

Protozoan parasites

Gwy-Am Shin

Office: Room 2335, 4225 Roosevelt Way NE

Phone: 206-543-9026

Email: gwyam@u.washington.edu

Pathogens in the environment

- Viruses and prions
- Bacteria and rickettsiae
- Fungi and Algae
- Protozoans
- Helminths

Protozoa (Introduction)

- Proto (=first) zoa (=animal)
 - Unicellular (one-celled) animals
 - > 50,000 species (mostly free-living)
- Protozoa vs. Humans
 - Normally not harmful
 - Inapparent or mild infections in normal individuals
 - Sometimes life-threatening infections in immunosuppressed people (e.g. AIDS patients)
 - *Cryptosporidium parvum*, *Toxoplasma gondii*, *Microsporidia* spp. (now fungi?), and so on

Protozoa (structure I)

- Size
 - Usually 10-50 μm
 - smallest: 1-10 μm , largest: $\sim 150 \mu\text{m}$ (*Balantidium coli*)
- Many organelles
 - Nucleus (or nuclei)
 - Cytosome (cell mouth), food vacuoles, contractile vacuoles (osmoregulation), Golgi apparatus, mitochondria, lysosomes,...
 - Locomotive structures: pseudopodia, flagella, cilia
- Cell cycle and reproduction
 - Asexual (binary fission) and sexual (various life stages)

Sizes of microorganisms

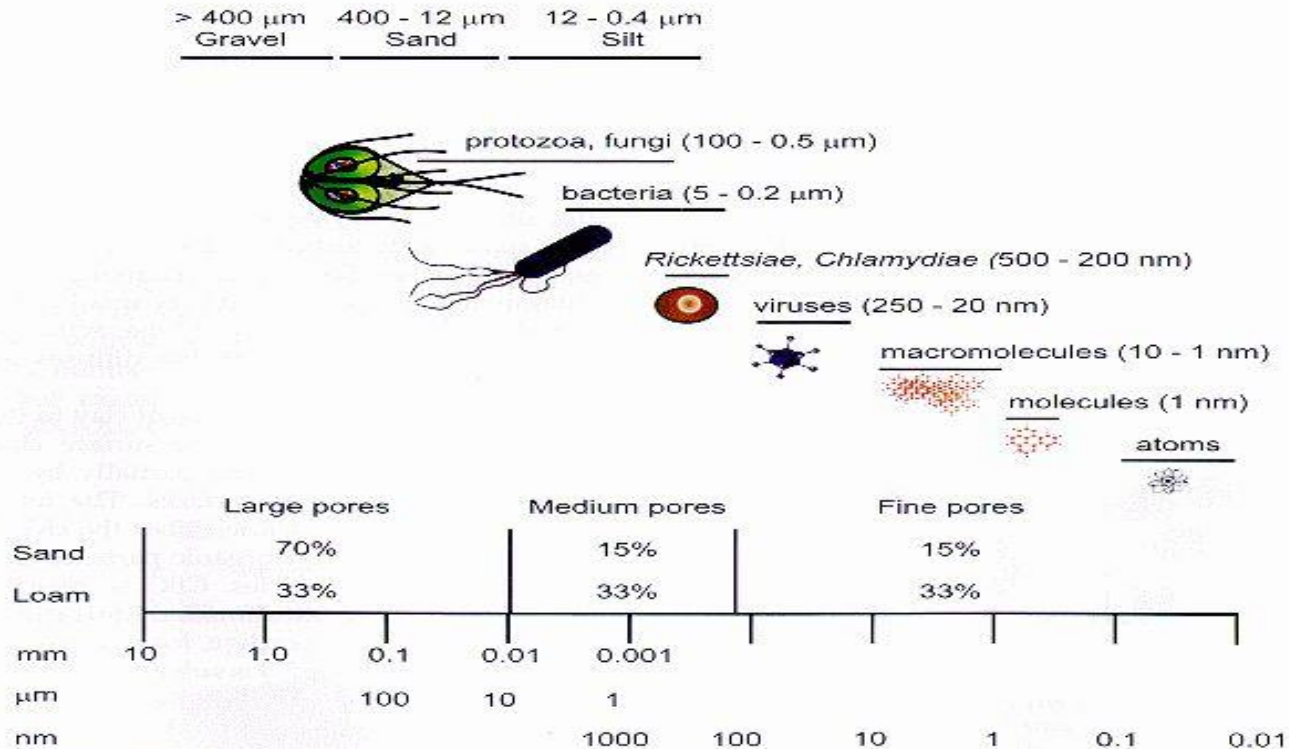


FIGURE 4.5 Comparison of sizes of bacteria, viruses, and molecules with hydraulic equivalent diameters of pore canals. (Adapted from *J. Contam. Hydrol.*, 2, G. Matthess, A. Pekdeger, and J. Schroeder, Persistence and transport of bacteria and viruses in groundwater—a conceptual evaluation, 171–188, © 1988, with permission from Elsevier Science.)

Structure of prokaryotic cells

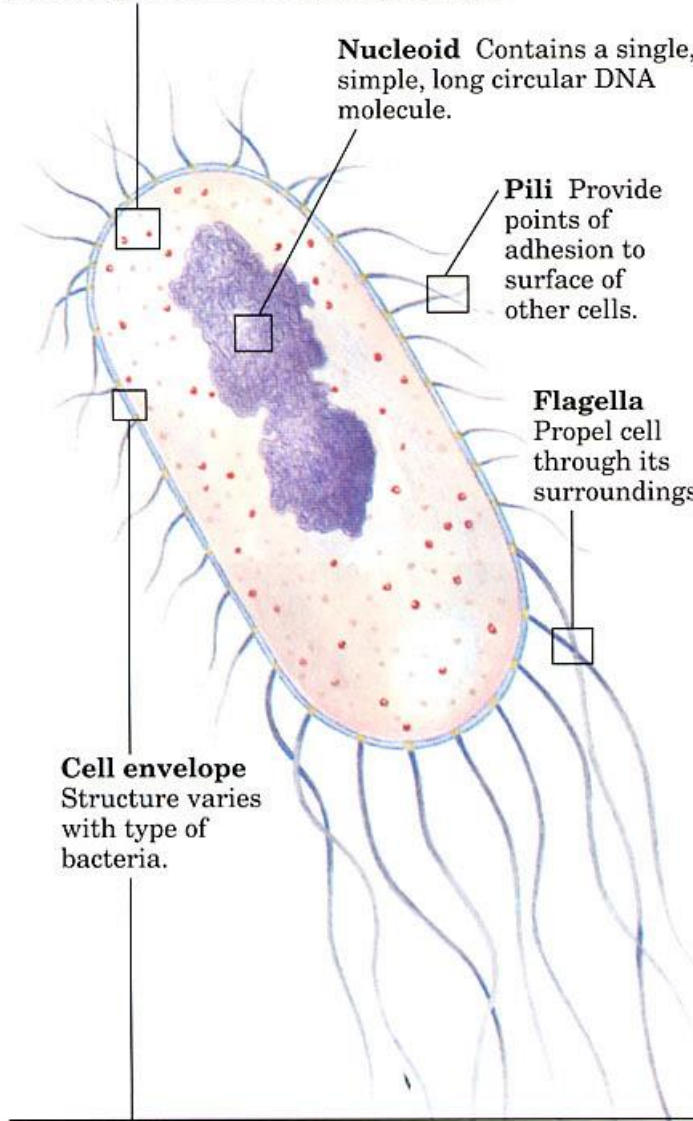
Ribosomes Bacterial ribosomes are smaller than eukaryotic ribosomes, but serve the same function—protein synthesis from an RNA message.

Nucleoid Contains a single, simple, long circular DNA molecule.

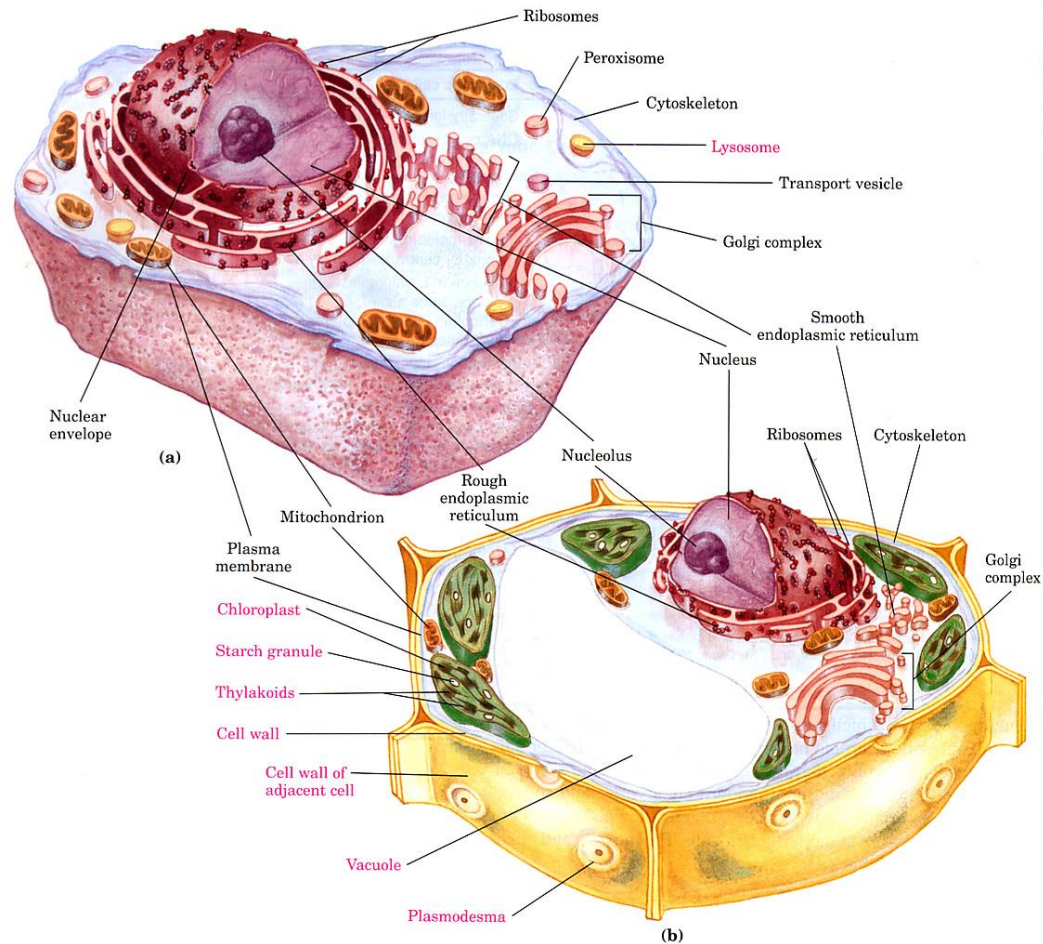
Pili Provide points of adhesion to surface of other cells.

Flagella Propel cell through its surroundings.

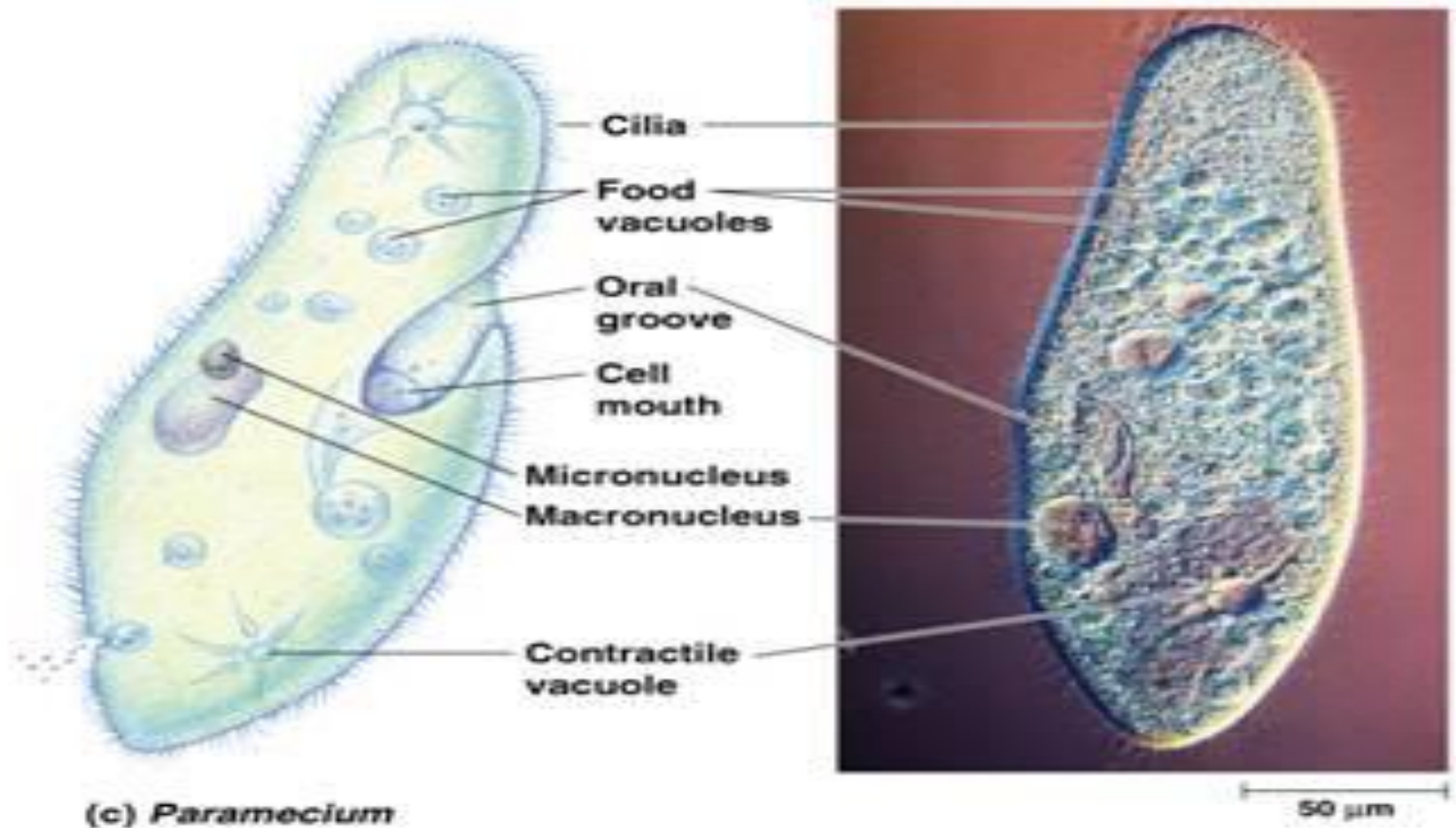
Cell envelope
Structure varies with type of bacteria.



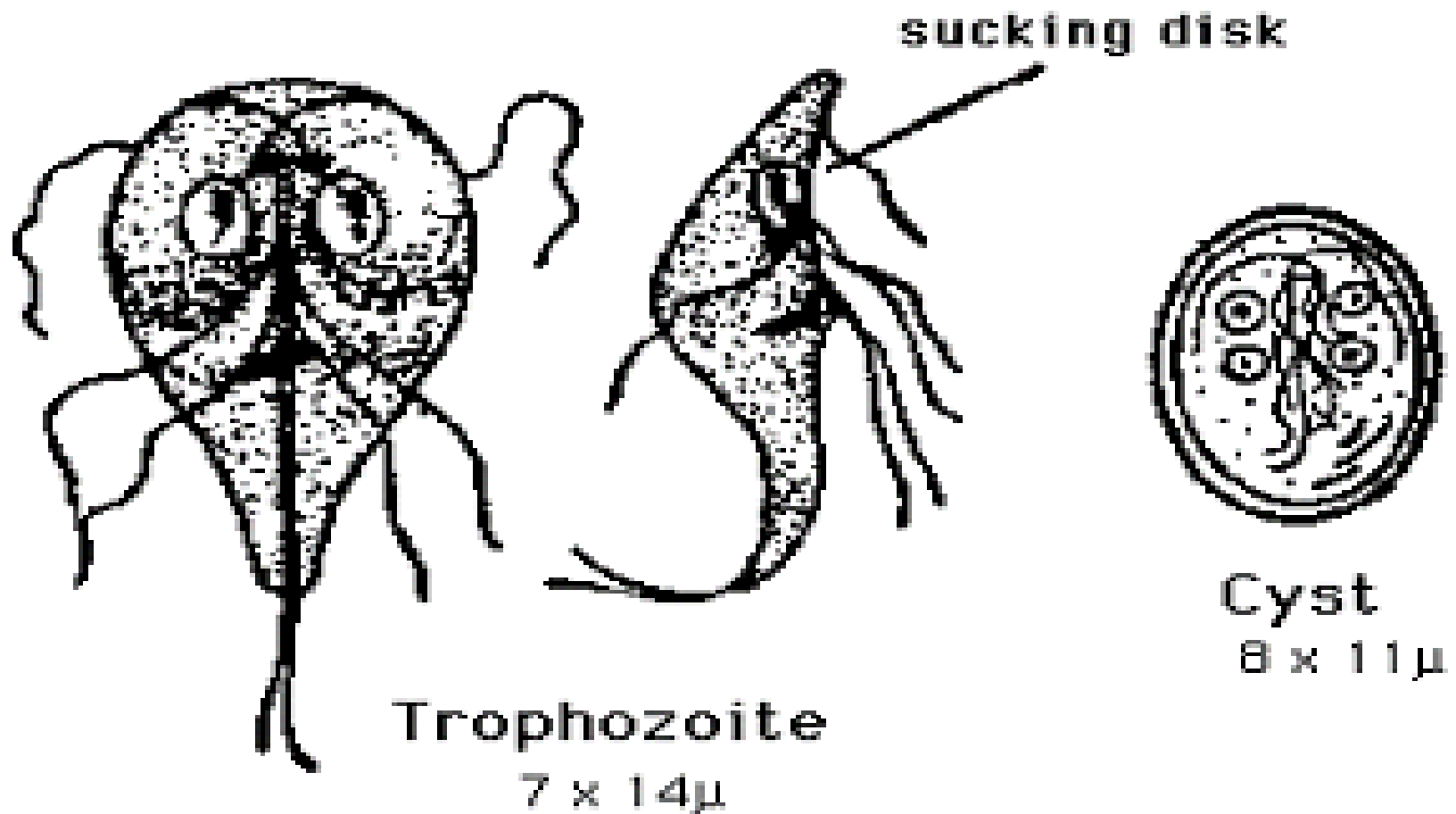
Structure of eukaryotic cells



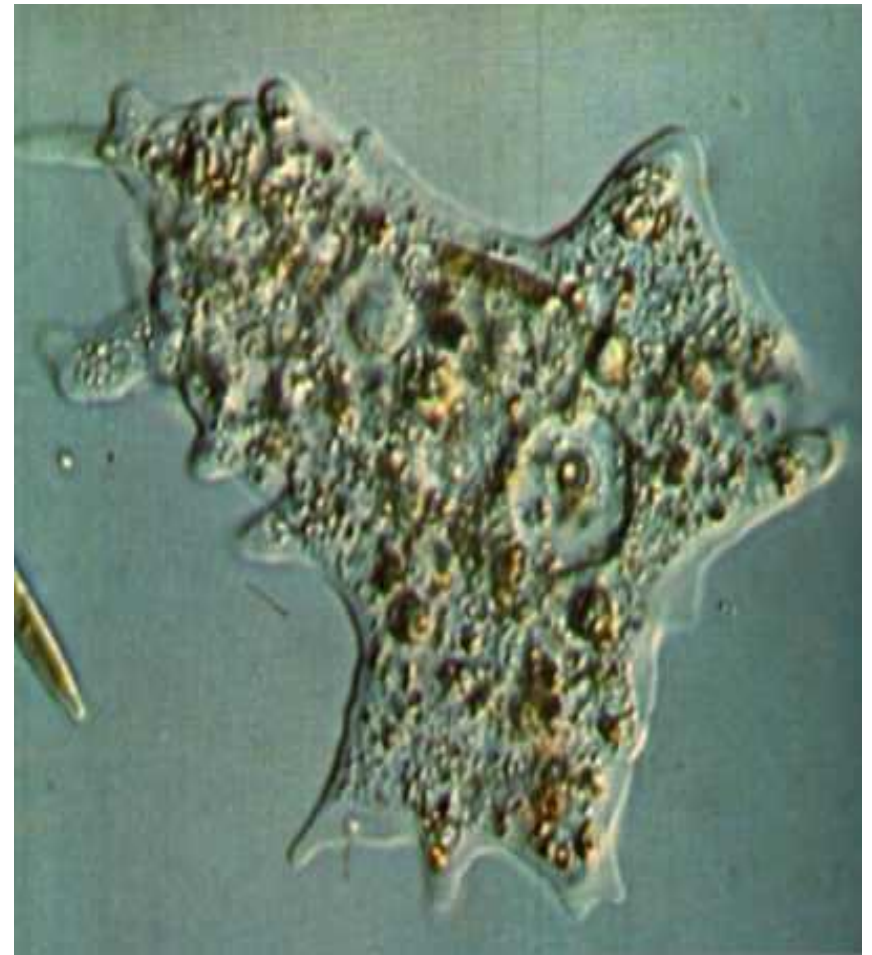
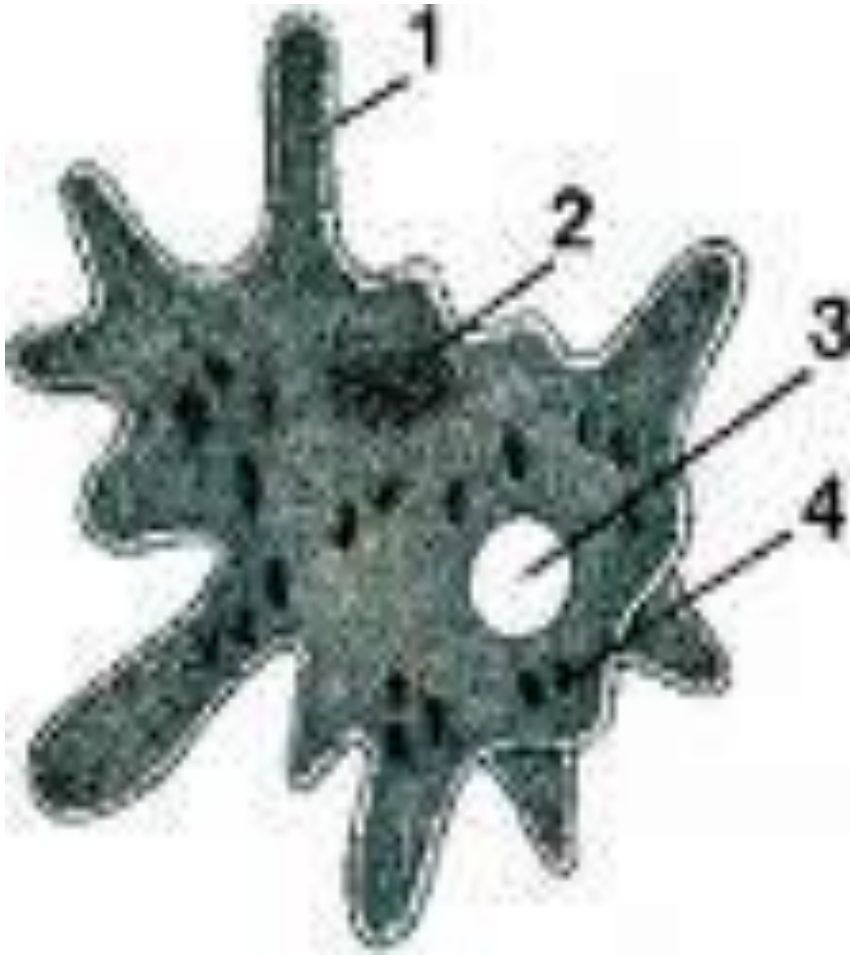
Protozoa (structure II)



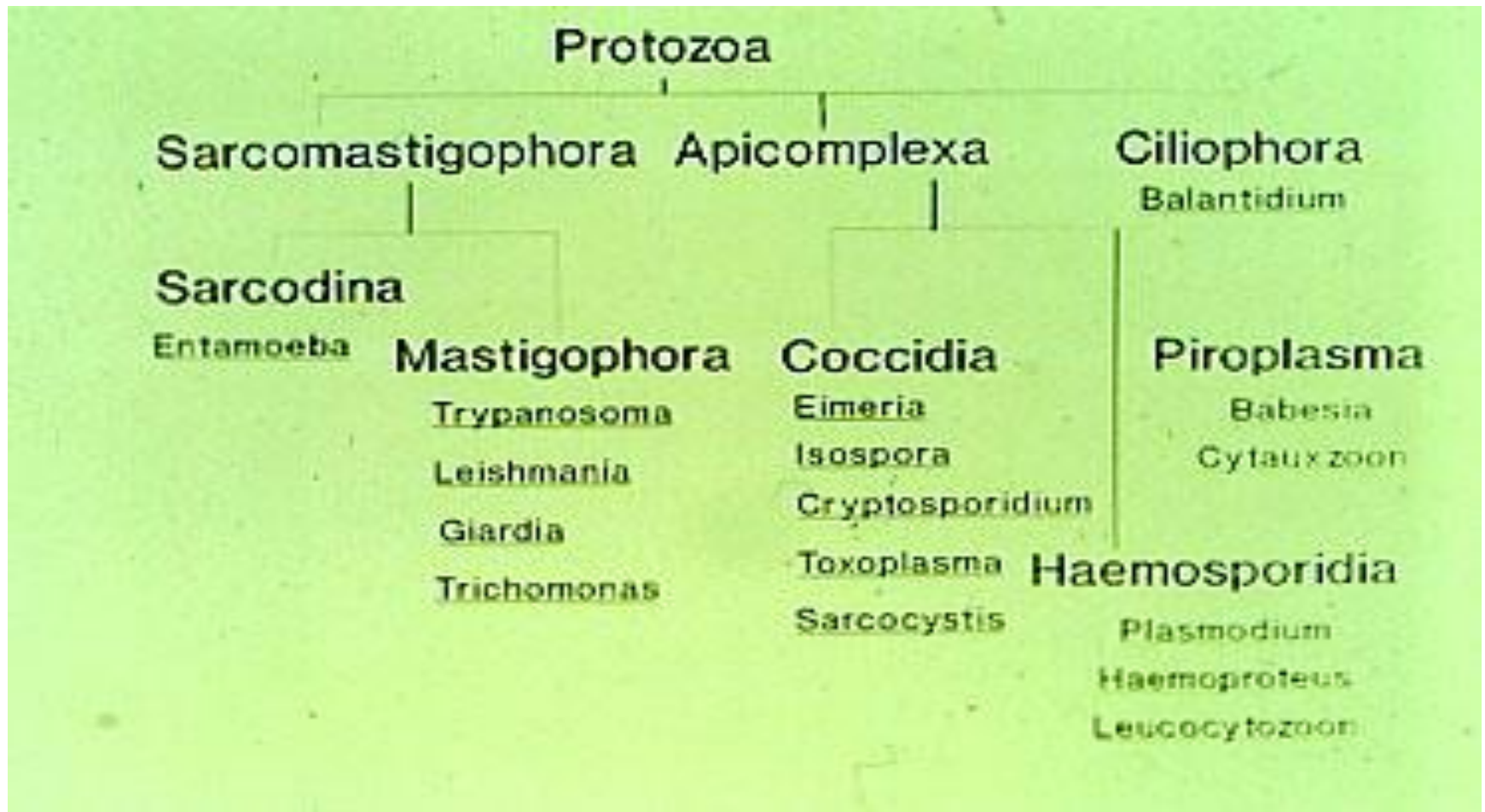
Protozoa (structure III)



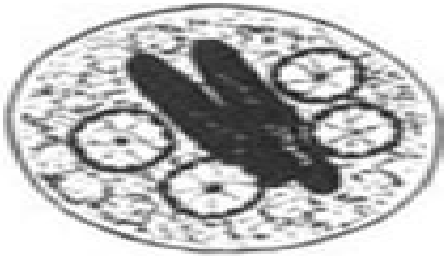
Protozoa (structure III)



Protozoa (classification I)



Entamoeba histolytica



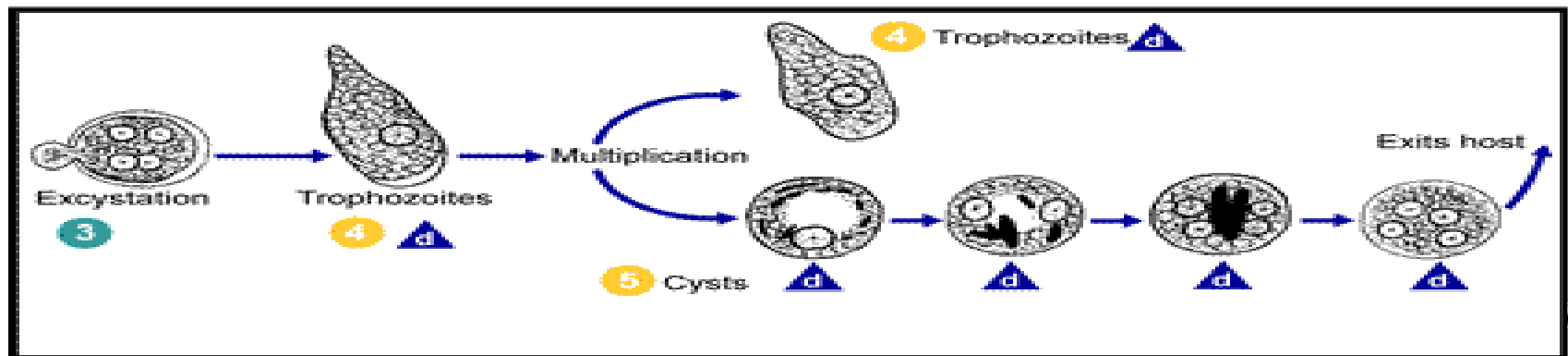
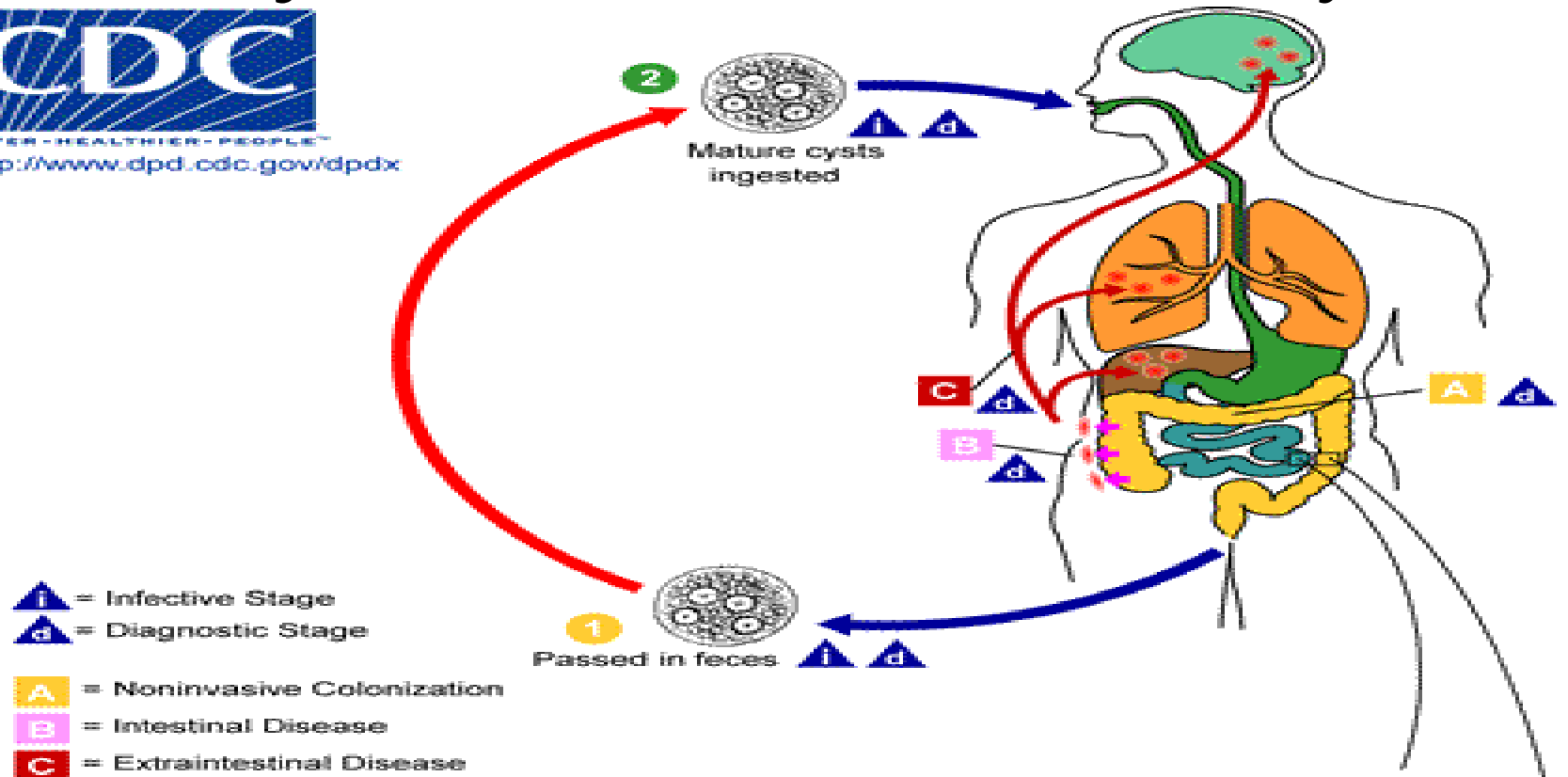
- Sarcomastigophora (Sarcodina)
- Cyst
 - 10-20 μm
 - 4 nuclei
 - 2 chromatoidal bars
- Trophozoite
 - 12-50 μm
 - 1 nucleus
 - actively mobile
- Reproduction
 - binary fission of trophozoite
 - development of several (up to 4) trophozoites within the mature multinucleated cyst.



Life cycle of *Entamoeba histolytica*



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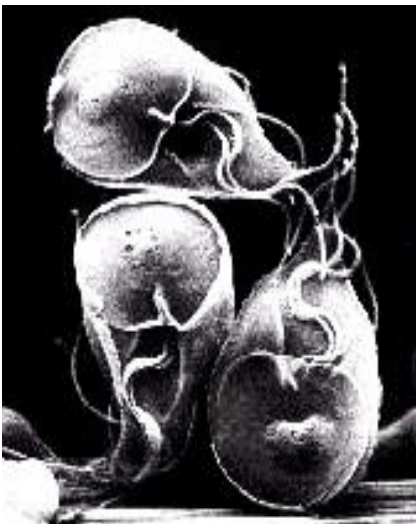
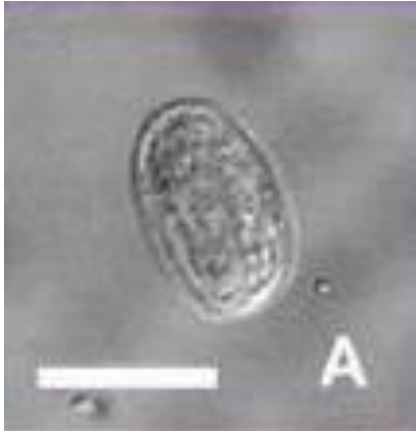
Epidemiology (*Entamoeba histolytica*)

- Worldwide
 - 0.5 % prevalence in developed countries
 - 10-15 % (sometimes 50-80 %) in developing countries
- Most infections are inapparent (asymptomatic)
 - Still shed large number of cysts in their feces
- Incubation period: 1-4 weeks
- Mild GI symptoms (abdominal pain, cramps, colitis and diarrhea), bloody diarrhea (amoebic dysentery)
- High risk groups: travelers, recent immigrants, male homosexuals, institutioned populations

Epidemiology (*Entamoeba histolytica*)

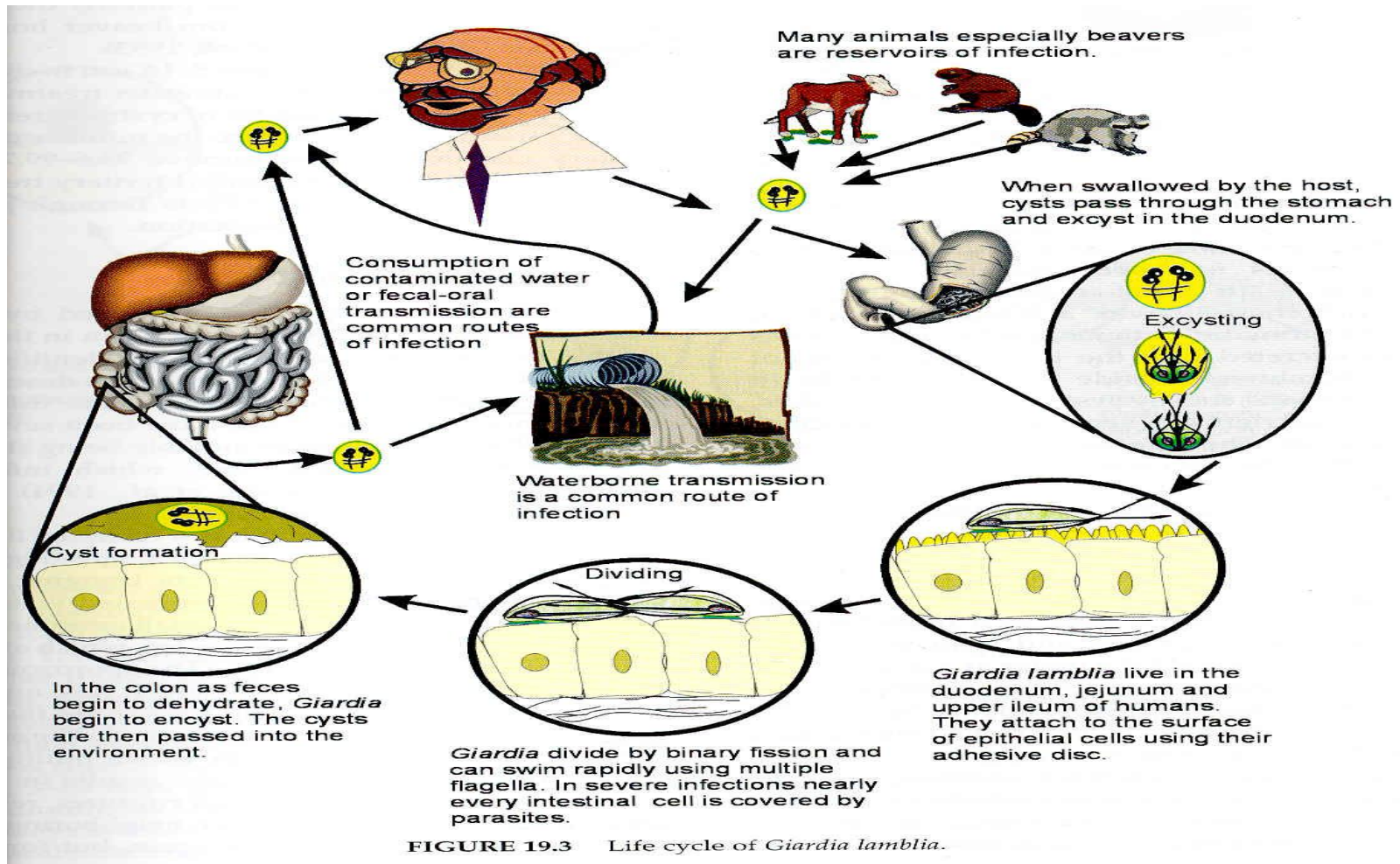
- Reservoir: human is the only host
- Transmission: Direct transmission (sexually transmission), fecal-oral route, waterborne, foodborne
- Prevention: adequate sanitation and excreta disposal, provision of non-fecally contaminated water and food

Giardia lamblia



- Sarcomastigophora (Mastigophora)
- Cyst
 - 8-14 μm
 - 2-4 nuclei
 - thick cyst wall (0.3 μm)
- Trophozoite
 - Heart-shaped, symmetric
 - 10-18 μm long, 6-8 μm wide
 - 2 nuclei
 - 8 flagellas
- Reproduction
 - Binary fission of trophozoites

Life cycle of *Giardia lamblia*



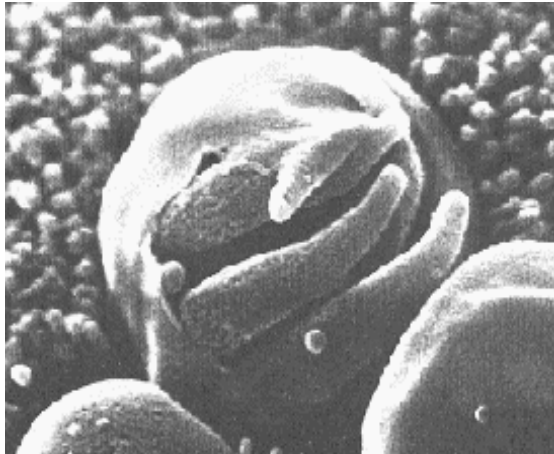
Epidemiology (*Giardia lamblia*)

- Worldwide
 - 7.2 % prevalence in USA
- Infectious dose: ~10 cysts
- Incubation period: 1-14 days
- Duration of illness: 1-3 weeks
- Symptoms: abdominal cramps, nausea, vomiting, anorexia, low-grade fever, flu-like headache, general malaise, weakness, weight loss, distension, profuse, greasy, bulky and foul-smelling diarrhea
- Fecal shedding: 10^3 - 10^8 cysts/gram (human), 10^7 - 10^8 cysts/gram (calves)
- Levels in sewage: 3,000-30,000 cysts/liter
- High risk groups: children (in day-care centers), immunosuppressed people, and institutioned populations

Epidemiology (*Giardia lamblia*)

- Reservoir: Human and animals (dogs, beaver, muskrat, elk, deer, voles, mice, horses, sheep, ...)
- Transmission: Fomites, waterborne, foodborne
- Prevention: personal hygiene, surface disinfection, water treatment, food safety program

Cryptosporidium parvum



- Apicomplexa (Coccidia)
- Oocyst
 - 4 - 6 μm
 - 4 sporozoites
 - Thick oocyst wall
- Sporozoite
 - No locomotive structure
- Reproduction
 - Both asexual and sexual

Life cycle of *Cryptosporidium parvum*

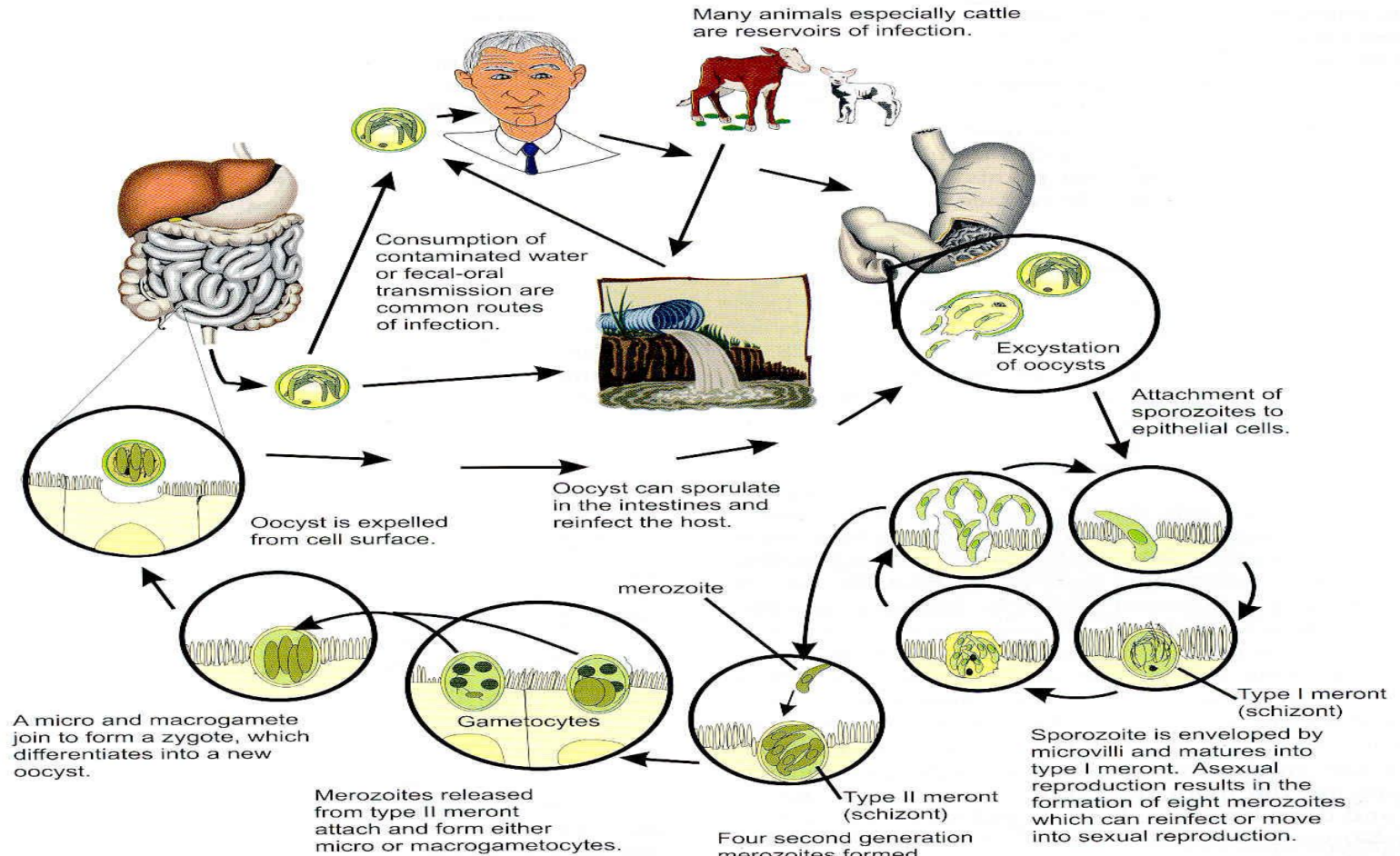


FIGURE 19.5 Life cycle of *Cryptosporidium parvum*.

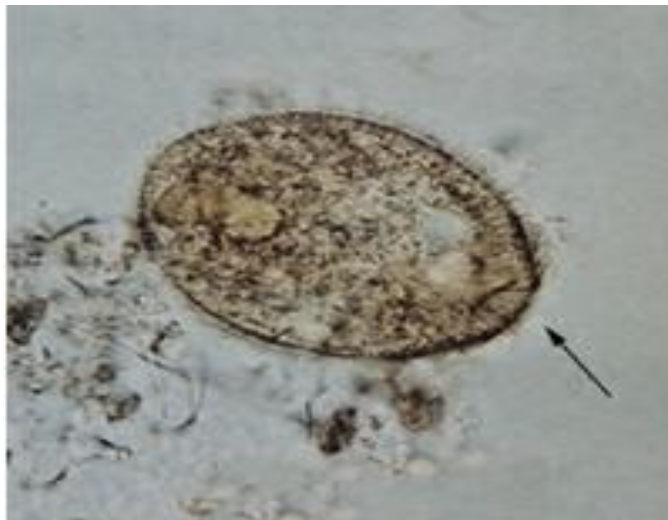
Epidemiology (*Cryptosporidium parvum*)

- Worldwide
 - 0.3 % prevalence (general population) and 6-54 % (day-care center children) in USA
- Infectious dose: < 10 oocysts
- Incubation period: 7 days
- Duration of illness: 1-4 weeks
- Symptoms
 - Immunocompetent people: similar to giardiasis
 - Immunocompromised people: life-threatening
 - **Fluid loss: 2-6liters/day (17 liters/day)**
 - Extra-intestinal infection: respiratory cryptosporidiosis (intestinal pneumonia)
- Levels in sewage: 10^4 oocysts/liter
- High risk groups: children, immunosuppressed people, institutioned populations

Epidemiology (*Cryptosporidium parvum*)

- Reservoir: Human and animals (calves, lambs, goats, horses, pigs, deer, squirrel, beaver, muskrat, woodchuck, rabbit, dogs, fox, cat, skunk, raccoon, bear, ...)
- Transmission: Fomites, waterborne, foodborne
- Prevention: personal hygiene, surface disinfection, water treatment, food safety program

Balantidium coli



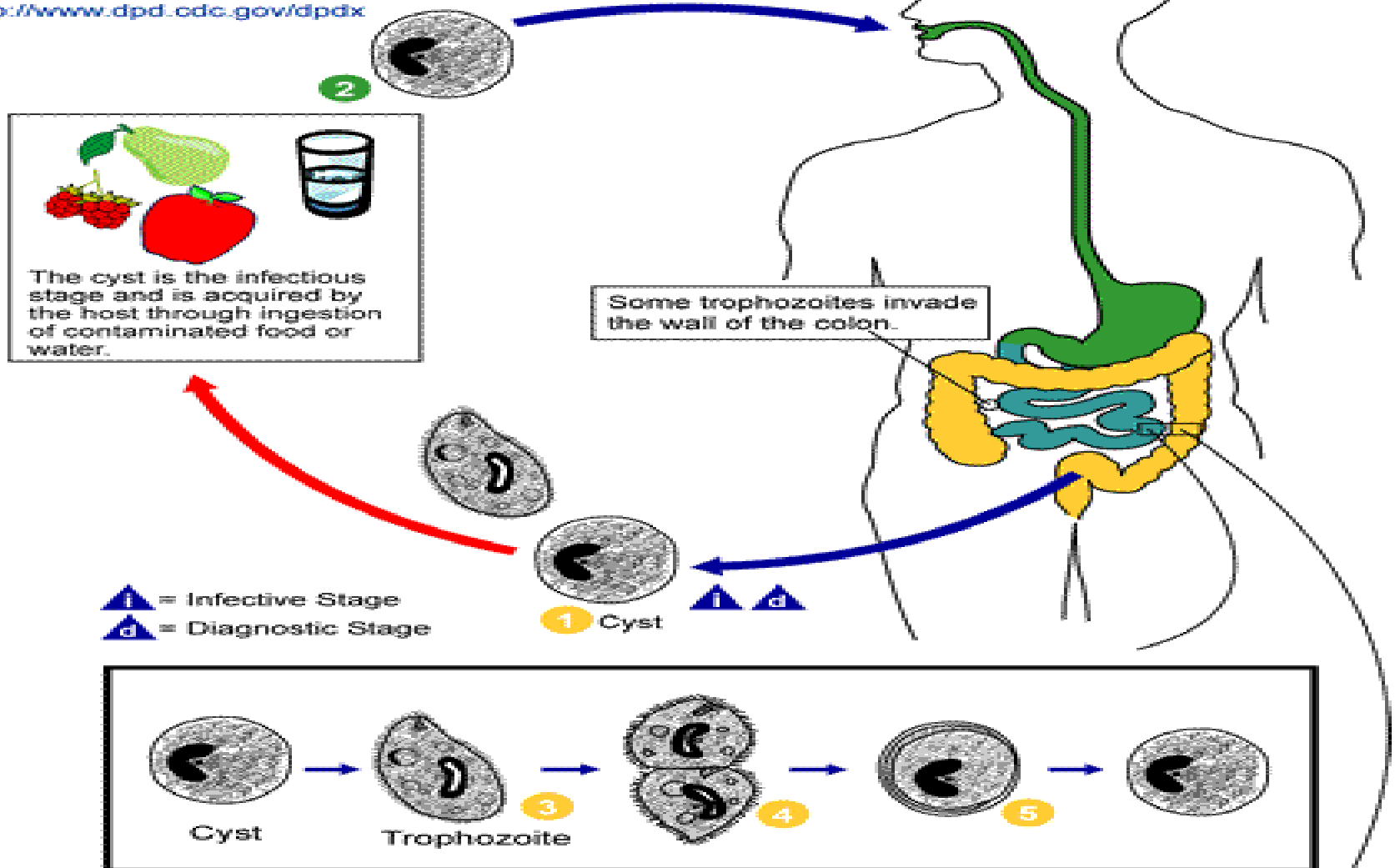
- Ciliophora
- Cyst
 - 50-70 μm
 - 2 nuclei
 - Various vacuoles
- Trophozoite
 - 50-100 μm long, 40-70 μm wide
 - 2 nuclei
 - Many vacuoles
 - Locomotive method: cilia
- Reproduction
 - Binary fission of trophozoites

Life cycle of *Balantidium coli*



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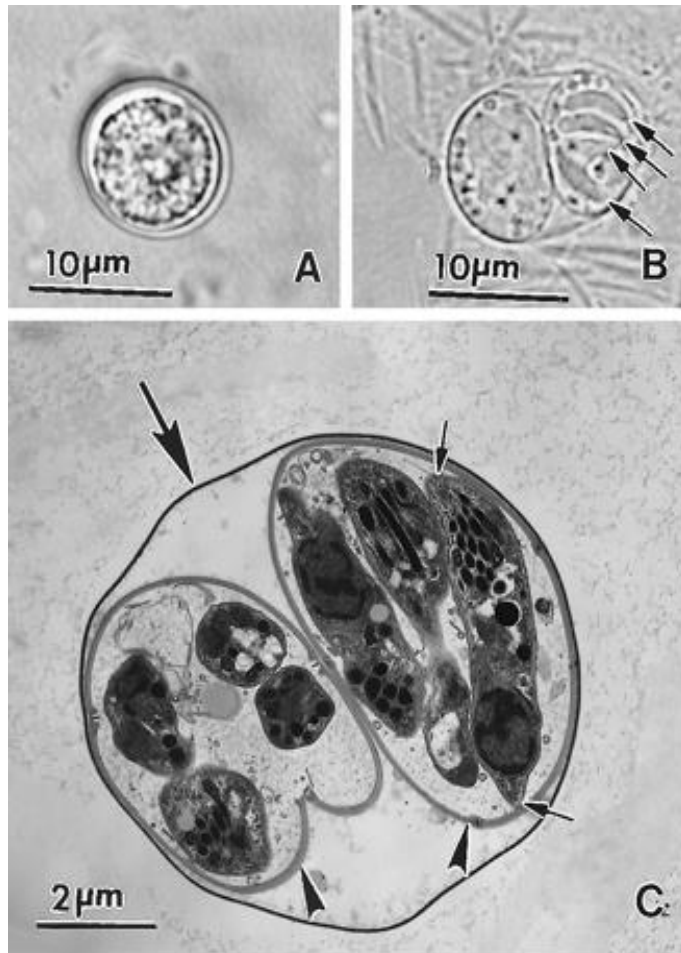
Epidemiology (*Balantidium coli*)

- Worldwide
- Symptoms: mostly asymptomatic or similar to amebiasis
- Reservoirs: Human and animals (pigs, chimpanzees,...)
- Transmission: waterborne, foodborne
- Prevention: personal hygiene, water treatment, food safety program

Emerging Protozoan Parasites

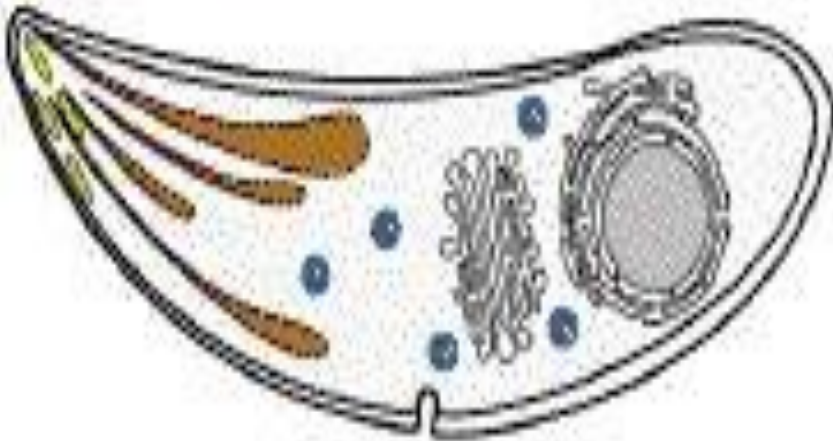
- *Toxoplasma gondii*
- *Microsporidia* spp.(now fungi?)

Toxoplasma gondii (oocysts)

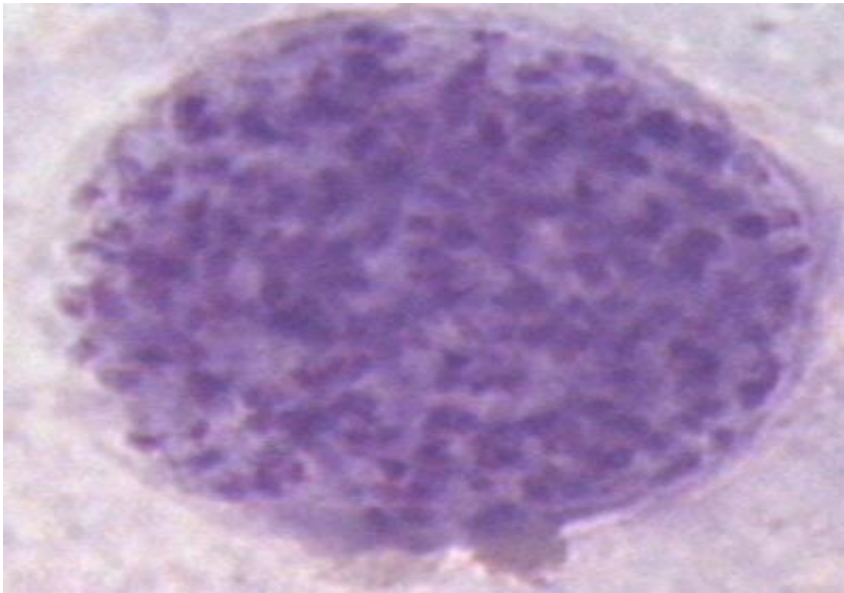


- Apicomplexa (Coccidia)
- Oocyst
 - Two phases
 - A: unsporulated
 - B: sporulated
 - 10 – 13 µm
 - two sporocysts
 - four sporozoites
 - distinctive cell walls
 - two or three layers
 - scatter UV
 - highly persistent in the environment
 - soil (months)
 - moist conditions (years)

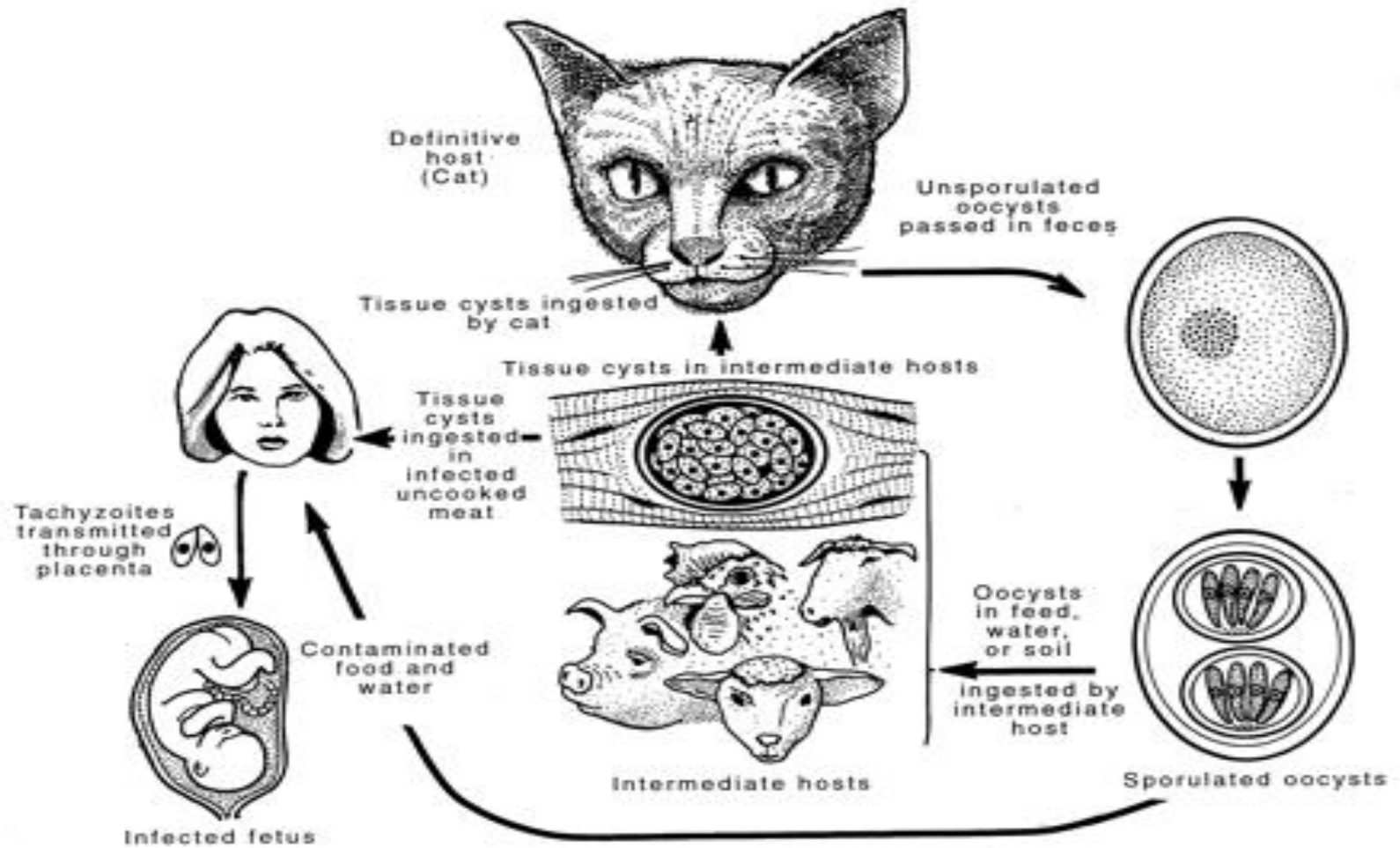
***Toxoplasma gondii* (other infectious forms)**



- **Tachyzoite**
 - Crescent-shaped
 - 2X6 μm
 - Rapidly multiplying
 - Transmitted through placenta
- **Bradyzoite**
 - Slowly multiplying
 - Tissues in intermediate hosts
- **Reproduction**
 - Both asexual (intermediate hosts) and sexual (definitive hosts: cats)



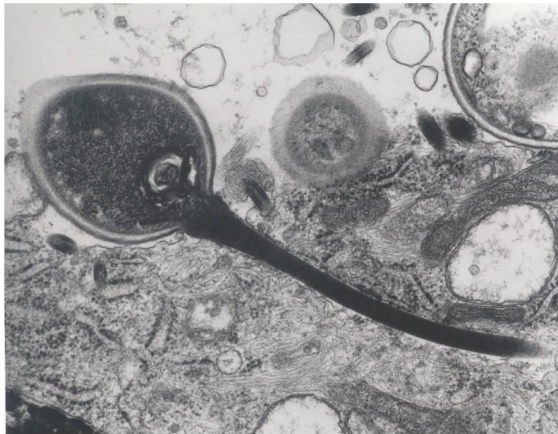
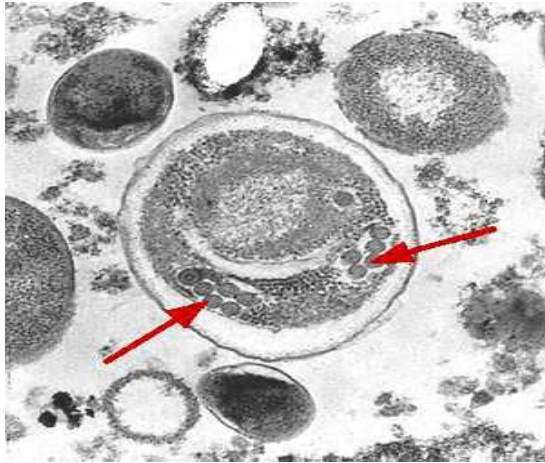
Transmission of *Toxoplasma gondii*



Epidemiology (*Toxoplasma gondii*)

- Worldwide
 - 22.5 % prevalence (general population) in USA between 1988-1994
 - Half billion people in the world
 - Unusually high prevalence in France (65-85%): raw or undercooked meat
 - High prevalence in Central America: large number of stray cats
- Symptoms
 - Immunocompetent people: mostly asymptomatic, some flu-like symptoms (swollen lymph glands, muscle aches and pains)
 - Immunocompromised people: life-threatening
 - **central nerve system disease (encephalitis)**
 - blindness, myocarditis, pneumonia
 - **Congenital infected children**
 - **impaired vision and mental retardation**
- Fecal shedding: 10^5 oocysts/gram (cats)
- High risk groups: infants born to infected mothers, immunosuppressed people

Microsporidia spp.



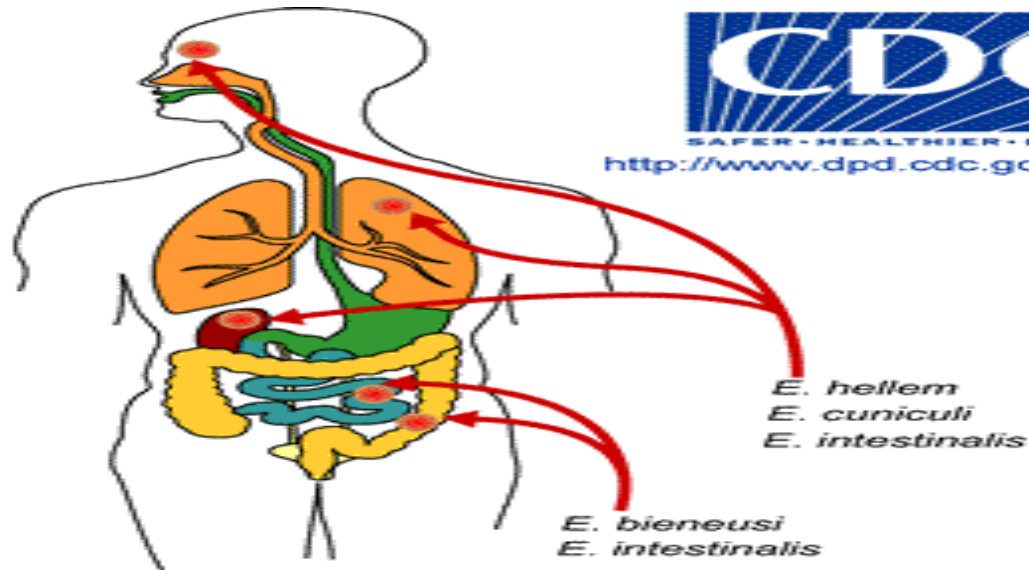
- New Phylum
 - 143 genera, >1200 species
 - 14 identified human pathogens
- Produce very resistant spores
 - Usually small (1-4 μm)
- A unique organelle (polar tubule)
 - Coiled inside the spores
 - Inject infective spore contents into the host cells

Life cycle of *Microsporidia* spp.

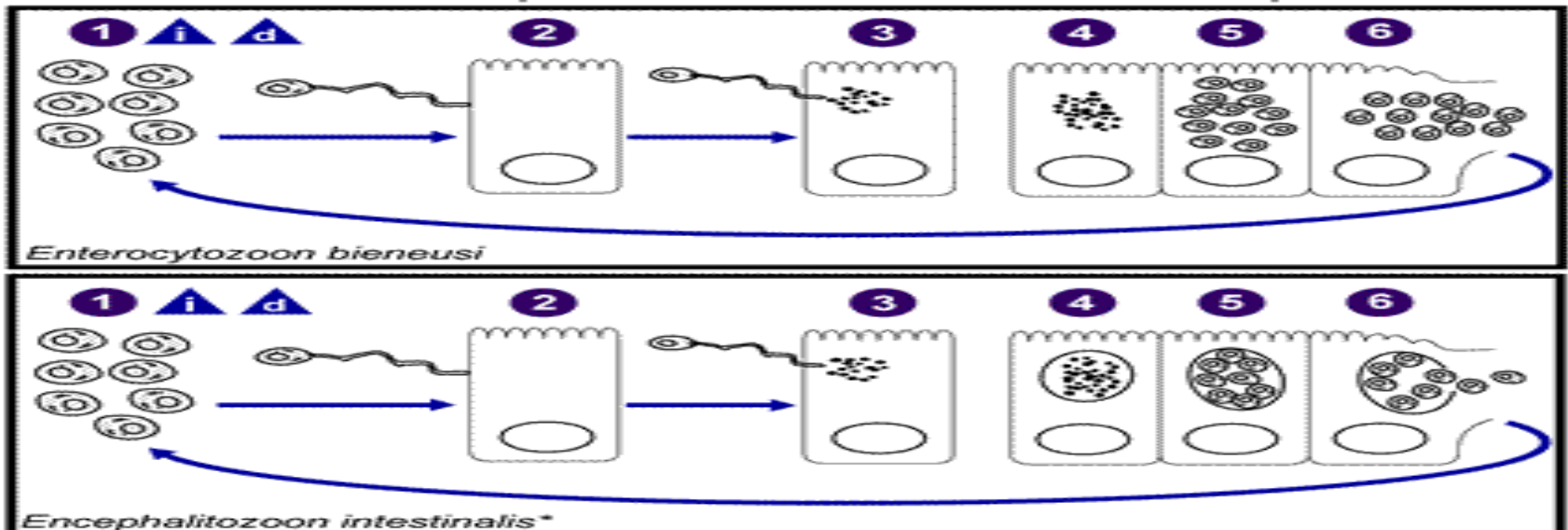
▲_i = Infective Stage
▲_d = Diagnostic Stage



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



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

Epidemiology (*Microsporidia* spp.)

- Worldwide
 - Both developed and developing countries
- Symptoms:
 - Immunocompetent people: asymptomatic or self-limiting diarrhea
 - Immunocompromised people:
 - **Chronic diarrhea**
 - Disseminated diseases (keratoconjunctivitis, bronchitis, pneumonia, hepatitis, ...)
- Reservoirs: human and animals (rabbits, mice, dogs, pigs, cats, cattle, wild birds (parrots), insects?)
- Transmission: uncertain
 - Airborne transmission?
 - Waterborne transmission?
 - Transplacental transmission? (*Encephalitozoon* spp.)

Other Protozoa

- Trypanosomes- Sleeping Sickness
 - African (Tsetse flies)
 - American (kissing bugs) “Chaga’s”
- *Acanthamoeba spp.* (GAE)
- *Balamuthia mandrillaris* (GAE)
- *Naegleria fowlerii* (PAM)
- *Pneumocystis carinii* (now *P. jiroveci* a fungus)