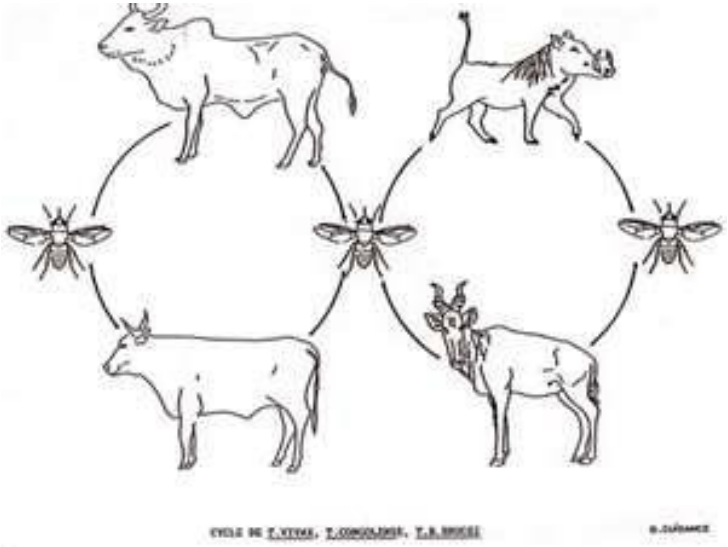
Diversity of parasitic life cycles and consequences for human and animal health



International Master
TU N°02, Infectiology
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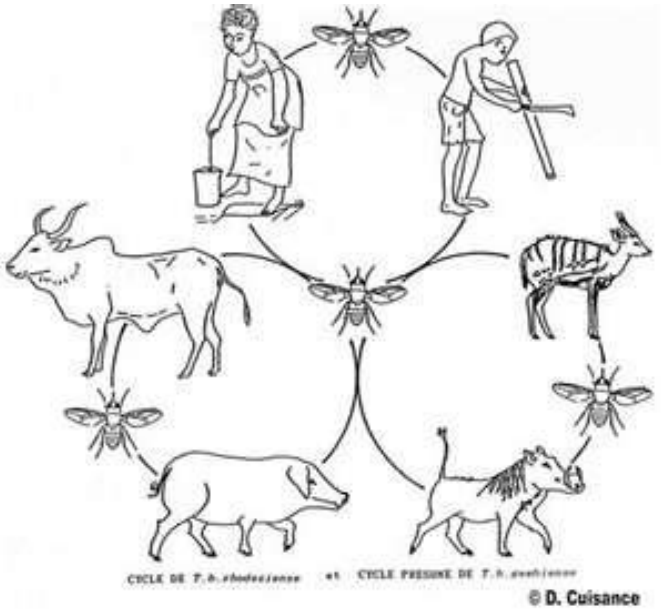


Some definitions in parasitology

Parasite

Living organism (animal or vegetal) dependent of another organism named « host »
→ This dependence being transitory or definitive during the parasite life

When parasites only infect humans → Anthroponosis
When animal parasites infect humans → Zoonosis
Epidemiological incidence → Adapted control in the field (One Health concept)
→ Survey, prophylaxis and therapy

Parasitism

Nutrient spoliation of the host towards the parasite
Unilateral physiological dependence → Parasite only gets the profit
whereas in the case of symbiosis → mutual benefits

Parasite positions

Taxonomic position:

→ Belong to Eukaryotes:

- → Protists (unicellular eucaryotic cells)
- → Helminths (pluricellular eukaryotes → worms)
- → Eumycetes (= fungi) (eukaryotes uni or pluricellular)

Anatomic location:

→ Ectoparasites :

- → on the host surface → inconvenience (itching, ….)

  Ex.: lices (insect).
- → dwell in teguments → diseases

  Ex.: sarcoptic mange: *Sarcoptes scabiei* (mite)

→ Endoparasites :

Different locations within the host:

- → cavities: intestine (*Taenia*)
- → blood vessels (schistosomes)
- → muscular tissue (*Trichinella*)
- → specific cells: erythrocyte (*Plasmodium*), macrophage (*Leishmania*)

Kinds of parasitism

- Accidental:

→ Ex.: fly larva within a wound

- Optional:

→ Normally saprophytes in the nature
→ but under certain conditions → parasites. Ex.: fungi

- Obligatory:

→ Temporary: parasite → a part of its life as parasite and a part of its life as free-living organism
Ex.: *Fasciola* = liver fluke (flatworm), and *Strongyloides* (→ anguillulosis)
→ Permanent: parasite → parasite life in one or several hosts
Ex.: *Filaria* and *Plasmodium*

- Erratic:
Parasite → in a precise location within its host
If the parasite in an unusual host → erratic parasitism
Ex.: Canine *Ascaris* (*Toxocara canis*) getting lost in human
→ *larva migrans* syndrome

Parasite specificity

Degree of fidelity more and less stringent between the parasite and its host(s)

- Stenoxenic parasites: high fidelity degree to a host
  - → Ex.: *Plasmodium / Anopheles sp.*
  - → the parasite can only infect species of hosts taxonomically close to each other

- Euryxenic parasites: low fidelity degree to a host
  - → Ex.: *Trypanosoma brucei rhodesiense*: in human and many mammals species

  - → Parasite specificity
    - → Great epidemiological incidence in the disease control management
      - → Difficult to control a disease when the parasite is present in many different hosts

Host

Living organism which harbours a pathogenic agent (the parasite)

- Final host: host harbouring the sexual form or the adult form of the parasite

- Intermediate host (IH): host harbouring the asexual form or the larval form of the parasite
  → the parasite should stay within this host → necessary to get transformations into the infective form exhibiting contamination abilities

  IH → passive when it harbours the infective form, without performing any movement to get it or transmit it (ex.: molluscs for the schistosomes)

  IH → active when it carries and inoculate the infective form of the parasite (ex.: *Anopheles sp.* for *Plasmodium*, sandflies for *Leishmania sp.*)
  → Active IH = vector

- Obligate host: when the parasite transforms /maturates within a host

  Facultative/ optional host: when there is no parasite transformation
  = Paratenic host

Vector:

= Host for a pathogenic agent and able to transmit it to another organism

→ hematophagous animal collecting the parasite in infected patients/animals, keeping it, carrying it, and inoculate it in naive patients/animals

→ Arthropods

Ex.: The *Anopheles* mosquito is the vector of malaria

→ Biological vectors:

→ ensure the parasite maturation or multiplication

→ therefore essential to the parasite life cycle as intermediate hosts

→ Mechanical vectors:

→ only a role of parasite transport

→ not necessary to the parasite life cycle

→ Ex.: Housefly carrying amoebal cysts

Parasite reservoir:

Animal, plant, external environment (soil, water, …) ensuring the parasite survival, sometimes during a long period, and making it available for the different hosts of the life cycle

Reservoir: notion often ascribed to the definitive host
Ex.: sheep: parasite reservoir of the liver fluke

→ Epidemiological incidence if:

→ the parasite and its host develop mutual tolerance along the time

→ the parasite and its host are in sufficient abundance in a given area

→ Giving a reasonable chance to the parasite to be transmitted to other hosts

Parasite reservoirs:

- Human parasite reservoir:
  - → When infection is strictly human → humans are reservoir (anthroponosis)
    - → but, some pathogens carried by humans can be transferred to animals
  - → When infection is common to humans and animals
    - → Human can be an accidental host → humans are therefore not a reservoir, because the epidemiologic role played by humans is not important
      Ex.: human trichinellosis and hydatidosis are parasitic impasses

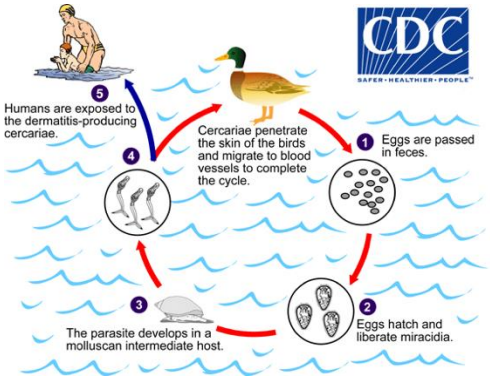
- Animal parasite reservoir:
  - → When infection is common to humans and animals
    - → Animals are reservoir (zoonosis = zoonotic disease) favouring the transmission to humans
      - → Infected wild animals → difficult to control → often efficient reservoirs because of a good tolerance of their parasites through poorly symptomatic infections

- Land-based parasite reservoir
  - → Soil → parasite reservoir
    - → cysts of Amoeba/Giardia, eggs of helminths, fungi …

Life cycle:

= Sequence of mandatory transformations occurring in a precise order for a parasite to get the next parasite generation

= result of the transformations of a parasite to ensure the continuation of its species



→ Direct cycle:

→ When the parasite evolution takes place within the same host or partially in external environment → Monoxenic life cycle

→ Short direct cycle → when eggs or larvae are directly infectious without necessity of passage within the external environment

→ Long direct cycle → when eggs or larvae should follow a development in external environment (soil, water, …) to become infectious

→ Indirect cycle:

→ When the parasite transformations take place in several successive hosts

→ Heteroxenous life cycle

Life cycle:

Life cycle → occurs according to a sequence of events
Sometimes → existence of optional host(s) in which there is no parasite transformation = waiting host → Paratenic host

Some life cycle → very complex (several hosts, …) → probability to be successful → low
→ Parasite should develop strategies to compensate the low probability of meeting betwen parasite and its hosts

→ High reproduction rate
Ex.: *Taenia saginata* → lay 150 million eggs a year

→ Multiplication during the larval phase: polyembryonny
Ex.: Trematodes

→ Exceptional resistance in external environment
Ex.: Ascaris eggs survive many years

→ Very long life time within the host
Ex.: *Plasmodium malariae*, *Strongyloides stercoralis*, filaria

Life cycle:

→ Balance between the reproduction rate of the parasite and environmental unfavourable conditions

Ex.: Liver fluke lays 1 million eggs a year

→ Each egg → 320 infective larvae

→ If all larvae would survive, each fluke

→ 320 million parasites a year

→ and the fluke lifetime is more than 10 years !

The role of parasitologists

→ Studying each step of the life cycles

→ to understand the mechanisms of infection

→ to propose the best strategies to control parasite transmission

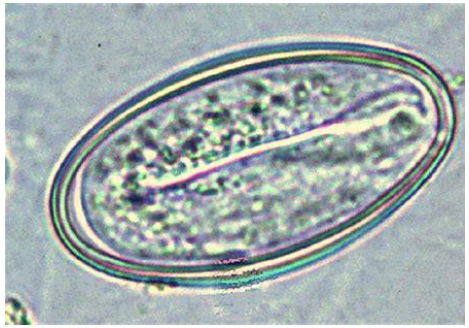
Forms of resistance:

- Eggs (Nematodes, Cestodes, Trematodes)
  - Quiescent eggs
    - Not directly infectious when eliminated in the stools
    - Require a maturation in the external environment

      Ex.: *Ascaris lumbricoides*

  - Embryonated eggs
    - Infectious as soon as eliminated in the stools

      Ex.: *Enterobius vermicularis*



Forms of resistance:

- Encysted larvae (Nematodes, Trematodes)
  - Ex.: Metacercariae of liver fluke → fixed on aquatic plants
    - Infectious when ingested

- Cysts (Protists)
  - Cysts of resistance (*Entamoeba histolytica*)
  - Vegetative cysts or division cysts
    - Gametocyte → gametogenesis then fecondation (*Plasmodium sp.*)
    - Oocysts → = « encapsulated egg »
    - Sporocysts → divide into sporozoites
    - Cysts containing bradyzoites (*Toxoplasma*)
  - Spores (microsporidiae)

Modes of parasite transmission 1

The parasite transmission can occur through:

- oral route
- muco-cutaneous route
- respiratory route
- vectorial origin
- sexual route
- congenital route
- transfusion route
- transplantation

Eggs, cysts, or infective stage (larvae) can be:

→ free in the soil, in contaminated water and food

→ in an hematophagous vector which transmit the parasite during its bloodmeal

Modes of parasite transmission 2

- Oral transmission

→ By external environment through contaminated water and food
→ faecal peril

→ Parasitoses provoked by protists:
→ Amoebiasis, giardiasis, cryptosporidiosis, microsporidiosis, cyclosporosis, isosporosis

→ Parasitoses provoked by nematodes:
→ Ascaridiasis, oxyuriasis, toxocariasis, trichocephalosis

→ Parasitoses provoked by cestodes:
→ Hymenolepiasis, hydatidiasis, alveolar echinococcosis

Modes of parasite transmission 3

- Oral transmission

→By external environment through contaminated water and food

→ faecal peril

→ Parasitoses provoked by protists:

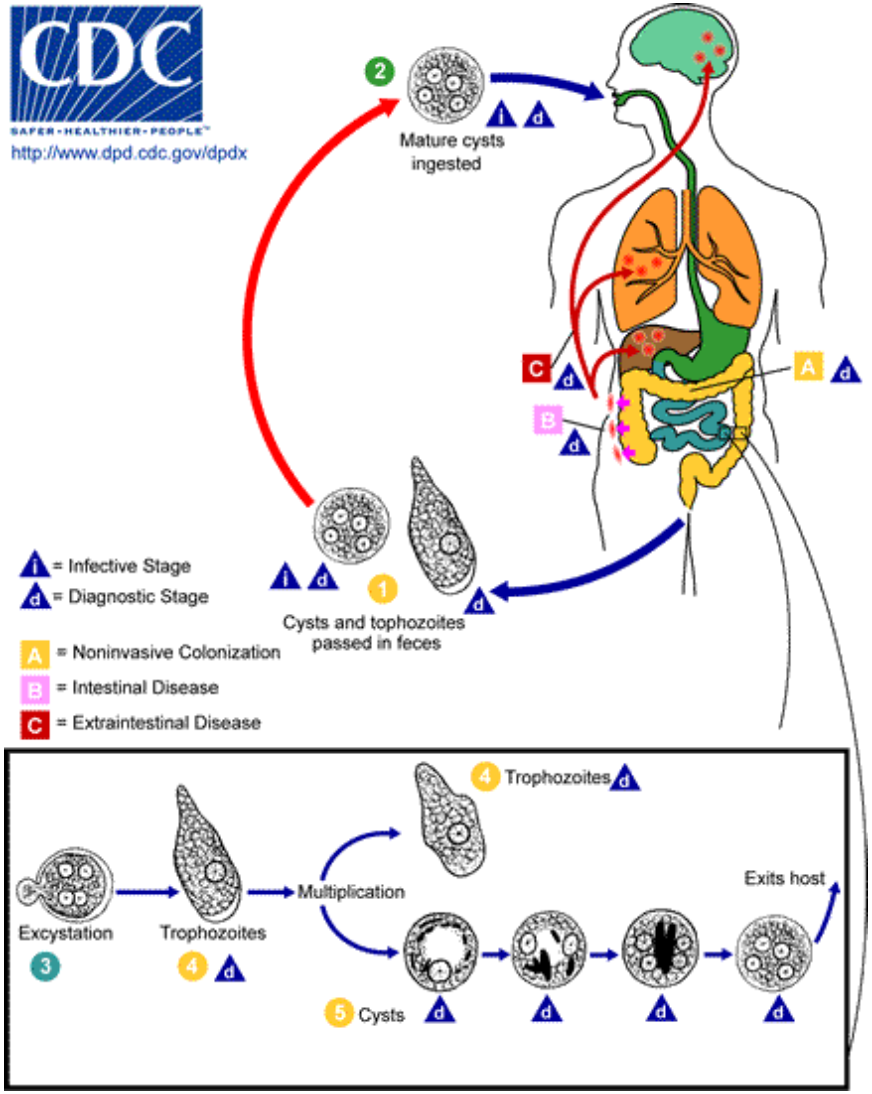
Amoebosis

→ *Entamoeba histolytica*

→ Ingestion of mature cysts in water and food

→ Monoxenous life cycle

→ Diarrhea and serious abcesses (liver, lung, brain…)



Modes of parasite transmission 4

- Oral transmission

→ By external environment through contaminated water and food

→ faecal peril

→ Parasitoses provoked by protists:

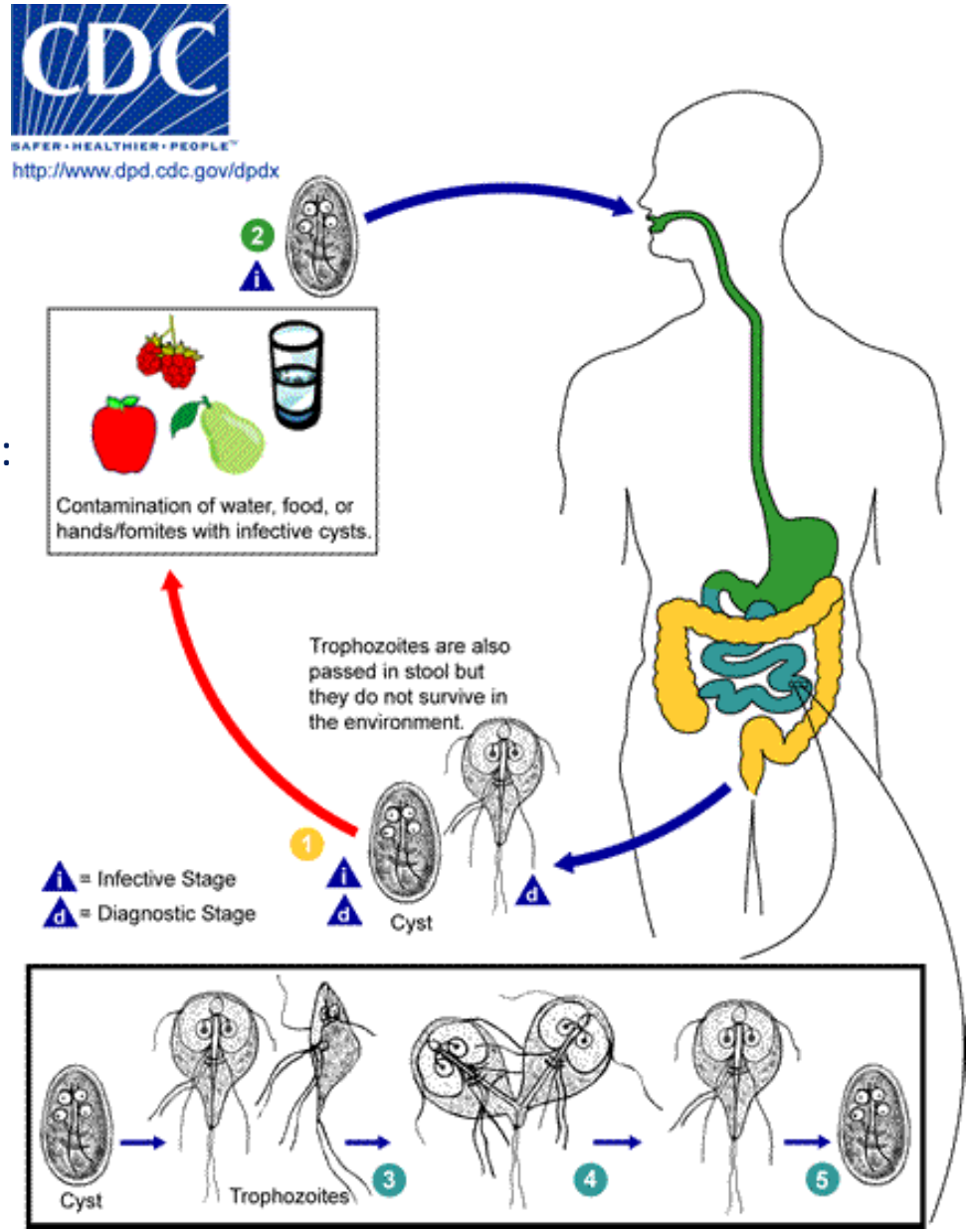
Giardiosis

→ *Giardia intestinalis*
= Giardia lamblia
= Giardia duodenalis

→Ingestion of mature cysts in water and food

→ Monoxenous life cycle

→ Diarrhea



Modes of parasite transmission 5

- Oral transmission

→ By external environment through contaminated water and food

→ faecal peril

→ Parasitoses provoked by protists:

Cryptosporidiosis

→ *Cryptosporidium parvum*

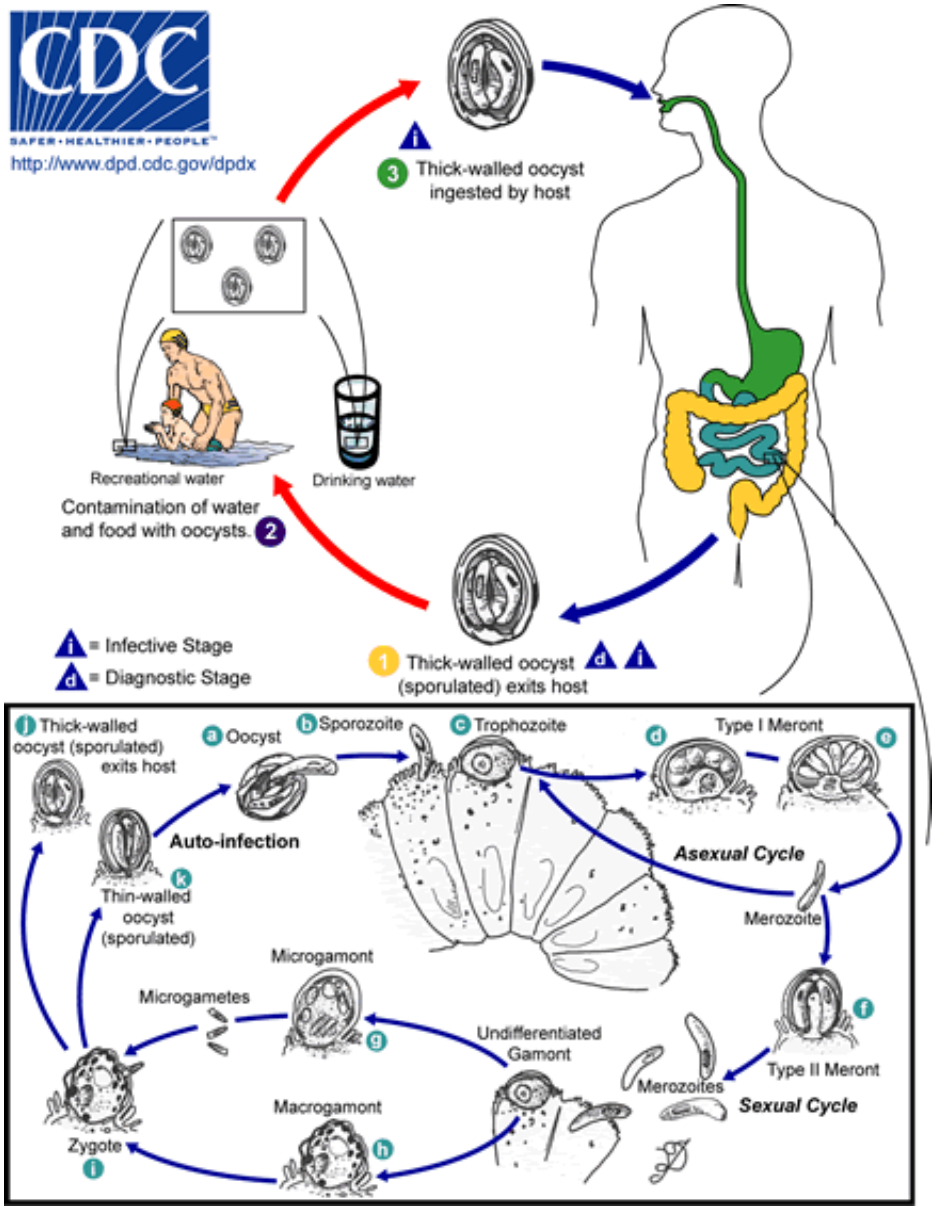
→ Ingestion of oocysts from water and food

→ Monoxenous life cycle

→ Diarrhea

→ *C. felis, C. canis, C. muris*

→ can infect humans



Modes of parasite transmission 6

- Oral transmission

→ By external environment through contaminated water and food

→ faecal peril

→ Parasitoses provoked by protists:

Microsporidiosis

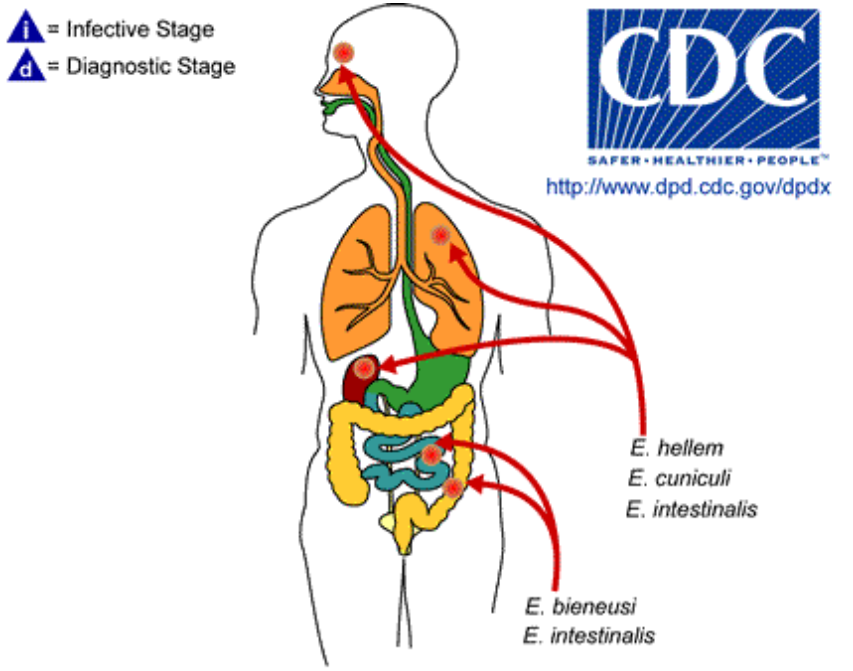
→*Enterocytozoon bieneusi*
→*Encephalitozoon cuniculi*

→ Ingestion of spores in water and food

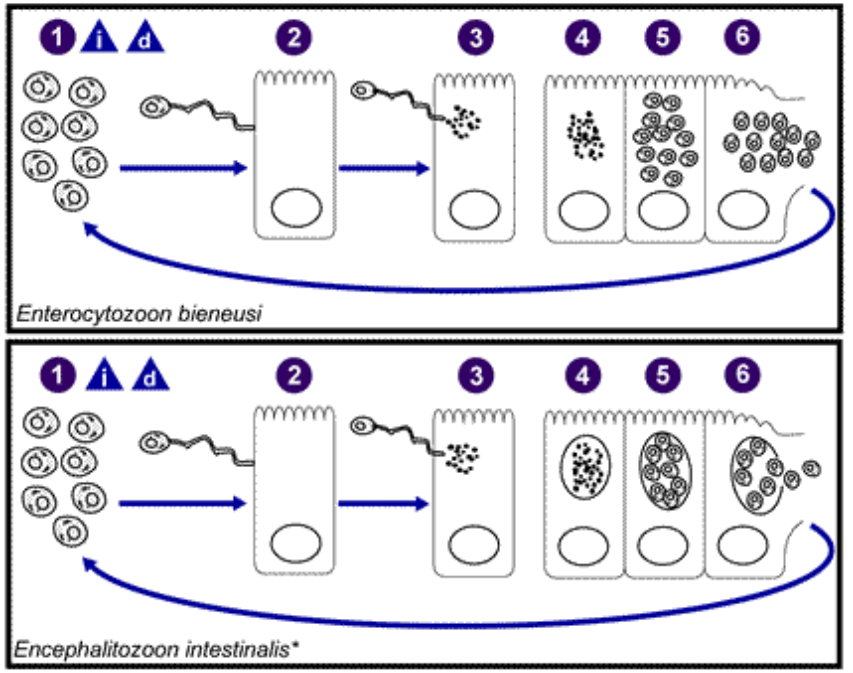
→ Monoxenous life cycle

→ Diarrhea

→ can infect pets and humans



Intracellular development of *E. bieneusi* and *E. intestinalis* spores.



*Development inside parasitophorous vacuole also occurs in *E. hellem* and *E. cuniculi*.

Modes of parasite transmission 7

- Oral transmission

→ By external environment through contaminated water and food

→ faecal peril

→ Parasitoses provoked by protists:

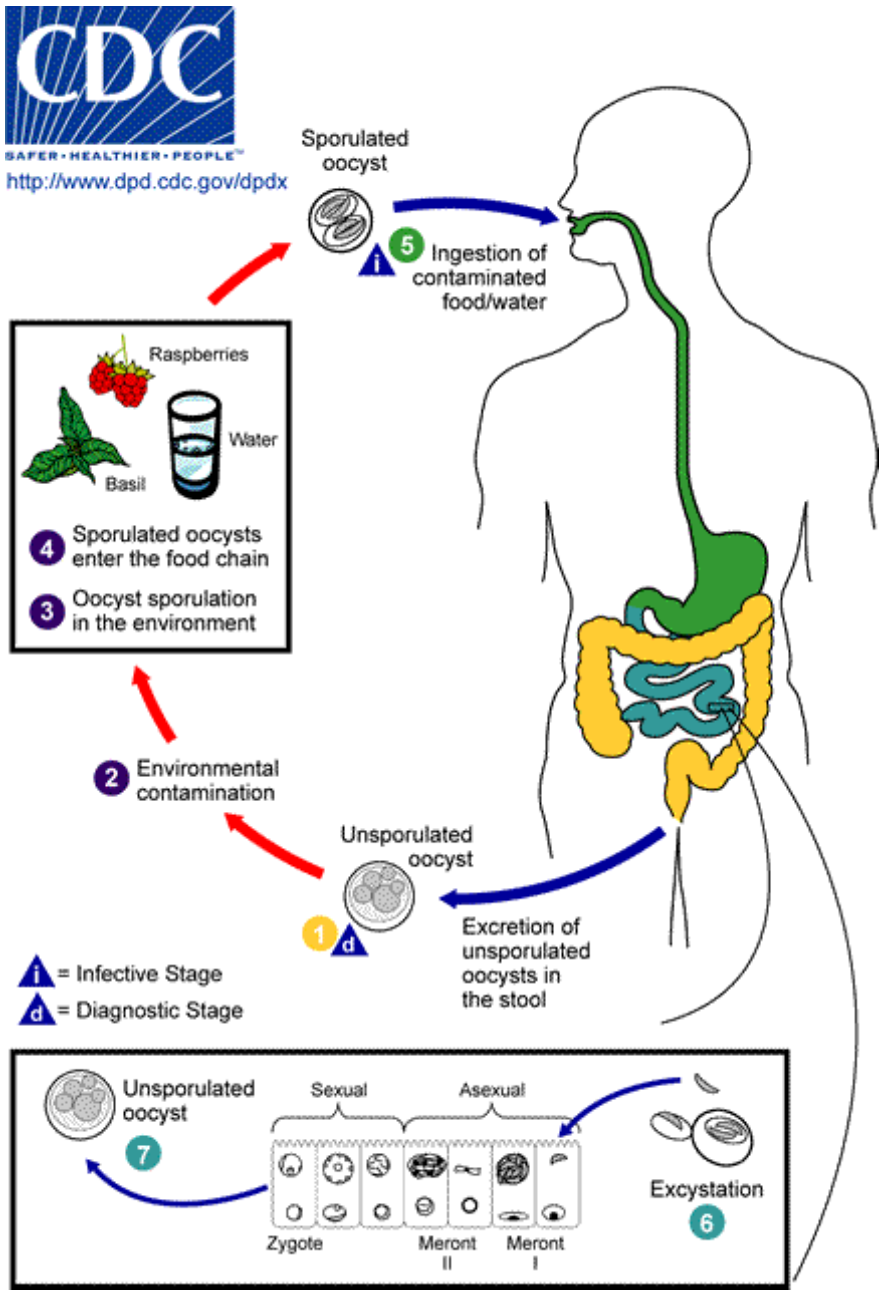
Cyclosporosis

→*Cyclospora cayetanensis*

→ Ingestion of sporulated oocysts from water and food

→ Monoxenous life cycle

→ Diarrhea



Modes of parasite transmission 8

- Oral transmission

→ By external environment through contaminated water and food

→ faecal peril

→ Parasitoses provoked by protists:

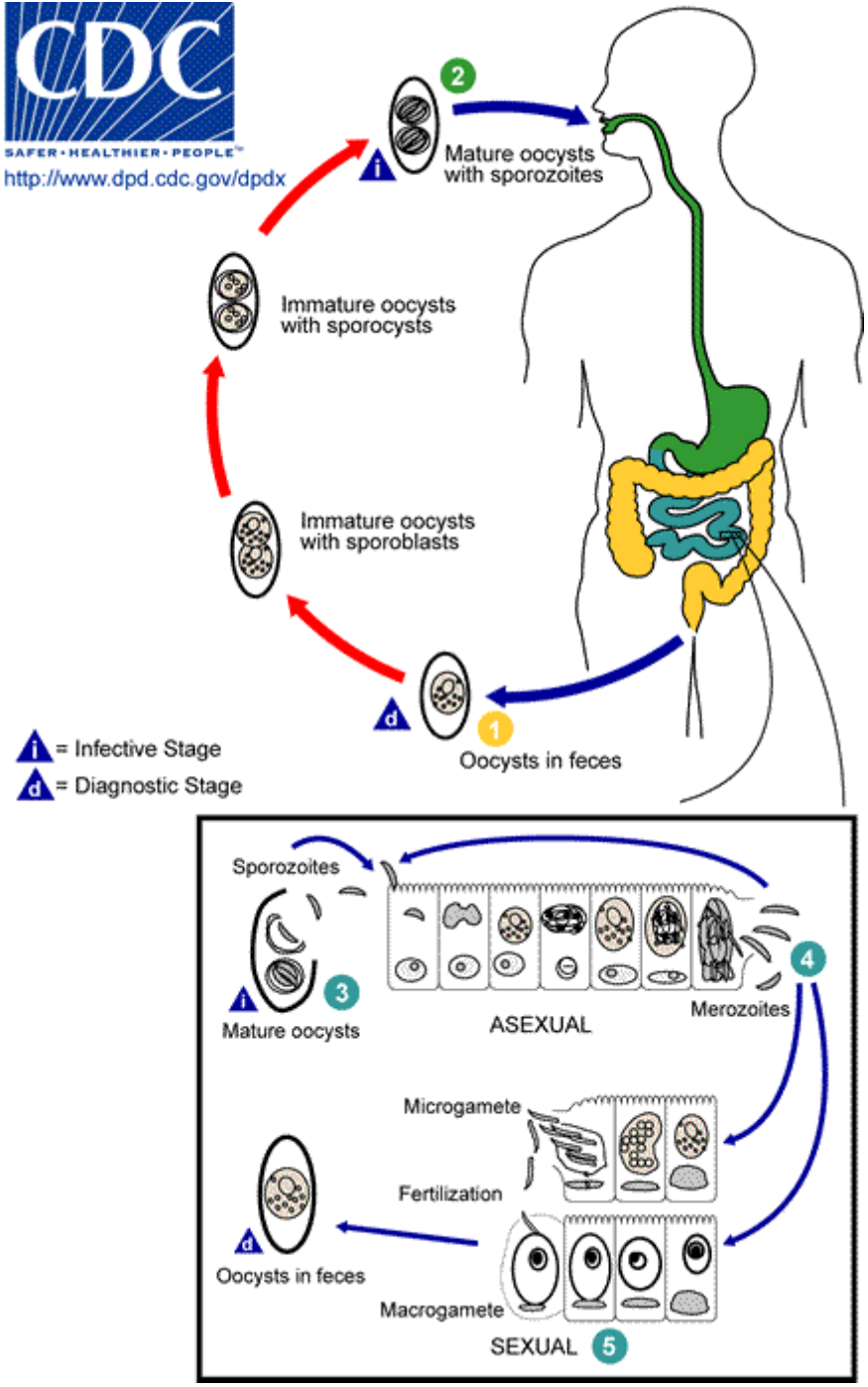
Isosporose

→ *Isospora belli*

→ Ingestion of mature oocysts containing sporozoites from water and food

→ Monoxenous life cycle

→ Diarrhea



Modes of parasite transmission 9

- Oral transmission

→ By external environment through contaminated food/environment

→ faecal peril

→ Parasitoses

provoked by helminths:

Ascaridiosis

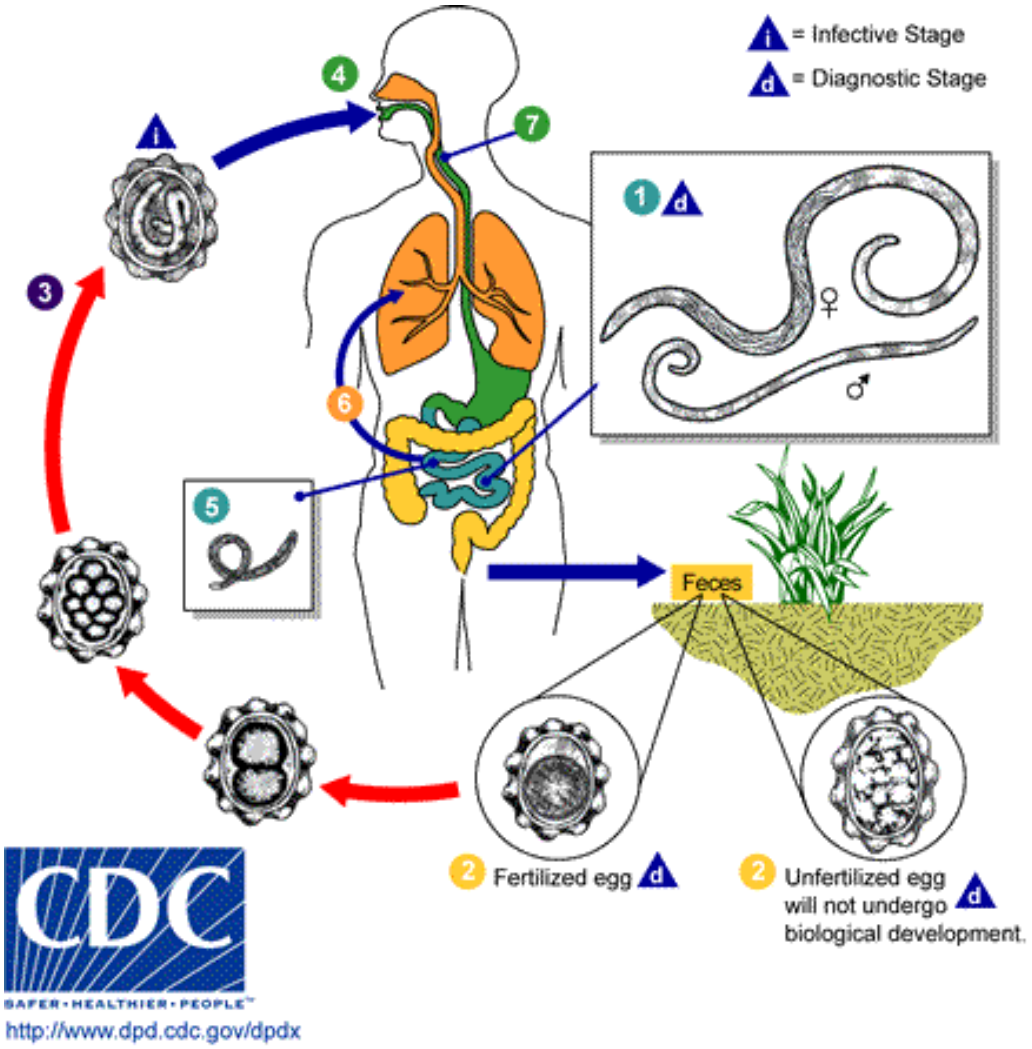
→ *Ascaris lumbricoides*

→ Ingestion of embryonated eggs in water/contaminated food

→ Monoxenous cycle

→ Intestinal pain

→ Sometimes, intestinal obstruction



Modes of parasite transmission 10

- Oral transmission

→ By external environment through contaminated food/dust

→ faecal peril

→ Parasitoses provoked by helminths:

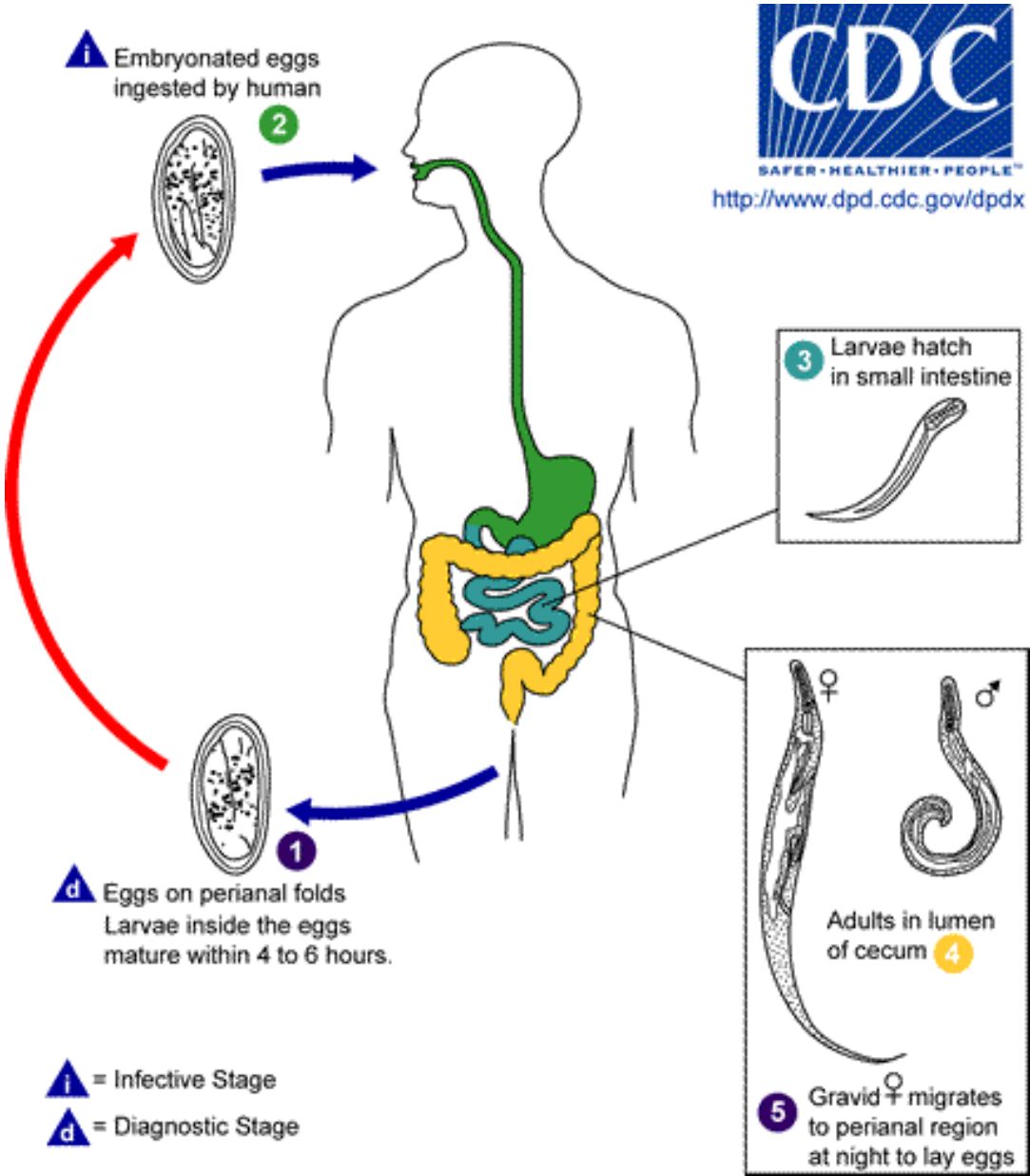
Oxyurosis

→ *Enterobius vermicularis*

→ Ingestion of embryonated eggs from the environment

→ Monoxenous life cycle

→ Intestinal pain



Modes of parasite transmission 11

- Oral transmission

→ By external environment through contaminated water and food

→ faecal peril

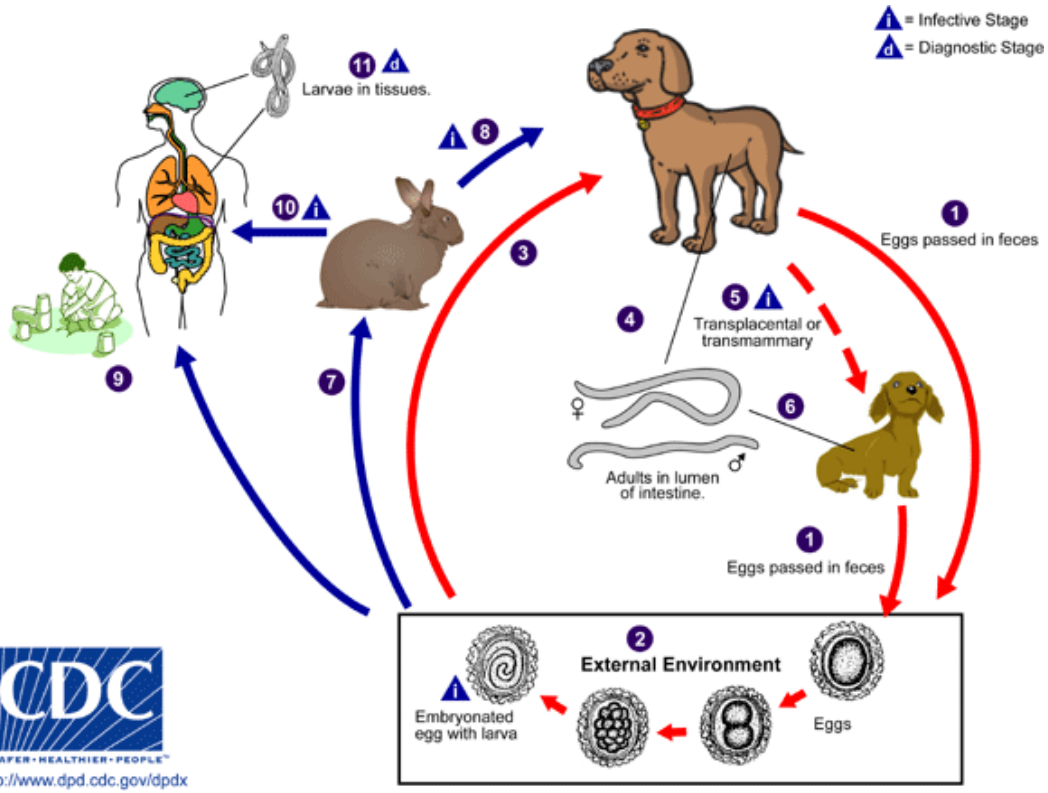
→ Parasitoses

provoked by helminths:

Toxocariasis

→ *Toxocara canis*

→ *Toxocara cati*



→ Ingestion of embryonated eggs from the environment

→ Monoxenous life cycle with parasitic impasse in humans

→ Sometimes, visceral and ocular damage → blindness

Modes of parasite transmission 12

- Oral transmission

→ By external environment through contaminated water and food

→ faecal peril

→ Parasitoses provoked by helminths:

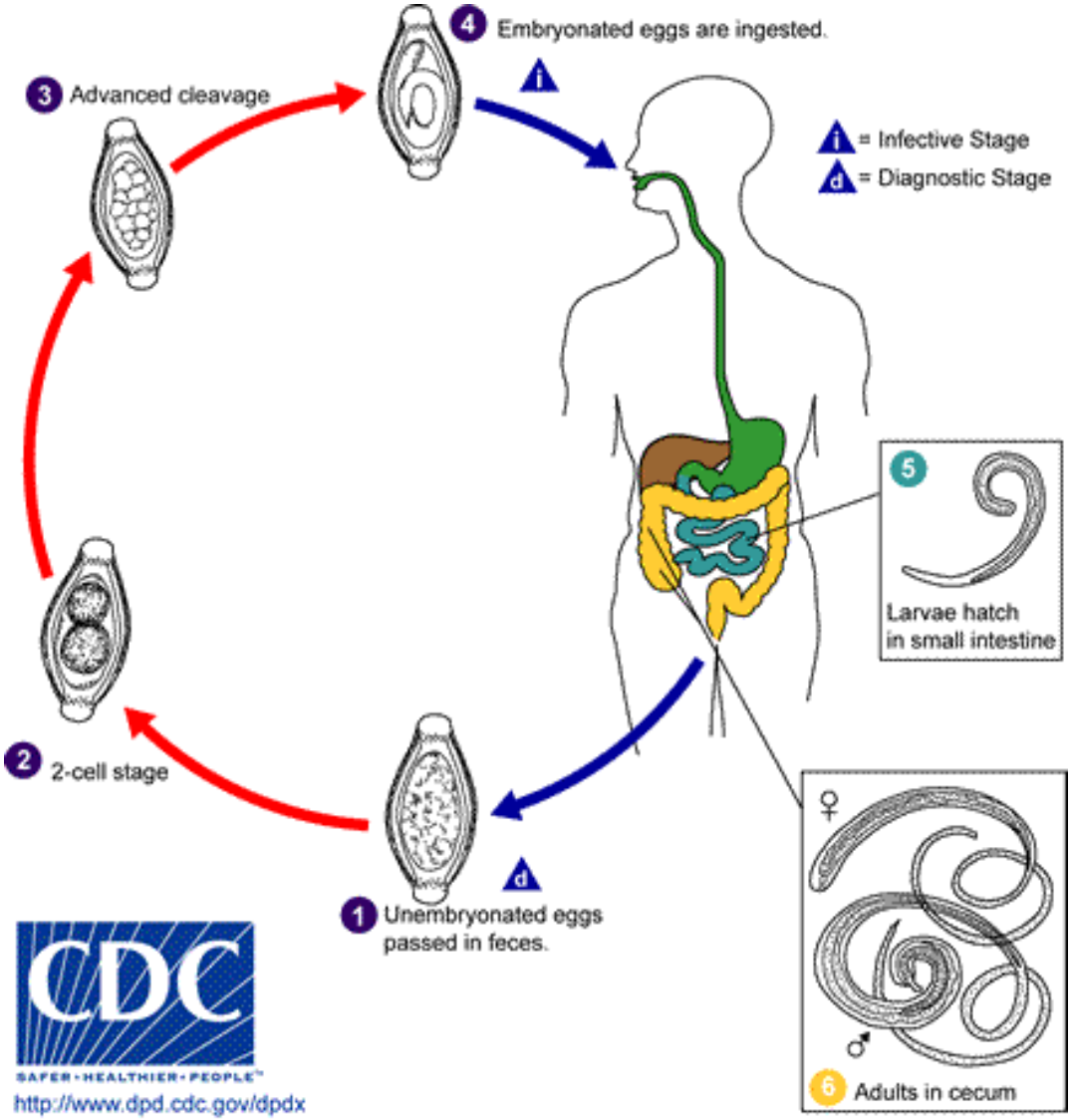
Trichocephalosis

→ *Trichuris trichiura*

→ Ingestion of embryonated eggs from environment

→ Monoxenous life cycle

→ Anaemia, growth delay



Modes of parasite transmission 13

- Oral transmission

→ By external environment through contaminated water and food

→ faecal peril

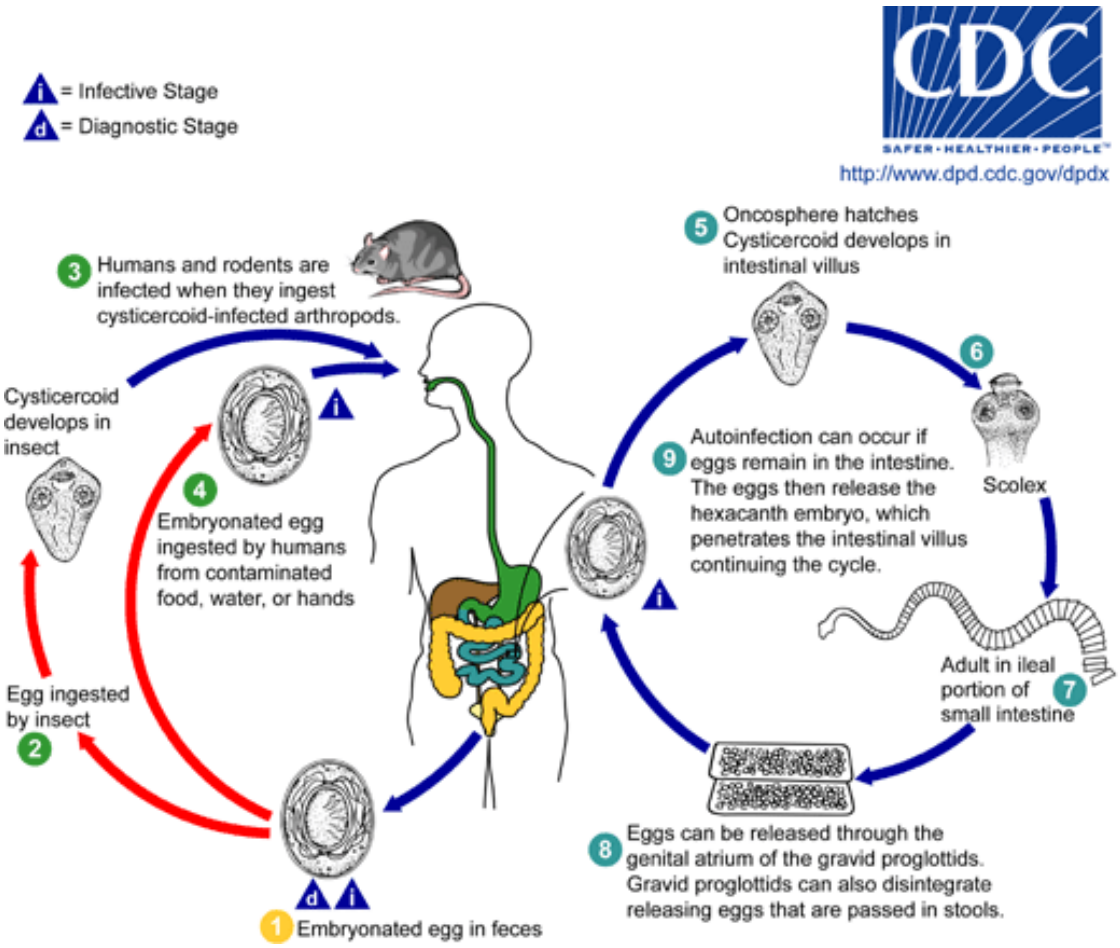
→ Parasitoses provoked by helminths:

Hymenolepiasis

→ *Hymenolepis nana*

→ + ingestion of arthropodes containing cysticercoid larvae in food

→ Heteroxenous life cycle
→ Diarrhea, abdominal pain



Modes of parasite transmission 14

- Oral transmission

→ By external environment through contaminated water and food

→ faecal peril

→ Parasitoses provoked by helminths:

Hydatidosis

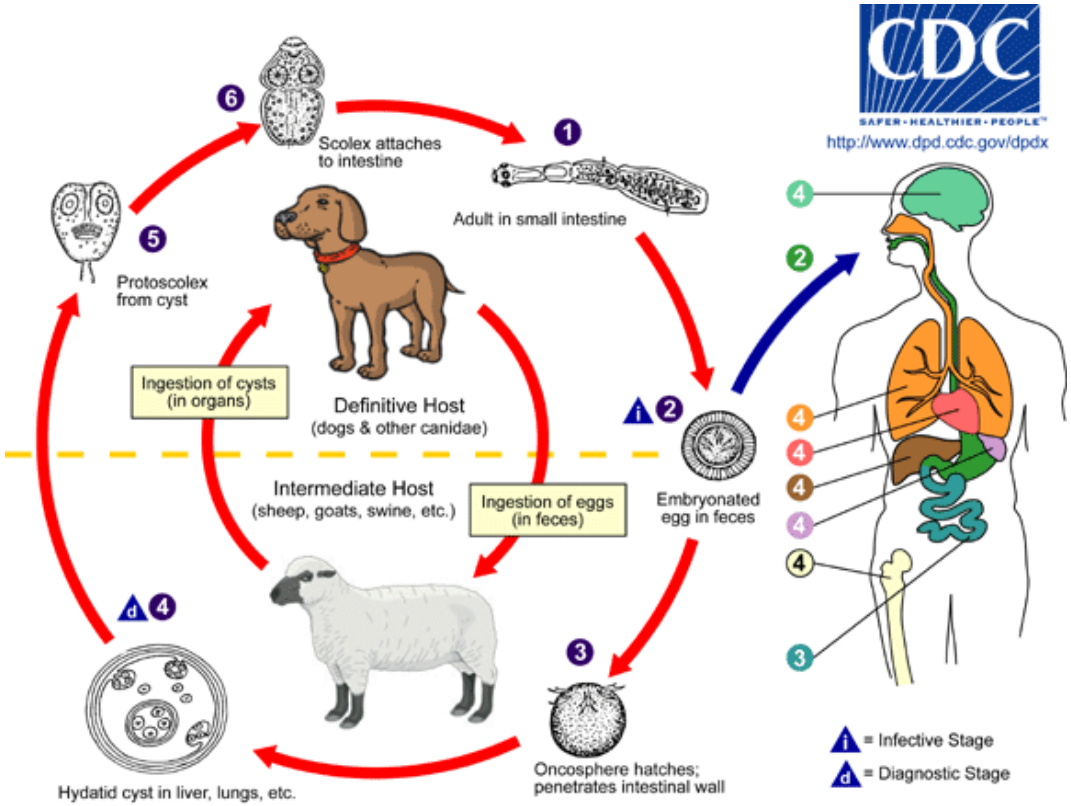
→ *Echinococcus granulosus*

→ ingestion of embryonated eggs

→ heteroxenous life cycle

→ Hydatid cyst mainly in the liver

→ Sometimes pulmonary and cerebral hydatid cysts



Modes of parasite transmission 15

- Oral transmission

→ Contact with animals
→ Ingestion of animal origin products (undercooked meat)
→ Ingestion of intermediate hosts or plant supports

Parasitoses transmitted by Protists
Toxoplasmosis

Parasitoses transmitted by Nematods:
Toxocariasis, angiostrongylosis, trichinellosis, anisakiosis

Parasitoses transmitted by Cestodes:
Taeniases, cysticercosis, hydatidiasis, bothriocephalosis

Parasitoses transmitted by Trematodes:
Fasciolosis, clonorchiosis

Modes of parasite transmission 16

- Oral transmission

→ through contact with animals, ingestion of undercooked meat, and of animal intermediate hosts or uncooked vegetables

Parasitosis transmitted by protists:

Toxoplasmosis

→ *Toxoplasma gondii*

Heteroxenous life cycle

→ Human contamination:

→ After eating undercooked meat containing bradyzoites

→ After eating food and drinking water contaminated by cat infected stool containing oocysts

→ Rapid transformation into tachyzoites able to penetrate nervous and muscular tissues

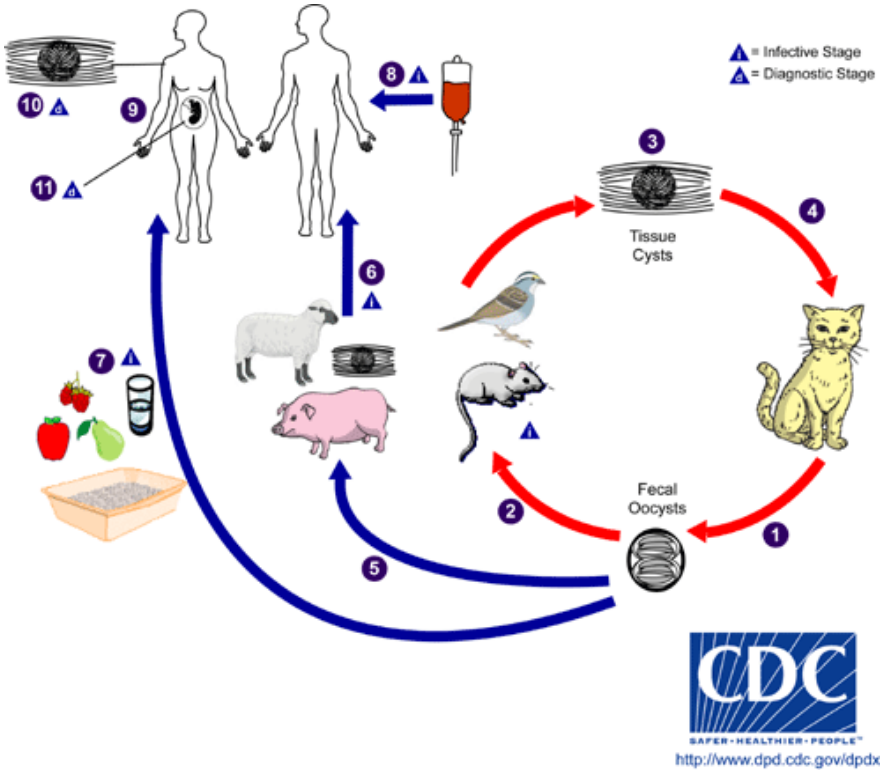
→ Transform into bradyzoites

→ Blood transfusion and organ transplant

→ Mother-child transplacental contamination by tachyzoïtes

→Risk: congenital toxoplasmosis → serious damages when contamination occurs at the beginning of pregnancy and fetal ocular lesions when contamination occurs later

→ Immunosuppressed patients



Modes of parasite transmission 17

- Oral transmission

→ through contacts with animals, ingestion of undercooked contaminated food

Parasitosis transmitted by nematodes :

Angiostrongylosis

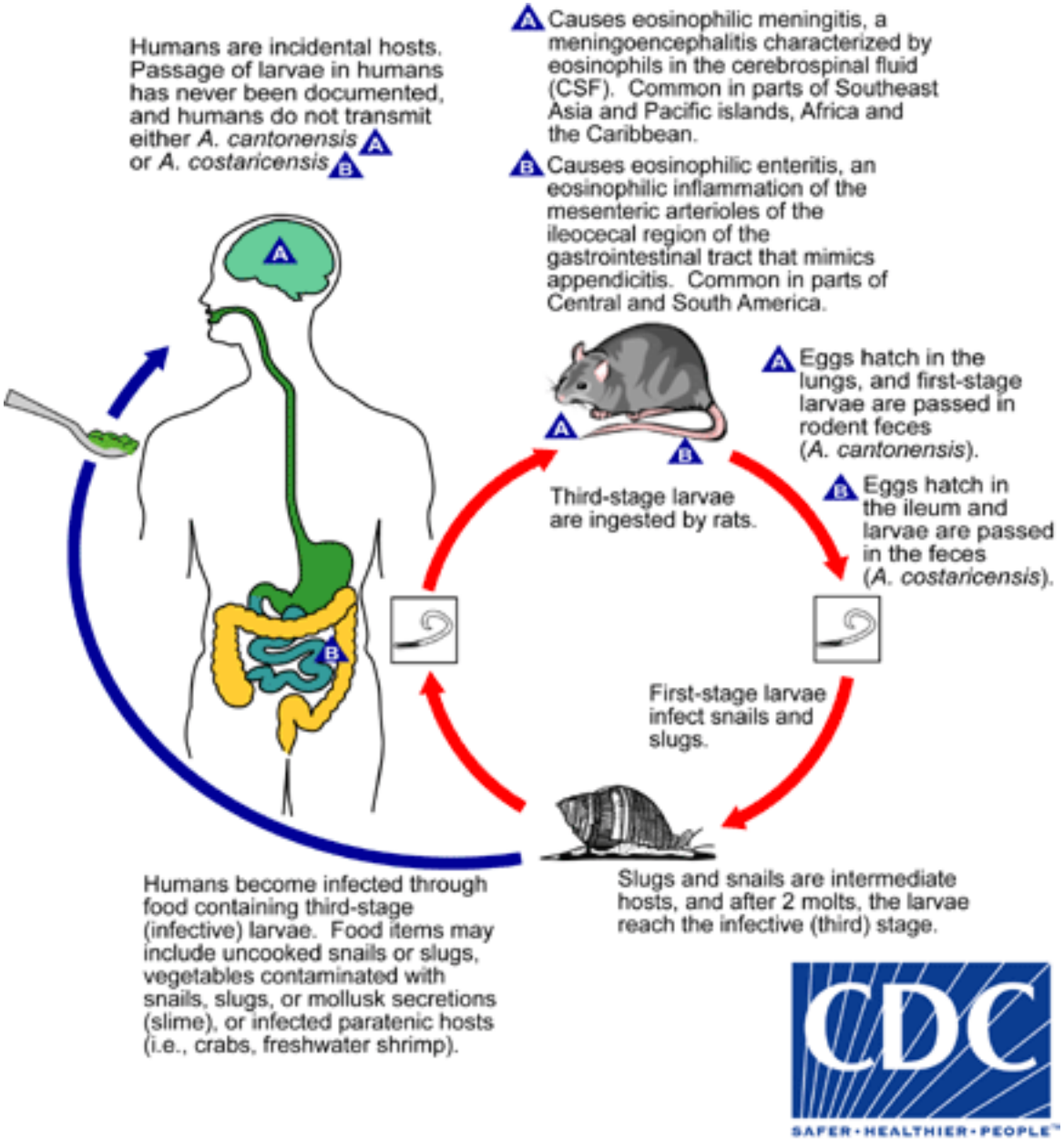
→ *Angiostrongylus cantonensis*

→ *Angiostrongylus costaricensis*

→ Meningitis

→ Healing in several weeks

→ Rarely → death



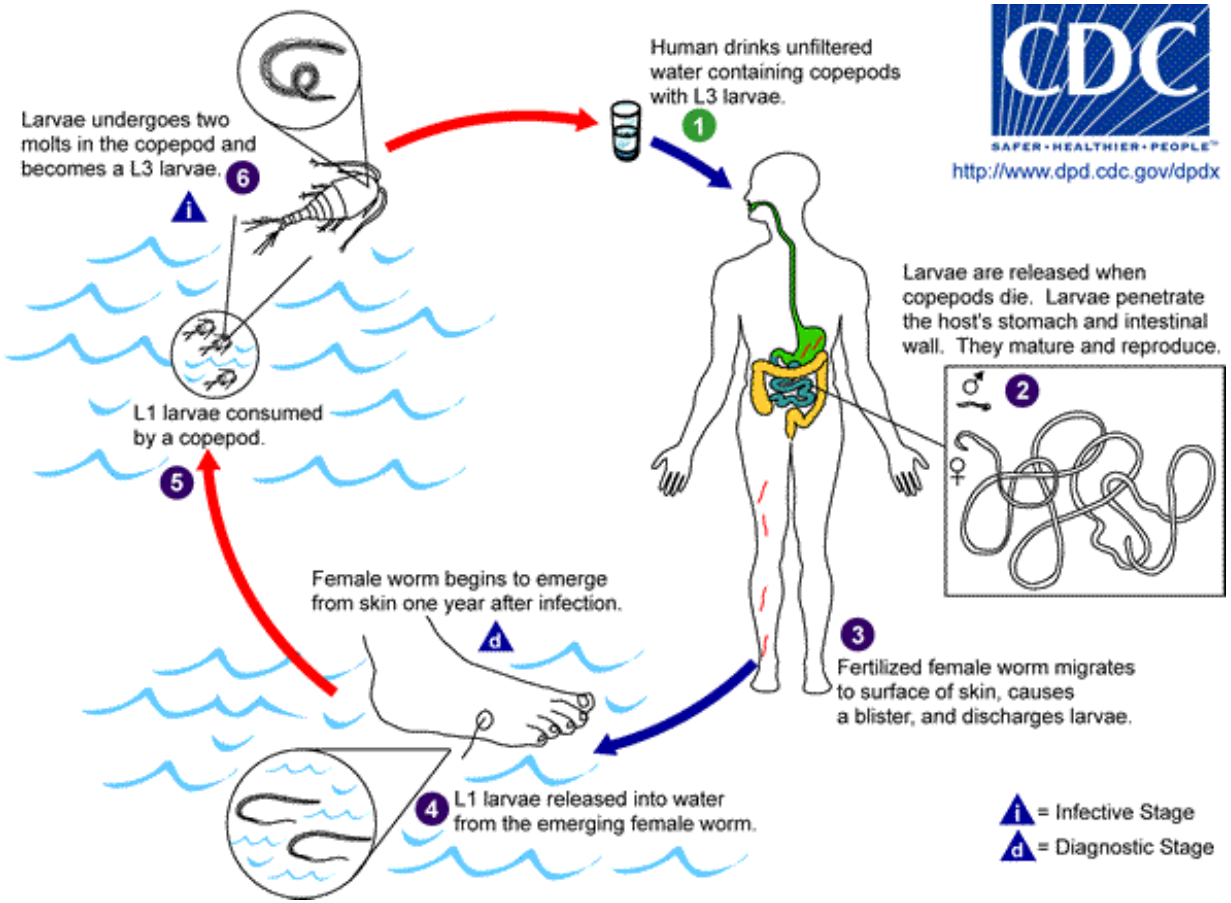
Modes of parasite transmission 18

- Oral transmission

→ through ingestion of passive aquatic intermediate host (Cyclops):
Dracunculosis

→ *Dracunculus medinensis*
→ Painful oedema
→ Possible secondary infection

→ Eradication almost obtained through water filtration before drinking
→ Cyclops elimination

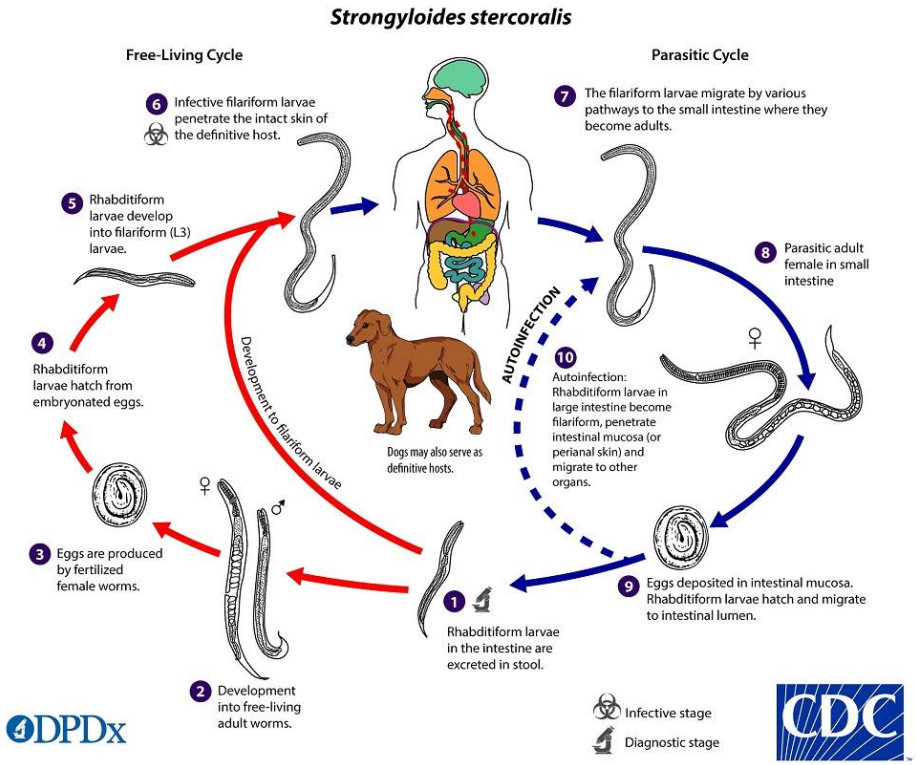


Modes of parasite transmission 19

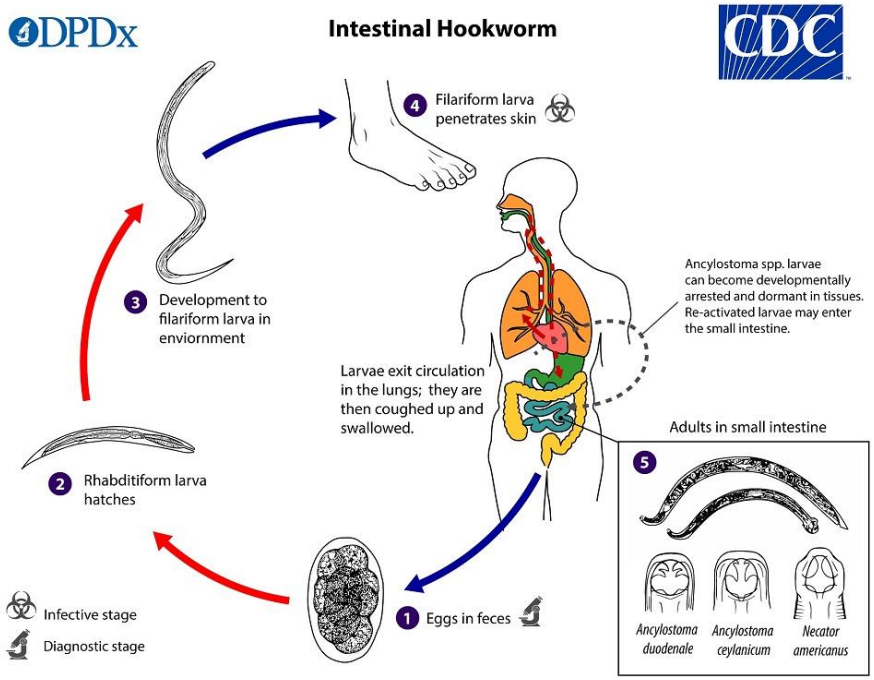
- Muco-cutaneous transmission

→ through water and moist soil :

Anguillulosis = Strongyloidiasis



Ancylostomiasis (hookworm)

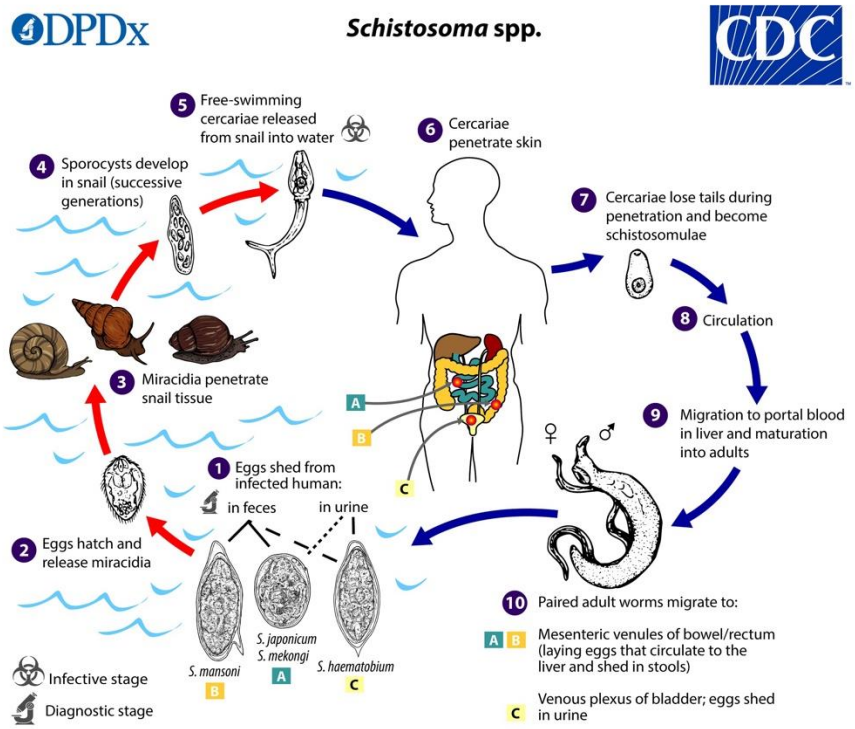


Modes of parasite transmission 20

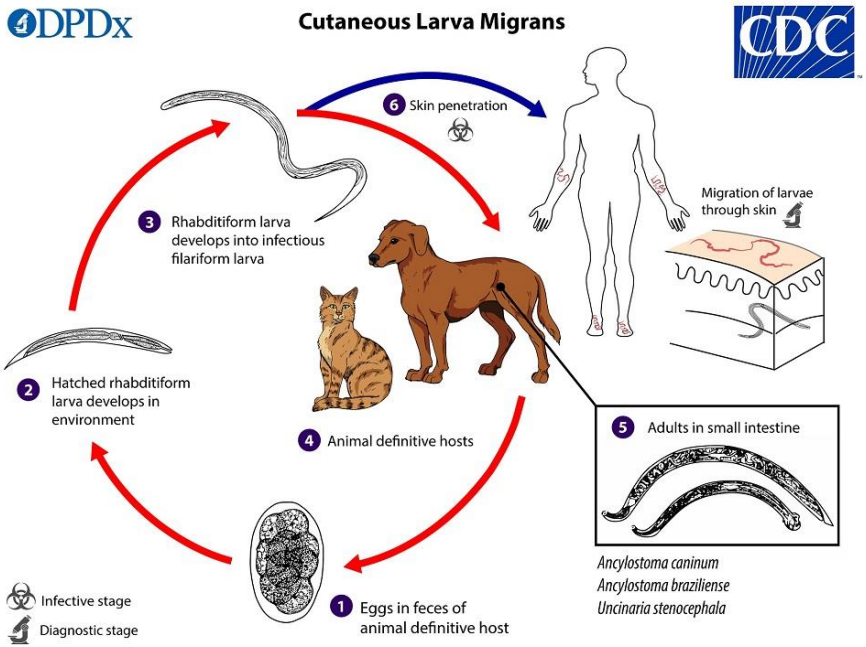
- Muco-cutaneous transmission

→ through water and moist soil :

Schistosomiasis



Cutaneous larva migrans

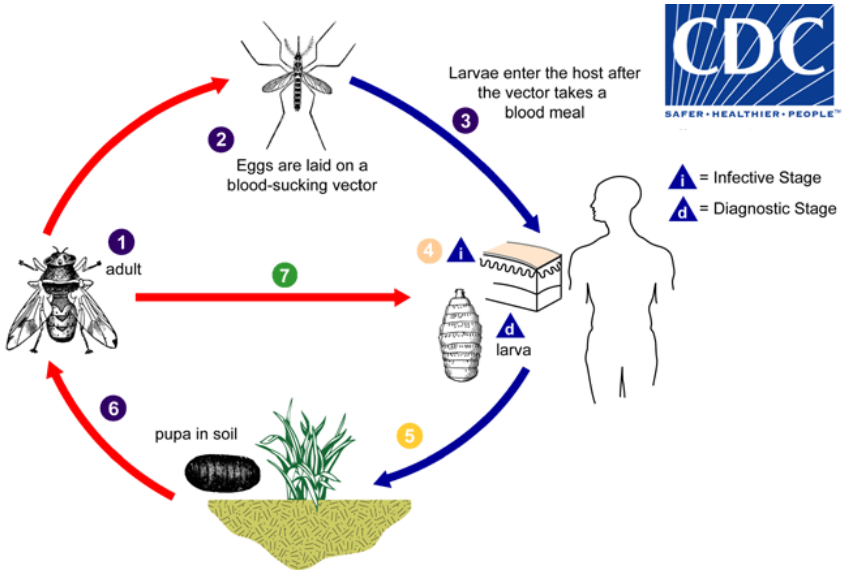


Modes of parasite transmission 21

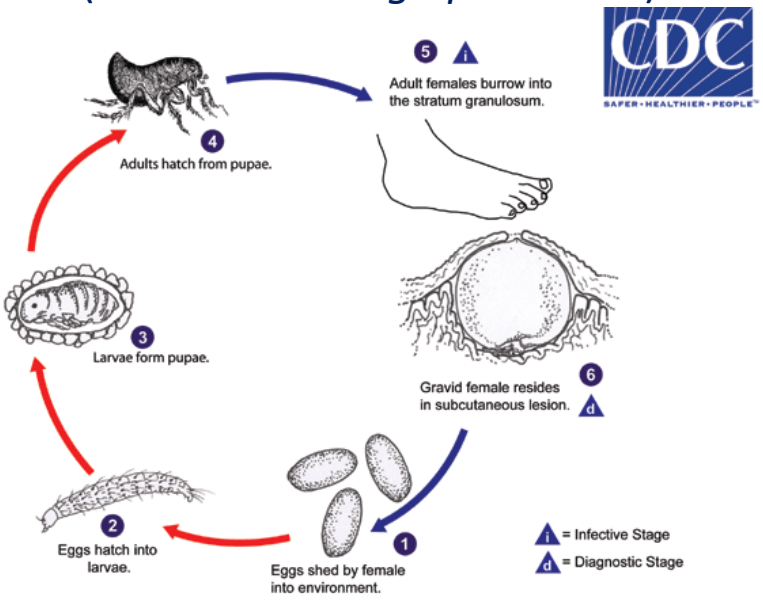
- Muco-cutaneous transmission

→ through dry environment:

Myiases



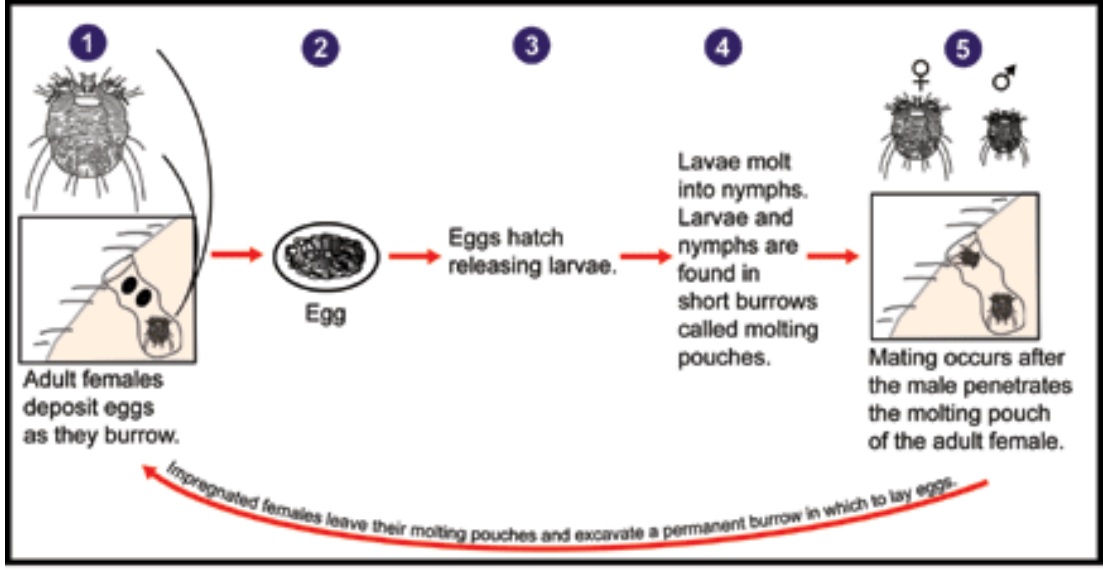
Tungiasis (sand flea = *Tunga penetrans*)

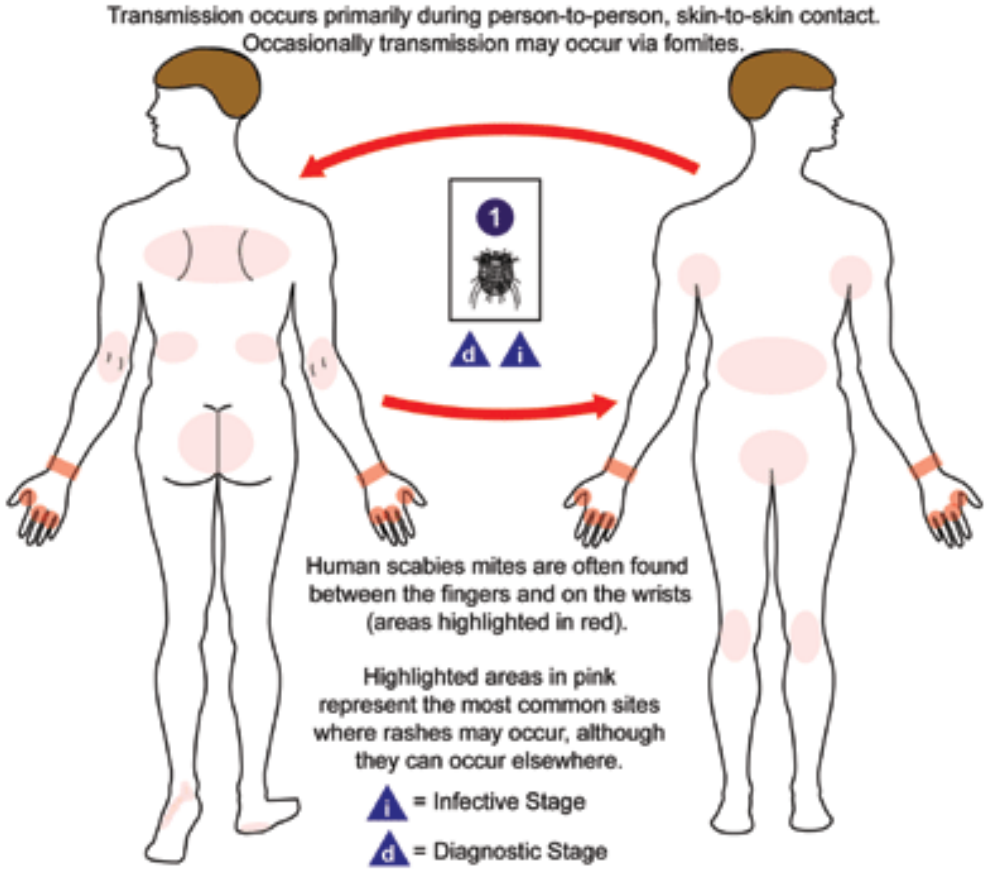


Modes of parasite transmission 22

- Muco-cutaneous transmission

→ through human contacts
(sick person or asymptomatic carrier)
Sexually transmitted infections,
cutaneous parasitosis





Scabies:
Contagious dermatitis
→ Provoked by the mite
Sarcoptes scabiei

Modes of parasite transmission 23

- Vector-borne Transmission

→ By flying insect vectors:

- Evening and night- insect vectors:
Malaria (Mosquito: *Anopheles*); Leishmaniases (sandflies); Lymphatic filariases (Mosquitoes: *Culex, Anopheles, Aedes, Mansonia*)

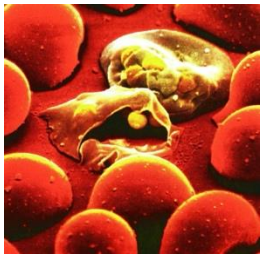
- Diurnal insect vectors:
Trypanosomiases (Tse-tse fly); Loasis (Chrysops); Onchocercosis (Blackflies); Mansonellosis (Culicoides)

→ By terrestrial insect vectors:

Chagas disease (bug)

Babesiosis (tick)

Modes of parasite transmission 24



- Vector-borne transmission

→ Evening and night- insect vector

→ By Anopheles mosquito bite

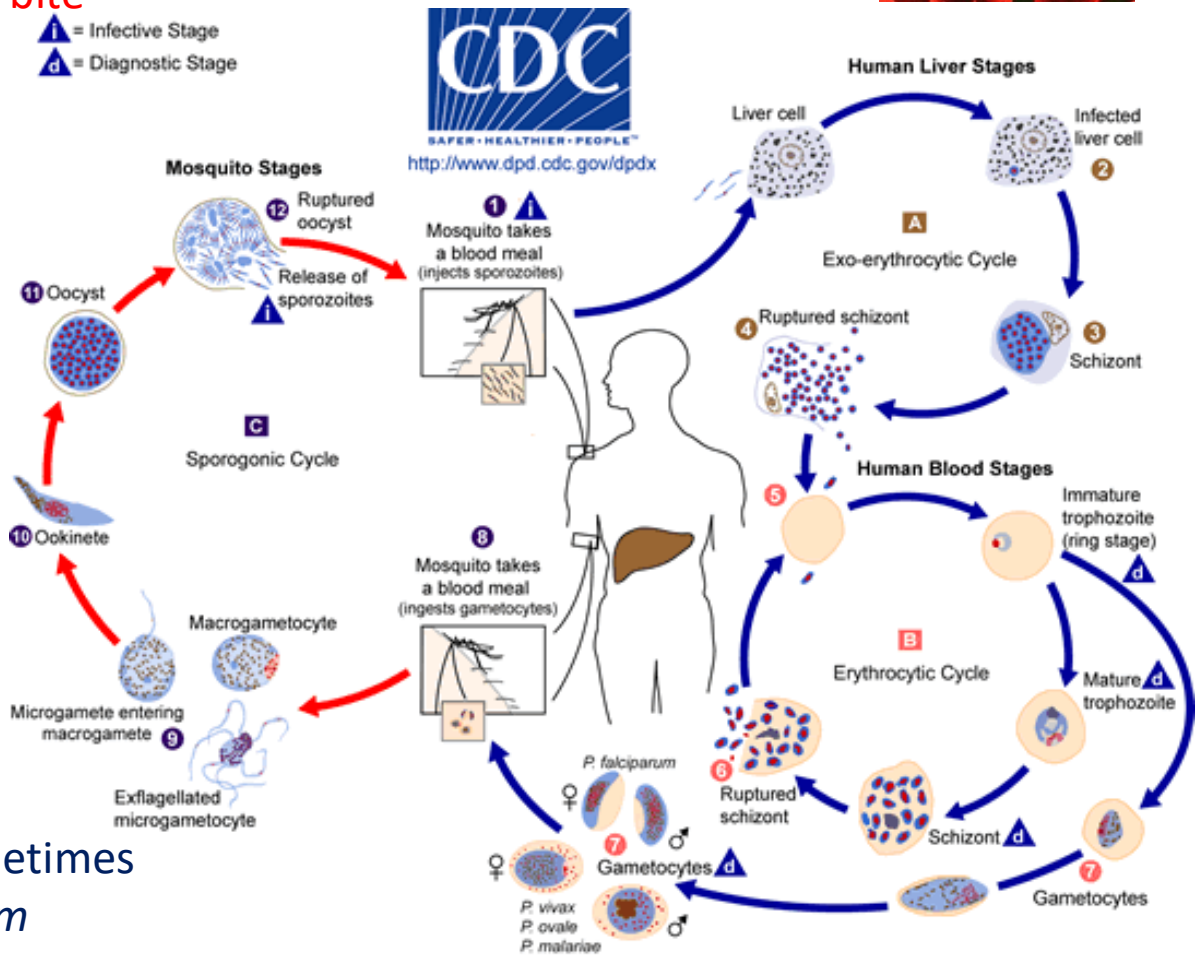
→ Parasitoses provoked by Protists:

Malaria

→ *Plasmodium falciparum*
→ *Plasmodium vivax*
→ *Plasmodium malariae*
→ *Plasmodium ovale*
→ *Plasmodium knowlesi*

→ Heteroxenous life cycle

→ Cyclic fever, anemia and sometimes severe malaria with *P. falciparum*



Modes of parasite transmission 25

- Vector-borne transmission

→ Evening and night- insect vector

→ By sandfly (*Phlebotomus/Lutzomyia* bite)

→ Parasitoses provoked by Protists:

Leishmaniases

→ *Leishmania donovani*

→ *Leishmania infantum*

→ *Leishmania major*

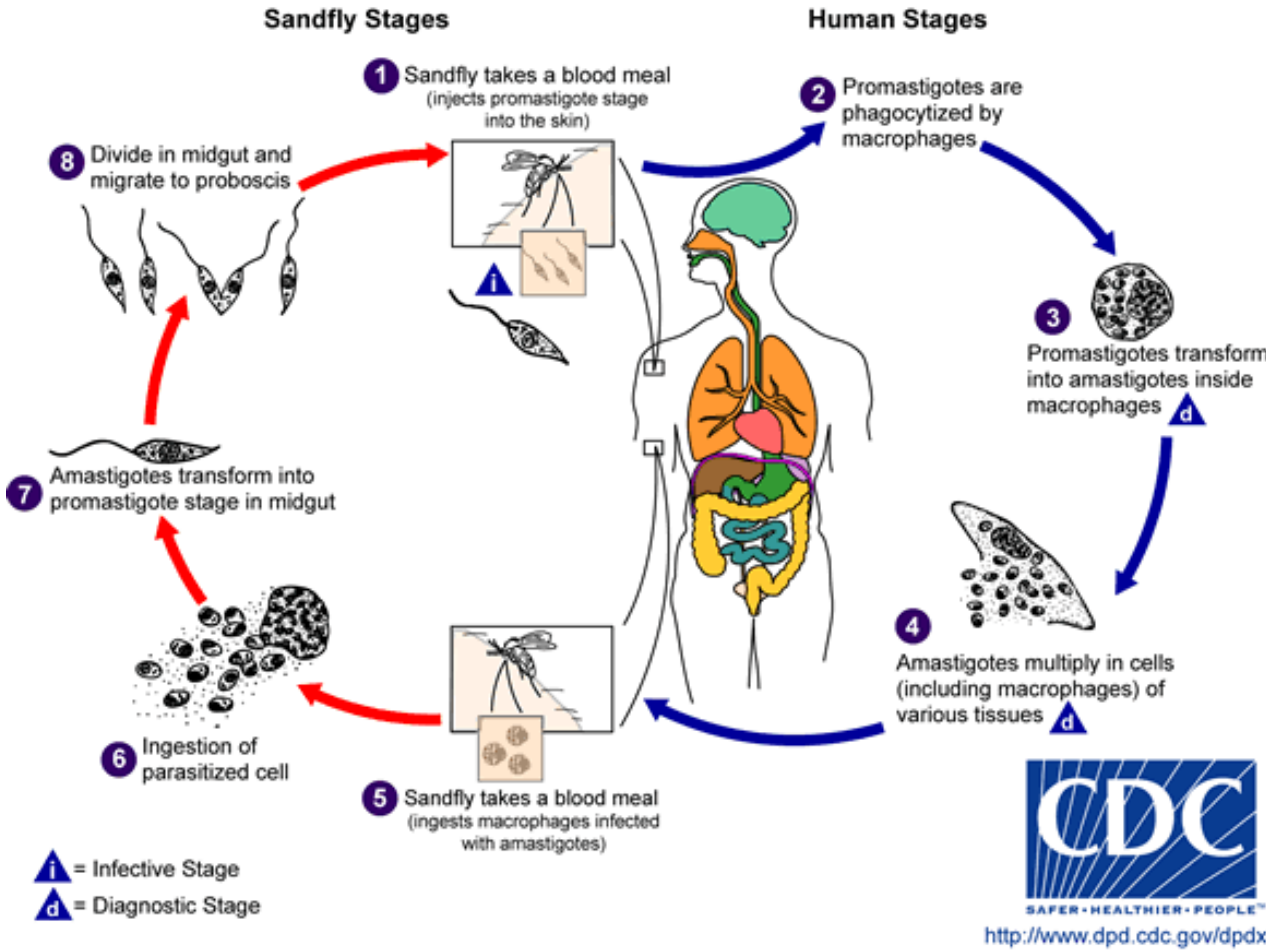
→ *Leishmania braziliensis*

→ And many others, …

→ Heteroxenous life cycle

→ Visceral, cutaneous, or muco-cutaneous symptoms (fever, anemia,….)

→ More or less severe as a function of the species



Modes of parasite transmission 26

- Vector-borne transmission

→ Evening and night- insect vector

→ By mosquito bite

→ Parasitoses
provoked by Helminths:

Lymphatic filariasis

→ *Wuchereria bancrofi*

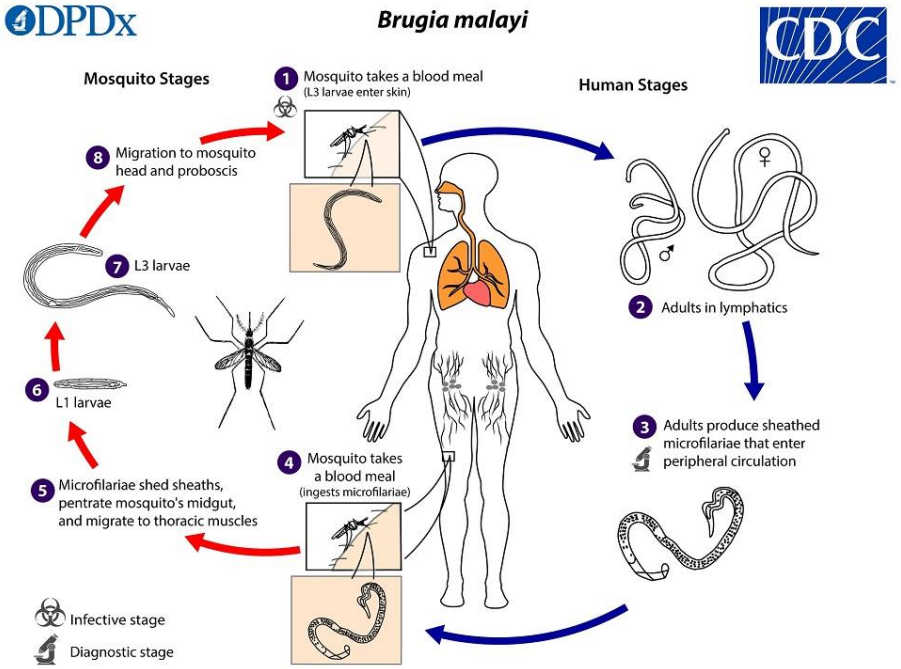
→ *Brugia malayi*

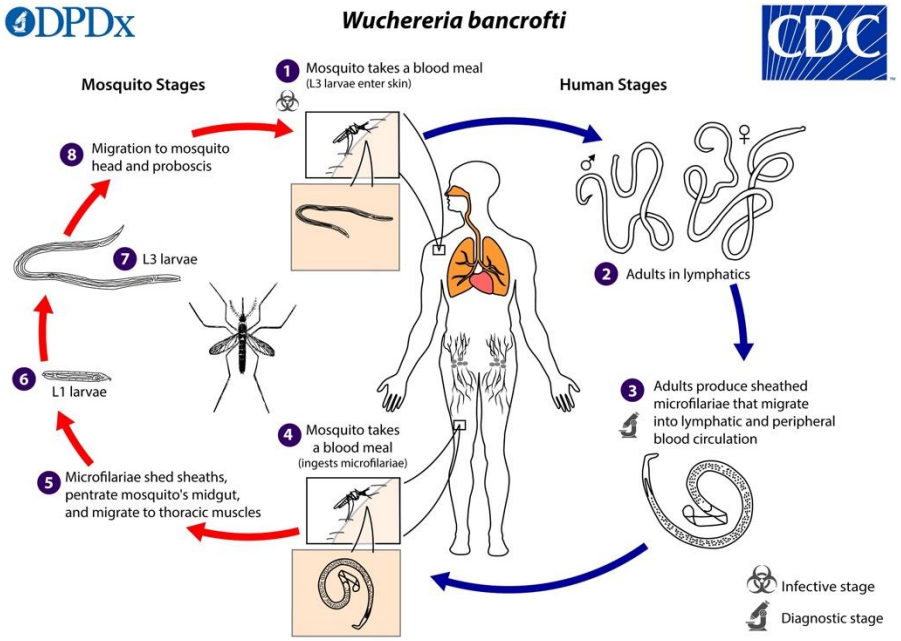
→ *Brugia timori*

→ Heteroxenous life cycle

→ Lymphedema

→ Bacterial infections in the skin





Modes of parasite transmission 27

- Vector-borne transmission

→ Diurnal insect vector

→ By Tsetse fly bite

→ Parasitoses
provoked by Protists:

Human African trypanosomiasis

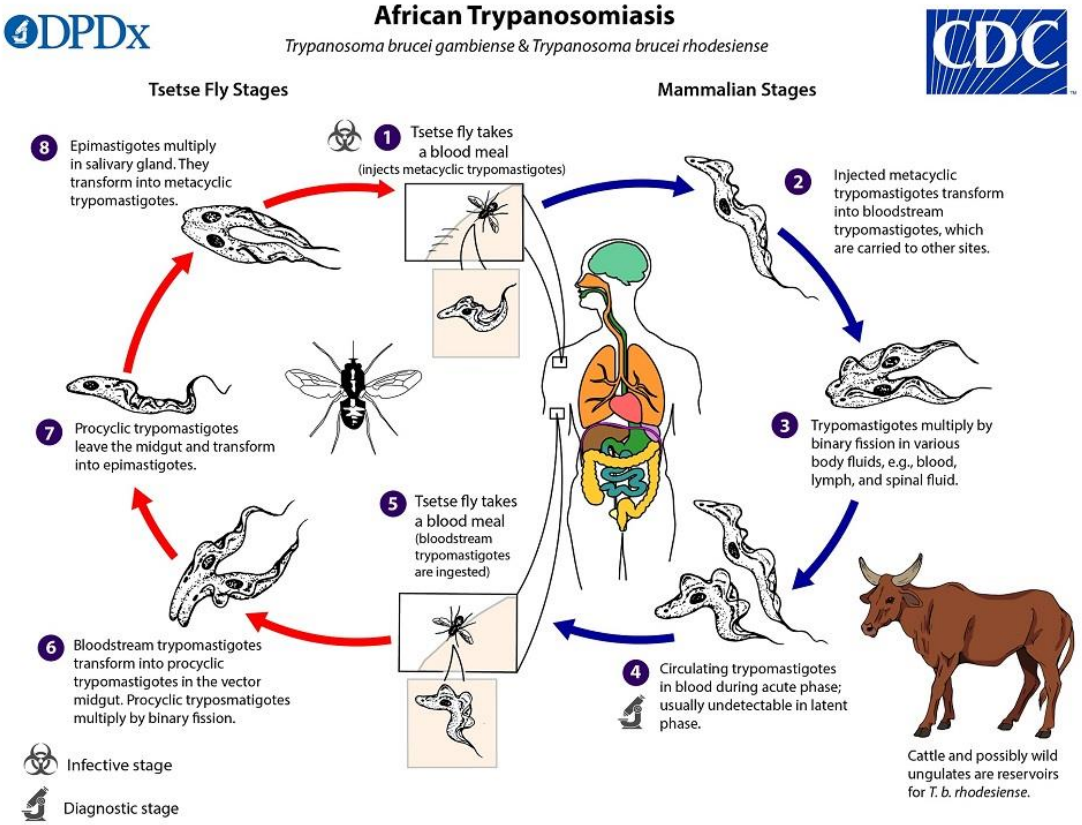
→ *Trypanosoma brucei gambiense*

→ *Trypanosoma brucei rhodesiense*

→ Heteroxenous life cycle

→ Central nervous system infection

→ Coma, death



Modes of parasite transmission 28

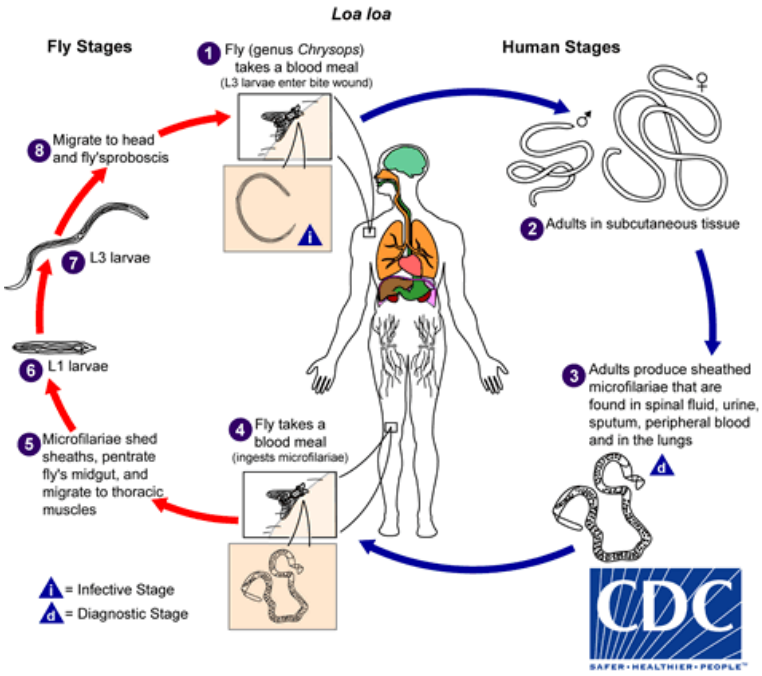
- Vector-borne transmission

→ Diurnal insect vector

→ By Chrysops bite → Loasis (filariasis)

→ By blackflies → Onchocerciasis (Filariasis)

→ Parasitoses
provoked by Helminths:

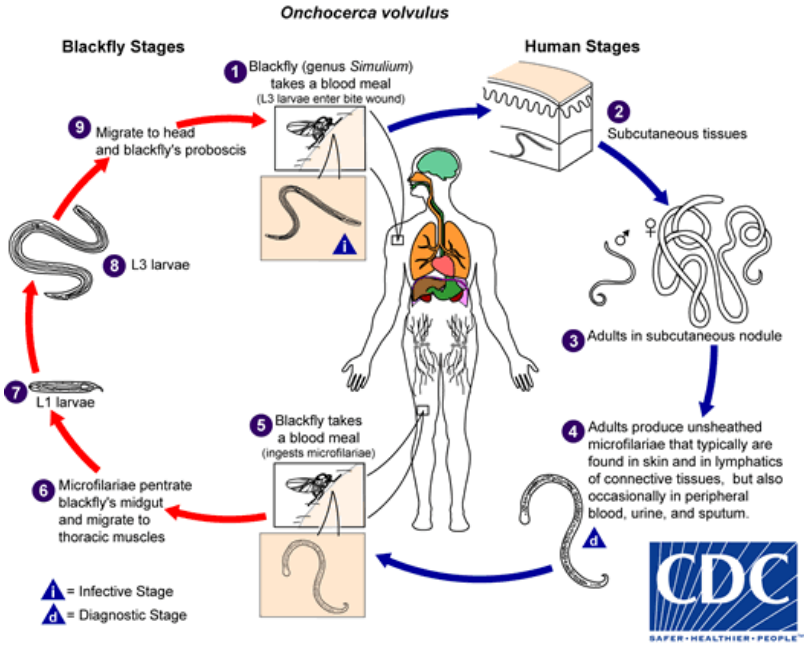


→ Heteroxenous life cycle

→ Loiasis → Calabar swellings (itchy swellings) and eye worm (few symptoms)

→ Onchocerciasis → Itchy skin rashes, nodules under the skin, and vision changes

→ Blindness



Modes of parasite transmission 29

- Vector-borne transmission

→ By terrestrial insect vectors:

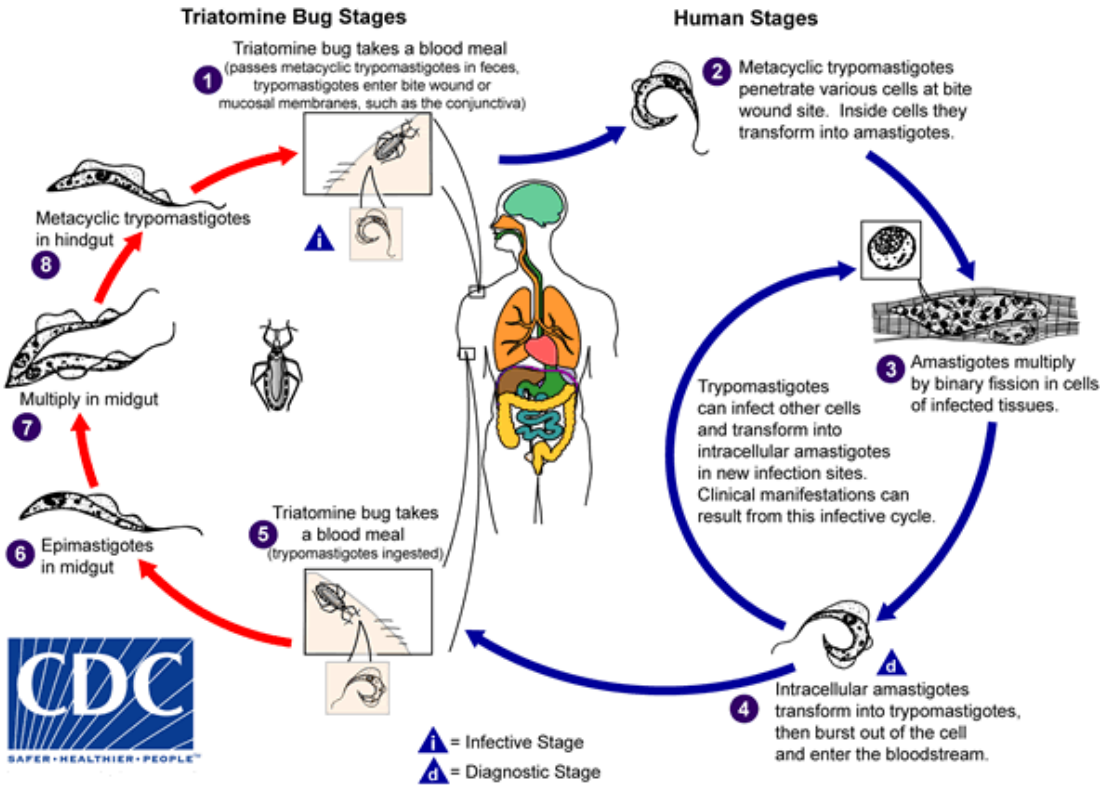
By a « kissing bug » taking a blood meal and releasing trypomastigotes in its feces near the site of the bite wound

→ Parasitoses provoked by Protists:

Chagas disease
= American trypanosomiasis

→ *Trypanosoma cruzi*

→ Heteroxenous life cycle



→ Heart rhythm abnormalities that can cause sudden death

→ Dilated heart that doesn't pump well blood

→ Dilated esophagus or colon, leading to difficulties with eating or passing stool

Modes of parasite transmission 31

- Airborne transmission

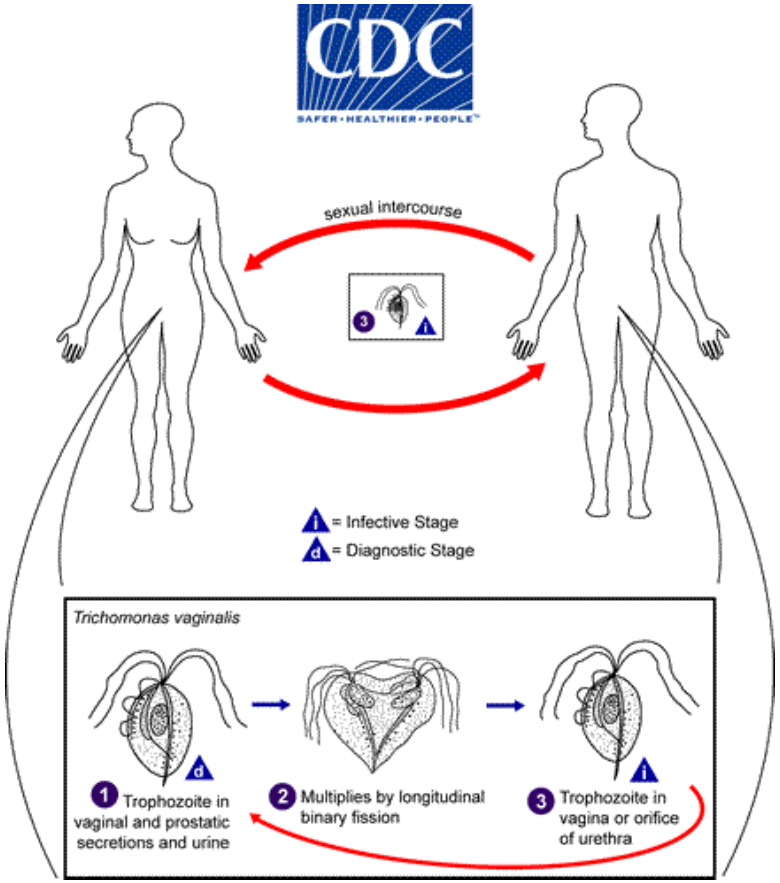
Pneumocystosis (Fungi)

- Sexual transmission

Uro-genital trichomoniasis → →

- Congenital transmission

Toxoplasmosis, Malaria



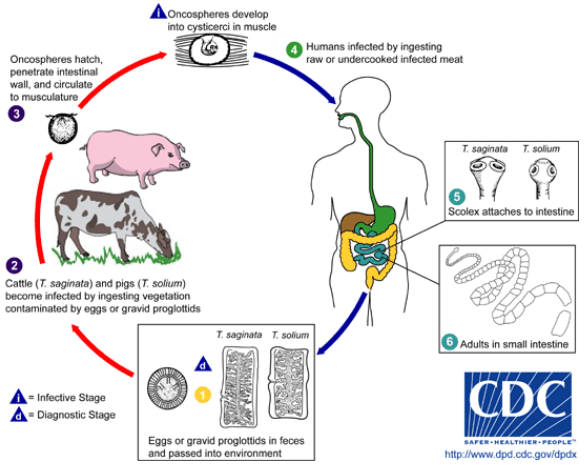
- Transmission by blood transfusion

Malaria, trypanosomiases, filariases, toxoplasmosis

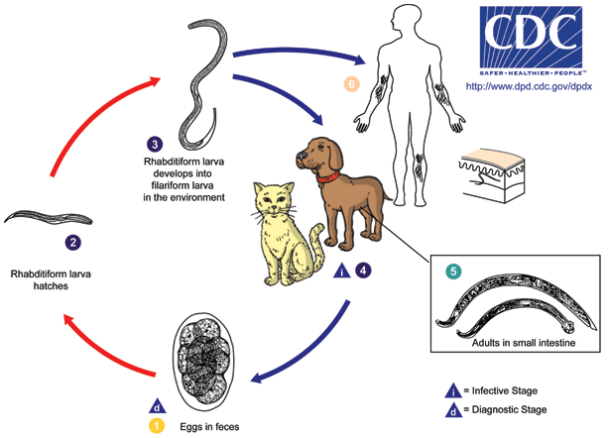
- Transmission by organ transplant

Toxoplasmosis

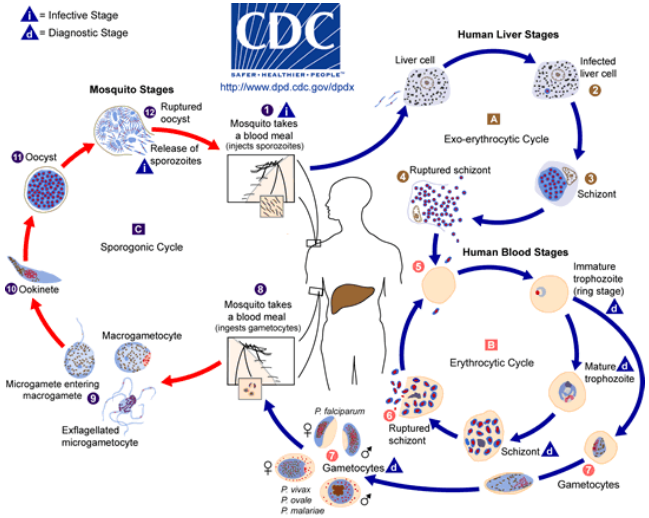
Conclusion 1 : Role of humans in parasite life cycles



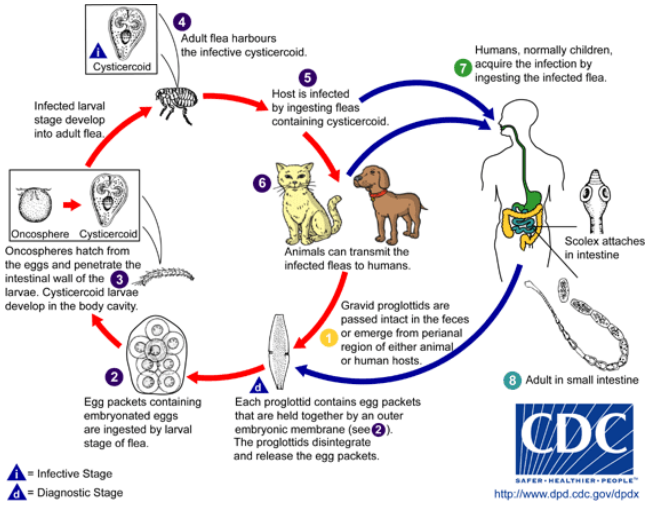
Taenia: Final host



Larva migrans: Dead-end host



Plasmodium : Intermediate host



Dipylidium caninum: Secondary host

Conclusion 2 : Search for control strategies adapted to parasite life cycles

→ Control strategies are fundamentally dependent of the knowledge of life cycle characteristics

Environmental aspects in control
- → Control of food and water quality
- → Control of vectors
- → Control of intermediate host populations

Therapeutic aspects in control
- → Chemotherapy
- → Vaccines

Many things have been done, and …..many things remain to be done !