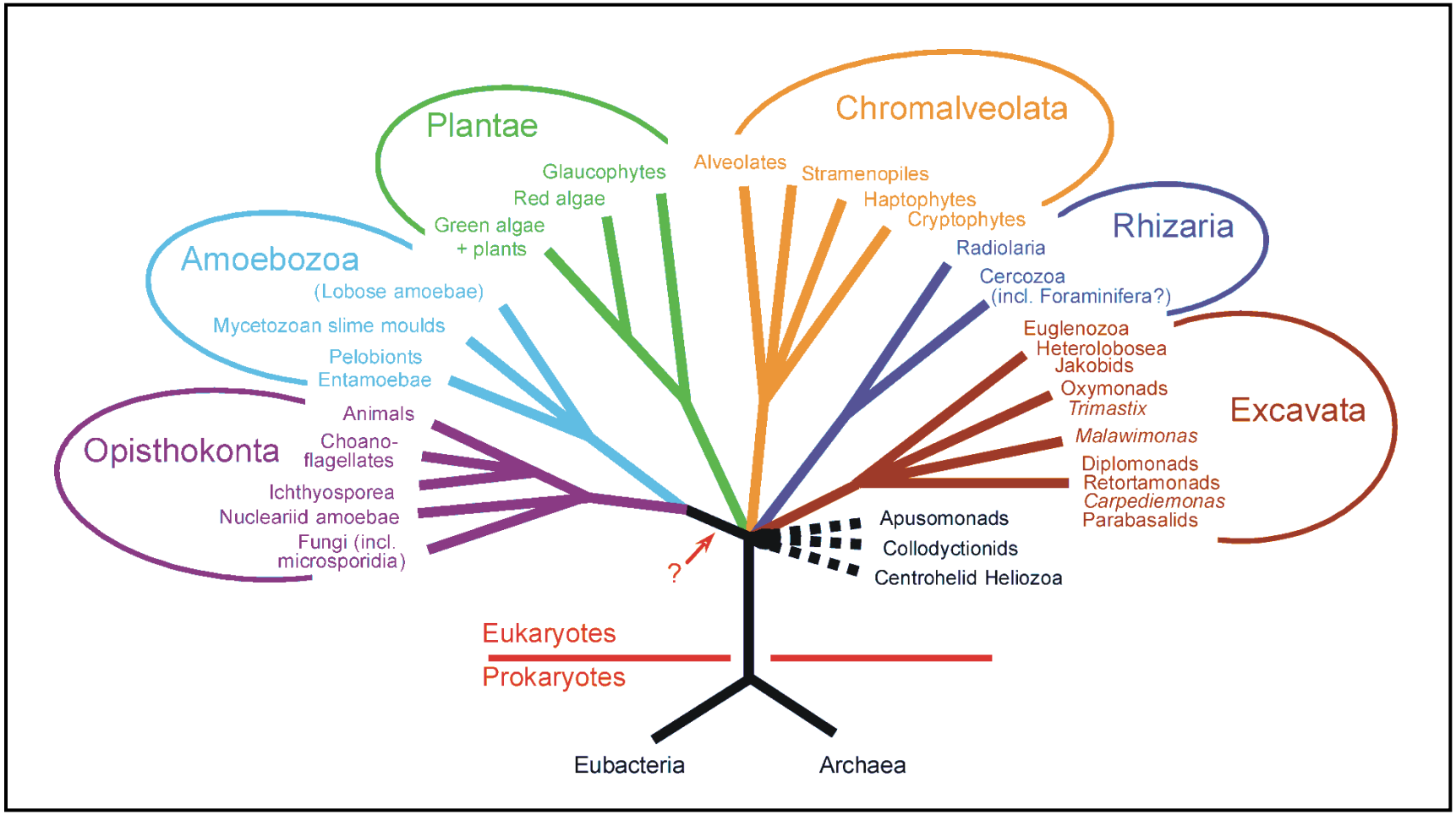
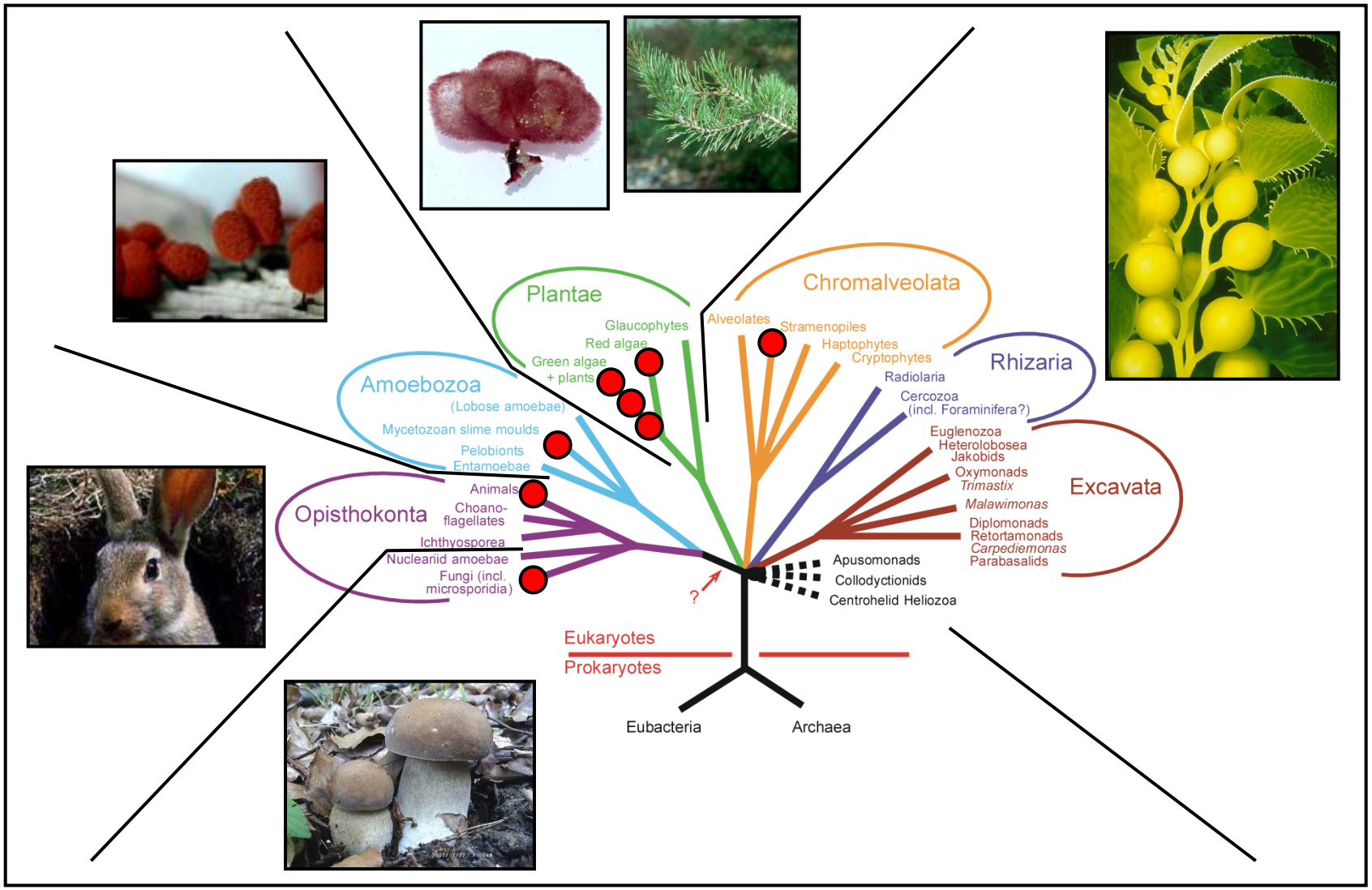


Simpson AGB, Roger AJ (2004) Curr Biol 14: R693-R696

Multicellular eukaryots



„PROTOZOA“

SYSTEM of PROTOZOA

(Adl et al., 2005)

EXCAVATA

1. phylum: Metamonada
2. phylum : Parabasalia
3. phylum : Euglenozoa
4. phylum : Heterolobosea
5. phylum: Preaxostyla

RHIZARIA

1. phylum: Phytomyxea
2. phylum : Foraminifera
3. phylum : Radiolaria

AMOEBOZOA

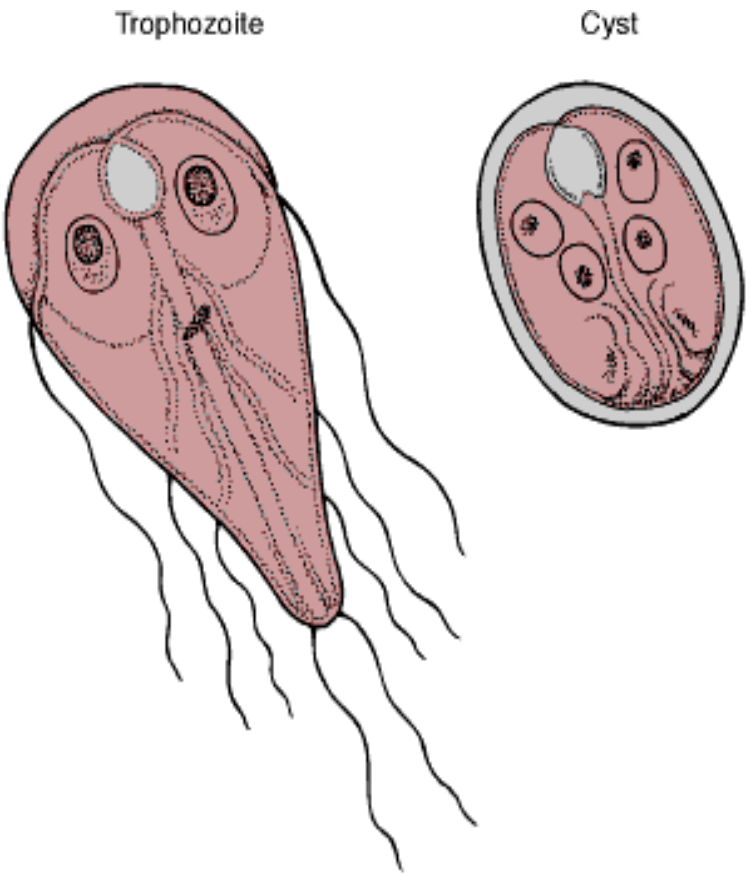
- phylum : Amoebozoa

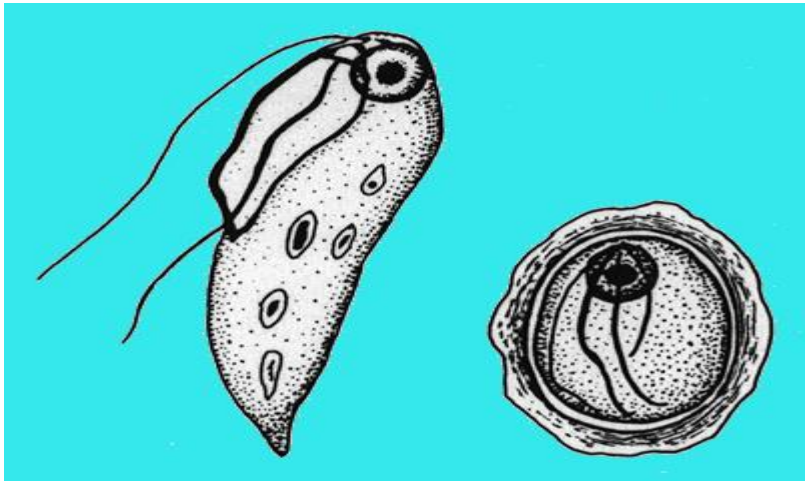
CHROMALVEOLATA

1. phylum: Dinoflagellata
2. phylum: Apicomplexa
3. phylum: Ciliophora

PROTOZOA (PROTISTS)

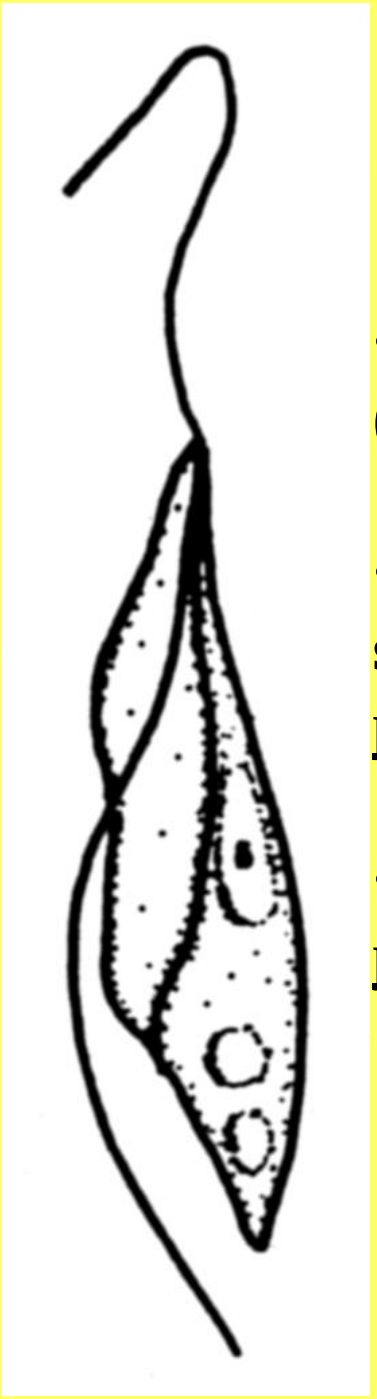
- eukaryotic cell
- endomembrane systems
- membrane-bound nuclei
- endoplasmatic reticulum
- nuclei contain multiple DNA strands (unlike prokaryotes)
- numerous organelles
- can reproduce mitotically, some are capable of meiosis for sexual reproduction
- **most are unicellular, some are colonial**





- **<u>The life cycle</u>** of majority of protozoans alternates between **trophozoite** and **cyst** (oocyst)

EXCAVATA



EXCAVATA

•**with suspension-feeding groove – cytostome (presumed to be secondarily lost in many taxa)**

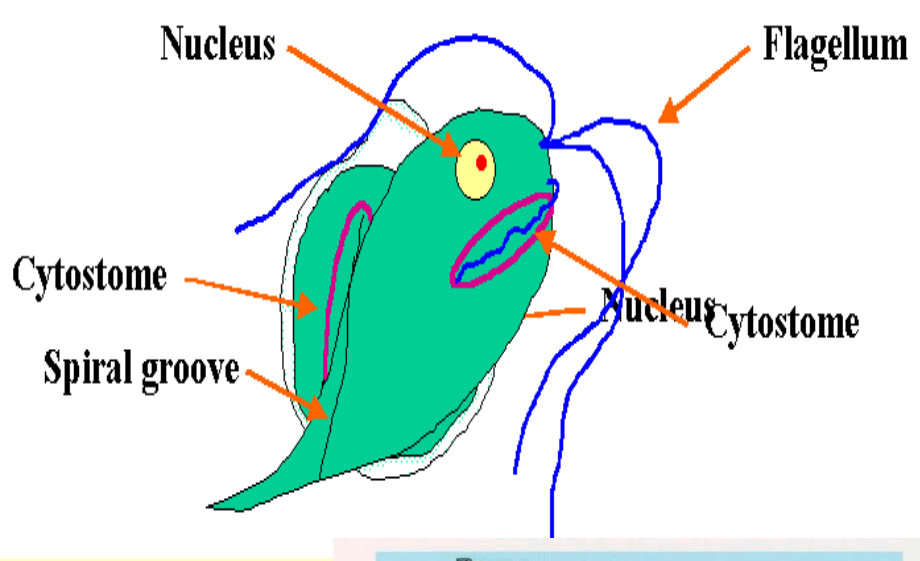
• feeding groove used for capture and ingestion of small particles from feeding current generated by a posteriorly directed flagellum

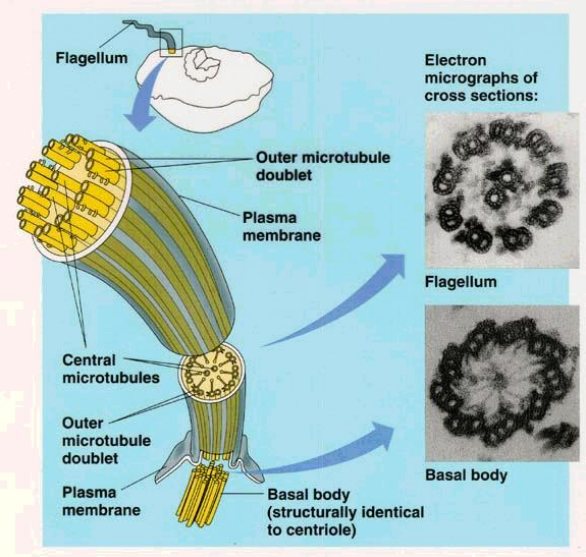
•right margin and floor of groove are supported by parts of the microtubular root

Jakoba libera

1.Phyllum: Metamonada

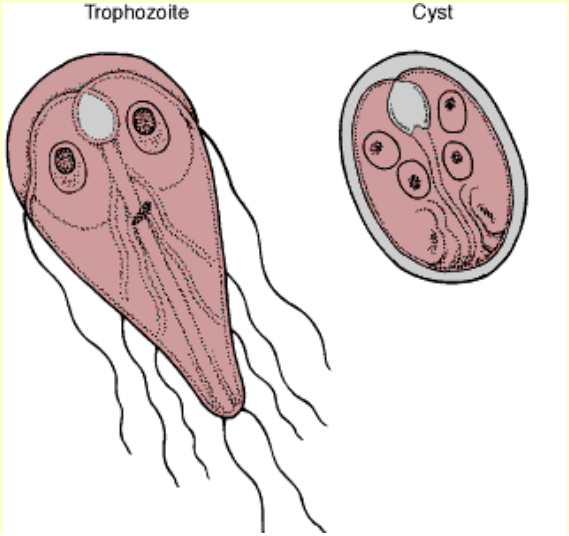
- no mitochondria (hydrogenosoms)
- no Golgi apparatus
- feeding groove with flagellum running through it
- flagella have no paraxial rod
- flagellates - anterior flagella and recurrent flagellum

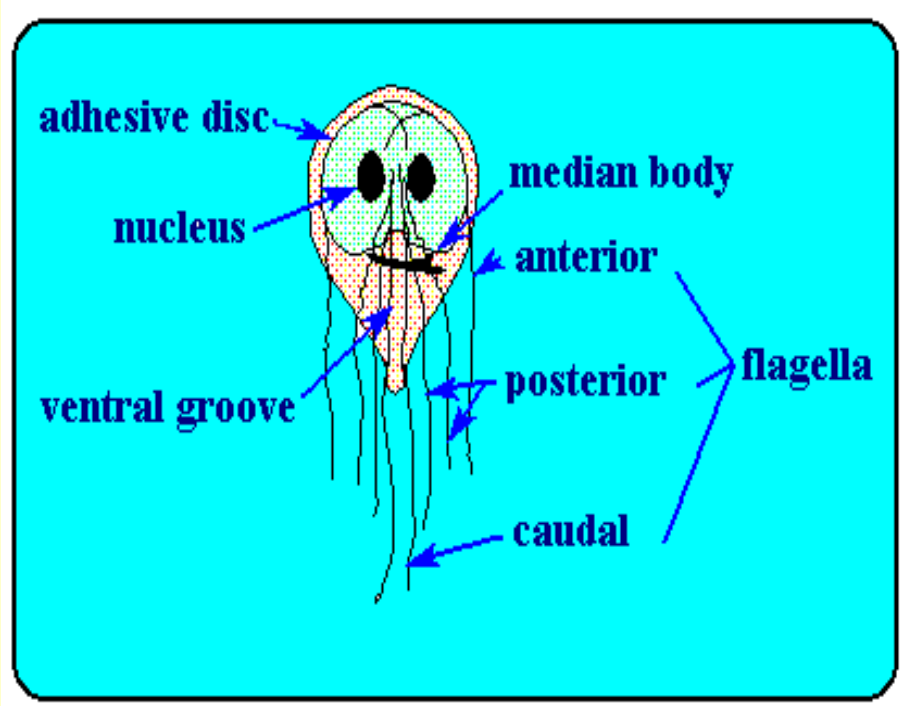




Genus *Giardia*

- **9-20 x 7-12 µm**
- **" tear-drop" shape**
- **two nuclei**
- **8 flagella**
- **suction disk**
- **mammals, vertebrates**





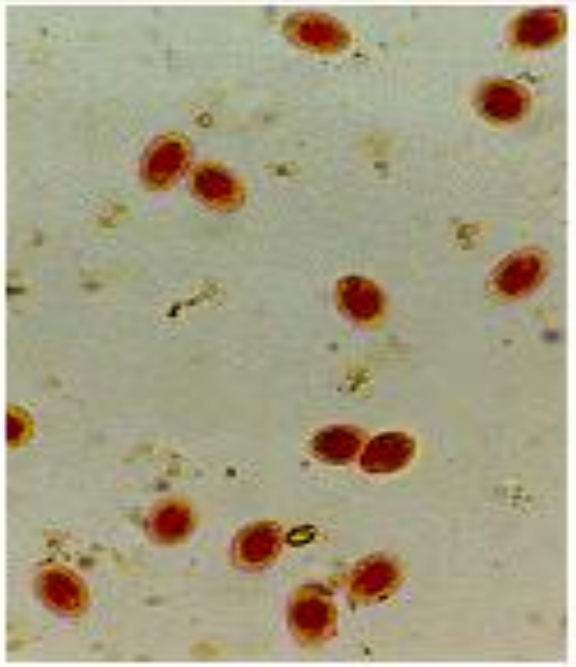
Transmission:

- **elliptically shaped cysts**
- **(6 – 10 microns)**

- **passed in the feces**

- **resistant to environmental factors**
- **and disinfection**

- **giardiasis is most frequently associated with the <u>consumption of contaminated water</u>**



Giardia lamblia

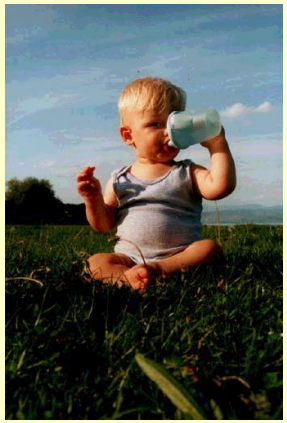
small intestine **of the human,** **domestic animals** (dogs and cats) and **wild animals** (beavers and bears)

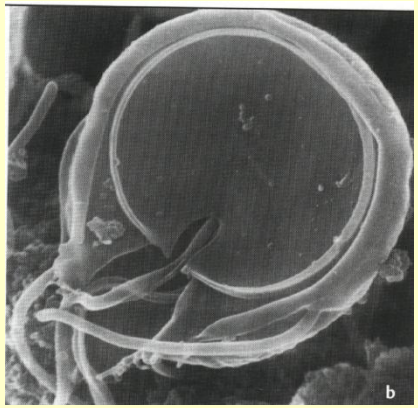
the most frequent cause of human non-bacterial diarrhea in North America

more prevalent in children than in adults

the infection prevent the absorption of essential nutrients and vitamins

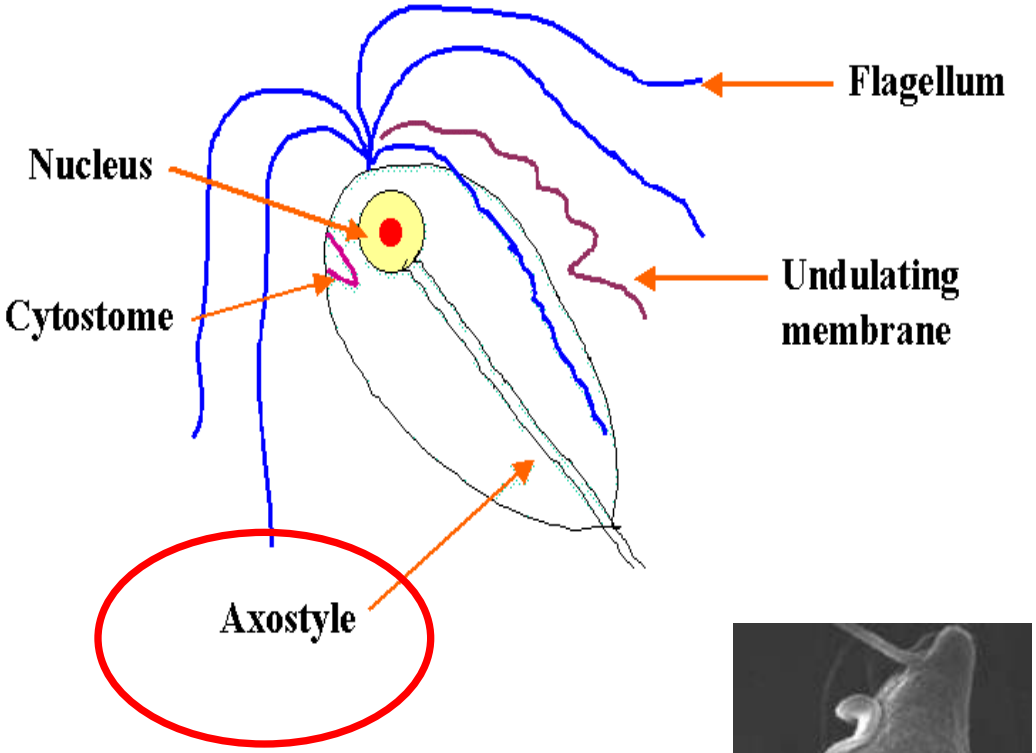
with diminished resistance, other diseases can attack host





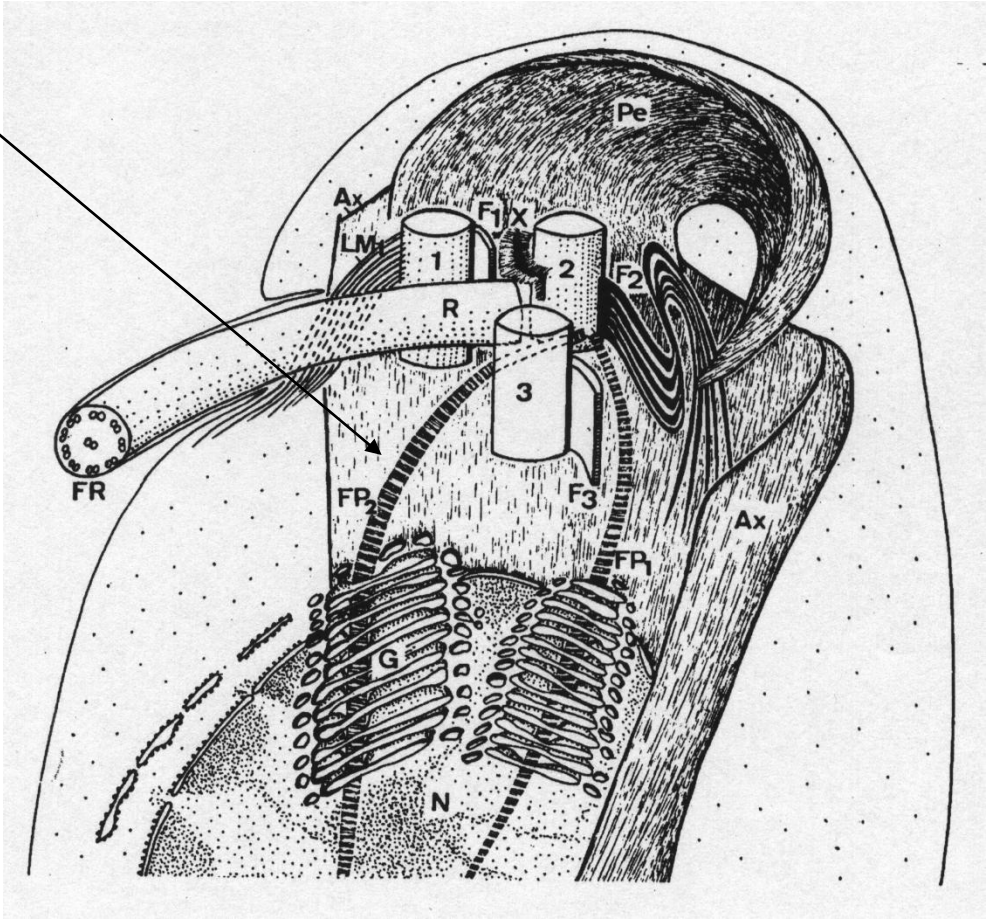
2.Phylum: Parabasalia

- **parabasal apparatus**
- no mitochondria - hydrogenosoms
- flagella have no paraxial rod
- with axostyle made of microtubulus

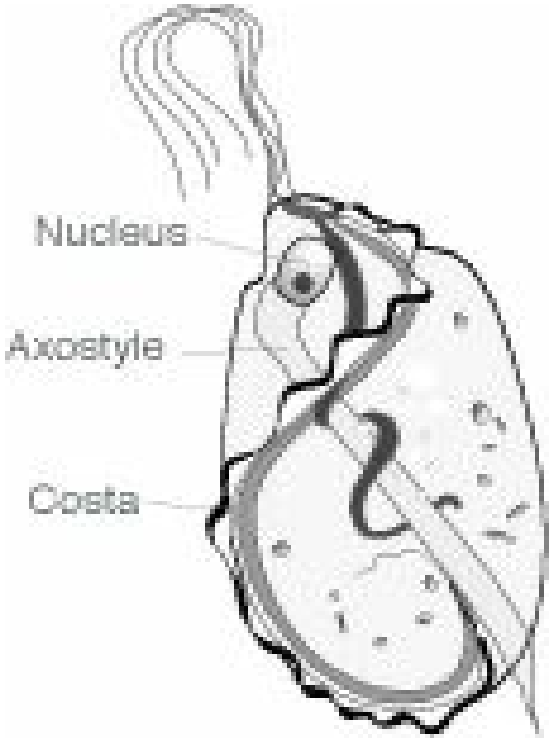


parabasal apparatus

- two or more striated parabasal fibres connecting the Golgi-dictyosomes to the flagellar apparatus



Order: TRICHOMONADIDA



- pyriform shape
- anterior tuft of flagella
- median rod (axostyle)
- **undulating membrane along the recurrent flagellum**
- parabasal body present
- cysts

Human Trichomonads

- *Trichomonas vaginalis*
- veneral disease

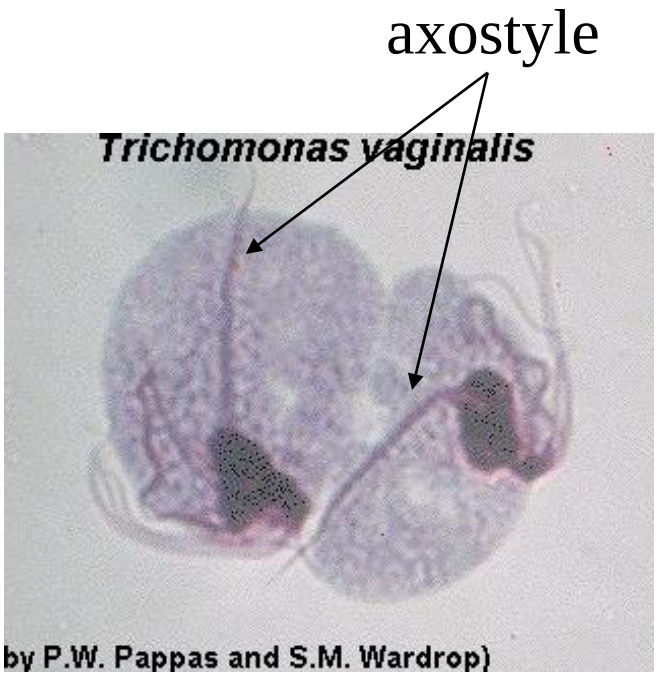
- *Trichomonas tenax*
- commensal in mouth

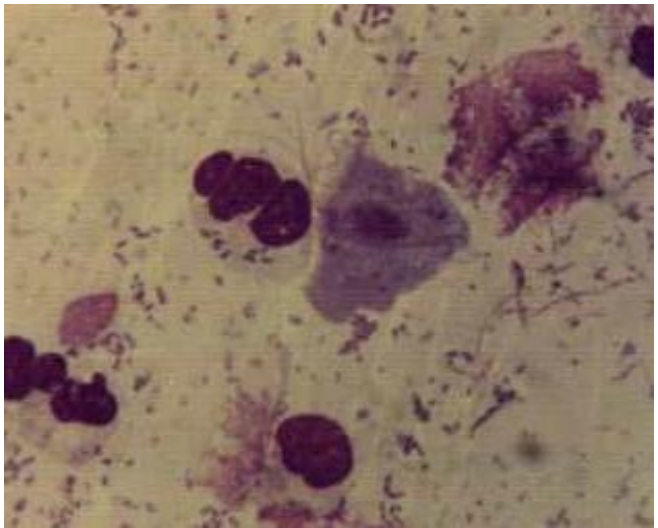
- *Pentatrichomonas hominis*
- commensal in intestine

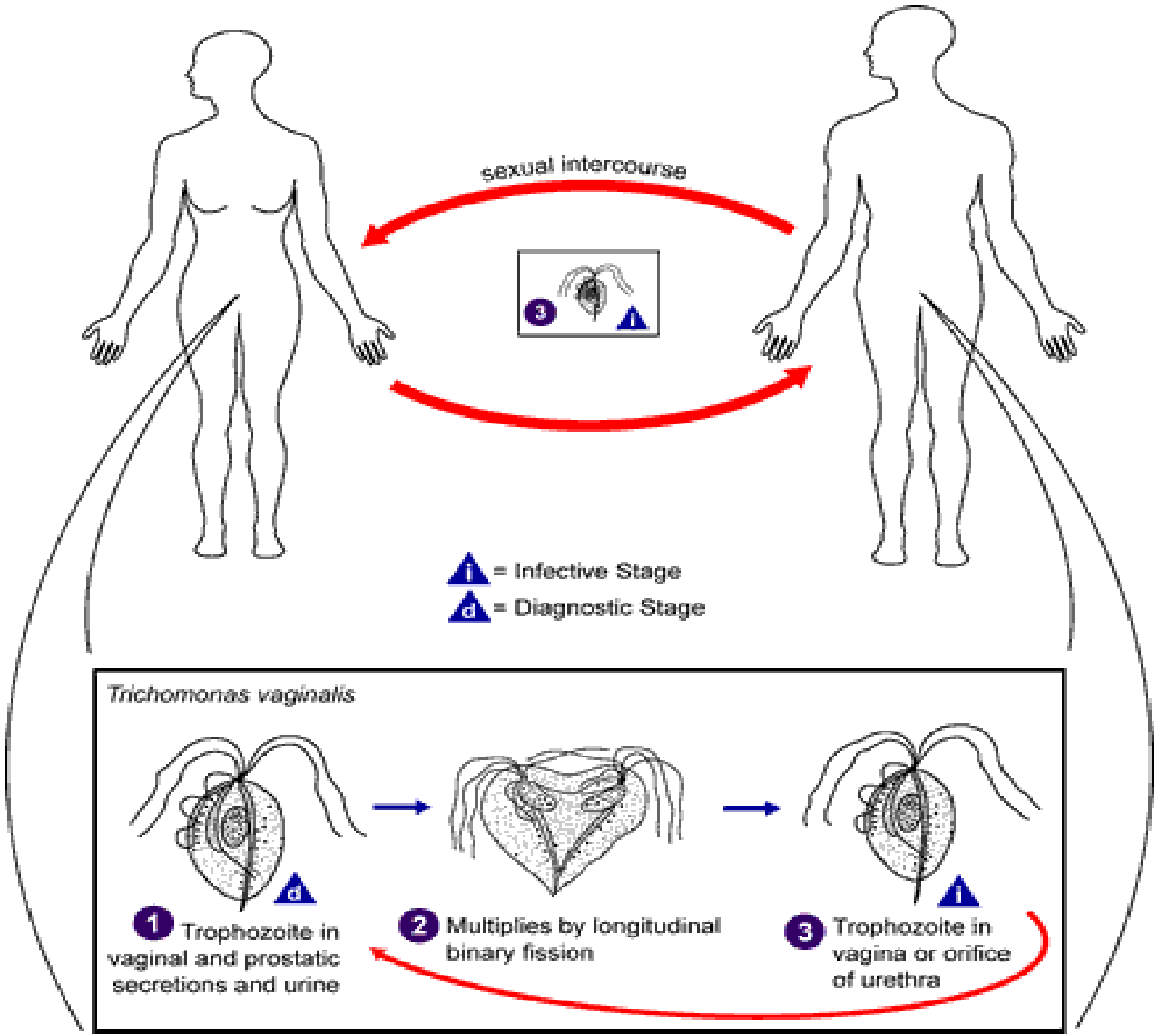
- *Dientamoeba fragilis*
- parasite

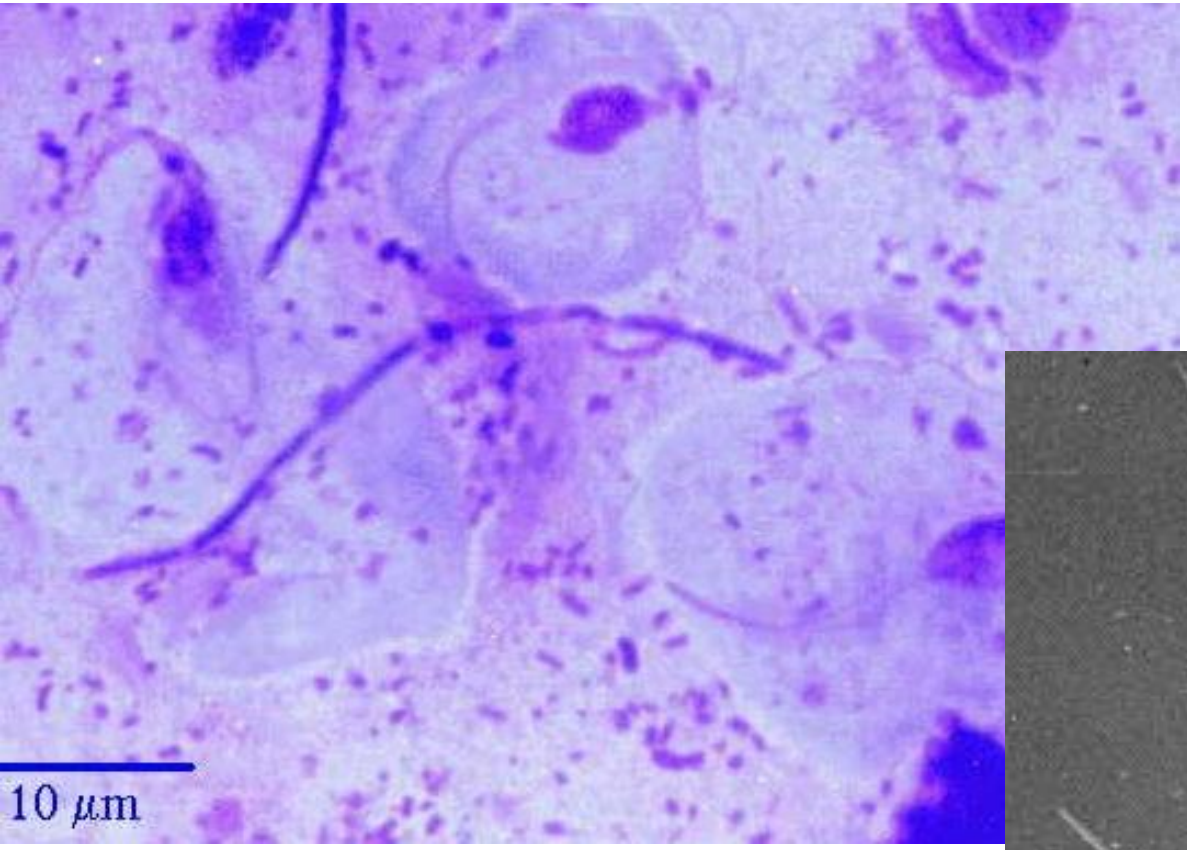
Trichomonas vaginalis

- approximate size = 26 μm
- 5 flagellum (4 and undulating flagellum)
- transmitted <u>through vaginal intercourse</u>
- often asymptomatic
- infection can cause <u>vaginitis in women and urethritis in men</u>
- prevalence 2-5%

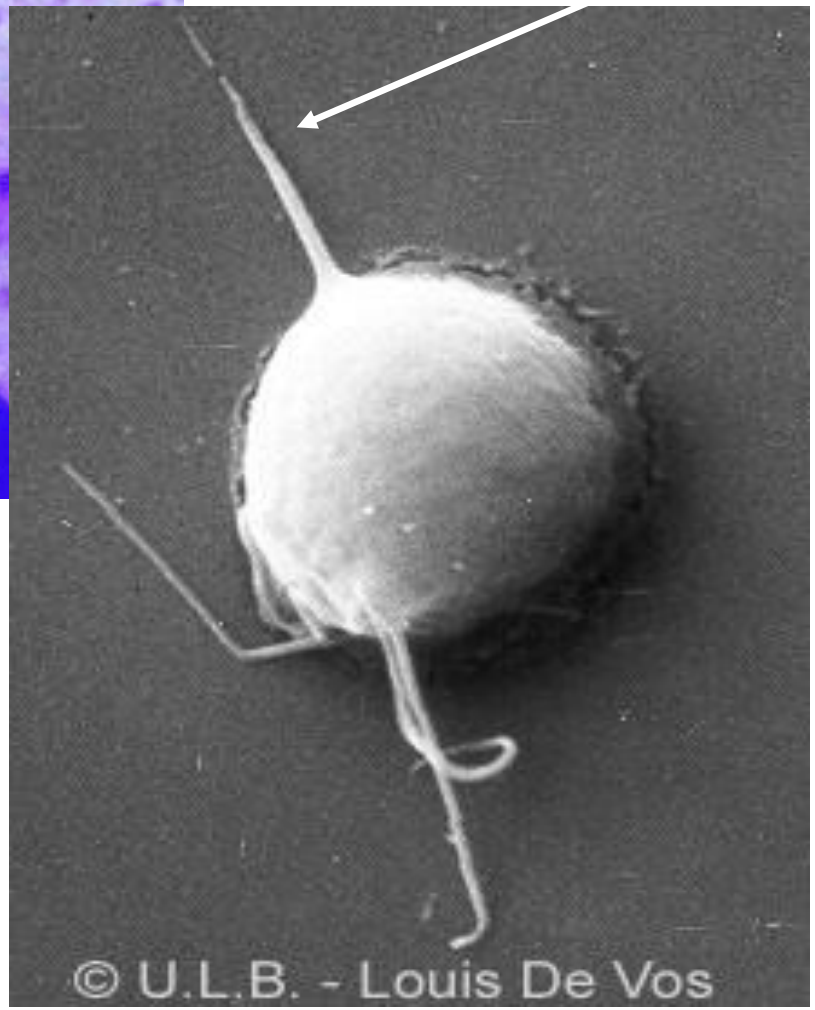





sexual intercourse
3
i
i = Infective Stage
d = Diagnostic Stage
Trichomonas vaginalis
d
1 Trophozoite in vaginal and prostatic secretions and urine
2 Multiplies by longitudinal binary fission
i
3 Trophozoite in vagina or orifice of urethra

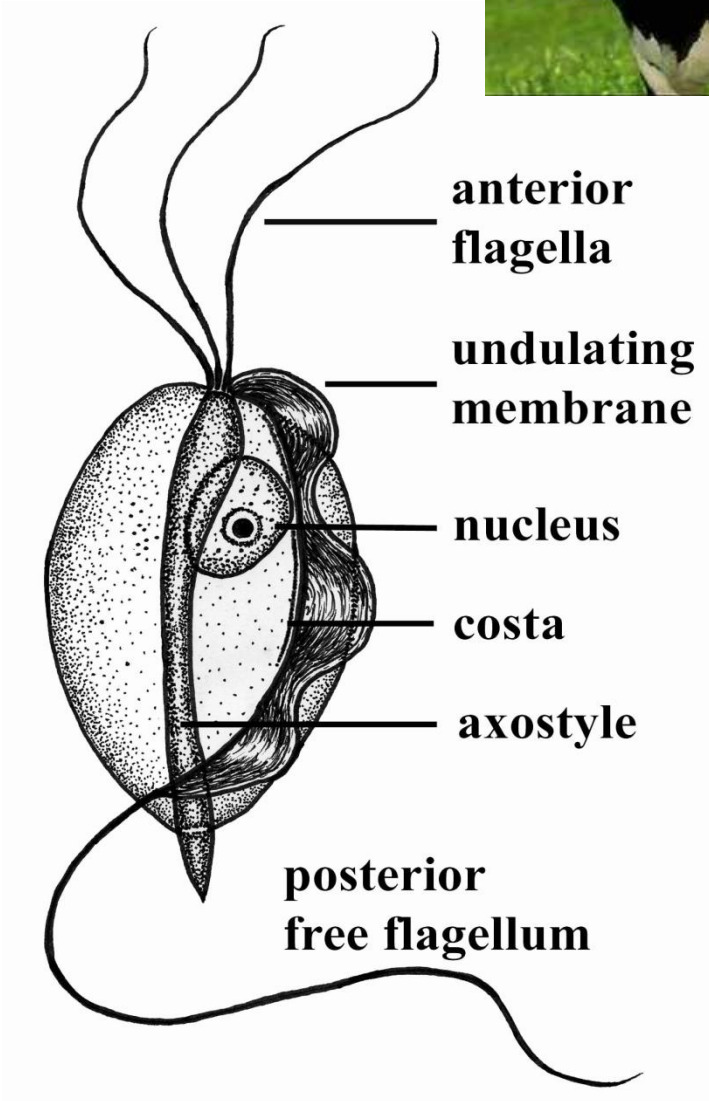


axostyle



Tritrichomonas foetus

- **reproductive disease in cattle** (infertility, abortion and endometritis)
- a sexually transmitted disease worldwide distribution
- prevalence of infection from relatively low percentages (2% to 5%) to significant levels (15% to 40%) in others
- **diarrhea in cats**




Courtesy of University of Minnesota - SVM


10 µm

Trichomonas gallinae

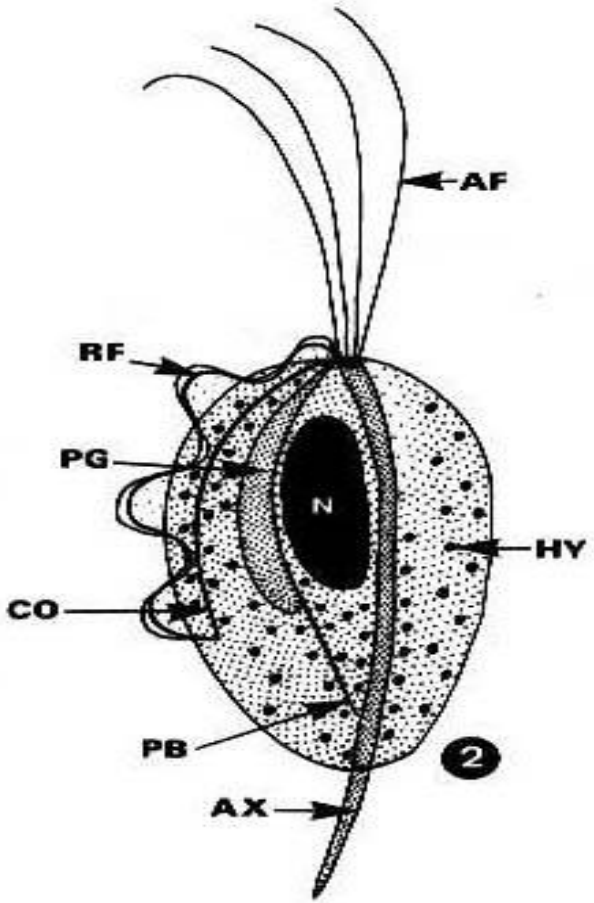
- parasite of upper digestive tract of many avian species (pigeons, doves, turkeys, chickens, quail, hawks, eagles, falcons, canaries, parrots)

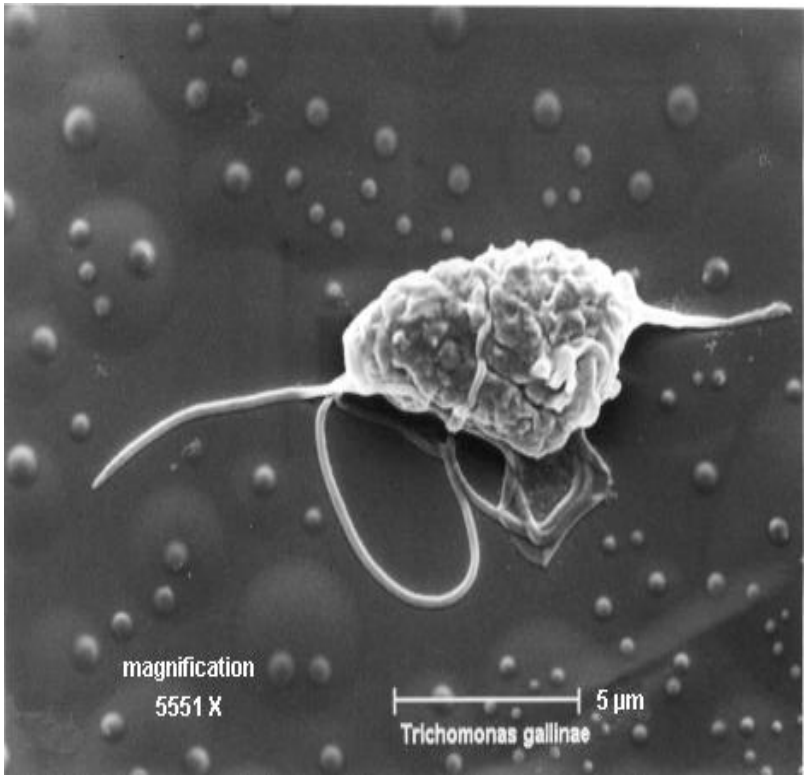
- cause white plaques and inflammation in th oral cavity
- accumulation of necrotic material in the mouth and esophagus (yellow growths)

- a disease of young birds (pigeon milk produced in the crop)

- avirulent strains (not cause disease), highly virulent strains (causing disease and death)

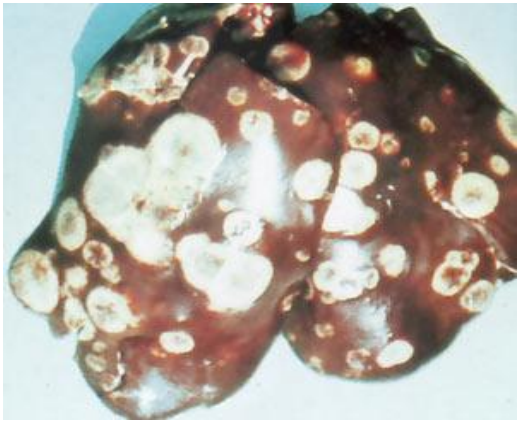
- much less frequent than was the case in the past

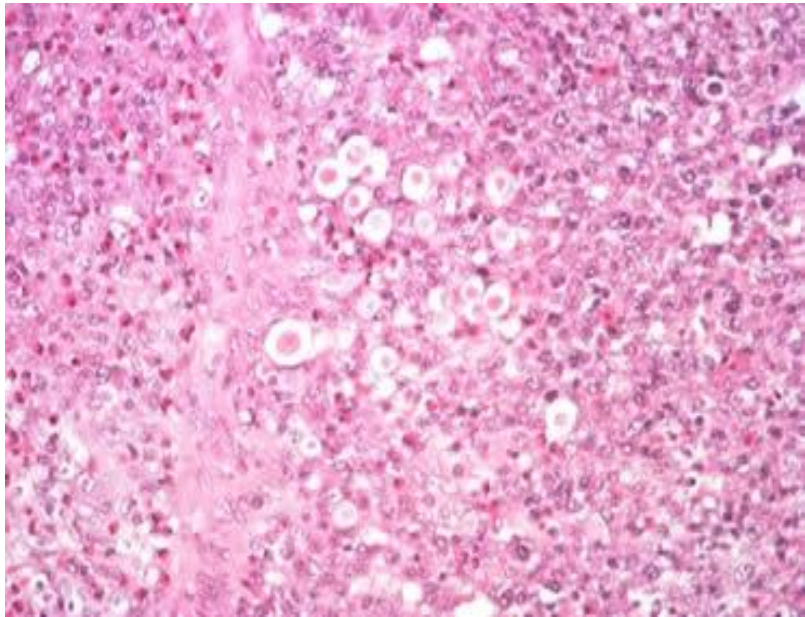



magnification
5551 X
5 µm
Trichomonas gallinae

Histomonas meleagridis

- affects **turkeys, chickens**, and occasionally other galliform birds
- in turkeys, most infections are fatal (**blackhead**)
- disease of the digestive tract (caecal wall and liver)
- affected birds – depressed, dull, reluctant to move to take food



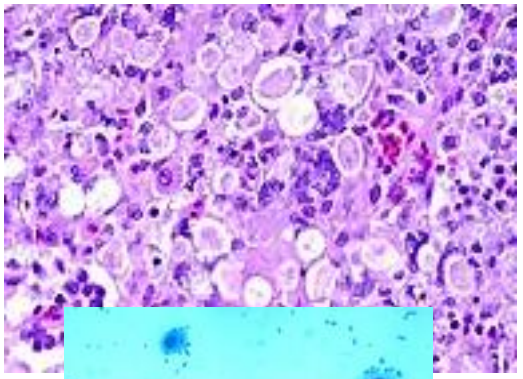


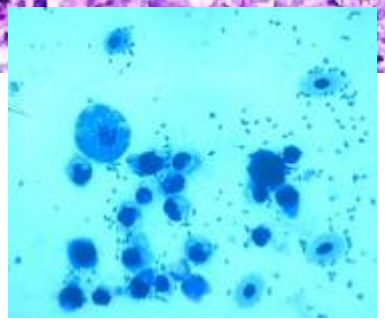
Life cycle

•in embryonated eggs of the *Heterakis gallinarum*

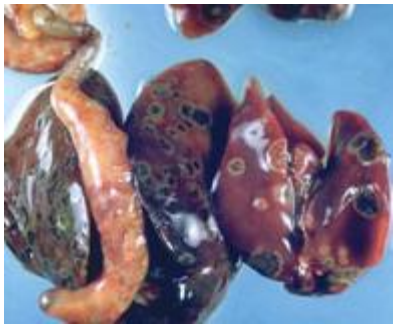
•Histomonads are released from *Heterakis* larvae in the ceca

•submucosa and muscularis mucosae (extensive and severe necrosis)



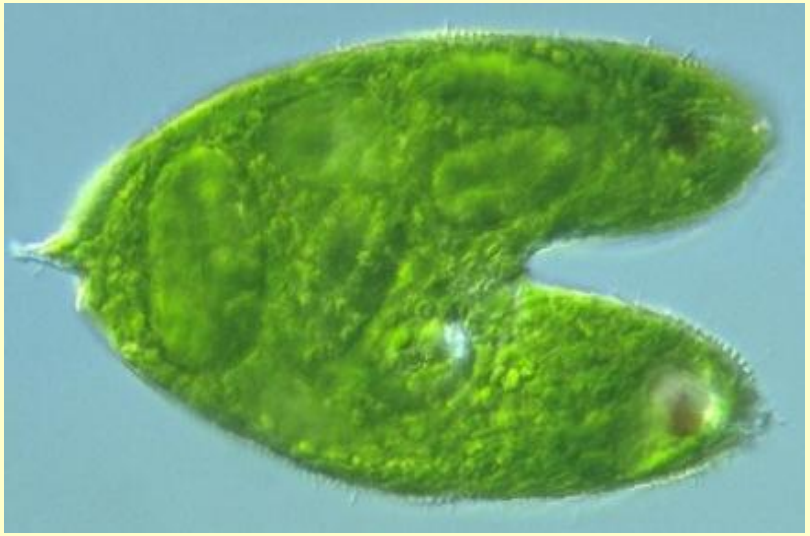


•liver (either by the vascular system or via the peritoneal cavity)



3. Phylum Euglenozoa

- **a uniform nucleus**
- **one or more flagella** (may have pseudopodia)
- **flagella with the paraxial rod**

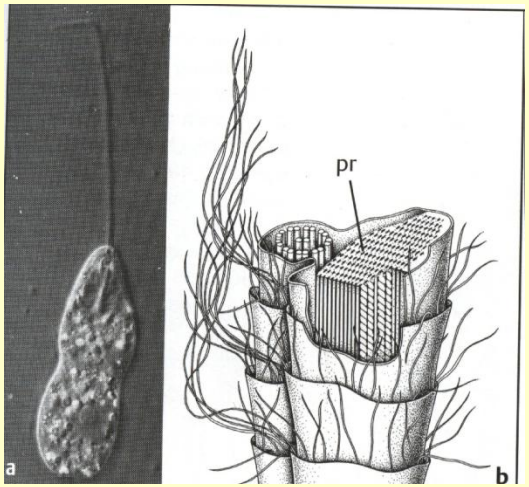


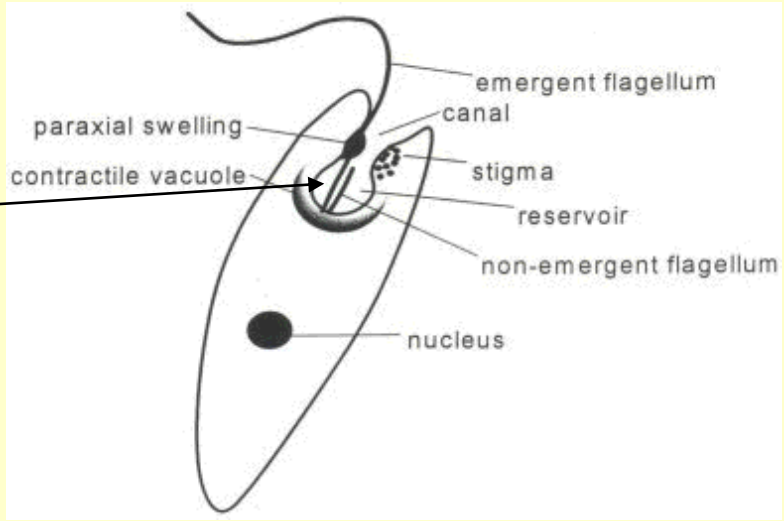
- **autotrophic or heterotrophic**
- **unicellular or colonial**
- **asexual or sexual**

Subfyllum: Euglenida
Subfyllum: Kinetoplastida

flagella with the paraxial rod

- **<u>9 + 2 pattern of microtubules</u>**
- <u>with paraxial rod</u>
- the 2 flagellae with mostly unequal length
- originate <u>in the apical saccula flagellae</u>





Phylum Euglenozoa

- **Subphylum: EUGLENIDA**
- **Subphylum: KINETOPLASTIDA**

Subphylum: EUGLENIDA

- **pellicle**
- **one third have the chloroplasts – chlorophyll a**
- **paramylon is the carbohydrate store**

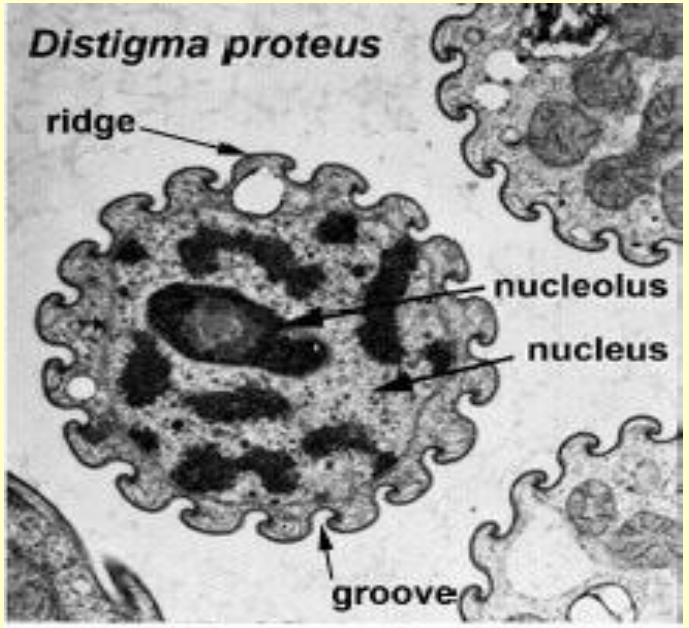
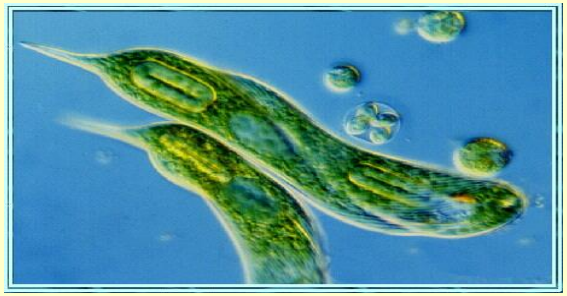


Fig. 1. Cross-section through the pellicle of a euglenoid.



- **pellicle** is organized as a series of <u>ridges and grooves</u>

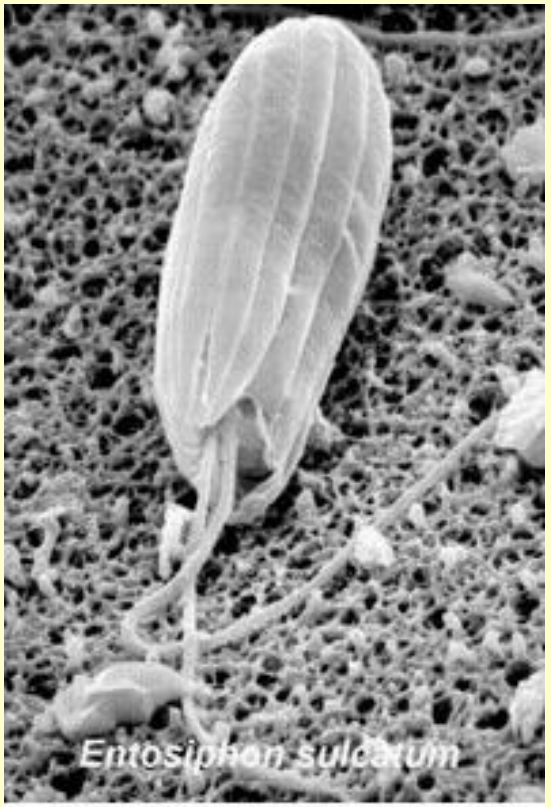
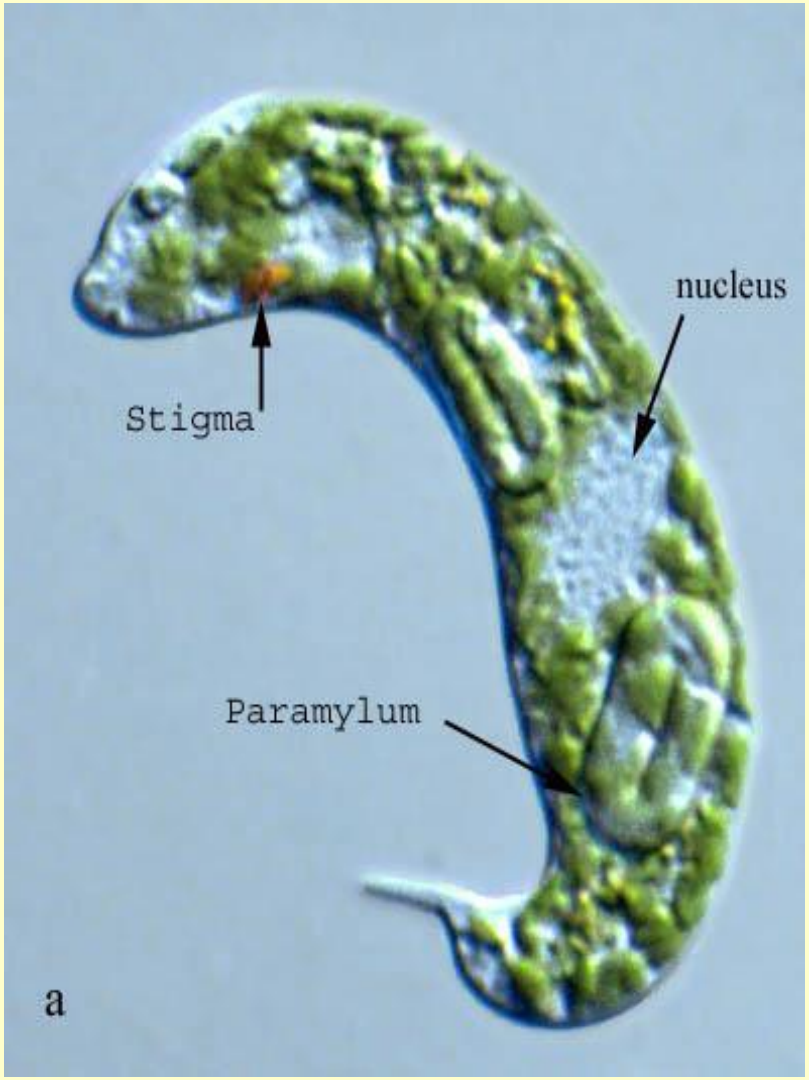
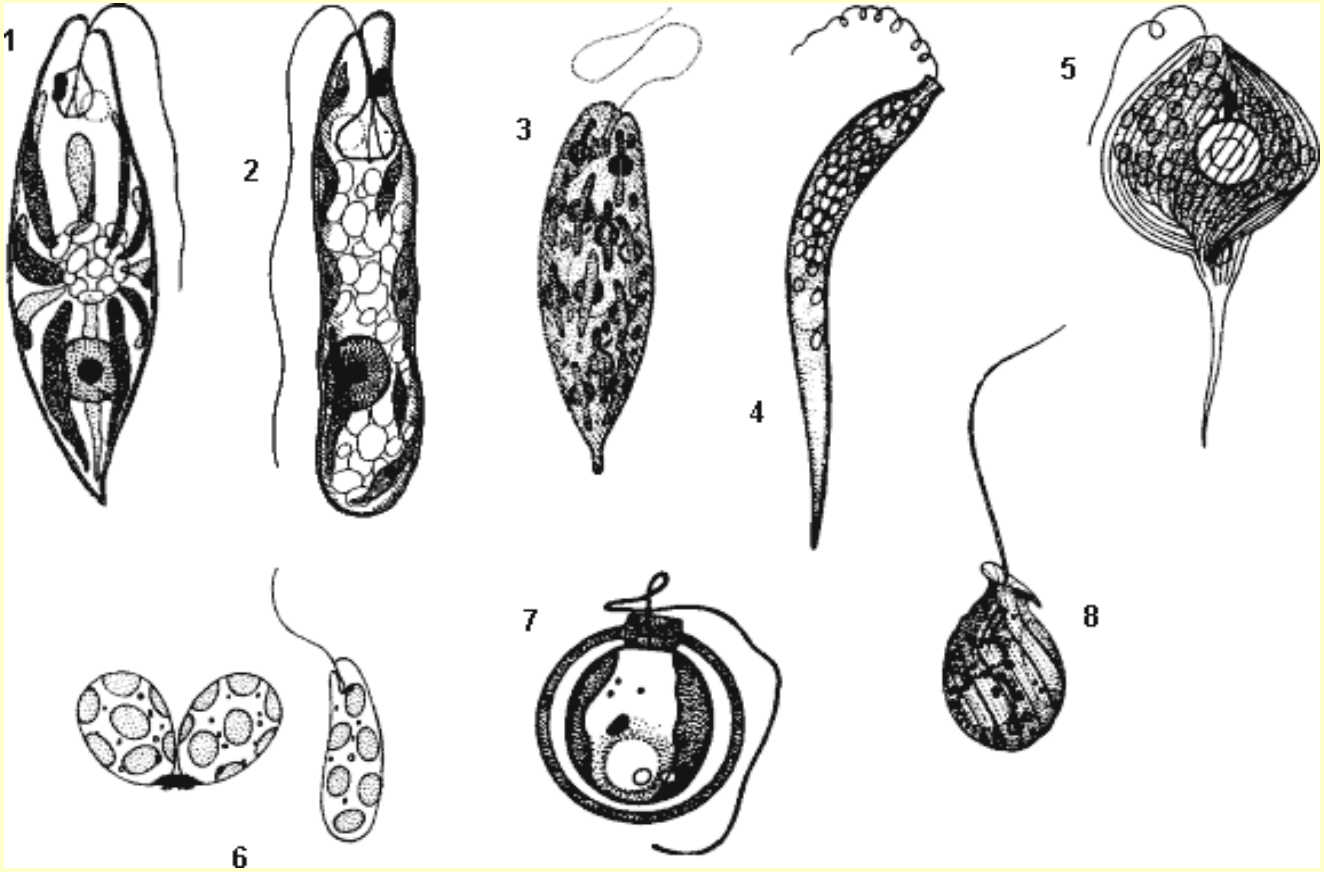


Fig. 3. Scanning electron micrograph of a pellicle with few longitudinally arranged strips.

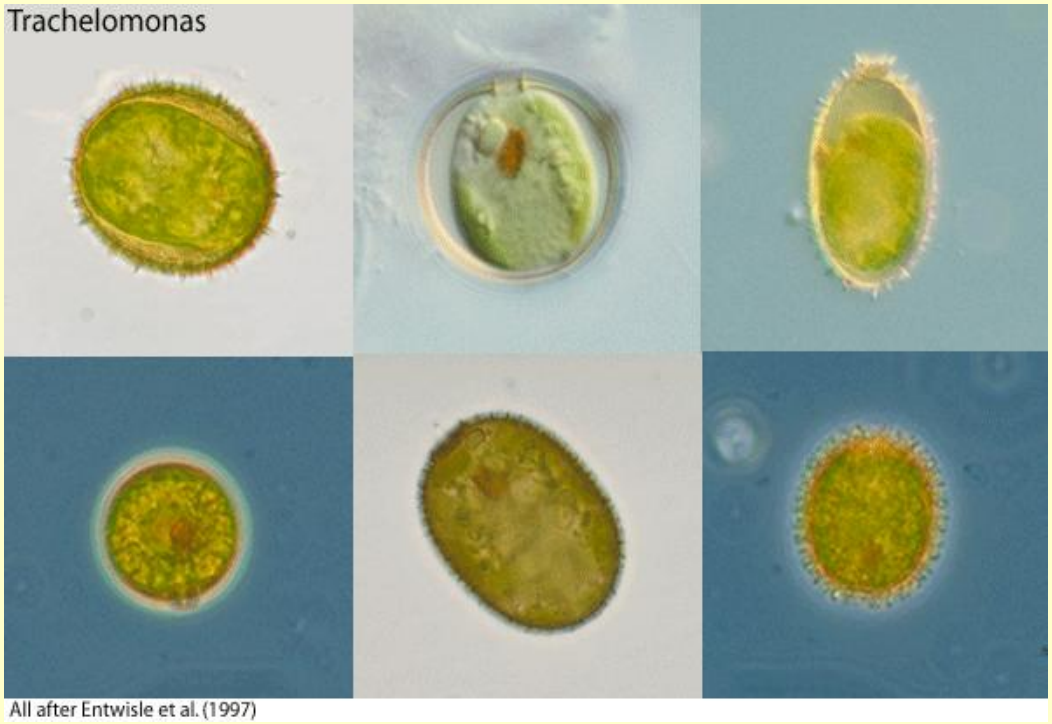
- **green plastids**
- switch from auto- to heterotrophy
- most phototropic species need supplementary substances - auxotropic



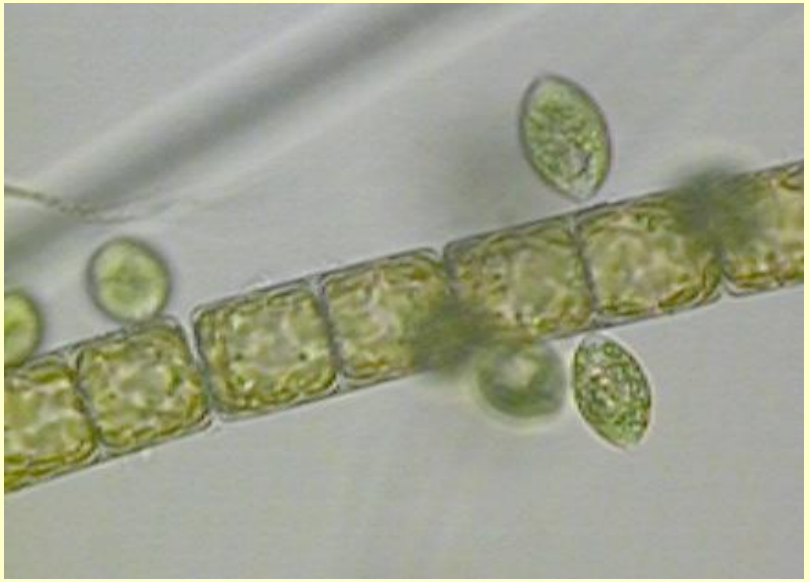


1 *Euglena viridis*, 2 *Euglena gracilis*, 3 *Euglena polymorpha*, 4 *Menoidium tortuosum*, 5 *Phacus tortus*, 6 *Colacium cyclopicola*, 7 *Trachelomonas volvocina*, 8 *Urceolus cyclostomus*

- *Trachelomonas*

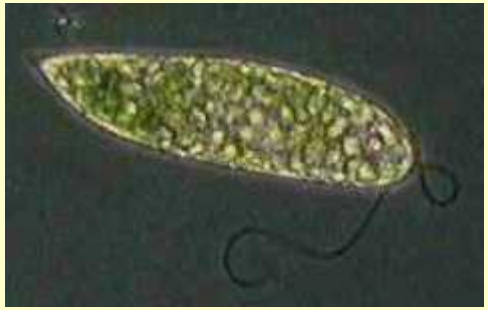


- *Colacium*



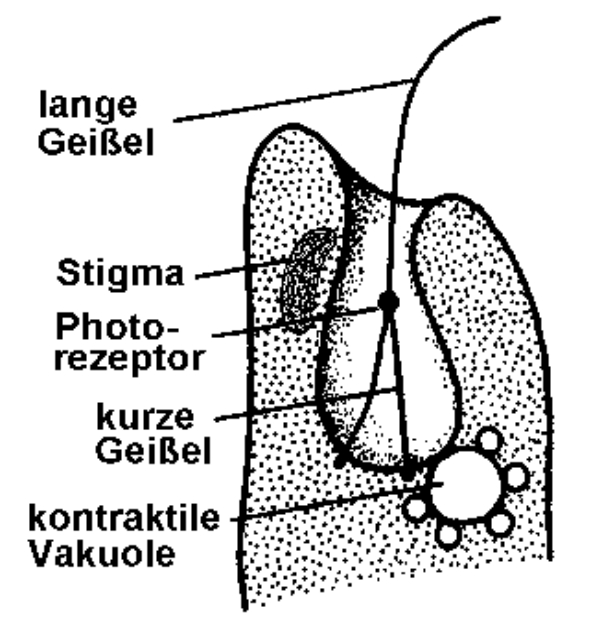
Genus *Euglena*

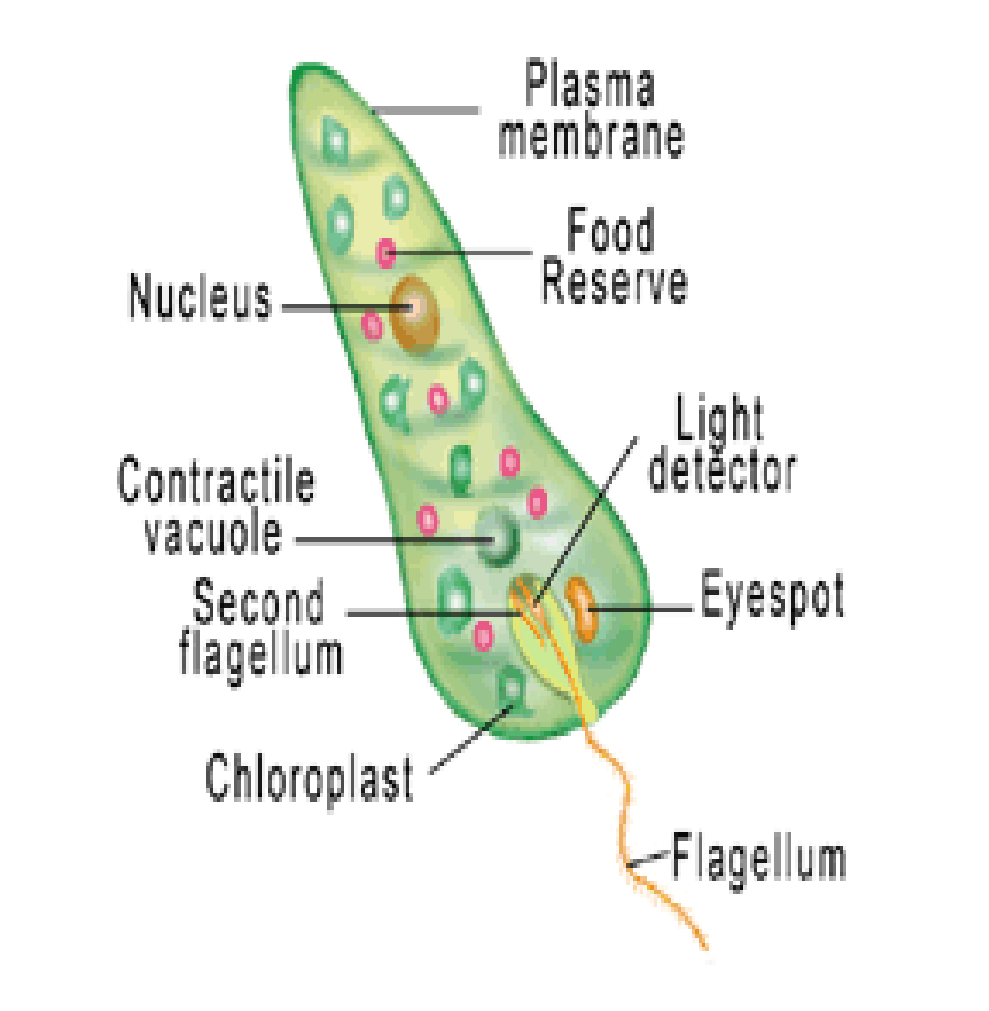
- freshwater
- about 150 species
- spindle - shaped bodies
- 0.025 to 0.254 millimeter



Phototaxis is co-ordinated:

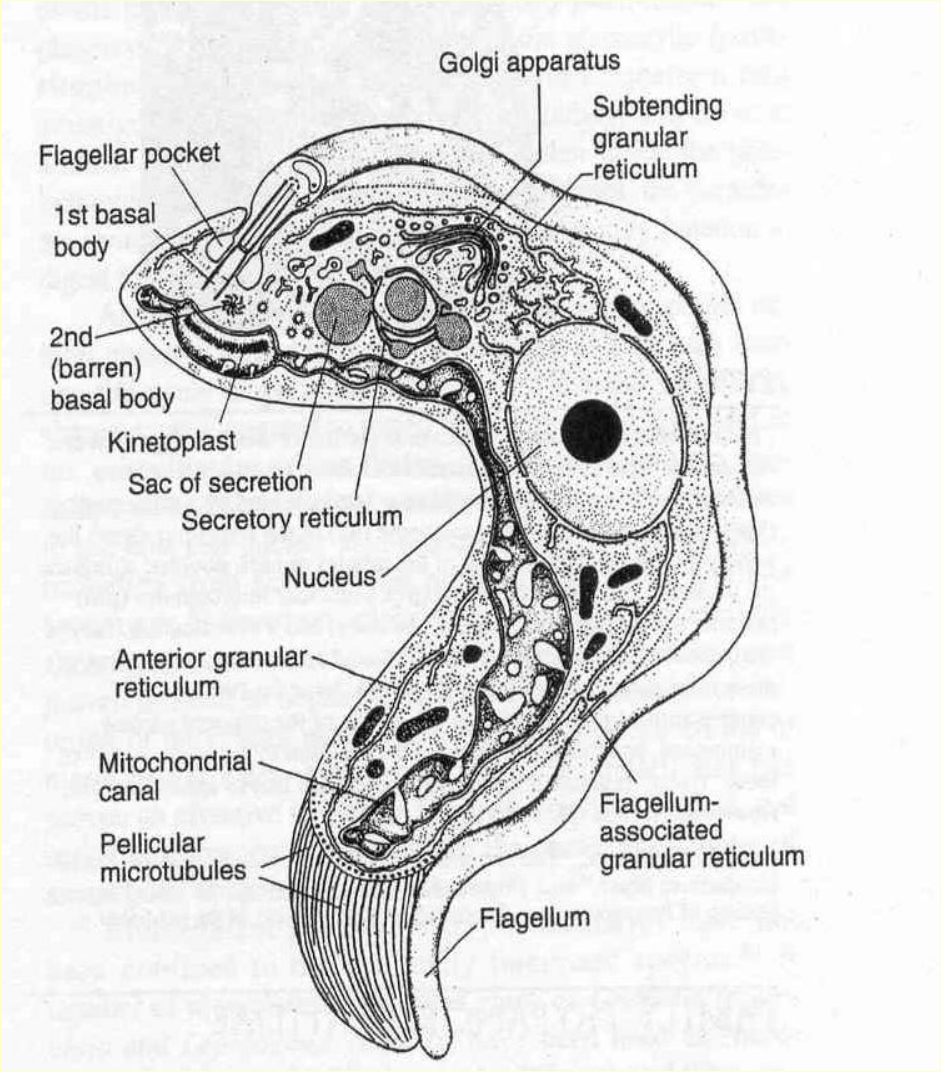
- sensoric paraflagellar body
- light-absorbing stigma





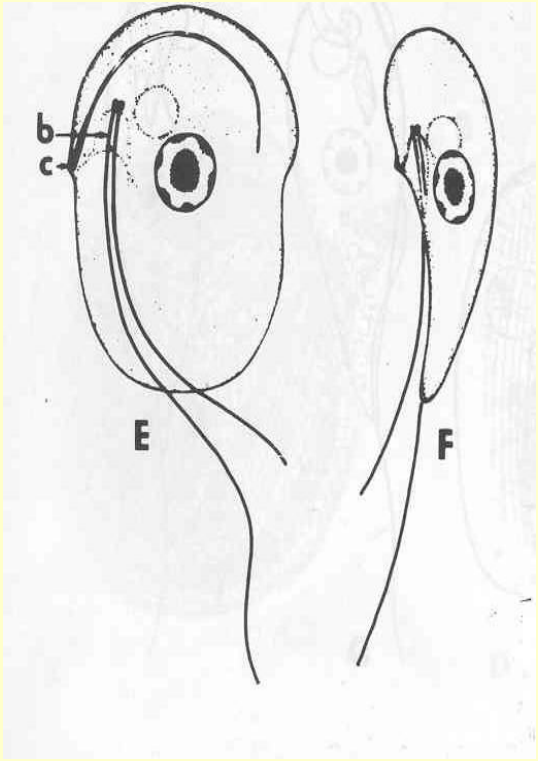
Subphylum: KINETOPLASTIDA

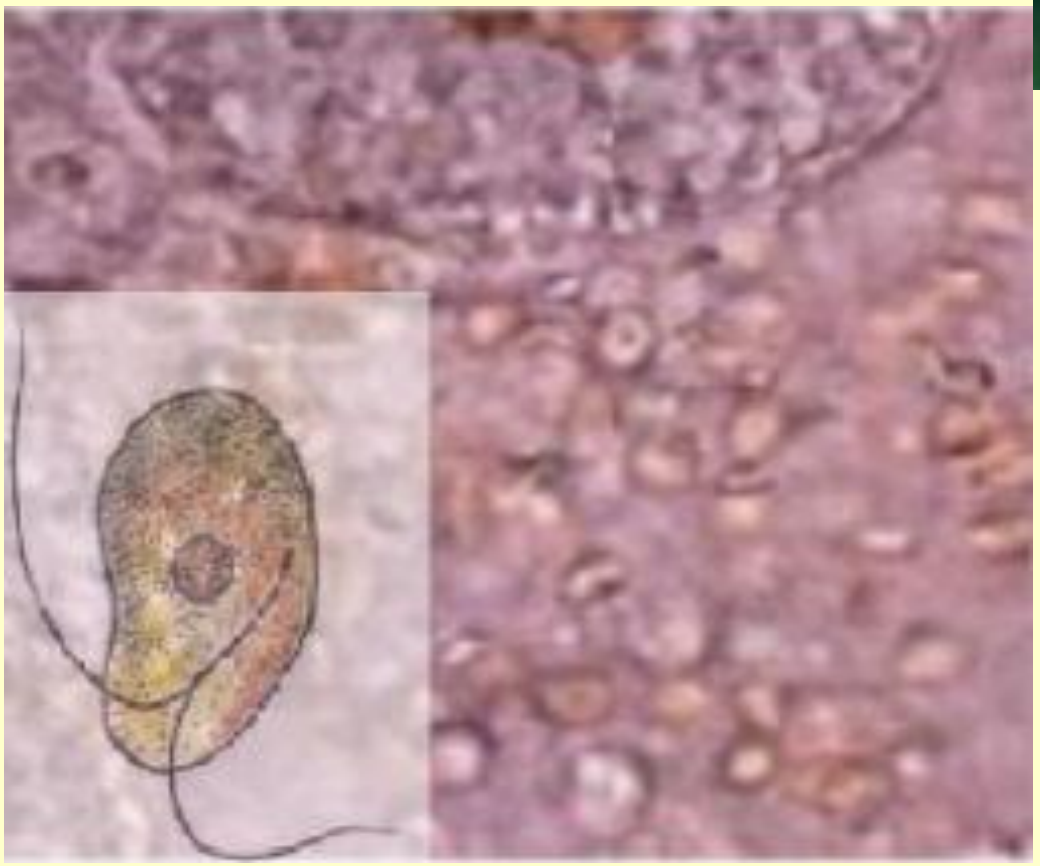
- **unique mitochondrion**
- **kinetoplast**
- **one or two flagella**
- **are best known for causing serious diseases in the tropics, some free-living**

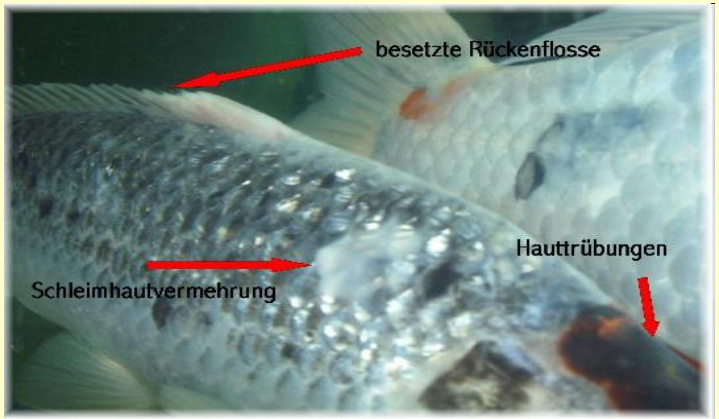


Ichthyobodo necator („costia“)

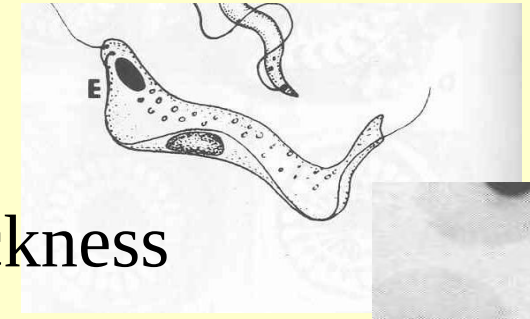
- the skin and gills
- 10 – 20 μm
- two unequal flagella
- cause significant aquaculture losses worldwide
- multispecies complex with differing host preferences
- free and parasite forms
- cysts



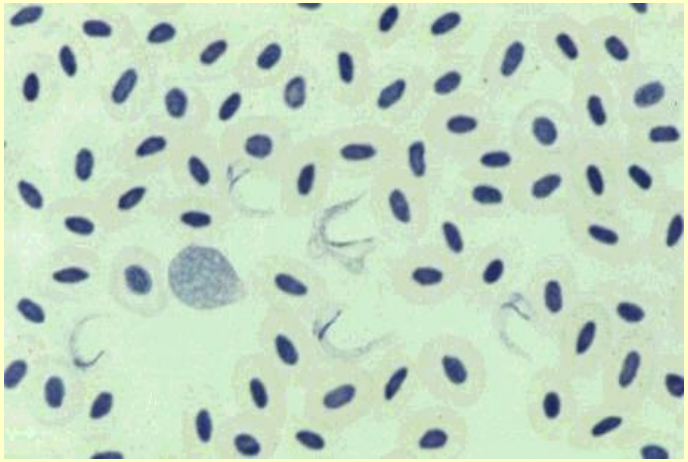



besetzte Rückenflosse
Hauttrübungen
Schleimhautvermehrung

Trypanoplasma borreli



- fish sleeping sickness
- blood parasite of carp and other fish
- 10 - 30 μm in length
- transmitted by several species of leeches



Blood smear of carp infected with ***Trypanoplasma borelli***

Bodo candatus, B. urinarius

- **length: 10-25 µm**
- moves in a "jerking" or "corkscrew" fashion
- **INDICATORS IN THE ACTIVATED- SLUDGE PROCESS**
- indicate an **unstable wastewater environment** and a sludge that is in poor health
- high numbers during type up of a treatment plant, during recovery from a toxic discharge to the treatment plant, or at low dissolved oxygen levels

Trypanosoma brucei

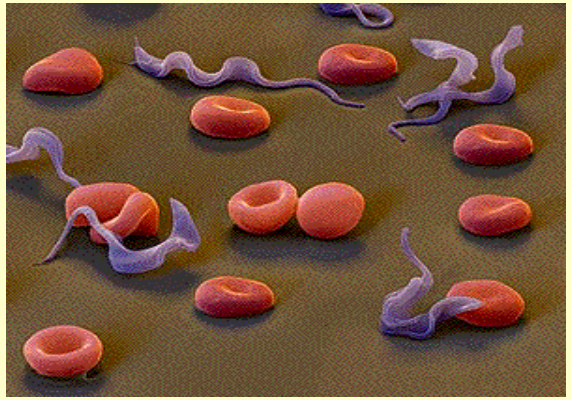
(T.b.brucei, T.b.gambiense,T.b.rhodesiense)

•parasitic protist species that causes African trypanosomiasis (or **sleeping sickness**) in humans and **nagana** in animals in Africa.

•the insect vectors - ***Glossina*** *morsitans, G. pallidipes, G.swynnertoni (T.b.b.,T.b.r.)* and *G. palpalis a G. tachinoides (T.b.g.)*

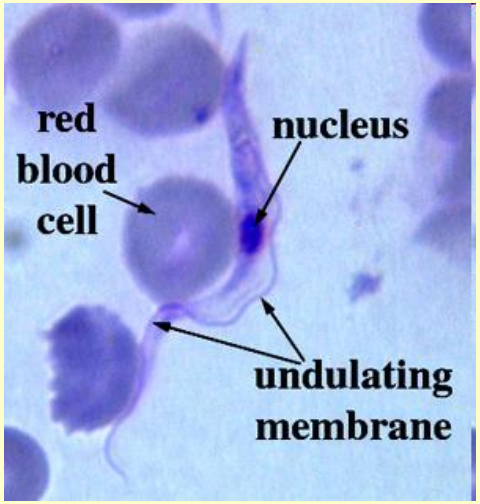
•parasites develop in the **anterior portions** of digestive tract

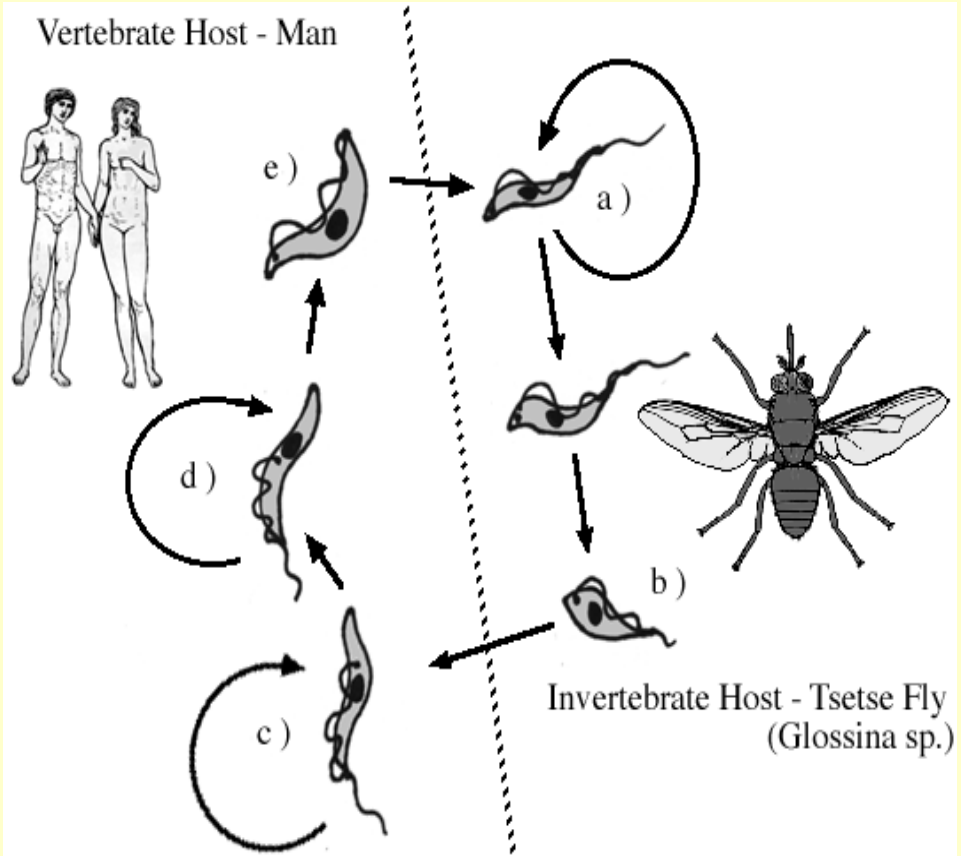
•fly inoculate a host **from the salivary glands**

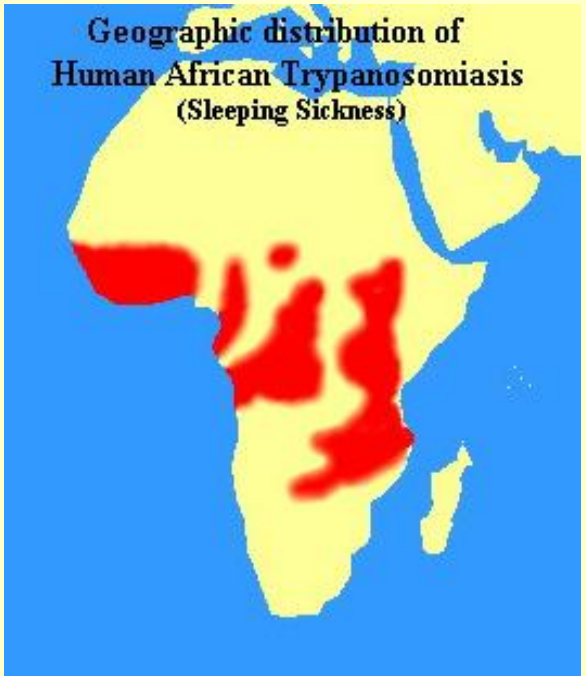


Trypanosoma brucei gambiense, T.b.rhodesiense

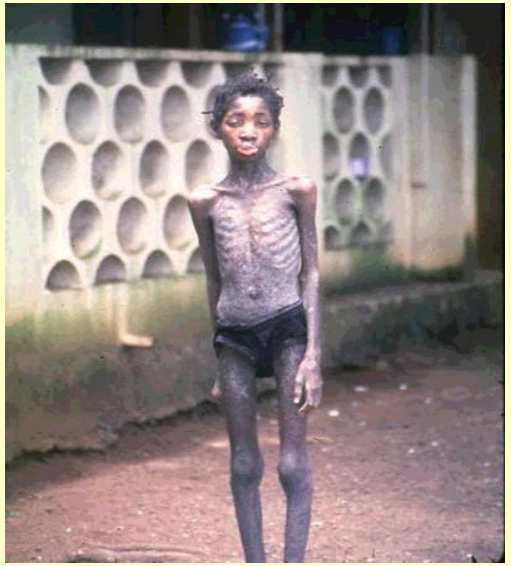
•etiological agents of **African sleeping sickness**





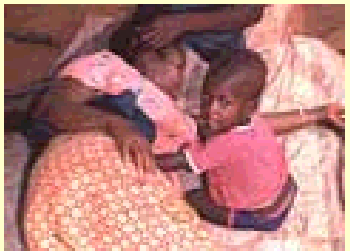


Pathogenesis



- **repeated changes in surface antigens**
- host immune system greatly stimulated
- huge amount of immunoglobulins are produced

- **swelling lymph nodes**
- **invade nervous systems** (sleeping stage of infection)



Trypanosoma brucei brucei

- parasite of native antelopes and other African ruminants

- **<u>NAGANA</u>**

Trypanosoma cruzi

•**CHAGAS DISEASE**

also called American trypanosomiasis

•distributed throughout most of **South and Central America**

•another 35 million people are exposed to infection

•**16-18 million people are infected**

•**50,000 will die each year**

•many kinds of wild and domestic mammals serve as reservoir

•the insect vectors are **bugs (Hemiptera, Reduviidae, subfamily Triatominae)**

•trypanosomes develops **in hindgut (undergo posterior station development)**

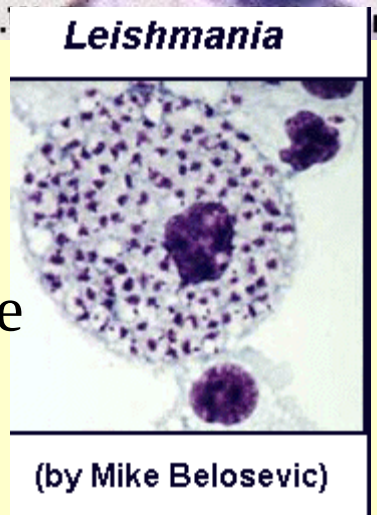
an infected bug deposits feces on a person's skin

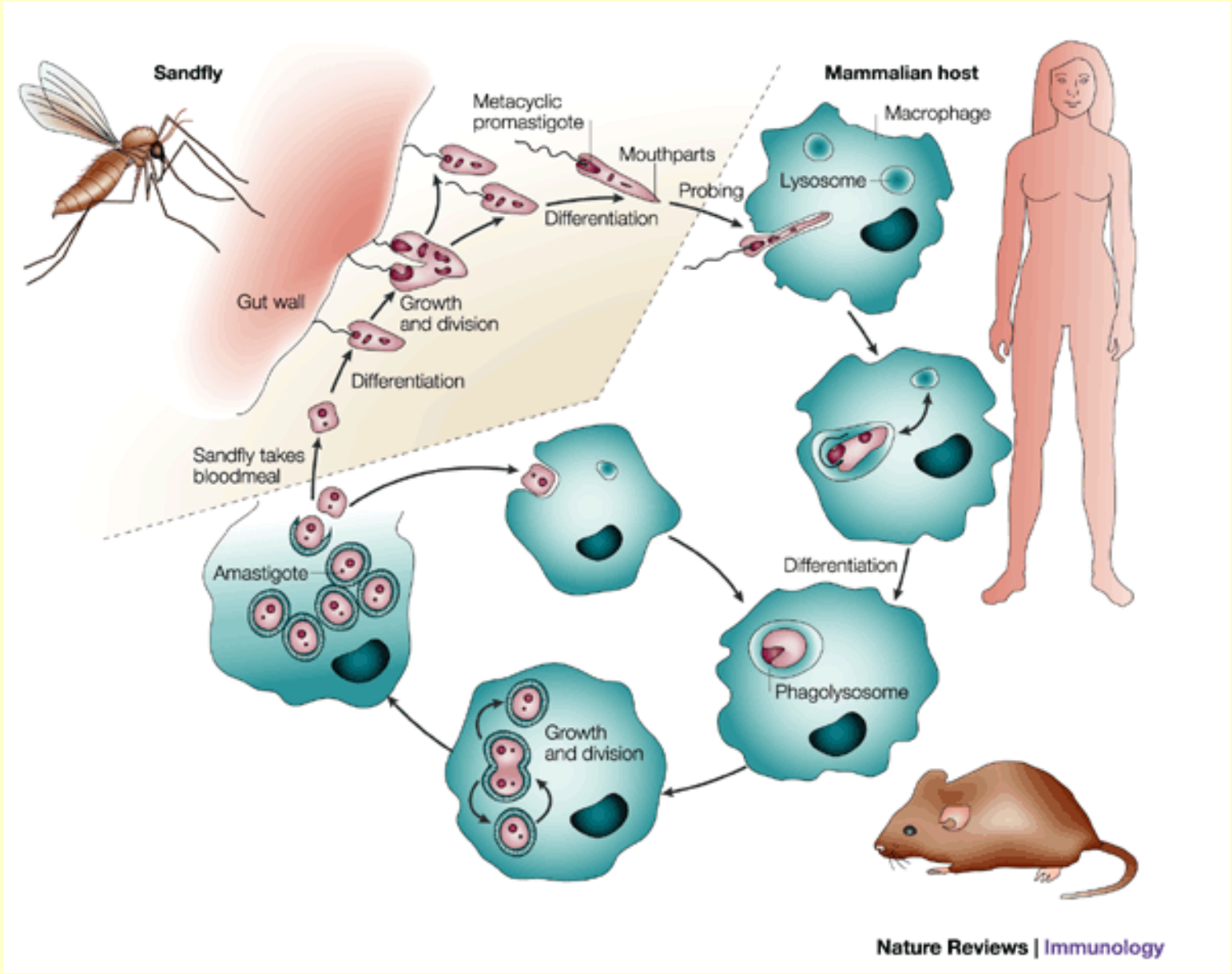
The person **rubs the feces into the bite wound**, an open cut, the eyes, or mouth.

Leishmania spp.

- heteroxenous
- vector - **fly (*Phlebotomus*)**
- **parasite of vertebrate tissues**
- in the gut the form of a **promastigote**
- in tissues only **amastigote** form

amastigote



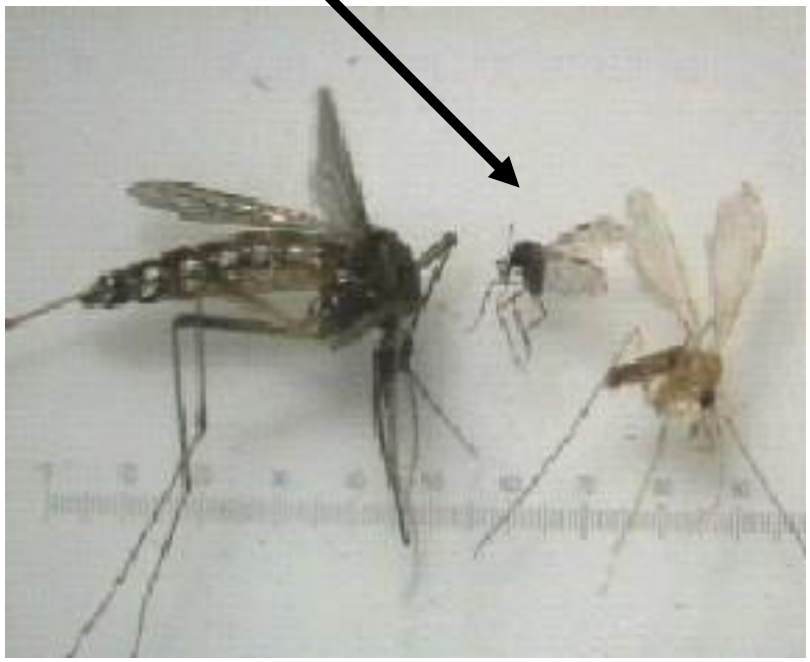

Sandfly
Mammalian host
Metacyclic promastigote
Mouthparts
Macrophage
Lysosome
Probing
Differentiation
Gut wall
Growth and division
Differentiation
Sandfly takes bloodmeal
Amastigote
Differentiation
Phagolysosome
Growth and division
Nature Reviews | Immunology

Leishmania tropica, L. major

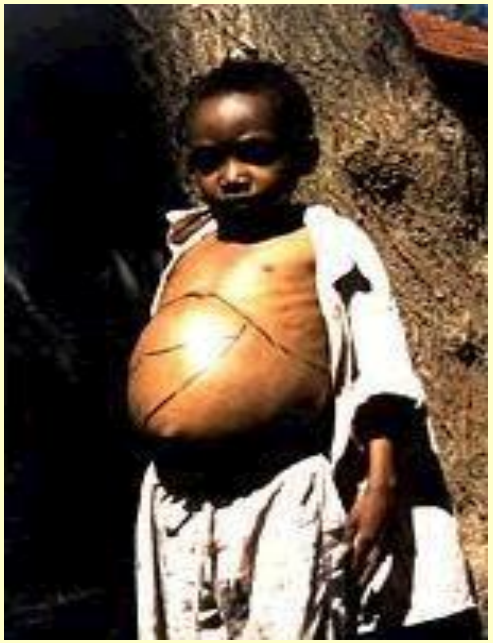
- produce **cutaneous ulcers** variously known as oriental sore, cutaneous leishmaniasis, Jericho boil, delhi boil
- they are found in west-central Africa, the Middle East, Asia Minor into India

L.tropica

Phlebotomus

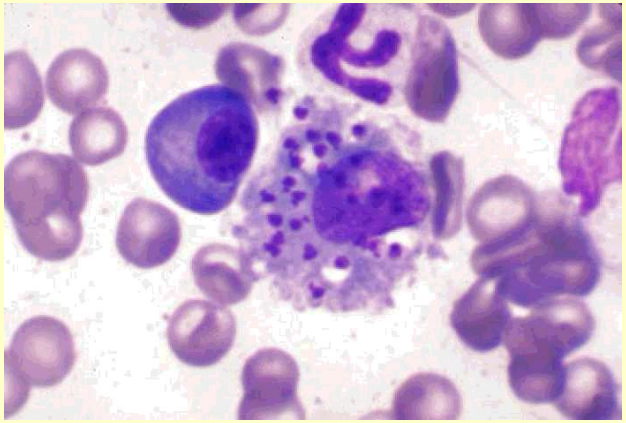


L. donovani - Kala-azar

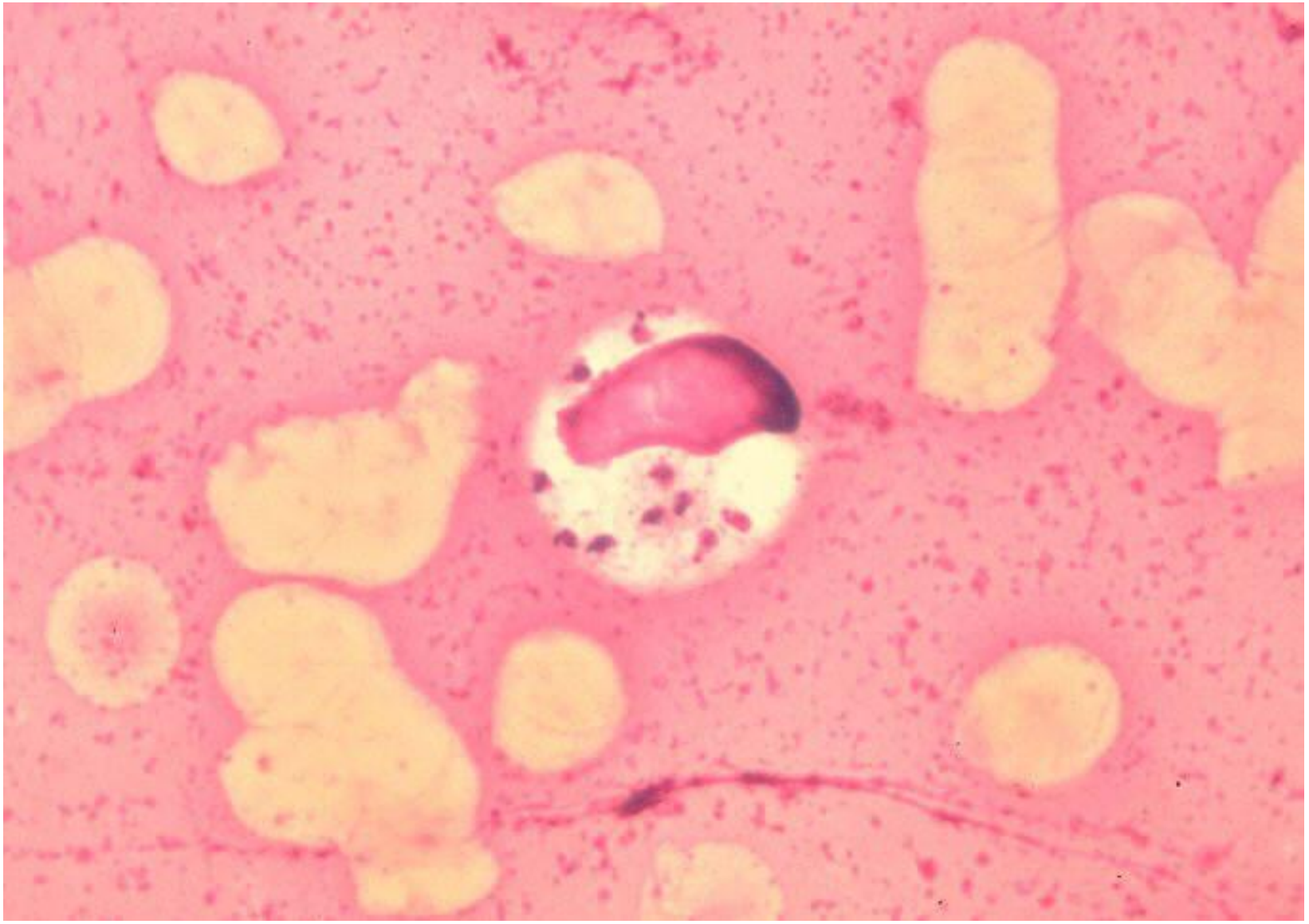


- **<u>Dum-Dum fever or kala-azar</u>**

- **<u>diseases:</u>**
- **lowgrade fever and malaise**
- **wasting and anemia,**
- **protrusion of the abdomen** (from enlarged liver and spleen)
- **death in two to three years**

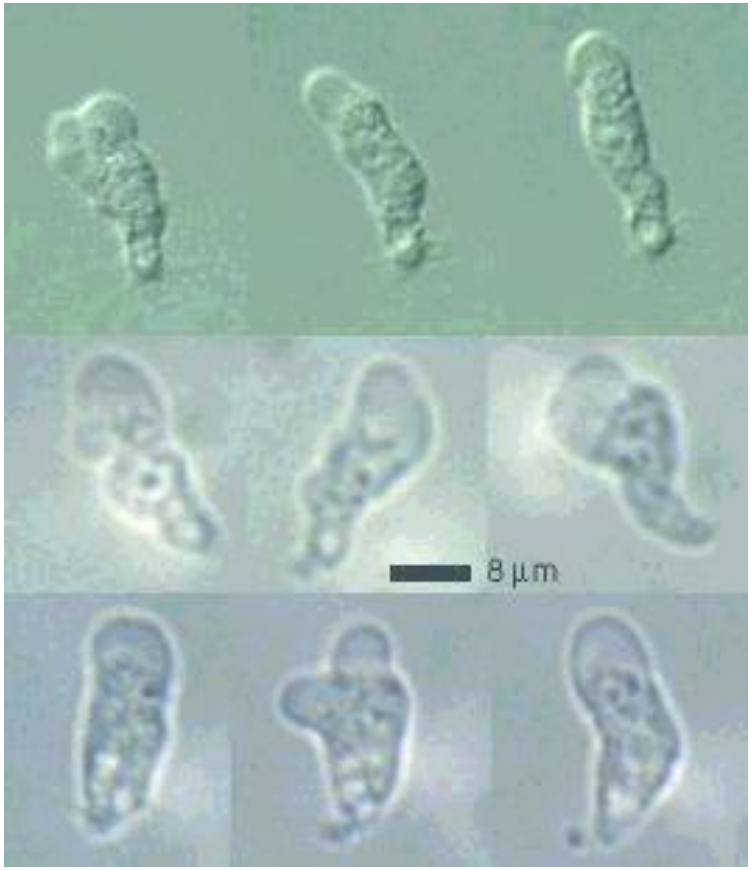


Leishmania donovani



4. Phylum: Amoeboflagellates (Heterolobosea)

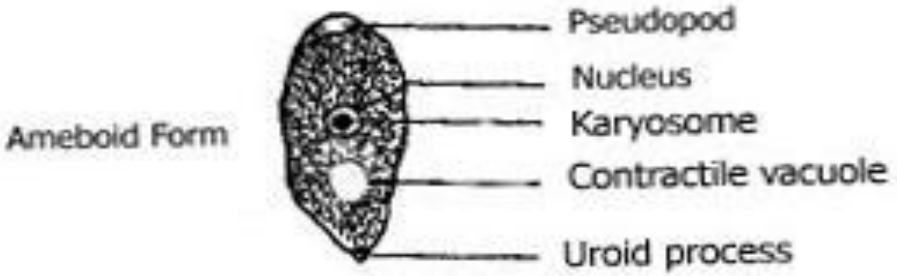
- **ameboid** protozoa
- most species have a temporary **flagellate stage**
- free living (soil), rarely parasitic, symbiont

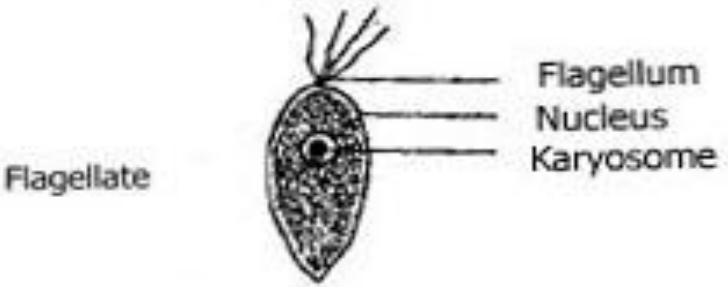


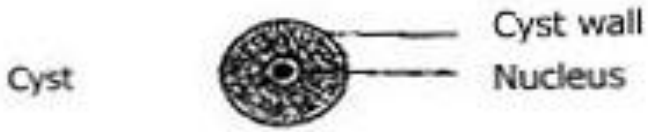
Naegleria fowleri

- causal agent of **primary amoebic meningoencephalitis (PAM)**
- brain inflammation

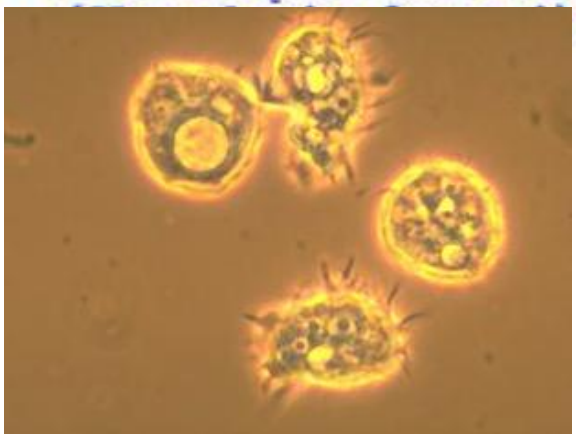
- ubiquitous in the environment, in soil, water (warm), and air

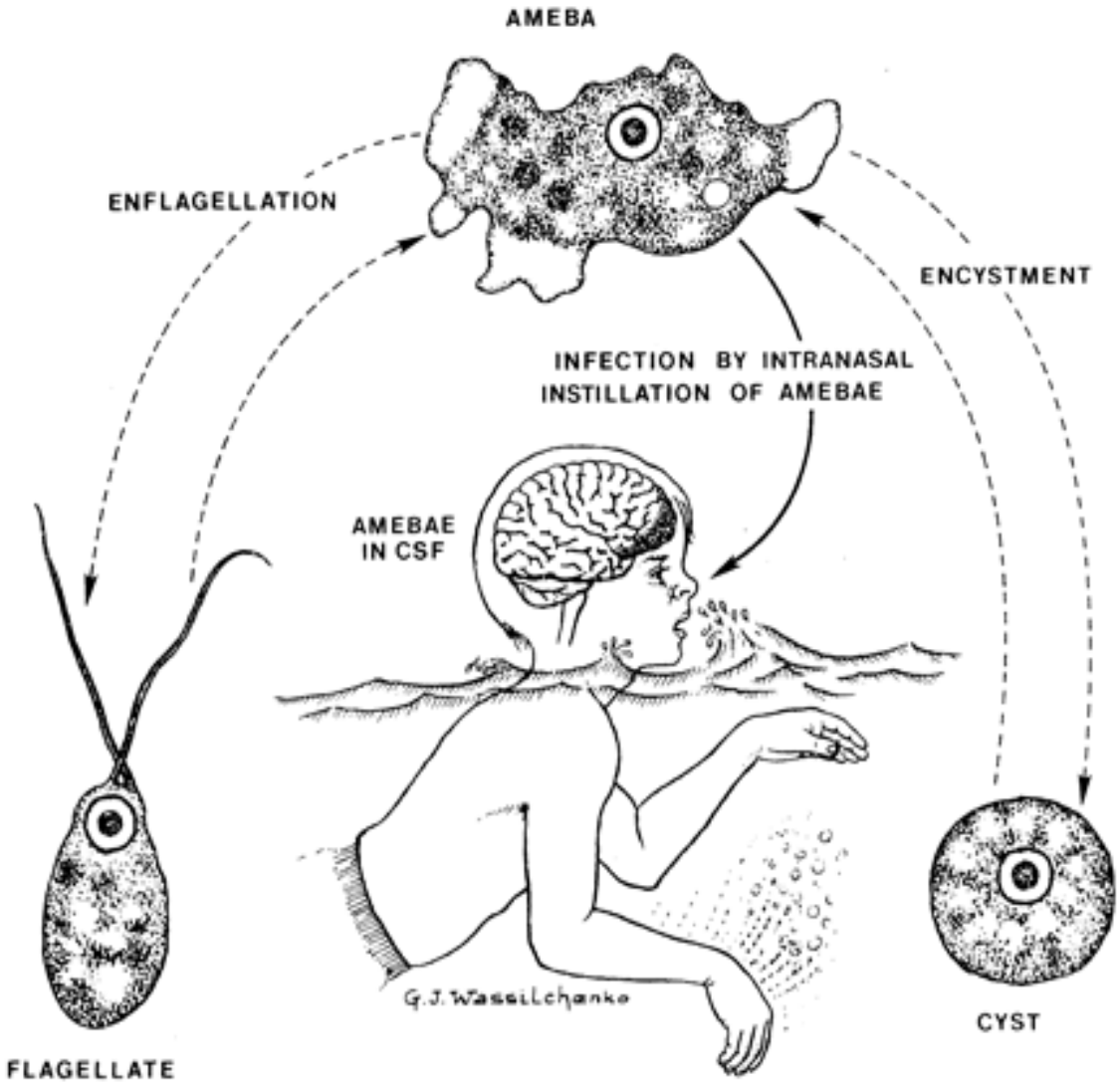


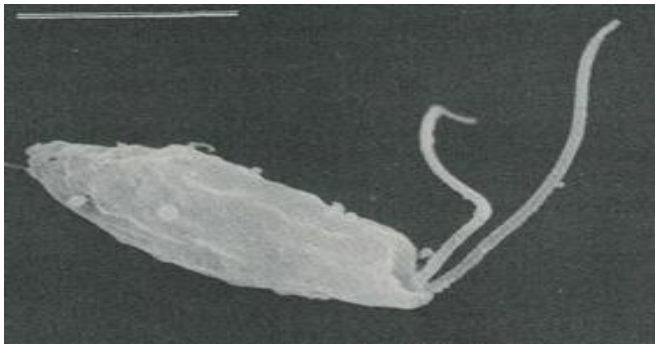


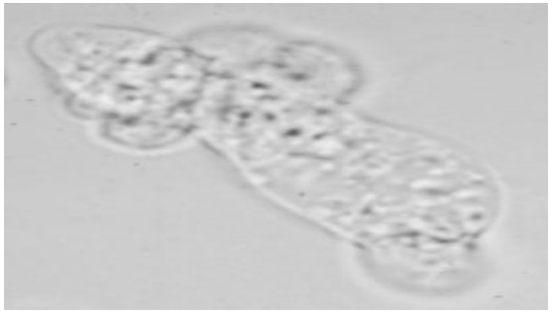


อะมีบาสายพันธุ์เนจีเรีย ฟาวเลอรี่



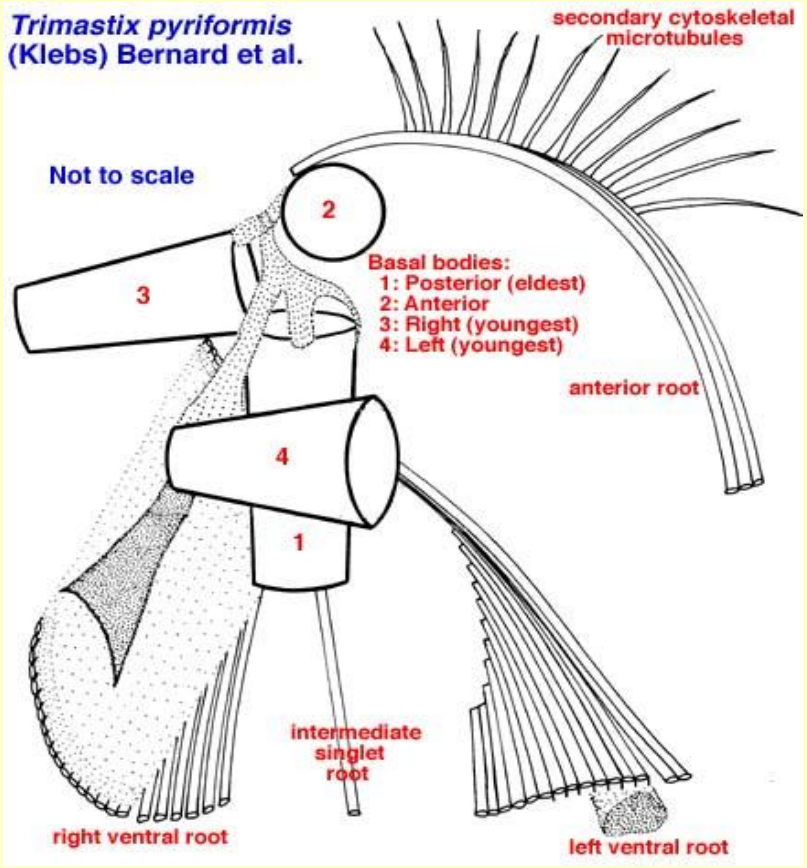

AMEBA
ENFLAGELLATION
ENCYSTMENT
INFECTION BY INTRANASAL
INSTILLATION OF AMEBAE
AMEBAE
IN CSF
G.J. Wasilchenko
FLAGELLATE
CYST



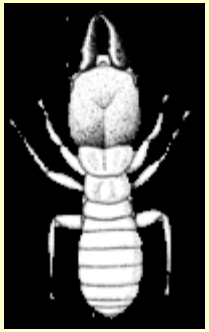


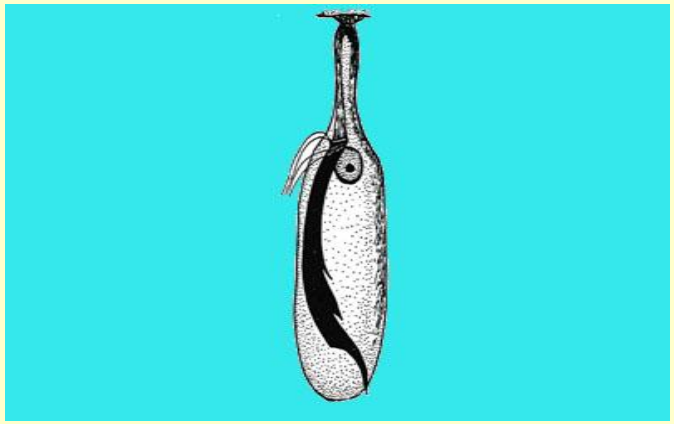
5. Phylum: Preaxostyla

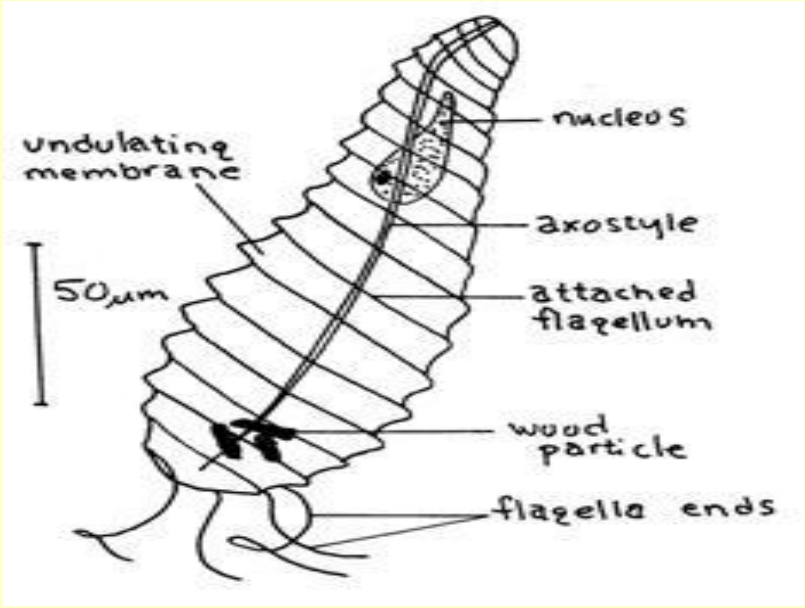
- unicells with flagella and kinetosomes per kinetid
- lacking mitochondria
- ‘‘preaxostylar’’ substructure



Class: Oxymonadida



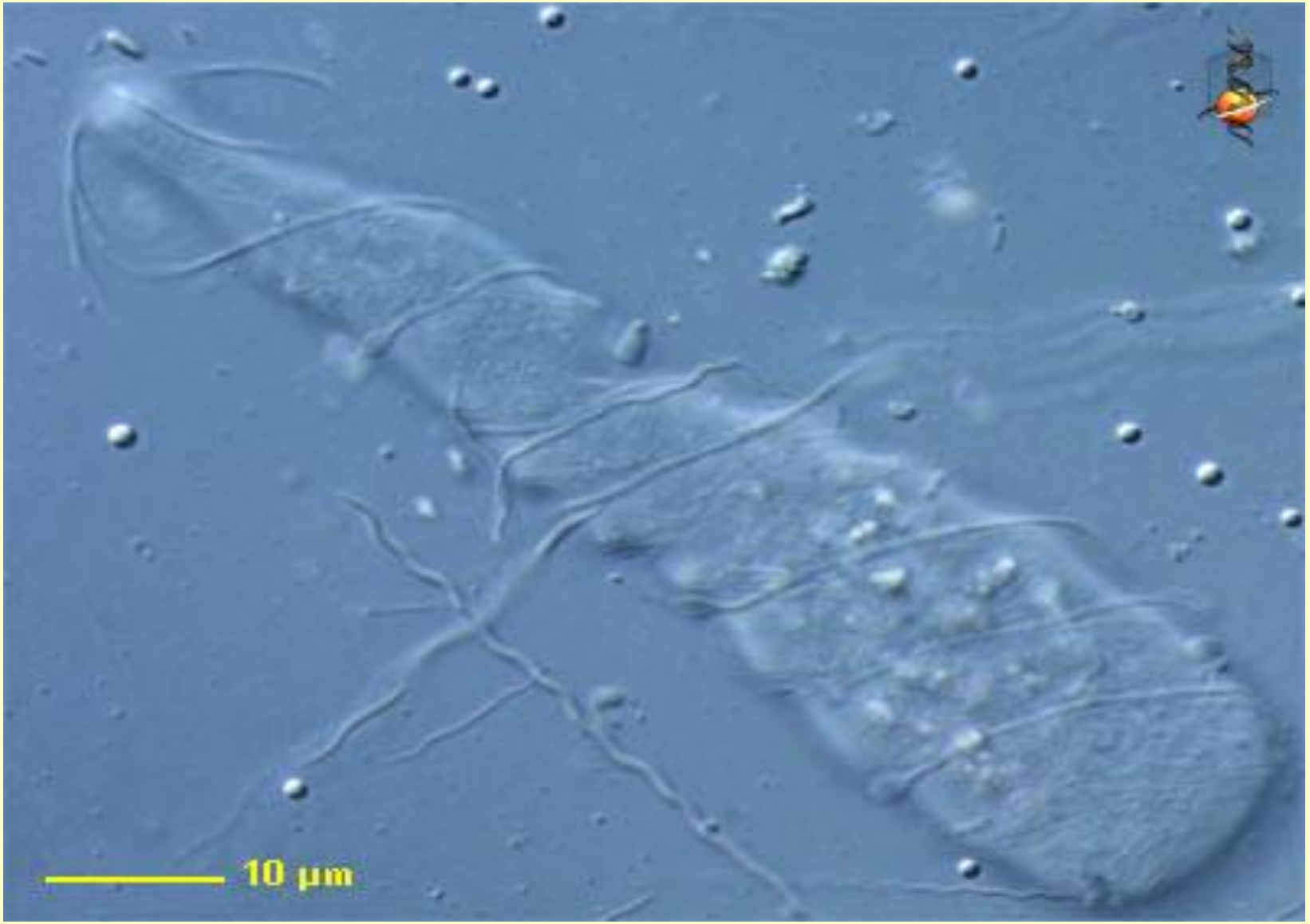


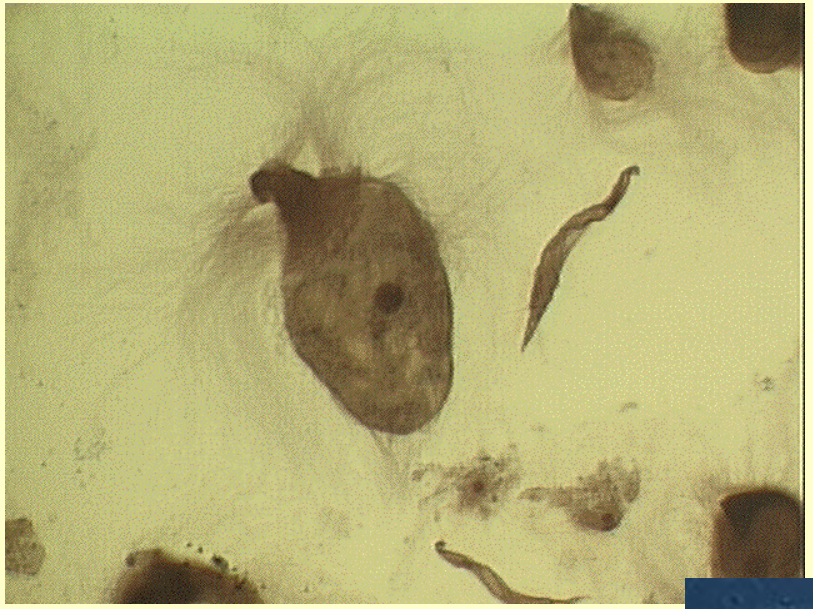


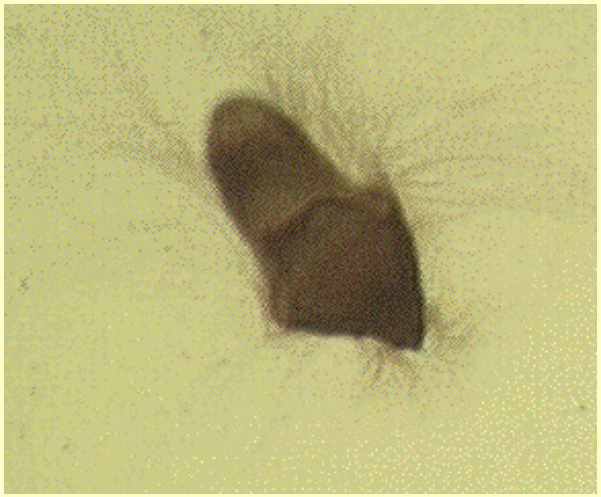
- symbionts of termites

- axostyle
- no extranuclear spindle
- many flagella
- no pellicle
- use pseupodia, phagocytosis

- **digest cellulose**
- transmit protozoans from termit to termit via licks one´s excrements


10 µm





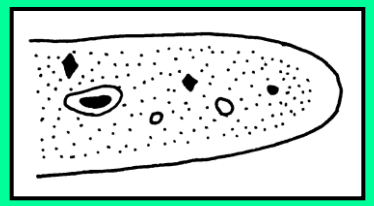
Trichonympha sp. with many long flagella

Rhizaria

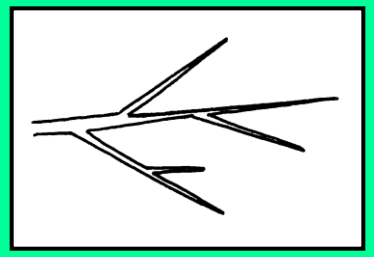
ameboid body

filose, reticulose, microtubule-supported pseudopods

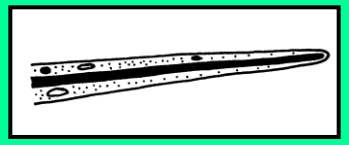
shells or skeletons



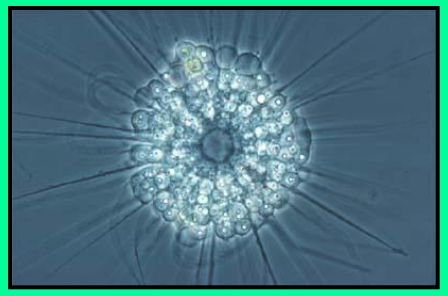
lobopods

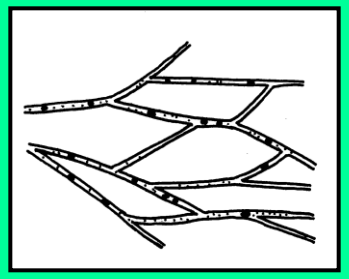


filopods



axopods





reticulopods

1. Phylum: **Phytomyxea**

- protozoans, not fungi
- plant pathogens

- zoospores with two, anterior flagella
- multinucleated protoplasts (plasmodia)
- cruciform nuclear division

- obligate, intracellular parasitis
- environmentally-resistant resting spores (cysts)

- **10 genera**

alls (arrows) on *Zannichellia palustris* caused by *Tetramyxa parasitica*
h is a 20 pennia piece from Finland.

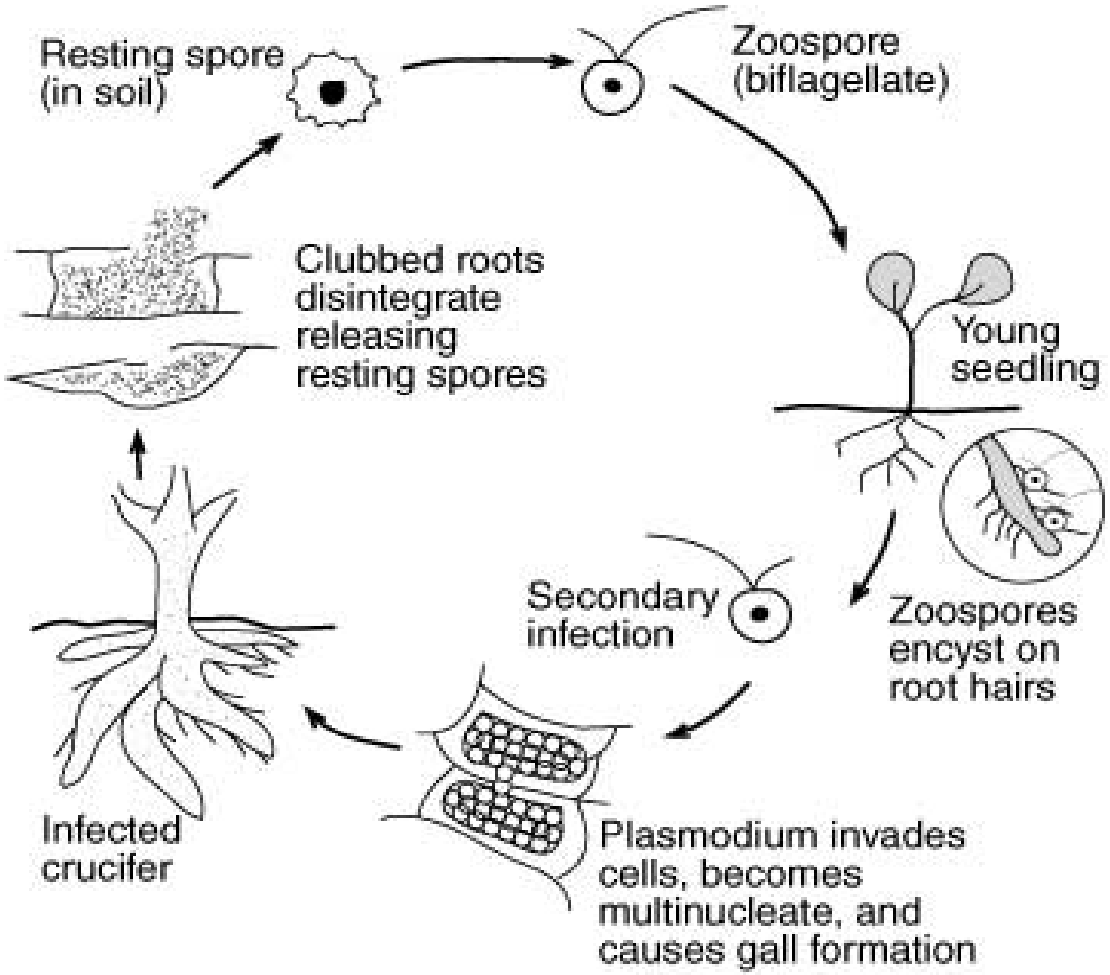
Gall on Veronica caused by Sorosphaera

Membranosorus heterantherae on *Heteranthera dubia*

Shoot of *Halodule wrightii* infected with *Plasmodiophora diplantherae*, collected from Indian River, FL, 20 March 1984.

Life Cycle

Plasmodiophora brassicae



Economically significant plasmodiophorids

***Plasmodiophora brassicae* -** clubroot of cabbage and other brassicaceous crops

***Spongospora subterranea subterranea* -** powdery scab of potato

***S. subterranea* sp. *nasturtii* -** crook root of watercress

***Polymyxa betae* -** rhizomania of sugar beet

Polymyxa graminis, *P. betae*, and *S. subterranea* serve as vectors for viruses of crops including barley, wheat, potatoes, and watercress.

Spongospora subterranea

2.Phyllum: Foraminifera

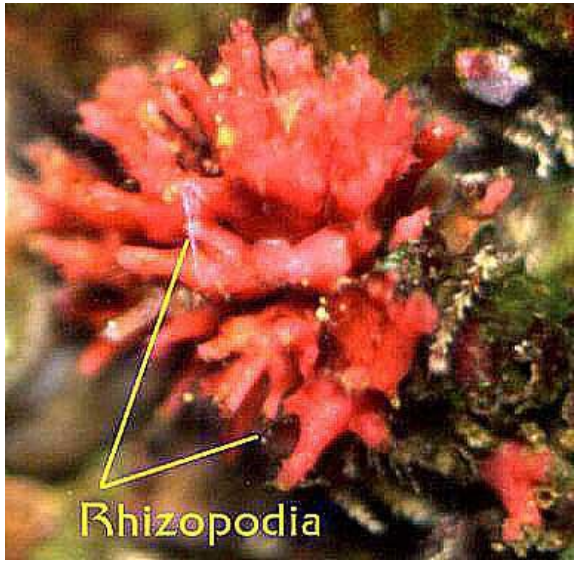
- **marine**
- **benthic, planktic (**which live in the upper 300 feet or so of the ocean)
- typically range from 0.1 mm to 1 mm in size
- **granuloreticulose pseudopodia** (thin, fairly rigid)

- **form skeletons (calcite, organic compounds and sand grains)**
- the shells (or tests) are commonly **divided into chambers**
- **geologic significance**

2. Foraminiferans

- $CaCO_3$ test

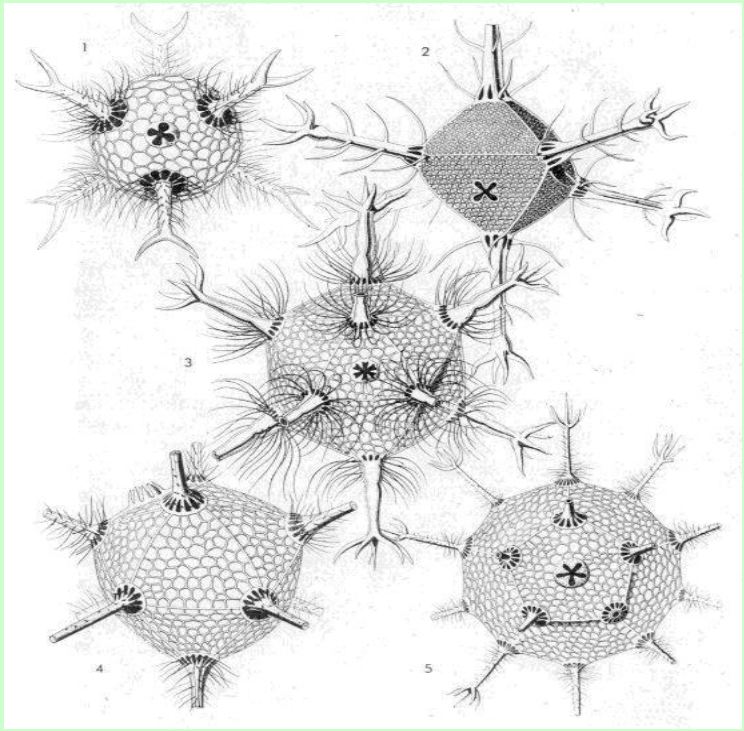

SESSILE FORAMINIFERAN
Homotrema rubra
Reticulopodia (feeding)
PHOTO BY JOHN PRICE

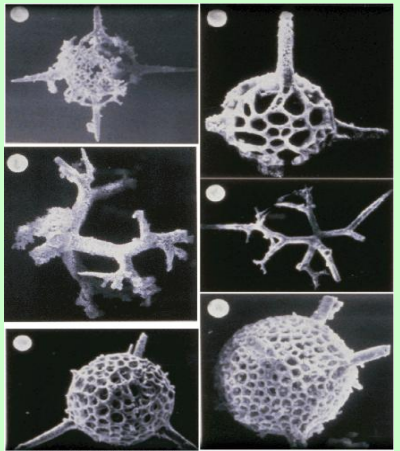

Rhizopodia

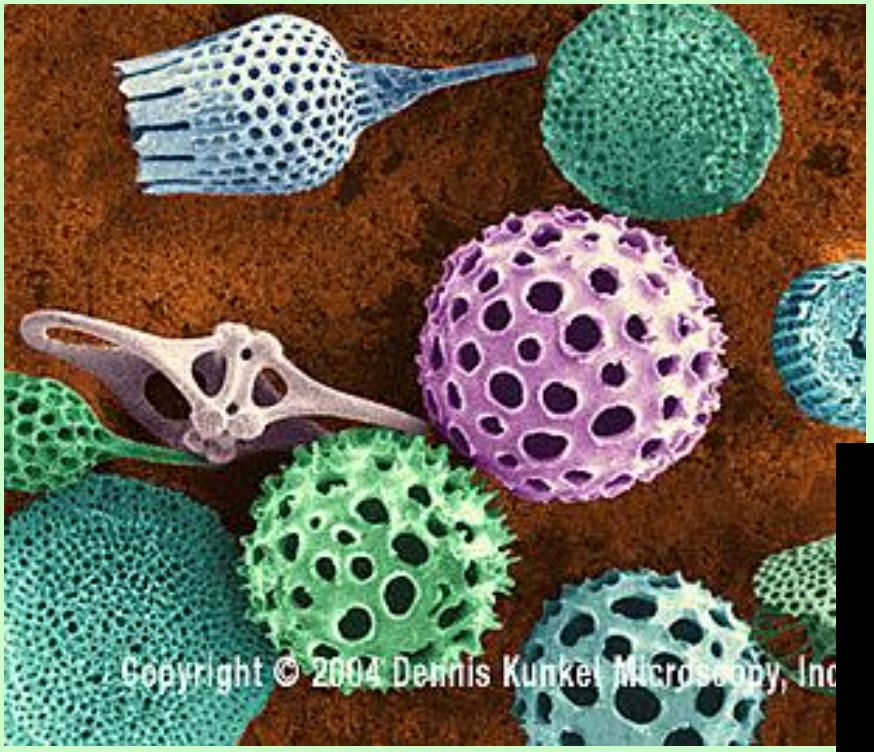

PINK SAND BEACH
Homotrema rubra
PHOTO BY GOVERNMENT INFORMATION

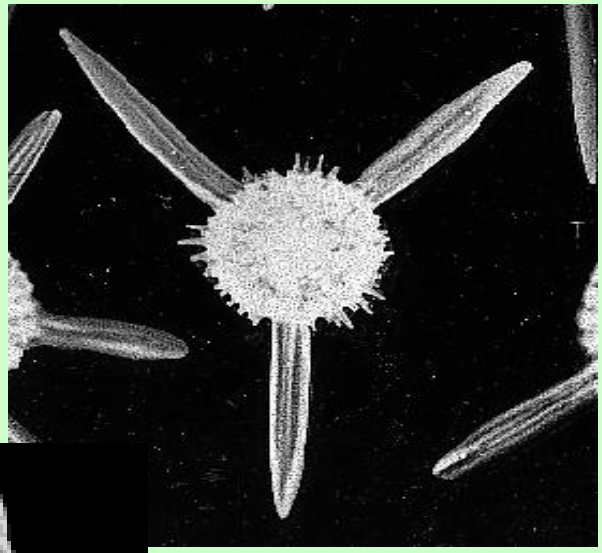
3.Phyllum: Radiolaria

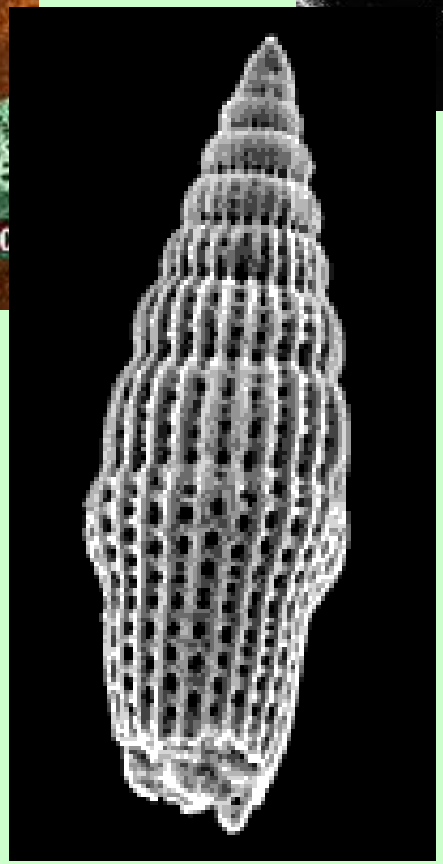
- **planktonic protozoa**
- **axopods**
- **shells** (silica, strontium sulphate)
- **the radial symmetry**
- spherical, cone-like and tetrahedral forms
- **in many rocks**
- 50 - 1000 μm

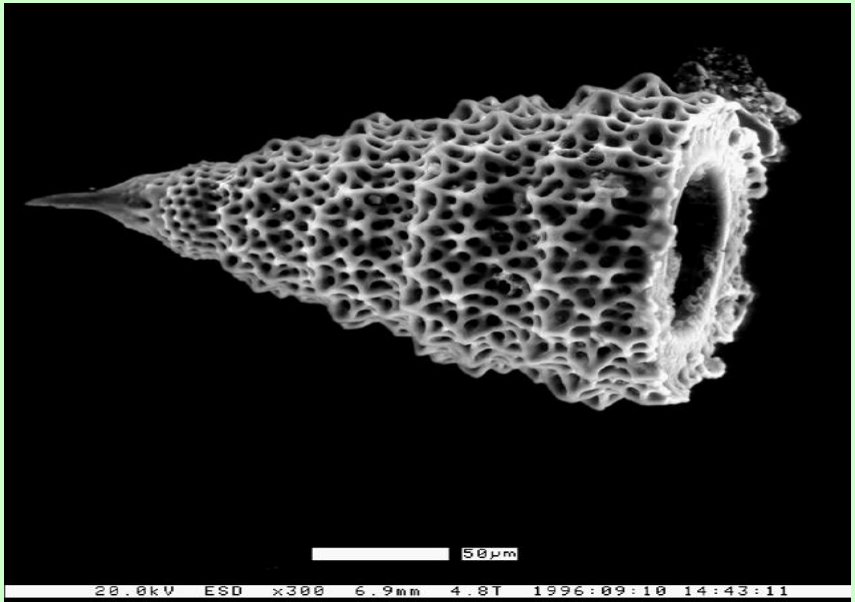





Copyright © 2004 Dennis Kunkel Microscopy, Inc





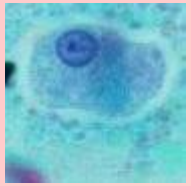

50µm
20.0kV ESD x300 6.9mm 4.8T 1996:09:10 14:43:11

AMOEBOZOA

pseudopods, cells ‘‘naked’’ or testate,
cysts common

1.Phyllum: AMEBAS (Amoebozoa)

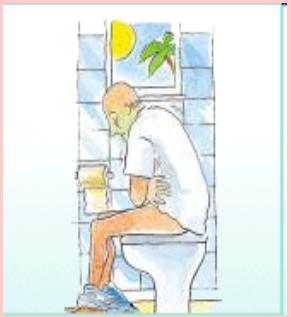
- temporary extension (pseudopodia)
- no flagellate stage
- contain a single nucleus
- body naked (without pellicle)
- may produce skeletons or test
- feed mainly on bacteria or detritus



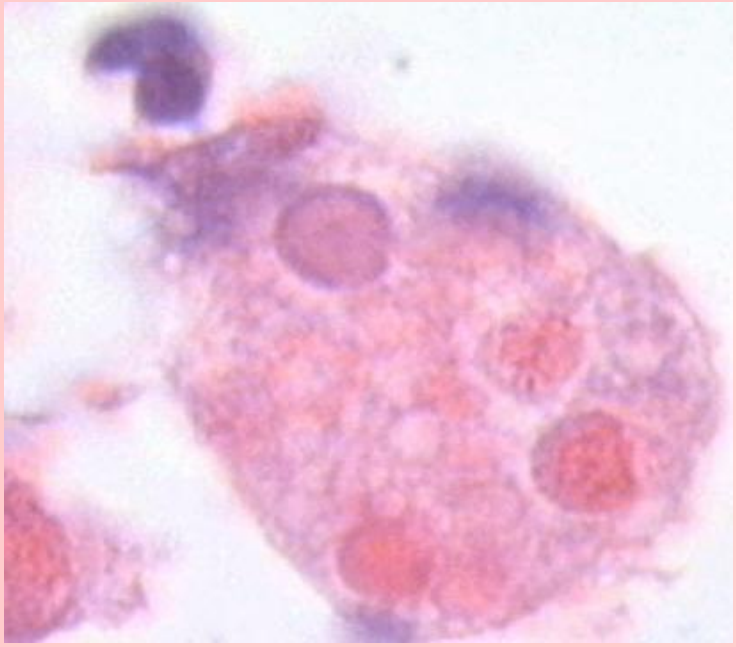
- vary in size from about 1/100 inch (0.25 millimeter) to 1/10 inch (2.5 millimeters) across
- if conditions are unfavorable, amebas secrete a firm protective covering

Entamoeba histolitica

- **amebic dysentry** of man and other animals
- **amoebic liver abscess**

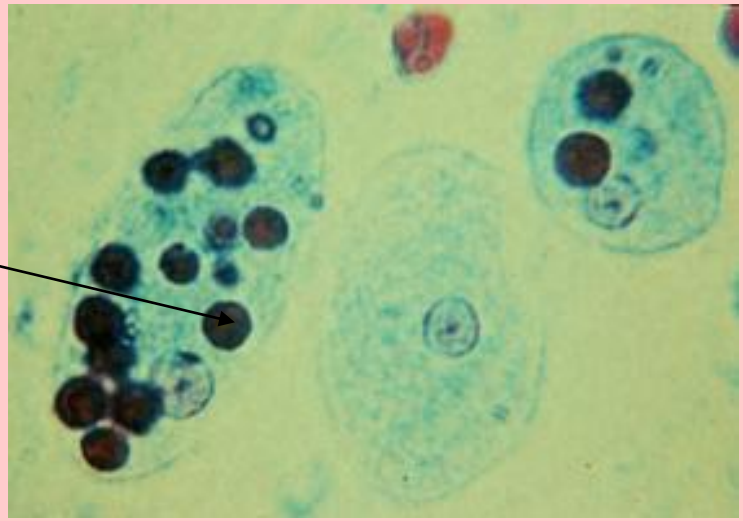


- 50 million infection, and about 100 000 deaths
- particularly in the developing world

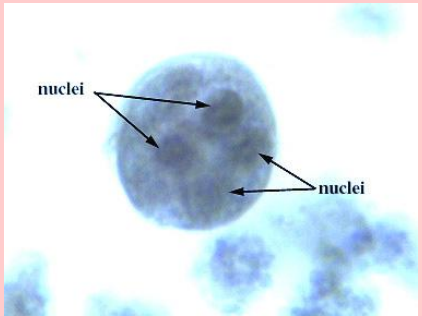


The main stages in the life cycle:

- **Trophozoites**
- diameter 20 - 50 μm
- **initiate tissue invasion (hydrolyse** mucosal cell)
- blood-ingesting



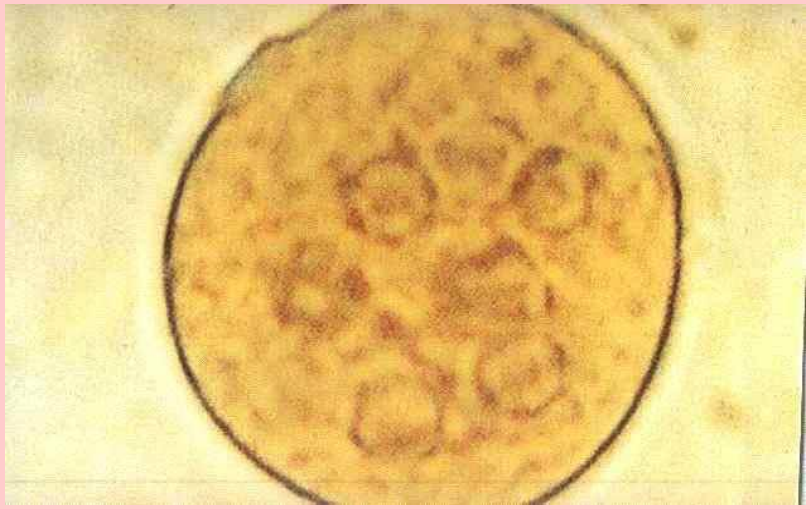
- **cyst** - very resistant, diameter 5-10 μm (with 4 nuclei)




赤痢アメーバの流行地域

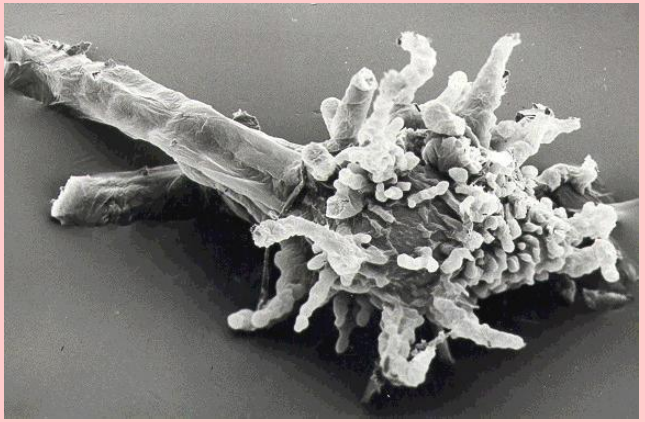
Entamoeba coli

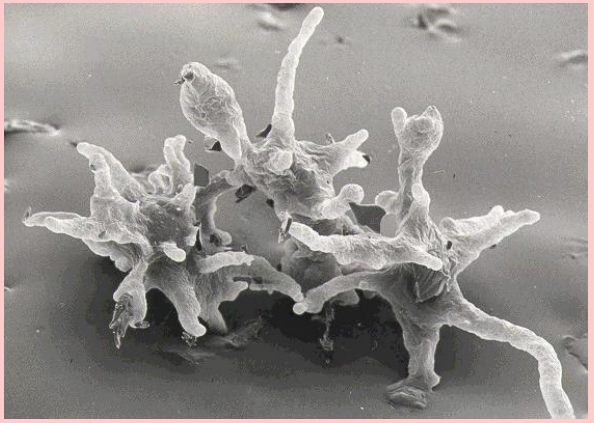
- nonpathogen
- coexist with *E. histolitica*
- the morphologies of *E. histolytica* and *E. coli* are similar in most of the stages
- cysts with five or more nuclei



Amoeba proteus

- **300-1000** μm long
- on the surface of water plant





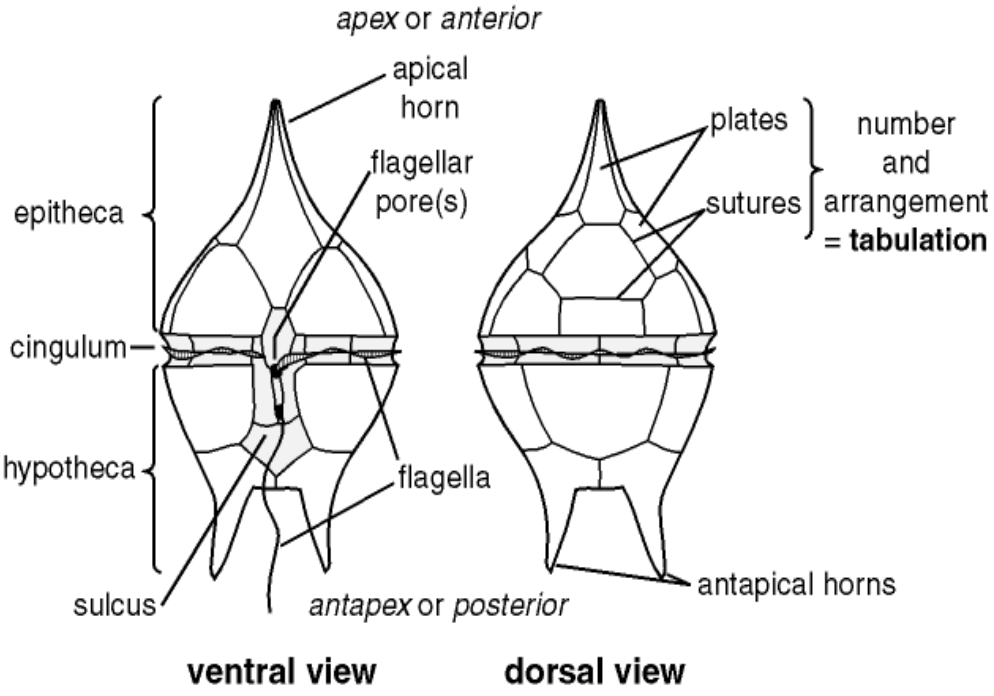
CHROMALVEOLATA

Plastid from secondary endosymbiosis with an ancestral archaeplastid

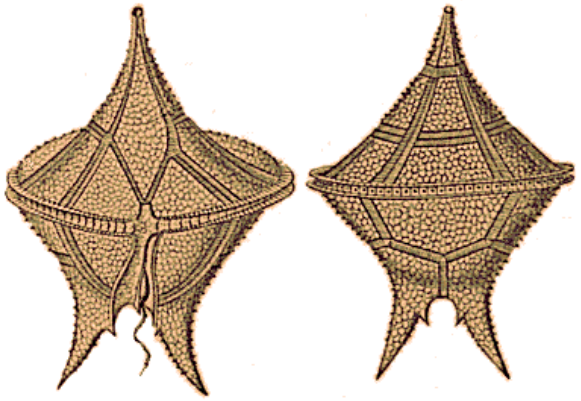
plastid secondarily lost or reduced in some

1. phylum: Dinoflagellata

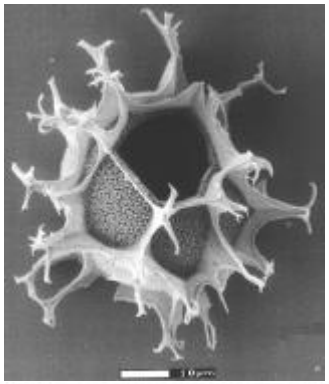
- **commonly regarded as "algae"**
- **freshwater and marine environments**
- **<u>transverse flagellum</u> (encircles the body in a groove known as the cingulum)**
- **<u>longitudinal flagellum</u>**
- **cell wall of many dinoflagellates is <u>divided into plates of cellulose</u>**



- **bizarre in shape and appearance**

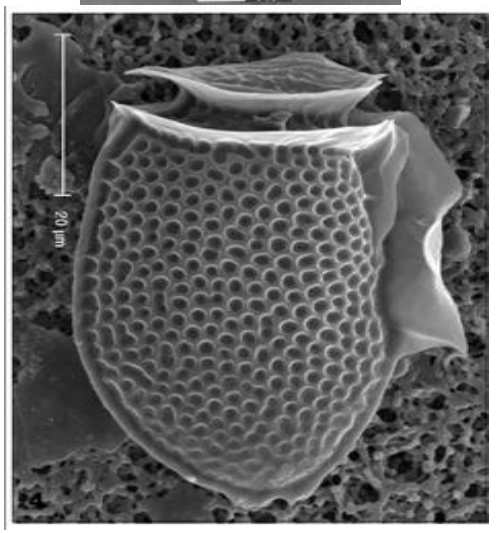


- heterotrophic and autotrophic (photosynthetic)



- bioluminescence

- free living, some parasites on fish or on other protists



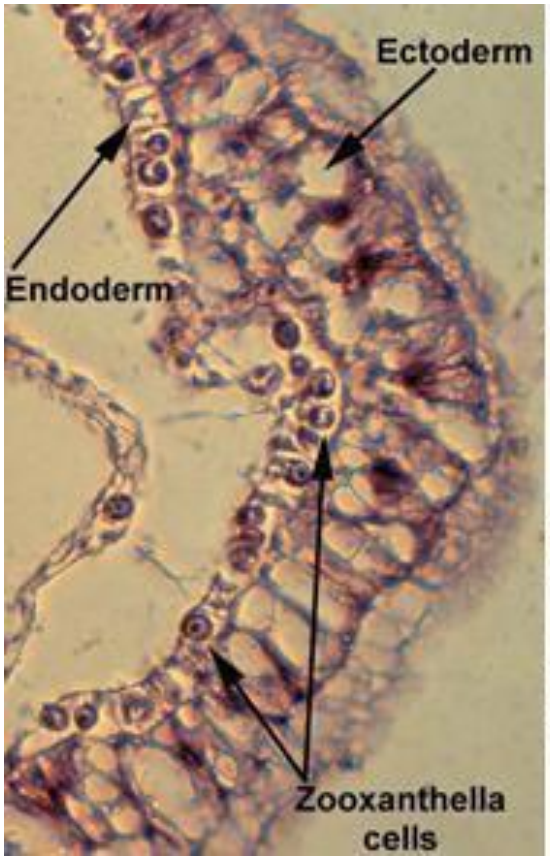
- about 2100 species

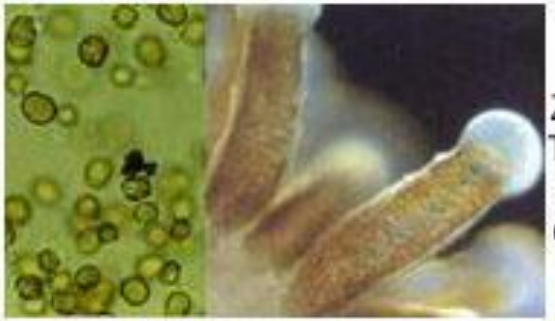
"red tide"

- "bloom" during the warm months of summer
- reproduce in great numbers
- produce a neurotoxin
- ciguatera, PSP (can be serious but are not usually fatal

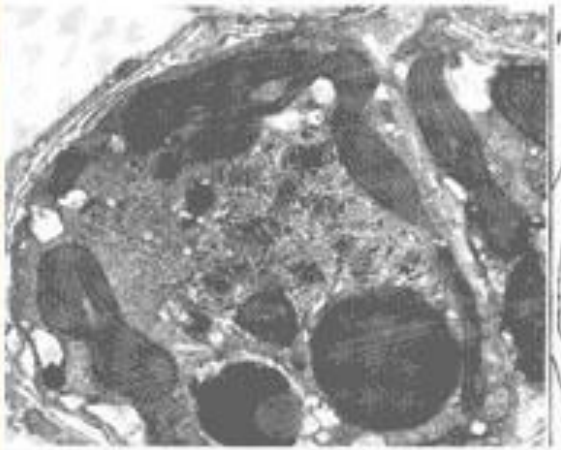
Zooxantella, Symbiodinium

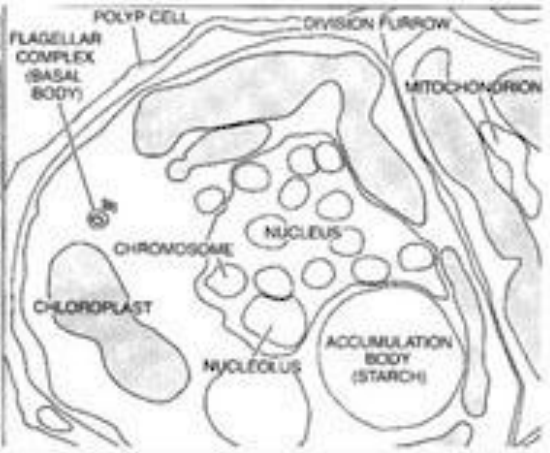
- endosymbionts of corals





Zooxanthellae SEM enlargement. The striated sacs within the cells are sections through a single large chloroplast, where photosynthesis takes place



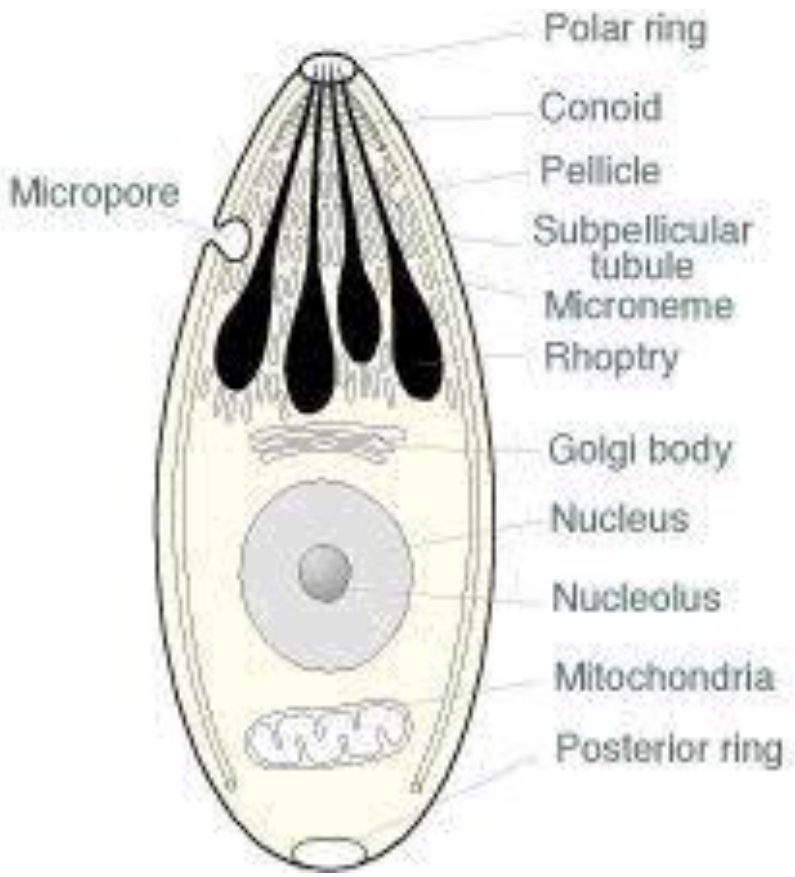


http://www.nsm.buffalo.edu/Bio/burr/montipora.htm

2. phylum: APICOMPLEXA

- **apical complex** (**micronemes and rhoptries, polar rings, conoid**)

- the apical organelles play a role in these host-parasite interactions



APICOMPLEXA cause serious illnesses

- genus *Plasmodium* cause malaria (450 million people are infected with malaria, and over 1 million die from it each year)

- coccidiosis and toxoplasmosis

- apicomplexans that infect insects have been used experimentally **to control populations of insect pests**

APICOMPLEXA

classification

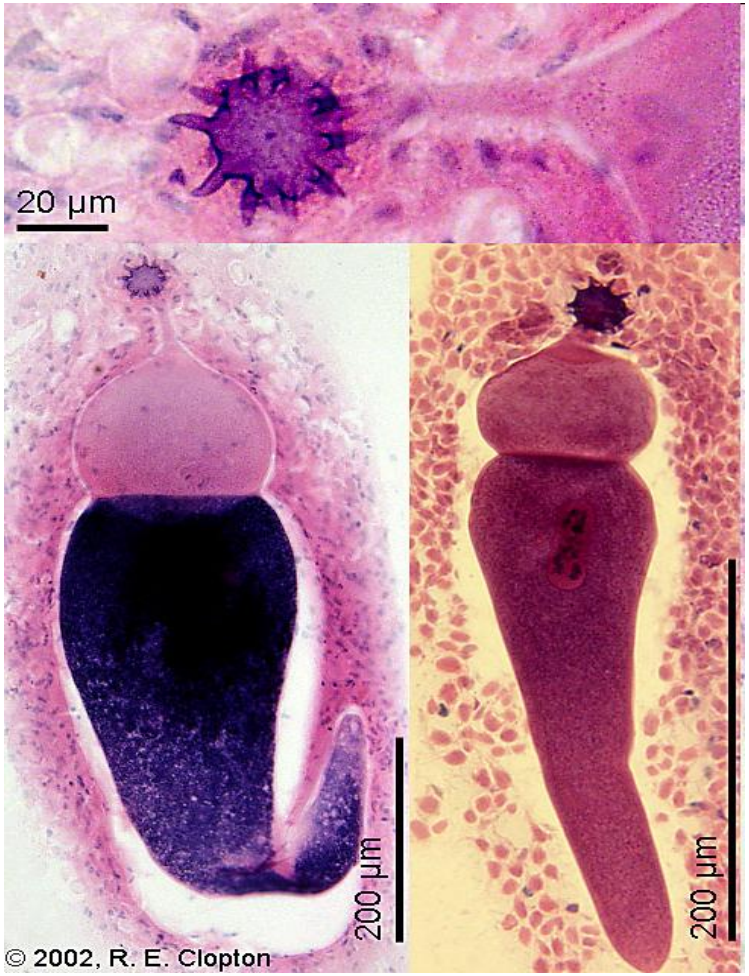
- **Classes:**

1. **Gregarinea**
2. **Cryptosporidea**
3. **Coccidea**
4. **Haematozoea**

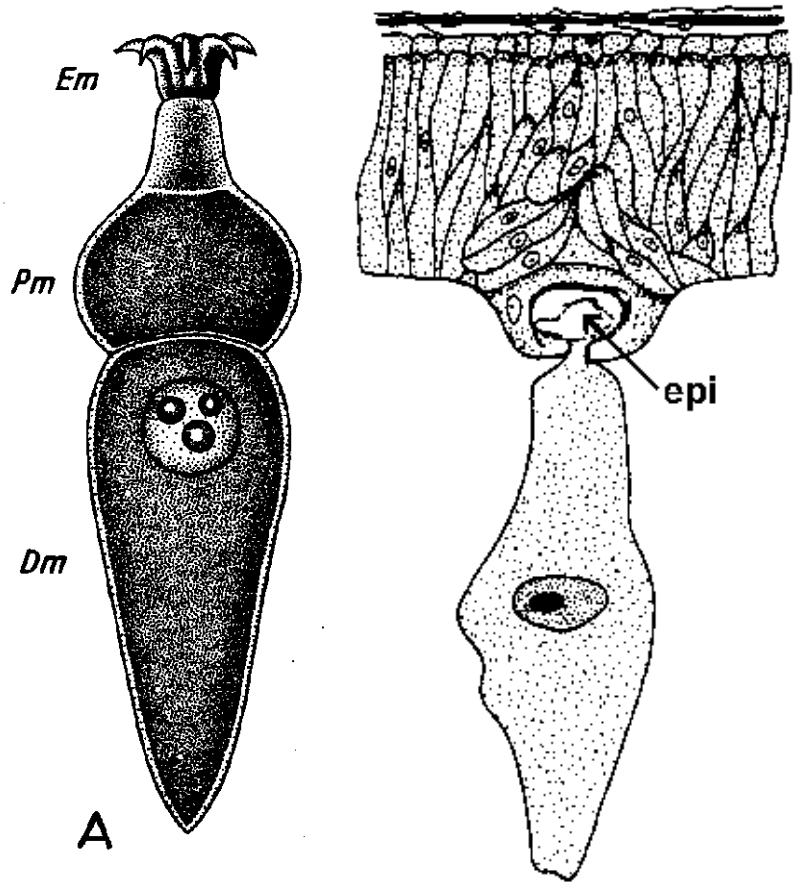
1.Class: GREGARINEA

- mature trophozoit **extracellular, large** (to 10 mm)

- parasites of gut and body cavities of **invertebrates**



- **epimerite** (region specialised for attachment to the host tissue)
- **protomerite**
- **deutomerite** containing nucleus

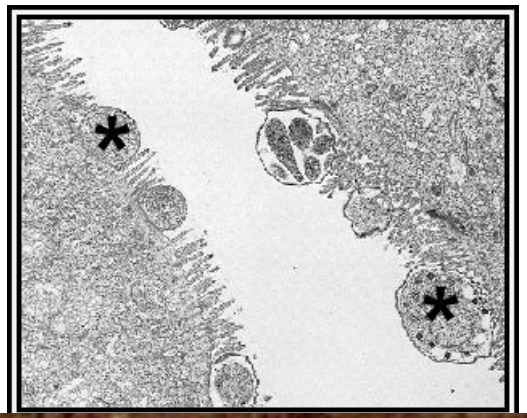


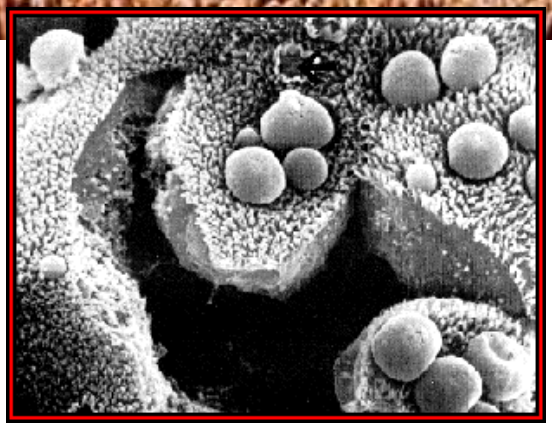
Monocystis lumbrici

- Host: earthworms

2.Class: CRYPTOSPORIDEA

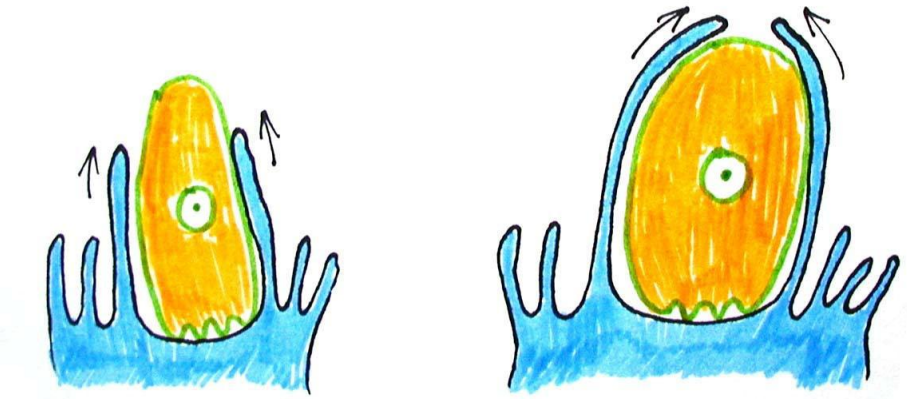
- monoxenous
- 3-5 μm
- **parasites of the intestinal tracts** of fishes, reptiles, birds, and mammals
- do not display a high degree of host specificity

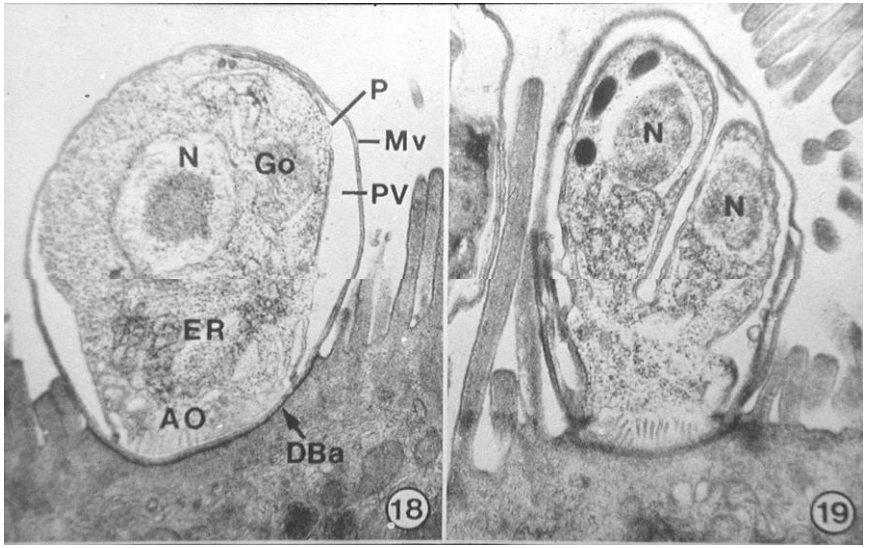




- it lives on the surface of the cells lining the **<u>small intestine</u>**

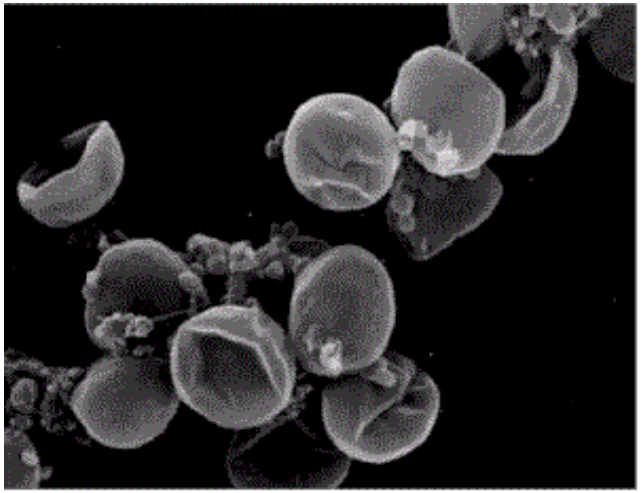
- **cells' membrane envelops them**





transmission of the infection occurs via the **oocysts**.

- **thick-walled oocysts** with 4 sporozoites passed in the feces
- **thin-walled oocysts** remain in gut, excysting and releasing merozoites (= autoinfection)



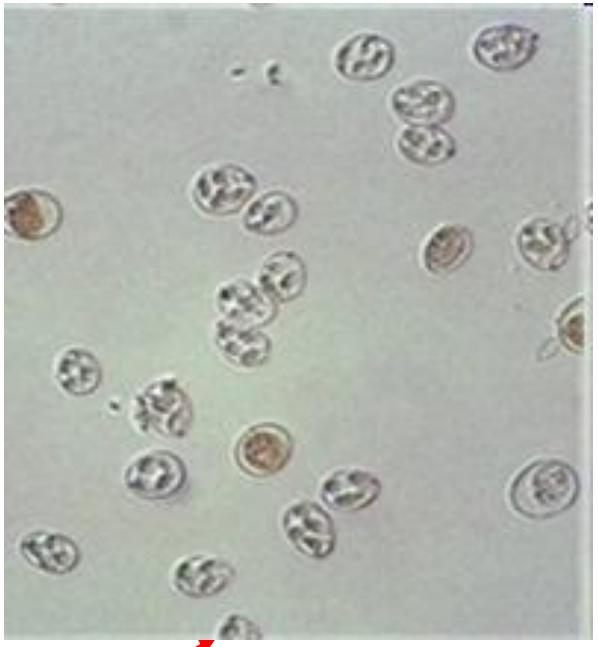
photograph courtesy of B. Stein, TUSVM

Cryptosporidium parvum

- *Cryptosporidium* isolated from humans (calfs, dogs) is now referred to as ***C. parvum***
- **parasite of mammals, birds**
- in immunocompromised hosts
- **the contamination of drinking water** with oocysts from agricultural "run-off" (i.e., drainage from pastures), so it is considered a zoonosis
- the infection causes a **short term, mild diarrhea**
- **the symptoms of cryptosporidiosis**- the most common include watery diarrhoea, abdominal cramps, nausea, and headaches. These symptoms occur within two to 25 days of infection and usually last one or two weeks; in some cases they stick around for up to a month.

3.Class: COCCIDEA

- small, intracellular
- parasites of many tissues of vertebrates and invertebrates
- some monoxenous, others heteroxenous
- many species are **pathogenic**
- infective stage - **oocyst**



life cycle with three major phases

- asexual: **sporogony**
- asexual: **merogony** (schizogony)
- sexual: **gametogony**

transmission:
via the oocysts

- **MONOXENOUS LIVE CYCLE (one host)**
- ***Eimeria* spp.**

- **HETEROXENOUS LIVE CYCLE (two hosts)**
- ***Sarcosystis* spp., *Toxoplasma* spp.**

Eimeriidae (*Eimeria* spp.)

- **monoxenous life cycle**
- **most species parasitize domestic animals**, (poultry, rabbits, calfs, sheeps, goats, piglings)
- dangerous mainly **for kittens** (frequently lethal course)
- factors: **animal concentration, stress, hygiene**
- **host-specific** (restricted to a certain host species)

Life cycle of *Eimeria tenella*

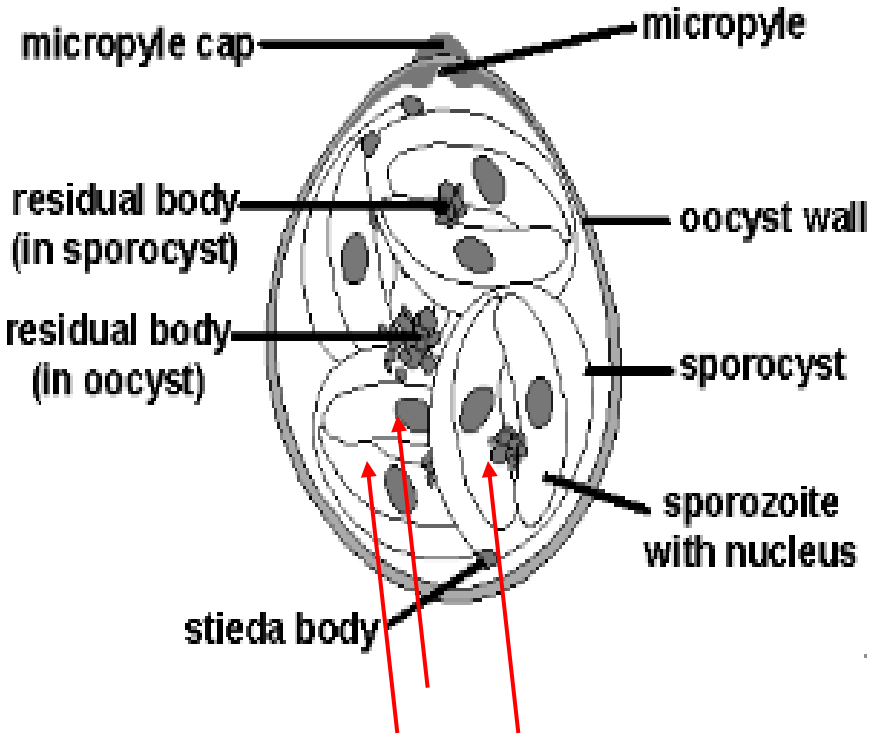
- MEROGONY
- GAMETOGONY
- SPOROGONY

Life cycle of *Eimeria tenella*

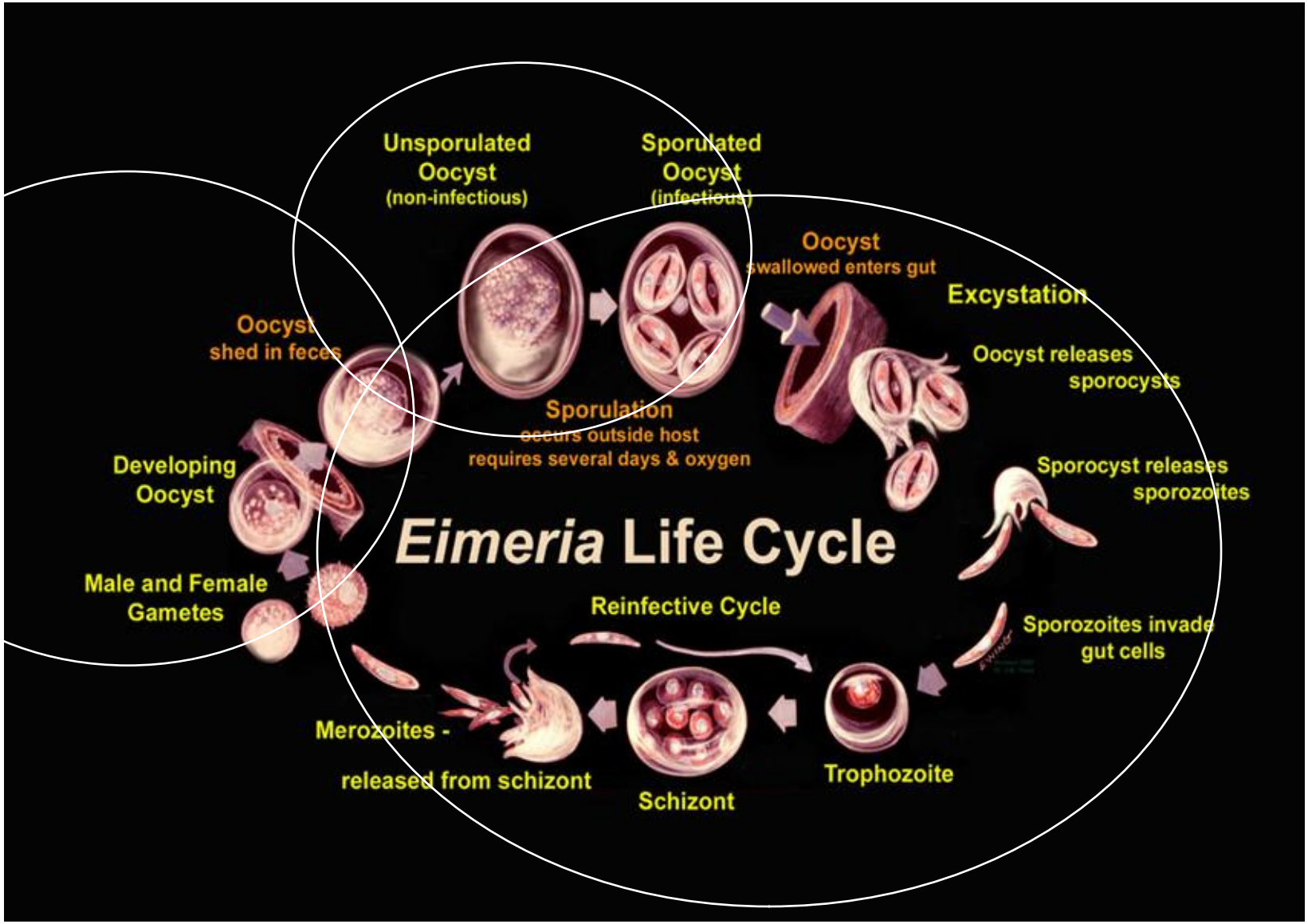
the infectious stage:

the sporulated oocysts:

- **4 sporocysts** containing **2 sporozoites** each
- **micropyle**
- **bilayer oocyst wall**
- **'stieda body'**

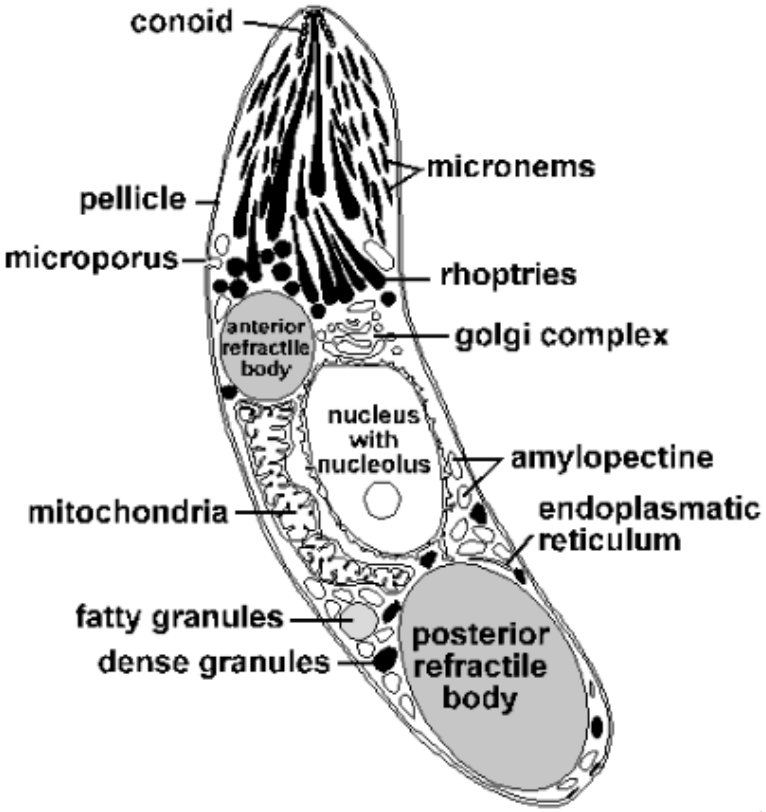


parasites (sporozoites)

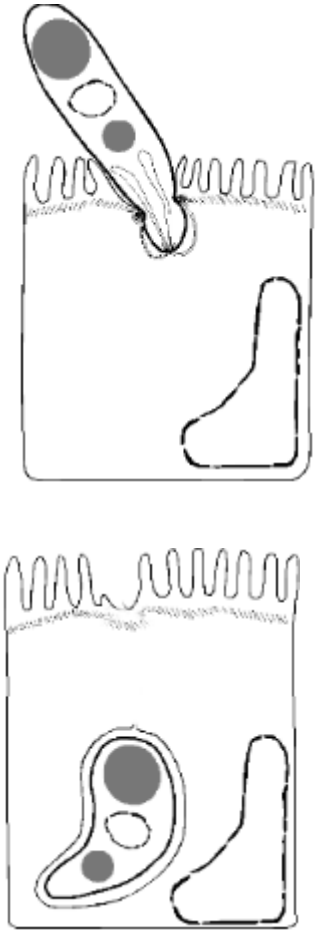

Unsporulated Oocyst (non-infectious)
Sporulated Oocyst (infectious)
Oocyst swallowed enters gut
Excystation
Oocyst releases sporocysts
Sporocyst releases sporozoites
Sporozoites invade gut cells
Trophozoite
Schizont
Merozoites - released from schizont
Reinfective Cycle
Male and Female Gametes
Developing Oocyst
Oocyst shed in feces
Sporulation
occurs outside host
requires several days & oxygen
Eimeria Life Cycle

Invading the host cell

Sporozoite



Sporozoite

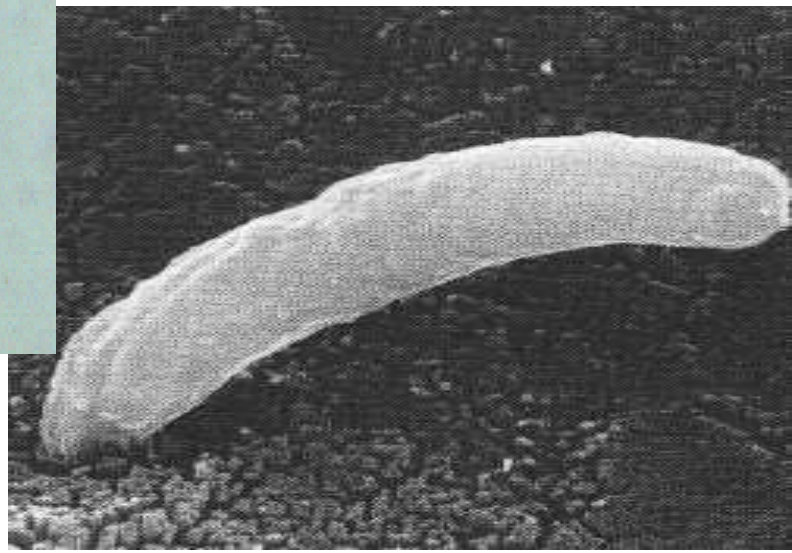


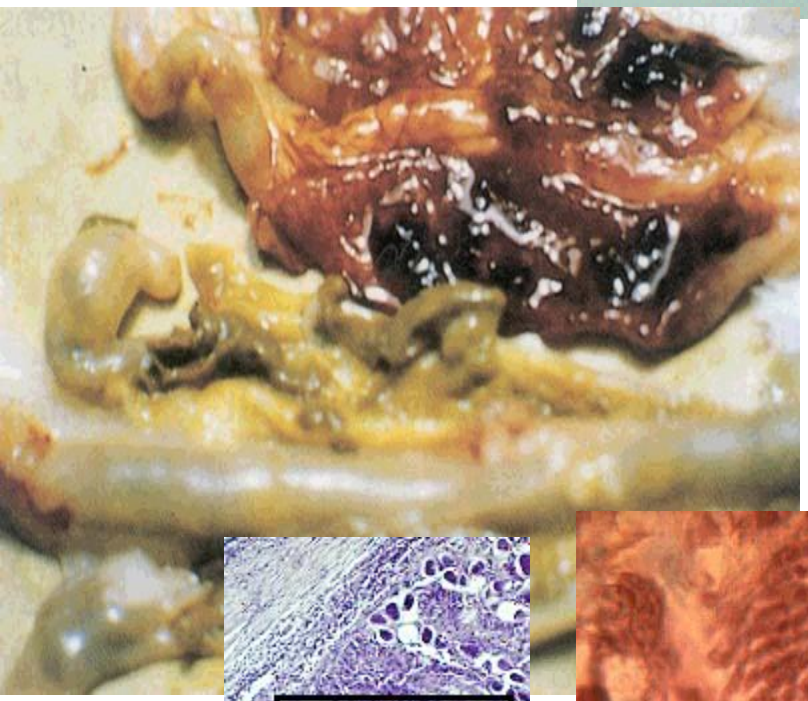

WWW.POULTRYMED.COM

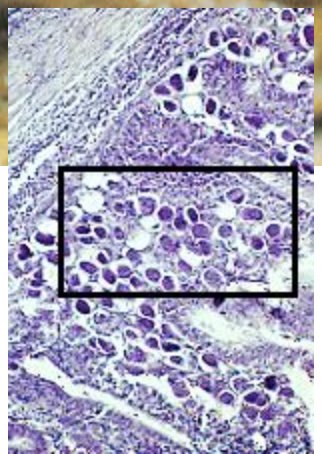

WWW.POULTRYMED.COM

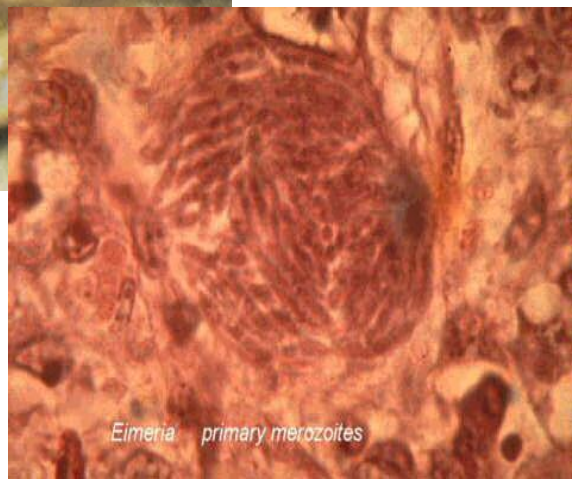

WWW.POULTRYMED.COM

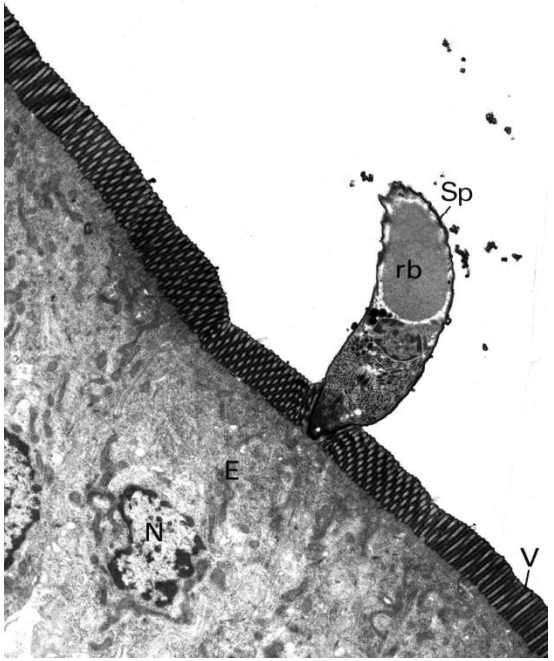

Coccidiosis








Eimeria primary merozoites


Sp
rb
E
N
V

Coccidia of domestic fowl

- *Eimeria acervulina*

Eimeria brunetti

Eimeria maxima

Eimeria mitis

- *Eimeria mivati*

Eimeria necatrix

Eimeria praecox

Eimeria tenella

Control of coccidiosis

- **Hygienic measures**
- **Zootechnic, management measures**
- **Chemotherapy**
- **Vaccination methods**

Hygienic measures

- basic **regular cleaning and disinfection** (common disinfectants do not destroy oocysts)
- gassing of metallic cages and structures by soldering lamp
- **regular exchange of bedding**
- mechanical cleaning and disinfection of haunts
- **regular removal of faeces** and biothermal sterilization of faeces at dung-pits
- maintaining the **lowest humidity** of environment and bedding possible

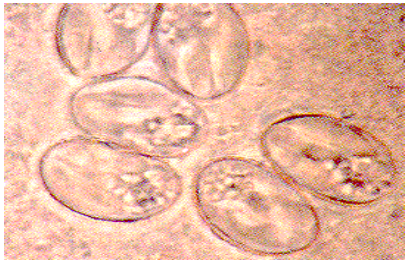
Zootechnical measures

- not overcrowding the animals
- cage fostering
- separated breeding of the young and older animals
- quarantine and examination of new animals

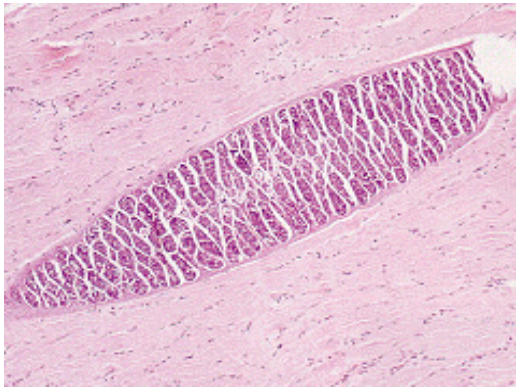
Heteroxenous life cycle

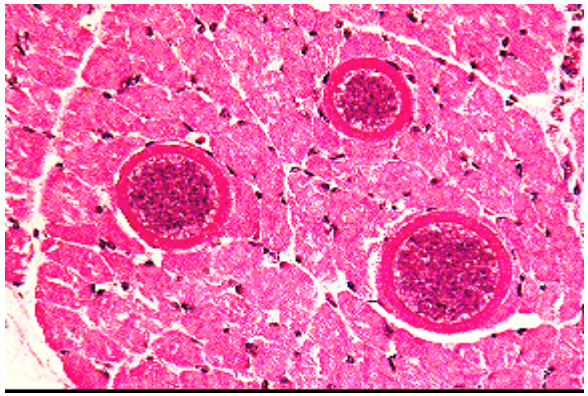
(*Sarcocystic* spp., *Toxoplasma gondi*)

- **Sporogony** **(into the environment)**



- **Merogony** - formation **zoitocysts (or tissue cysts)** in muscle of **herbivorous intermediate host**





- **Gametogony** - **in definitive hosts (mainly carnivorous mammals) merozoits transform into gamonts and produce micro and macrogametocytes.**

- ***Sarcosystis* spp.**

- intermediate host, definitive host - both of them **host-specific**
- only **vertical transmission** (from intermediate to definitive host)

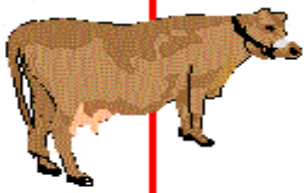
- ***Toxoplasma gondi***

- intermediate host **nonspecific**, definitive host only **felines**
- **vertical and horizontal transmission, transplacental transmission**

THE LIFE CYCLE OF *SARCOCYSTIS CRUZI*

The parasites infect the intestinal tissues of the host, reproduce asexually, and finally produce oocysts.

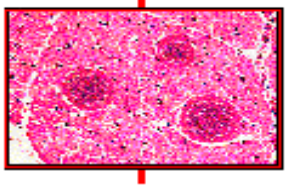
Oocysts are passed in the host's feces.



Oocysts are ingested by the intermediate host.

The definitive host is infected when it ingests bradyzoites in the tissue.

Zoitocysts, sarcocysts, or Miescher's tubules, filled with bradyzoites, form in the host's tissues.



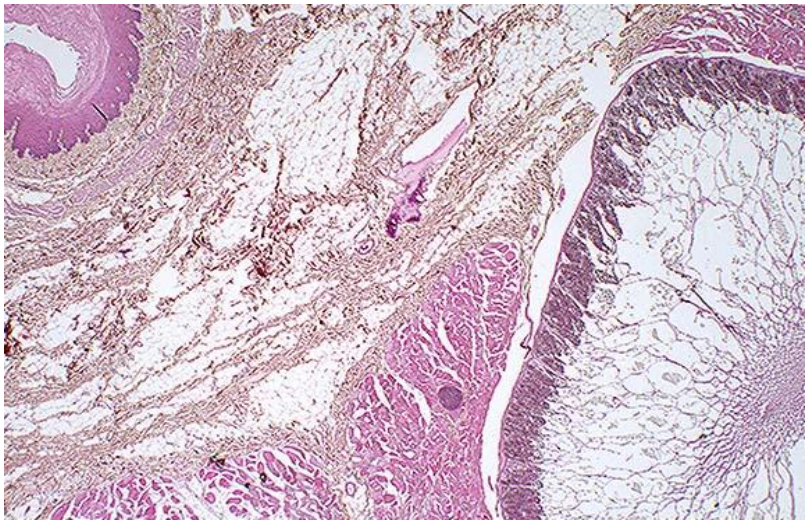
The oocysts excyst, and the parasites infect the host's tissues.

(Parasites and Parasitological Resources)

	INTERMEDIATE HOST	FINAL HOST
Sarcosystis cruzi	cattle	**dog**
Sarcocystis hominis	cattle	**human**
Sarcocystis gigantea	sheep	**cat**

Sarcocystis gigantea

- Esophagus.

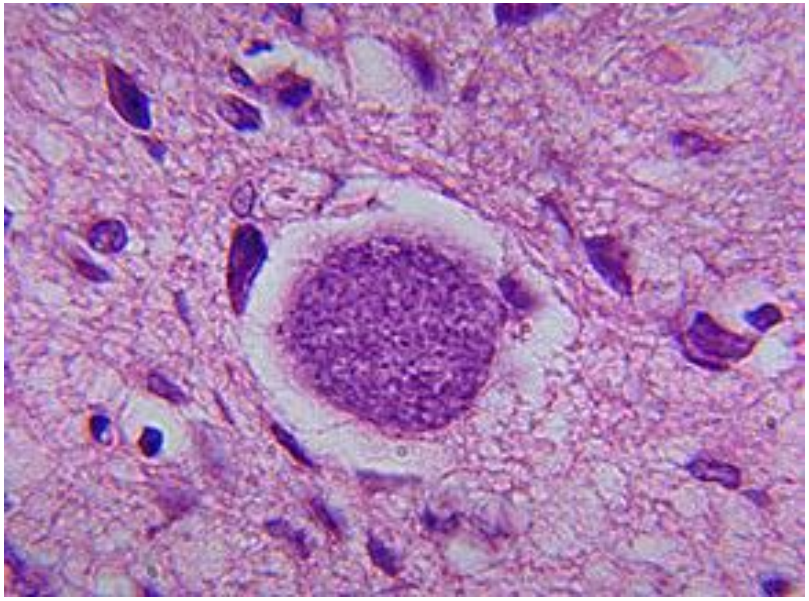


TOXOPLASMA GONDI

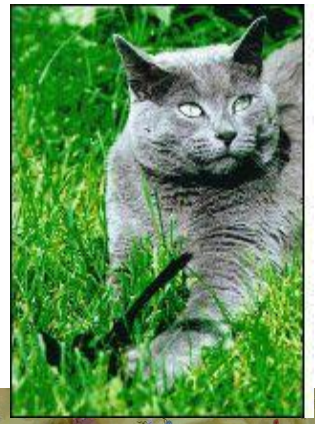
- **the most important zooantroponosis in Europe (in all temperate zone)**
- 30 % of the population of the Czech Republic are infected with *Toxoplasma gondi*

- **toxoplasma is cosmopolitan in the human population**

- toxoplasma infection is common, but **full-blown disease** is rare

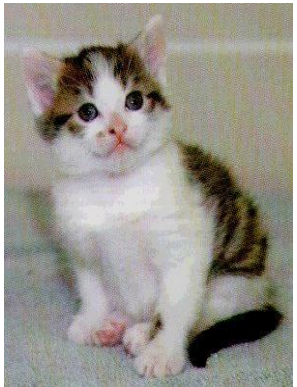


LIFE CYCLE



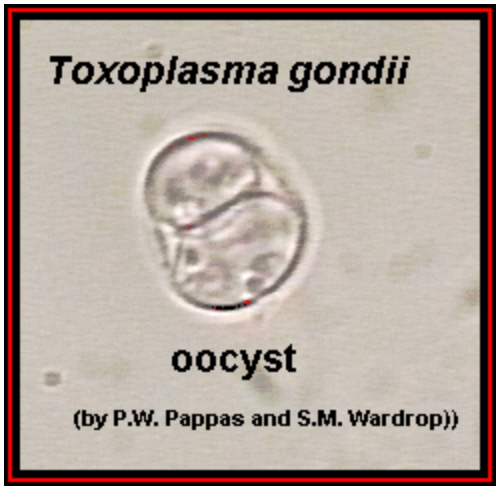
- **the INTERMEDIATE host**
- all **warm-blooded** animals, including man

- **the FINAL host**
- **domestic, wild, and feral cats**



FINAL host

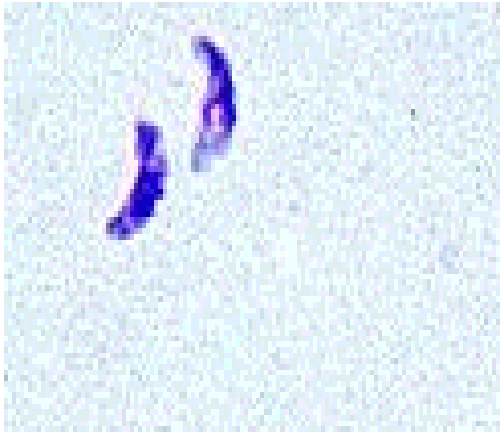
- cats - **20 % to 100 % infection rate with *T. gondii*.**
- **stray and feral cats** have a higher incidence of infection than pet cats
- **oocysts** are excreted in the feces **for two to three weeks**
- **oocysts can survive in moist shaded soil or sand for months**



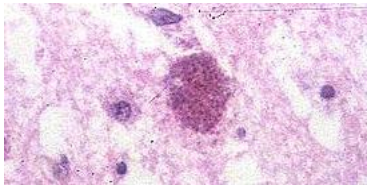
INTERMEDIATE host !!

the intermediate hosts **become infected**

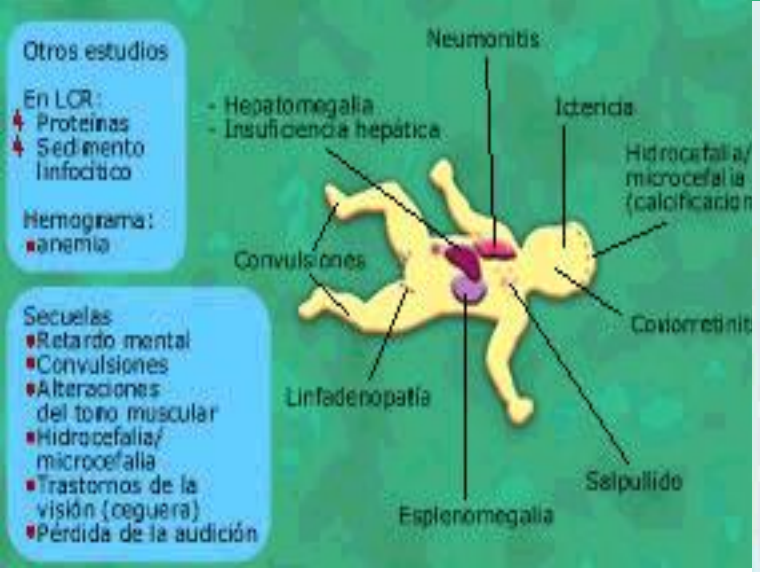
- **by eating sporulated oocysts (**oocyst contains 2 sporocysts with 4 sporozoites)



- **by eating raw contaminated meat**



- **transovarially**


Otros estudios
En LCR:
Proteínas
Sedimento linfocítico
Hemograma:
anemia
Secuelas
Retardo mental
Convulsiones
Alteraciones del tono muscular
Hidrocefalia/ microcefalia
Trastornos de la visión (ceguera)
Pérdida de la audición
Neumonitis
- Hepatomegalia
- Insuficiencia hepática
Ictericia
Hidrocefalia/ microcefalia (calcificacion
Convulsiones
Coriorretinit
Linfadenopatía
Salpullido
Esplenomegalia


Macerated Fetus
Micrognathia
Tetralogy of Fallot

4. Class: Haematozoa

- life cycle in outside environment absent
- heteroxenous
- sporozoites in invertebrates

- **1 order: Haemosporida**
- **2 order: Piroplasmida**

Order: Haemosporida

1. zygote motile (ookinete)

2. heteroxenous, definitive host - blood sucking insect

1. hemozoin pigment produced in some genera

PLASMODIUM

- **genus *Plasmodium:*** are responsible for the disease **„malaria“** in both animals and man

- produce pigment called **hemozoin**

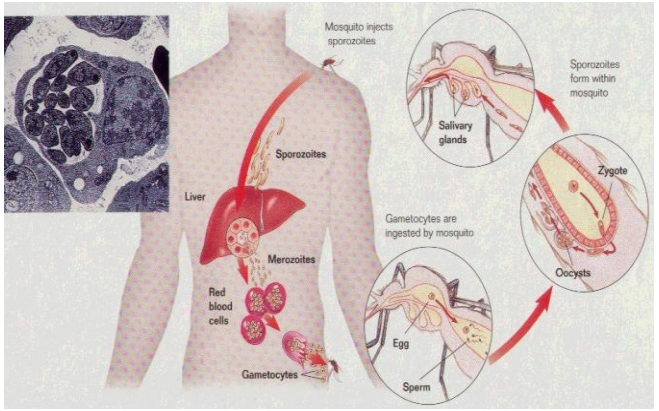
- **„malaria“ is caused by *Plasmodium ovale, P.malarie, P.vivax* a *P. falciparum* -** transmitted by ***Anopheles (A.gambiae)***

Life cycle of *Plasmodium*

- asexual: **sporogony (mosquito)**
- asexual: **merogony(mammal)**
- sexual: **gametogony (mosquito/mammal)**

HUMAN

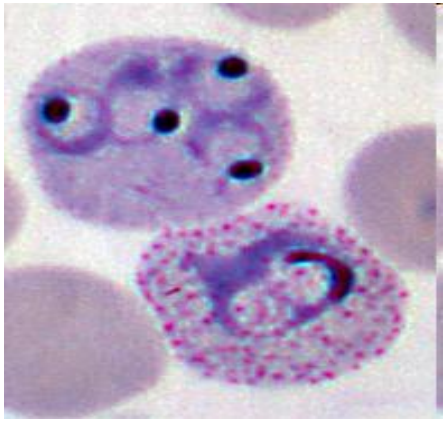
- The mosquito **injects sporozoites into the** human when it feeds



MEROGONY:

1. The sporozoites **develop in the liver cells (the hepatocytes)**

2. Merozoites invade **blood cells**



Once established, the parasite cell ingests hemoglobin and enlarges to form a "schizont"

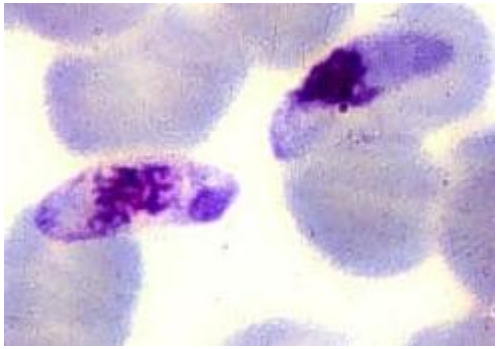
The schizont ruptures, and the next generation of merozoites is released to invade new RBC's.

GAMETOGONY

1. **in vertebrates (man)**
2. **in *Anopheles***

GAMETOGONY in vertebrates:

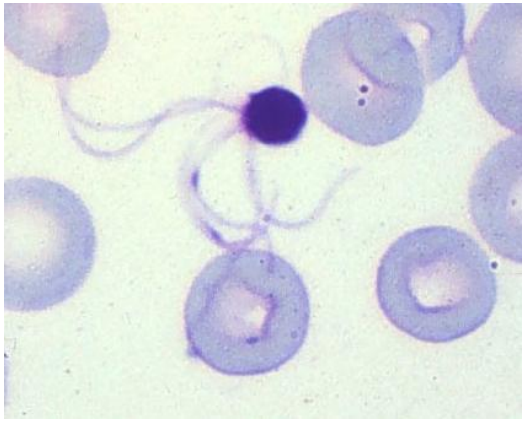
- the merozoites enter red blood cells and develop into **gametocytes**
- male and female gametocytes circulate in peripheral blood
- get sucked up as part of blood meal by female mosquitos



GAMETOGONY in mosquitos:

- male gametocytes

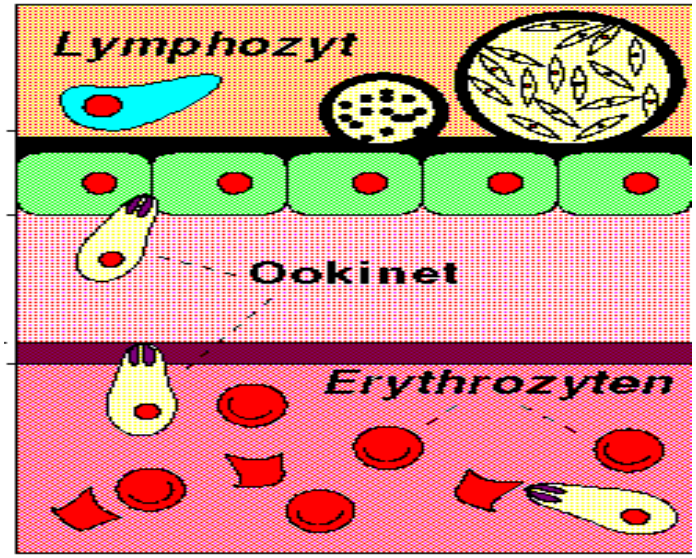
seek female gamectocytes



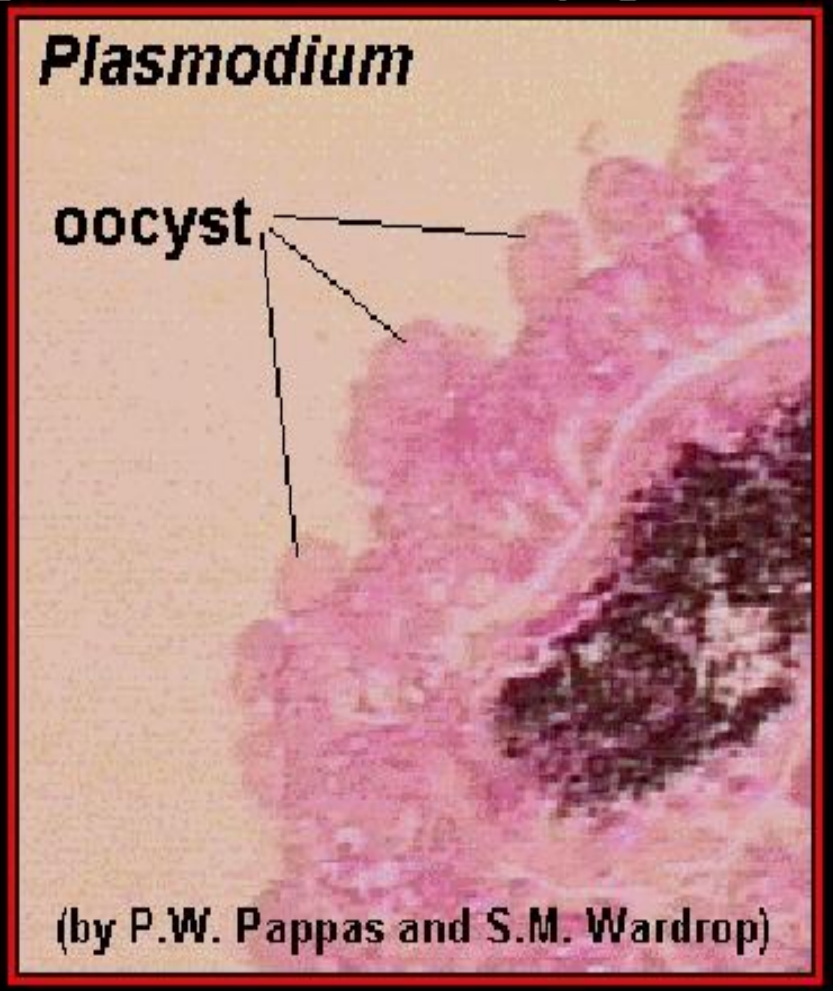
- **ookinete**

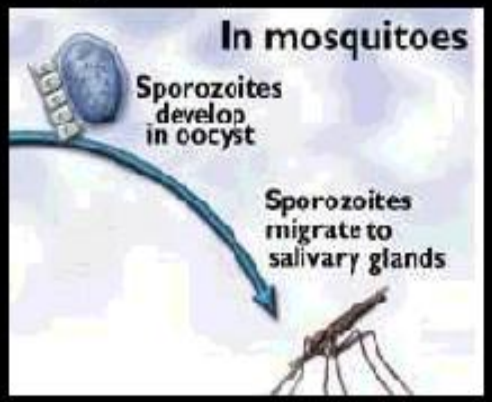
- ookinete migrate through gut wall

- **oocyst** outside wall of mosquito stomach



When fully developed, the oocyst may contain thousands of infective sporozoites, which migrate to the salivary gland.

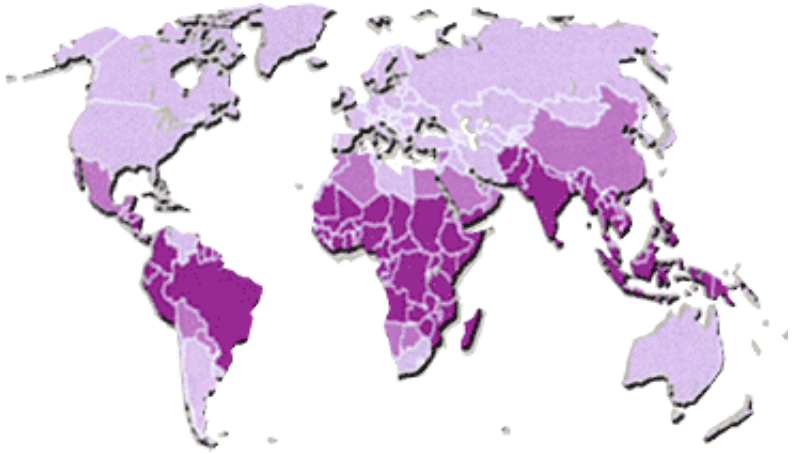




MALARIA of man

species of *Plasmodium*

- ***P. ovale***
- ***P.malarie***
- ***P.vivax***
- ***P. falciparum***



DISEASE

clinical manifestation may be attributed to two general factors:
1, **host inflammatory response** (chills, fever)
2, **anemia,** arising from enormous destruction of red blood cells

- ***Falciparum*** malaria is the most serious form (cerebral malaria) and *vivax* and *ovale* the least dangerous
- **kidney, liver, brain damage**
- worlwide prevalence 500 million
- 5 mil. are fatal

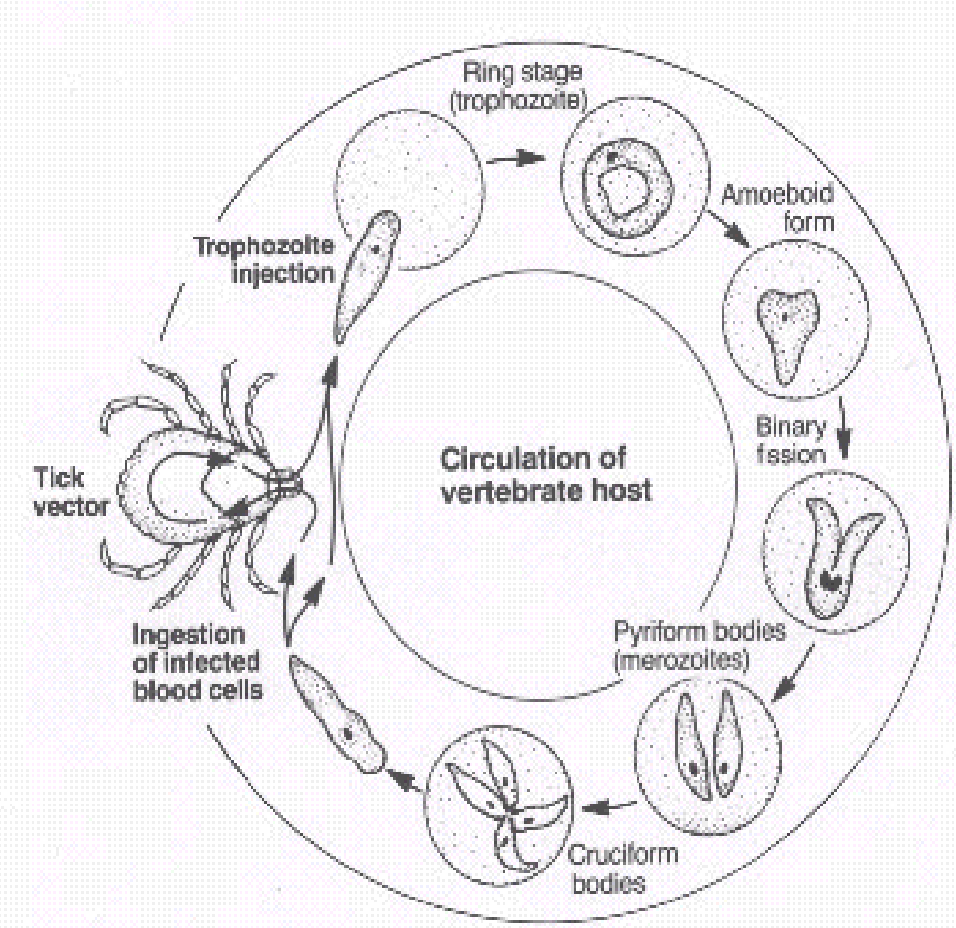
- **life cycle cannot take place in temperatures below 17 °C**

- most important of antimalarials - **chloroquine**

Order: Piroplasmida

Babesia bigemina
B.bovis

- **merogony in vertebrates, gametogony, sporogony in invertebrates (tick)**
- **transstadial** transmission in the tick
- undergo **binary fission** in blood cell of vertebrates and ultimately kill their host cell
- in **red blood cell** (***Babesia***), or in both **white and red cell** (***Theileria***)



Babesia

***Babesia* spp.**

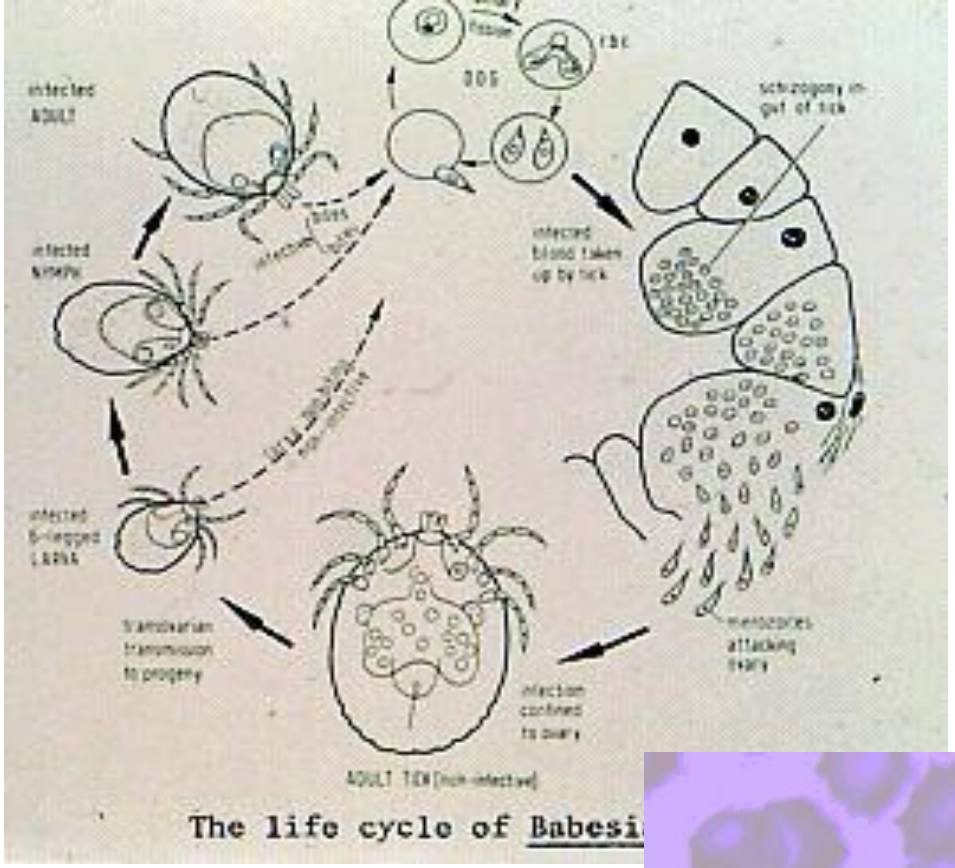
- infect **mammals,** particularly **cattle, sheep, goats, horses, pigs, dogs and cats** and occasionally **man**

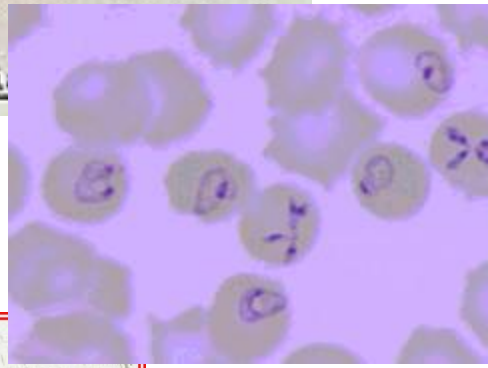
- **Babesiosis**, '**redwater fever'** or '**tick fever'**
- major impact on the livestock industries in many countries
- **vector - the one-host ticks, belonging to the genus *Boophilus*** (*Boophilus microplus*, *B. decoloratus* and *B. annulatus*) and *Rhipicephalus*

- transovarian transmission
- in contrast to the malaria life cycle, there is no tissue stage for *Babesia*

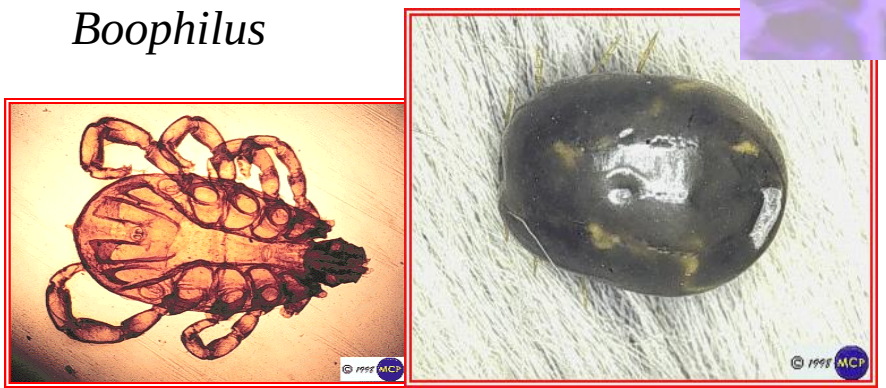
- fever disease, anemie
- **<u>red-colored urine resulting</u> from massive destruction of erythrocytes**

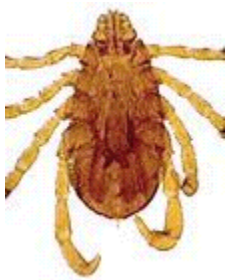
- ***Babesia bovis*** - in Europe
- ***Babesia bigemina*** -Texas cattle fever (mortality rate in acute cases in untreated cattle is as high as 50 - 90%)
- ***Babesia microti*** - infects human, rodents





Boophilus



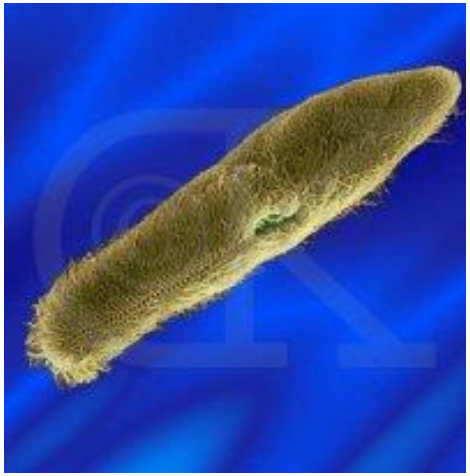


Rhipicephalus

3. Phylum:Ciliophora

- presence of hair-like organelles called **cilia** (identical in structure to **flagella**)

- ecto - and endosymbiotic members
- obligate and opportunistic parasites
- a large protozoa, a few reaching 2 mm in length
- water – lakes, ponds, oceans, and soils
- 10,500 species

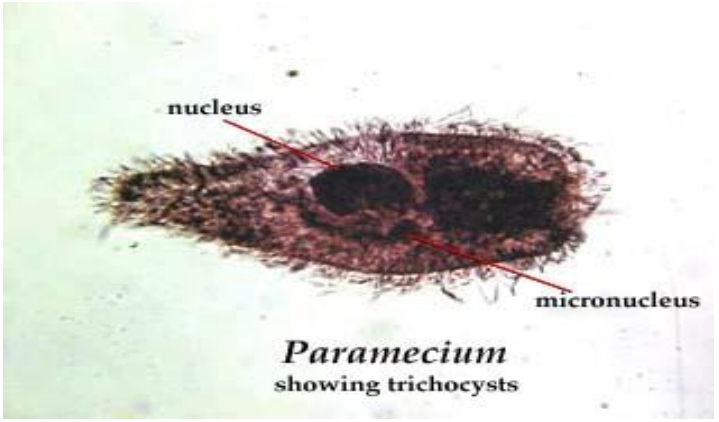


- **CILIA arranged in longitudinal rows (kineties)**

- **cytostome (cell mouth)**

- **nuclear dualism** - two types of nuclei in every cell

1. polygenomic (polyploid) somatic **macronuclei** - more important for protein synthesis
2. diploid germinal **micronuclei** - important for reproduction

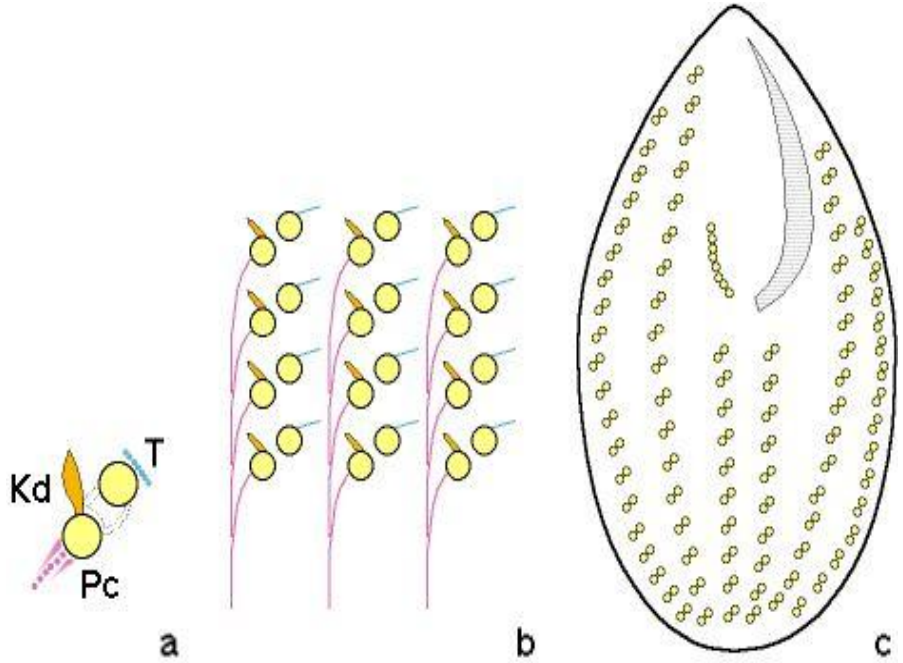


- **cross fission**
- **conjugation**, a sexual process involving temporary union of two cells

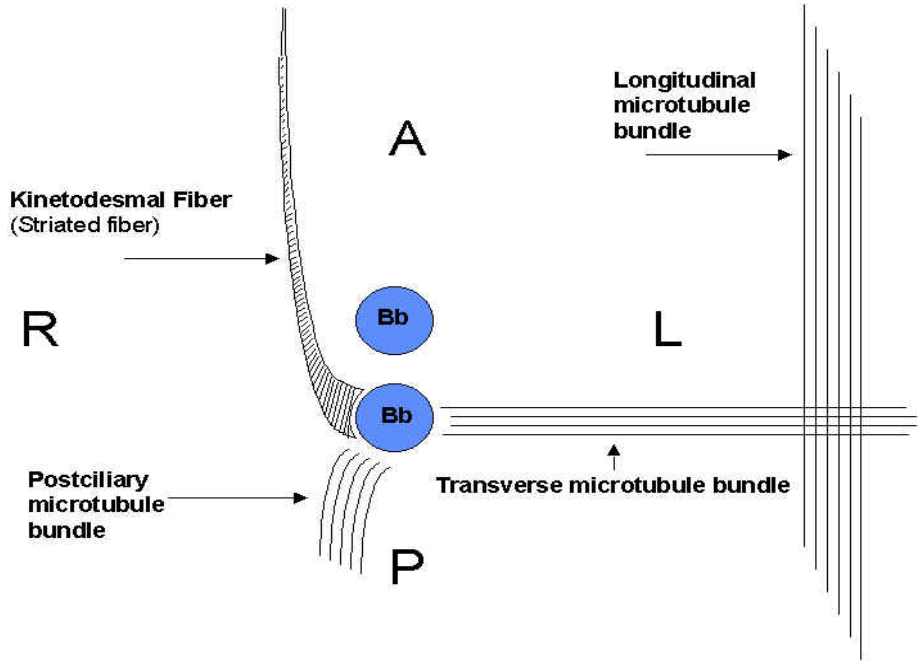
- **CORTEX**

Cilia

- cilia are arranged in **mono, di or polykinetids**

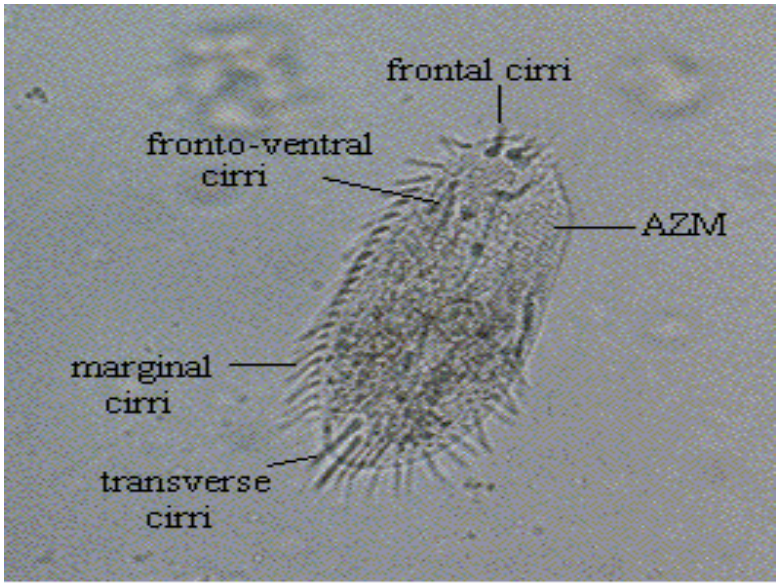


- **KINETID:**
- one, two or more **kinetosomes (basal bodies)**
- **fibres**
- **microtubule bundles**

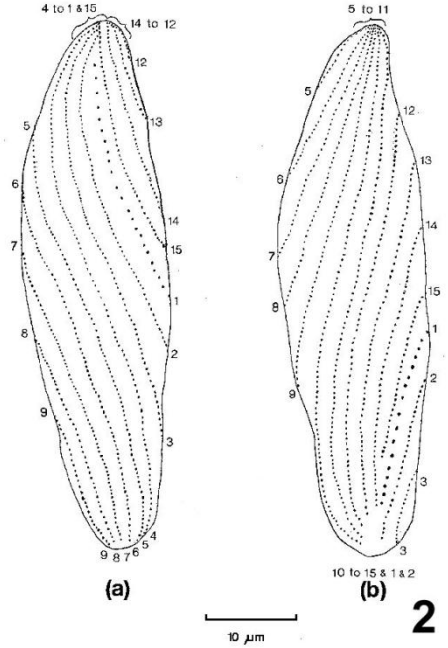


Polykinetids

- **polykinetids** form bristles called **cirri**
- these are arranged into rows called **kineties**



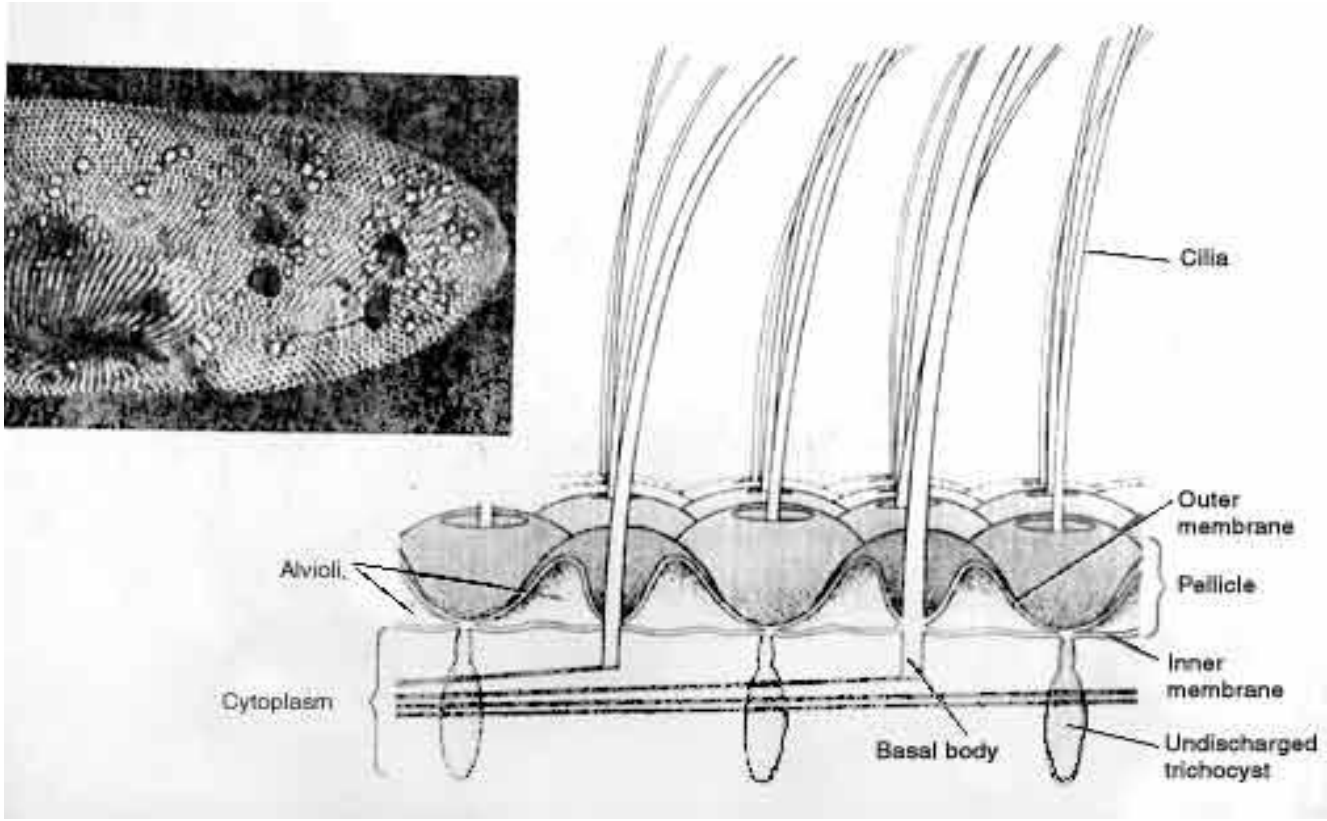
cirri (photo by Kuniyasu)



Infraciliature

- **kinetids**
- **fibrils**
- **microtubules**

involved in coordinating the cilia

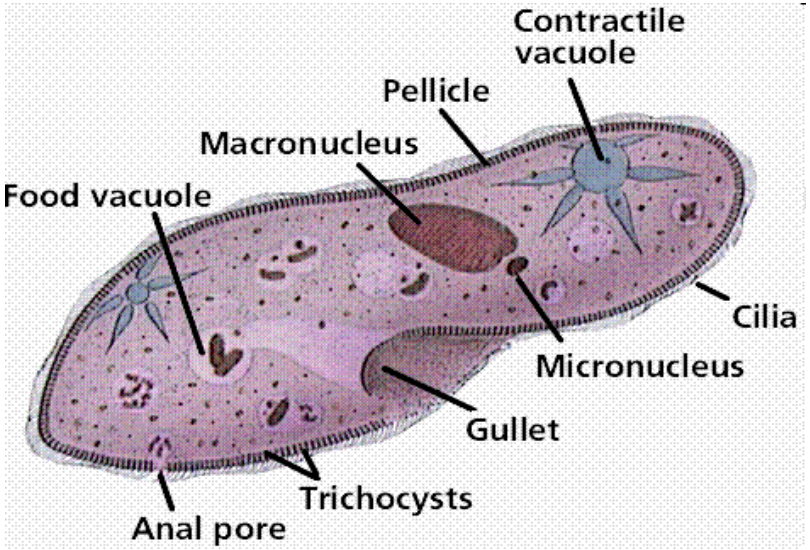


Cell cortex

1. **pellicle**
2. **the infraciliature**
3. **the alveoli** (small vesicles under the cell membrane that are packed against it)

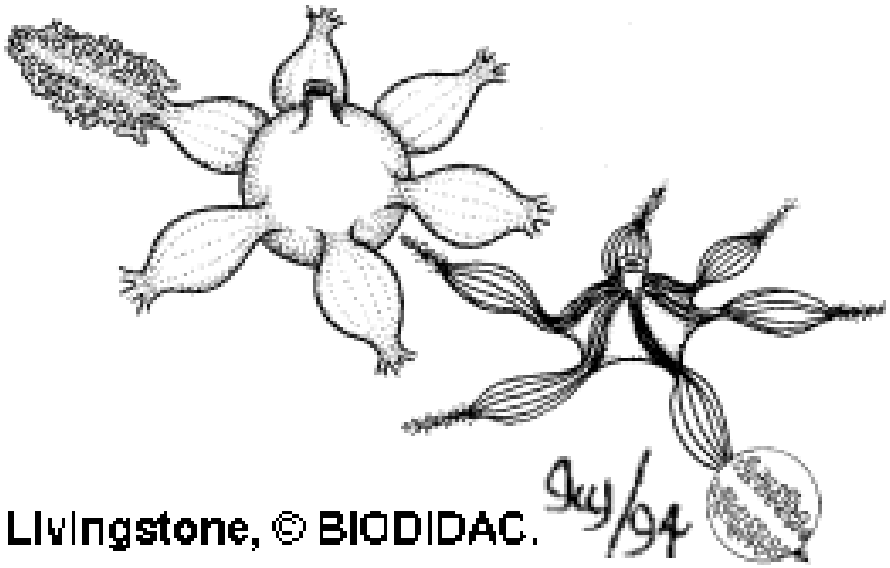
Oral and Other Structures

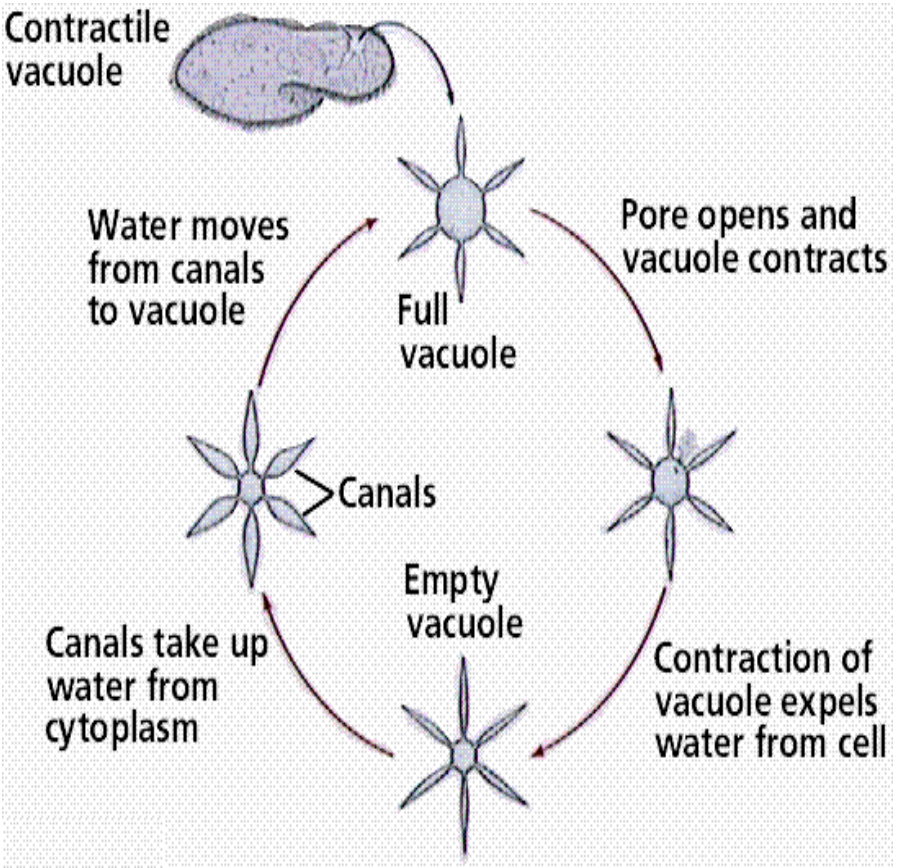
- mouth (cytostome)
- oral structures
- food vycuoles
- path through the cell
- cytoproct



Contractile vacuole

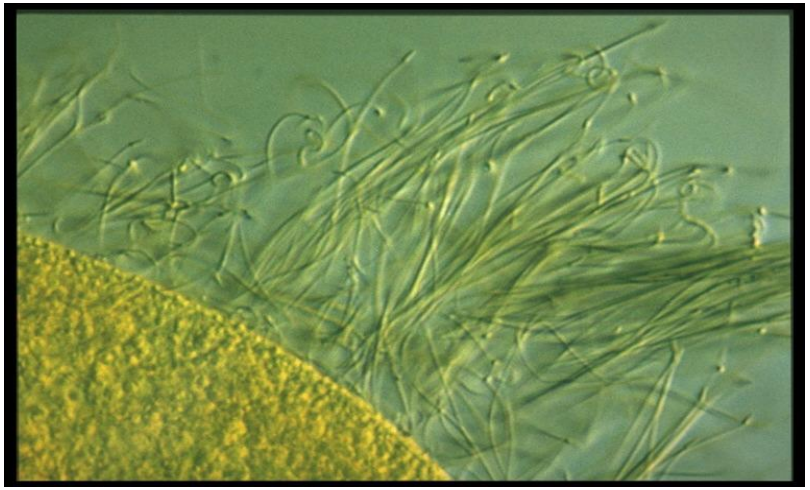
- maintaining ionic balance





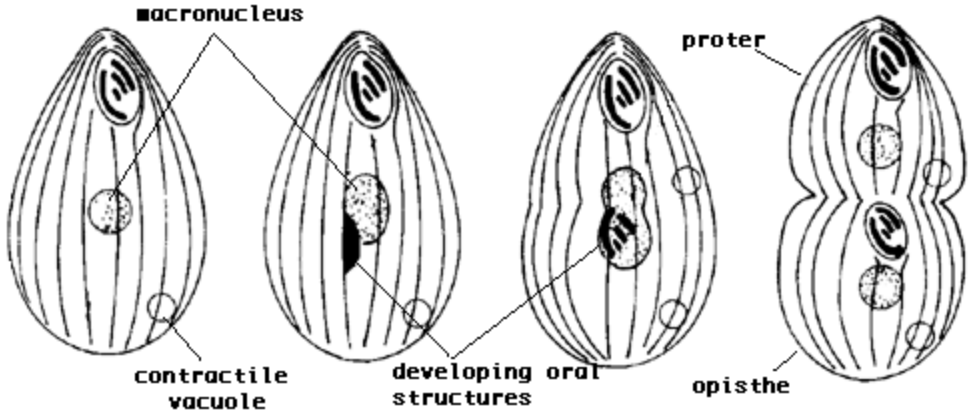
Extrusomes

- are membrane-bound structures
- **<u>discharge their contents outside the cell</u>**
- used as a defense against would-be predators

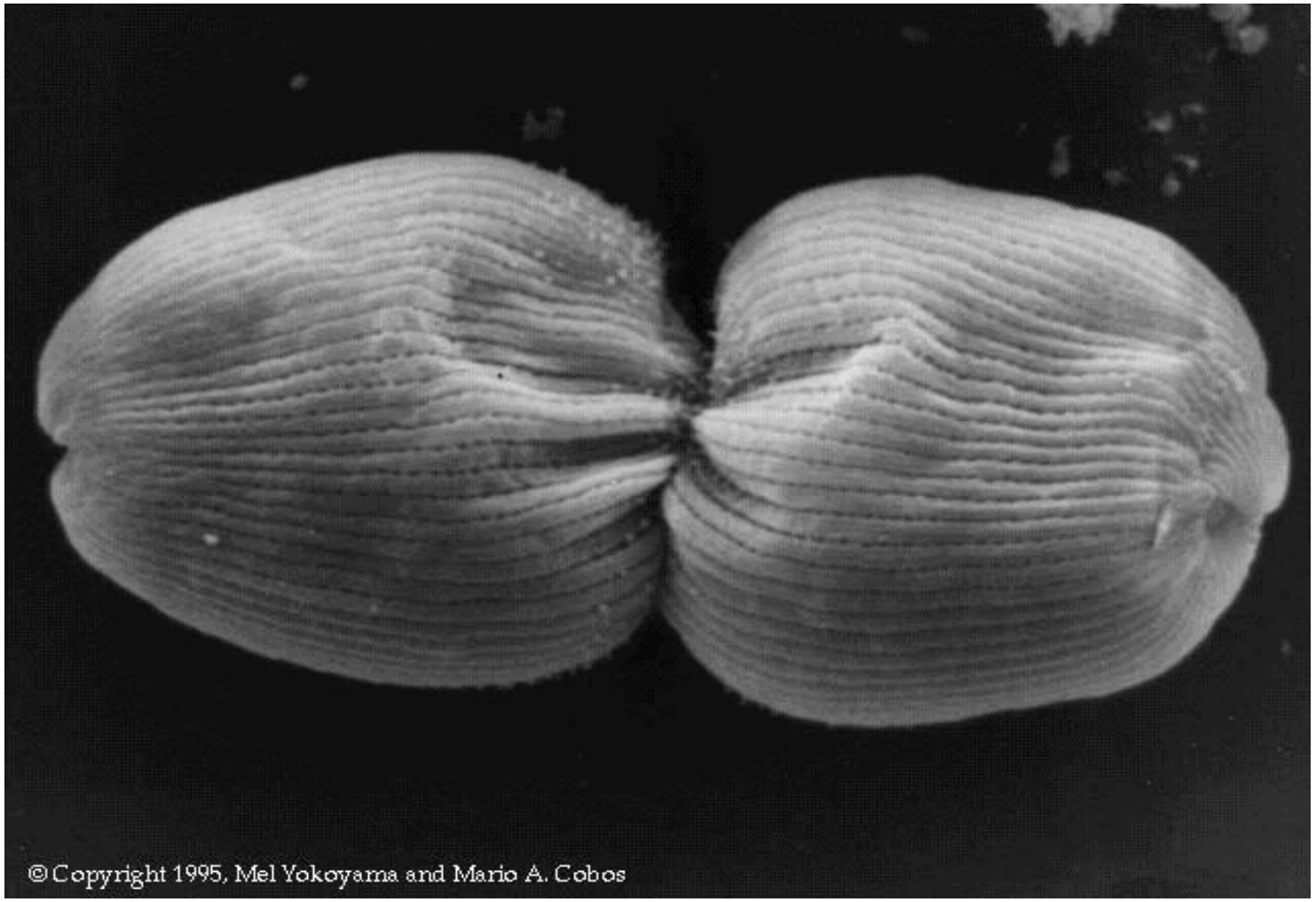


Reproduction

- reproduce asexually - **cross dividing**
- exchange genetic information - **conjugation**
- during this process two cells unite, the micronuclei undergo meiosis, then pair up and fuse with similar haploid micronuclei from the other organism, mixing the DNA from the two organisms.



cross dividing



- 1. Class Spirotrichea
- 2. Class Litostomatea
- 3. Class: Phyllopharyngea
- 4. Class: Nassophorea
- 5. Class: Oligohymenophorea

1. Class Spirotrichea

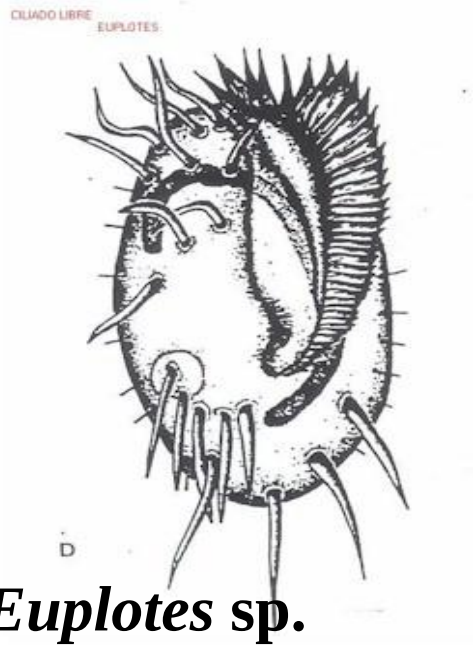
- bristles called **cirri**

- dikinetids, polykinetids

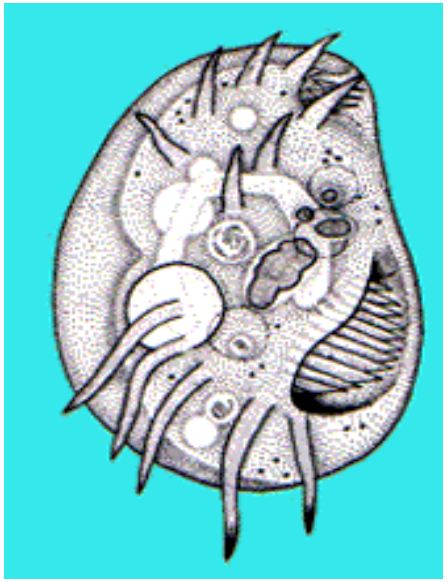
- right and left oral and/or preoral ciliature (polykinetids - "undulating membranes")

Euplotes sp., *Aspidisca* sp. *Oxytricha* sp.

- **<u>crawler ciliates</u>** ("crawl" over surfaces such activated sludge floc)
- the "setae" which act as their legs
- both ***Euplotes*** and ***Aspidisca*** are common in activated sludge and their presence is desired as they indicate a well operating plant

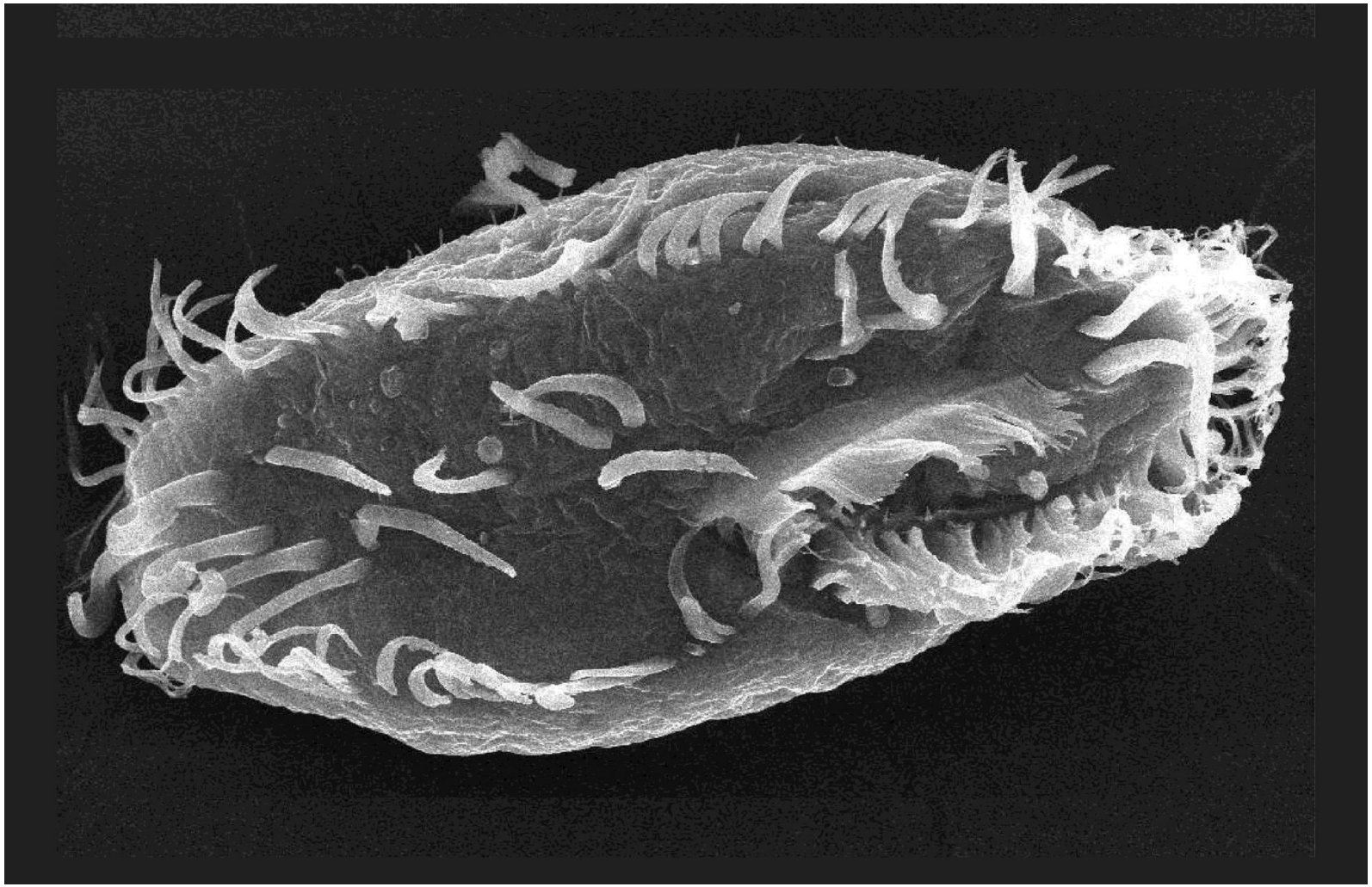


***Euplotes* sp.**



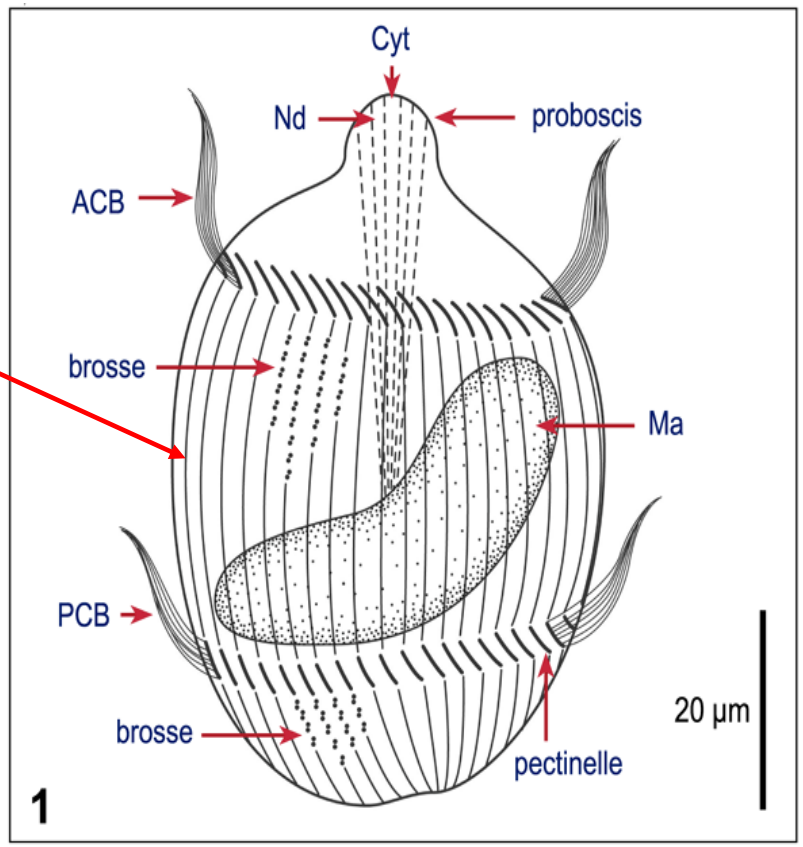
***Aspidisca* sp.**

Oxytrixa trifallax



2. Class Litostomatea

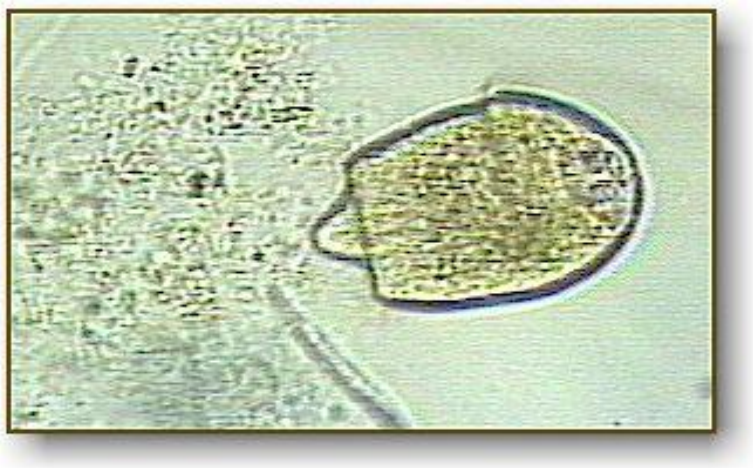
- **monokinetids** - ultrastructural arrangement characteristic to the group



Litostomatea

- divided into two groups, ranked as subclasses

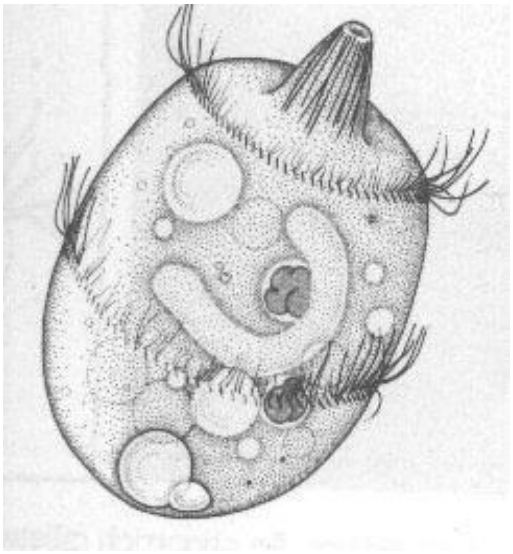
- The **HAPTORIA** includes mostly carnivorous forms, for instance *Didinium*, which preys exclusively on the ciliate *Paramecium*

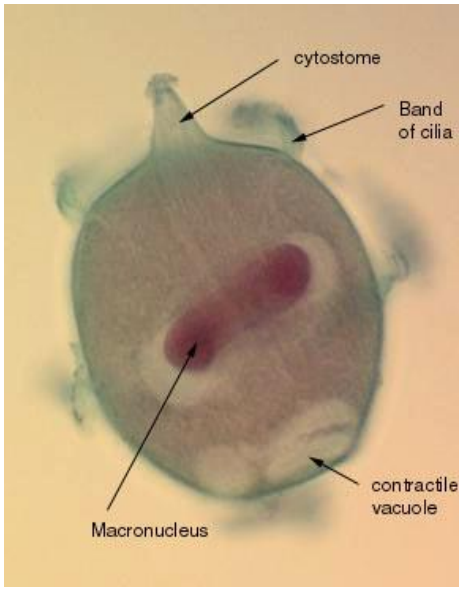


- The **TRICHOSTOMATIA** are mostly endosymbionts in the digestive tracts of vertebrates. These include the species *Balantidium coli*, which is the only ciliate parasitic in humans.

HAPTORIA

Didinium

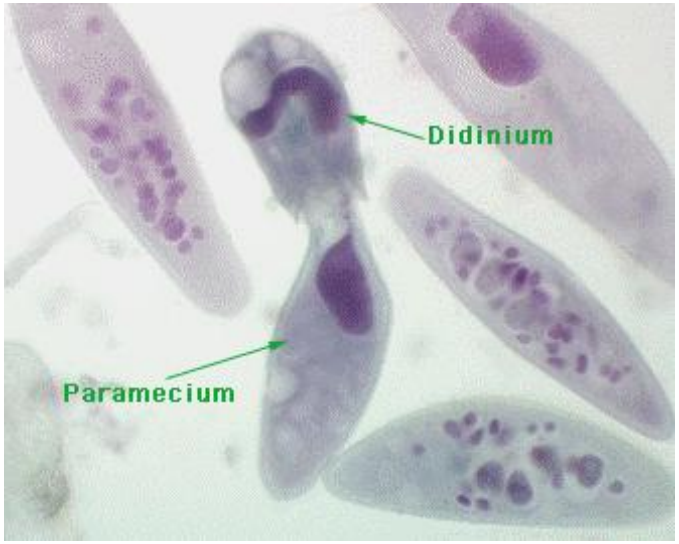




- **<u>the mouth is surrounded:</u>**

1. by a **<u>ring of coronal cilia</u>**
2. by a ring of **<u>extrusomes called *toxicysts*</u>**.

- These discharge on contact with prey, penetrating and immobilizing them, and beginning digestion.



TRICHOSTOMATIA

- the mouth lies in a depression, or vestibule
- containing modified somatic cilia.

- Order **Entodiniomorphida**
- the cilia are arranged into tufts or bands, and may be packed together to form **syncilia, membranelles and cirri**
- **endosymbionts** in the digestive tracts of vertebrates

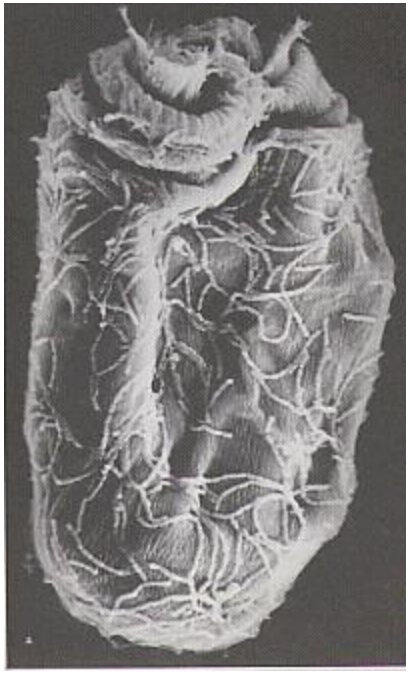
Entodiniomorphida - infusorian symbionts

several hundred thousand to 2 mil. protozoa in each millilitre of rumen contents

120 species of infusorias

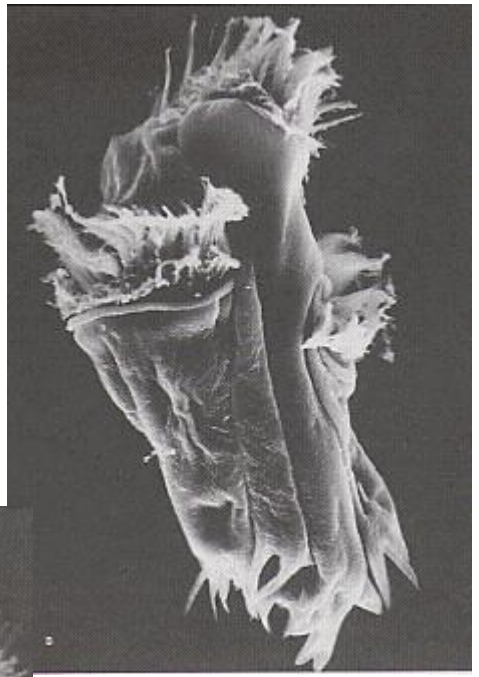
symbiotic cellulose digestion is the **only way that cellulose beomes available to mammals**

•**cellulase activity** **only by some species of infusorias**

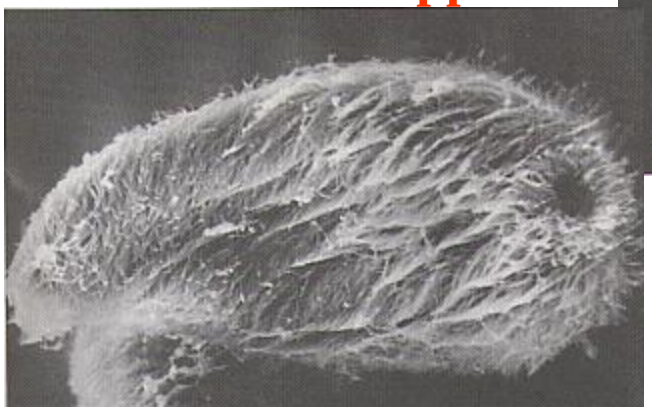


***Diplodinium* spp.** with adherent bacteria on the (x 1065)

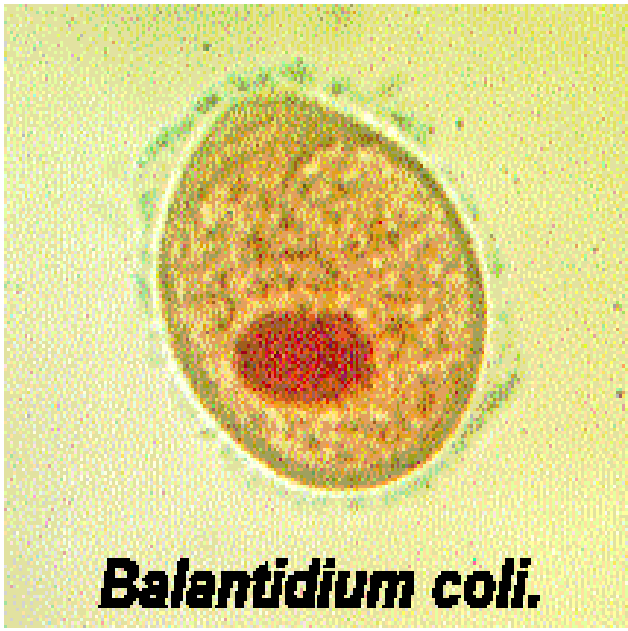
***Ophryoscolex* spp.**



***Isotricha* spp.**



Balantidium coli



- 0,05-0,2 mm
- cilia seriated longitudinaly
- in the cecum and colon **of pigs, rats, where it feeds on the contents as a commensal**
- **parasite of human** -invades the mucosa as a pathogen
- produce **proteolytic enzymes** that digest away intestinal epithelium of the host

pathogenesis:

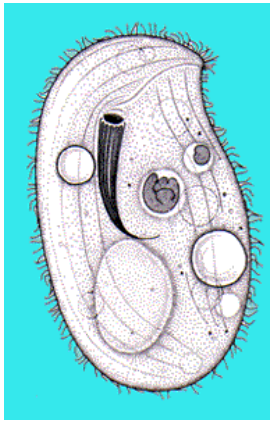
- diarrhea
- dysentery (bloody diarrhea)
- colitis
- abdominal pain

- **prevention**
- proper hand washing practices
- water treatment
- separation of human and swine habitats
- proper waste disposal

3. Class: Phyllopharyngea

- **tubular cytopharyngeal apparatus** (**cyrtos)**
- free living, some **parasites** on fish
- some which are **extremely specialized**

Cyrtos (tubular cytopharyngeal apparatus)



Chilodonella cyprini

- **Ektoparasites of fish**
- oval or heart shape

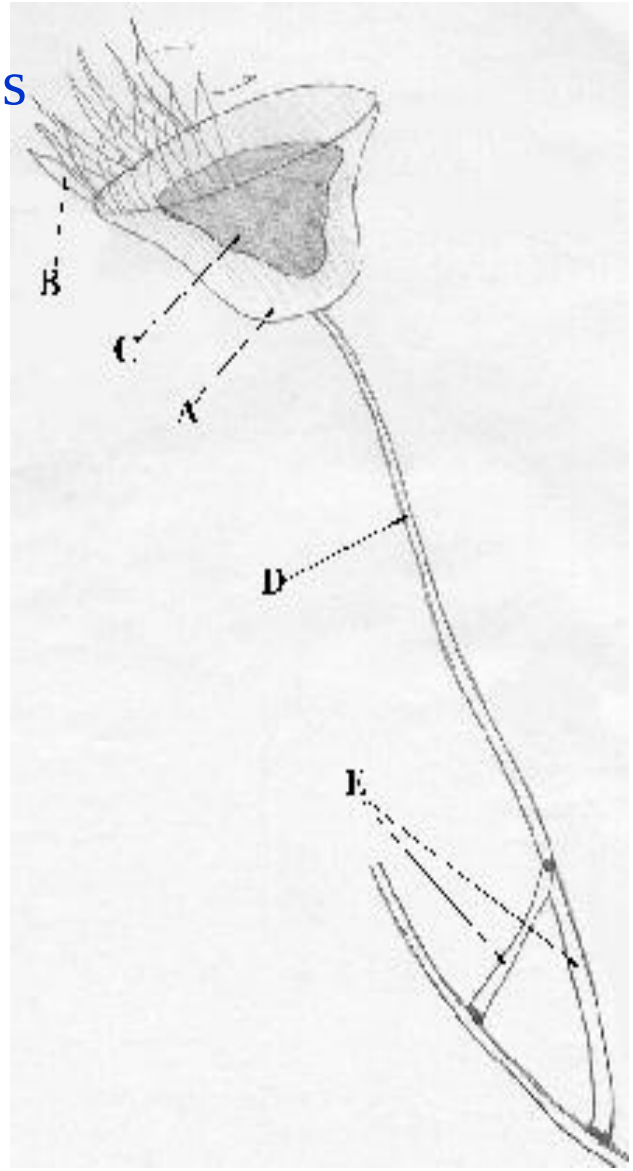
- size between 40 and 70 µm
- cilia are arranged in rows along its underside
- causes a slimy skin appearance, the skin and gills discoloured showing bluish-white to grey

- heavily infested - epithelial damage, skin erosion
- weak, young fish in spring

Suctoria

- **sessile and lack cilia in the adult phase**
- the mouth is often modified to form an extensible **tentacle, with toxic extrusomes**
- non-contractile **stalk** and often a **lorica or shell**
- 15-30 μm
- **freshwater and marine environments**
-

tentacles



A bell shaped cell body
B tentacles that extend all the way around the bell
C macronucleus, large pink body shaped like a "C"
D stalk, may be very faint

- typically **feed on other ciliates**

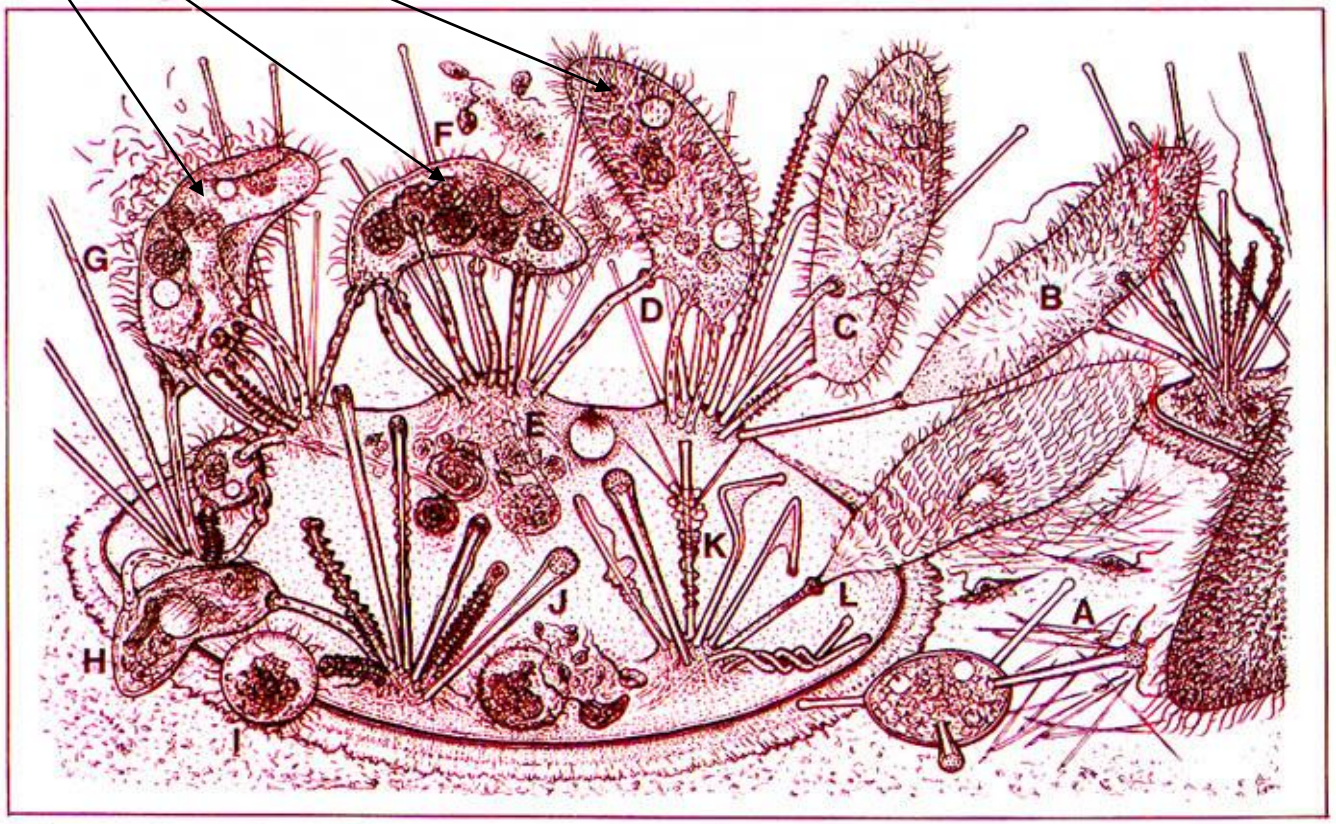
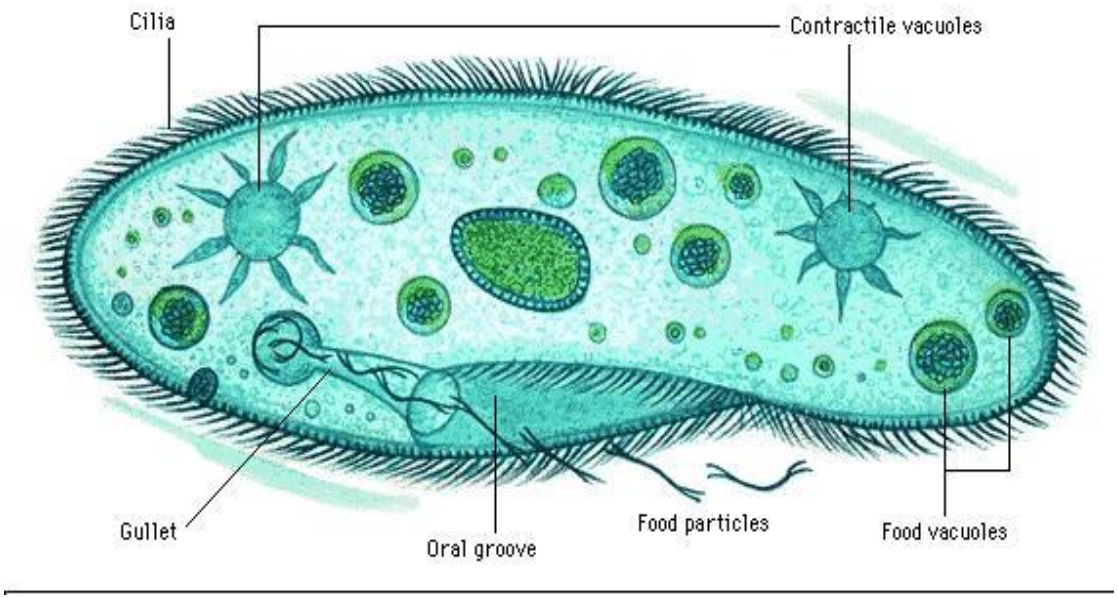


Figure 2–46 A colony of the suctorian *Heliophrya* feeding on *Paramecium*. Some individuals of *Paramecium* have just been captured. Others have been ingested to various degrees. (From Spoon et al., 1976: Observations on the behavior and feeding mechanisms of the suctorian *Heliophyra erhardi* preying on *Paramecium*. Trans. Am. Micros. Soc., 95:443–462.) *From R. D. Barnes*

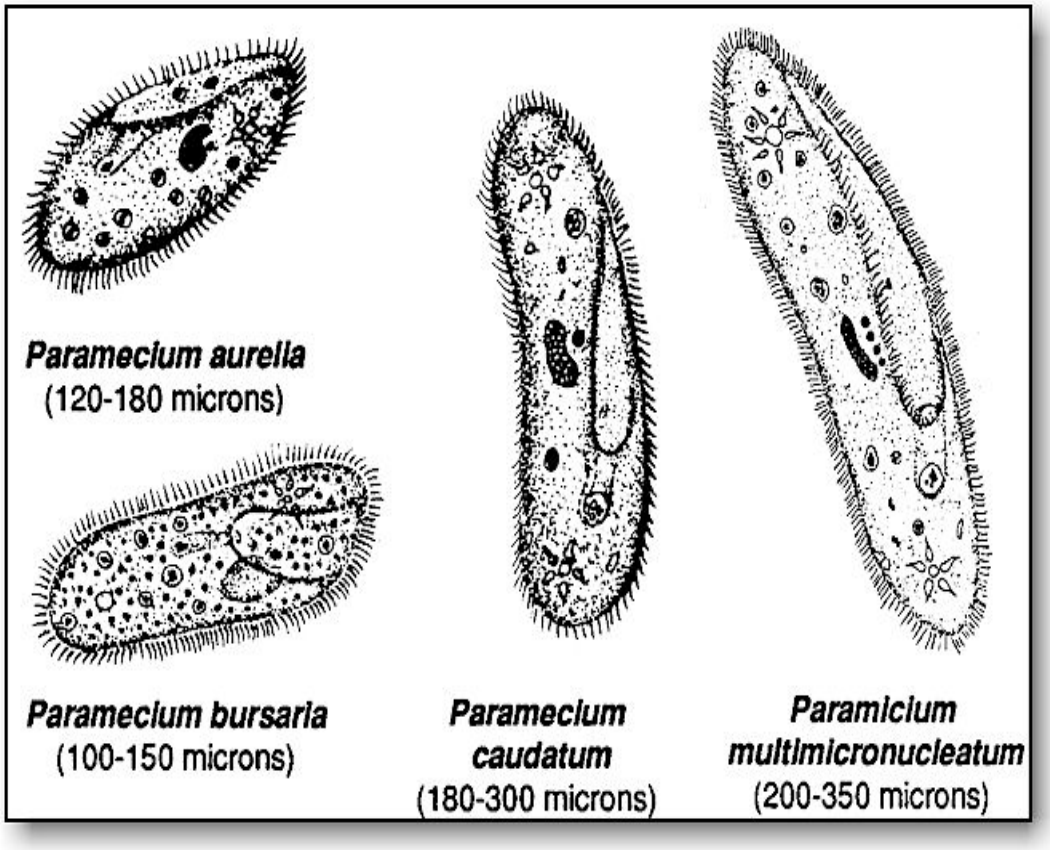
4. Class: Nassophorea

- **cyrtos well-developed** („basket“) in several groups, and typical of class



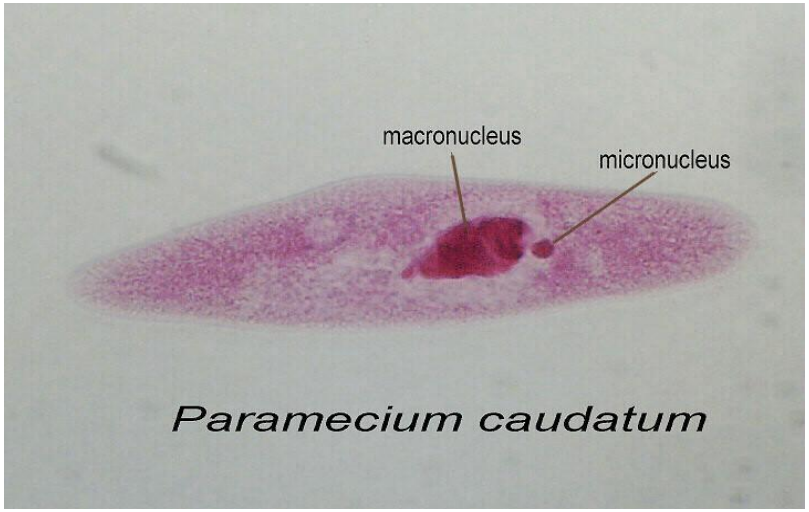
Paramecium sp.

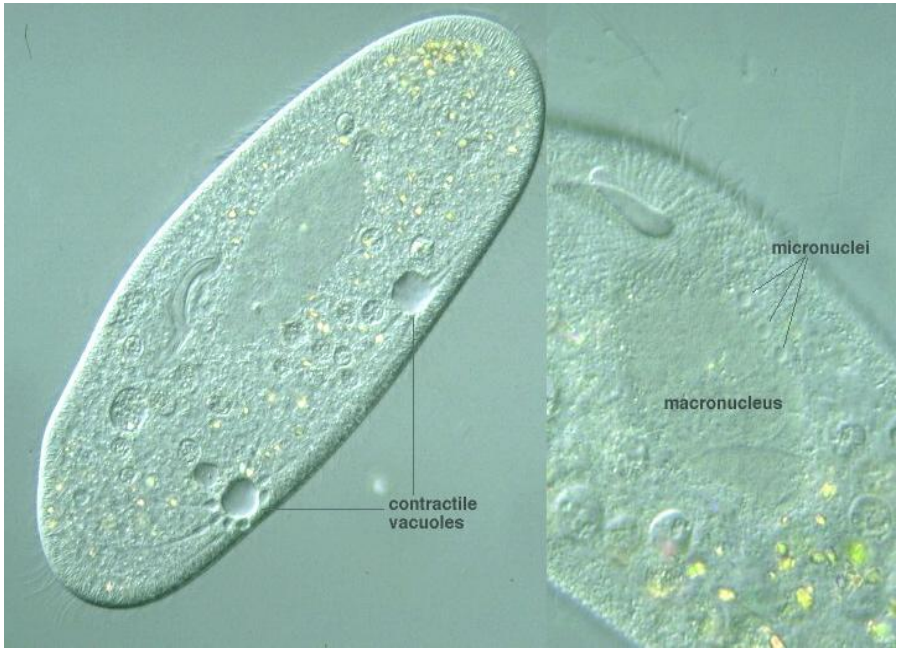
- from 100-350 um long
- foot-shaped or cigar-shaped
- uniformly ciliated over the entire body surface with longer cilia tufts at the rear of the cell
- a large feeding groove
- filter-feeding - its cilia move and filter bacteria from the water

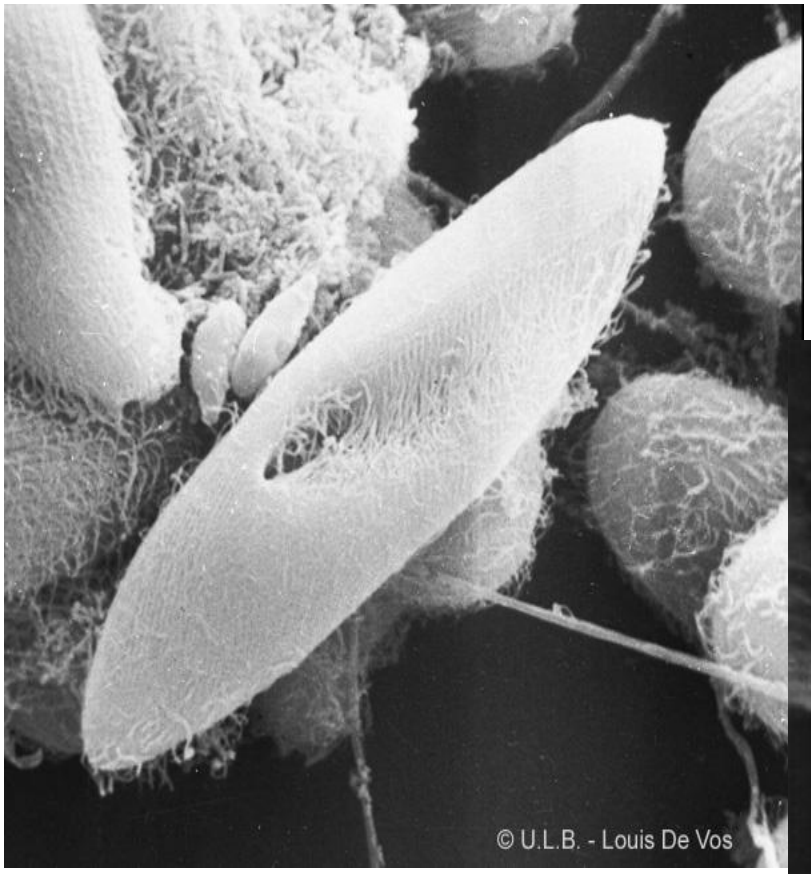


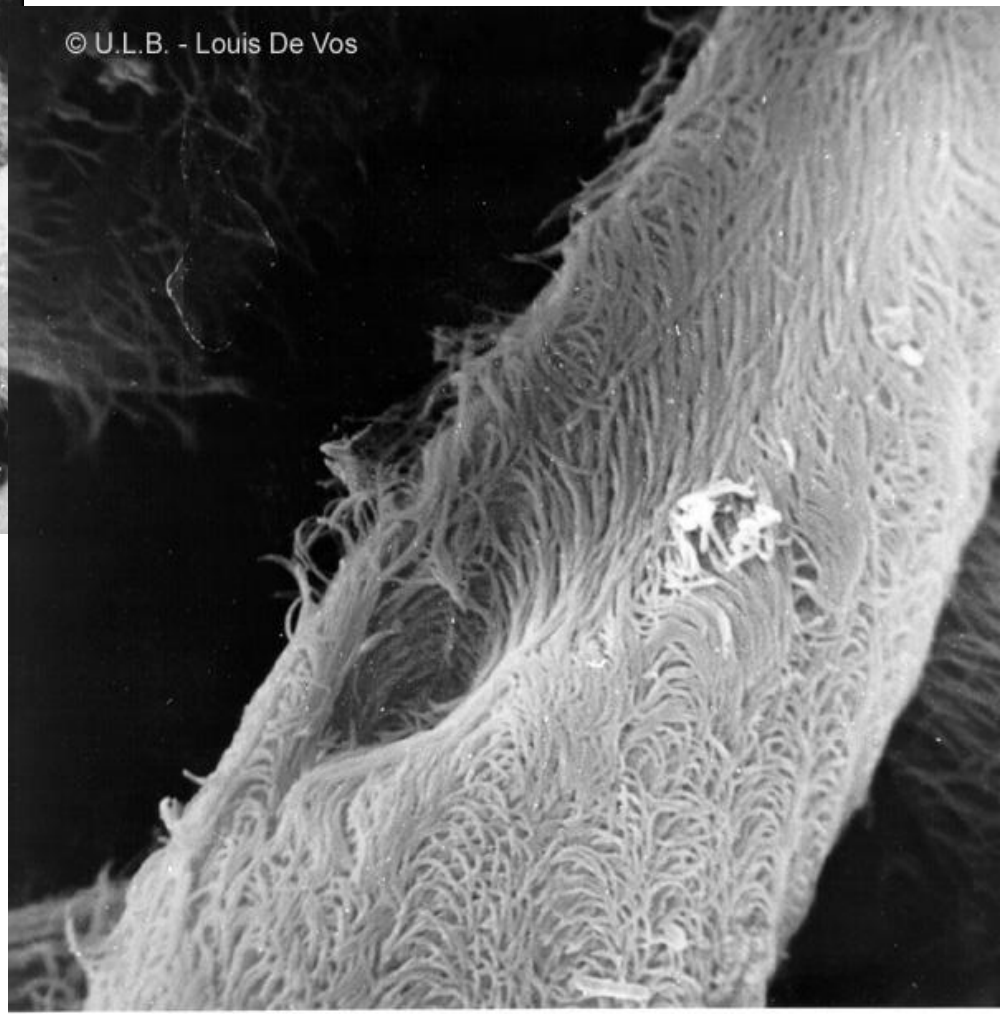
Paramecium caudatum

- **easily maintained and cultured**
- **feed on bacteria**
- **fresh water**



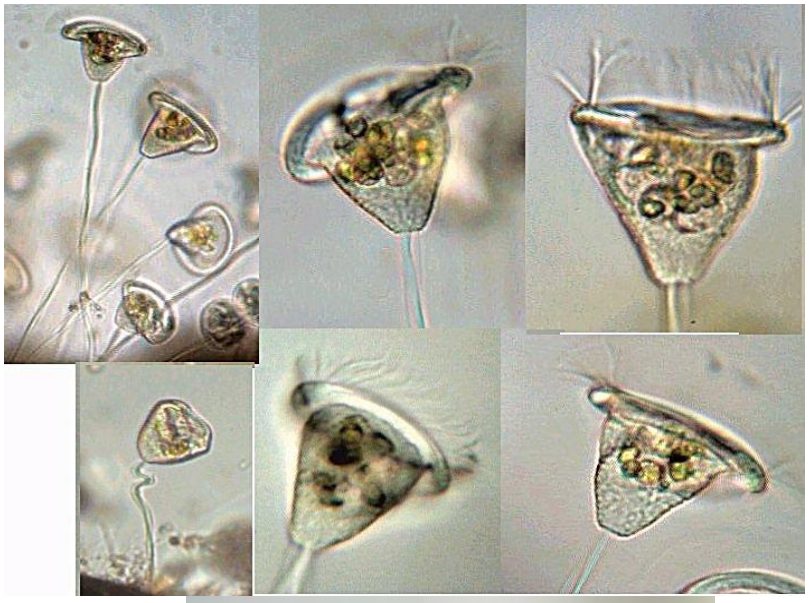



© U.L.B. - Louis De Vos


© U.L.B. - Louis De Vos

5. Class: Oligohymenophorea

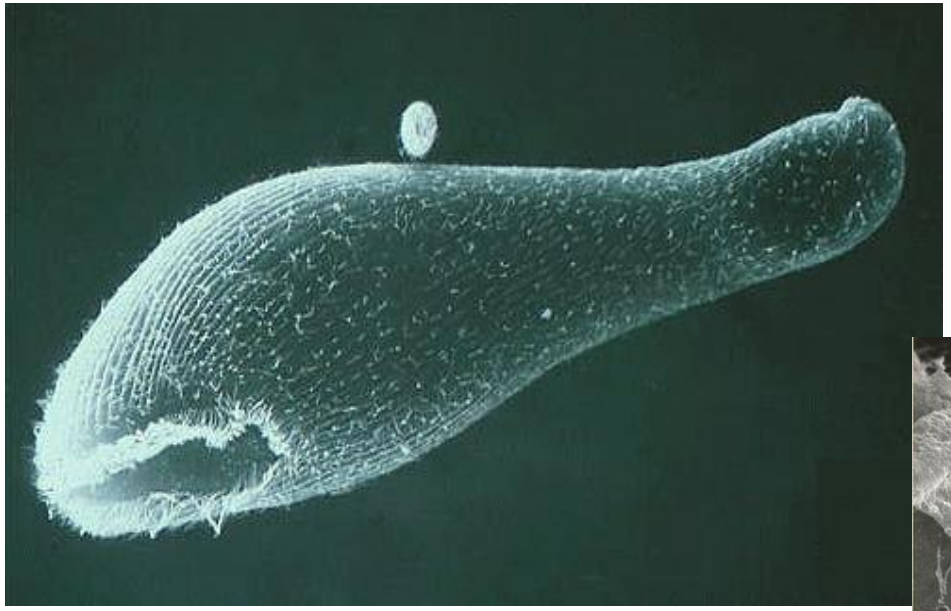
- **ventral groove** containing the mouth and distinct oral cilia

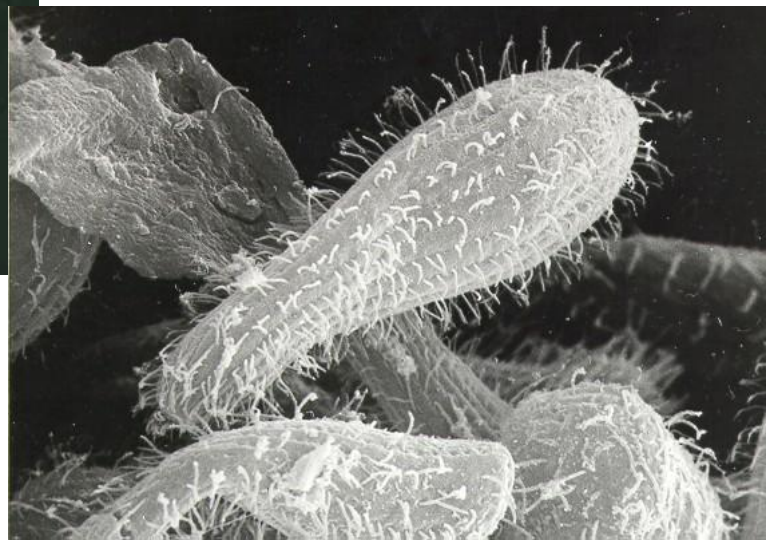


- these include a **paroral membrane** to the right of the mouth and **membranelles, usually three** in number, to its left

- widely distributed
- many free-living (typically fresh-water, but many marine)
- symbiotic forms

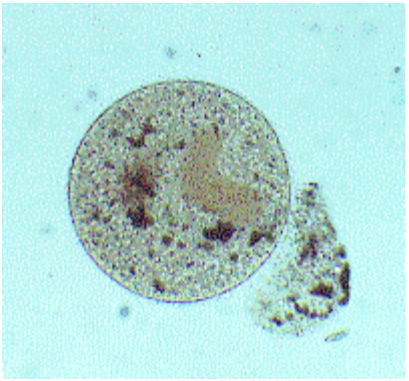
Tetrahymena pyriformis





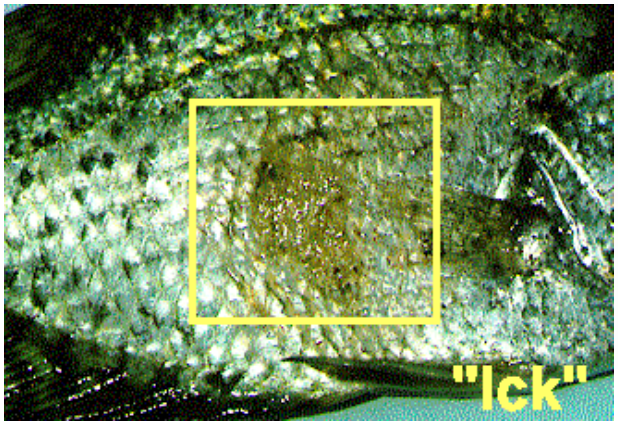
Ichthyophthirius multifiliis

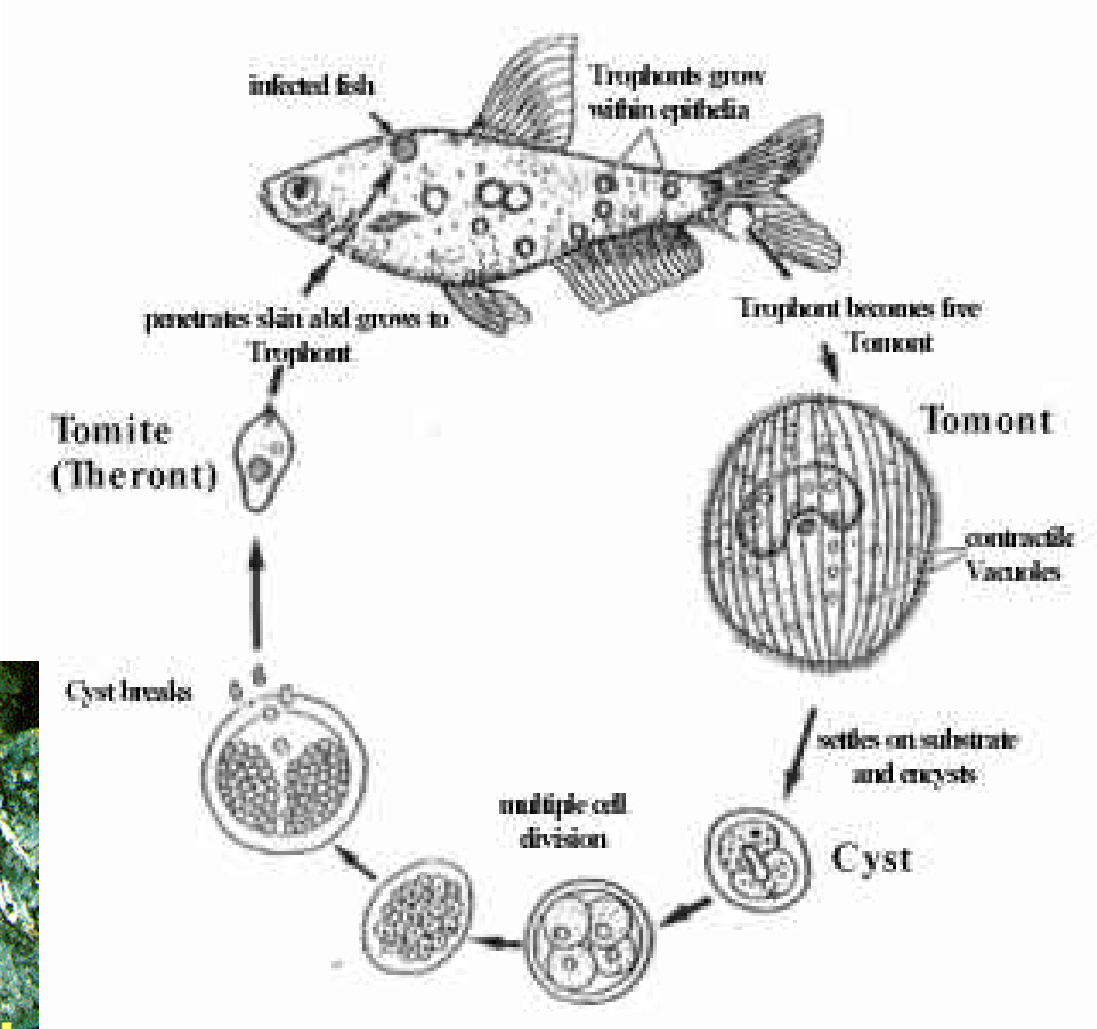
- 0,5 - 1 mm



- causes common disease known as **ich**
- attacks the epidermis, cornea, and gill filaments
- form pustule in the skin

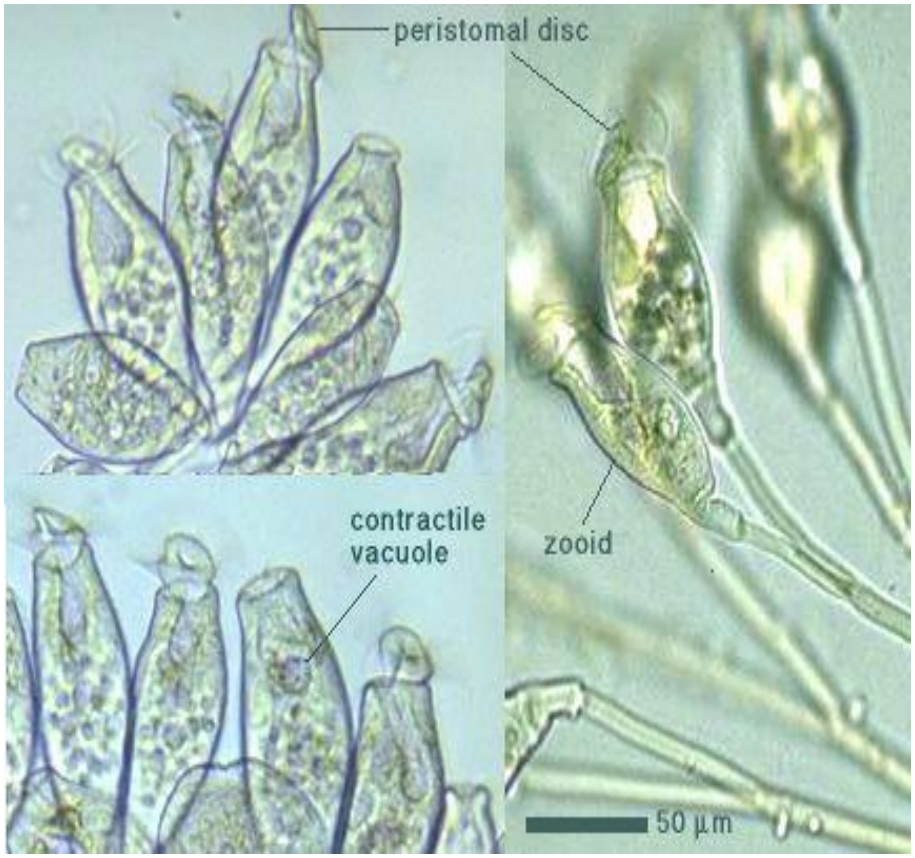
- infective stage (termed **therons or swarmers**) can survive about 96 hour without a host





Order: Sessilida

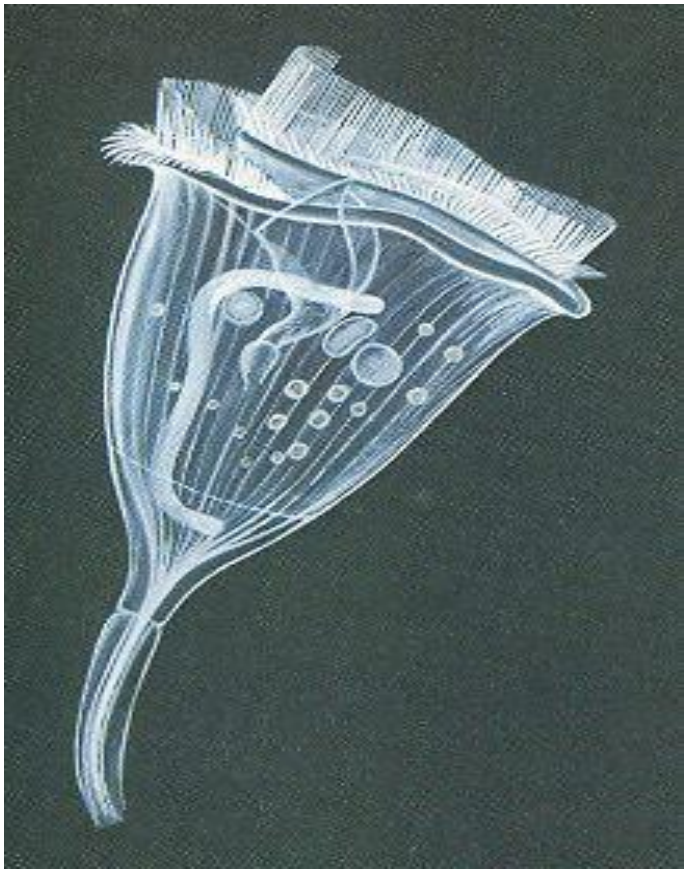
- settled lifestyle
- modified posterior kinetosomes which secrete a **contractile stalk**
- bell or disc shaped
- prominent paroral membrane arising from the oral cavity



- the unattached stage, called a **telotroch**, is mouthless
- common in both freshwater and marine environments
- many live attached to aquatic plants and animals
- the rest of the body is unciliated, except for a **telotroch band** circling the posterior in mobile species and stages

Vorticella sp.

- ranging in length from about 30 to 150 µm
- food source is suspended bacteria
- the contracting stalk provides some mobility to help the organism capture bacteria and avoid predators
- **Indicator:**
- treatment conditions are bad - *Vorticella* will leave their stalks
- a bunch of empty stalks indicates poor conditions in an activated sludge system
- ***Vorticella* sp. are present when the plant effluent quality is high.**



Order: Mobilida

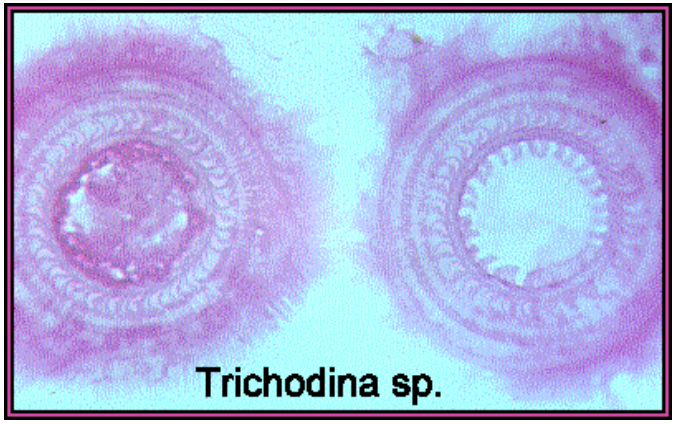
- the posterior of the cell is enlarged and modified to form a **complex holdfast** (allowing attach to some host organism)

- **parasite -** most live on the integument or gills of freshwater and marine invertebrates, fish and even other ciliates, and other locations as well

- some can be pathenogenic in high populations

Trichodina domerquei

- **round or disc-shaped**, with a flattened underside



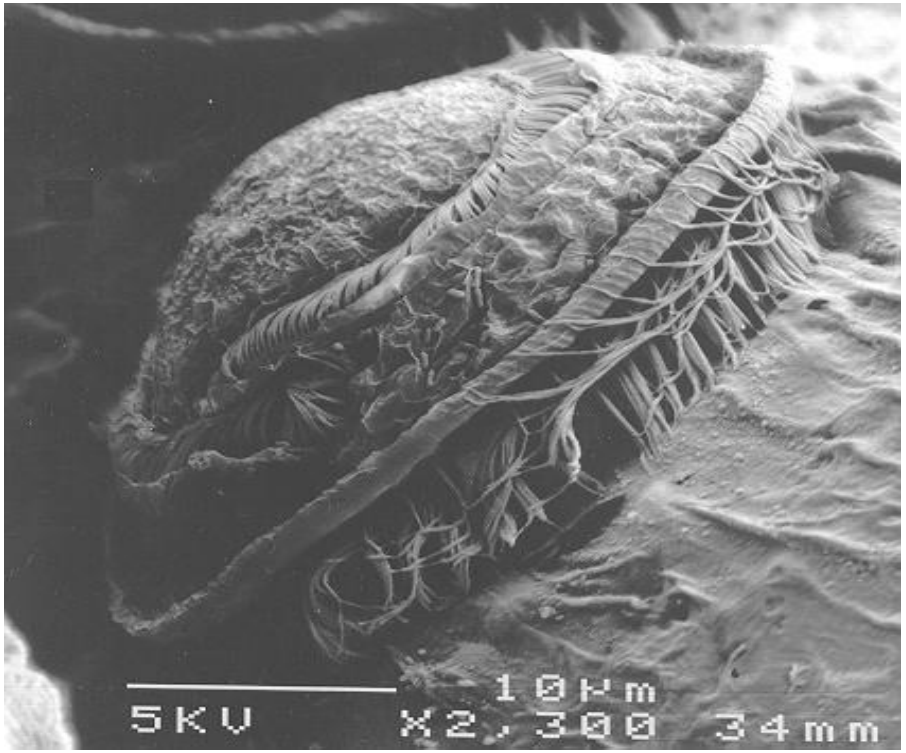
- underside reveals a **suction attachment with a ring of hooks** located within it

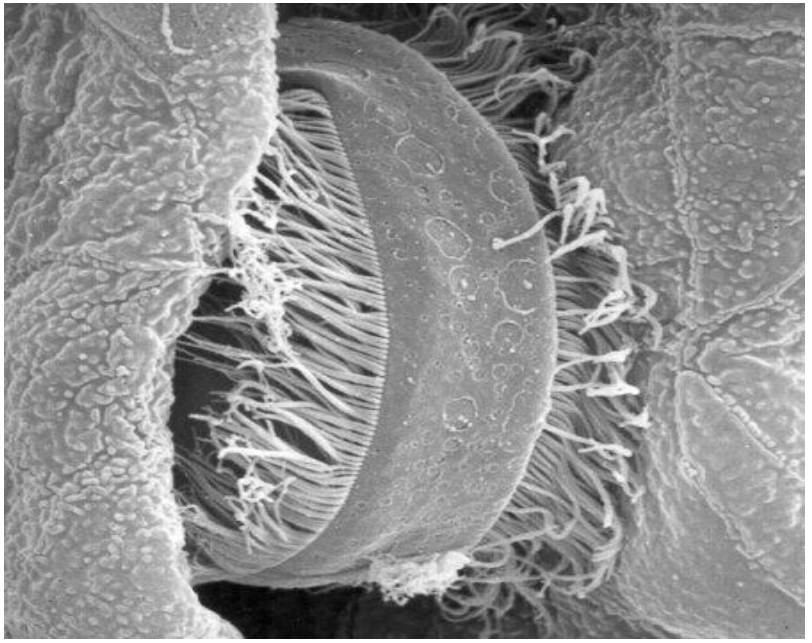
- once the parasite attaches to its host it continually rotates

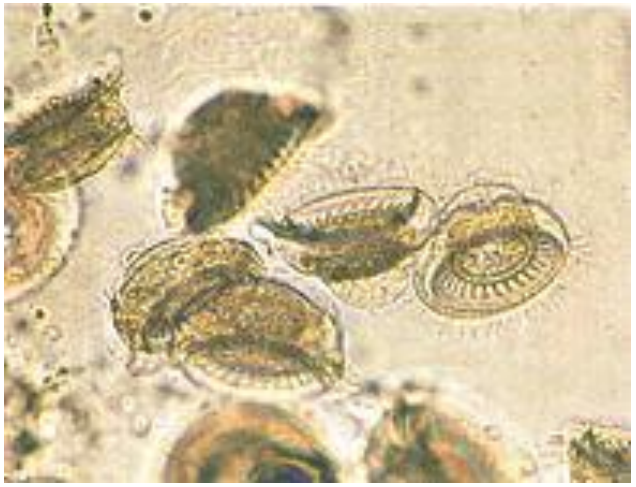
common symptoms :

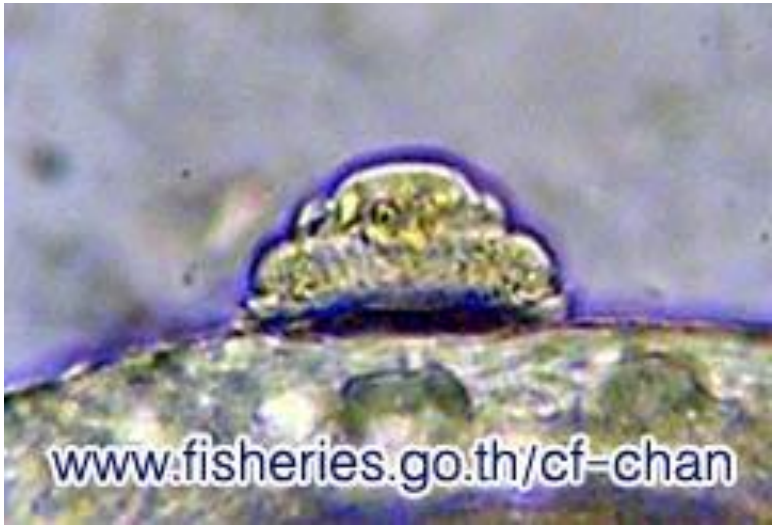
- slimy secretion
- Irritation
- skin damage
- gasping for air at the surface
- loss of weight

- can survive in free-swimming form for up to 24 hours


10µm
5KV X2,300 34mm

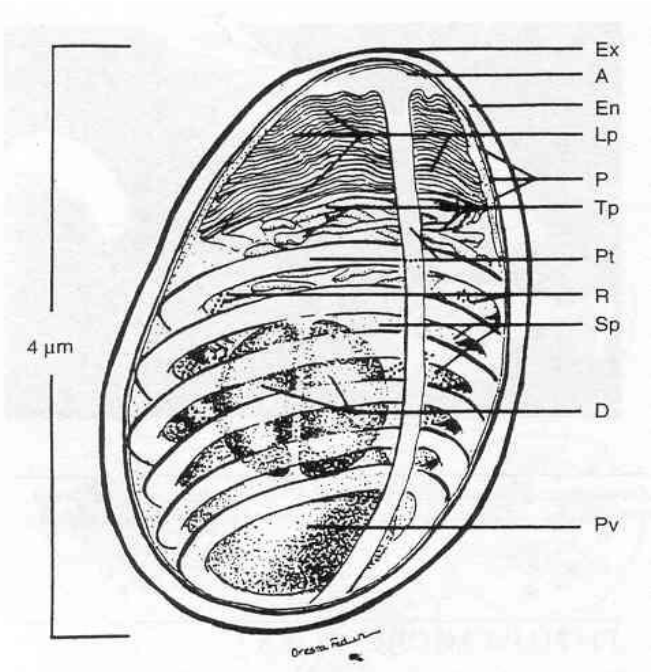





www.fisheries.go.th/cf-chan

FUNGI
Microsporea

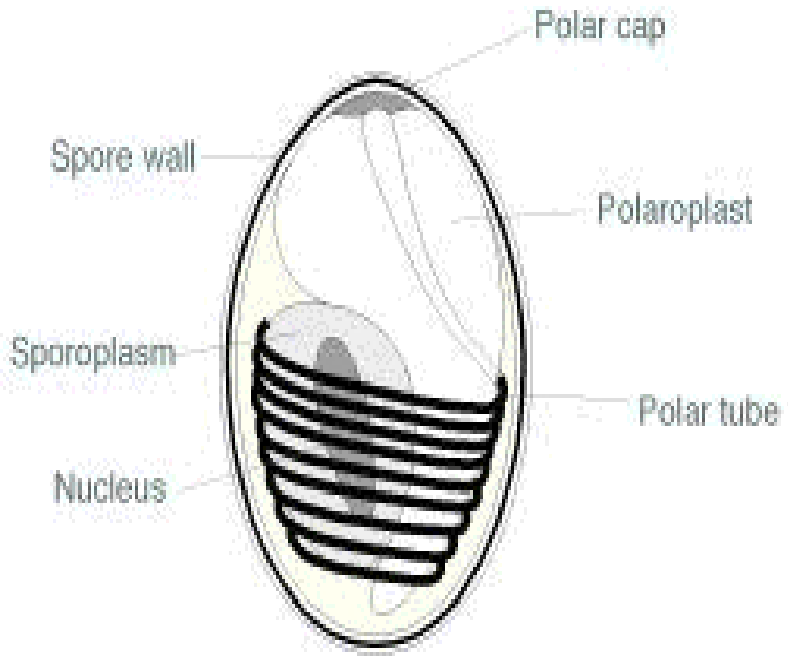
- **intracelular parasites**
- without mitochondria
- **extrusion apparatus**
- **transmitted by the spores (unicellular** and have a single sporoplasm)
- life cycle: **change sporogony and schizogony** (the process may not be strictly analogous to merogony found in the Apicomplexa)
- usually 3 to 6 μm in length



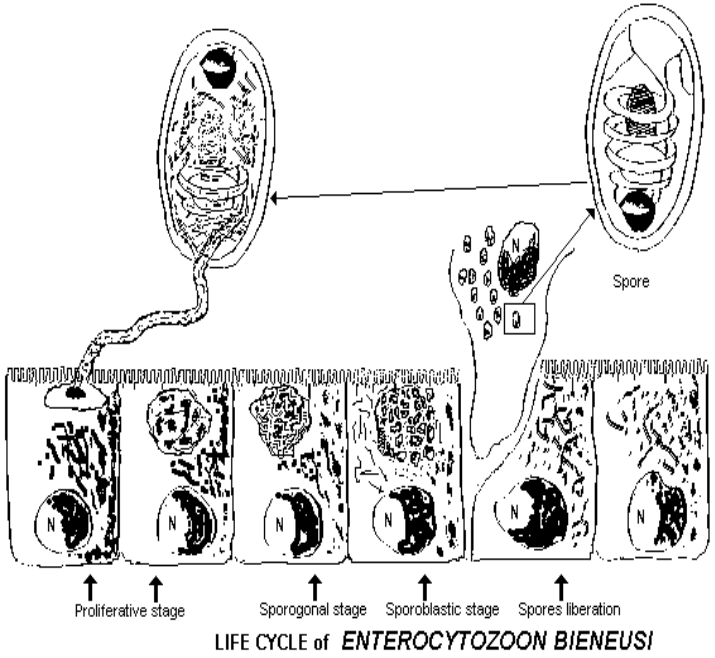
- ameboid **sporoplasm surrounds** the extrusion apparatus

- nucleus and most of cytoplasm lying within the coils of the filament

- **polar cap or sac** covering the attached end of the filament



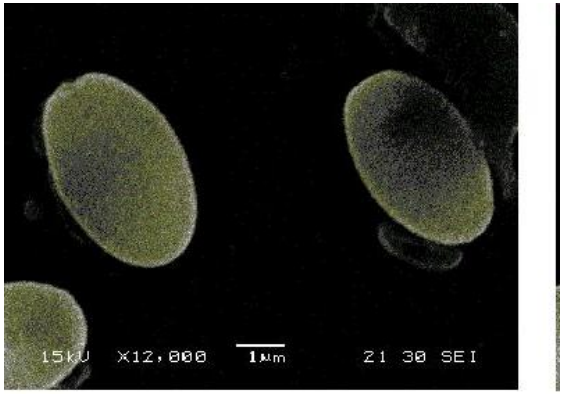
- infected hosts defecate spores that are infective to other host
- swallowed spores enter the midgut and lodge on the peritrophic membrane
- **<u>extruded filaments pierce the peritrophic membrane</u>** and intestinal epithelial cell and **<u>sporoplasm enters epithelial cell</u>**
- the sporoplasm flows through the tubular filament, thereby gaining acces to its host cell
-

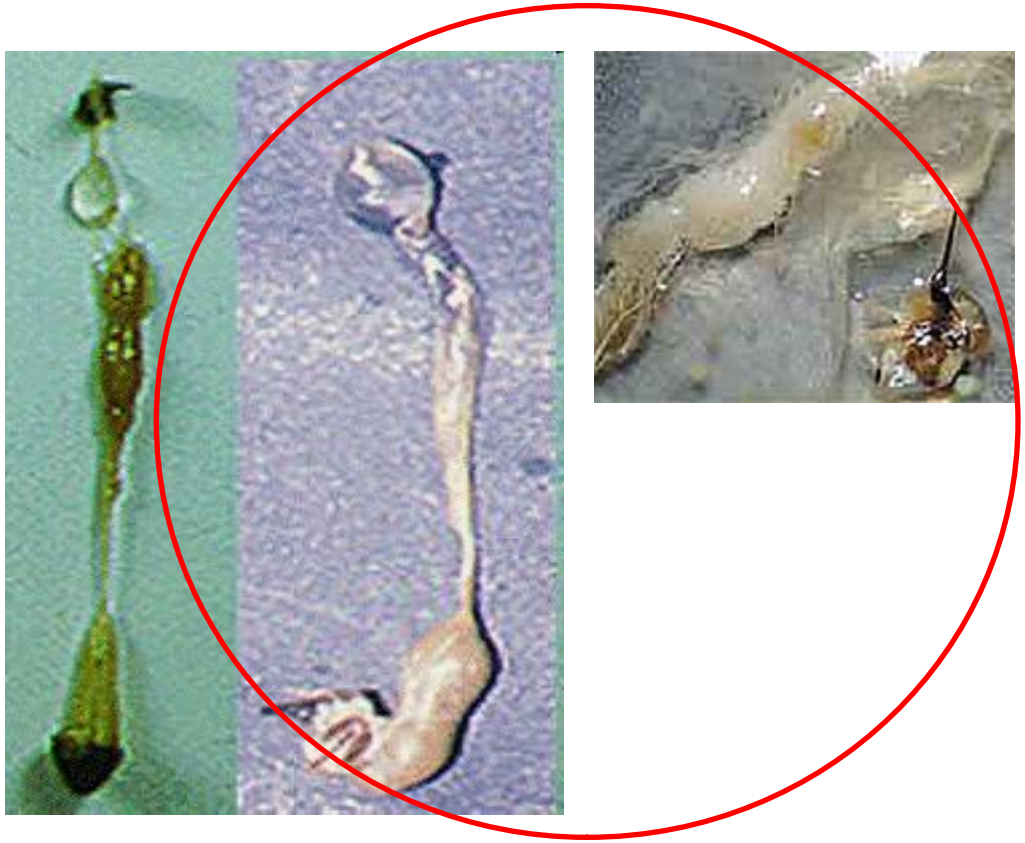


Nosema apis

- cause ***Nosema*** disease and **dysentery in honeybees**
- is widespread and can cause extensive losses of adult bees
- **symptoms :**
- inability of bees to fly
- excreta on combs or lighting boards
- a pile of dead or dying bees on the ground in front of the hive

- bees become infected when **they pick up the spores in the excreta as they clean the soiled combs**
- spores will **remain viable for many months** in dried spots of excreta on brood combs





http://max.af.czu.cz/kzr/natural/index.htm