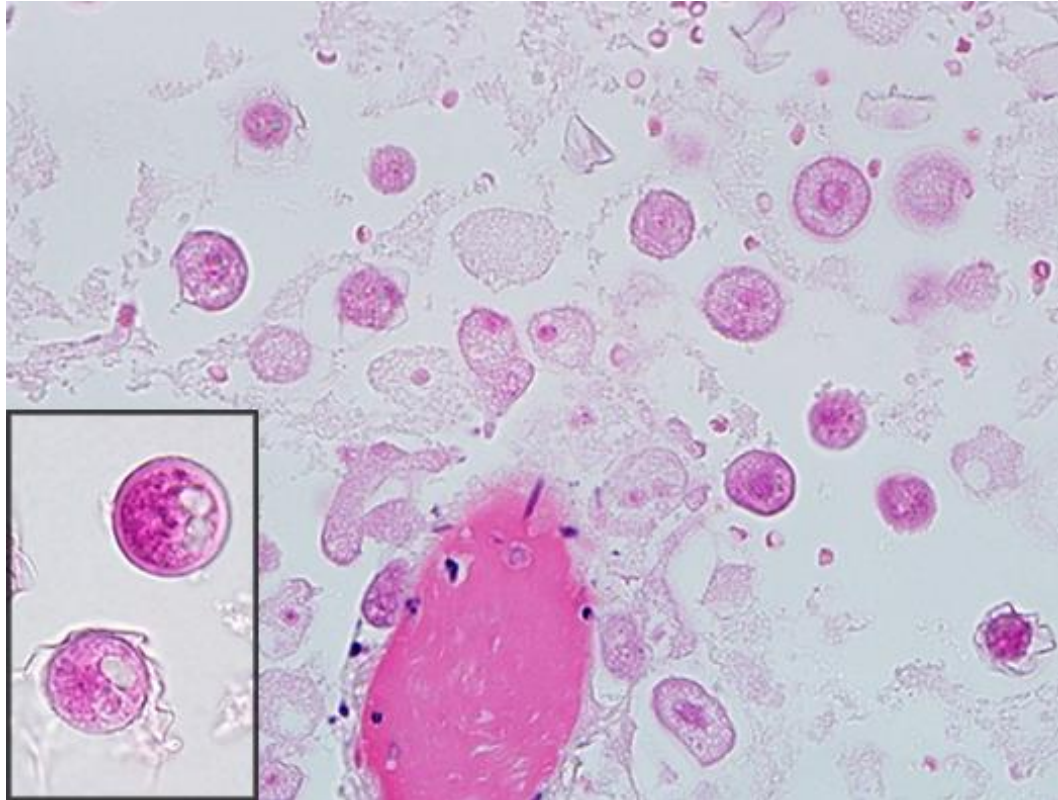
- Diagnosis usually made on autopsy by histopathology examination of brain tissue
 - » Observation of live trophozoites in fresh wet mount of CSF; confirm with Giemsa, trichrome
 - » PCR of CSF (CDC, large reference labs)
 - » Culture [delay issues]
- Treatment: Miltefosine + medically controlled hypothermia

Granulomatous Amebic Encephalitis (GAE)

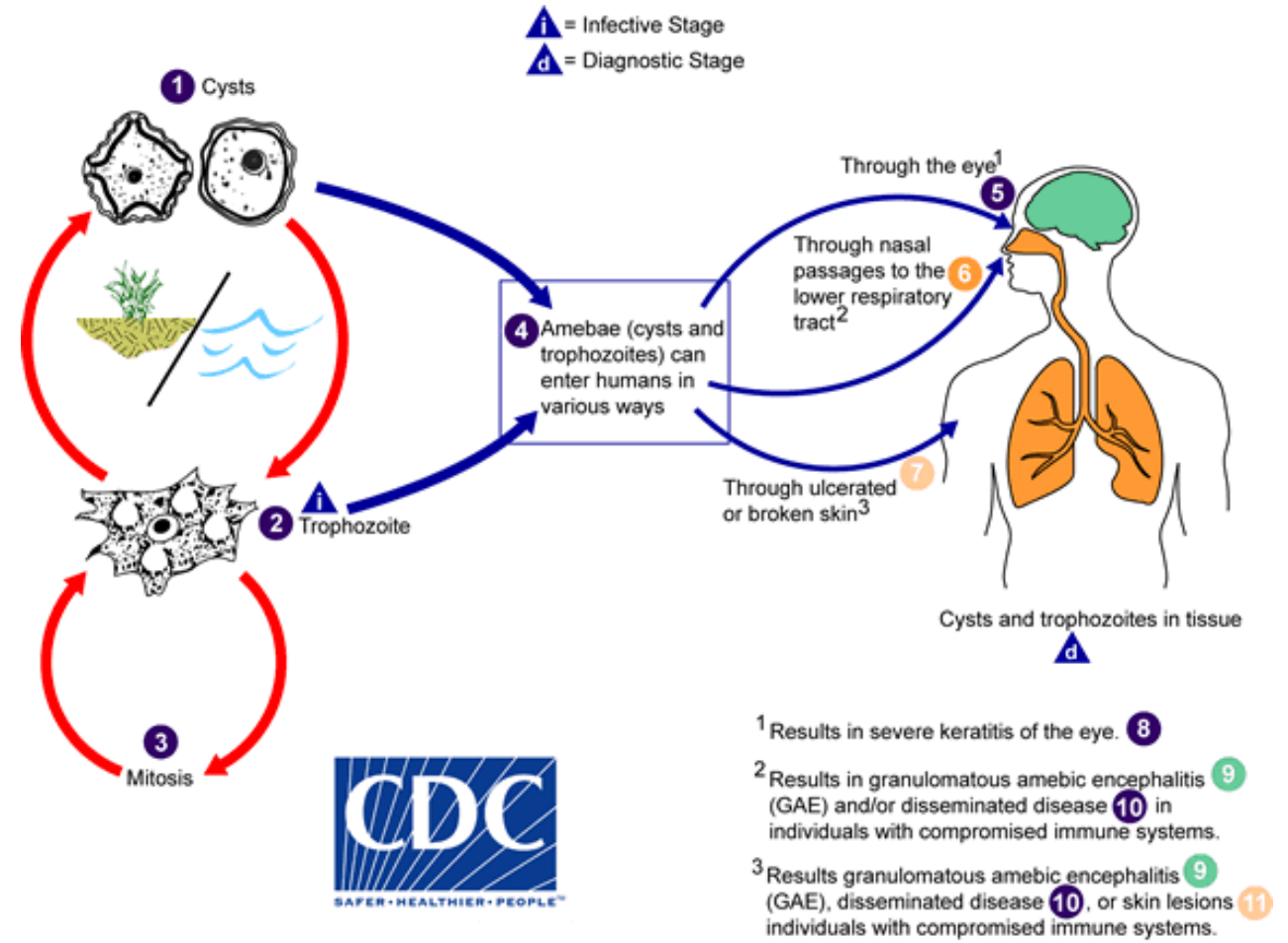
- Caused by free-living amebae *Balamuthia mandrillaris* & *Acanthamoeba* spp.
- Not 'true parasites'; part of normal soil and water fauna. Humans are accidental hosts.
- Route of infection: lower respiratory tract or ulcerated or broken skin.
 - » *Acanthamoeba* species can also enter the eye, causing amebic keratitis (AK)
- Symptoms
 - » Meningoencephalitis/encephalitis
 - » More chronic than PAM



Life Cycle of *Acanthamoeba/Balamuthia*



Balamuthia in brain tissue, H&E stain



Granulomatous Amebic Encephalitis (GAE)

- More commonly seen in immunocompromised patients
- Diagnosis usually made on autopsy by histopathology examination of brain tissue
 - » Giemsa and calcofluor white stain of specimens
 - » Culture
 - » PCR (CDC, large reference labs)
- Treatment: None. Most cases are fatal

Free-living Amebic Infections

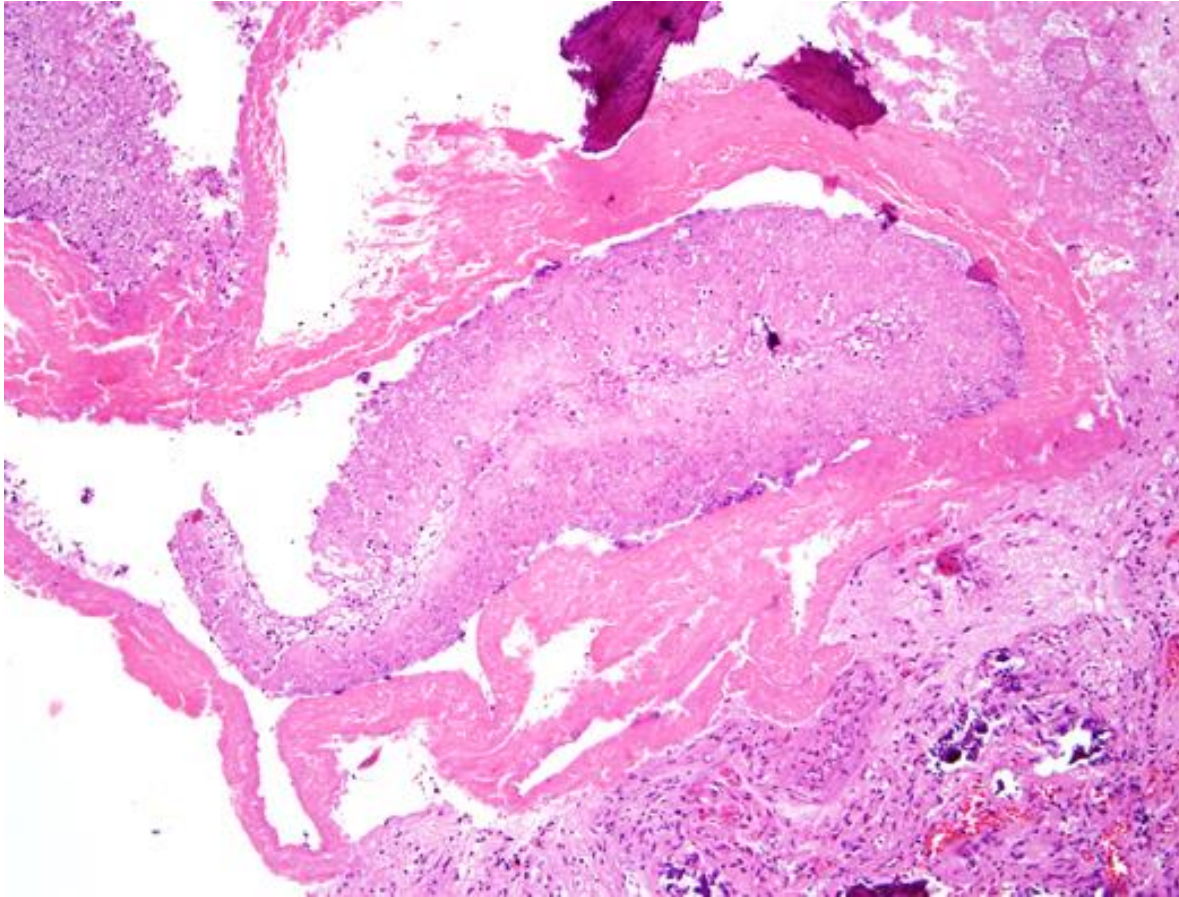
	Primary Amebic Meningoencephalitis	Granulomatous Amebic Encephalitis
Causal Agent(s)	<i>Naegleria fowleri</i>	<i>Acanthamoeba</i> spp., <i>Balamuthia mandrillaris</i>
Source of Infection	Inhalation when water forced into nasal cavity	Inhalation to lower respiratory tract; cuts and abrasions
Route to brain	Olfactory nerve	Hematogenous
Risk groups	Children, teens, young adults	Usually immunocompromised
Diagnosis	Wet mounts/Giemsa stain, PCR, histopathology, [culture]	Giemsa/Calcoflour white stains; PCR; histopathology; [culture]
Stage(s) in human tissue	Trophozoites only	Trophozoites, cysts
Treatment	Amphotericin B, Mitefosine + therapeutic hypothermia	Combos of pentamidine, sulfadiazine, flucytosine, AND fluconazole or itraconazole (<i>Acanthamoeba</i>) or azithromycin or clarithromycin (<i>Balamuthia</i>)

Neurocysticercosis

- Caused by the larval stage (cysticercus) of *Taenia solium* (the 'pork' tapeworm).
 - » Latin America, SE Asia
- Acquired: eating *T. solium* eggs in food, fomites contaminated with human stool.
- Clinical manifestations: vary by number, size, & state of cysticerci & inflammatory response to degenerating cysts.
 - » Epilepsy most-common manifestation, also intracranial hypertension, hydrocephalus, chronic meningitis, & cranial nerve abnormalities



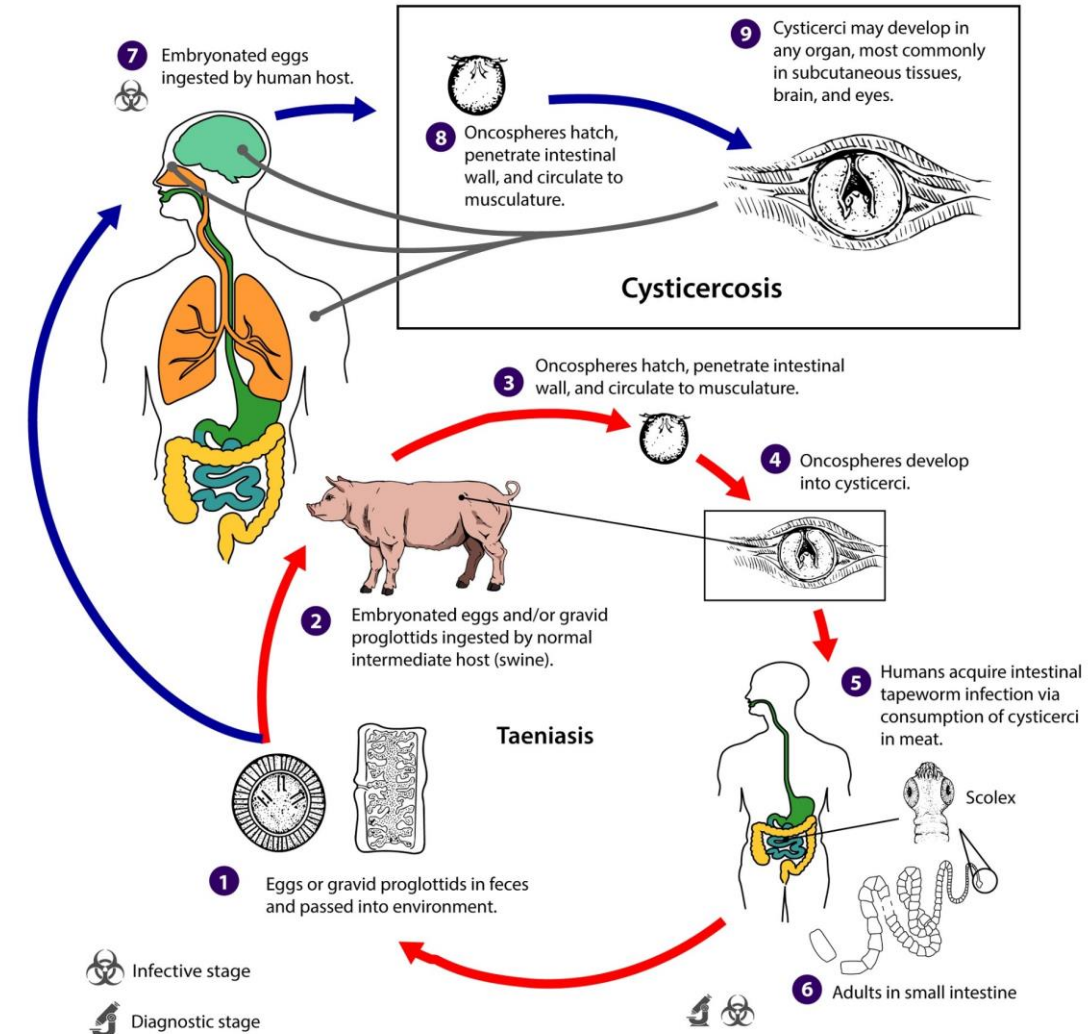
Life Cycle of *Taenia solium*



Degrading cysticercus in brain biopsy



Taenia solium

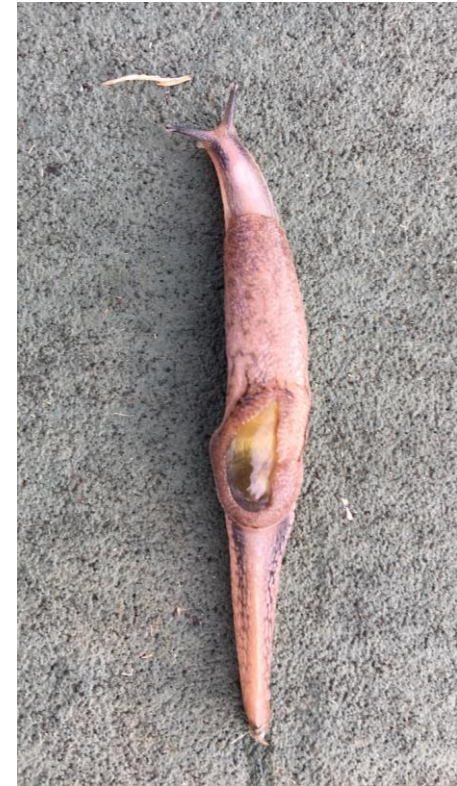


Neurocysticercosis

- Diagnosis primarily by **imaging**, confirmed w/ **antibody detection**
 - » EIA for initial screening
 - » CDC immunoblot recommended by WHO & PAHO for confirmation
- Larval worms may be seen in biopsy specimens, but undesirable to biopsy the brain
- Treatment: control of symptoms; antihelminthic therapy might increase symptoms!
 - » Corticosteroids usually co-administered to combat these effects.
 - » Albendazole may be better than praziquantel; combined albendazole/praziquantel with corticosteroids if >2 active parenchymal cysts

Angiostrongyliasis

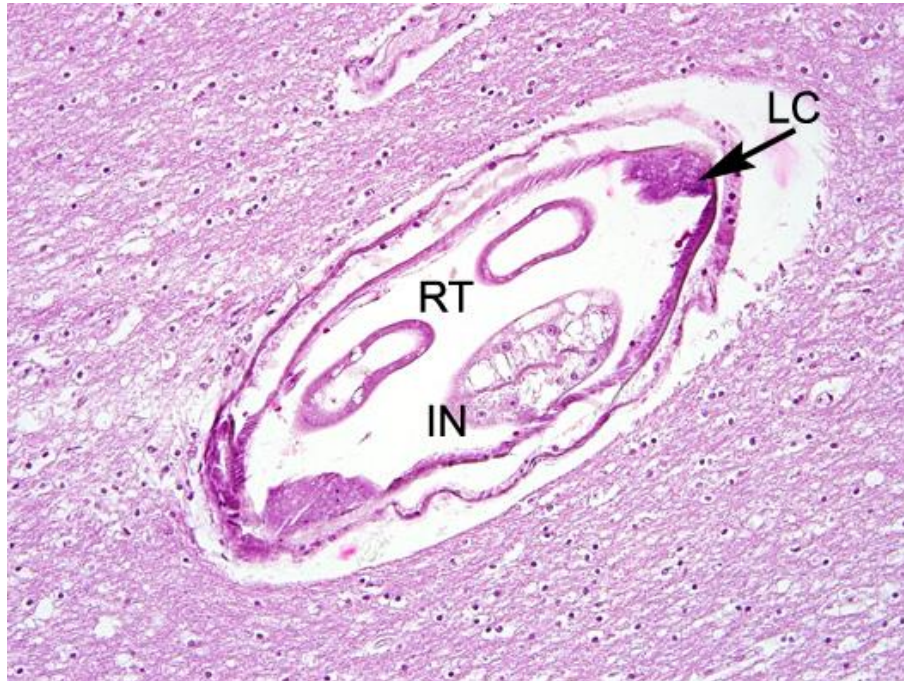
- Caused by the nematode, *Angiostrongylus cantonensis*.
 - » Human infection in Asia/South Pacific; Africa, Latin America, Caribbean, **Hawaii**
- Natural definitive hosts are rats; intermediate hosts are mollusks
- Human infection: **ingesting raw or undercooked snails and slugs** containing infectious (third stage, L3) larvae
- Clinical symptoms: bi-temporal headache, nausea, vomiting, stiff neck, & **eosinophilic pleocytosis of the CSF**
 - » Symptoms related to death of larvae in brain and directly proportional to parasite load



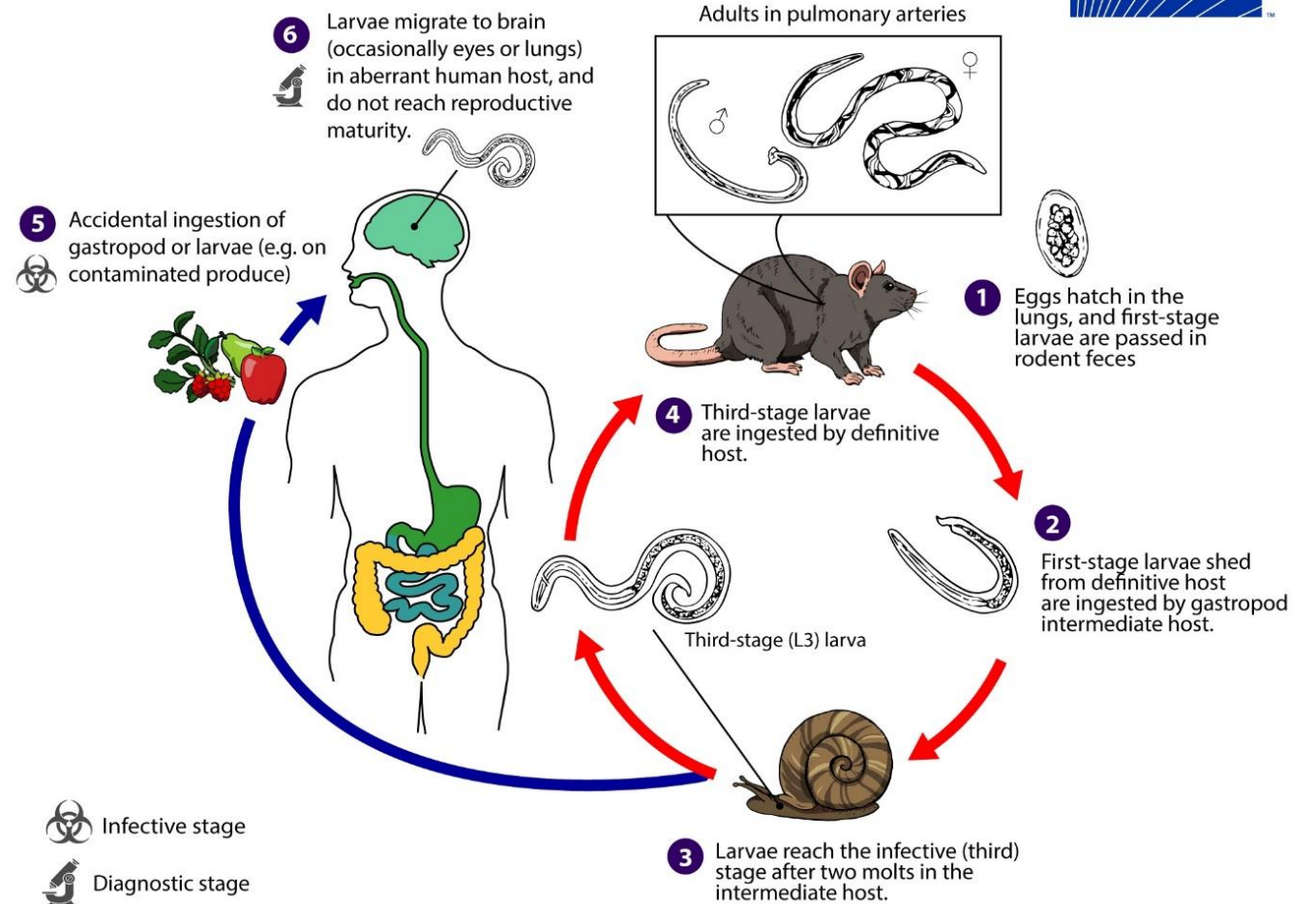
Life Cycle of *Angiostrongylus cantonensis*



Angiostrongylus cantonensis



L4/young adult in brain autopsy specimen



Angiostrongyliasis

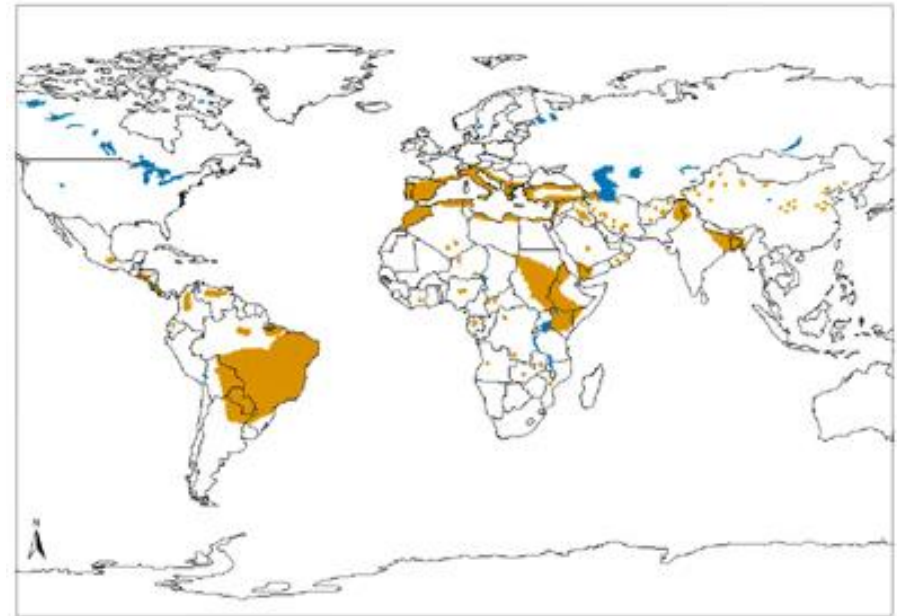
- Diagnosis:
 - » PCR (CDC, HI DOH)
 - » Observations of L4 larvae in CSF or brain biopsy/autopsy specimens
 - » Antibody detection not available in the US
- Treatment usually limited to analgesics for pain and corticosteroids for inflammation; removal of CSF to relieve headache and pressure

Parasites of the Skin and Soft tissue



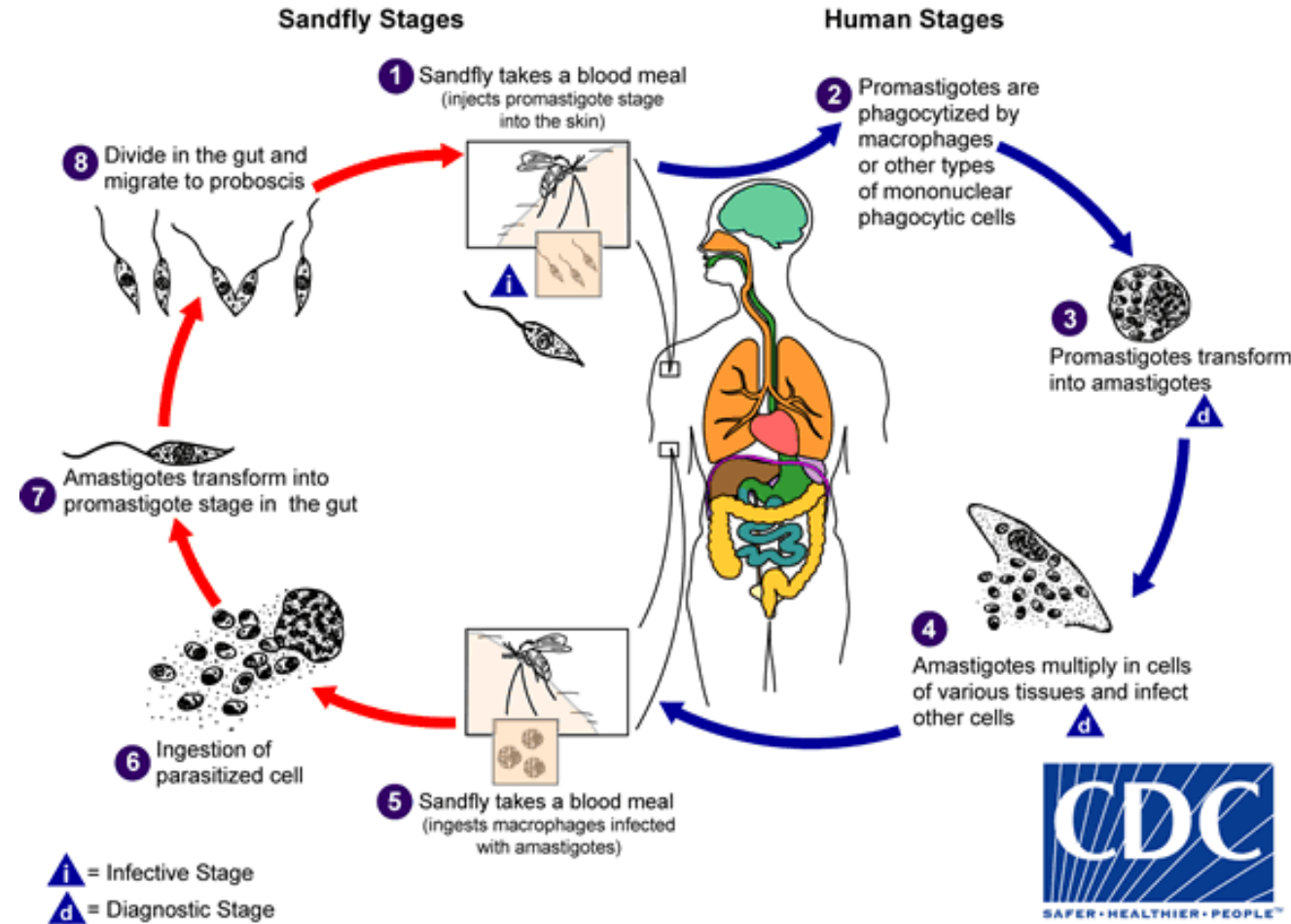
Leishmaniasis

- Caused by hemoflagellate protozoa, *Leishmania*
- Infect many mammals
 - » 21 of 30 known species infect humans
- Vectored to humans by the phlebotomine sand fly
- Geographically dispersed:
 - » Tropic/sub-tropics
 - C. & S. America
 - Africa
 - Asia
 - Middle East
 - S. Europe



Leishmaniasis

- Clinical manifestations
 - » Cutaneous (pizza lesion)
 - Painless or painful
 - » Mucocutaneous
 - Dissemination of cutaneous
 - » Visceral (kala-azar)
 - Fever, weight loss, hepatosplenomegaly
 - Anemia
 - Thrombocytopenia
 - Leukopenia
- Different species w/ different clinical manifestations

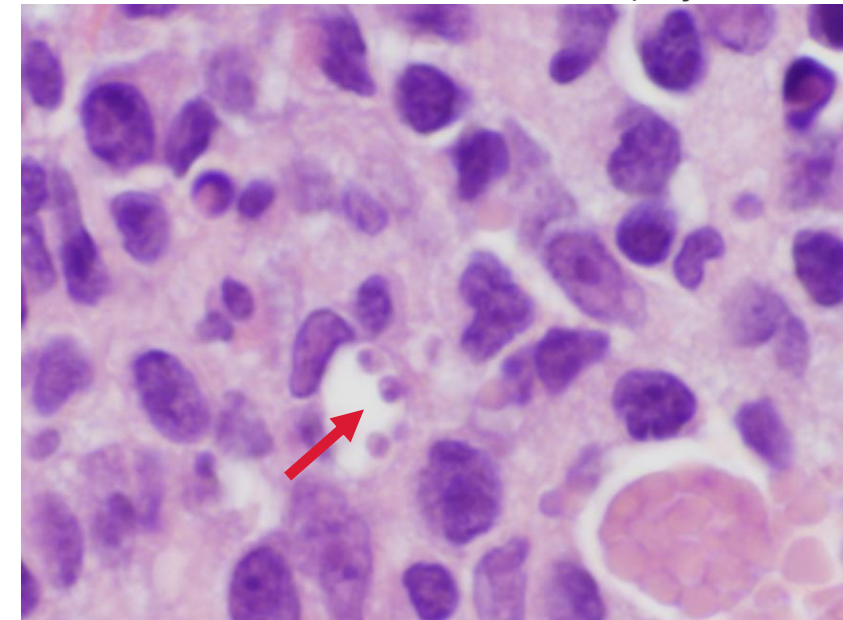


Leishmaniasis

- Diagnosis:
 - » Histopathologic examination of tissue (biopsy, aspirate)
 - » Serology
 - » PCR
- Treatment:
 - » Pentavalent antimony (investigational from CDC)
 - » Liposomal amphotericin B (visceral only)
 - » Miltefosine (cutaneous, mucocutaneous, visceral)

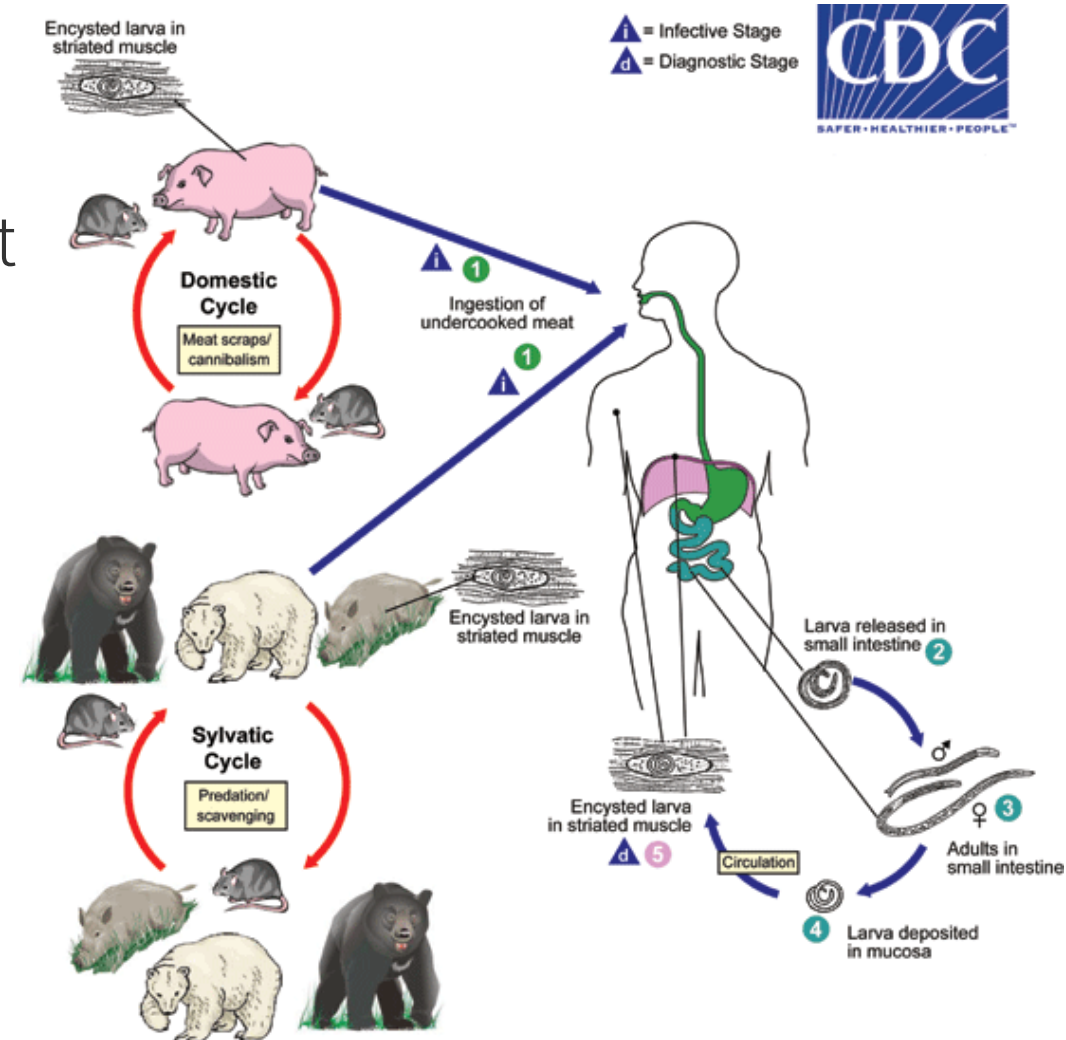


H&E stained skin biopsy



Trichinellosis

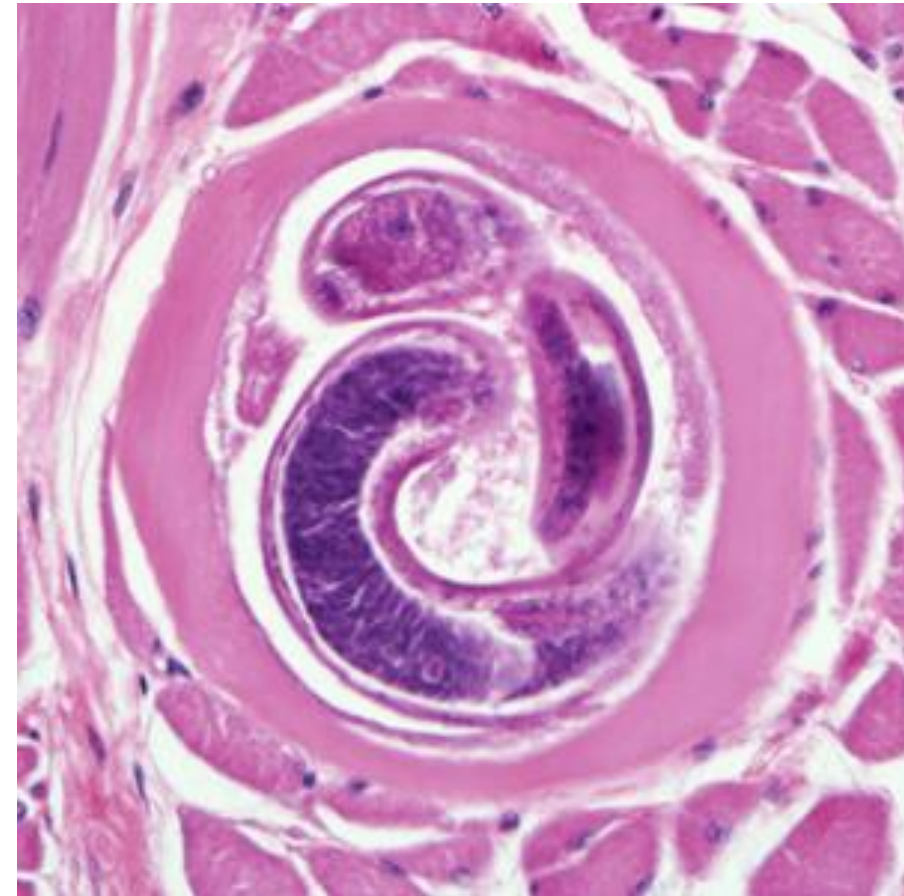
- Caused by nematode, *Trichinella*
- Acquired: ingestion of undercooked meat containing encysted larvae
- Geographically dispersed:
 - » Worldwide with bias towards
 - Europe
 - N. America



Trichinellosis

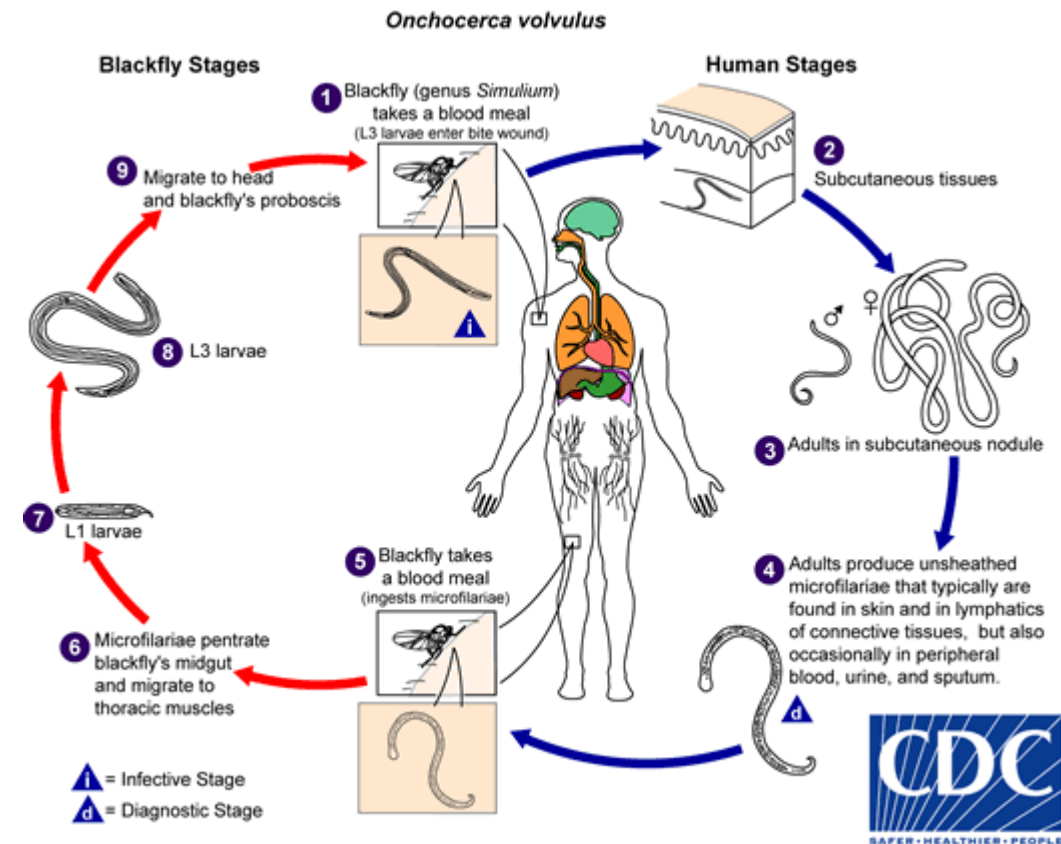
- Symptoms:
 - » May be asymptomatic
 - » Initially GI: diarrhea, cramping, emesis
 - » >1 Week: Muscle invasion
 - Periorbital & facial edema
 - Fever, myalgias, rashes
 - **Peripheral eosinophilia**
 - » Larvae encyst in muscle: myalgia & weakness → cessation of symptoms
- Diagnosis:
 - » Social history
 - » Serology
 - » Tissue stain & microscopy

Encysted larvae in muscle H&E stain



Onchoceriasis

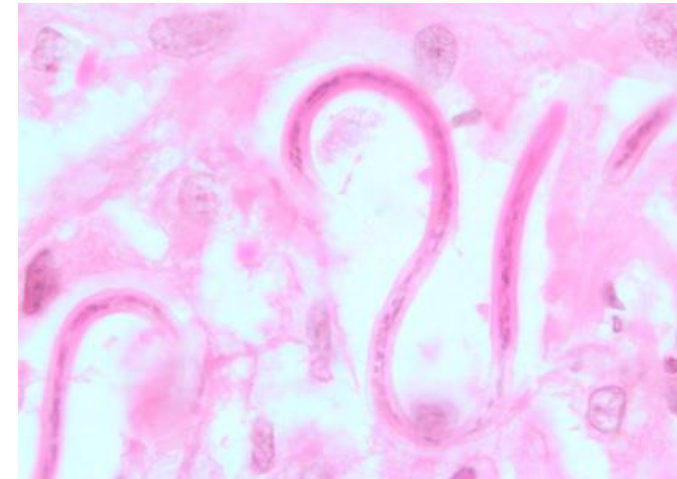
- Caused by the nematode *Onchocerca volvulus*
- Acquired via the bite of *Simulium* (black fly)
- Geographically constrained:
 - » Africa (Sub-Saharan)
 - » Latin America (focal)
 - » Middle East (Yemen)



Onchocerciasis



- Symptoms:
 - » Most symptoms are result of inflammatory reactions to dead or dying worms
 - Itchy skin rash
 - Subcutaneous nodules
 - Vision change
 - » Continued inflammation of cornea and optic nerve results in blindness
 - River blindness
- Diagnosis: skin snip and histology
- Treatment:
 - » Ivermectin



<https://www.npr.org/sections/goatsandsoda/2016/01/14/462911189/the-farmer-and-fisherman-who-lost-his-sight-to-river-blindness>

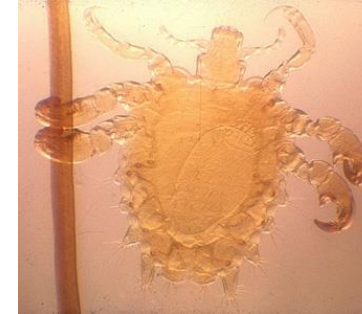
Scabies

- *Sarcoptes scabiei* (itch mite)
- Acquired by direct contact with mite infected surfaces
- Symptoms: Severe pruritus serpiginous burrows
 - » Common between digits and behind large joints
- Geographically distributed worldwide
 - » Low socioeconomic status
 - » Institutional settings
- Diagnosis: macroscopic identification of mite
- Treatment:
 - » Permethrin (human)
 - » Cleaning (environment)



Lice

- *Pediculus humanus* (head and body louse)
- *Pthirus pubis* (pubic louse)
- Symptoms: Itching of infected site
 - » Can transmit serious human diseases
 - Epidemic typhus, relapsing fever, trench fever
- Diagnosis: macroscopic identification of louse
- Treatment:
 - » Ivermectin lotion (human)
 - » Nit combing (human)
 - » Environmental cleaning



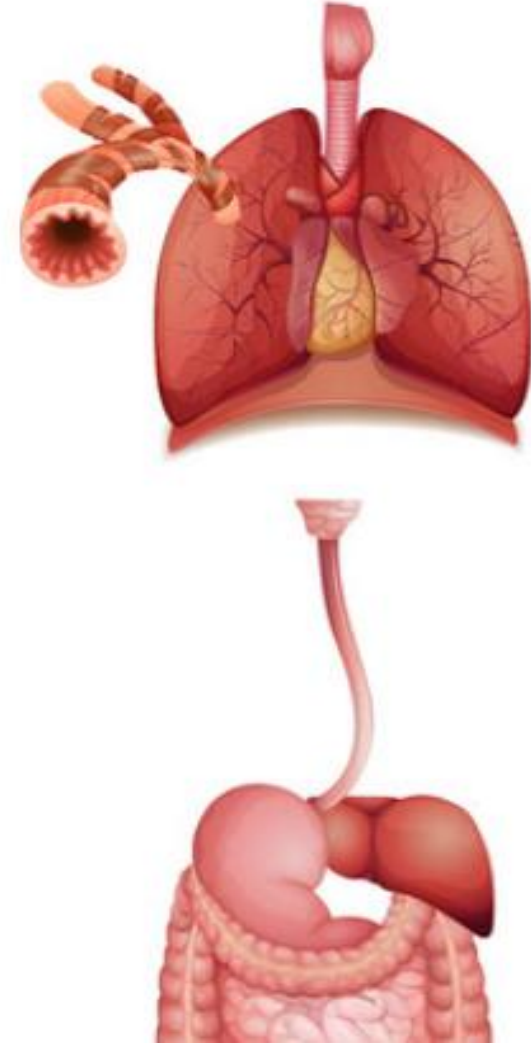
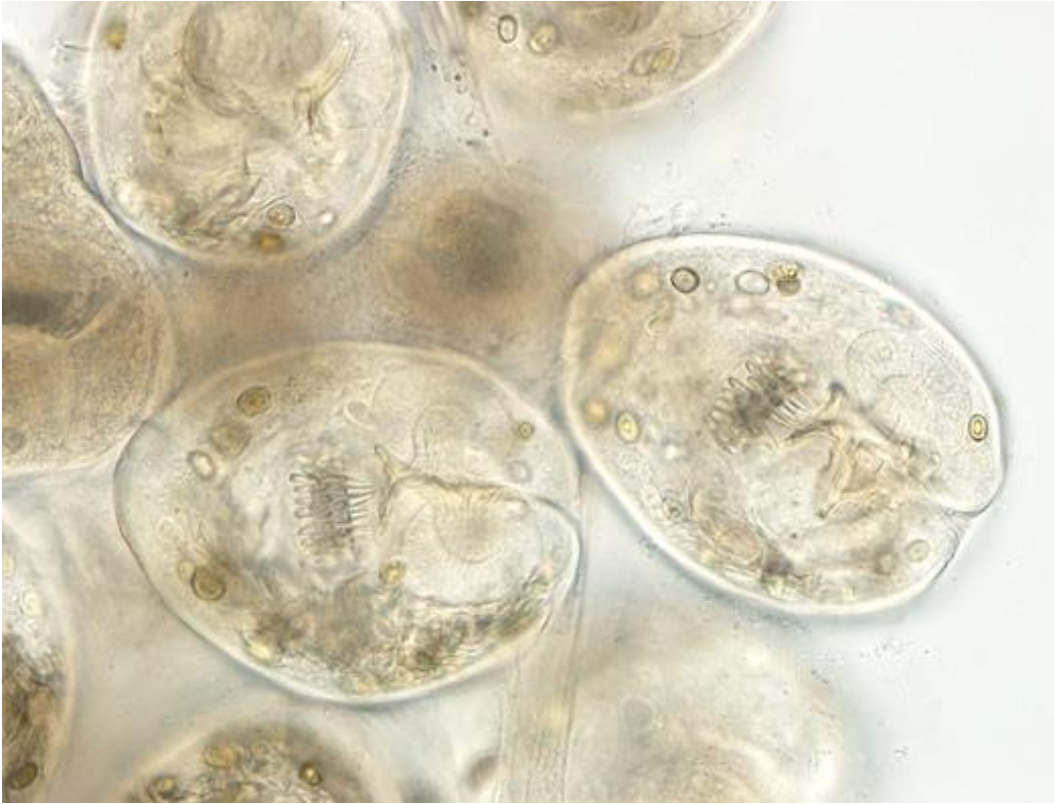
Pubic louse



Head louse



Parasites of Lung and Liver



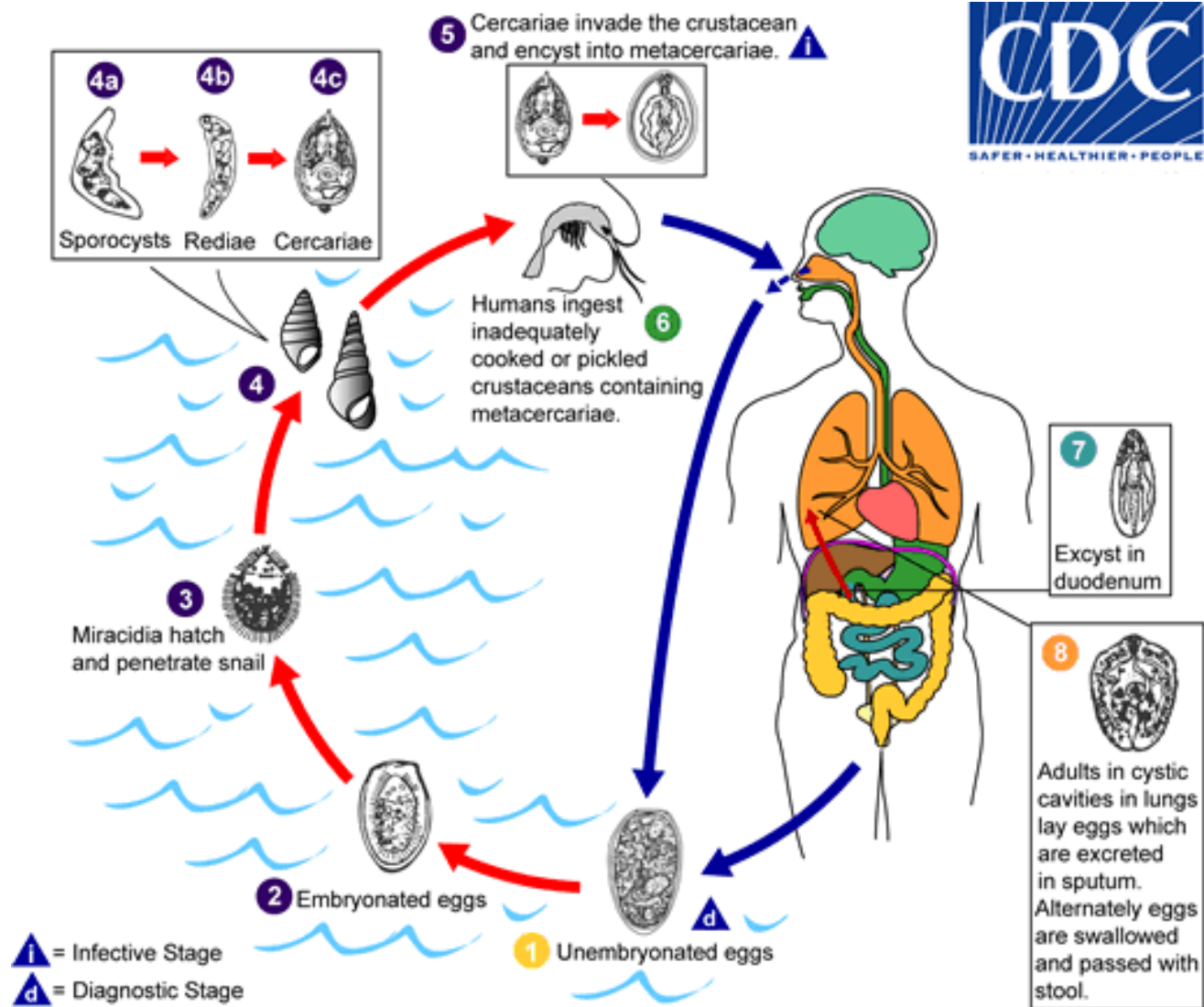
Paragonimiasis

- Caused by lung flukes in the genus *Paragonimus*.
 - » *Paragonimus westermani* & *P. heterotremus* in southeast Asia
 - » *Paragonimus kellicotti* in the United States.
- Infections occur from the ingestion of raw or undercooked freshwater crustaceans.
- Symptoms:
 - » Acute: diarrhea, abdominal pain, fever, cough, urticaria, eosinophilia
 - » Chronic: cough, expectoration of discolored sputum (“iron fillings”), hemoptysis



‘crab martini’

Life Cycle of *Paragonimus* spp.



Paragonimiasis

- Diagnosis
 - » morphology
(eggs in respiratory specimens & stool)
 - » Serology
- Treatment: praziquantel



Eggs of *Paragonimus* in respiratory specimen

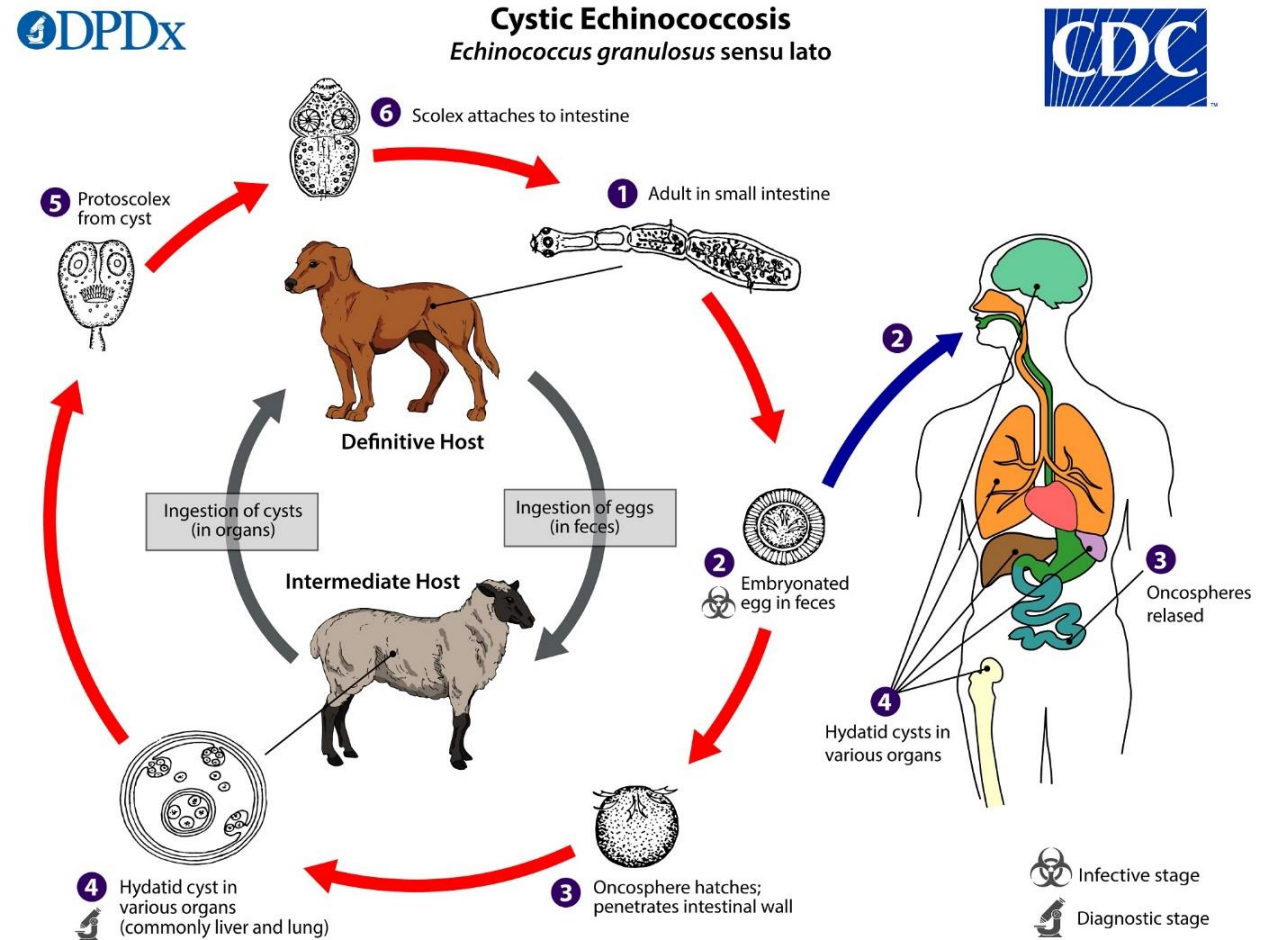
Echinococcosis

- Caused by cestodes in the genus *Echinococcus*.
 - » *Echinococcus granulosus* (complex) – cystic echinococcosis
 - » *Echinococcus multilocularis* - alveolar echinococcosis
- Infection caused by the ingestion of tapeworm eggs in food and fomites contaminated with dog feces.
- Parasites cannot mature in human host (humans are dead-end hosts)
- Symptoms:
 - » Cystic: dependent on size, number, and location of cysts (hepatic, pulmonary most common)
 - Cyst rupture: anaphylaxis, urticarial, eosinophilia
 - » Alveolar: slow-growing, destructive tumor; abdominal pain and biliary obstruction (high case fatality rate untreated).

Life Cycle of *Echinococcus granulosus*

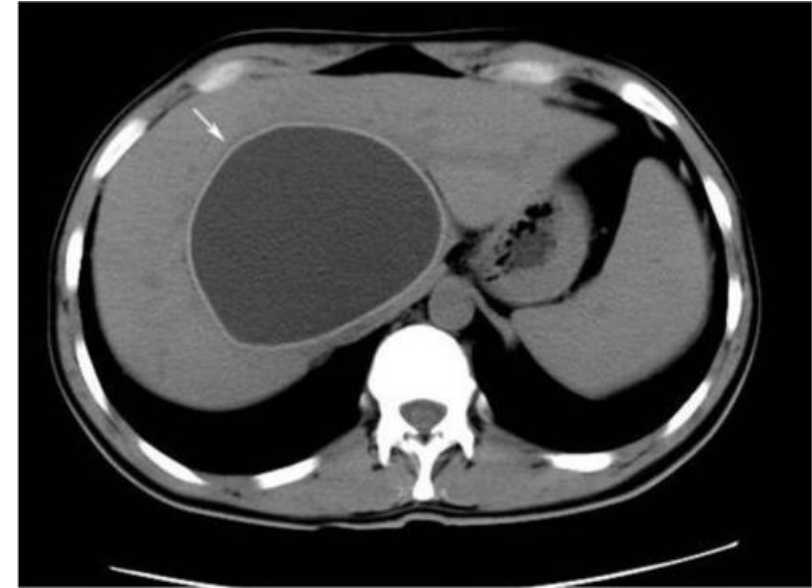


Protoscoleces in 'hydatid sand' in liver aspirate



Echinococcosis

- Diagnosis
 - » Imaging (CT, MRI)
 - » Antibody detection
 - » Morphology (e.g. hydatid sand in aspirates)
- Treatment:
 - » Albendazole (praziquantel preoperative)
 - » Surgical removal of cyst (as indicated)
 - » PAIR (percutaneous aspiration, injection, reaspiration)
 - » Nothing (as indicated)



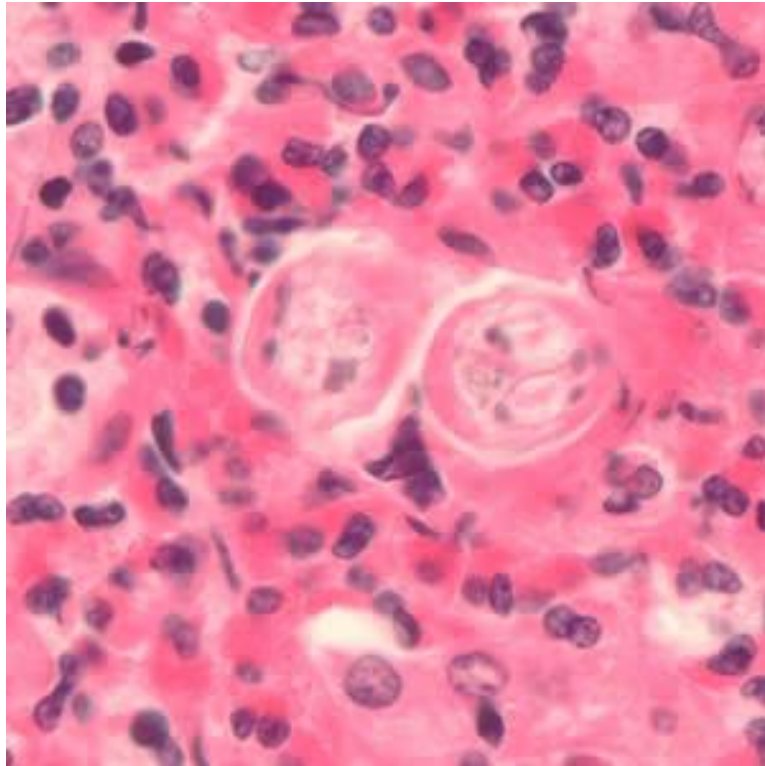
CT image of hepatic hydatid cyst

Visceral Larval Migrants

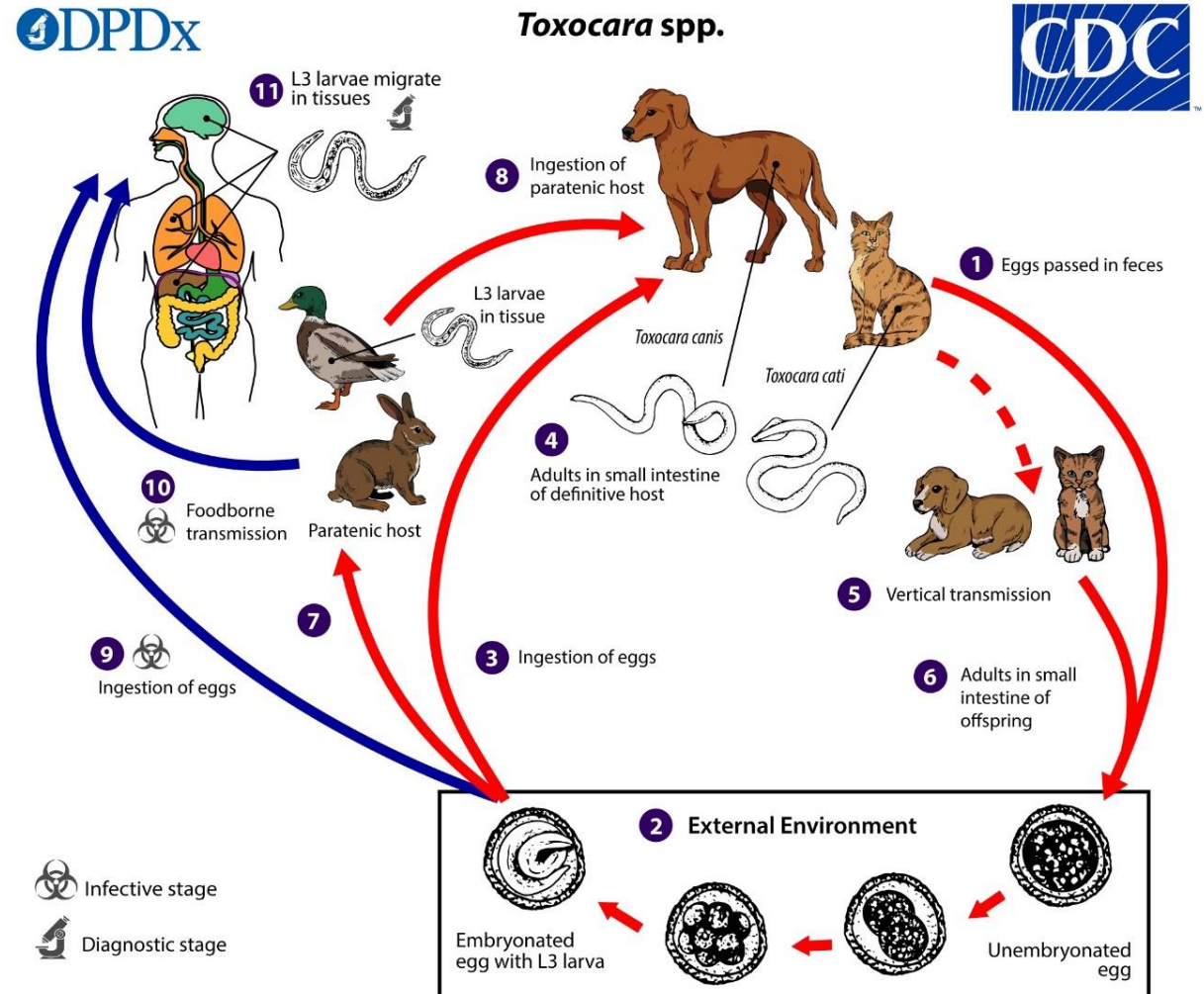


- Caused by larvae of nematodes of animals:
 - » *Toxocara canis* & *T. cati* (dogs and cats)
 - » *Baylisascaris procyonis* (raccoons) [predilection for CNS]
- Humans ingest fully-embryonated eggs
 - » Soil, food, & on fomites contaminated with feces of natural definitive host or eating paratenic hosts.
- Humans are dead-end hosts
- Symptoms: fever, myalgia, weight loss, cough, rashes, hepatosplenomegaly, hypereosinophilia
 - » Eosinophilic meningoencephalitis uncommon
 - » Ocular – uveitis, retinitis, endophthalmitis

Life Cycle of *Toxocara* spp.



Cross sections of larvae in liver biopsy



Visceral Larval Migrants

- Diagnosis: antibody detection
- Treatment:
 - » Visceral: albendazole or mebendazole with steroids
 - » Ocular: albendazole or mebendazole with topical steroids

Clonorchiasis/Opisthorchiasis

- Caused by liver flukes *Opisthorchis viverrini*, *O. felineus*, and *Clonorchis sinensis* (Chinese liver fluke).
 - » *Clonorchis*: parts of Asia incl. China, Japan, Korea, Taiwan, & Vietnam.
 - » *Opisthorchis viverrini*: mainly in NE Thailand & Laos
 - » *O. felineus*: Eastern Europe and Russia.
- Infection: ingestion of raw or undercooked fish containing metacercariae.



'koi' – raw fish dish eaten in Laos and Thailand

Life Cycle of *Clonorchis sinensis*



Egg in wet mount of stool

DPDx

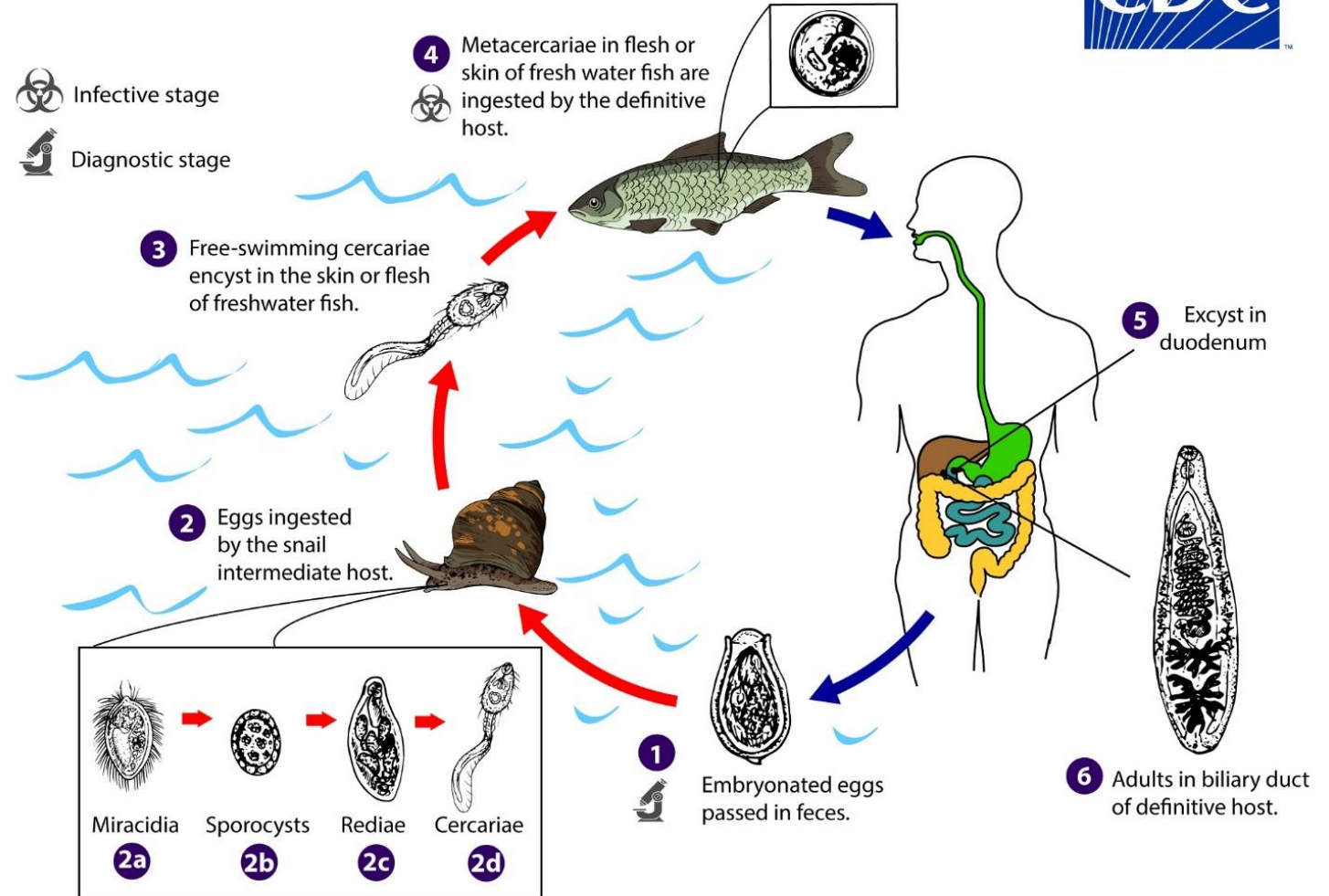
Clonorchis sinensis



Infective stage



Diagnostic stage



Clonorchiasis/Opisthorchiasis

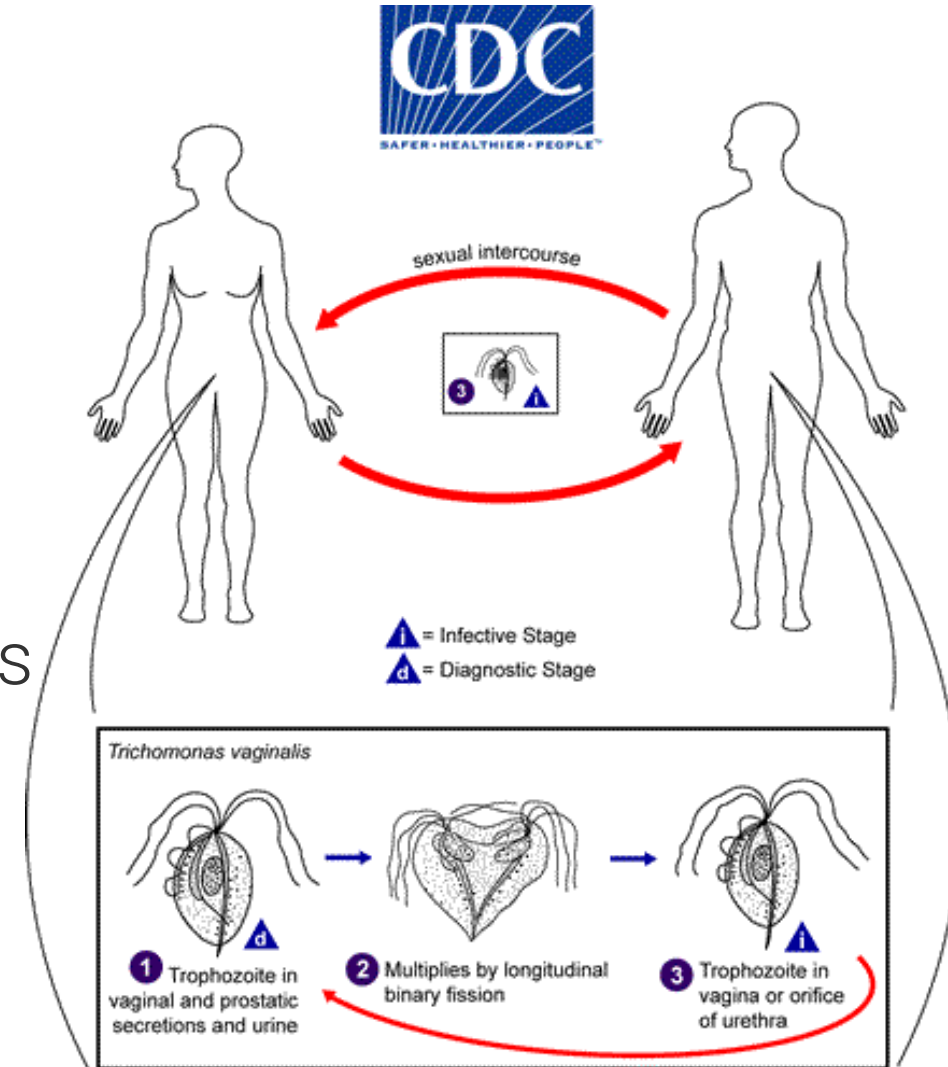
- Symptoms related to worm burden
 - » Inflammation, intermittent obstruction of biliary ducts; abdominal pain (RUQ)
 - » Toxicity (metabolic products of worms), secondary bacterial infections
 - » Leading cause of **cholangiocarcinoma**; also cholangitis, cholecystitis, pancreatitis.
- Diagnosis: detection of eggs in feces.
- Treatment: praziquantel

Parasites of Genitourinary tract



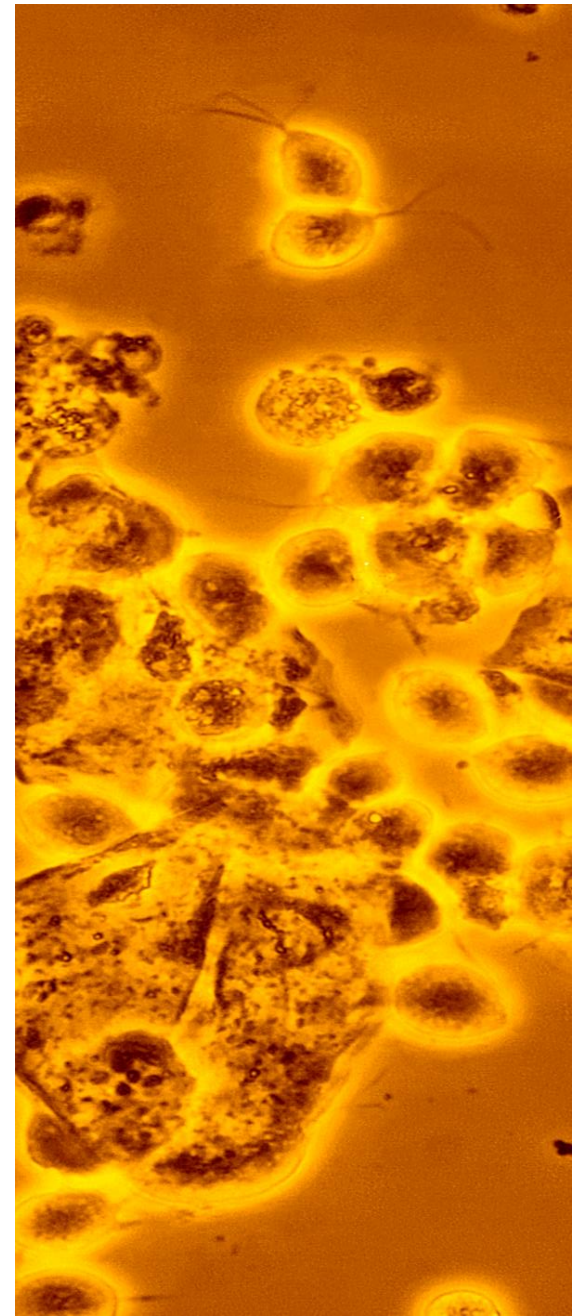
Trichomoniasis

- Caused by the protozoa *Trichomonis vaginalis*
- Acquired by direct sexual contact with infected human
- Worldwide distribution
 - » Increased prevalence among populations w/multiple sexual partners



Trichomoniasis

- Symptoms:
 - » Women: **vaginitis w/purulent discharge**
 - Can lead to adverse pregnancy outcomes
 - Rarely cervical lesions, abdominal pain, dysuria
 - » Men: **Typically asymptomatic**
 - Rarely urethritis, prostatitis, epididymitis
- Diagnosis:
 - » NAAT testing (preferred clinically)
 - » Wet mount exam (obsolescence)
- Treatment: **single dose metronidazole**



Microsporidia

- Obligate intracellular *fungal* parasites of most animal phyla
 - » Thought to be ingested
- Most-commonly seen in immunocompromised patients.
 - » May disseminate
- Numerous species are known to be involved in human infections
- Treatment: Albendazole (for most species)

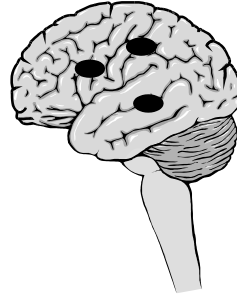
Human Microsporidiosis

CNS microsporidiosis:

E. cuniculi

E. intestinalis

Trachipleistophora anthropopthera



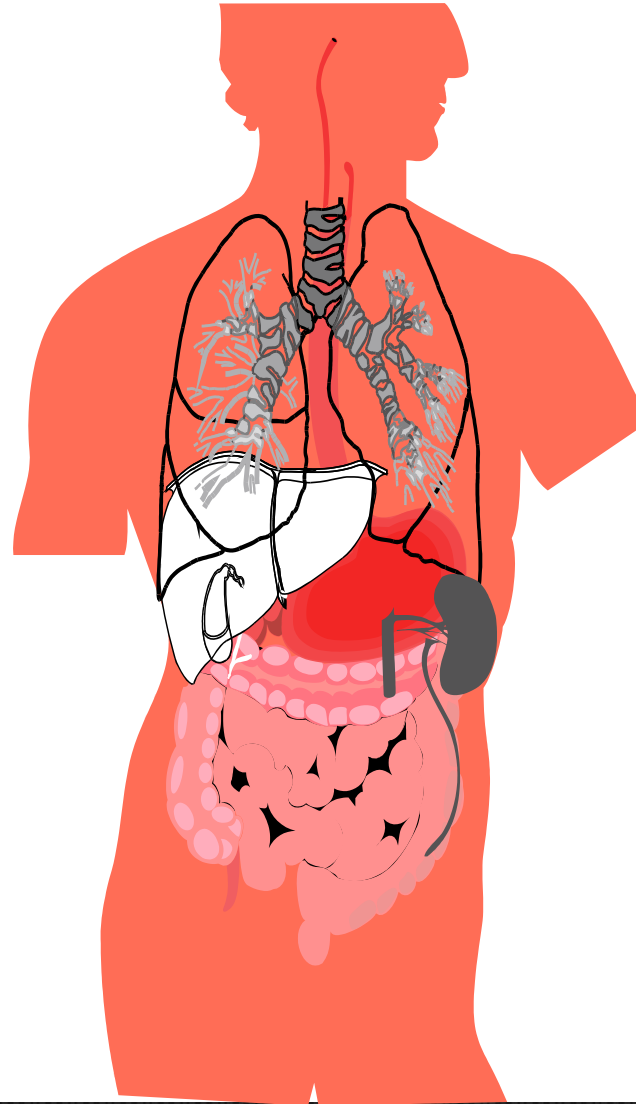
Skin lesions

Anncaliia algerae

Gastrointestinal and biliary tract microsporidiosis:

E. bieneusi

E. intestinalis

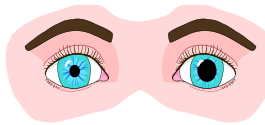


Ocular microsporidiosis:

Encephalitozoon spp. (*E. cuniculi*, *E. hellem*, *E. intestinalis*)

Vittaforma corneae

Anncaliia algerae



Disseminated microsporidiosis:

E. hellem

E. cuniculi

E. intestinalis

Trachipleistophora anthropopthera

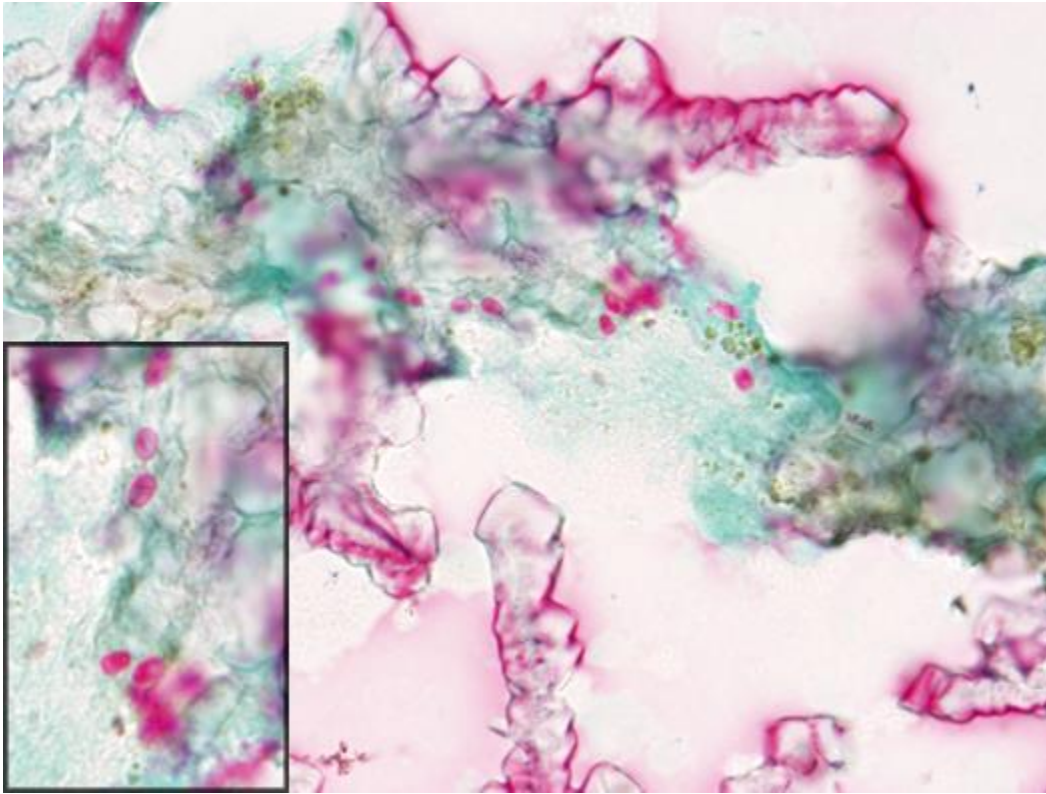
Trachipleistophora hominis

Tubulinosema acridophagus

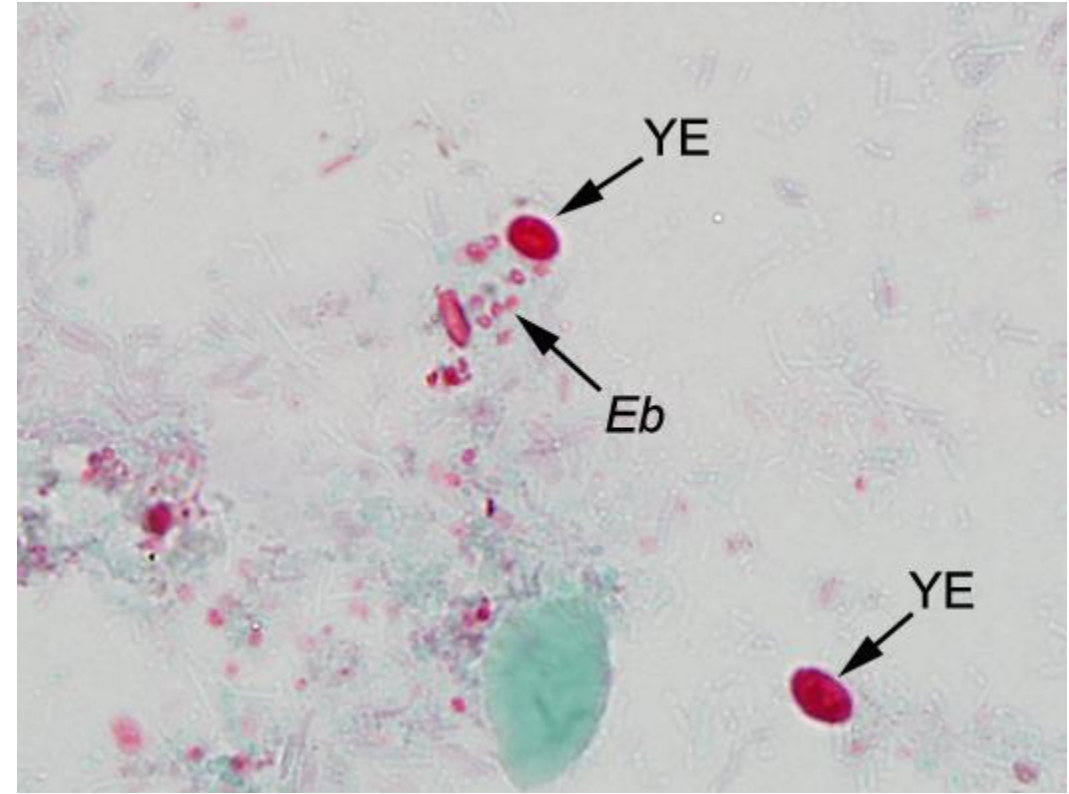
Microsporidiosis - Diagnosis

- Not readily detected by traditional stool O&P
 - » Very small & do not retaining trichrome stain
 - » Require special stains
- PCR and DNA sequencing typically used for species-level identification
 - » PCR not practical for routine screening.

Microsporidia stained with Modified trichrome



BAL



Stool

Key Points

- *Toxoplasma* – cats, congenital infections, & immunocompromised hosts
- *Angiostrongylus* – eosinophilic meningitis
- *Cysticercosis* – Caused by the pork tapeworm but not acquired from eating pork! Brain lesions
- *Naegleria* – Diving into fresh warm water, rapidly fatal meningoencephalitis
- *Acanthamoeba* – brain and cornea infections, often fatal

Key Points

- *Leishmania* – disfiguring lesions, severe visceral form (*kala azar*)
- *Trichinella* – undercooked pork/bear, larvae in muscles
- *Onchocerca* – River Blindness, subcutaneous nodules
- *Paragonimus* – Iron fillings → hemoptysis, raw crustaceans
- *Echinococcus* – liver cysts, sheep dog exposures
- *Clonorchis* – cholangiocarcinoma, raw fish
- *Trichomonas* – Vaginitis w/discharge (♀), asymptomatic (♂)



A nonprofit enterprise of the University of Utah and its Department of Pathology