Protozoa that Could be Tested

Edward Mitre, MD
Rockville, MD

Disclaimer: Dr. Mitre is giving this presentation in a personal capacity. The views expressed in this presentation are the sole responsibility of the presenter and do not necessarily reflect the views, opinions, or policies of the Uniformed Services University of the Health Sciences, the Department of Defense, or the United States Government.

8/8/2026

Disclosures of Financial Relationships with Relevant Commercial Interests

- None

Protozoa*

Extraintestinal	Intestinal
Apicomplexa (SAR)	**Apicomplexa (SAR)**
Plasmodia	Cryptosporidium (no apicoplast)
(Babesia)	Cyclospora
(Toxoplasma)	Cystoisospora
Flagellates (Excavata)	**Flagellates (Excavata)**
Leishmania (kinetoplast)	Giardia (metamonad)
Trypanosomes (kinetoplast)	Dientamoeba (metamonad)
(Trichomonas) (metamonad/no mitochondria)	**Amoebae (Amoebozoa)**
Amoebae (Amoebozoa)	Entamoeba
Acanthamoeba	**Ciliates (SAR)**
Balamuthia	Balantidium
Amoeboflagellate (Excavata)	**Non-motile (SAR)**
Naegleria	Blastocystis

*Note: There has been a shift from categorizing organisms that used to be known as Protozoa into the SAR (Stramenopiles/Alveolata/Rhizaria), Excavata, and Amoebozoa Supergroups. These are levels of taxonomic organization which are below the domain level of Eukaryota and above the traditional kingdom level. This recategorization occurred b/c taxonomists learned that many organisms in the prior Kingdom Protista were more closely related to animals, plants, or fungi than they were to each other. In terms of motility, Apicomplexans move via gliding motility via a glideosome apparatus which contains actin and myosin whereas Amoebae move via pseudopodia. Naegleria in humans exists in its trophozoite (amoeboid) form but under certain environmental conditions can develop into a flagellate form. Naegleria also has a cyst stage.

Kingdom Fungi Microsporidiosis agents

Protozoa*

Extraintestinal	Intestinal
Apicomplexa (SAR)	**Apicomplexa (SAR)**
Plasmodia	Cryptosporidium (no apicoplast)
(Babesia)	Cyclospora
(Toxoplasma)	Cystoisospora
Flagellates (Excavata)	**Flagellates (Excavata)**
Leishmania (kinetoplast)	Giardia (metamonad)
Trypanosomes (kinetoplast)	Dientamoeba (metamonad)
(Trichomonas) (metamonad/no mitochondria)	**Amoebae (Amoebozoa)**
Amoebae (Amoebozoa)	Entamoeba
Acanthamoeba	**Ciliates (SAR)**
Balamuthia	Balantidium
Amoeboflagellate (Excavata)	**Non-motile (SAR)**
Naegleria	Blastocystis

Kingdom Fungi Microsporidiosis agents

11 Protozoa That Could Be Tested
Speaker: Edward Mitre, MD

© 2026 Infectious Disease Board Review

Question #1

A 54-year-old woman presents with fever, chills, and oliguria one week after travel to Malaysia.

Vitals: **39.0**°C, HR 96/min, RR 24/min, **BP 86/50**

Labs: Hct 31%, platelets14,000/µl, Cr of 3.2 mg/dL.

Peripheral blood smear has intraerythrocytic forms that are morphologically consistent with Plasmodium malariae.

Which is the most likely infectious agent causing the patient's illness?

A. Plasmodium malariae
B. Plasmodium knowlesi
C. Plasmodium vivax
D. Plasmodium falciparum
E. Babesia microti

P. knowlesi

*M*orphologically similar to *P. malariae*

Usually a parasite of long-tailed macaques

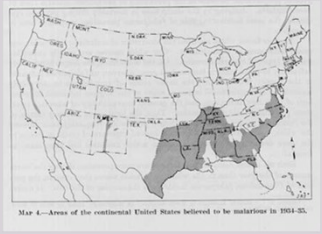
Increasingly recognized in Myanmar, Philippines, Indonesia, and Thailand

Causes high parasitemia

Highly morbid and can be lethal

Malaria

One Of The Most Important Pathogens In The History Of The World



Map 4.—Areas of the continental United States believed to be malarious in 1934-35.

National Malaria Elimination Program: 1947- 1951

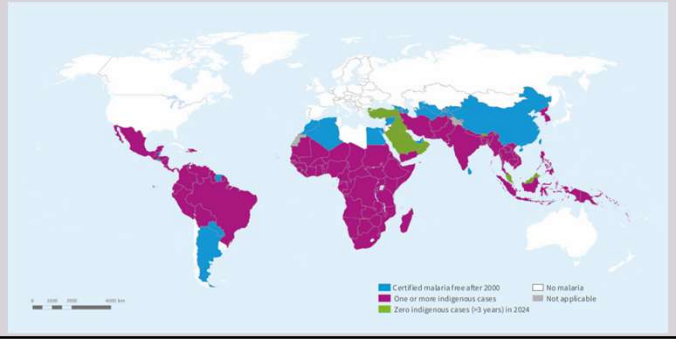
→ DDT spraying, drainage of wetlands

→ Atlanta was chosen for the Office of Malaria Control in War Areas (the predecessor agency of the CDC) in part because of its location in a malaria-endemic region

In 1775 the Continental Congress purchased quinine for George Washington's troops

Disease Burden - WHO 2025 World

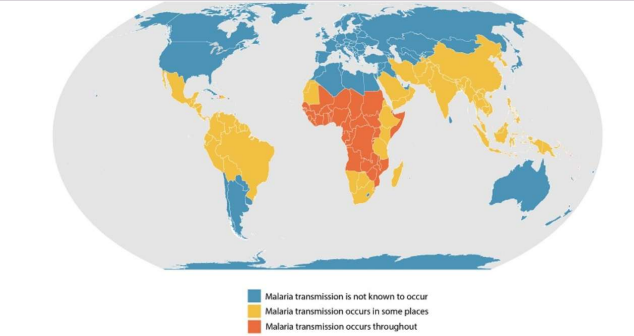
282 million cases
610,000 deaths
U.S. ~ 2000 cases reported each year



11 Protozoa That Could Be Tested
Speaker: Edward Mitre, MD

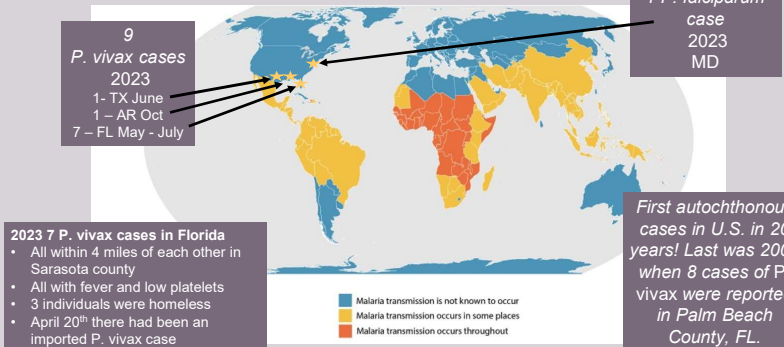
© 2026 Infectious Disease Board Review

Malaria Epidemiology – CDC Map From a Few Years Ago…What's Missing?



https://www.cdc.gov/malaria/about/distribution.html

2023 U.S. Malaria Cases



2023 7 P. vivax cases in Florida

- All within 4 miles of each other in Sarasota county
- All with fever and low platelets
- 3 individuals were homeless
- April 20th there had been an imported P. vivax case
- CDC testing of 407 Anopheles mosquitoes → 3 A. crucians were PCR+

First autochthonous cases in U.S. in 20 years! Last was 2003 when 8 cases of P. vivax were reported in Palm Beach County, FL.

https://www.cdc.gov/mmwr/volumes/72/wr/mm7236a1.htm
https://www.cdc.gov/malaria/about/distribution.html

In Non-immune Patients, Falciparum Malaria Is A Medical Emergency!!

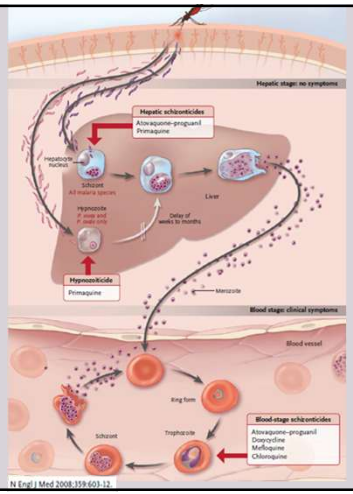
One of the most common causes of fever in a returned traveler

Infected individuals can rapidly progress from appearing well to being critically ill

Some Helpful Heuristics

If Patient Has	Make Sure Patient Doesn't Have
Fever and freshwater contact →	Malaria
Fever and unpasteurized milk →	Malaria
Fever and undercooked meat →	Malaria
Fever and raw vegetables →	Malaria
Fever and untreated water →	Malaria
Fever and wild dog bite →	Malaria
Fever and abdominal pain →	Malaria
Fever and headache →	Malaria
Fever and diarrhea →	Malaria
Fever and dysuria →	Malaria
Fever and cough →	Malaria

© 2026 Infectious Disease Board Review



Sporozoites
- **Infective stage**
- Come from mosquito

Liver schizont
- **Asymptomatic replicative stage**
- Become 10,000 to 30,000 merozoites

Hypnozoite
- Dormant liver stage in **vivax and ovale**
- Release merozoites weeks to months after primary infection

Merozoites
- Infect RBCs and develop into ring-stage trophozoites
- Mature into schizonts, which release merozoites which infect more RBCs

Gametocytes
- Infective stage for mosquitoes

Characteristics of Human Malaria Species

	P. falciparum	P. knowlesi	P. vivax	P. ovale	P. malariae
incubation	8 - 25 d	prob 8-25 d	~ 2 wks	~ 2 wks	~ 3-4 wks
hypnozoite	no	no	yes	yes	no
RBC age	any	any	young	young	old
parasitemia	high	high	< 2%	< 2%	< 1%
morbidity	high	high	high	moderate	low
mortality	high	moderate	low	low	low

Possible Evolutionary Defenses Against Malaria

Duffy antigen negative (*P. vivax* uses Duffy Ag to enter RBCs)

Sickle cell trait (increases survival during *P. falciparum* infection, perhaps by selective sickling of infected RBCs)

Glucose-6-phosphate dehydrogenase deficiency

(malaria parasites grow poorly in G6PD deficient RBCs, perhaps b/c this results in an overall increase in reactive oxygen species in RBCs)

Uncomplicated (Mild) Malaria

Symptoms: fevers, chills, headache, fatigue

*NOTE: abdominal pain presenting symptom in 20%

→ periodicity of fevers not common when patients seen acutely

Labs:
- Thrombocytopenia in 50%
- Mild anemia in 30%
- Typically no leukocytosis
- May see evidence of hemolysis with mild increase T bili and LDH

© 2026 Infectious Disease Board Review

Complicated (Severe) Malaria

- Cerebral malaria (altered mental status, seizures)
- Respiratory distress/pulmonary edema
- Severe anemia (hct <15% in children, <20% in adults)

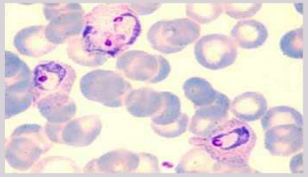
} Often seen in children of endemic countries. Adults more often get multiorgan failure.

- Renal failure
- Hypoglycemia
- Shock (SBP < 80 mm Hg or capillary refill > 3 seconds)
- Acidosis (often lactic acidosis)
- Jaundice (total bilirubin > 3 mg/dL)
- Bleeding disorder (spontaneous bleeding or evidence of DIC)

These complications primarily occur with *Plasmodium falciparum*, usually when parasitemia ≥ 2%

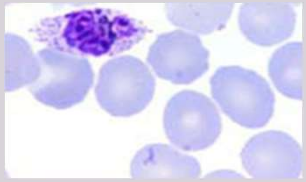
NOTE: in the absence of end organ damage, parasitemia ≥ 5% is often used as the cut-off to treat for severe malaria in the U.S.

P. vivax or ovale



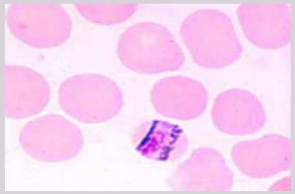
- Intracellular schüffner's dots
- Enlarged infected cells

P. ovale



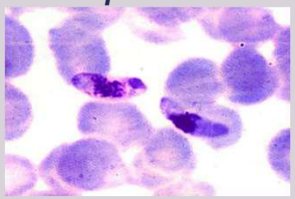
- Elongated or oval
- 6-12 merozoites (vs 12-24 for vivax)

P. malariae



- Band form (also seen in *P. Knowlesi*)

P. falciparum



- Banana shaped gametocyte

Malaria: Diagnosis

Rapid diagnostic antigen tests

→ sensitivity > 90% for P. falciparum
(about 85% for P. vivax, lower for P. knowlesi and P. ovale)

Binax Now® ICT assay for the detection of *Plasmodium falciparum* malaria according to the level of parasitemia

Parasitemia (no. of parasites/μL of whole blood)	Microscopy (no. positive)	NOW ICT (no. positive)	Sensitivity (%)
1–100	4	3	75.0
101–1,000	26	25	96.2
1,001–10,000	37	36	97.3
>10,000	34	33	97.1

Am. J. Trop. Med. Hyg., 69(6), 2003, pp. 589–592

for P. falciparum (T1) → tests for histidine-rich protein 2
for all species (T2) → tests for aldolase

*Most false-negative antigen tests are due to low parasite burden
→ Retest suspected patients that initially test negative

*Increasing false negative cases occurring worldwide due to mutations in HRP2

© 2026 Infectious Disease Board Review

Question #2

A 33-year-old woman is traveling to Uganda to do field studies in anthropology. She is two months pregnant.

Which of the following do you prescribe for malaria prophylaxis?

A. Doxycycline
B. Chloroquine
C. Mefloquine
D. Atovaquone/progruanil
E. No prophylaxis

Malaria Chemoprophylaxis

(Note: No Malaria Vaccine Approved For U.S. Travelers)

Some Regions In Central America and the Middle East

	Pre-Exposure	During	Post-Travel
Chloroquine 500mg tabs	1 Tab/wk x 2 wks	1 Tab/wk	4 Weeks
EVERYWHERE			
Atovaquone/proguanil 250/100mg	1 Tab daily x 2 d	1 Daily	7 Days
Doxycycline 100mg tabs	None	1 Daily	4 Weeks
Tafenoquine* 100mg tabs	2 Tab daily x 3 d	2 Tab/wk	2 Tab after 1 wk
Mefloquine (not SE Asia)** 250mg tabs	1 Tab/wk x 2-3 wks	1 Tab/wk	4 Weeks

**** Tafenoquine can precipitate severe hemolytic anemia in individuals that are G6PD deficient***

***** FDA black box warning mefloquine can cause neurologic symptoms, hallucinations, and feelings of anxiety, mistrust, and depression. Can also cause QT prolongation. Thus, many U.S. practitioners now reserve mefloquine for pregnant travelers to areas with chloroquine resistance.***

SEE ENLARGED SLIDE FOLLOWING ENTIRE PRESENTATION

P. falciparum Treatment

Excellent Review → 2022 JAMA, 328(5):460-47, PMID: 3591684

Uncomplicated P. falciparum malaria (no organ dysfunction, low parasitemia, able take PO)

- If chloroquine sensitive area → Chloroquine or hydroxychloroquine
- If not chloroquine sensitive area (most cases) → **Artemether/lumefantrine (Coartem)**
  ACTs are treatment of choice, WHO 2022 guidelines

Alternatives if artemether/lumefrantrine not available:
- Atovaquone/proguanil (Malarone), quinine + doxycycline, mefloquine

Severe Malaria
→ **IV artesunate** (CDC Malaria Hotline: 770-488-7788)

NOTES

1. Treatment failures can occur with artemether/lumefrantrine, especially when > 65 kg
   Abanyie F. et al, *Clinical Infectious Diseases* 2022 PMID: 36052468
2. Artemisinin resistance reported in SE Asia (Cambodia, Laos, Myanmar, Thailand, Vietnam), parts of Africa (Uganda, Rwanda), and in S. America (Guyuna)
3. Delayed-onset anemia in 2.7% of U.S. patients after treatment with artesunate
   Sonden K. et al, *Clinical Infectious Diseases* 2017 PMID: 27986683
4. Hypoglycemia and ARDS are complications that can occur during treatment of malaria. ARDS sometimes develops even as pt improving from malaria.

SEE ENLARGED SLIDE FOLLOWING ENTIRE PRESENTATION

P. vivax/P. ovale Treatment

Chloroquine x 3 days, or ACT (artemether/lumefrantrine in U.S.)
Note: PNG, Indonesia, Oceania have CLQ R P. vivax → use ACT

Then ANTIRELAPSE THERAPY with primaquine or tafenoquine

→ Need to check G6PD status before administering primaquine OR tafenoquine
(as both can cause severe hemolysis in patients with G6PD deficiency)

→ Both primaquine and tafenoquine contraindicated during pregnancy

- **Primaquine – weigh- based dosing and duration as determined by G6PD activity**

*****ALWAYS LOOK UP DOSING BEFORE ADMINISTERING*****

-> Usually 30 mg primaquine base per day x 14 days if normal G6PD activity
-> Do not exceed 30 mg primaquine base per day
-> If over 70 kg, can calculate total dose 6 mg/kg and then extend duration of 30 mg daily doses until total goal met
-> If G6PD deficient consider weekly chloroquine x 1 year

- **Tafenoquine (two 150 mg tabs once, given on 1st or 2nd day of chloroquine therapy)**
  (Tafenoquine was approved for radical cure of *P. vivax* in 2018, *P. ovale* treatment is off-label)

2020 : Company (GSK) reported some failures when tafenoquine was used after ACT treatment of P. vivax.
NEW FDA LABELING: **Tafenoquine now only approved and recommended after chloroquine treatment**

SEE ENLARGED SLIDE FOLLOWING ENTIRE PRESENTATION

https://www.cdc.gov/malaria/hcp/clinical-guidance/treatment-uncomplicated.html

© 2026 Infectious Disease Board Review

* Suggestions For All ID Practitioners *

1. Make sure the facility where one works has the means to rapidly test for malaria
2. Ensure that hospital pharmacy has access to appropriate medications for treatment of malaria

Babesia

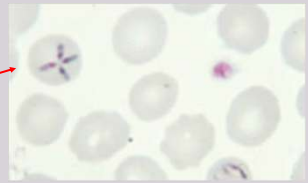
Transmission
- Ixodes ticks in Northeast and upper Midwest
  - Co-infection with Lyme and Anaplasma
- Transfusion
  (Ab and NAT screening tests approved by FDA 2018)

Symptoms
- Fever, headache, chills, myalgias
- Less common: nausea, dry cough, neck stiffness, vomiting, diarrhea, arthralgias
  - Severe disease: in HIV, asplenia

Labs
- Anemia, thrombocytopenia, mild increase LFTs, normal/low/high WBC

Diagnosis
- Small ring forms in RBCs, PCR, Ab
  merozoites can make tetrad ("Maltese cross")

Treatment
- Azithromycin + atovaquone
  (clindamycin + quinine is alternative)
  - Exchange transfusion for severe disease



CDC DpDx

Protozoa*

Extraintestinal	Intestinal
Apicomplexa (SAR)	**Apicomplexa (SAR)**
Plasmodia	Cryptosporidium (no apicoplast)
(Babesia)	Cyclospora
(Toxoplasma)	Cystoisospora
Flagellates (Excavata)	**Flagellates (Excavata)**
Leishmania (kinetoplast)	Giardia (metamonad)
Trypanosomes (kinetoplast)	Dientamoeba (metamonad)
(Trichomonas) (metamonad/no mitochondria)	**Amoebae (Amoebozoa)**
Amoebae (Amoebozoa)	Entamoeba
Acanthamoeba	**Ciliates (SAR)**
Balamuthia	Balantidium
Amoeboflagellate (Excavata)	**Non-motile (SAR)**
Naegleria	Blastocystis

Kingdom Fungi Microsporidiosis agents

Leishmaniasis

Obligate intracellular protozoan infection
Transmitted by sand flies (noiseless, active in evenings)

Lutzomyia
- New world leishmaniasis

Leishmaniasis
- Old world leishmaniasis

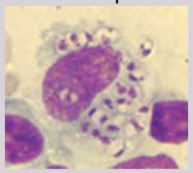
11 Protozoa That Could Be Tested
Speaker: Edward Mitre, MD

© 2026 Infectious Disease Board Review

Leishmania Life Cycle – Two Stages

Promastigote
- Extracellular, in sand fly
- 2 µm wide x 20 µm long
  - Flagella
  - Large central nucleus
  - Band shaped kinetoplast

Amastigote
- Intracellular (macrophages)
- Round or oval
- Wright-Giemsa:
  - Dark-purple nucleus
  - Small rod shaped kinetoplast



CDC DpDx

Question #3

A 42-year-old man from Bolivia presents with nasal stuffiness and is found to have nasal septal perforation. Biopsy demonstrates intracellular amastigotes consistent with Leishmania.

Which is the most likely species?

A. L. mexicana
B. L. braziliensis
C. L. peruviana
D. L. infantum chagasi
E. L. major

Leishmania Taxonomy and Disease Simplified

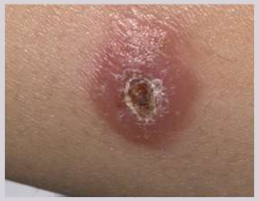
	Cutaneous	Mucosal	Visceral
NEW WORLD			
L. mexicana complex	X		
L. braziliensis	X	X	
L. infantum chagasi			X
OLD WORLD			
L. tropica	X		
L. major	X		
L. donovani			X
L. infantum chagasi			X

***Note: *L. braziliensis* is in the Viannia subgenus. *L. V. guyanensis* and *L. V. panamensis* also cause mucosal disease. *L. peruviana* DOES NOT**

Cutaneous Leishmaniasis
Clinical Presentation

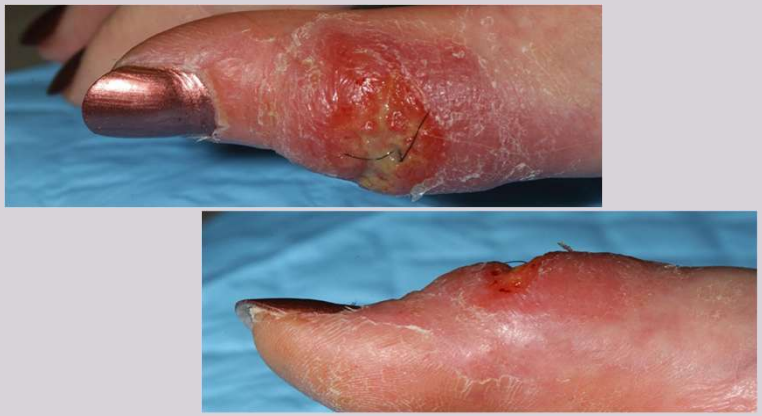
Papule → Nodule → Ulcerative lesion → Atrophic scar

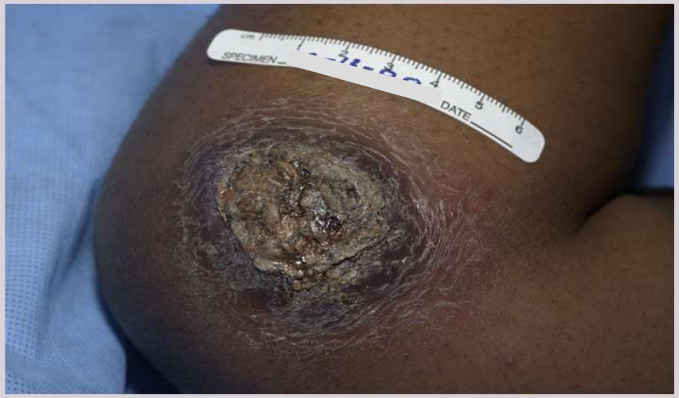
Ulcerative lesion may have:
- Induration
- Scaliness
- Central depression
- Raised border

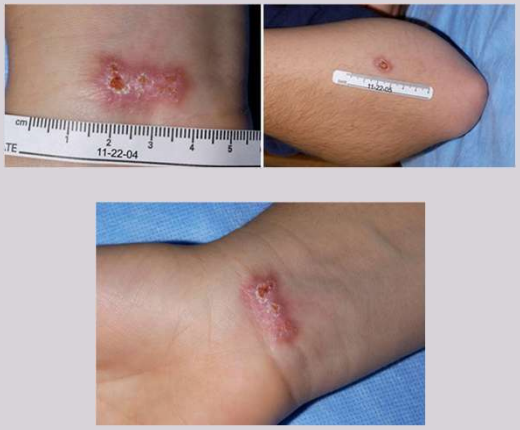


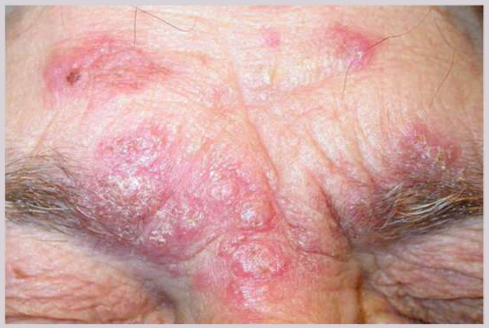
- Takes weeks to months to develop
- Usually painless, unless superinfected
- Most lesions will eventually resolve on their own

© 2026 Infectious Disease Board Review









11 Protozoa That Could Be Tested

Speaker: Edward Mitre, MD

© 2026 Infectious Disease Board Review

Cutaneous Leishmaniasis – Diagnosis

Definitive diagnosis is very helpful because

1. Allows you to rule out other possibilities
2. May help in deciding whether and how to treat

Diagnostic Tools (edge of ulcer skin: scraping, aspirate, punch)

Touch prep with examination under oil looking for amastigotes

Culture on triple N media (may take weeks to grow)

(Nicolle's modification of Novy and MacNeal's medium-biphasic)

Histology

PCR

Cutaneous Leishmaniasis
Treatment Recommendations

- Treat systemically if L. (V.) braziliensis, guyanensis, panamensis
- If not, ok to observe if there are:
  - Few lesions, they are < 5 cm, not on face/fingers/toes/genitals, normal host, no subcutaneous nodules

Treatment Options

- Local: heat with radiotherapy (FDA approved), cryotherapy, intralesional therapy systemic
  - Oral: miltefosine for certain species, especially New World CL species ketoconazole, fluconazole (off-label)
  - IV: Liposomal amphotericin B (off-label)

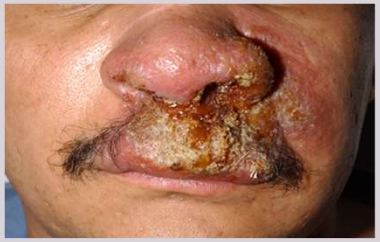
    Pentavalent antimony (meglumine antimoniate, ASTMH website has instructions for obtaining on IND from Sanofi)

2016 IDSA GUIDELINES FOR TREATMENT OF LEISHMANIA
http://www.idsociety.org/Guidelines/Patient_Care/IDSA_Practice_Guidelines/Infections_by_Organism/Parasites/Leishmaniasis/

Mucosal Leishmaniasis

Leishmania (Viannia) braziliensis, guyanensis, panemensis

- Dissemination to nasal mucosa
- Slow, progressive, destructive
- Can occur months or years after cutaneous ulcer

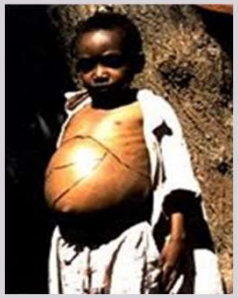


Treatment

- Oral miltefosine
  (FDA approved for *L. braziliensis*)
- IV lip. amphotericin (off-label)
- IV antimony (no longer commercially available)

Miltefosine Notes
side effects: nausea, vomiting, diarrhea, increased AST/ALT
contraindicated in pregnancy, use contraception for 5 months after treatment ($t_{1/2}$ = 30 d)

Visceral Leishmaniasis



L. donovani *(South Asia, East Africa)*

L. infantum chagasi *(Middle East, Central Asia, Mediterranean, Central and S. America)*

Amastigotes in macrophages go to local LNs then hematogenously to liver, spleen, bone marrow

A persistent disease that can reactivate
TNF blockade, HIV CD4 < 200

- Weeks/months of fevers, chills, hepatosplenomegaly
- Pancytopenia & hypergammaglobulinemia

Diagnosis: PCR, culture, or histopathology for intracellular amastigotes
→ Bone marrow aspirate preferred, can also check LN, spleen, or buffy coat antibody to rK39 recombinant Ag

Treatment: Liposomal ampho B (FDA approved)
Miltefosine (oral) FDA approved for *L. donovani*

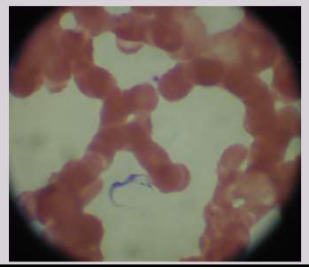
(Combination treatment for L. donovani in people living with HIV in SE Asia)

SEE ENLARGED SLIDE FOLLOWING ENTIRE PRESENTATION

© 2026 Infectious Disease Board Review

Question #4

A 41-year-old woman presented to a local emergency department with a one-day history of fever associated with swelling and redness in her groin four days after returning from safari in Tanzania. Peripheral blood smear is obtained.



What is the most likely diagnosis?

A. *Leishmania donovani*
B. *Plasmodium vivax*
C. *Trypanosoma brucei*
D. *Wuchereria bancrofti*
E. *Leptospira interrogans*

African Trypanosomiasis
Sleeping Sickness

Vector = Tsetse fly (Glossina sp)

Trypanosoma brucei gambiense (W. Africa)
Humans as reservoirs
Progression over many months

Trypanosoma brucei rhodesiense (E. Africa)
Cattle and game park animals as reservoirs
Progression over weeks

Disease

Within 5 days: Chancre at Tsetse fly bite
Regional lymphadenopathy
For weeks: Fever, hepatosplenomegaly, lymphadenopathy, faint rash, headache
Late: Mental status changes, terminal somnolent state

W.H.O.

African Trypanosomiasis
Lab Findings

Non-specific Lab Findings

- Anemia
- Thrombocytopenia
- Elevated IgM
- Hypergammaglobulinemia

Diagnostic Lab Findings

- Detection of parasite in lymph node, circulating blood, or CSF
  - Do FNA of lymph node while massaging node, then push out the aspirate onto a slide and immediately inspect under 400x power. Trypanosomes can be seen moving for 15-20minutes, usually at edge of the coverslip
- A card agglutination test that detects *T.b.gambiense* sp. antibodies.
  - V. sensitive (94-98%), but poor specificity
  - Can get false +s in pts with Schisto, filaria, toxo, malaria

African Trypanosomiasis – Life Cycle

Why are Trypanosoma brucei infections associated with persistently elevated IgM levels?

Because they keep changing their outer surface protein

- T. brucei contains as many as 1000 genes encoding different VSGs (VSG = variant surface glycoprotein)
- Each trypanosome expresses one, and only one, VSG at a time
- Individual parasites can spontaneously switch the VSG they express

© 2026 Infectious Disease Board Review

African Trypanosomiasis
The Lady Gaga of the Microbial World

African Trypanosomiasis – Treatment

July 16, 2021: Oral fexinidazole FDA approved for *T. gambiense*

West African (*T. gambiense*)

If < 6 yo or < 20 kg: lumbar puncture

CSF < 5 WBC/ul → iv pentamidine

CSF > 5 WBC/ul → iv eflornithine + nifurtimox

If > 6 yo and > 20kg: confusion, ataxia, anxiety, abnl speech, motor weakness, abnl gait?

No suspicion of late disease → oral fexinidazole

If suspicion of CNS disease →obtain lumbar puncture

CSF < 100 cells/ul (non-severe 2nd stage) →oral fexinidazole

CSF > 100 cells/ul → iv eflornithine+ nifurtimox

East African (*T. rhodesiense*)

If < 6 yo or < 20 kg: lumbar puncture

CSF < 5 WBC/ul → suramin

CSF > 5 WBC/ul → melarsoprol

If > 6 yo and > 20kg → oral fexinidazole (IV melarsoprol or suramin depending on CSF counts if unable to take PO)

Notes: *1. Melarsoprol associated with ~5% death rate due to reactive encephalopathy*

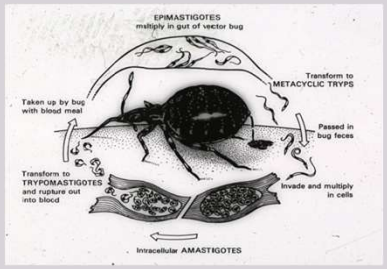
2. This is reduced by co-administration of corticosteroids

SEE ENLARGED SLIDE FOLLOWING ENTIRE PRESENTATION

Chagas Disease

- Caused by Trypanosoma cruzi
  (Also blood transfusion and congenitally)
- Vector: reduviid (triatomine) bugs
- Reservoirs: opossums, rats, armadillos, raccoons, dogs, cats
- Autochthonous cases in the U.S.
  - Texas
  - Louisiana
  - Mississippi
  - Missouri
  - California

Oral ingestion of food and drinks contaminated with reduviid bugs or the feces of those bugs is a major route of infection (acai and sugar cane juice)

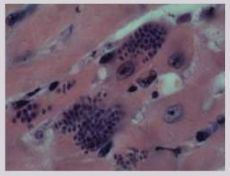


Chagas – Clinical Disease

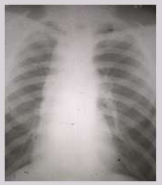
Acute (starts 1 week after infection, can persist for 8 weeks)
- Fever
- Local lymphadenopathy
- Unilateral, painless periorbital edema

Indeterminate stage
- Serology positive, no evidence of disease

Chronic



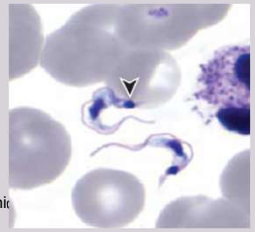
Dilated cardiomyopathy, R>L
(CHF, syncope, arrythmia)



Megaesophagus

© 2026 Infectious Disease Board Review

Chagas Diagnosis & Rx



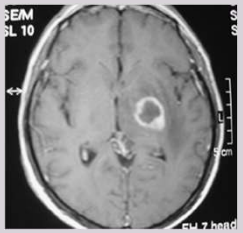
Acute Disease
- Identification of parasites in blood

Chronic Disease
- *T. cruzi* specific IgG antibodies in serum
- Two antibody tests using different antigens and different techni
  (research: xenodiagnosis, hemoculture, PCR)

NOTE: U.S. blood supply screened for 1st time donors

Treatment
- Benznidazole for 30-60 d, alternative: Nifurtimox (both FDA approved)
- **Benznidazole AEs**: peripheral neuropathy, granulocytopenia, rash
- **Nifurtimox AEs**: abdominal pain/vomiting, tremors, peripheral neuropathy
- **Always offer**: acute infection, congenital, < 18 yo, reactivation disease
- **Usually offer**: 19-50 years old and no advanced cardiac disease
- **Individual decision**: > 50 years old and no advanced cardiac disease

Chagas in Immunosuppressed Patients



2008 Int J Infectious Diseases

***T. cruzi* and AIDS**

Primarily reactivation neurologic disease
- Acute, diffuse, necrotic, meningoencephalitis
- Focal CNS lesions (similar to Toxo)**

***T. cruzi* and solid organ transplant**
- Recipient of infected organ: fevers, hepatosplenomegaly, myocarditis
- Disease often does not occur until months after transplant

ALSO…Reactivation myocarditis occurs in ~40% of patients that receive heart transplant because of Chagas cardiomyopathy

Protozoa*

Extraintestinal

Apicomplexa (SAR)
- Plasmodia
- (Babesia)
- (Toxoplasma)

Flagellates (Excavata)
- Leishmania (kinetoplast)
- Trypanosomes (kinetoplast)
- (Trichomonas) (metamonad/no mitochondria)

Amoebae (Amoebozoa)
- Acanthamoeba
- Balamuthia

Amoeboflagellate (Excavata)
- Naegleria

Intestinal

Apicomplexa (SAR)
- Cryptosporidium (no apicoplast)
- Cyclospora
- Cystoisospora

Flagellates (Excavata)
- Giardia (metamonad)
- Dientamoeba (metamonad)

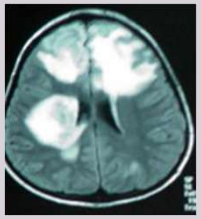
Amoebae (Amoebozoa)
- Entamoeba

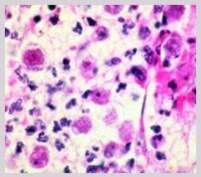
Ciliates (SAR)
- Balantidium

Non-motile (SAR)
- Blastocystis

Kingdom Fungi Microsporidiosis agents

Free-living Amoebae





Naegleria fowleri (amoeboflagellate!)
- Warm freshwater exposure
- Enters through olfactory neuroepithelium
- Fulminant meningoencephalitis
- Immunocompetent children/young adults

Acanthamoeba
- Found in soil and water
- Enter through lower respiratory tract or broken skin
- Subacute granulomatous encephalitis
- Immunocompromised hosts
- Chronic granulomatous keratitis (contact lens, LASIK)

Balamuthia mandrillaris
- Likely enters through lower respiratory tract or broken skin
- Transmission by solid organ transplantation has been reported
- Subacute granulomatous encephalitis
- Normal and immunocompromised hosts

Outcome → often fatal (amphotericin B, azoles, pentamidine, others tried)

SEE ENLARGED SLIDE FOLLOWING ENTIRE PRESENTATION

11 Protozoa That Could Be Tested

Speaker: Edward Mitre, MD

© 2026 Infectious Disease Board Review

Protozoa*

Extraintestinal	Intestinal
Apicomplexa (SAR)	**Apicomplexa (SAR)**
Plasmodia	Cryptosporidium (no apicoplast)
(Babesia)	Cyclospora
(Toxoplasma)	Cystoisospora
Flagellates (Excavata)	**Flagellates (Excavata)**
Leishmania (kinetoplast)	Giardia (metamonad)
Trypanosomes (kinetoplast)	Dientamoeba (metamonad)
(Trichomonas) (metamonad/no mitochondria)	**Amoebae (Amoebozoa)**
Amoebae (Amoebozoa)	Entamoeba
Acanthamoeba	**Ciliates (SAR)**
Balamuthia	Balantidium
Amoeboflagellate (Excavata)	**Non-motile (SAR)**
Naegleria	Blastocystis

Kingdom Fungi Microsporidiosis agents

When to Suspect an Intestinal Protozoan Infection

Patient has:

- Protracted watery diarrhea (weeks to months)

AND/OR:

- History of travel [domestic (esp. Camping) or foreign]
- Recreational water activities
- Altered immunity (HIV infection)
- Exposure to group care (daycare)

Note: Discussion will focus on intestinal protozoa as they occur in patients seen in the U.S. These are leading causes of diarrhea, morbidity, and mortality worldwide, especially in young children.

Intestinal Apicomplexa Parasites

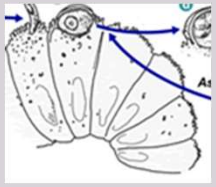
Cryptosporidium

- C. parvum: cows
- C. hominis: humans

Cyclospora cayetanensis

Cystoisospora belli

- All have worldwide distribution
- All transmitted by water or food contaminated with oocysts
- Organisms invade enterocytes
- All cause watery diarrhea that can be prolonged & severe in immunocompromised



Cryptosporidium in enterocyte. CDC DpDx

Intestinal Apicomplexa: Clinical Clues

Cryptosporidium

- Watery diarrhea of several weeks
- Cattle workers and daycare outbreaks
- Cysts are resistant to chlorine (water supply outbreaks)
- #1 cause of water park/swimming pool outbreaks

Cyclospora cayetanensis

- Self-limited immunocompetent BUT can last up to 10 weeks!
- Abrupt onset with nausea, vomiting, and fever early
- Anorexia, weight loss, fatigue late in course
- Food associated outbreaks: raspberries, lettuce, herbs
- Esp. Nepal, Peru, Guatemala

Cystoisospora belli

- No animal reservoirs known
- Watery diarrhea
- May be associated with a peripheral eosinophilia!

© 2026 Infectious Disease Board Review

Intestinal Apicomplexa Characteristics

Pathogen	Size	Stain	Treatment
Cryptosporidium	4 µm	M acid-fast	(None) nitazoxanide or paromomycin
Cyclospora	10 µm	M acid-fast	TMP/SMX
Cystoisospora	20 µm	M acid-fast	TMP/SMX

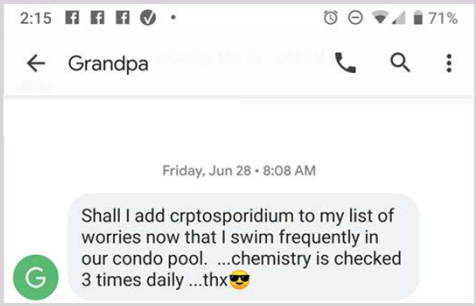
CDC

Molecular Tests

Most stool multiplex PCR assays detect cryptosporidium AND cyclospora
But NOT cystoisospora

Stool Ag tests are commercially available for cryptosporidium

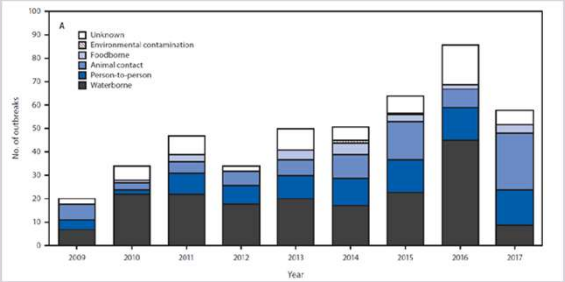
SEE ENLARGED SLIDE FOLLOWING ENTIRE PRESENTATION



Morbidity and Mortality Weekly Report

Cryptosporidiosis Outbreaks – United States, 2009 – 2017

MMWR / June 28, 2019 / Vol. 68 / No. 25



"The number of reported outbreaks has increased an average of approximately 13% per year."

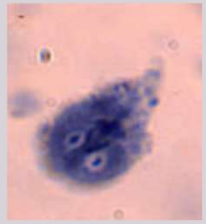
Giardia duodenalis

→ described by Antony van Leeuwenhoek in 1681!

Flagellated Protozoan
- Fecal/oral via ingestion of cyst form in food/water
- Cyst is chlorine resistant
- Cysts from humans (beavers, muskrats)

Disease in U.S.
- Most common parasitic infection in the U.S.
- (20k cases reported/year, likely 2m)
  - U.S-acquired cases peak in the late summer/early fall
  - A leading cause of traveler's diarrhea

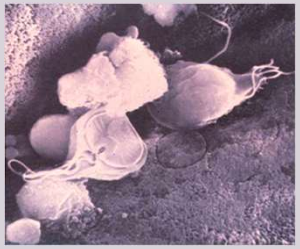
Symptoms
- Intermittent watery diarrhea weeks to months
- Foul smelling stools, flatulence, "sulfur burps"



© 2026 Infectious Disease Board Review

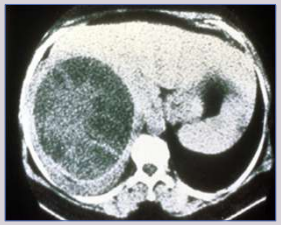
Giardia duodenalis

- **At Risk Populations**
  - International travelers
  - Swimming in lakes/streams, outdoor survival/camping
  - Infants in daycare
  - Childcare workers
  - Immunoglobulin deficiencies (esp CVID)
  - HIV when CD4 < 100
- **Diagnosis**
  - Stool antigen test
  - Stool multiplex PCR
- **Treatment**
  - Tinidazole (FDA approved)
  - Metronidazole (off-label), nitazoxanide (FDA-approved), and albendazole (off label)



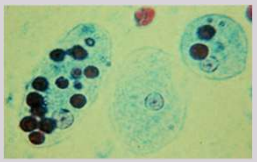
Entamoeba histolytica

- **Strictly Human Pathogen**
  - Fecal/oral (contaminated food/water)
  - Cysts = infective stage
  - Trophozoites = active form, tissue-destructive
- **Clinical Presentations**
  - Asymptomatic
  - Traveler's diarrhea
  - Colitis
    - Sharp abdominal pain
    - Bloody diarrhea
    - Fever
    - Flask-shaped ulcerations
    - Onset can occur weeks to months after travel



- Ameboma
- Liver and brain abscesses, esp in young men, usually 2-5 months after travel

Entamoeba histolytica



E. histolytica trophozoites with ingested RBCs.

Diagnosis

Stool PCR (multiplex or single)
- Close to 100% sensitivity and specificity

Stool O/P
- Only 50% sensitive for colitis and abscess
- Poor specificity b/c unable to differentiate *E.Histolytica* from non-pathogenic *E. Dispar* and the diarrhea-only causing *E. Moshkovskii*
  (Note: ingested RBCs suggestive of *eh*, but not 100%)

Stool antigen testing > 85% sensitive for intestinal disease

Serology 95% sensitive for liver abscess, 85% sensitive for intestinal infection

Treatment
- Asymptomatic: luminal agents such as paromomycin
- Symptomatic: tissue agents such as metronidazole or tinidazole THEN luminal agent
- Liver abscess: medical therapy (tissue agent then luminal agent) usually sufficient!
- Drainage if no response to medical therapy or dx unclear or v large abscess

Question #5

A 28-year-old woman returns after studying mosquito breeding habits in Honduras for one year. She reports intermittent abdominal pain and diarrhea for several months. Stool ova and parasite exam is positive for the presence of a ciliated single cell organism.

What is the most likely diagnosis?

A. Balantidium coli
B. Entamoeba histolytica
C. Giardia lamblia
D. Dientamoeba fragilis
E. Endolimax nana

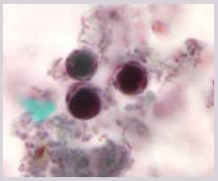
© 2026 Infectious Disease Board Review

Balantidium coli

CDC DpDx

- The only ciliated pathogen of humans!
- Largest protozoan pathogen of humans!
  - (About 70 µm wide and up to 200 µm long)
- Found worldwide, especially central and S. America, S.E. Asia, and Papua New Guinea
- Associated with eating food/water contaminated with pig feces
- Symptoms: most people asymptomatic
  - Can cause colitis with abdominal pain, weight loss, +/- diarrhea
  - (Especially in malnourished and immunocompromised)
- Treatment: tetracycline (!) or metronidazole

Blastocystis



Blastocystis cyst-like forms ,trichrome (CDC DpDx)

What is it?

- Currently classified as a protozoa
- Forms are 5-40 microns wide
- Anaerobic, Eukaryotic
  cystic, ameboid, granular, and vacuolar forms

Often the most common eukaryotic organism found in human stool samples

Does it cause disease?

- Maybe
- Associated with watery diarrhea, abdominal discomfort, nausea, and flatulence

Diagnosis

- Light microscopy of stool samples

Treatment?

- Metronidazole, tinidazole, TMP/SMX, or nitazoxanide (none FDA-approved)

Other Intestinal Protozoa

Non-pathogens

Amoebae	Flagellates
Entamoeba dispar	Chilomastix mesnili
Entamoeba hartmanni	Trichomonas hominis
Entamoeba coli	
Endolimax nana	
Iodamoeba bütschlii	

Treat if symptomatic: Dientamoeba fragilis (implicated in IBS)

Protozoa*

Extraintestinal	Intestinal
Apicomplexa (SAR)	**Apicomplexa (SAR)**
Plasmodia	Cryptosporidium (no apicoplast)
(Babesia)	Cyclospora
(Toxoplasma)	Cystoisospora
Flagellates (Excavata)	**Flagellates (Excavata)**
Leishmania (kinetoplast)	Giardia (metamonad)
Trypanosomes (kinetoplast)	Dientamoeba (metamonad)
(Trichomonas) (metamonad/no mitochondria)	**Amoebae (Amoebozoa)**
Amoebae (Amoebozoa)	Entamoeba
Acanthamoeba	**Ciliates (SAR)**
Balamuthia	Balantidium
Amoeboflagellate (Excavata)	**Non-motile (SAR)**
Naegleria	Blastocystis

Kingdom Fungi Microsporidiosis agents

11 Protozoa That Could Be Tested

Speaker: Edward Mitre, MD

© 2026 Infectious Disease Board Review

Microsporidia: Obligate Intracellular Fungi!

→ Produce extracellular, 1-2 micron, infective spores
→ Spores have a coiled organelle called a polar tubule
→ After ingestion, the spore germinates and the polar tubule is used to inject sporoplasm into a host cell

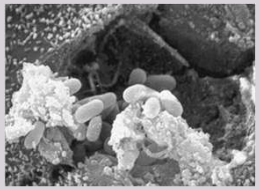
Enterocytozoon bieneusi
- Watery diarrhea
- Biliary disease (cholangitis, acalculous cholecystitis)

Encephalitozoon intestinalis
- Watery diarrhea
- Biliary disease
- Disseminated disease (liver, kidney, lung, sinuses)

Encephalitozoon cuniculi, hellem
- Can cause disseminated disease of multiple organs, plus eye

Many species (including *Vittaforma corneae*):
Punctate keratoconjunctivitis (contact lens use, after eye surgery, bathing in hot springs)

Diagnosis: modified trichrome stain, Calcofluor white, IFA to detect spores in stool
Treatment: albendazole (not effective for *E. bieneusi*)


Spores of *E. hellem* bursting out of a cell (CDC DpDx)


Polar tubule inserted into a eukaryotic cell (CDC DpDx)

Protozoan Infections that Can Reactivate in the Severely Immunocompromised

- **Toxoplasmosis**
  - Encephalitis with mass lesions
  - Pneumonitis
  - Retinitis
- **Leishmania**
  - Reactivation of visceral and cutaneous reported
  - Visceral with fever, hepatosplenomegaly, pancytopenia

Protozoan Infections that Can Reactivate in the Severely Immunocompromised

- **Chagas**
  - Encephalitis with mass lesions
  - Hepatosplenomegaly and fevers
  - Myocarditis in 40% that receive heart transplant b/c chagas disease
- **Malaria**

Some other protozoa that can cause severe disease in immunocompromised
- Cryptosporidium
- Giardia
- Microsporidia
- Babesia
- Acanthamoeba

Good luck on the exam!

Edward Mitre, M.D.
edwardmitre@gmail.com

© 2026 Infectious Disease Board Review