

APPLIED ENTOMOLOGY AND PARASITOLOGY

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Lecture (2)

Which Parasites Are Important for Humans?

Groups of Parasites

The selected parasites here belong mainly to a few groups inside the animal kingdom:

[1]- PROTISTS/PROTOZOA

... Unicellular organism and reduced specimens of different origins

[2]- HELMINTHS

... Worms, which belong to the animal phyla: *Platyhelminthes* (flatworms), *Nemathelminthes*, *Aschelminthes* (roundworms), *Acanthocephala* (thorny headed worms), *Annelida* (e.g. leeches) or *Pentastomida* (tongue worms).

... The members of these different worms range in a size from a few millimetres up to 30 m.

[3]- ARTHROPODA

... The name comes from a Greek term and means “feet with segments”.

... This worldwide distributed group includes subgroups such as *Chelicerata* (=Greek: horny claws, e.g. spiders), *insects* (=Latin: animals with a clearly segmented body, e.g. beetles, mosquitoes, bugs, etc.) and *Crustacea* (=Latin: animals with a hard body cover, e.g. shrimps, etc.).

... All members of these groups are characterized by a rather thick body cover containing chitin and often in addition lime components. All this together forms a stiff exoskeleton, the segments of which are interconnected by smooth ligaments thus guaranteeing flexibility.

... The specimens of this group harm their hosts either directly, e.g. by their sucking activity or by transmission of agents of diseases (viruses, bacteria, fungi and/or other parasites).

the below-listed simplified system gives just a short overview on the distribution of parasites among different groups of animals and humans:

Kingdom: Animalia (animals)

Subkingdom: Protozoa/Protista (unicellular stages)

Phylum: Sarcomastigophora – some parasitic species

Phylum: Opalozoa – commensals/parasitic

Phylum: Apicomplexa – many parasitic species

Phylum: Microspora – parasitic

Phylum: Myxozoa – multicellular stages, but looking like protozoa, parasitic

Phylum: Ascetospora – parasitic

Phylum: Ciliophora – some parasitic species

One of the modern systematics classifies the groups of Apicomplexa (Sporozoa), Dinoflagellata and Ciliophora into the new phylum Alveolata.

Intermediate group: Mesozoa – parasitic, e.g. reduced helminths

Subkingdom: Metazoa (multicellular organisms).

Phylum: Platyhelminthes (flatworms)

Class: Turbellaria – free living

Class: Trematodes – parasitic

Class: Cestodes – parasitic

Phylum: Nemathelminthes/Aschelminthes (roundworms)

Subphylum: Nematodes (thread worms) – some parasitic species

Phylum: Acanthocephala (thorny-headed worms) – parasitic

Phylum: Pentastomida (tongue worms) – parasitic

Phylum: Annelida

Class: Polychaeta – free living

Class: Clitellata (leeches) – parasitic

Phylum: Arthropoda – several parasitic species

Subphylum: Chelicerata (ticks, mites) – parasitic

Subphylum: Branchiata (Crustacea) – some parasitic species

Subphylum: Tracheata (insects) – many parasitic species

Organs of Humans and Their Typical (Common) Parasites

Localization	Parasitic stages	
Lumen of intestine and feces	Cysts of amoebae	
	<i>Giardia</i>	
	<i>Isoospora</i> oocysts	
	<i>Caryospora</i> oocysts	
	<i>Sarcocystis</i> oocysts	
	<i>Cryptosporidium</i> oocysts	
	<i>Balantidium</i> cysts	
	Microsporidian cysts	
	<i>Blastocystis</i> cysts	
	Worm eggs	
	Larvae of worms	
	Adult worms	
	Wall of the intestine	<i>Entamoeba</i> , magna forms
		<i>Giardia</i> trophozoites
<i>Isoospora</i> stages		
<i>Cryptosporidium</i> stages		
<i>Sarcocystis</i> stages		
<i>Caryospora</i> stages		
<i>Balantidium</i> trophozoites		
Microsporidian stages		
Adult trematodes		
Adult cestodes		
Hookworms		
<i>Anisakis</i> worms		
<i>Trichuris</i> worms		
<i>Gnathostoma</i> worms		
Acanthocephalan stages		
Pentastomid stages		
Lungs		<i>Pneumocystis carinii</i> stages
	<i>Paragonimus</i> worms	
	<i>Schistosoma</i> granulomes, adult worms	
	<i>Capillaria</i> stages	
Saliva	<i>Pneumocystis jirovecii</i> stages	
	Eggs of lung trematodes	
	<i>Echinococcus</i> hooks	
	Nematode larvae	
	<i>Trichomonas</i> mouth species	
Brain	<i>Entamoeba</i> species	
	Facultative amoebae	
	Cysts of amoebae	
	<i>Toxoplasma gondii</i>	
	<i>Encephalitozoon</i> stages	

Localization	Parasitic stages
Fluid	Cysticercus of tapeworms
	Larvae of nematodes
	<i>Trypanosoma</i> species
	Amoebae
Lymph, lymph nodes	<i>Toxoplasma gondii</i> zoites
	<i>Angiostrongylus cantonensis</i>
	<i>Leishmania</i> stages
	<i>Toxoplasma gondii</i> zoites
	Filarial larvae
Blood	<i>Trypanosoma</i> stages
	<i>Leishmania</i> stages
	<i>Plasmodium</i> stages
	<i>Babesia</i> stages
	<i>Schistosoma</i> larvae, adults
	<i>Dirofilaria</i> stages
	Filarial larvae
	<i>Angiostrongylus</i> stages
	<i>Loa loa</i> stages
	<i>Onchocerca volvulus</i> stages
<i>Dracunculus medinensis</i> stages	
Subcutaneous tissues	<i>Mansonella</i> stages
	<i>Leishmania</i> stages
	<i>Onchocerca</i> stages
Inside skin	Mites
	Sand fleas (<i>Tunga</i>)
On the skin surface	Mosquitoes
	Flies
	Midges
	Simuliids
	Tabanids
	Fleas
	Lice
	Bugs
	Mites
	Ticks
Eye	Leeches
	Vampire bats
	<i>Acanthamoeba</i> stages
	<i>Loa loa</i> worms
	<i>Onchocerca volvulus</i> larvae
	<i>Philophthalmus</i> species
	<i>Thelazia</i> species
	Microsporidian stages

Localization	Parasitic stages
Nose	Larvae of tapeworms and trematodes
	Pentastomids
	<i>Leishmania</i> species
	Amoebae
Spleen	<i>Microsporidia</i>
	Fly larvae
	Pentastomid worms
	<i>Leishmania</i> species
Bone marrow	<i>Toxoplasma gondii</i>
	Filarial larvae
	<i>Leishmania donovani</i>
	<i>Trypanosoma cruzi</i>
Genital- and excretion organs	<i>Toxoplasma gondii</i>
	<i>Microsporidia</i>
	<i>Trichomonas vaginalis</i>
	<i>Microsporidia</i>
	<i>Schistosoma</i> eggs
	Microfilariae
	<i>Diocotophyme renale</i> stages
	<i>Enterobius vermicularis</i>
	Fly maggots
	Vampire fish
Muscles	<i>Toxoplasma gondii</i>
	<i>Trypanosoma cruzi</i>
	<i>Sarcocystis</i> species
	Cysticerci of tapeworms
Liver	<i>Trichinella</i> species
	<i>Plasmodium</i> stages
	Abscesses of <i>Entamoeba histolytica</i>
	<i>Fasciola hepatica</i>
	<i>Dicrocoelium dendriticum</i>
	<i>Clonorchis sinensis</i>
	<i>Opisthorchis</i> species
	<i>Schistosoma</i> granulomes
	<i>Echinococcus</i> cysts and abscesses
	Larvae of nematodes
Pentastomids	

Attention: Many other parasites may be found accidentally in any through blooded organ!

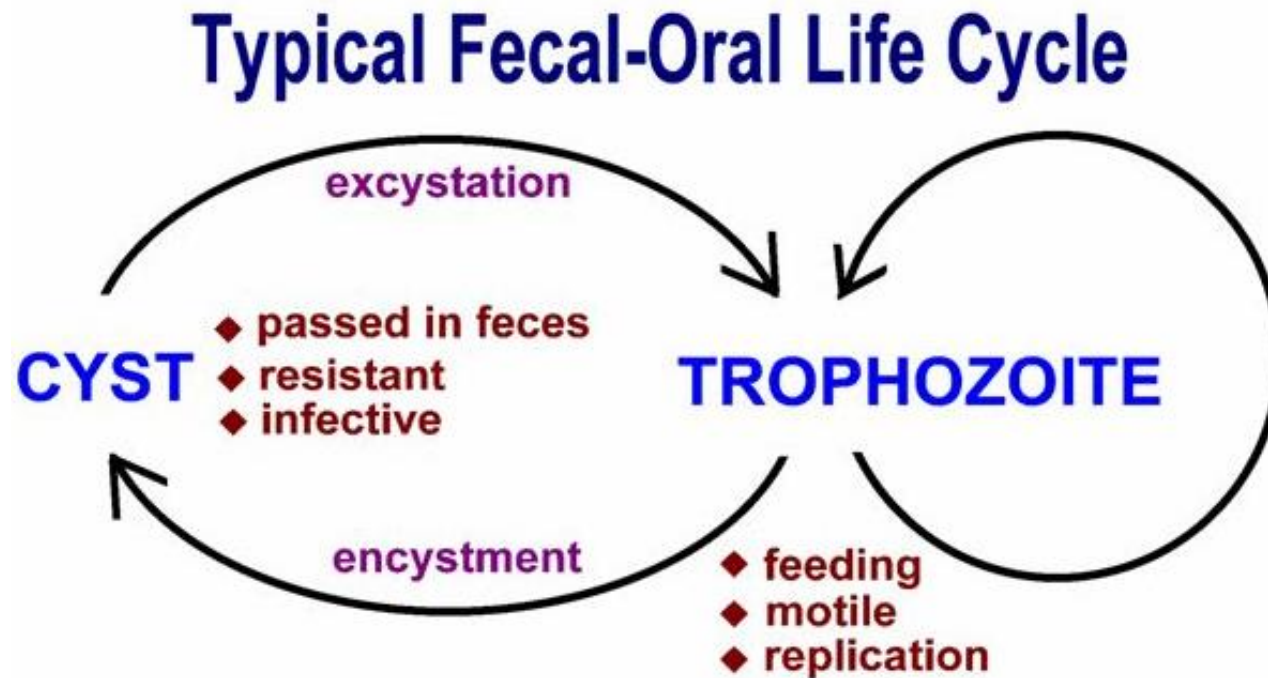
Protozoans Attacking Humans



Luminal Parasitic Protists

.... Protozoa colonize and infect the oro-pharynx, duodenum and colon.

.... They are transmitted by the fecal-oral route (food/water).



.... Outbreaks of diarrhea and dysentery are especially problematic in daycare centers.

.... The cyst forms of protozoa are resistant to chlorine and can become important when the municipal water supply is overburdened with these organisms

Flagellates:

- ***Giardia lamblia***
- *Dientamoeba fragilis*
- *Chilomastix mesnili*
- *Trichomonas hominis*
- *Enteromonas hominis*
- *Retortamonas intestinalis*

Ameba:

- ***Entamoeba histolytica***
- *Entamoeba dispar*
- *Entamoeba coli*
- *Entamoeba hartmanni*
- *Endolimax nana*
- *Iodamoeba bütschlii*

Apicomplexa:

- *Cryptosporidium parvum*
- *Cyclospora cayetanensis*
- *Isospora belli*

Microsporidia:

- *Enterocytozoon bieneusi*
- *Encephalitozoon intestinalis*

Other:

- *Blastocystis hominis*
- *Balantidium coli*

INTESTINAL PROTOZOA

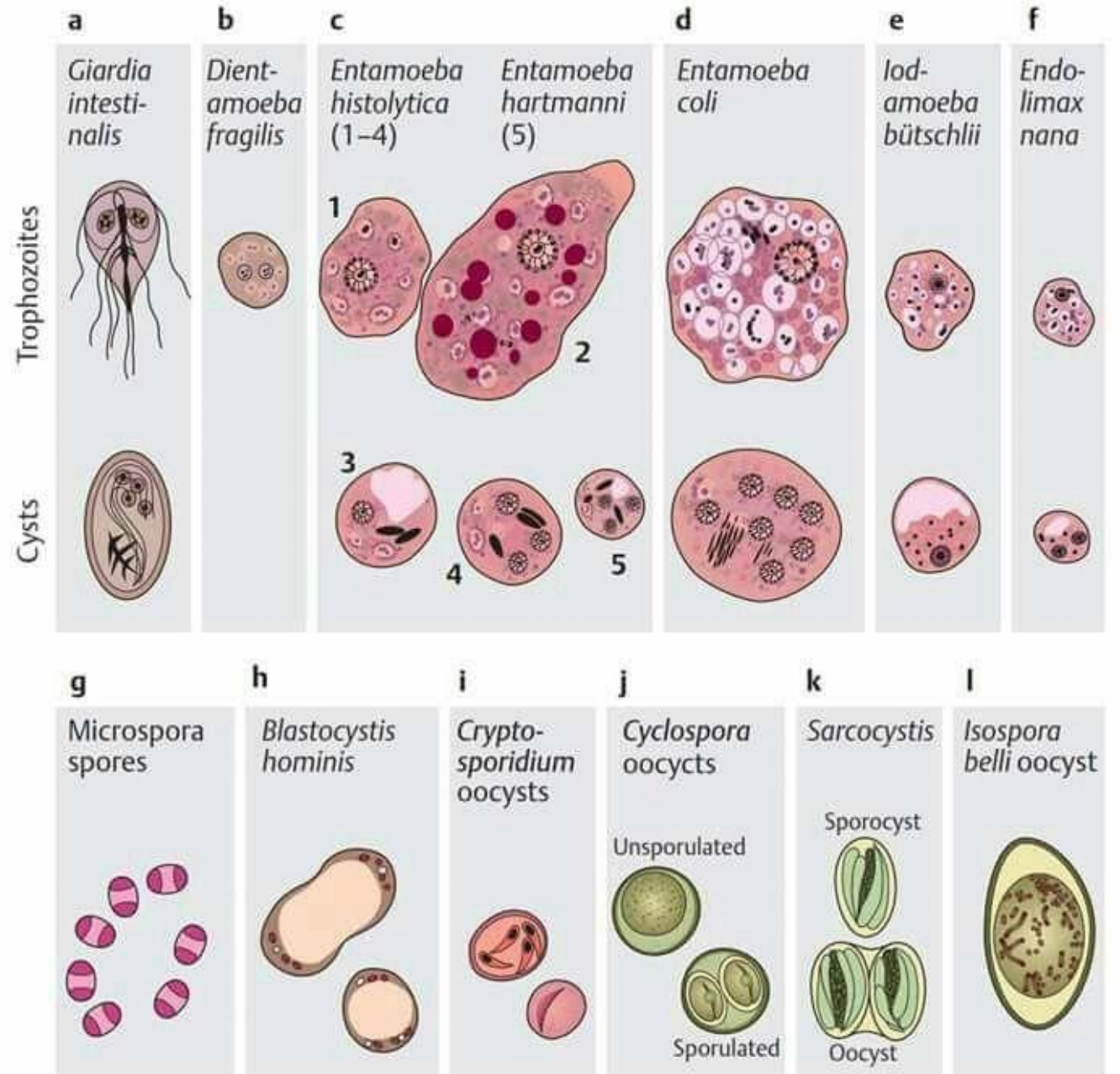
• Pathogenic

- *Entamoeba histolytica*
- *Balantidium coli*
- *Giardia lamblia*
- *Dientamoeba fragilis*
- *Cryptosporidium parvum*
- *Enterocytozoon bieneusi*
- *Septata intestinalis*
- *Cyclospora cayentanensis*
- *Isospora belli*

• Commensal

- *Entamoeba hartmani*
- *Entamoeba dispar*
- *Entamoeba coli*
- *Endolimax nana*
- *Iodamoeba bütschlii*
- *Chilomastix mesnili*
- *Trichomonas hominis*
- *Blastocystis hominis*

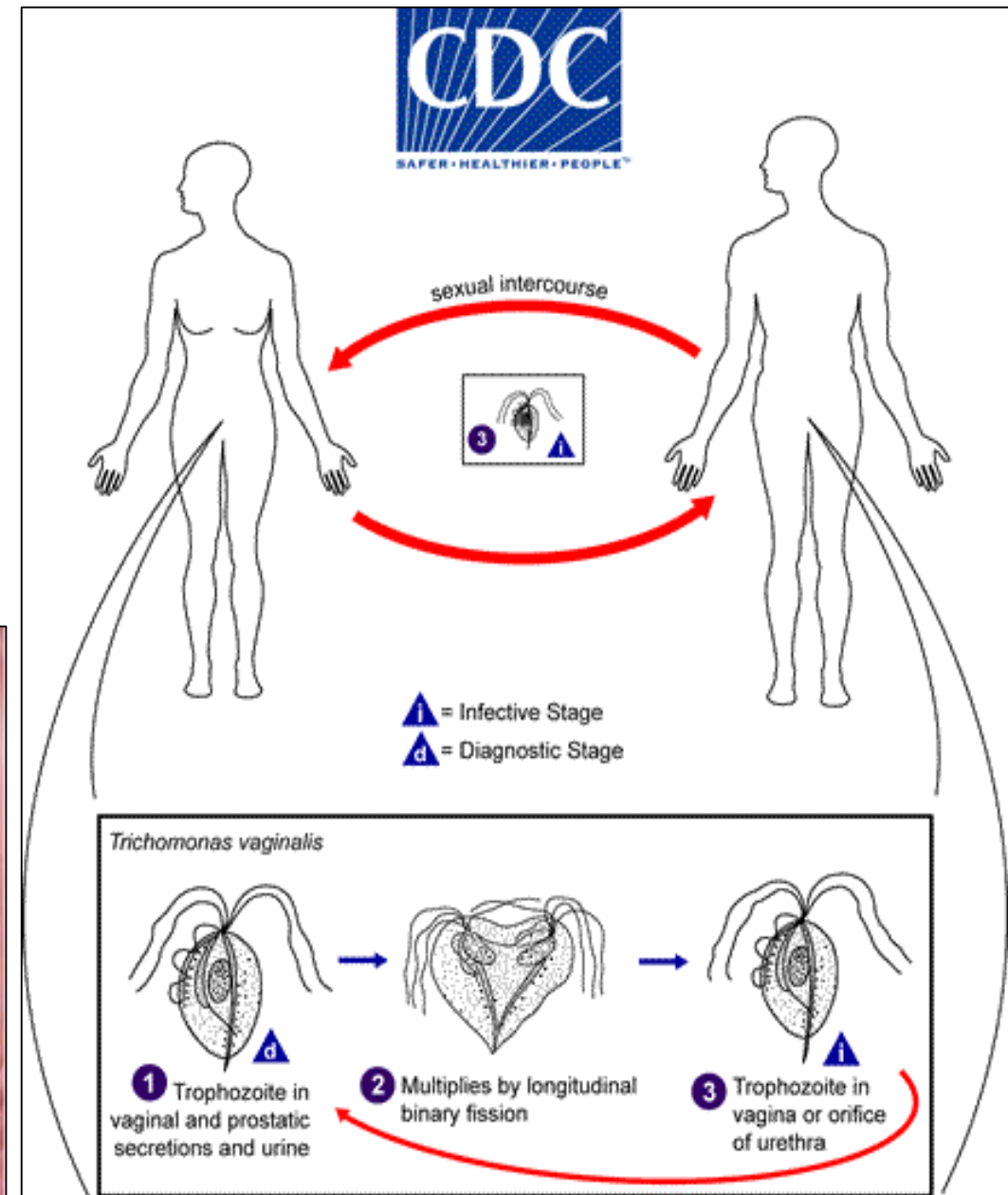
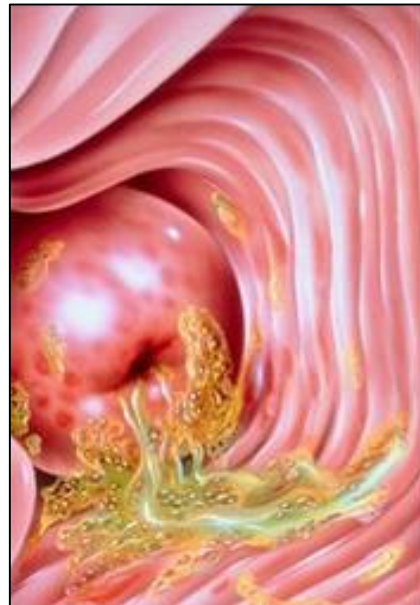
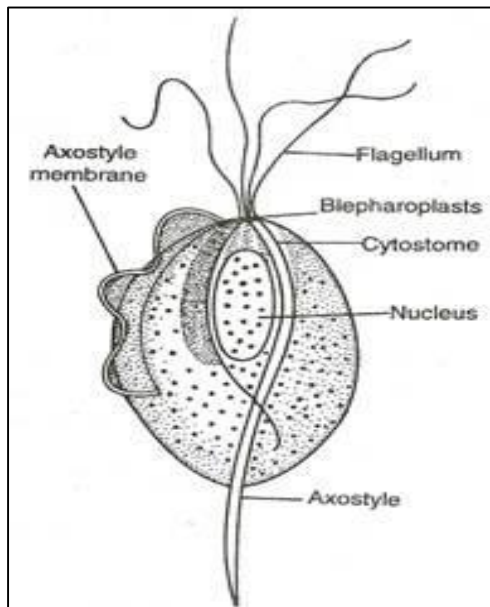
Differential Diagnosis of Intestinal Protozoa



Trichomonas vaginalis

It is the causative agent of **TRICHOMONIASIS**. Infection rates between men and women are similar with women usually being symptomatic, while infections in men are usually asymptomatic.

...*Trichomonas vaginalis* resides in the female lower genital tract and the male urethra and prostate, where it replicates by binary fission. The parasite does not appear to have a cyst form, and does not survive well in the external environment. *Trichomonas vaginalis* is transmitted among humans by *sexual intercourse*.



Symptoms of the disease (trichomoniasis):

The incubation time ranges from a few days to several weeks.



In case of infections of females, slimy whitish-yellowish excretions may occur on the mucosa of the vagina. If there occurs a pelvic inflammatory disease, other agents of diseases have to be considered, too.



In case of infections of males, the excretion of urine may be blocked partly in the urethra. If prostatitis or epididymitis occurs, other agents of diseases have to be considered, too.

Longtime trichomoniasis in males and females may lead to infertility.

Patency:

Several months to years in cases of lack of hygiene or due to reinfection (ping-pong type) via an infected partner who does not show symptoms.

Therapy:

It is important that both sexual partners must be treated at the same time to prevent a new infection.

Nitroimidazole derivatives (e.g. metronidazole) are highly recommended by using either 2 g as a single dose or (especially in case of therapy failure) 2 × 500 mg daily for 7 days eventually in combination with vaginal suppositories containing metronidazole (100 mg daily).

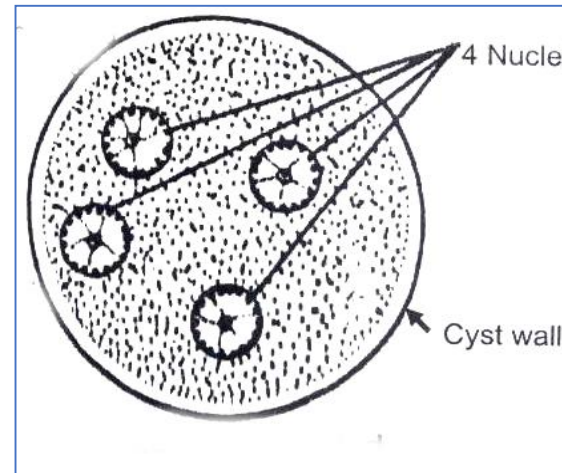
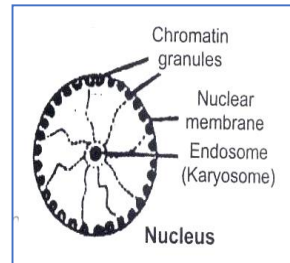
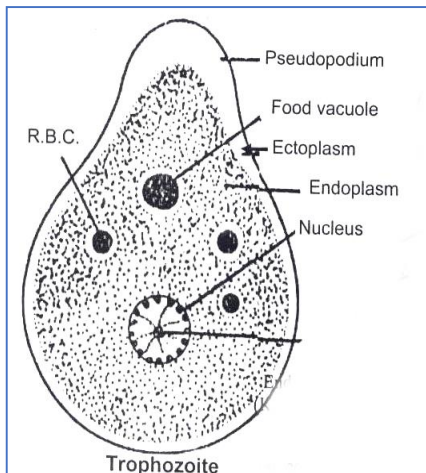
Entamoeba histolytica

(Entamobiasis, Amoebiasis and Bloody Flu)

... It is an amoeba that feeds on cells in the human colon. It is the cause of amebic dysentery (bloody diarrhea) as well as colonic ulcerations. The infection is also known as *amebiasis*. *If it is spread throughout the body via the bloodstream, it cause abscesses in the liver and other organs.*

... The infective stage is *quadrinucleate cyst*.

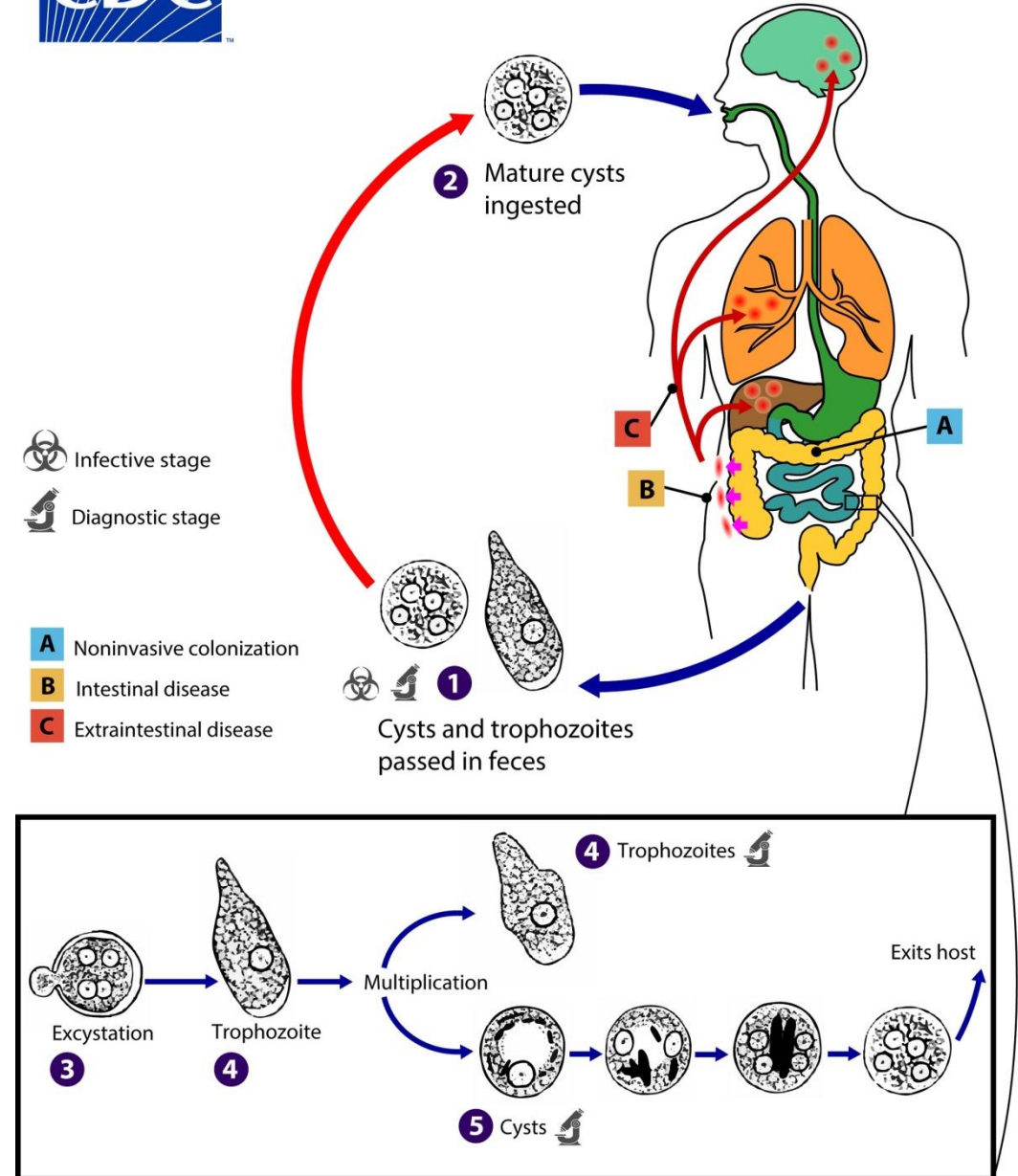
... *Mode of infection* via eating raw vegetables, drinking contaminated water, flies, Faecal-oral route (autoinfection).



Two stages of *E. histolytica* which are trophozoite and cysts



Amebiasis



Clinical aspect

[1]- Asymptomatic infection

The infected persons are usually healthy carriers who excrete millions of cysts/day without any clinical symptoms. Very dangerous as a source of infection and spread.

[2]- Symptomatic infection

A- Intestinal amoebiasis

- Acute dysentery (diarrhea alternating with constipation, tenesmus with blood and mucus in stool).
- Chronic non-dysenteric amoebiasis.

B- Extra-intestinal amoebiasis

- The trophozoite may disseminate via blood to other extra-intestinal sites e.g. in the liver, lung, brain, etc.)

Therapy.

Metronidazole- penetrates deeper tissues and destroys amoeba present in liver, brain, lungs, etc...

Paromomycin- is the second drug used to eradicate the amoeba present in the intestinal lumen.

Incubation period: 2–21 days for intestinal stages; liver abscesses mostly occur about 2–3 months after oral infection.

Patency: Eventually years.

The organism's metabolism converts the drug into its lethal form.

Attention: Metronidazole and paromomycin are not allowed during pregnancy.

Entamoeba gingivalis

... It is spread in the gingival and dental plaque of more than 50% of humans. It commonly feed on bacteria within plaques.

... *It is characterized by:*

a very distinctive ectoplasm, the chromatin of the nucleus is slightly more even distributed than in the case of *E. histolytica*, the nucleolus is situated in the center of the cell, vacuoles with lyophilized leucocytes often occur in the endoplasm.

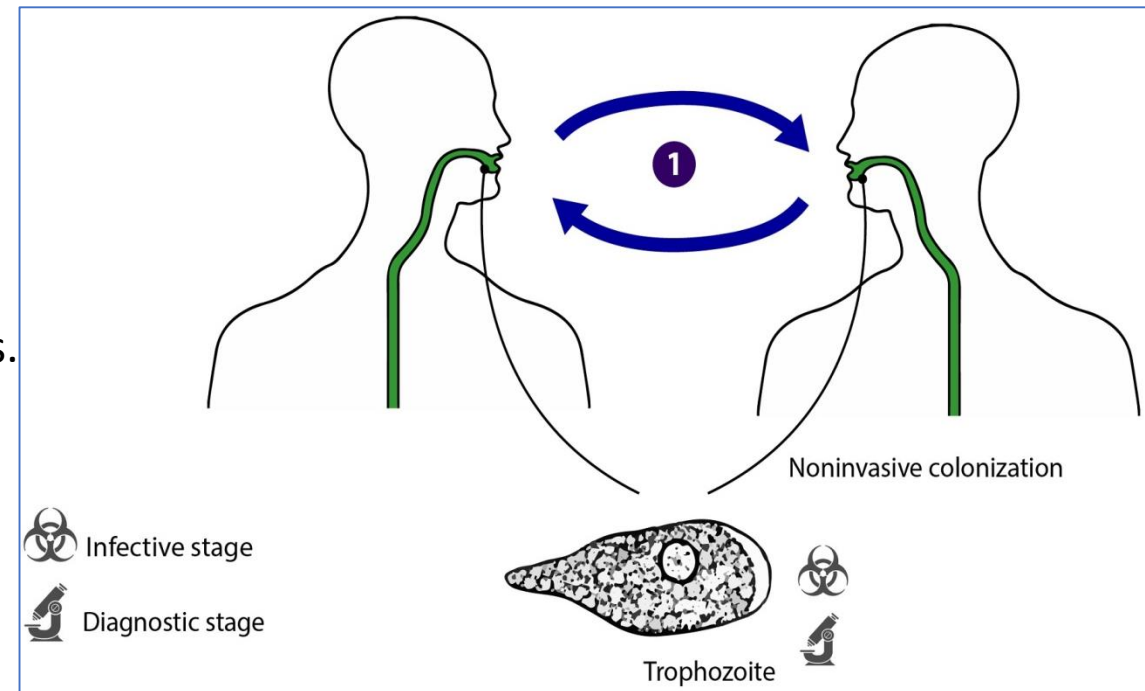
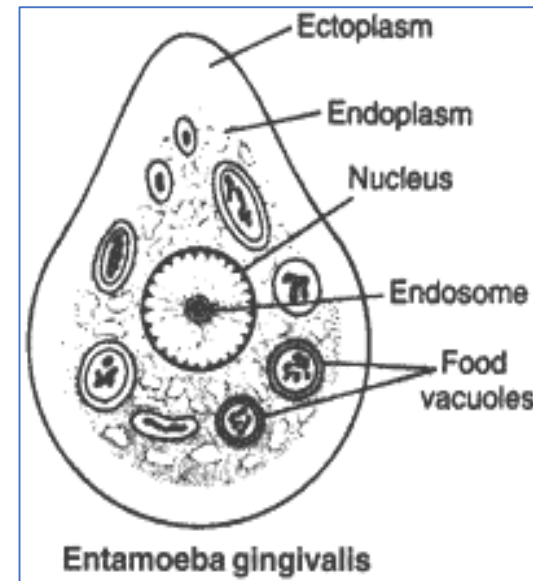
Do not produce cysts and thus they do not survive an intestinal passage. Therefore they have to be transmitted during *mouth to mouth contacts*.

Symptoms of the disease: None, or forming maxillo-dental abscesses.

Incubation period: Unknown

Patency: Months to years in cases of poor hygiene of the mouth.

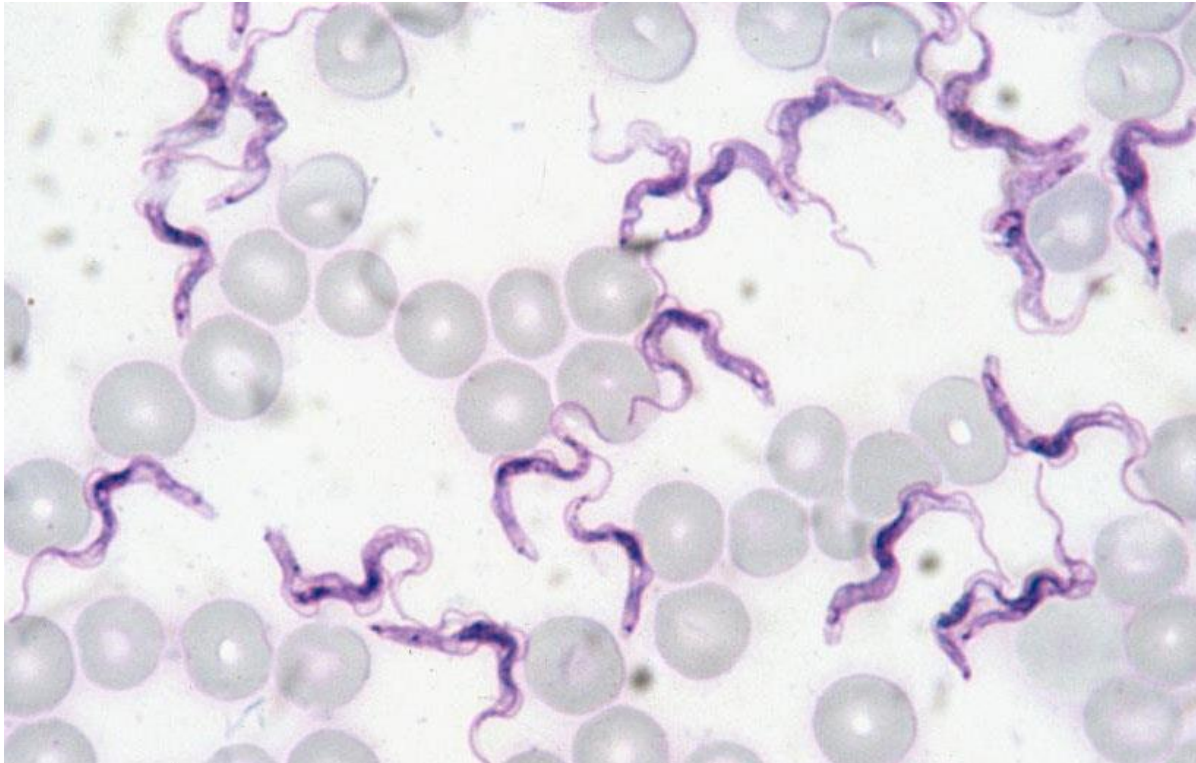
Therapy: Not necessary in cases of adequate mouth hygiene.



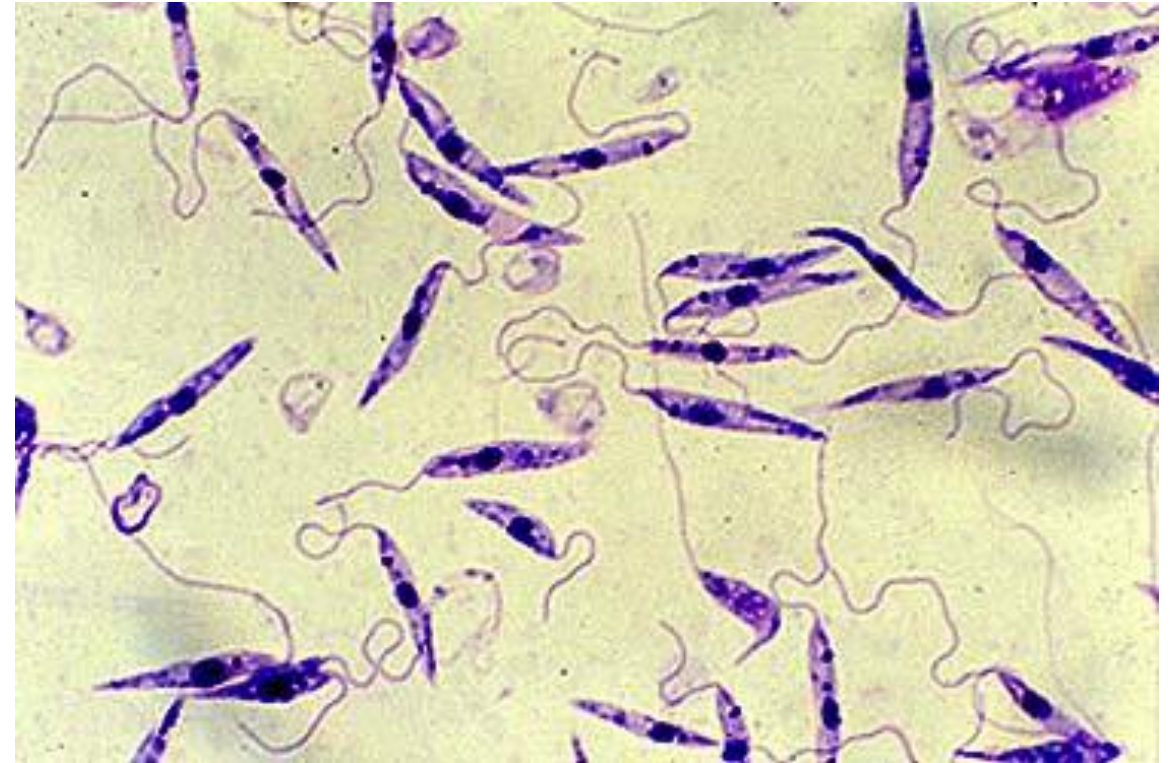
HEMOFLAGELLATES

The family **Trypanosomatidae** contains only two genera that parasitize humans.

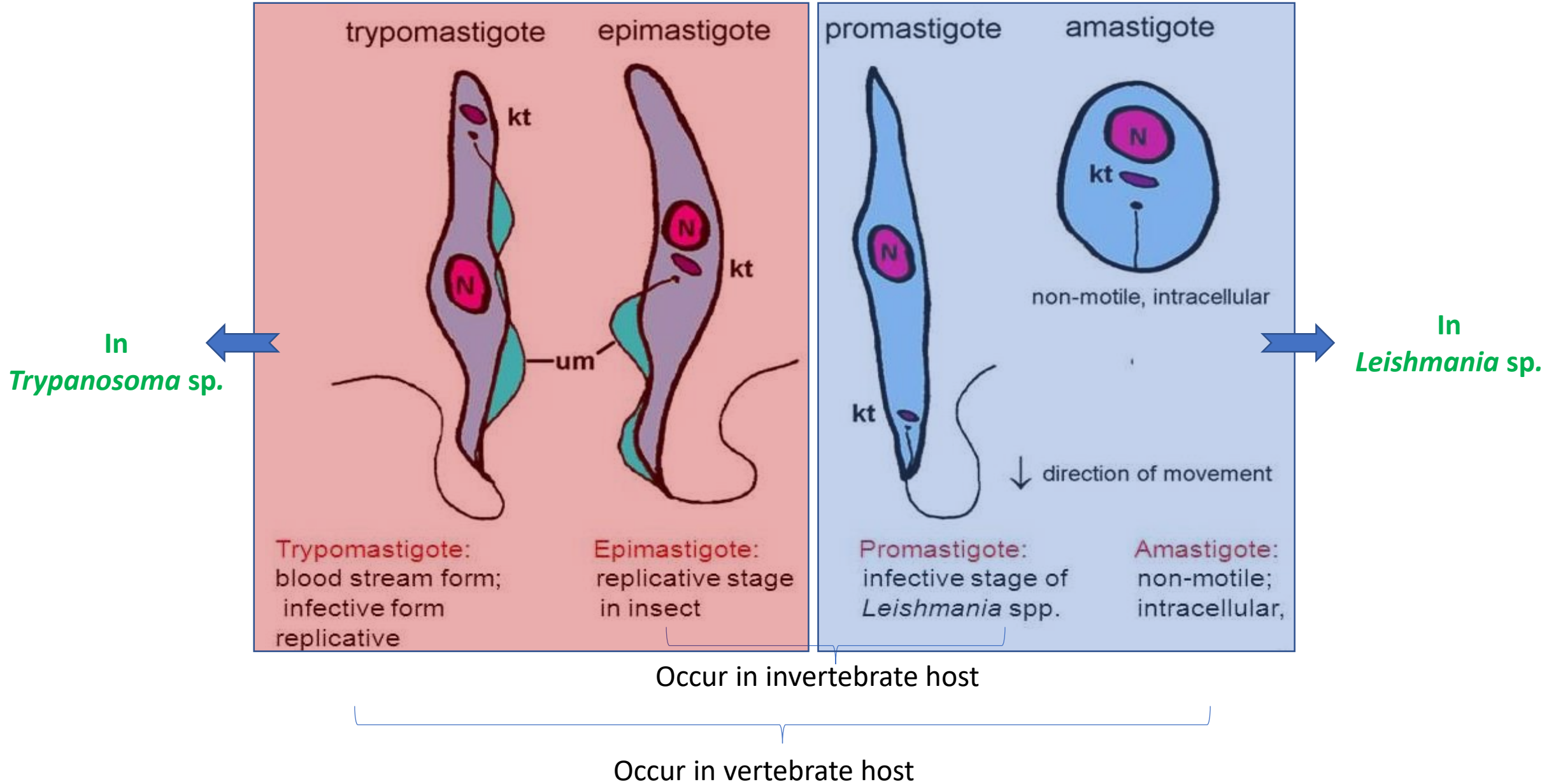
Genus *Trypanosoma* contains members that may be found intercellularly in the circulating blood cells.



Genus *Leishmania* are always intracellularly, principally in cells of the reticuloendothelial system.



Morphotype classes of trypanosomatids:

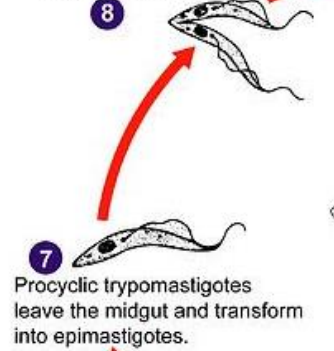


Sleeping Sickness, African (African trypanosomiasis)

(*Trypanosoma brucei gambiense*)
(*Trypanosoma brucei rhodesiense*)

Tsetse fly Stages

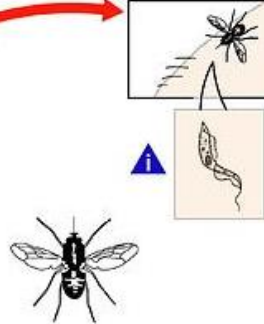
Epimastigotes multiply in salivary gland. They transform into metacyclic trypomastigotes.



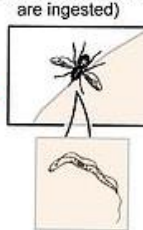
Procyclic trypomastigotes leave the midgut and transform into epimastigotes.

Bloodstream trypomastigotes transform into procyclic trypomastigotes in tsetse fly's midgut. Procyclic trypomastigotes multiply by binary fission.

1 Tsetse fly takes a blood meal (injects metacyclic trypomastigotes)



5 Tsetse fly takes a blood meal (bloodstream trypomastigotes are ingested)



Human Stages

2 Injected metacyclic trypomastigotes transform into bloodstream trypomastigotes, which are carried to other sites.

3 Trypomastigotes multiply by binary fission in various body fluids, e.g., blood, lymph, and spinal fluid.

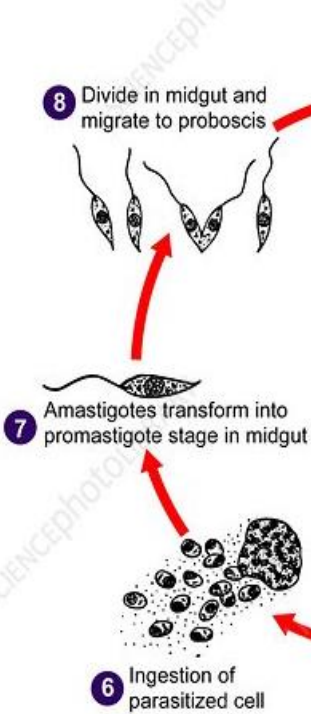
4 Trypomastigotes in blood

i = Infective Stage
d = Diagnostic Stage

Leishmaniasis

(*Leishmania spp.*)

Sandfly Stages



i = Infective Stage
d = Diagnostic Stage

1 Sandfly takes a blood meal (injects promastigote stage into the skin)

Human Stages

2 Promastigotes are phagocytized by macrophages

3 Promastigotes transform into amastigotes inside macrophages

4 Amastigotes multiply in cells (including macrophages) of various tissues

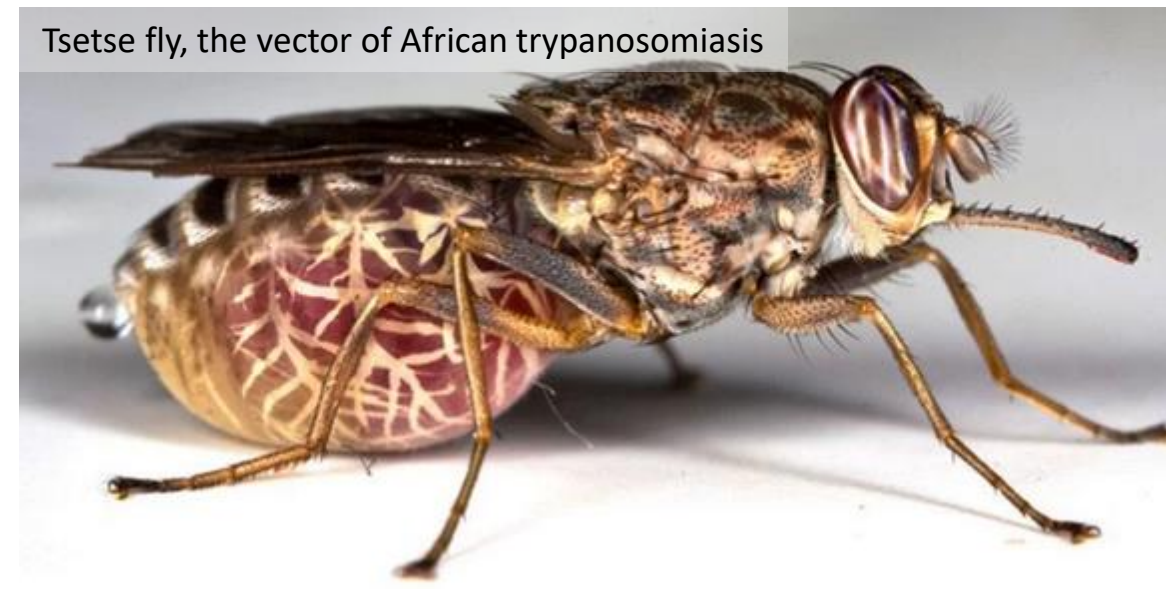
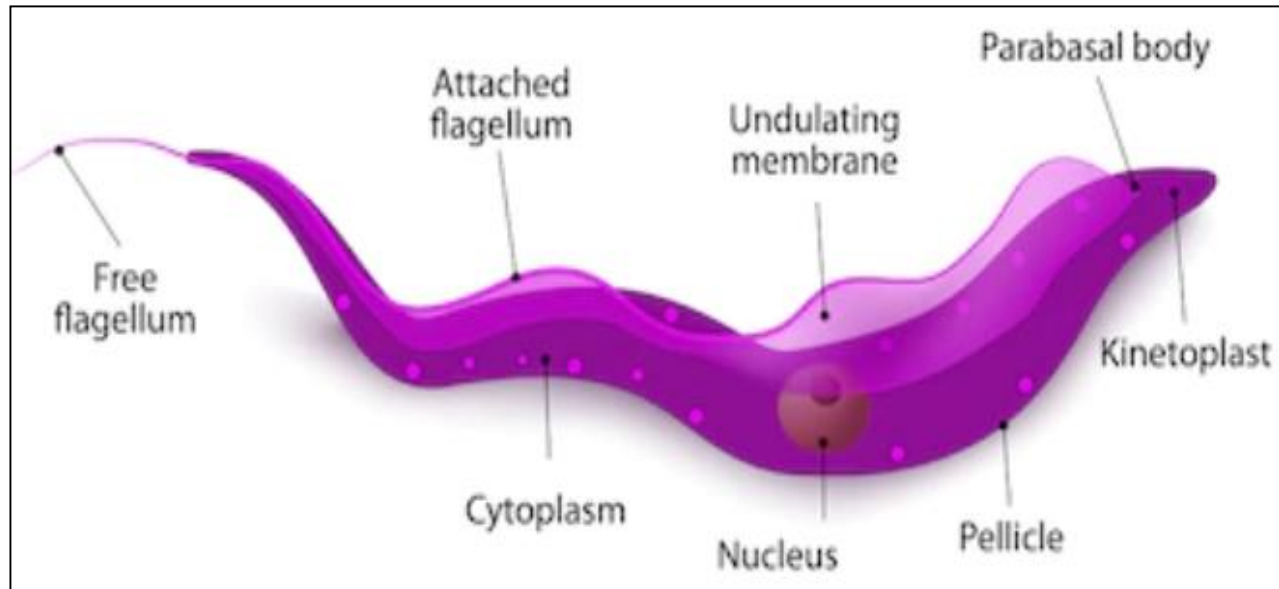
5 Sandfly takes a blood meal (ingests macrophages infected with amastigotes)

6 Ingestion of parasitized cell

i = Infective Stage
d = Diagnostic Stage

Trypanosoma brucei Group (African Trypanosomiasis)

...They are *Trypanosoma* species develop in the anterior portion of the insect gut. When the infective stages enter the salivary glands they will be Transmitted by *bite of an insect*.



Symptoms of the disease (trypanosomiasis, trypanosomosis)

[1]- First stage

Primary reactions appear as swellings at the biting site, followed by local oedema. They remain visible for about 1–3 weeks due to the massive local multiplication of the parasite.

Fever (reaching about 39 °C) occurs from 2–4 weeks after infection because of multiplication of the parasites in the circulating blood fluid. During this period the trypanosomes become first visible in blood smears. Therefore this period is called incubation time. Fever can last 2–3 weeks, depending on how quick most of the parasites are eliminated by human antibodies. They can be accompanied by shivers and chills in the case of *T. brucei rhodesiense*.

Lymph node swellings occur because the parasites spread over the whole lymph system at the time when the parasites first appear in the blood. Swellings in the neck region of the patients are very characteristic during this period. However, in the case of infections with *T. brucei rhodesiense*, lymph node swellings are rare.



[2]- Second stage

The invasion of the central nerve system of humans occurs in *T.b. rhodesiense* about 3 months after infection, while in the case of *T.b. gambiense*, it takes about 9–18 months, which leads to the formation of a progressing meningoencephalitis and ends fatal (if there is no treatment at an early date at the beginning of the brain invasion).

The untreated final phase of the disease is characterized by a permanent unconsciousness, which led to the trivial description of this disease as sleeping sickness.

Trypanosoma brucei brucei

(Vertebrate host or final hosts are ruminants and horses and while the vector is the tsetse flies; disease in animals termed **nagana disease**...symptoms fever, weakness, which lead to weight loss and anemia)

***Trypanosoma brucei gambiense***

(Humans are the main vertebrate host; vectors are the tsetse flies, they cause the **sleeping sickness** or the **West African trypanosomiasis**)

***Trypanosoma brucei rhodesiense***

(Humans are the vertebrate hosts; vectors are tsetse flies, they cause **sleeping sickness** or the **East African trypanosomiasis**)

**Incubation period:**

1–21 days after the bite of an infected tsetse fly, an oedema is produced at the biting site (primary effect). After 3 weeks high fever may start. However, it takes up to 1 year until cerebral symptoms occur after infections with *T.b. gambiense*, and in cases of *T.b. rhodesiense*, occur already after 3 months.

Patency:

Eventually years in cases of chronic infections with *T.b. gambiense*. Months in cases of *T.b. rhodesiense*, mostly leading to quick death in untreated cases.

Therapy.

[1]- West-African sleeping sickness

Without treatment this variation of the sleeping sickness leads to death. However, the following treatment scheme has shown good results:

Phase 1: The use of pentamidine (Company Sanofi-Aventis): 4 mg/kg body weight (max. daily doses 200 mg). Treatment is done for 7–10 days per intramuscular injection.

Phase 2: The use of melarsoprol & eflornithine; Melarsoprol, 10 days 2.2 mg/kg bodyweight. Eflornithine: 14 days, 4 × daily (=all 4 h) 100 mg/kg bodyweight applied as infusion. This compound is used especially in cases of melarsoprol resistance.

[2]- East-African sleeping sickness

Without immediate treatment this disease remains fatal. Even under treatment about 10–15% of the patients die.

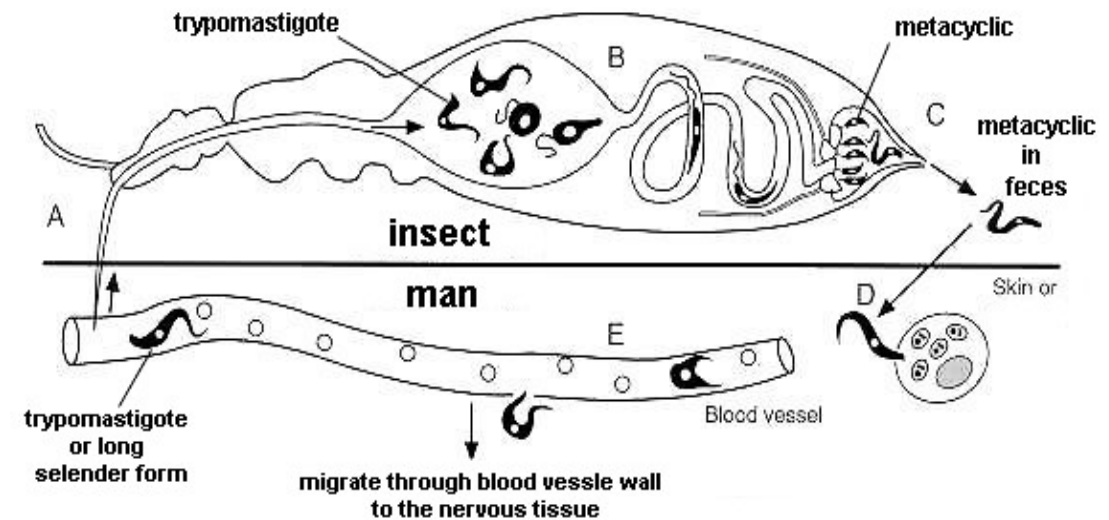
Phase 1: Still today the product Suramin[®] = Germanin[®] is the product of choice; a 10% solution has to be injected into veins (1 g per injection = 20 mg/ kg body weight) on days 1, 3, 7, 14 and 21. A total maximum of 5 g should not be exceeded.

Phase 2: The use of melarsoprol (Arsobal[®]) is still the product of choice. The daily simple dose (3.6 mg/kg body weight) should be injected for 3–4 days. Then a nontreatment period of several days should follow. In total 3–4 such cycles should be done.

Trypanosoma cruzi... "Chagas' disease".

...They are *Trypanosoma* species develop in posterior portion of insect gut (hind gut). Infective stages transmitted *in feces of insects*.

...Metacyclic (= infectious) stage inside rectum of bugs. These stages are set free in fecal droplets during blood meal on their hosts. They enter the skin after the blood meal through *a bite channel, or scratched skin*. Inside the mammalian host they penetrate into various cells.



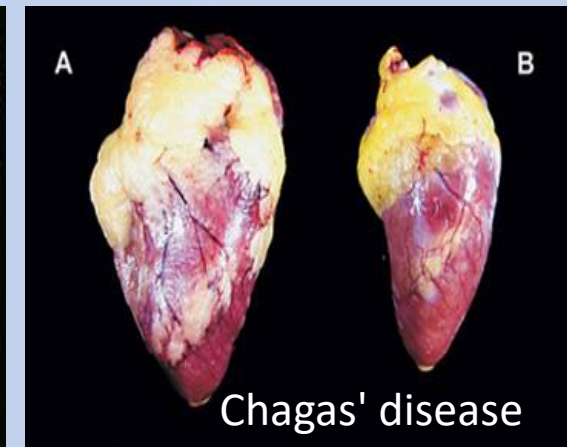
Pathogenesis:

a....Local acute inflammation at bite site (chagoma); if this occurs near eye with swelling of eyelid area, termed **Romana's sign**.

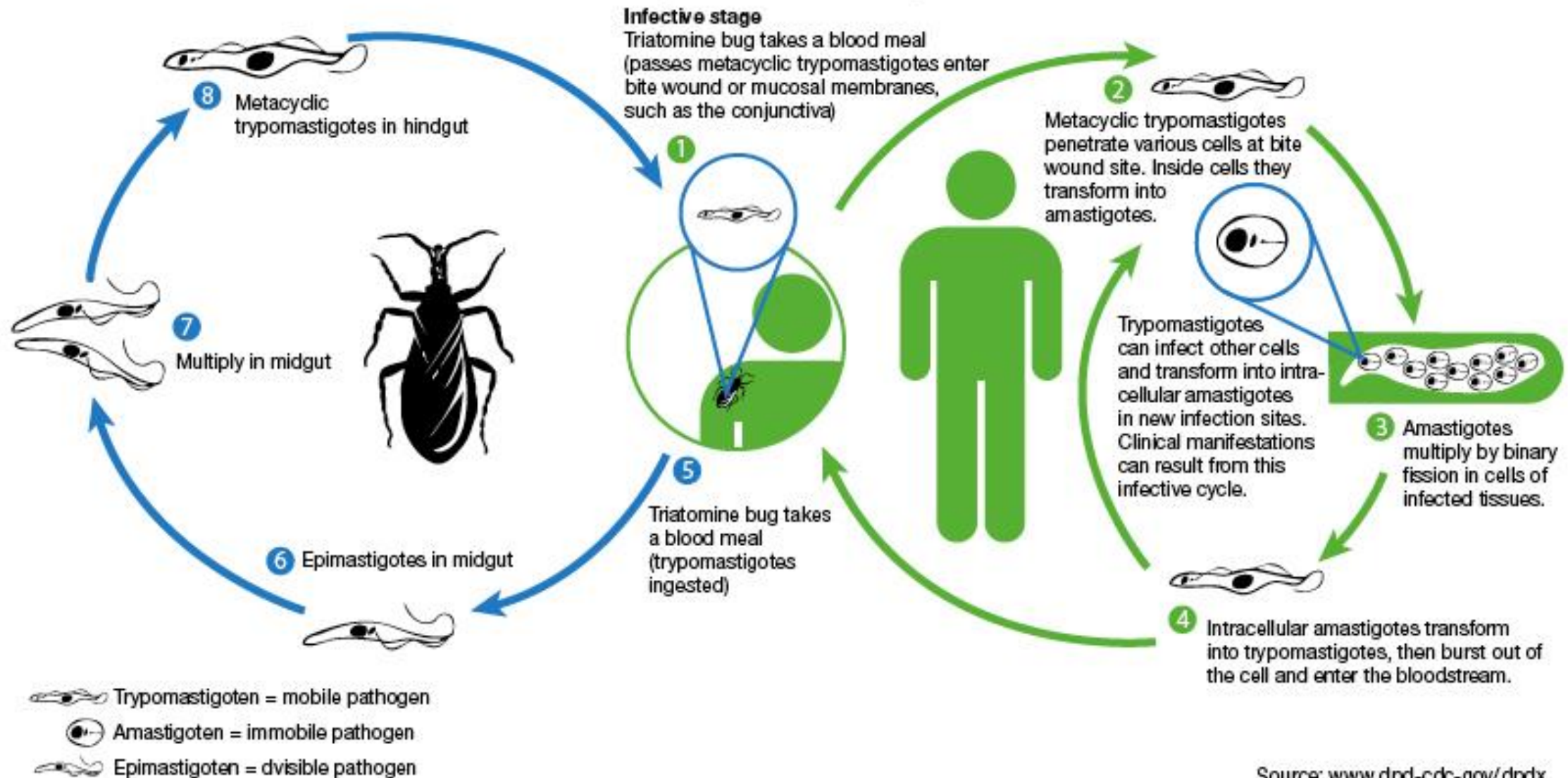
b....Gradual degeneration of tissues throughout body, the most severe of which are muscle cells which cannot be replaced.

c....Edema, chills, fever, muscle pain and weakness, megaesophagus, megacolon, heart failure, death.

d....Disease manifestations termed "**Chagas' disease**".



Infection cycles of Chagas disease



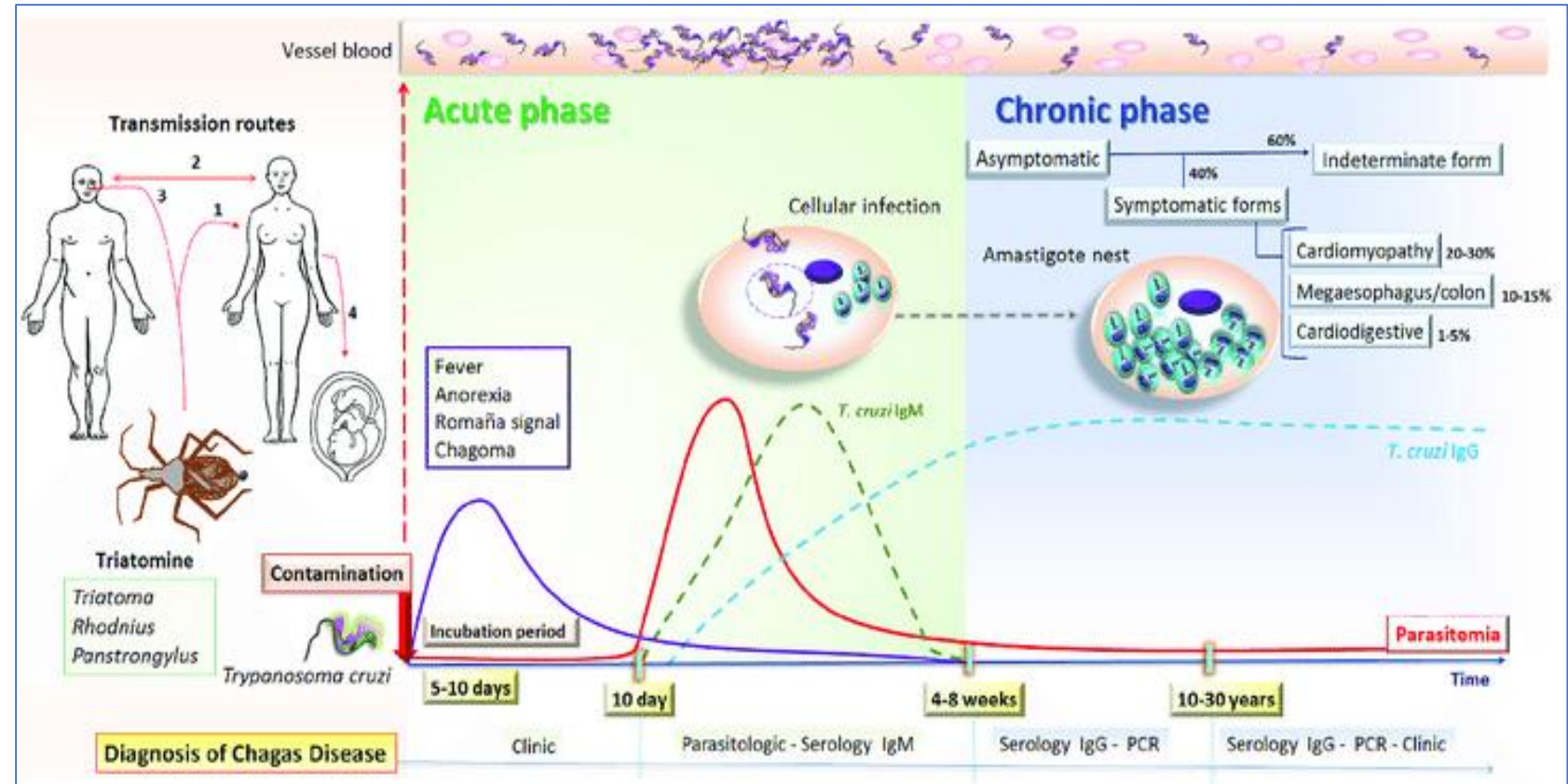
Incubation period:

5–20 days until occurrence of oedema (e.g. along the eyelid).

Patency:

Eventually many years in cases of chronic courses.

Therapy.



Nifurtimox (Lampit®) during the chronic phase:

1. 8–10 mg/kg body weight is recommended for adults (in three divided doses) for 90 days;
2. children should get higher doses (15–20 mg) for 90 days divided into four daily portions.

Benznidazole (Radanil®) is effective when given 5–7 mg/kg bodyweight in two divided portions for 60 days, while children should get daily 10 mg in the same way.

**Any
questions**

