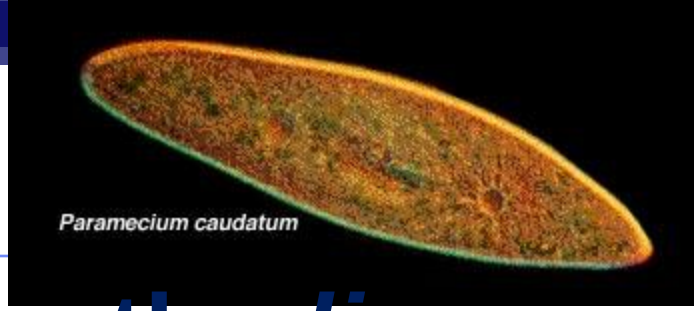
live organisms

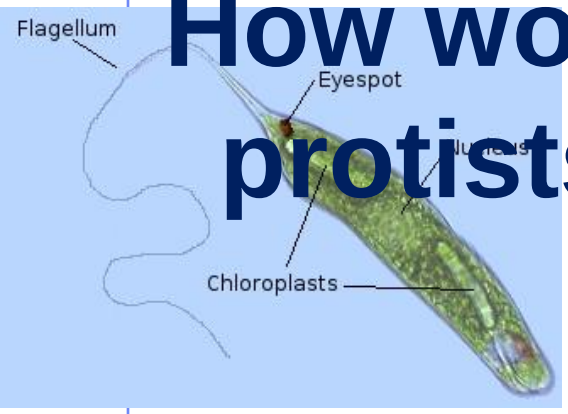
Blepharisma
Euglena
Paramecium caudatum
Phacus
Pelomyxa
Amoeba proteus
Actinosphaerium
Vorticella
Stentor

prepared slides

- ***Radiolarians***
- ***Vorticella***
- ***Trypanosomes***
- ***Giardia***
- ***Plasmodium***
- ***Foramenifera***
- ***Didinium***

Classification

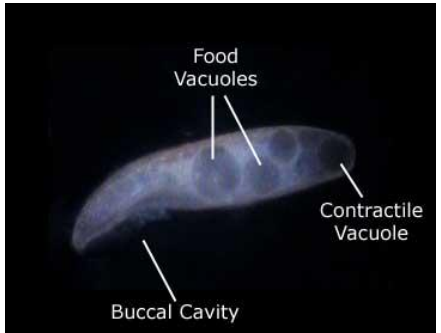




How would you group the *live* protists that you observed?

- *Blepharisma*
- *Euglena*
- *Paramecium caudatum*
- *Pelomyxa*
- *Phacus*

- *Amoeba proteus*
- *Actinosphaerium*
- *Vorticella*
- *Stentor*



Protist Diversity

movement

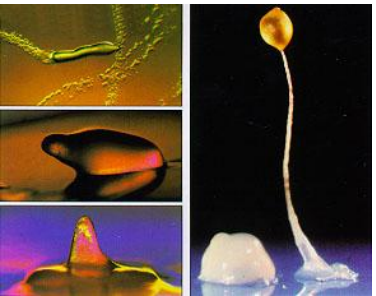
flagella
cilia
pseudopods
non-motile

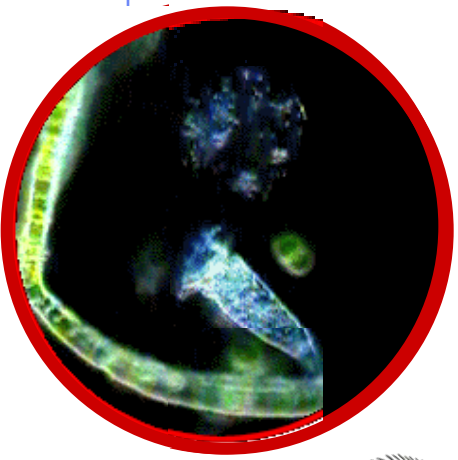
nutrition

autotrophs
ingestive heterotrophs
absorptive heterotrophs
mixotrophs

Possible kingdoms

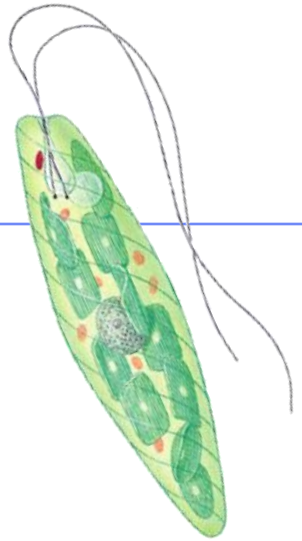
animal-like
plant-like
fungus-like

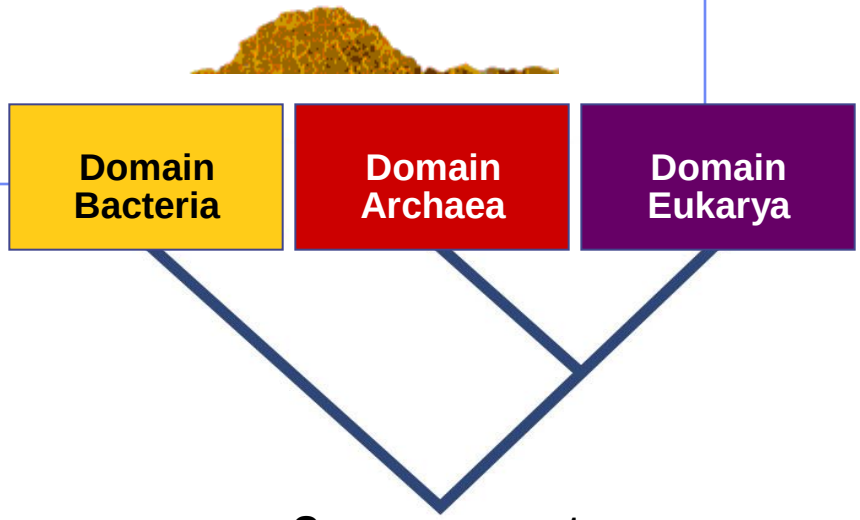




Kingdom: Protists

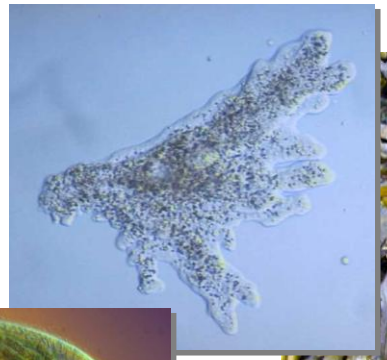
Domain Eukarya

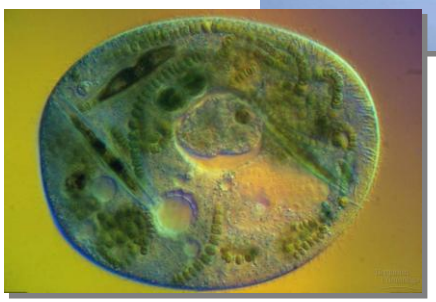




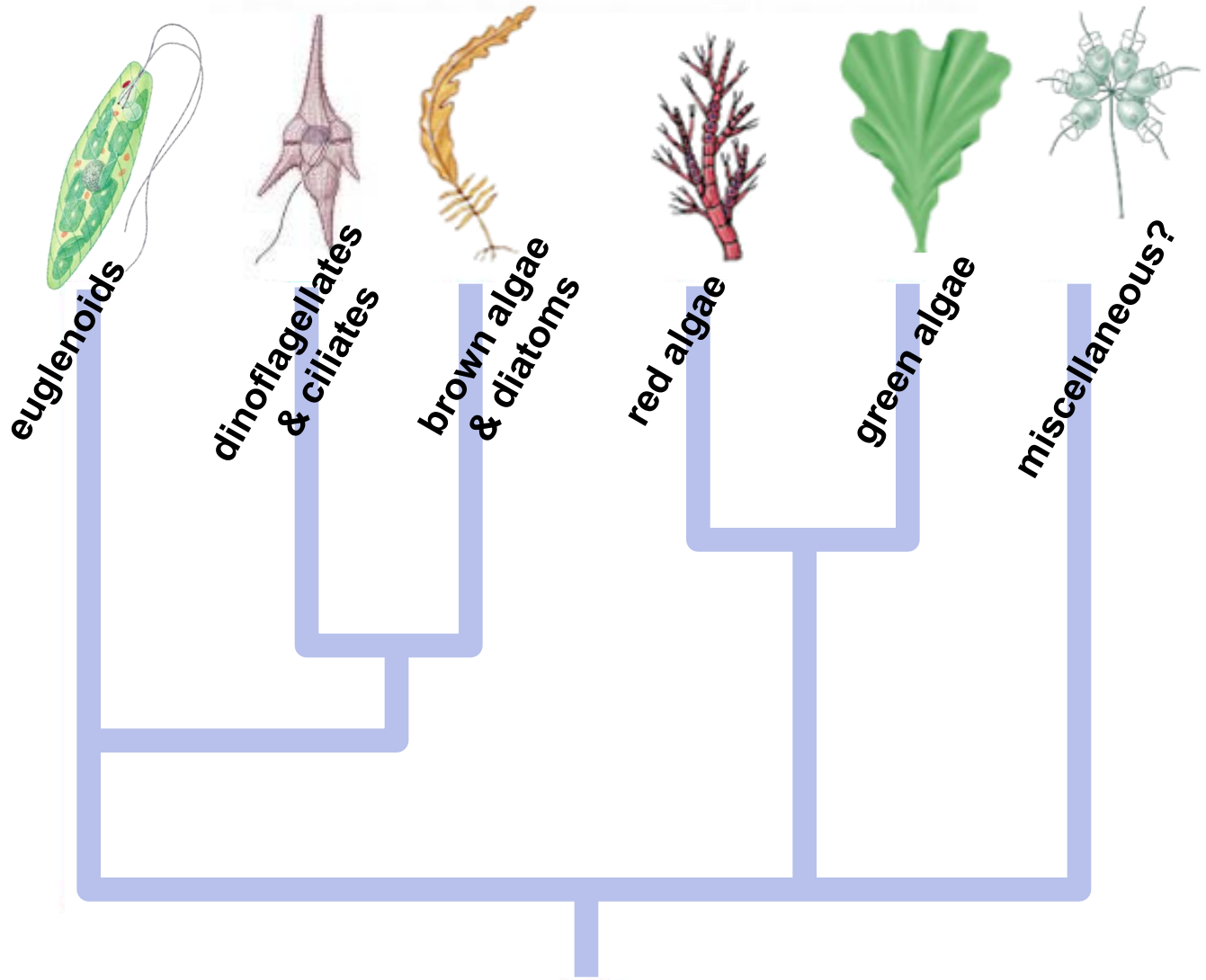
General characteristics

- **Classification criteria**
  - eukaryotes
  - not animal, plant or fungi



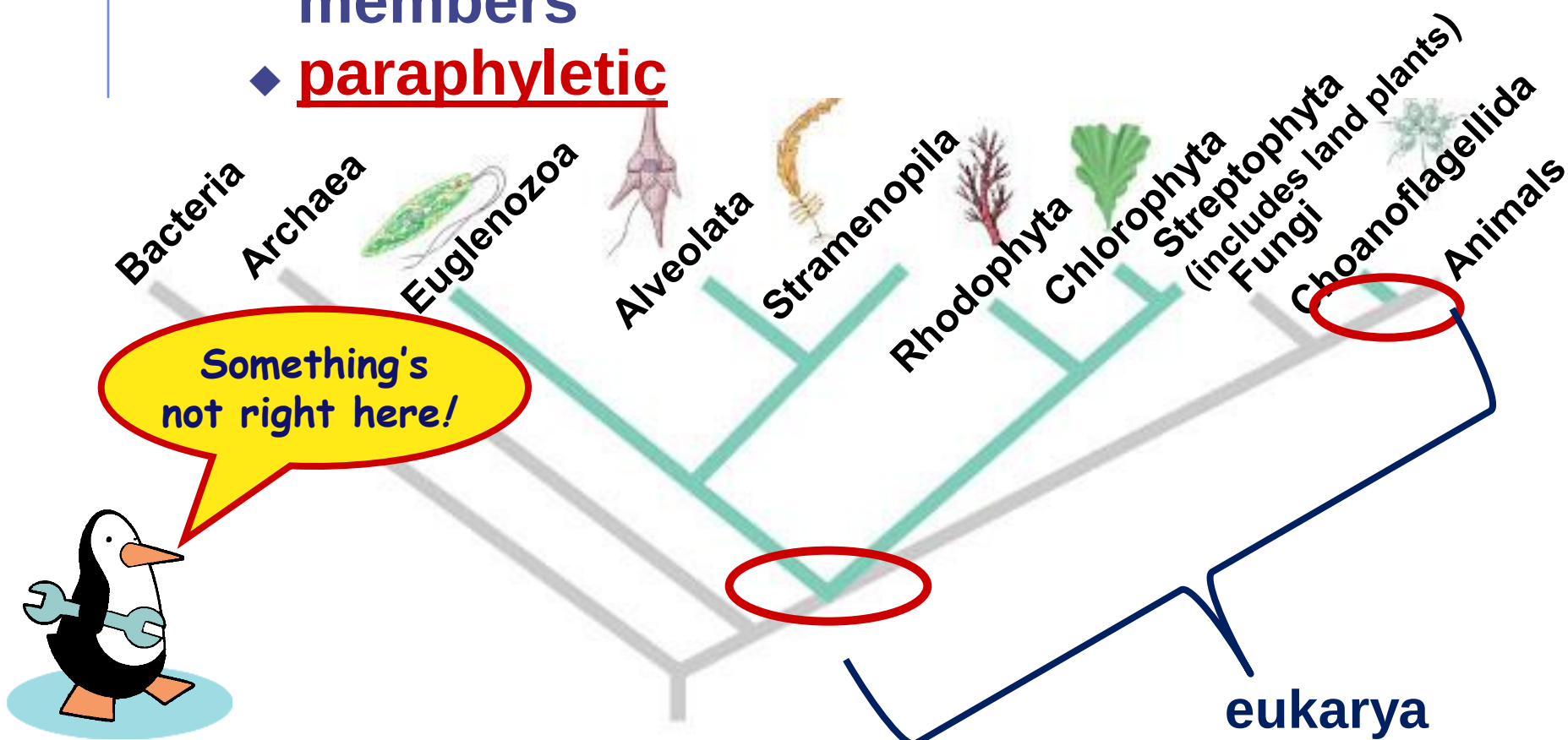


Great Diversity

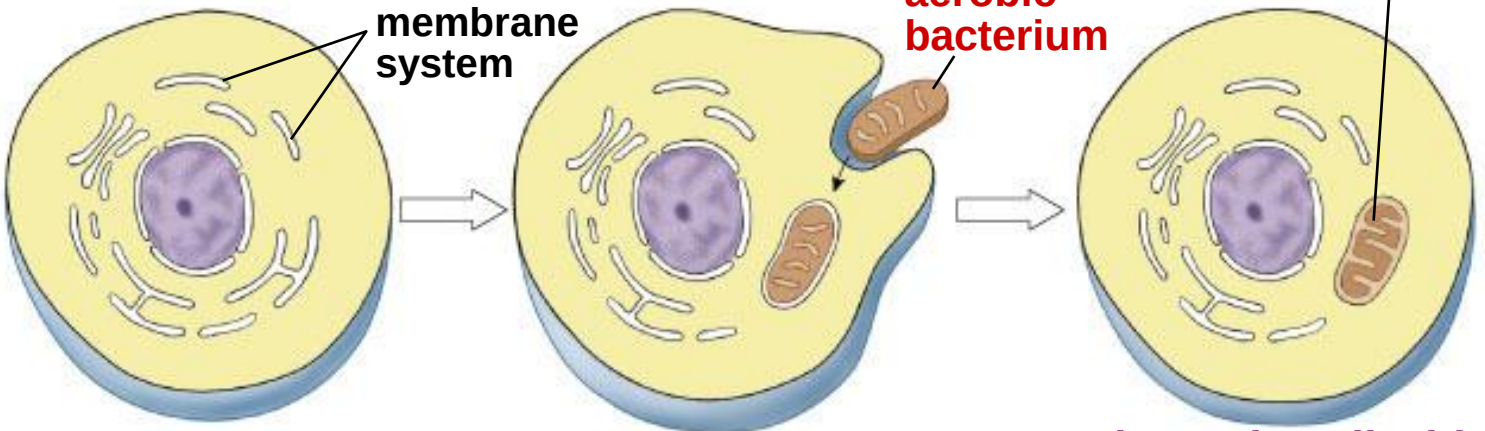


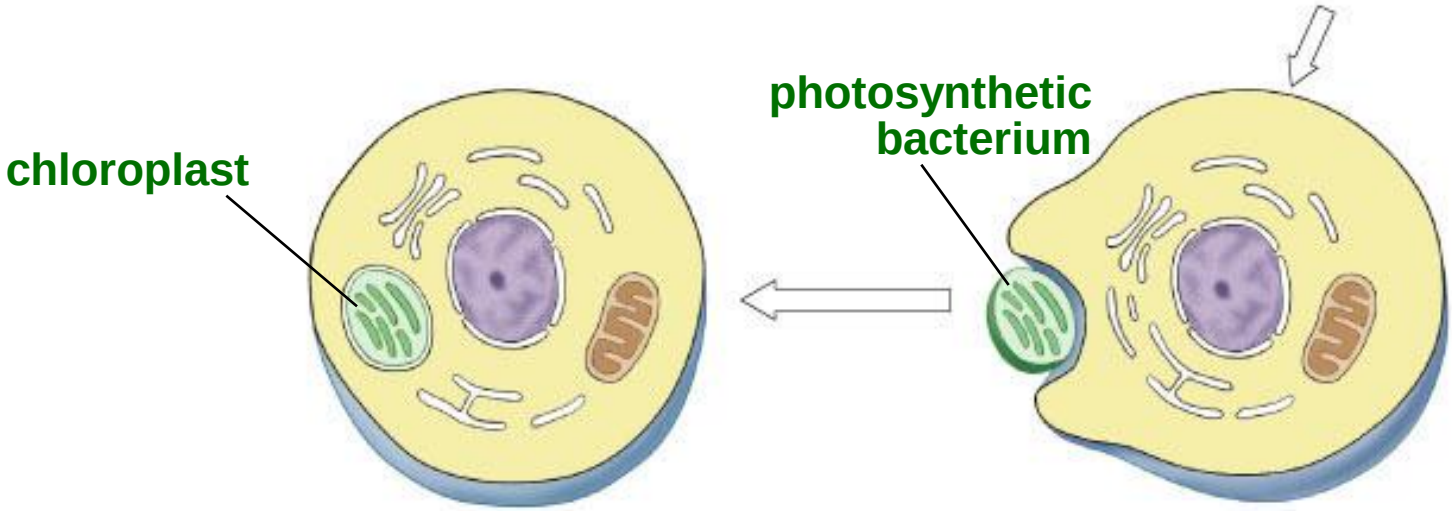
Problems with Protist Classification

- **Too Diverse!**
  - **doesn't reflect any evolutionary relationship among all kingdom members**
  - **paraphyletic**



Theory of Endosymbiosis



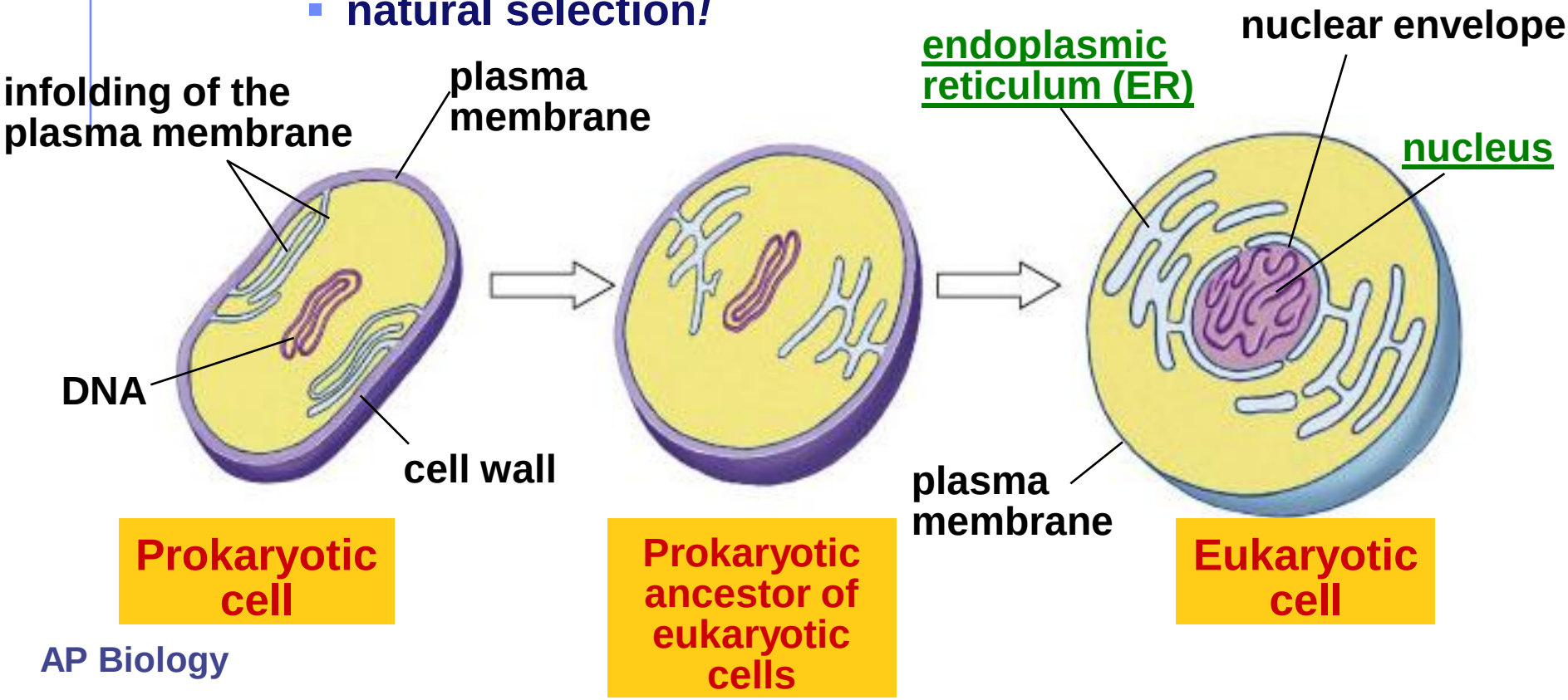


Paramecium **& symbiont *Chlorella***

First Eukaryotes

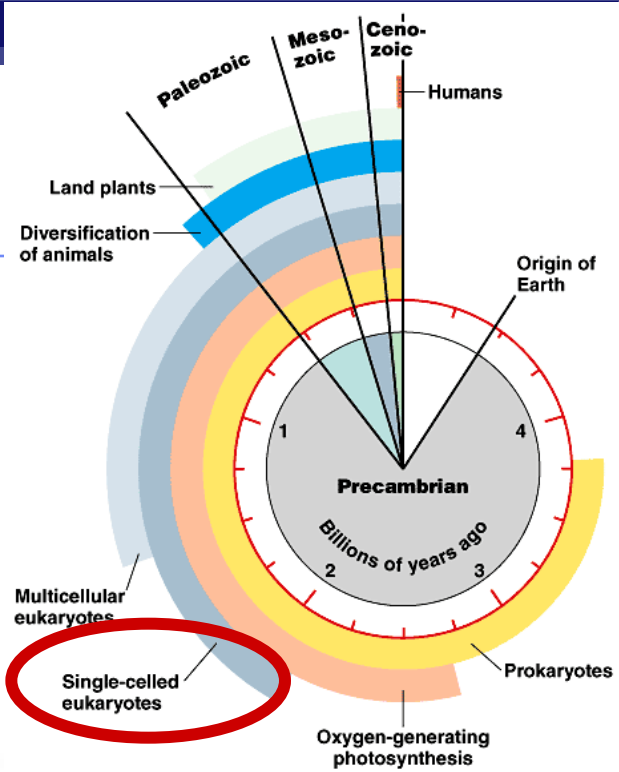
~2 bya

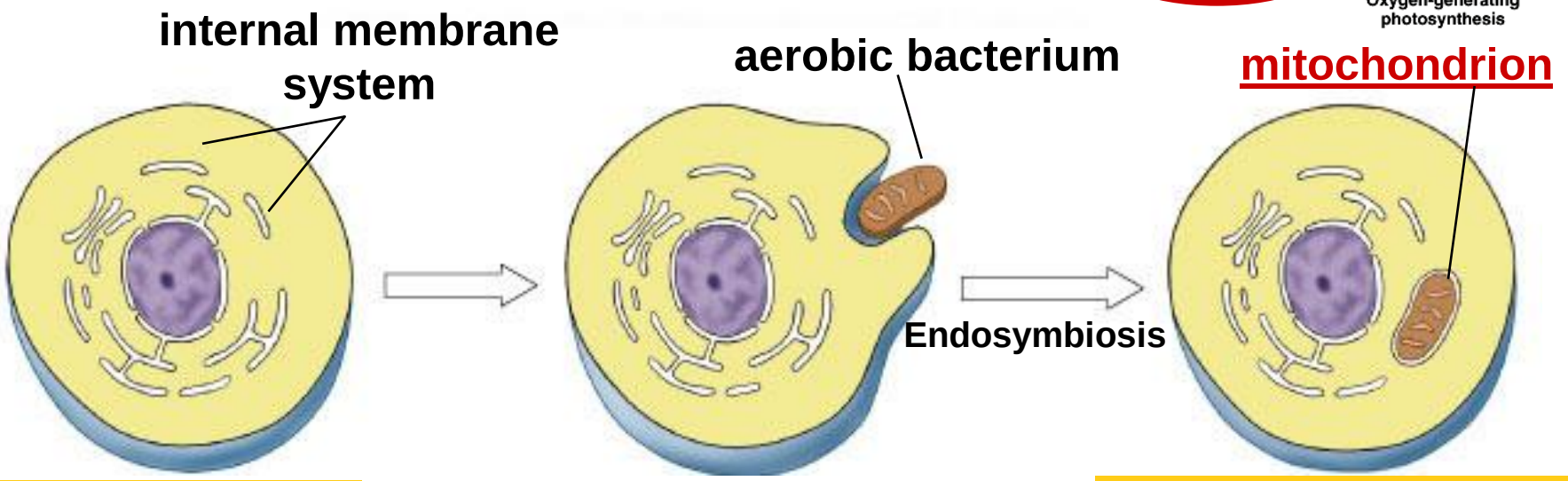
- Development of internal membranes
  - create internal micro-environments
  - advantage: specialization = increase efficiency
    - natural selection!



1st Endosymbiosis

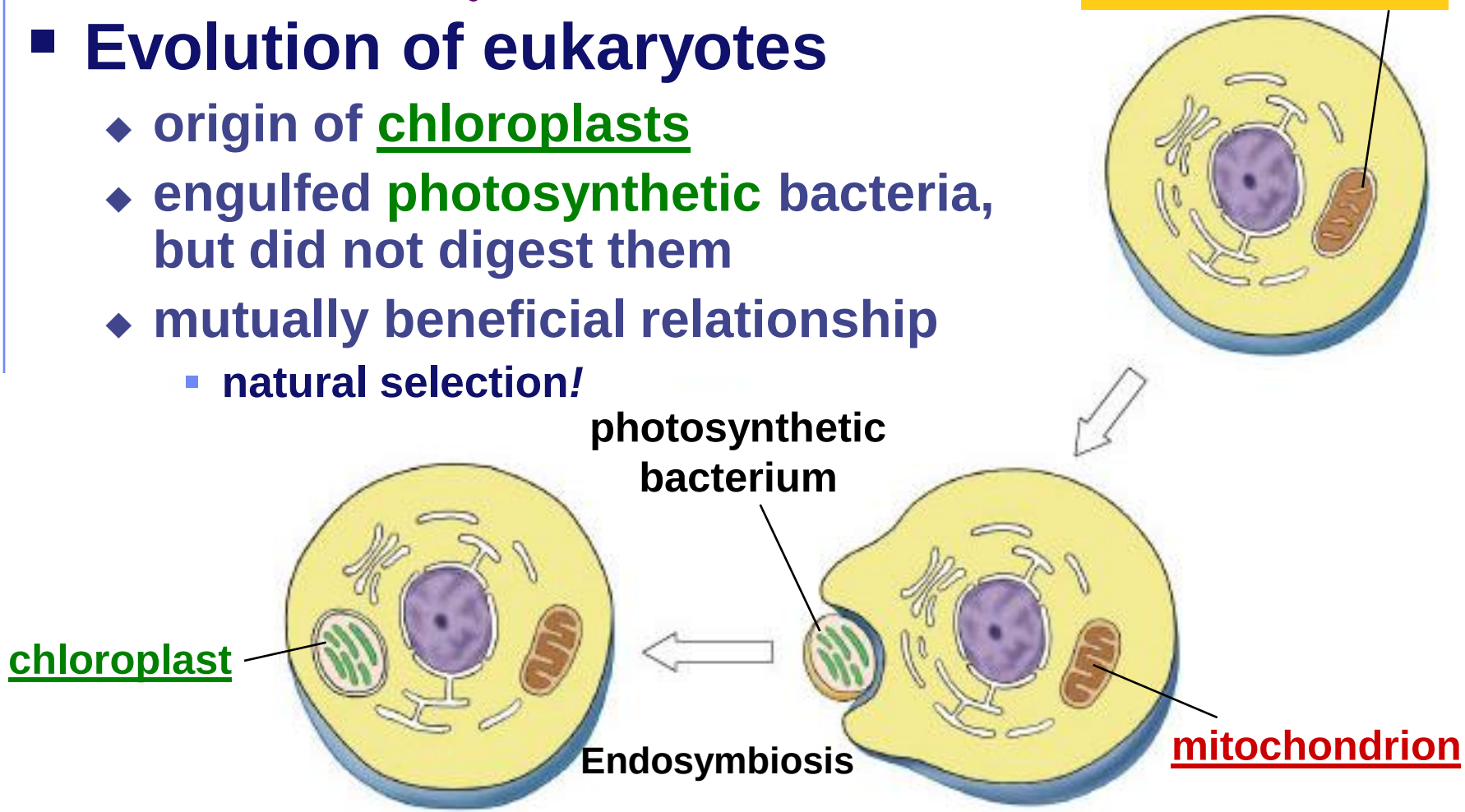
- **Evolution of eukaryotes**
  - origin of **mitochondria**
  - engulfed aerobic bacteria, but did not digest them
  - mutually beneficial relationship
    - natural selection*!*

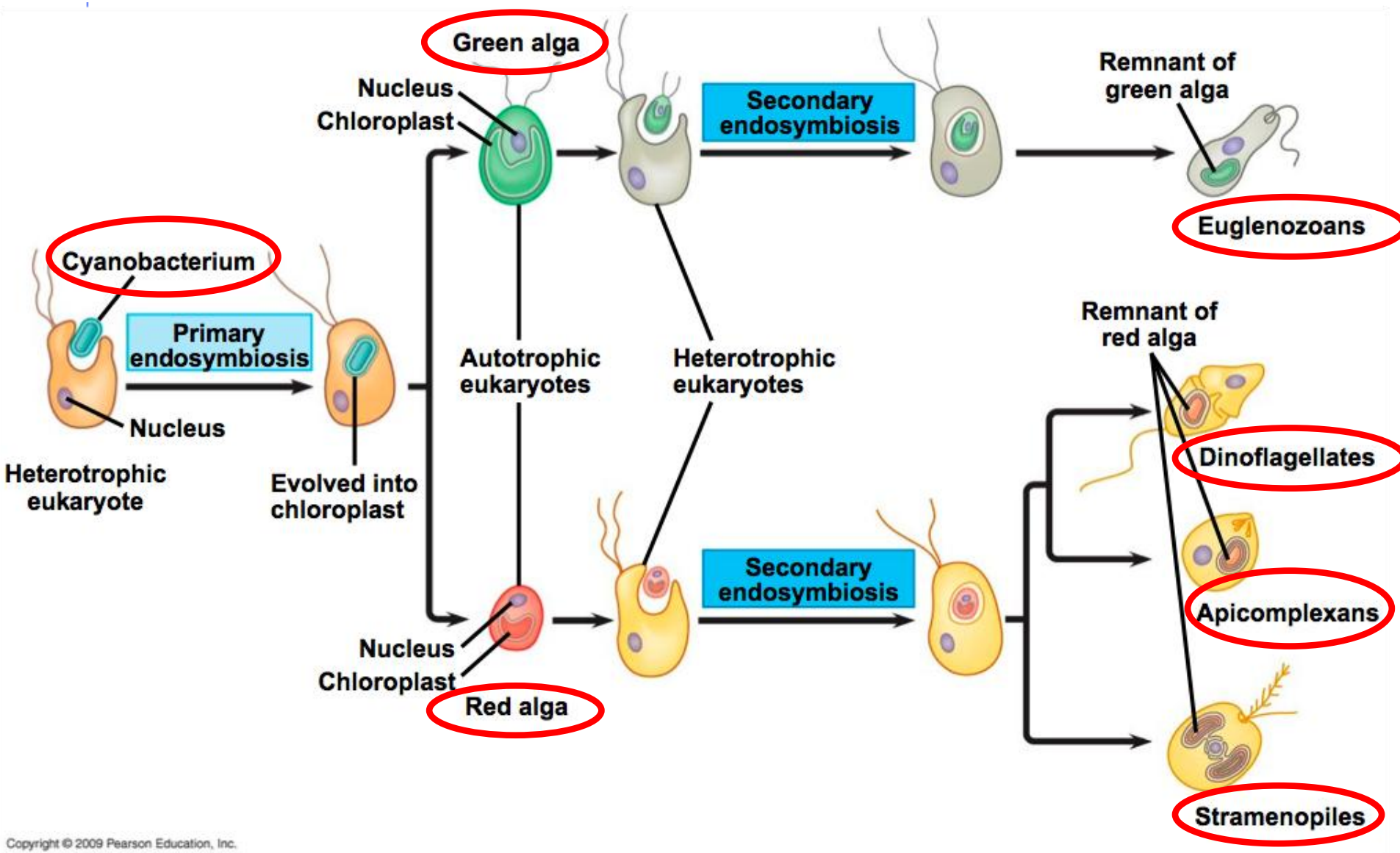




2nd Endosymbiosis

- Evolution of eukaryotes
  - origin of chloroplasts
  - engulfed photosynthetic bacteria, but did not digest them
  - mutually beneficial relationship
    - natural selection*!*





Theory of Endosymbiosis

- Evidence
  - structural
    - mitochondria & chloroplasts resemble bacterial structure
  - genetic
    - mitochondria & chloroplasts have their own circular DNA, like bacteria
  - functional
    - mitochondria & chloroplasts move freely within the cell
    - mitochondria & chloroplasts reproduce independently from the cell

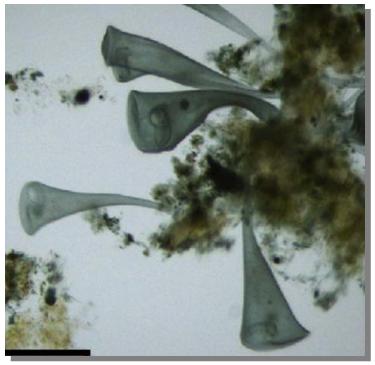
Lynn Margulis

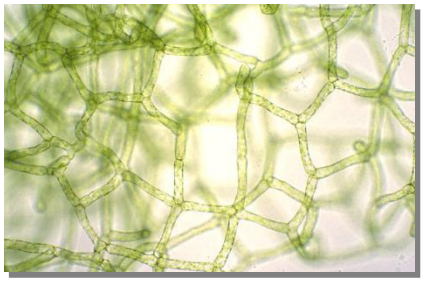
Evidence for Endosymbiotic Theory

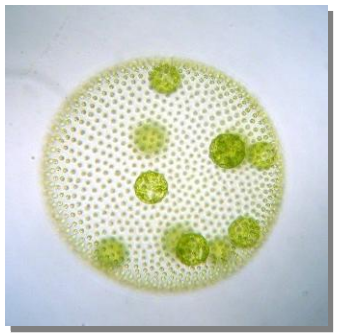
	Prokaryotes	Eukaryotes	Mitochondria of Eukaryotic cells	Chloroplasts of Photosynthetic eukaryotes
DNA	1 single, circular chromosome; no histones	Multiple linear chromosomes compartmentalized in a nucleus; yes histones	1 single, circular chromosome; no histones	1 single, circular chromosome; no histones
Reproduction	Binary Fission (1 cell splits into 2)	Mitosis	Binary Fission (1 cell splits into 2)	Binary Fission (1 cell splits into 2)
Ribosomes	"70 S"	"80 S"	"70 S"	"70 S"
Protein translation	initiator amino acid f-MET	initiator amino acid MET	initiator amino acid f-MET	initiator amino acid f-MET
Electron Transport Chain	Found in the plasma membrane around cell	Not found in the plasma membrane around cell (found only in the cell's mitochondria and chloroplasts)	Found in the plasma membrane around mitochondrion	Found in the plasma membrane around chloroplast
Size (approximate)	~1-10 microns	~50 - 500 microns	~1-10 microns	~1-10 microns

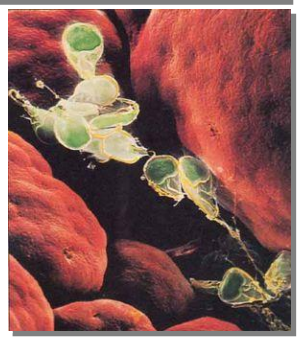
Protist Diversity

- The full spectrum of modes of life
  - from unicellular to multicellular
  - autotrophic to heterotrophic
  - asexual to sexual reproduction
  - pathogenic to beneficial
  - sessile to mobile



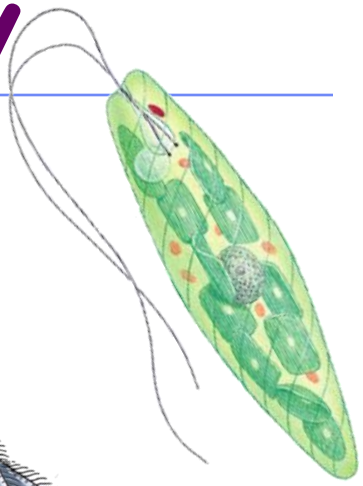


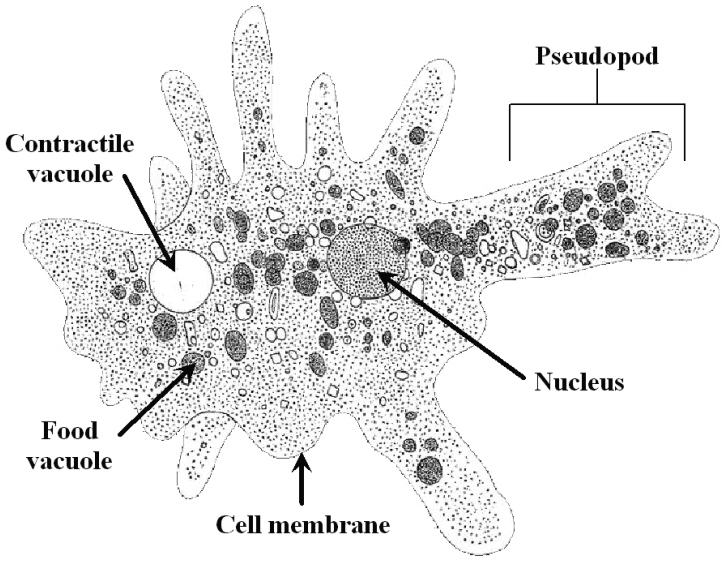


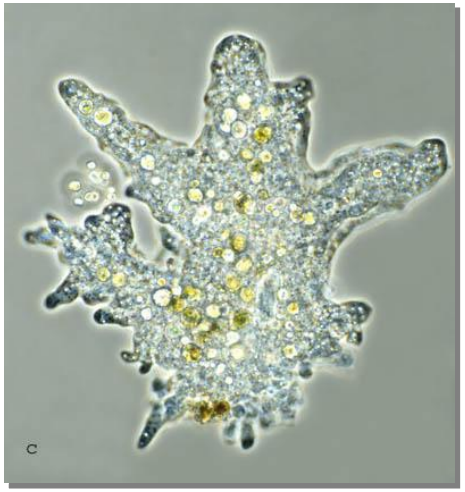


Mobility/Motility

- How Protists move
  - flagellum
  - cilia
  - pseudopod

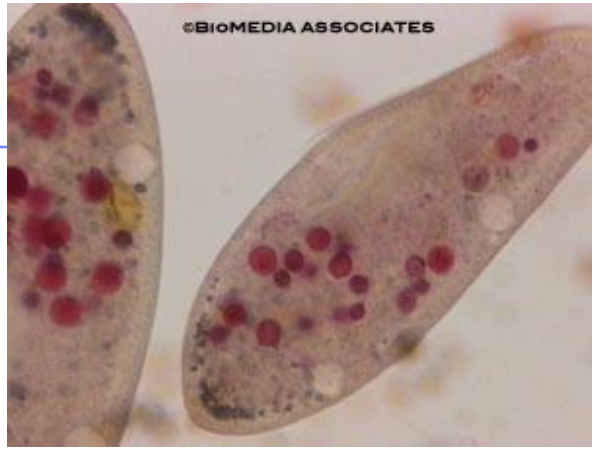






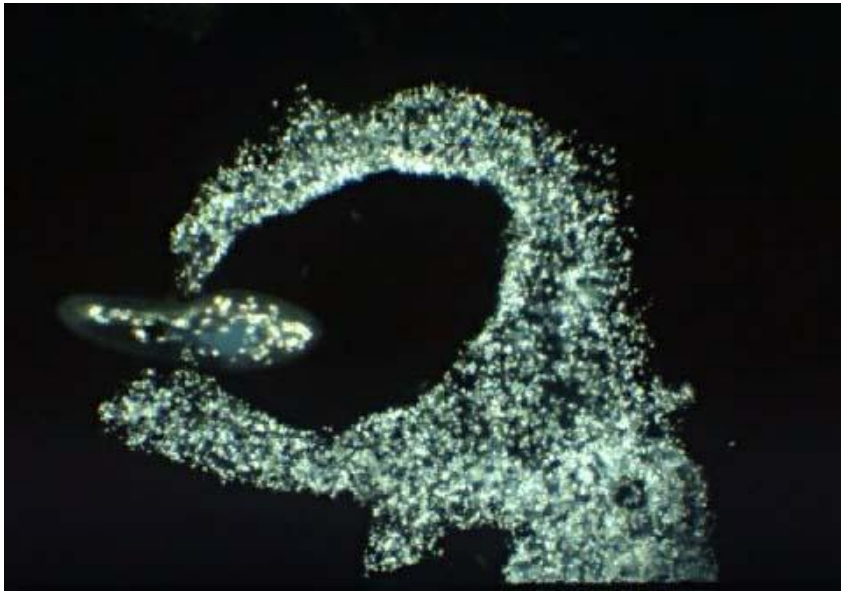
Protist Diversity

- **Animal-like Protists**
  - **heterotrophs, predators**
    - **Amoeba**
    - **Paramecium**
    - **Stentor**



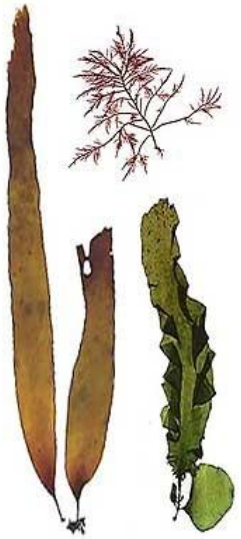
Paramecium with food vacuoles stained red

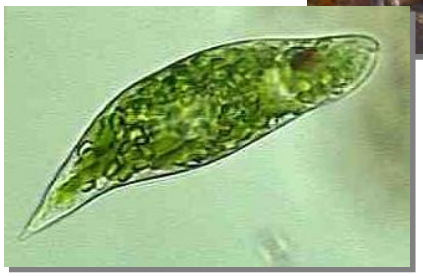
Amoeba ingesting a Paramecium

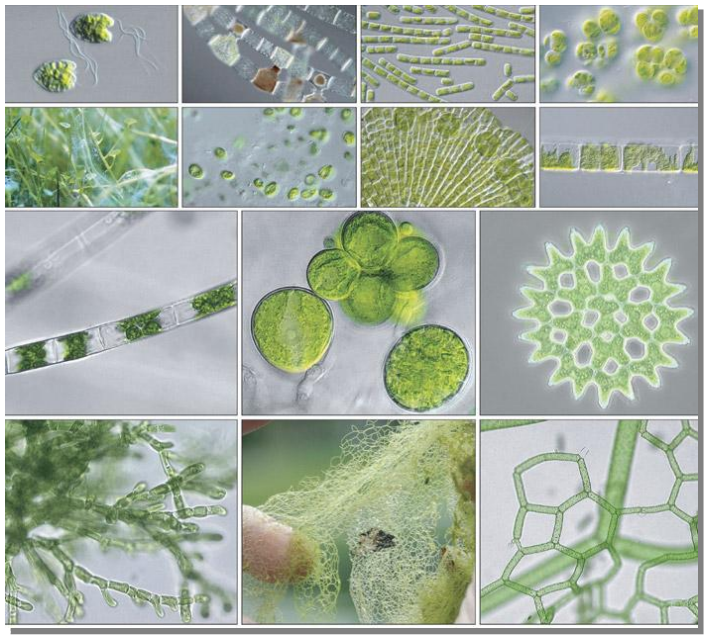


Protist Diversity

- Plant-like Protists
  - autotrophs, photosynthesis
    - Euglena
    - algae
    - diatoms





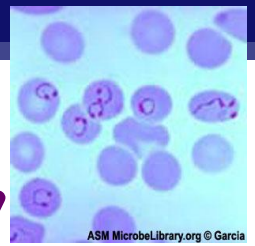


Protist Diversity

- **Fungi-like Protists**
  - Often brightly colored
  - Slime Molds
  - Myxomycota
  - Multicellular
  - Change form during life cycle
  - Tend to live in damp locations
  - The three stages are similar to that of other organisms

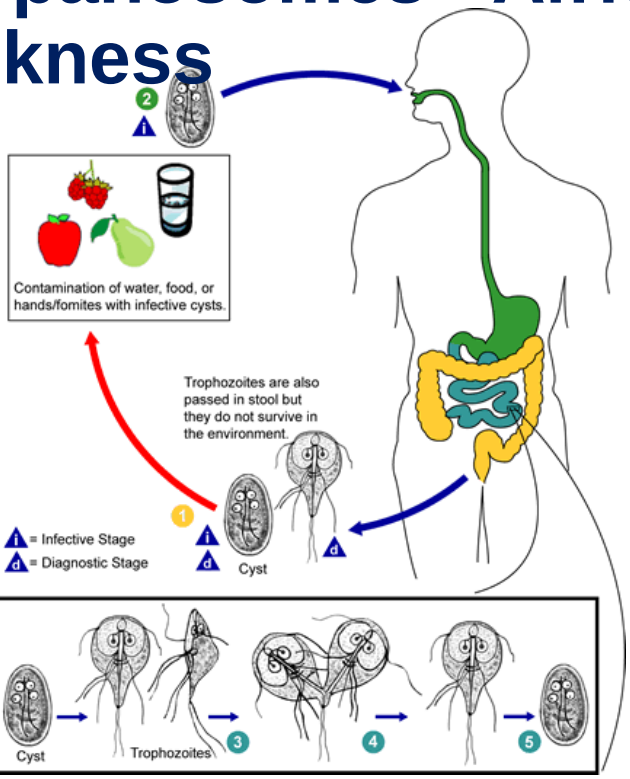
Know these! –covered on later slides

Protist Diversity

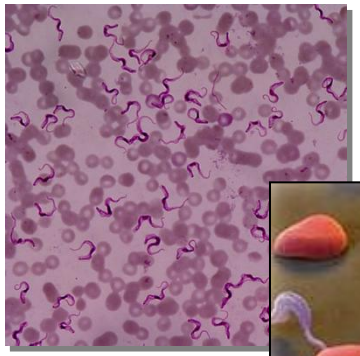


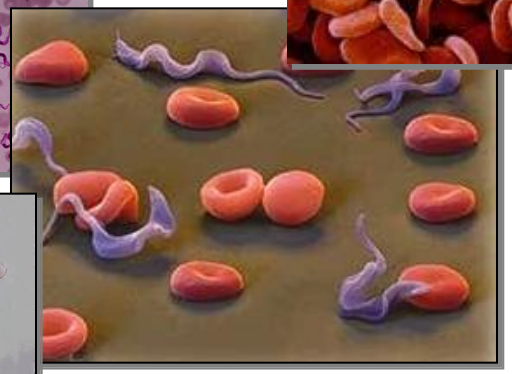
- **Parasitic & pathogenic Protists**
  - **malaria**
  - ***Giardia***
  - **Trypanosomes –African sleeping sickness**

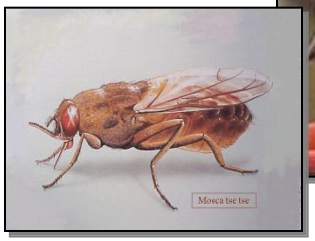
Plasmodium



Giardia







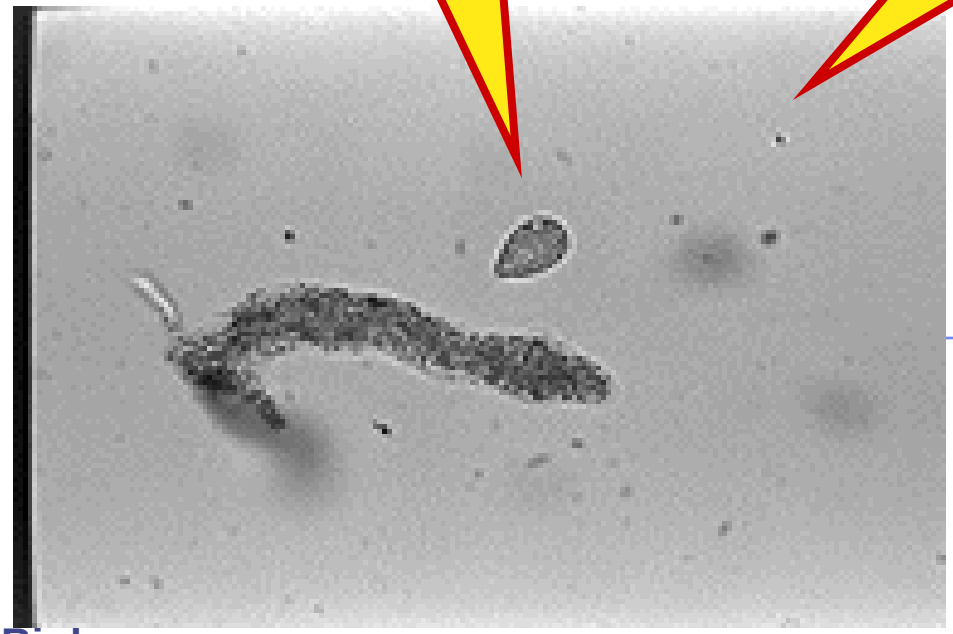
Trypanosoma

Protist Diversity

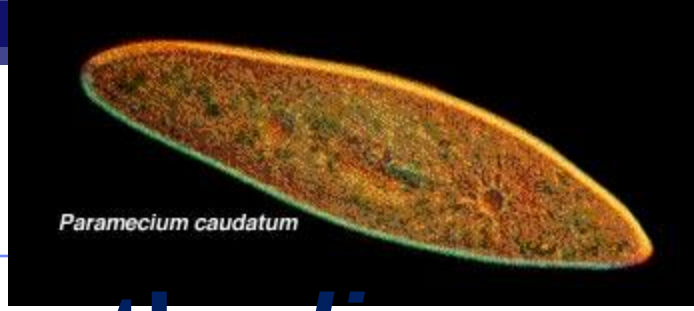
- **Beneficial & necessary Protists**
  - **phytoplankton**
    - small algae + diatoms
    - much of the world's photosynthesis
    - produces ~90% of atmospheric oxygen
  - **zooplankton**
    - heterotrophic protists + animals
    - key ecological role at base of marine food web

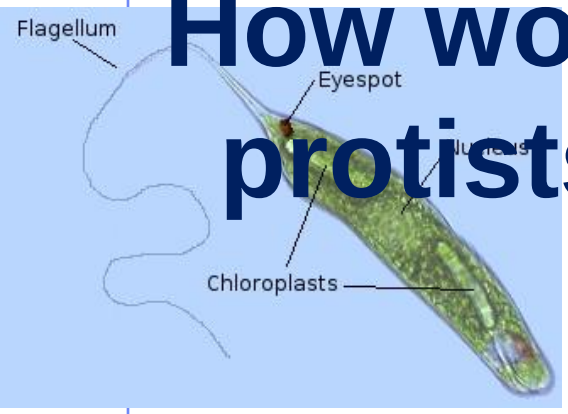
Oh No!

Any Questions?? Yum!



Classification





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- *Actinosphaerium*
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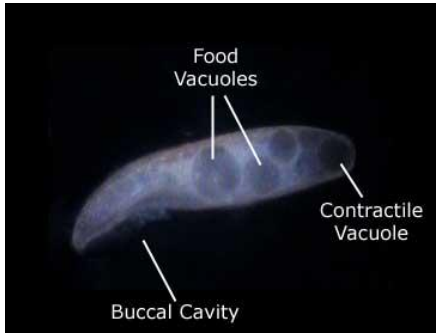
- *Stentor*



Protist Diversity

movement

flagella

cilia

pseudopods

non-motile

nutrition

autotrophs

ingestive heterotrophs

absorptive heterotrophs

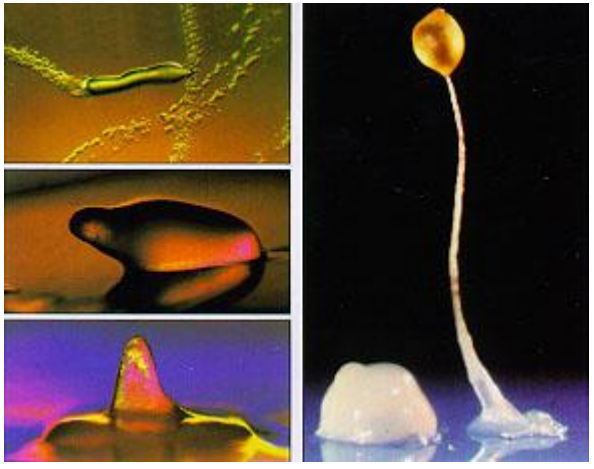
mixotrophs

Possible kingdoms

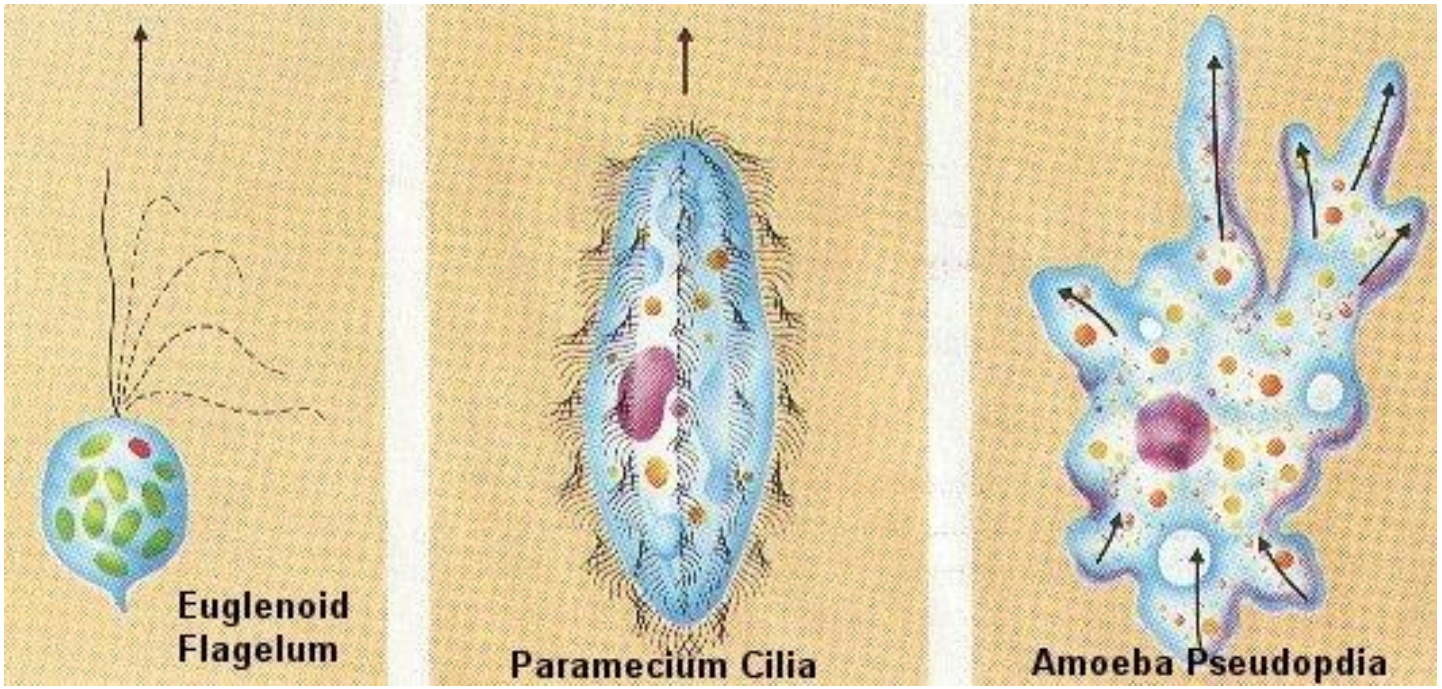
animal-like

plant-like

fungus-like

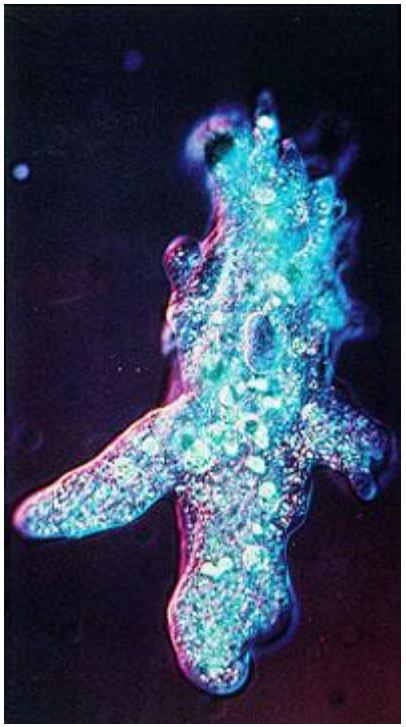


movement



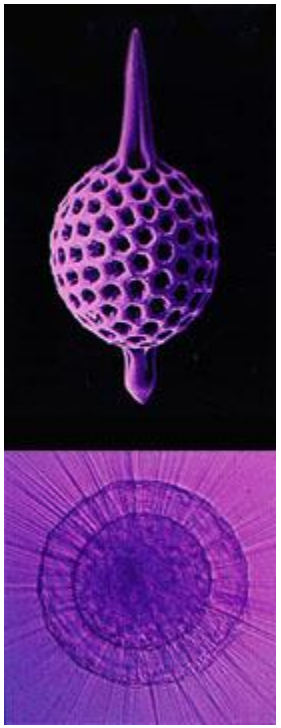
Animal-like protists

- **Sarcodina (ameboid) - these are either free-living or have tests (shells)**



An amoeba

Foraminifera

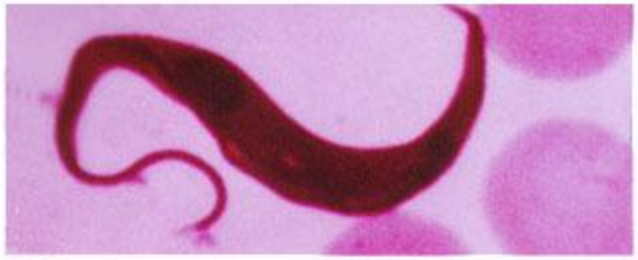


Helizoans

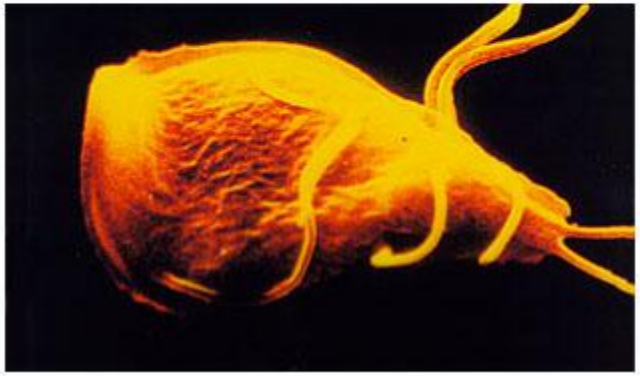
Animal-like protists

Mastigophora
(flagellated)
- frequently parasitic

Cilliaphora
(cilliates) - cilliated



Trypanosoma brucei

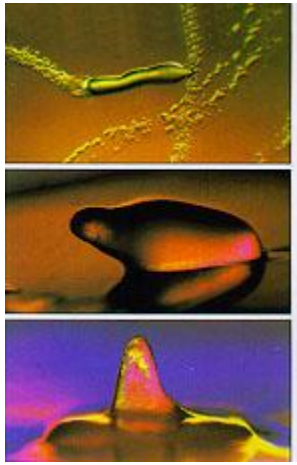


Giardia lamblia

Trichomonas vaginalis

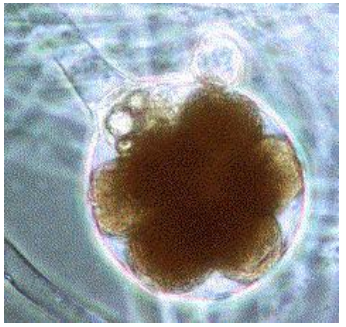
Fungal-like protists - decomposers

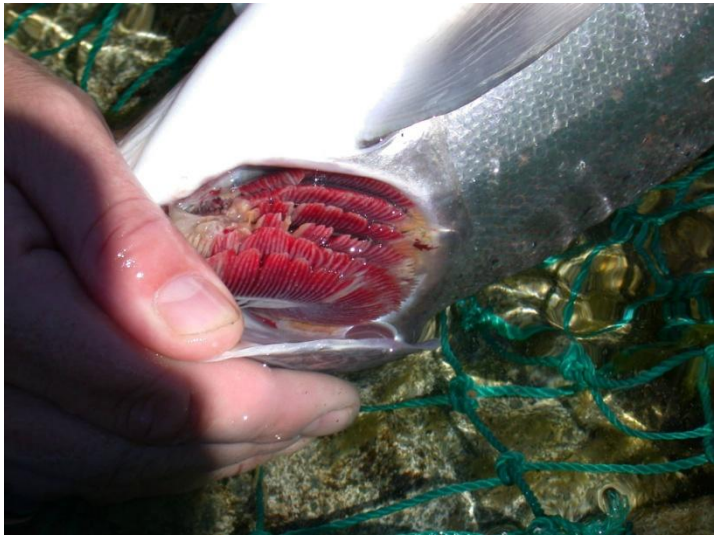
- Slime molds
  - have two stages in life cycle
    - free living (amoeboid) stage
    - plasmodial ("slug") stage
  - are often brightly colored
  - probably most closely related to sarcodina



Fungal-like protists (decomposers)

- **Water molds - closely related to true fungi**
  - **important marine decomposers**
  - ***Phytophthora infestans* caused Irish potato famine**
  - **ich, a fish-gill infestation, is also caused by a water mold**

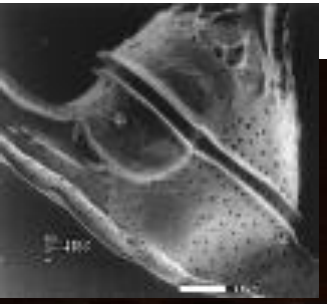


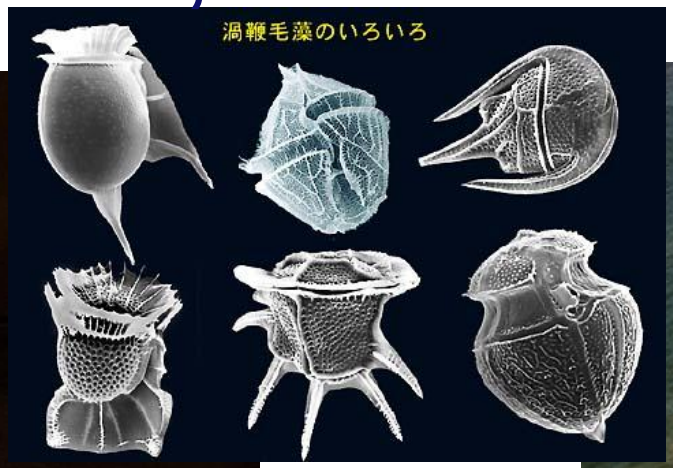


Plant-like protists - photosynthetic

- Euglenoids - flagellated, have photoreceptors, photosynthetic, autotrophic
- Dinoflagellates – 2 flagella

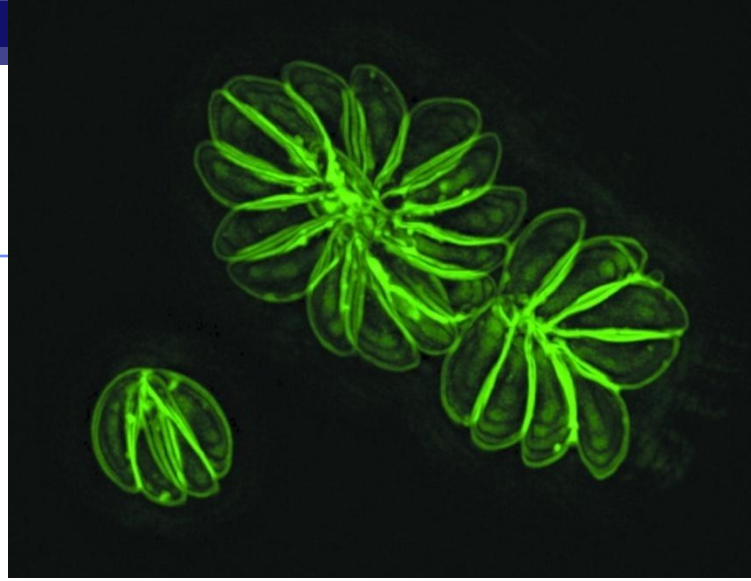
and a silicon test; causes red tides

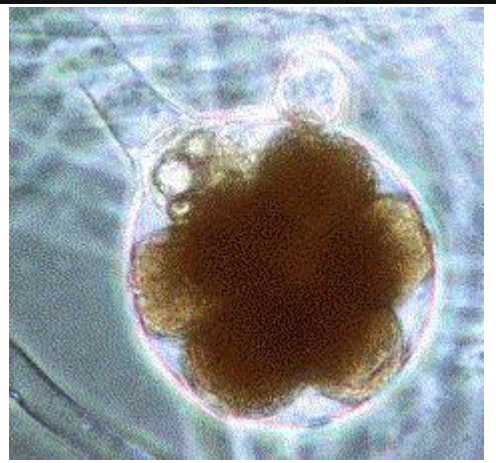


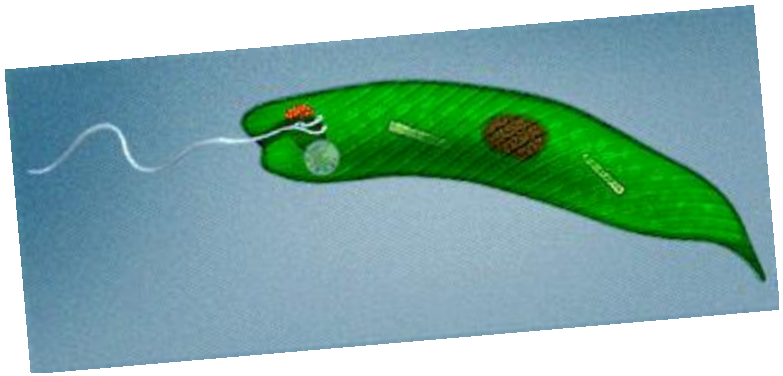


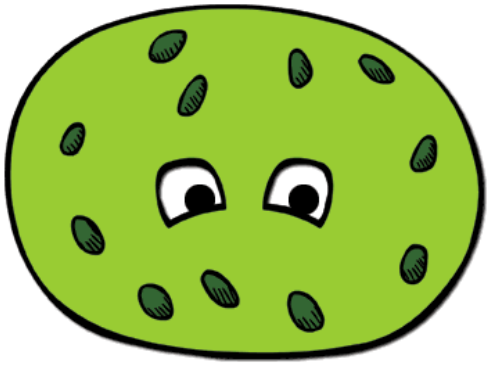
Protist Diversity

- Important Roles
- some are autotrophs
  - base of food chains
  - produce over 75% Earth's O_2
- some are decomposers
  - recycle of materials





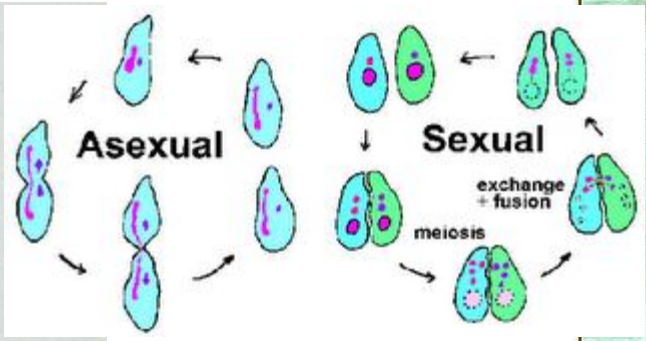


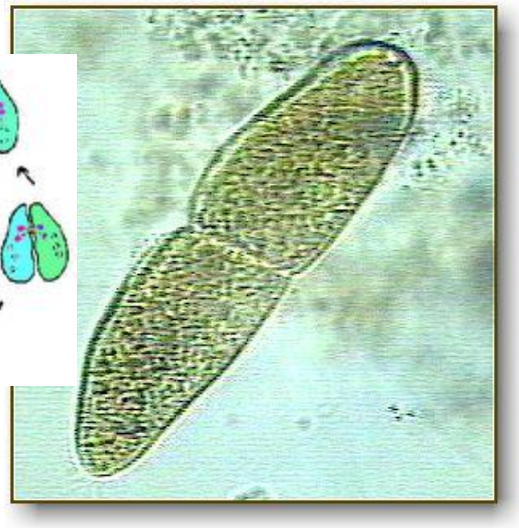


Protist Diversity

http://highered.mcgraw-hill.com/sites/9834092339/student_view0/chapter10/animation_-_cell_division.html

- **Reproduction**
  - **Asexual- binary fission**
  - **Sexual- sperm + egg**
  - **Conjugation- exchange genetic material w/o cell division**





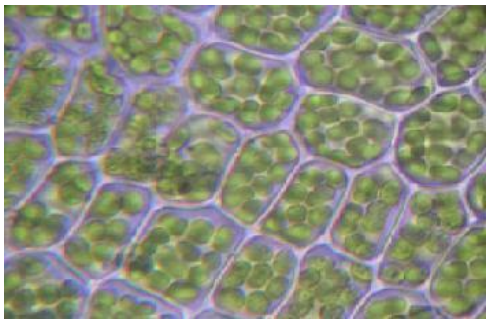
http://highered.mcgraw-hill.com/olcweb/cgi/pluginpop.cgi?it=swf::550::400::/sites/dl/free/0078759864/383925/CH19Visualizing_Paramecia_101906.swf::Visualizing%20Paramecia

Protist Diversity

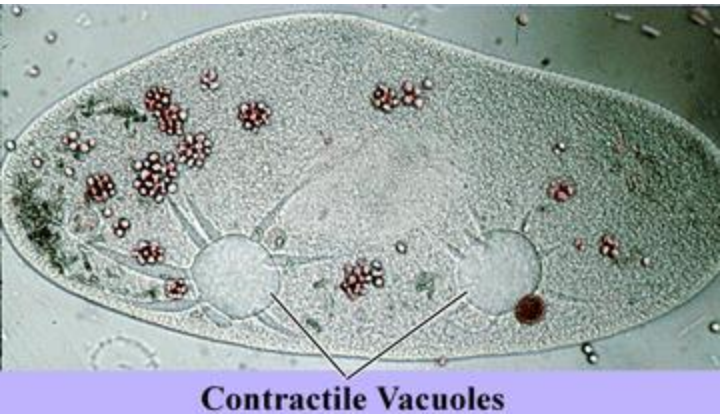
- **Organelles**
  - **plastid structure & function (evolved from cyanobacteria)**
  - **nuclear structure**
  - **vacuole types (food, contractile)**
  - **mitochondrial "status"**

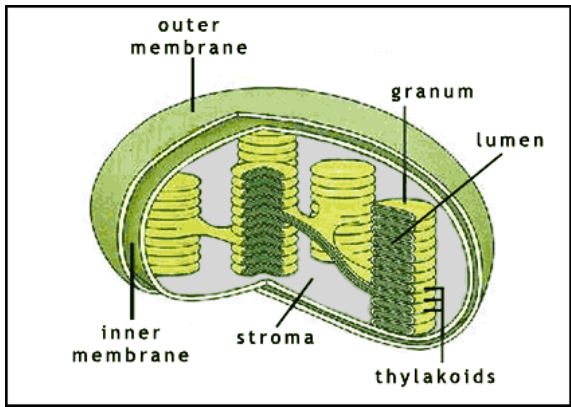
http://www.dnatube.com/video/357/Paramecium-and-Osmosis

http://www.youtube.com/watch?feature=endscreen&NR=1&v=YGZP0ijukt8



http://www.youtube.com/watch?v=iG6Dd3COug4&feature=related



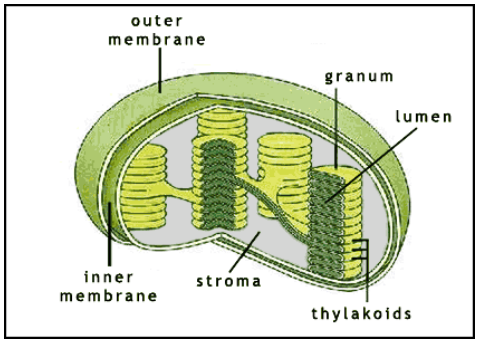


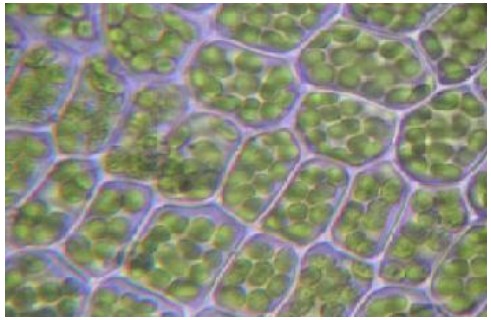
Endosymbionts

- Some contain Endosymbionts
- Some are Endosymbionts in other organisms
  - Termites contain a protist in their guts that contain prokaryotes that digest cellulose!

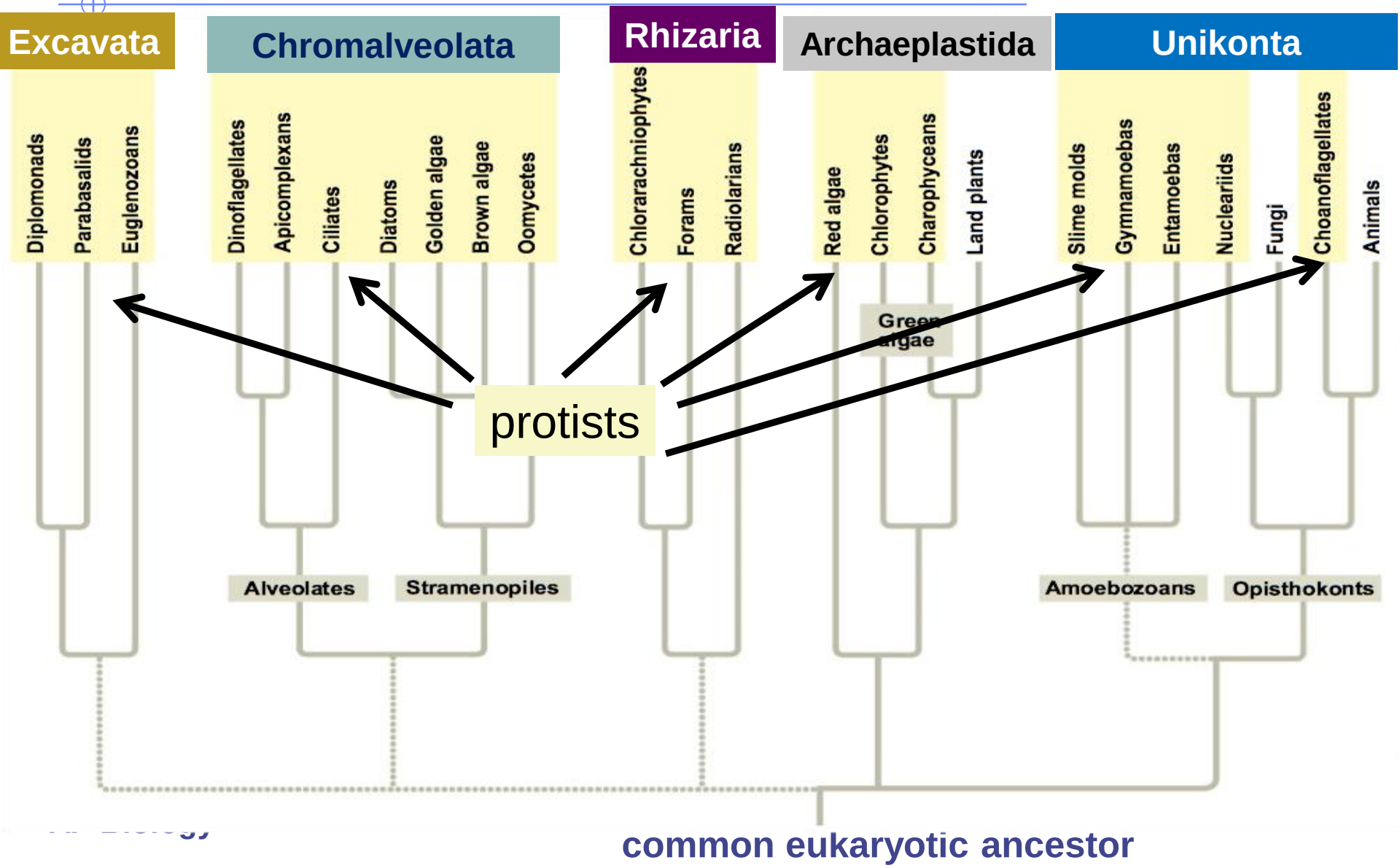
How are protists grouped?

- **Evidence to place protists in monophyletic groups**
- **Largely based on plastids**
  - **plastid-related DNA sequences**
  - **structure**
  - **function**
    - **similarities in cell structure**
    - **molecular evidence (DNA sequences)**

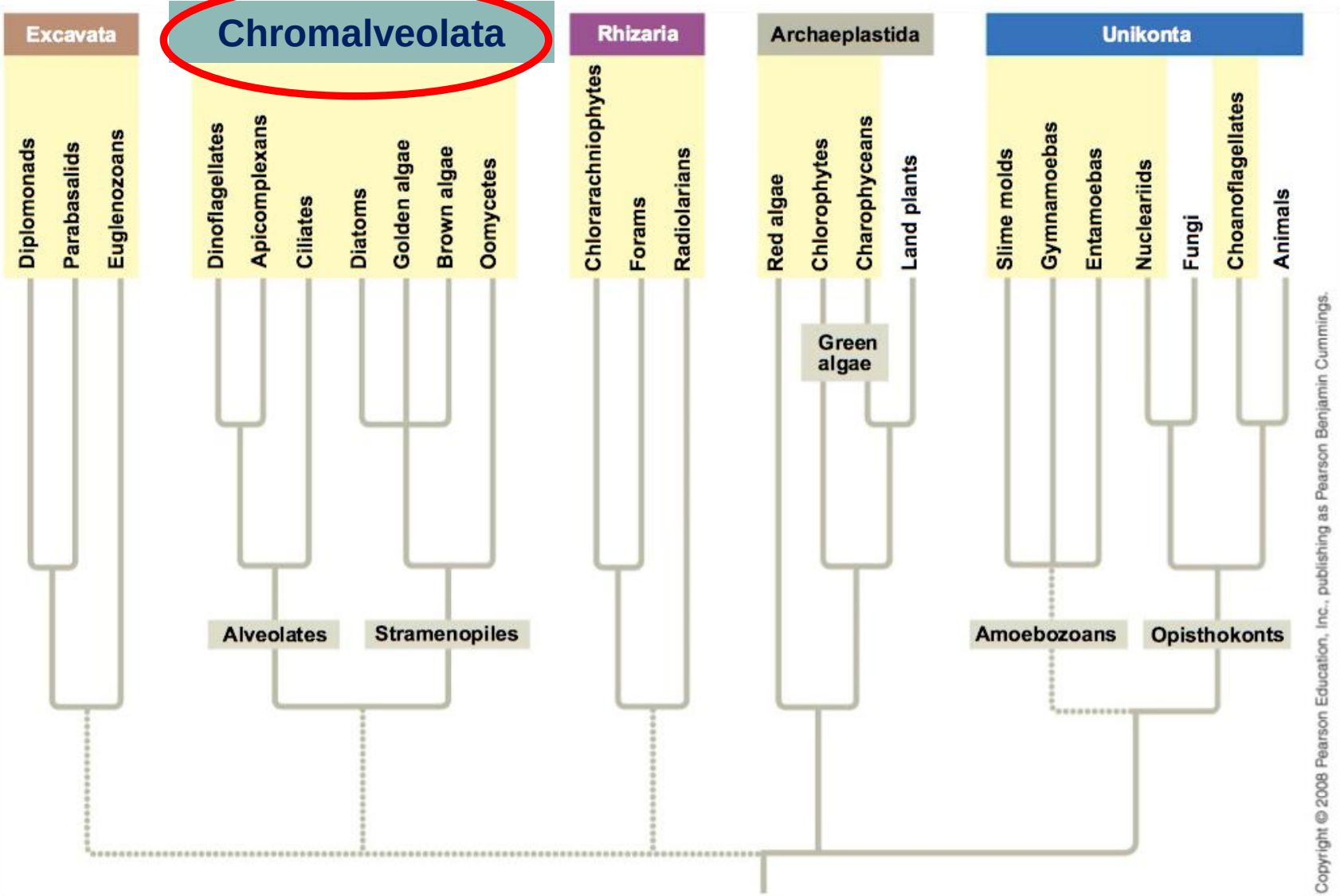




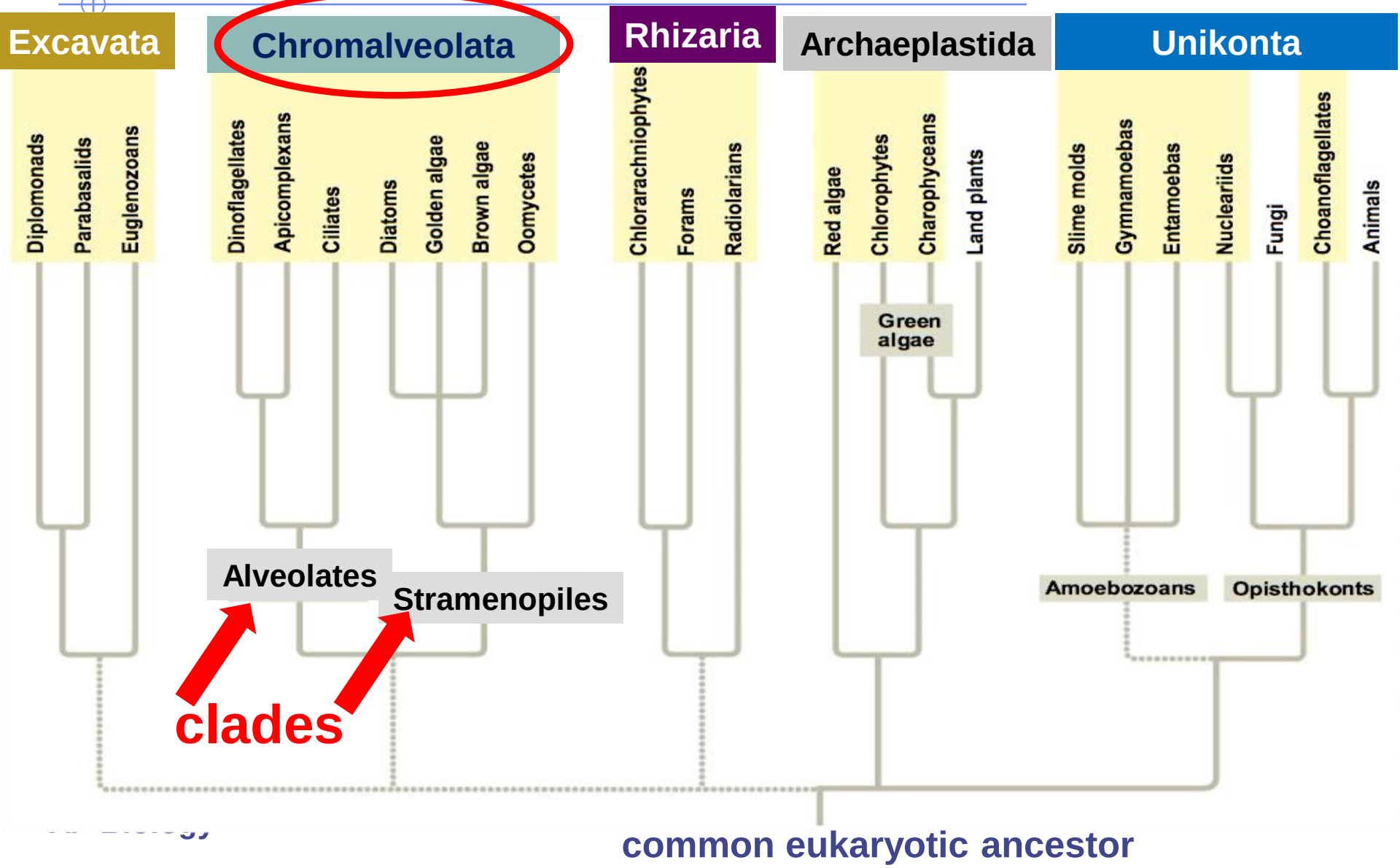
5 EUKARYOTIC SUPERGROUPS



Supergroup: Chromalveolata



Supergroup: Chromalveolata

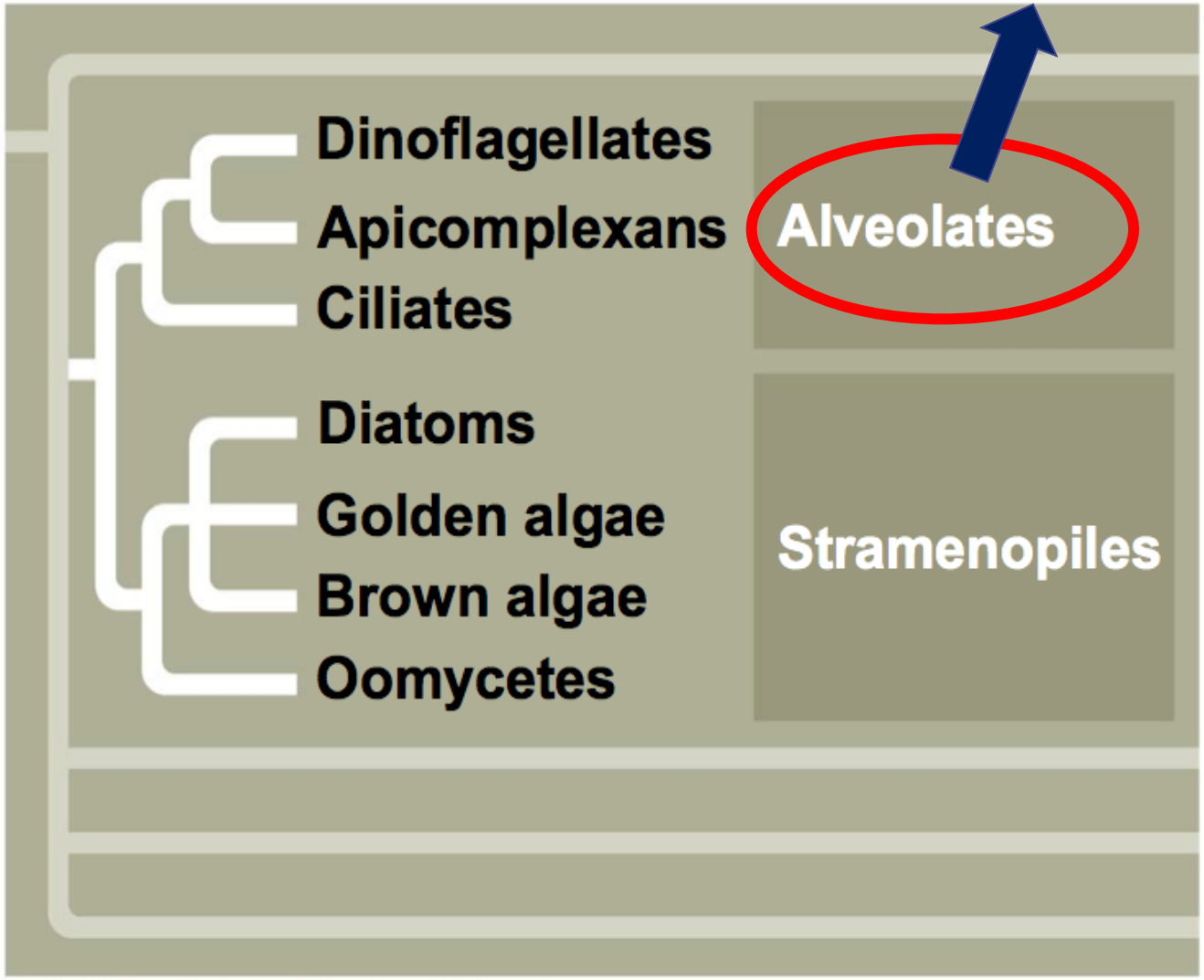


Supergroup: Chromalveolata

- monophyletic group: likely originated from ancient 2° endosymbiosis of red algae
- Includes clades:
  - Alveolates
  - Stramenopiles

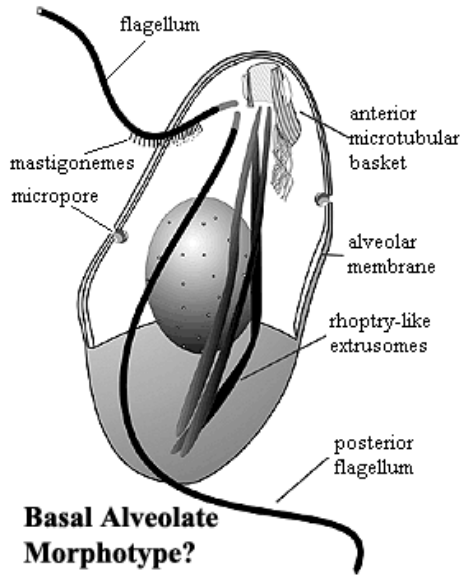
Chromalveolata

membrane-bound sacs (alveoli) just under c.m.



Excavata

Chromalveolata

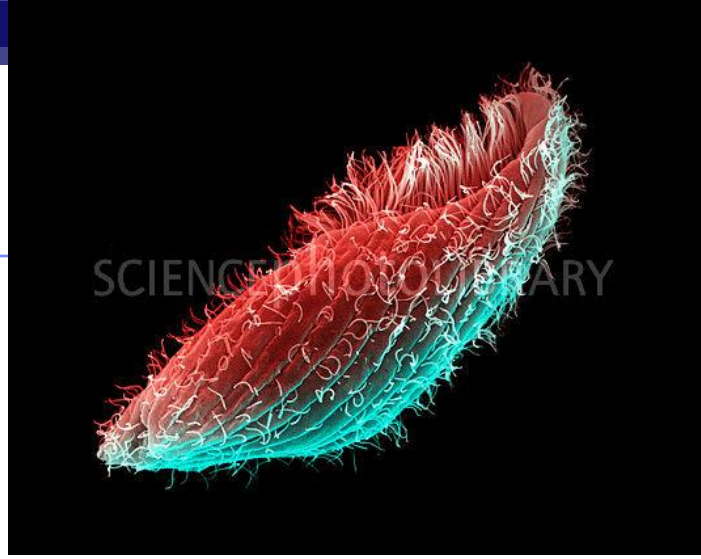


Rhizaria

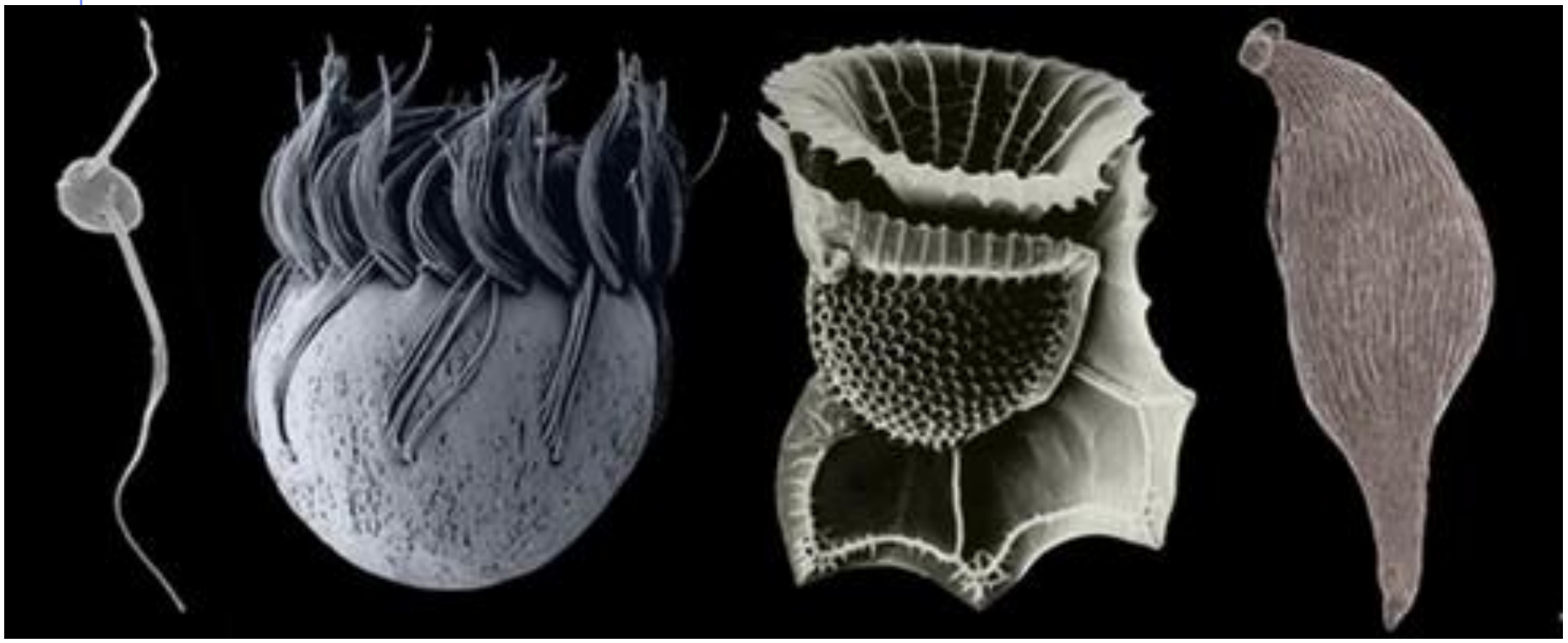
Archaeplastida

Unikonta

Clade: Alveolates

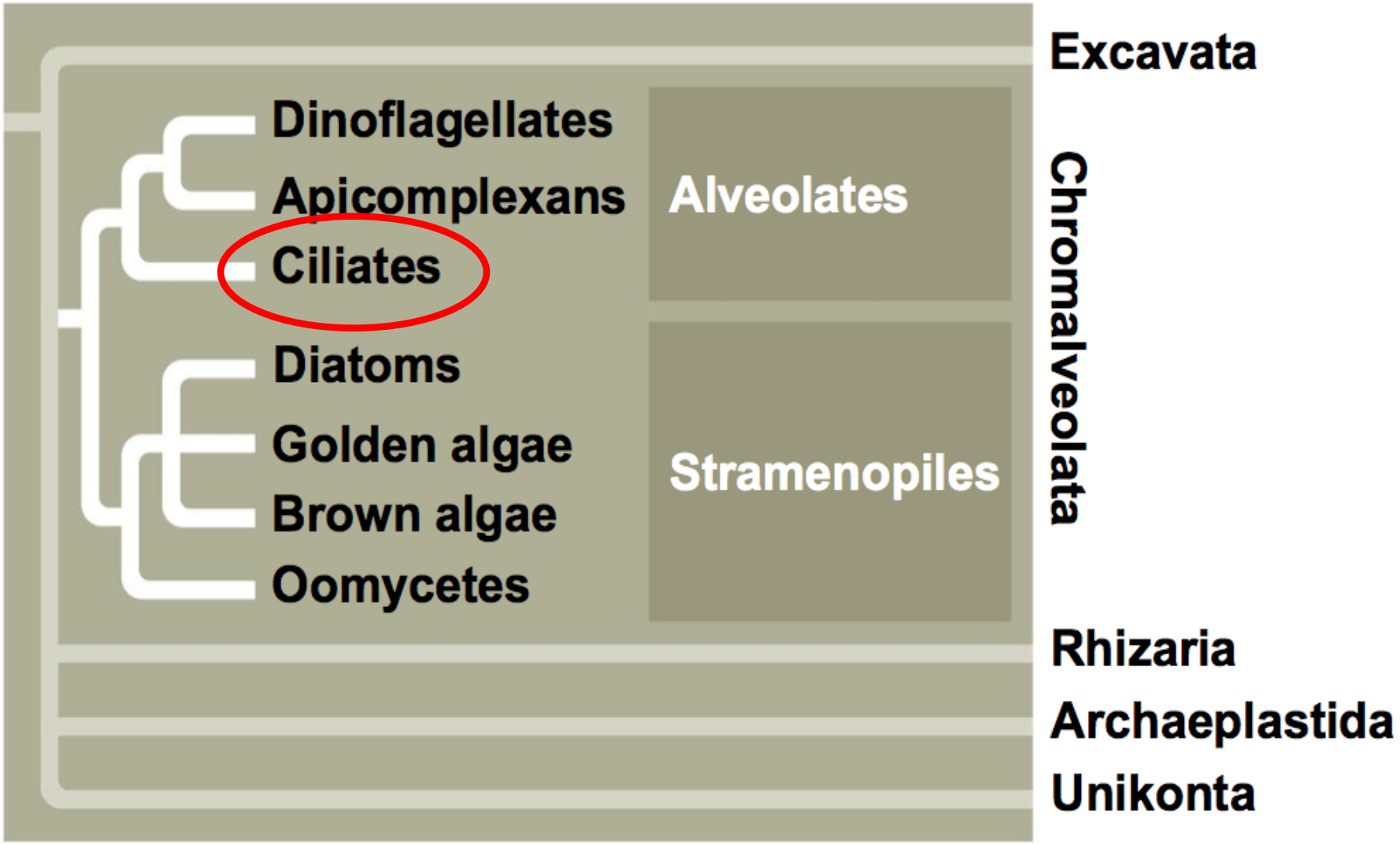


- Ciliates
- Dinoflagellates
- Apicomplexans



Ciliates

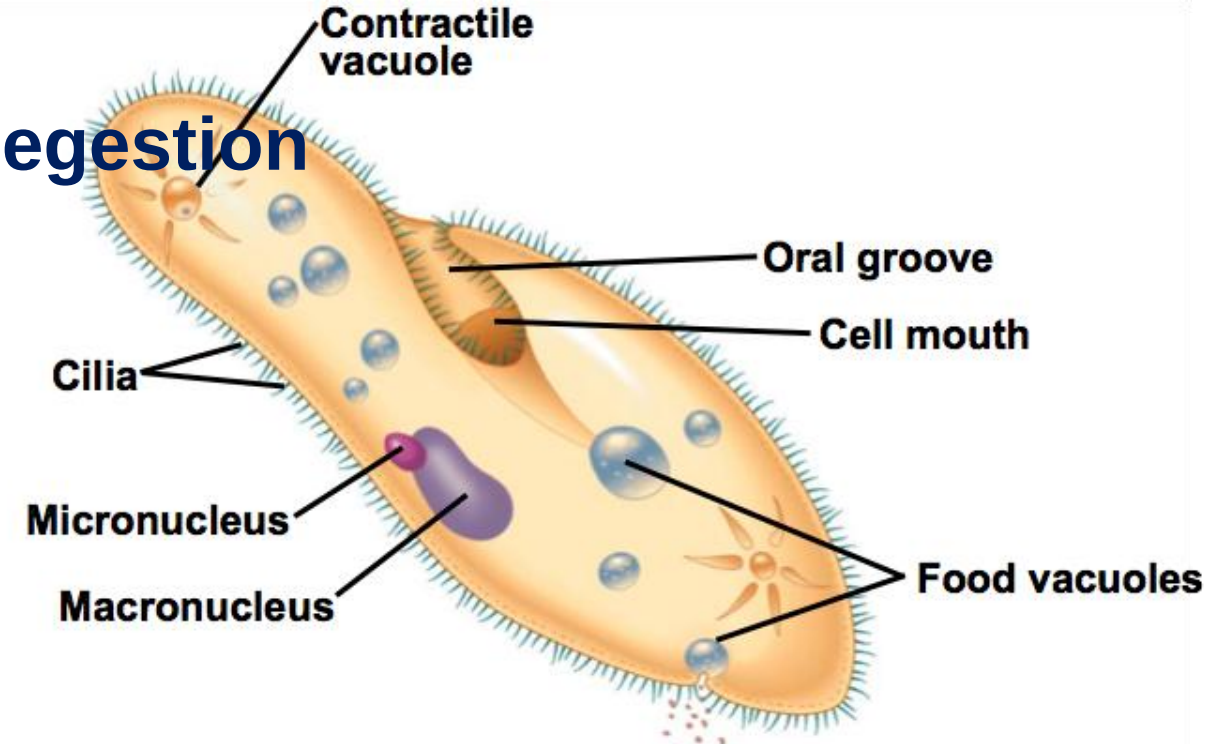
contain cilia (locomotion & nutr)



Ciliates

- **Nutrition**
  - **Heterotrophic**
  - **Ciliated oral groove for ingestion**
  - **Food vacuoles fuse with lysosomes for digestion**
  - **Anal pore for egestion**

Paramecium

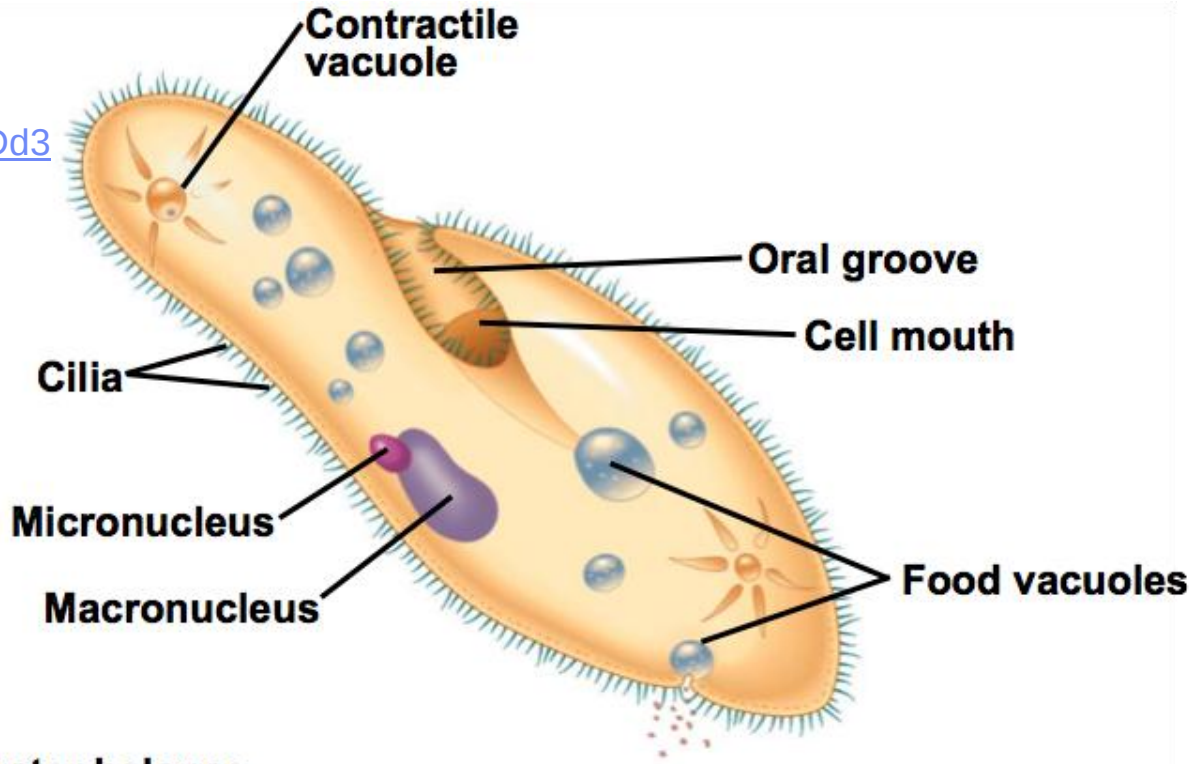


Ciliates

Paramecium

- **Contractile Vacuole: water balance**

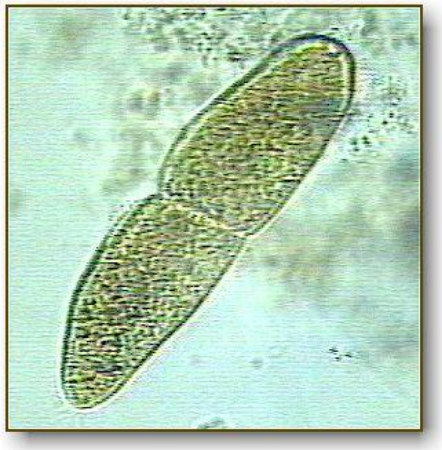
http://www.youtube.com/watch?v=iG6Dd3COug4&feature=player_detailpage



(a) Feeding, waste removal, and water balance

Ciliates: Reproduction

- Reproduction
  - Asexual by binary fission
  - Genetic exchange by conjugation

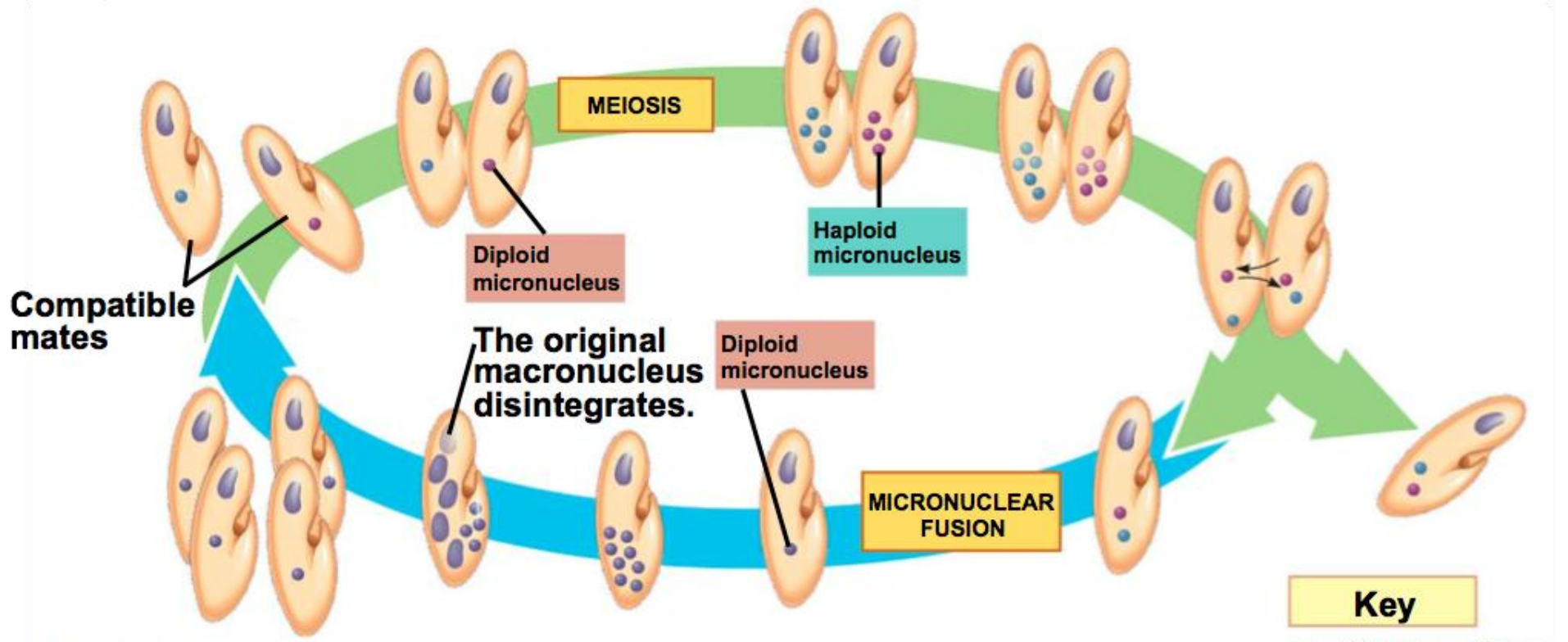


binary fission

conjugation

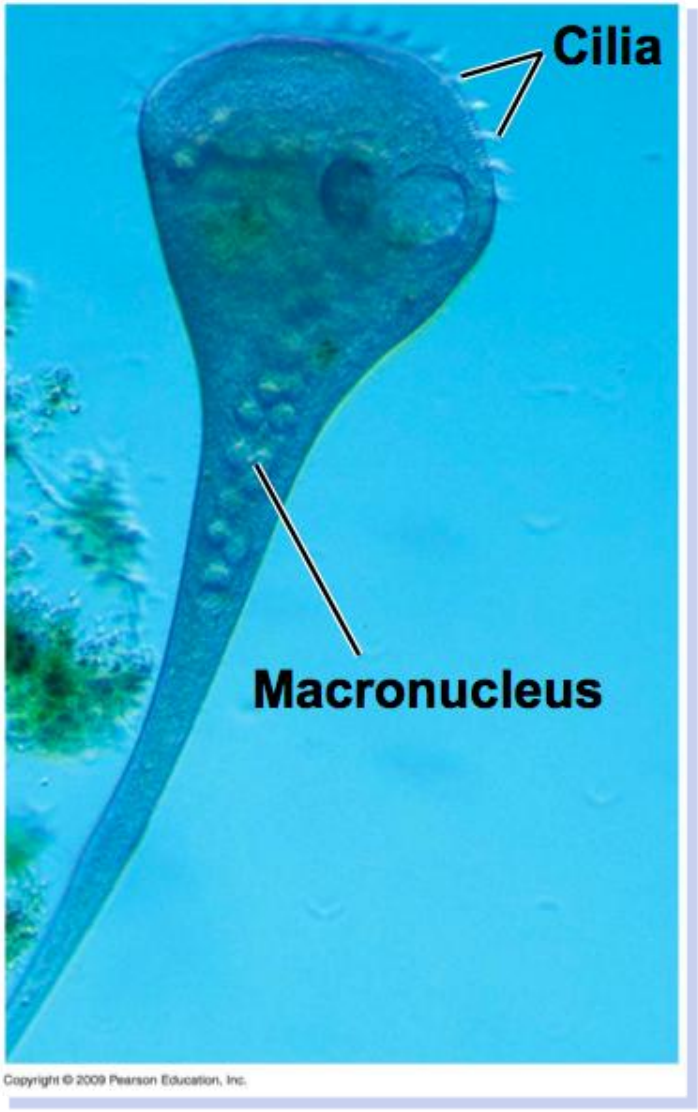
Ciliates: Reproduction

- Macronucleus & micronuclei
  - Micronuclei are diploid & undergo meiosis
    - genetic exchange by conjugation
    - can fuse to form macronucleus
  - Macronucleus is polyploid
    - directs daily cell functions



(b) Conjugation and reproduction

Ciliates



Stentor *is trumpet-shaped*

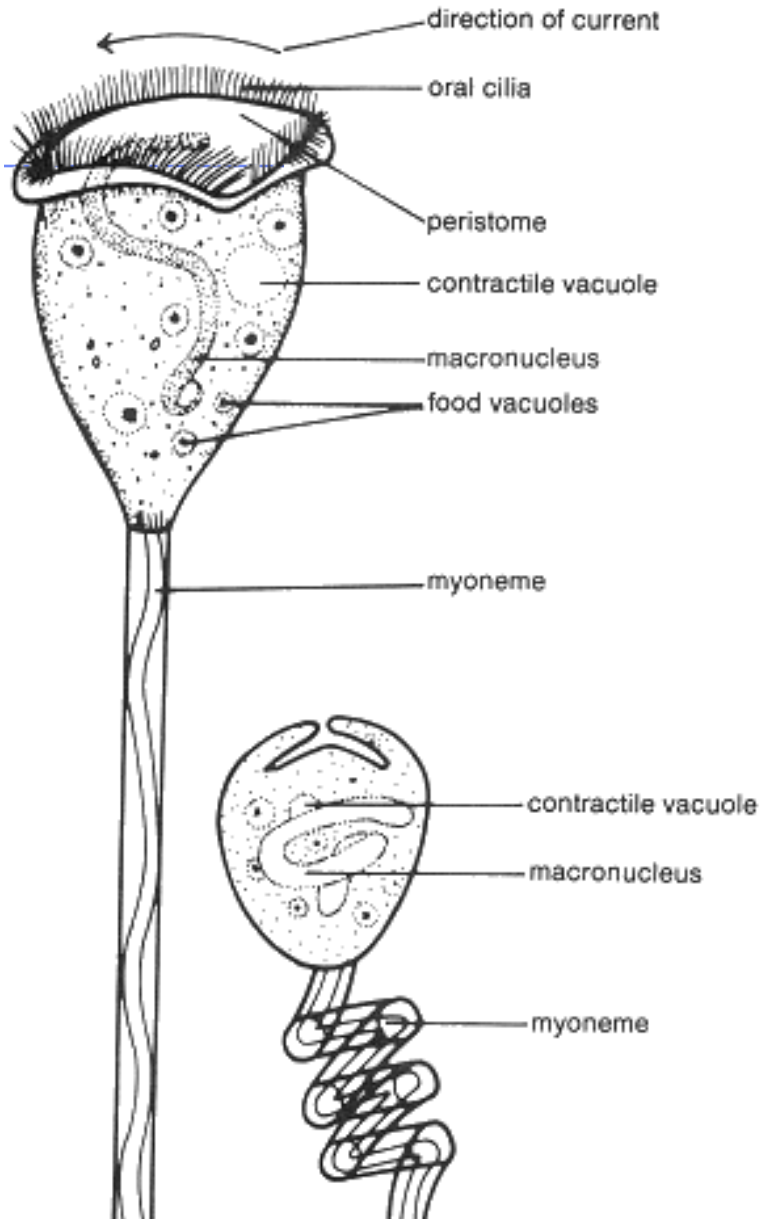
Ciliates

Stentor

- **myonemes**
- lengthwise contractile fibers
- actin + myosin
- shorten/lengthen body

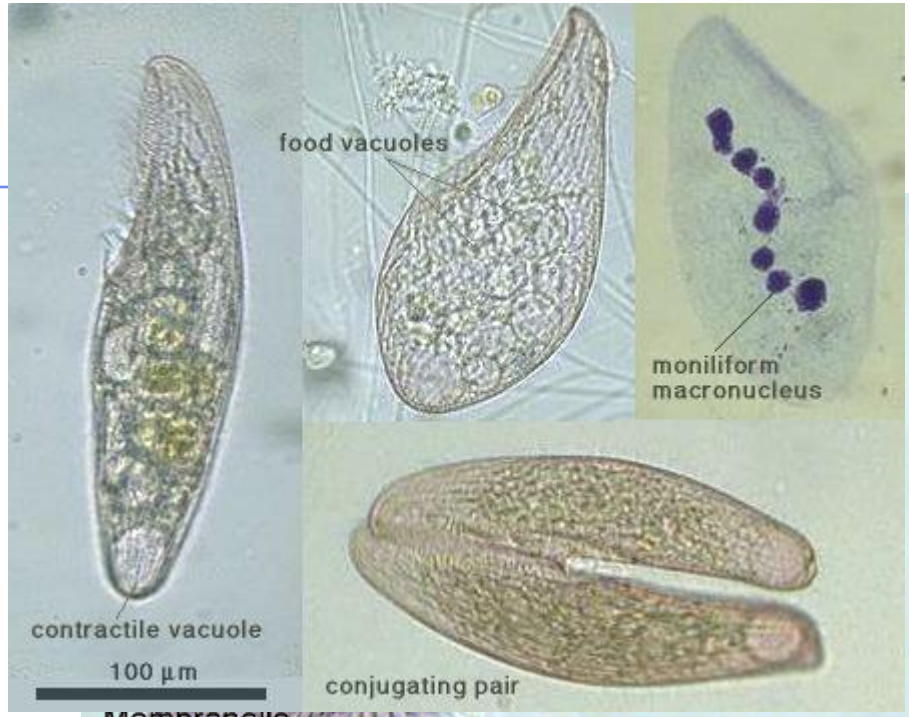
- attached (feeding) vs. free-swimming
- macronucleus resembles string of beads
- photophobic
- has photosensor called **stentorin**

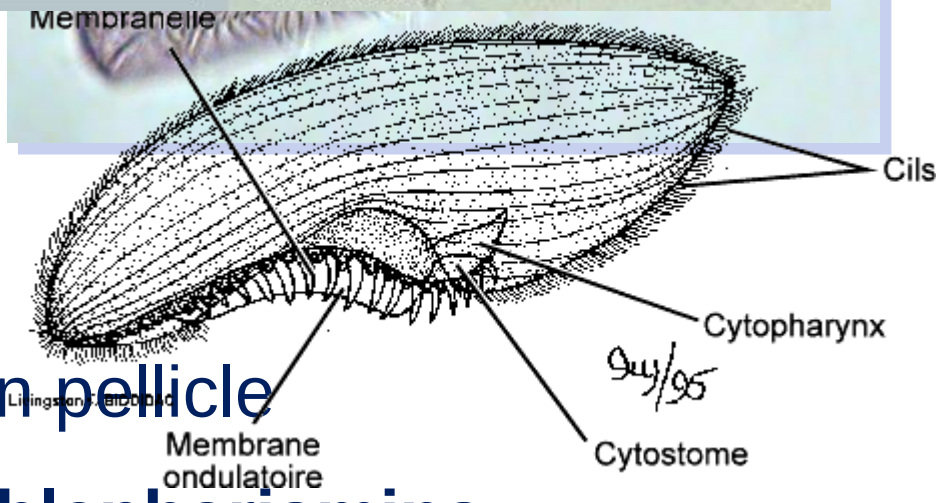
Ciliates



Vorticella (bell-shaped)

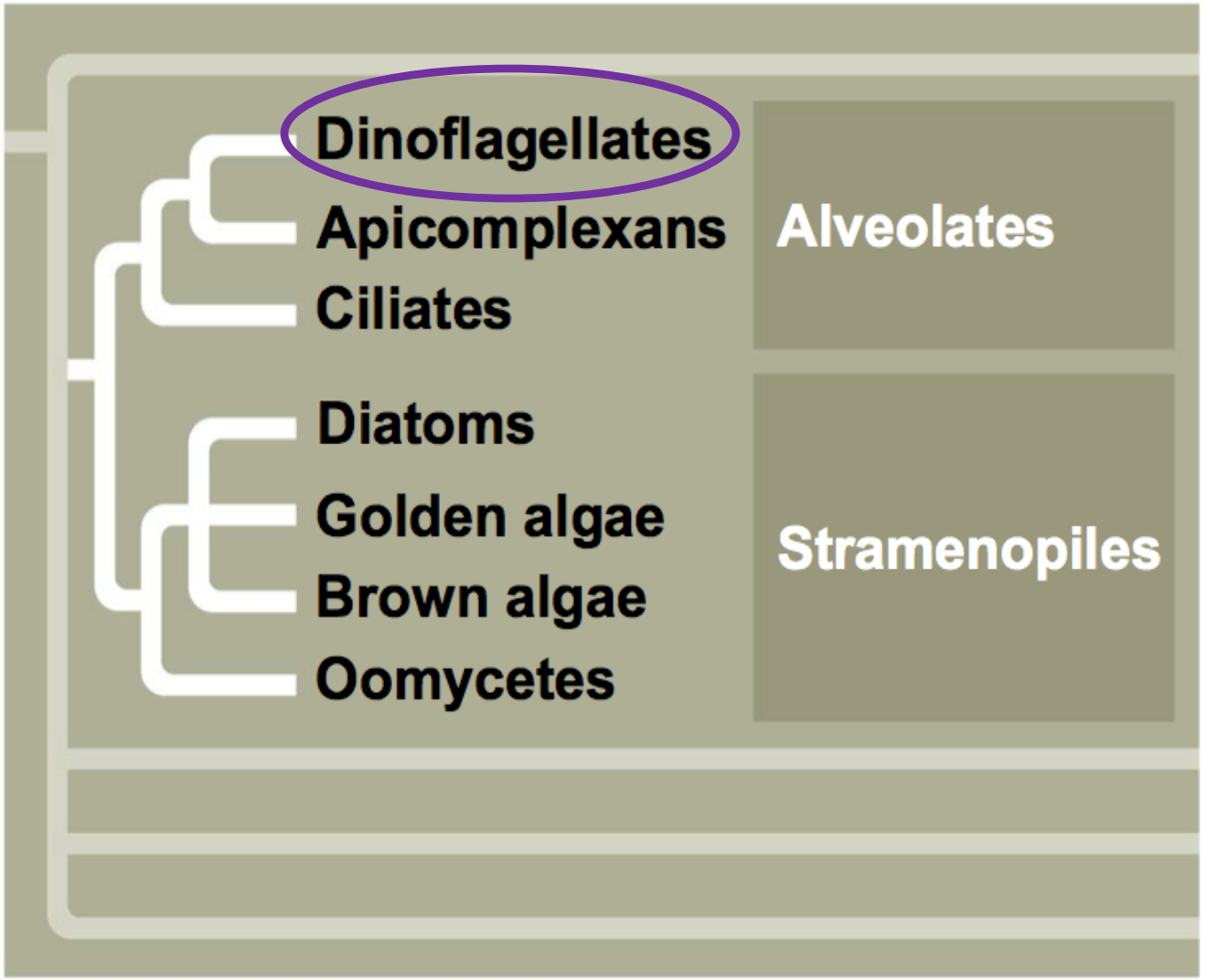
Ciliates
Blepharisma





- photophobic
- pale pink or red
  - photosensory pigments in pellicle
  - pigment granules called **blepharismins**

Dinoflagellates



Excavata

Chromalveolata

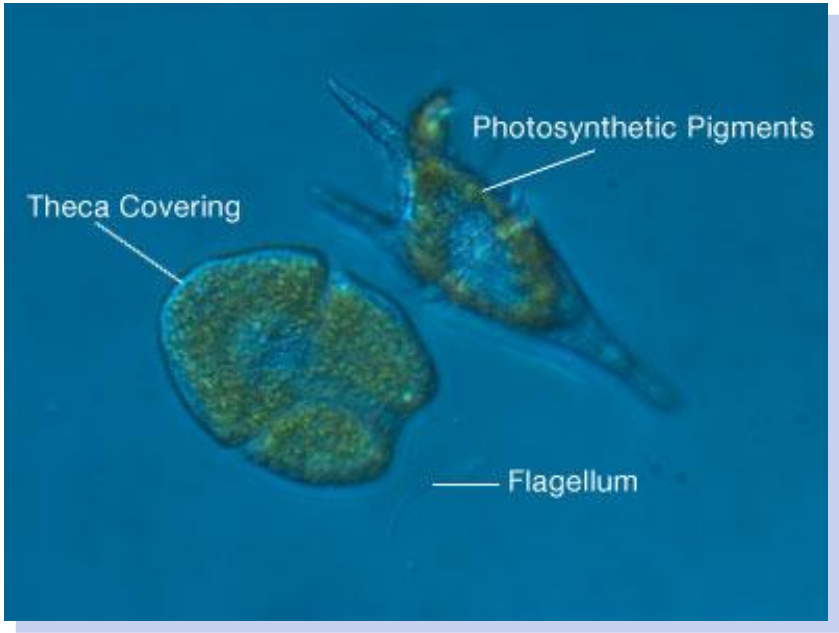
Rhizaria

Archaeplastida

Unikonta

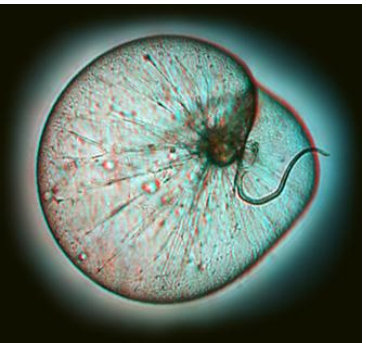
Dinoflagellates

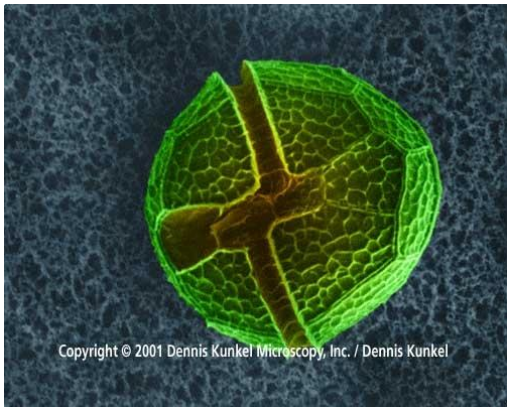
- Producers
- Photosynthetic
- Mixotrophs (some)
- Flagella for locomotion



Dinoflagellates cause toxic "Red Tide"

- nutrient imbalance causes dinoflagellate bloom
- dinoflagellates produce neurotoxin
  - kills fish
  - accumulates in filter feeders (ex. shellfish)
- food supply affected (for ecosystem & us)





Red Tide

http://news.discovery.com/videos/earth-bioluminescent-waves-explained.html

- **A bioluminescent algal bloom.**

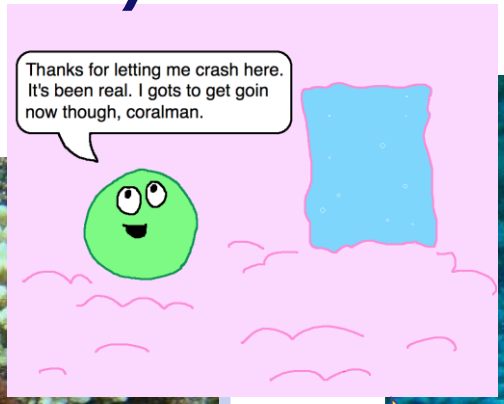
Zooxanthellae – dinofl. that are endosymbionts in coral animals

- **Corals engulf dinoflagellates but do not digest**
- **the zooxanthellae, live within the corals' tissues**
- mutualistic symbiosis:
  - Corals provide dinoflagellates a refuge safe refuge from predators and fluctuating environmental conditions.
  - The photosynthetic dinoflagellates provide the chief source of food (photosynthate or fixed carbon) for coral-building cnidarians.

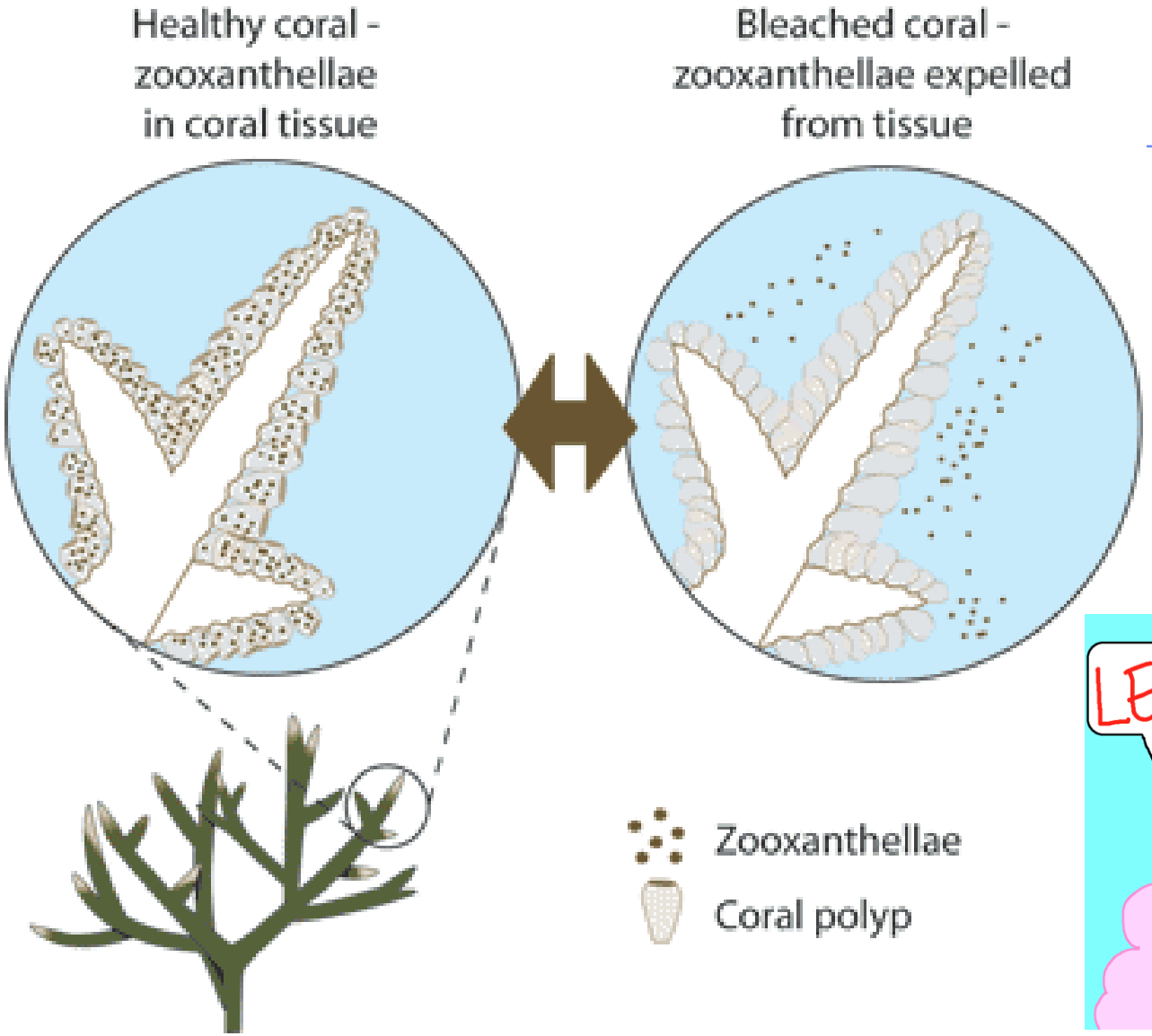
Individual cnidarian polyps (coral-building organisms).

Coral Bleaching

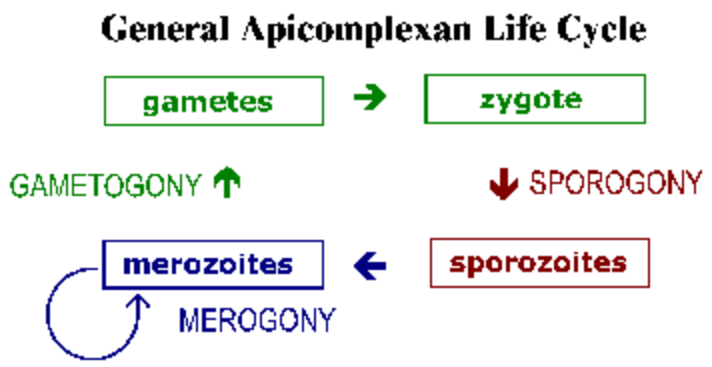
- Relationship between the zooxanthellae and the coral result in beautiful colors
- Coral bleaching: environmental stresses (UV, incr H2O temperature) causes zooxanthellae to leave



health of coral reef in jeopardy

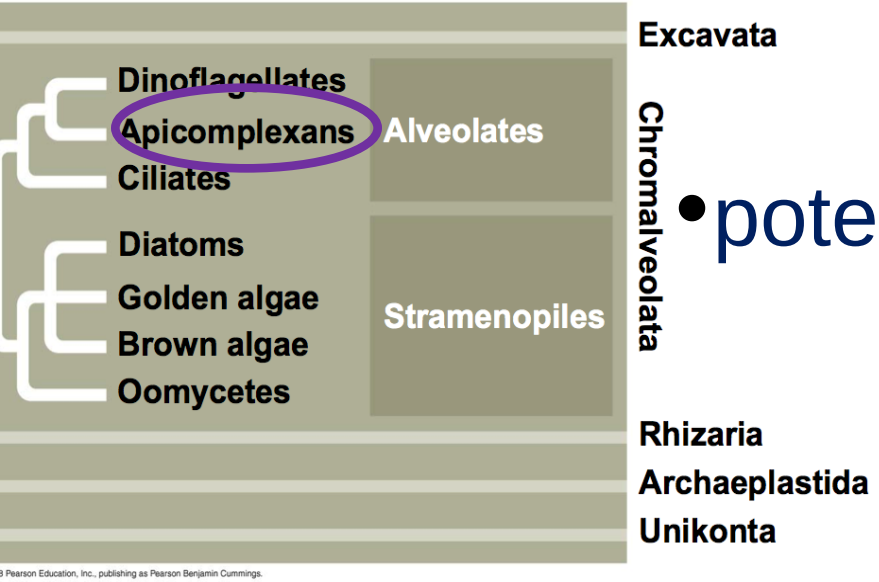


http://www.youtube.com/watch?v=60jof35WuAo&feature=player_detailpage

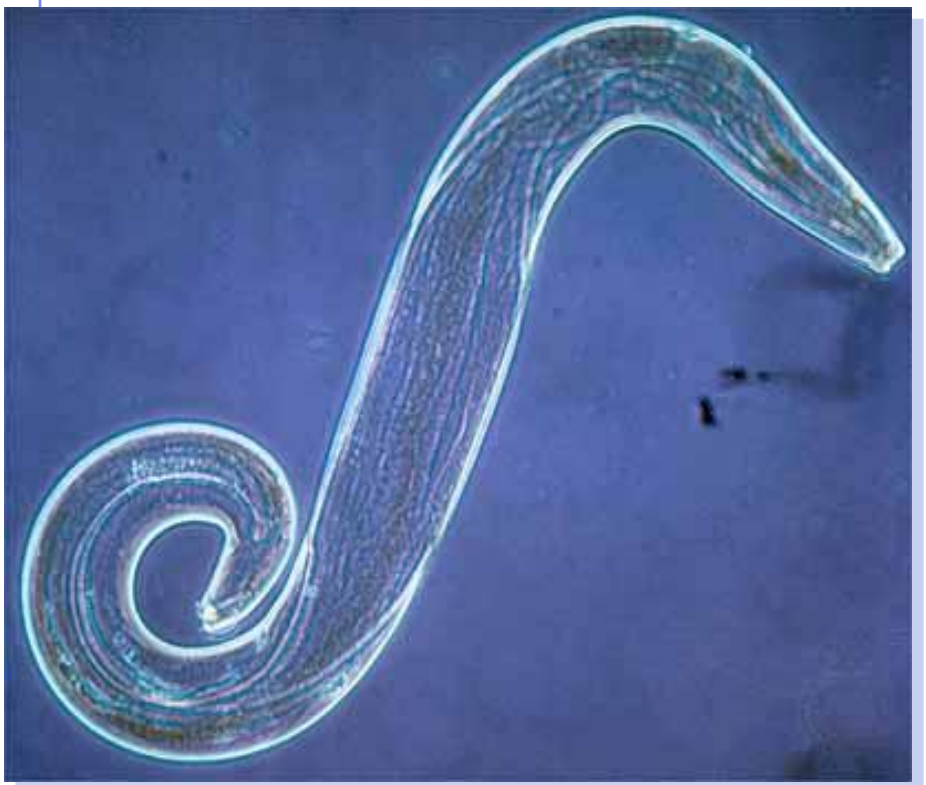


Apicomplexans

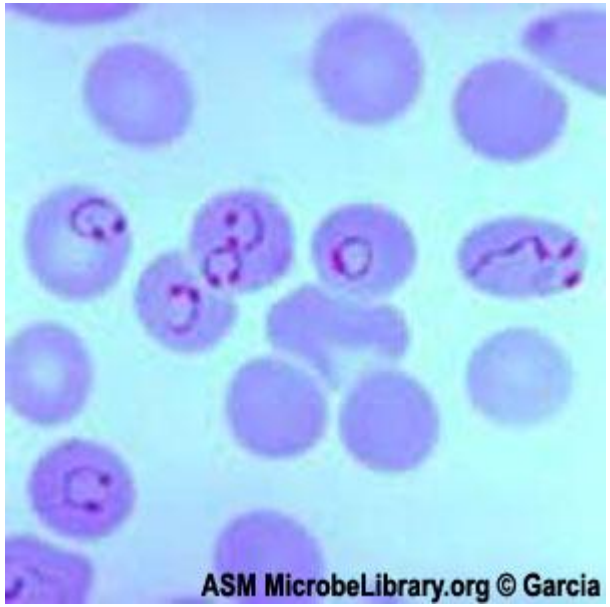
- obligate **parasites** of animals
- contains **complex** of organelles used to penetrate host cell
- **non-photosynthetic,** retain plastid called **apicoplast** likely related to red algae
- essential to organism
- potential target for anti-parasitic drugs



Apicomplexans

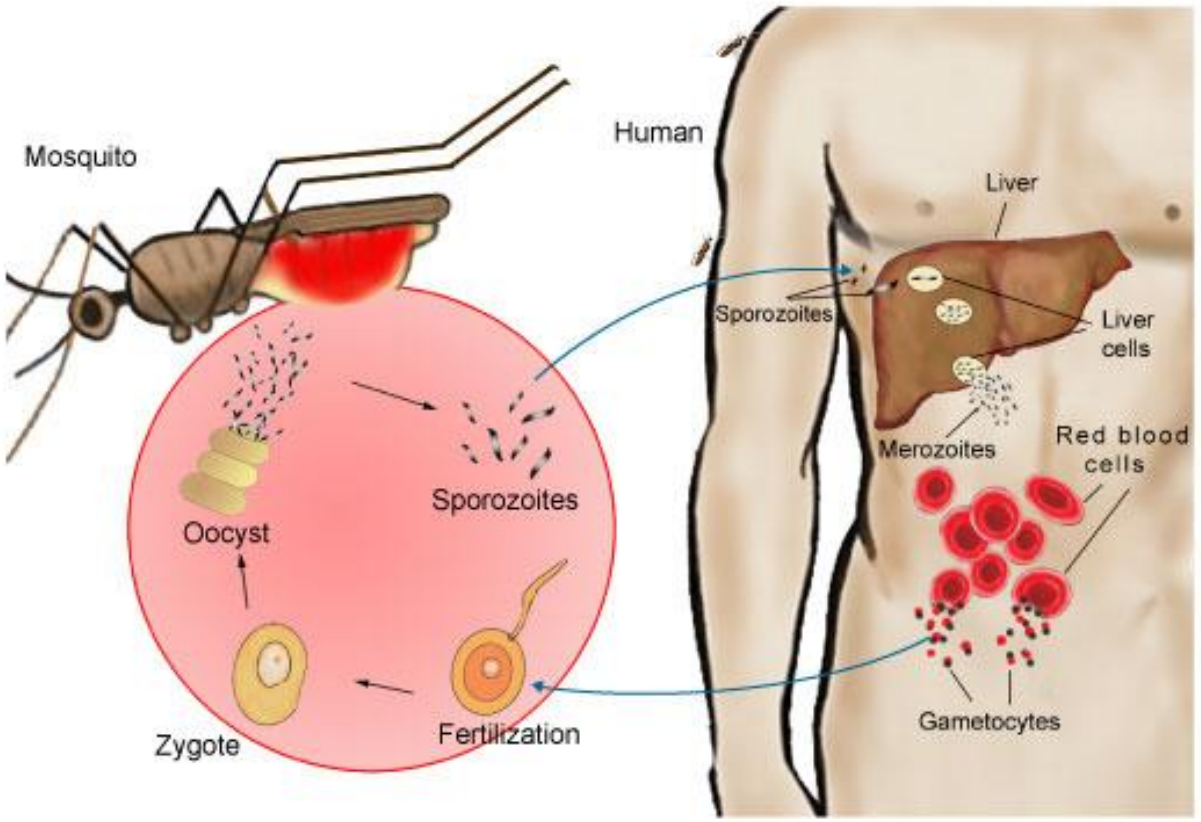


Plasmodium causes malaria in humans.



apicomplexans

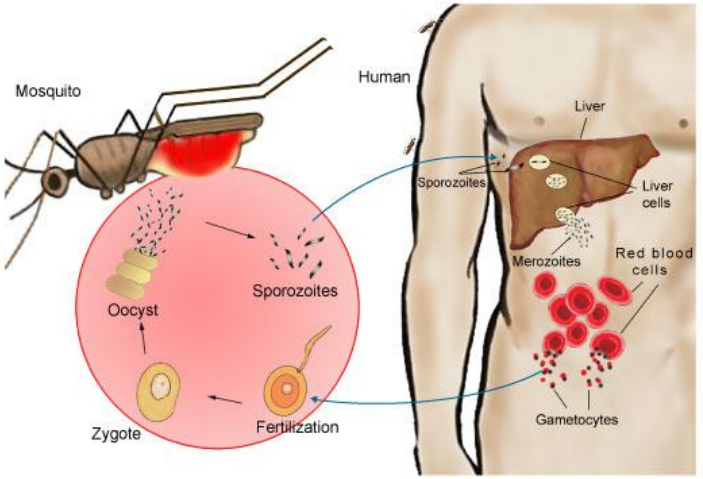
- life history of *Plasmodium*, the apicomplexan that causes malaria.



Life cycle of *Plasmodium*, protist that causes Malaria

Terminology

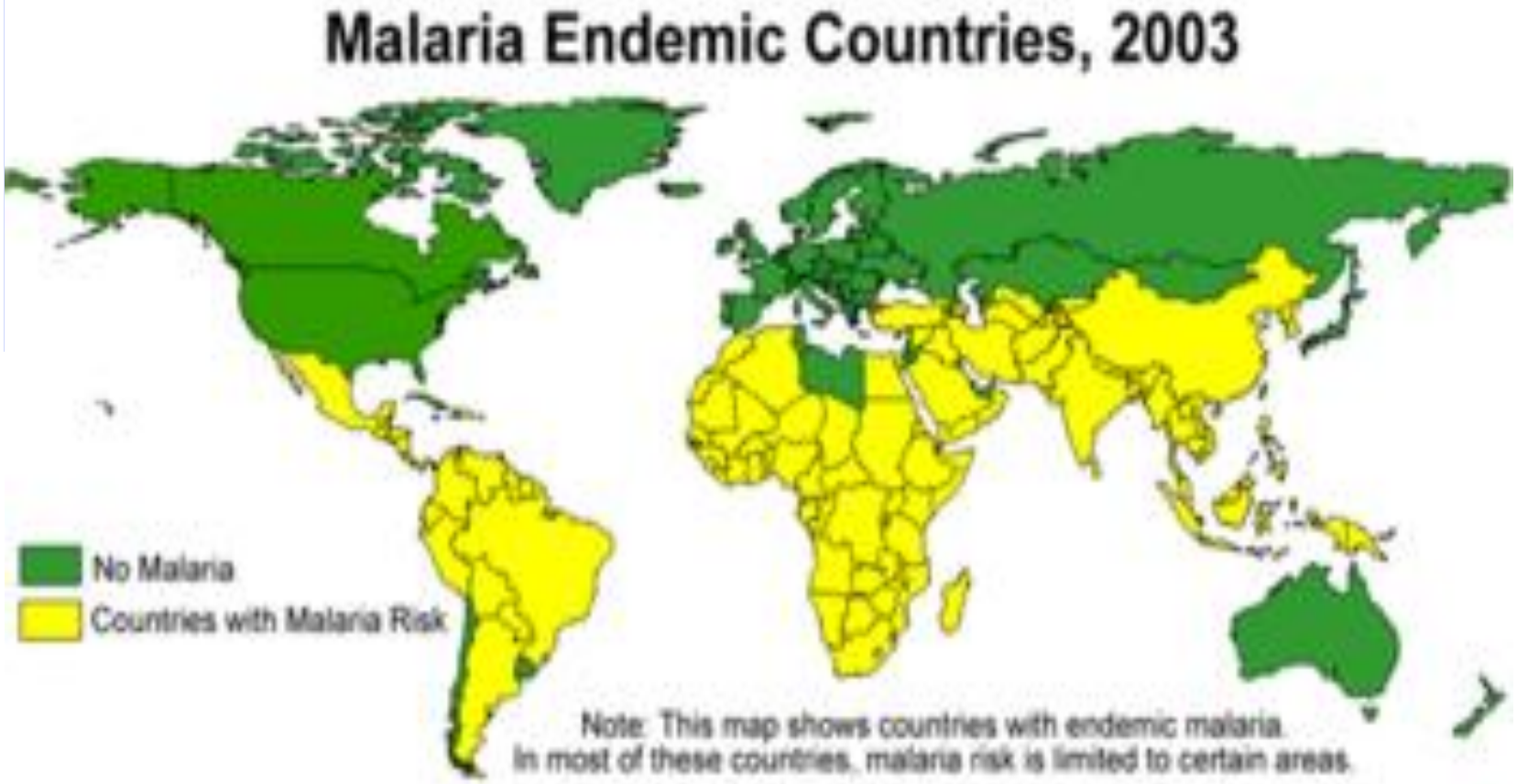
zoonotic infection: disease transmitted from animal to animal through a vector

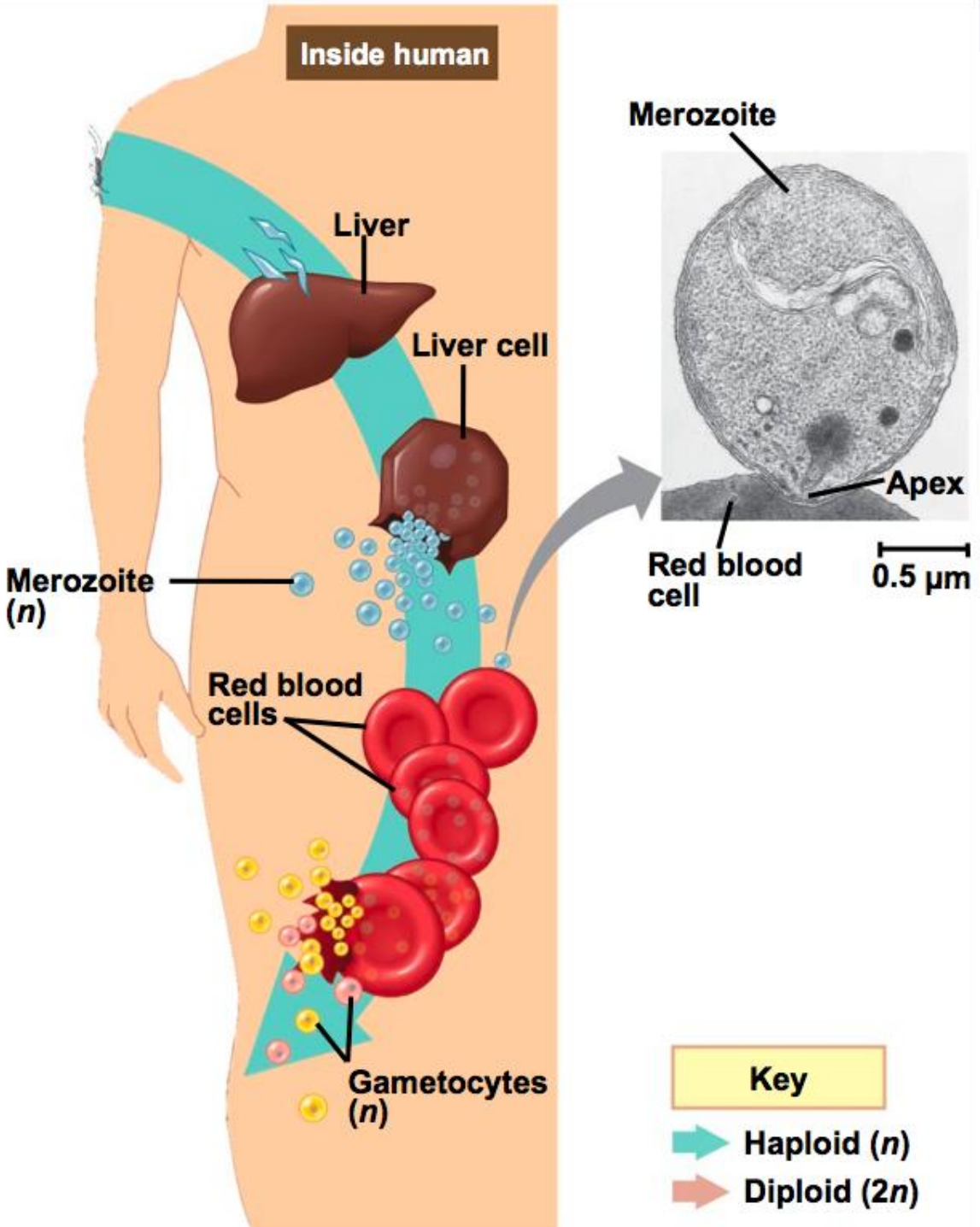


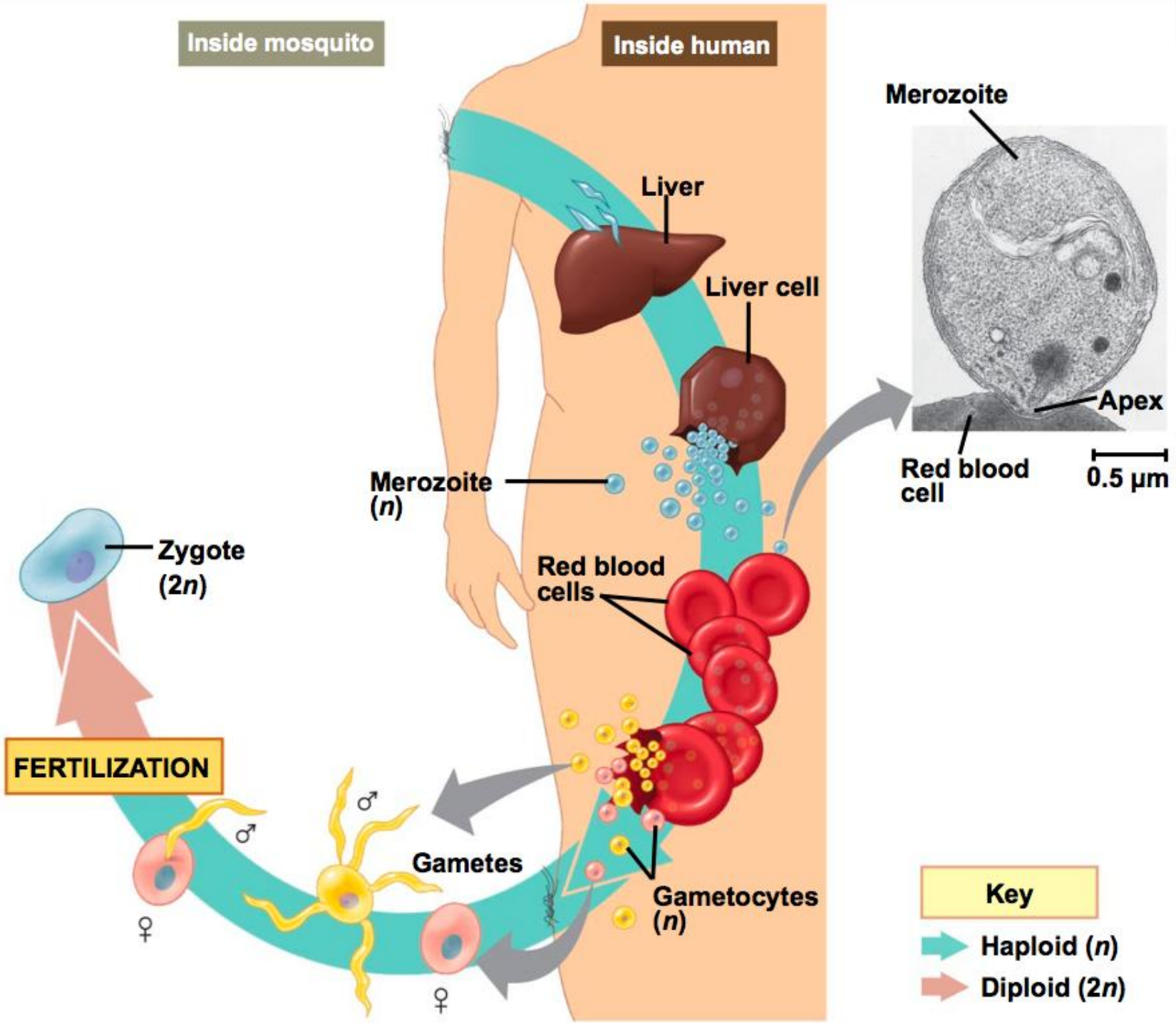
Life cycle of *Plasmodium*, protist that causes Malaria

vector: organism that *does not cause* disease but transmits pathogens from one host to another

250 million fevers, 1 million deaths annually




Inside human
Liver
Liver cell
Merozoite
(n)
Red blood
cells
Gametocytes
(n)
Merozoite
Apex
Red blood
cell
0.5 µm
Key
Haploid (n)
Diploid (2n)


Inside mosquito
Inside human
Liver
Liver cell
Merozoite
(n)
Zygote
(2n)
Red blood
cells
FERTILIZATION
Gametes
Gametocytes
(n)
Merozoite
Apex
Red blood
cell
0.5 µm
Key
Haploid (n)
Diploid (2n)

Inside mosquito

Inside human

Sporozoites
(*n*)

Liver

Liver cell

Oocyst

MEIOSIS

Merozoite
(*n*)

Zygote
(2*n*)

Red blood
cells

FERTILIZATION

♂

♂

♀

Gametes

♂

♀

Gametocytes
(*n*)

Merozoite

Apex

Red blood
cell

0.5 µm

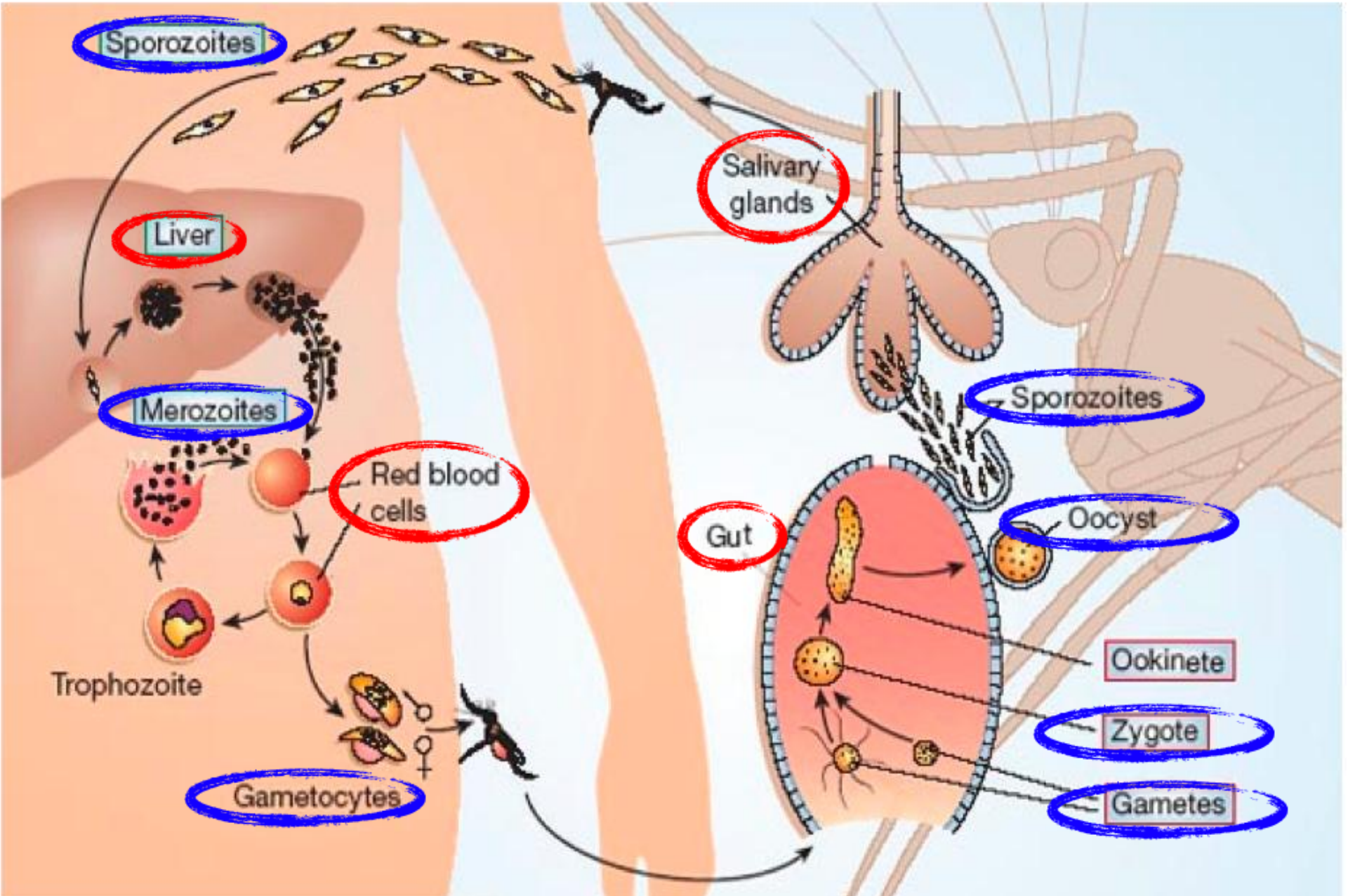
Key

Haploid (*n*)

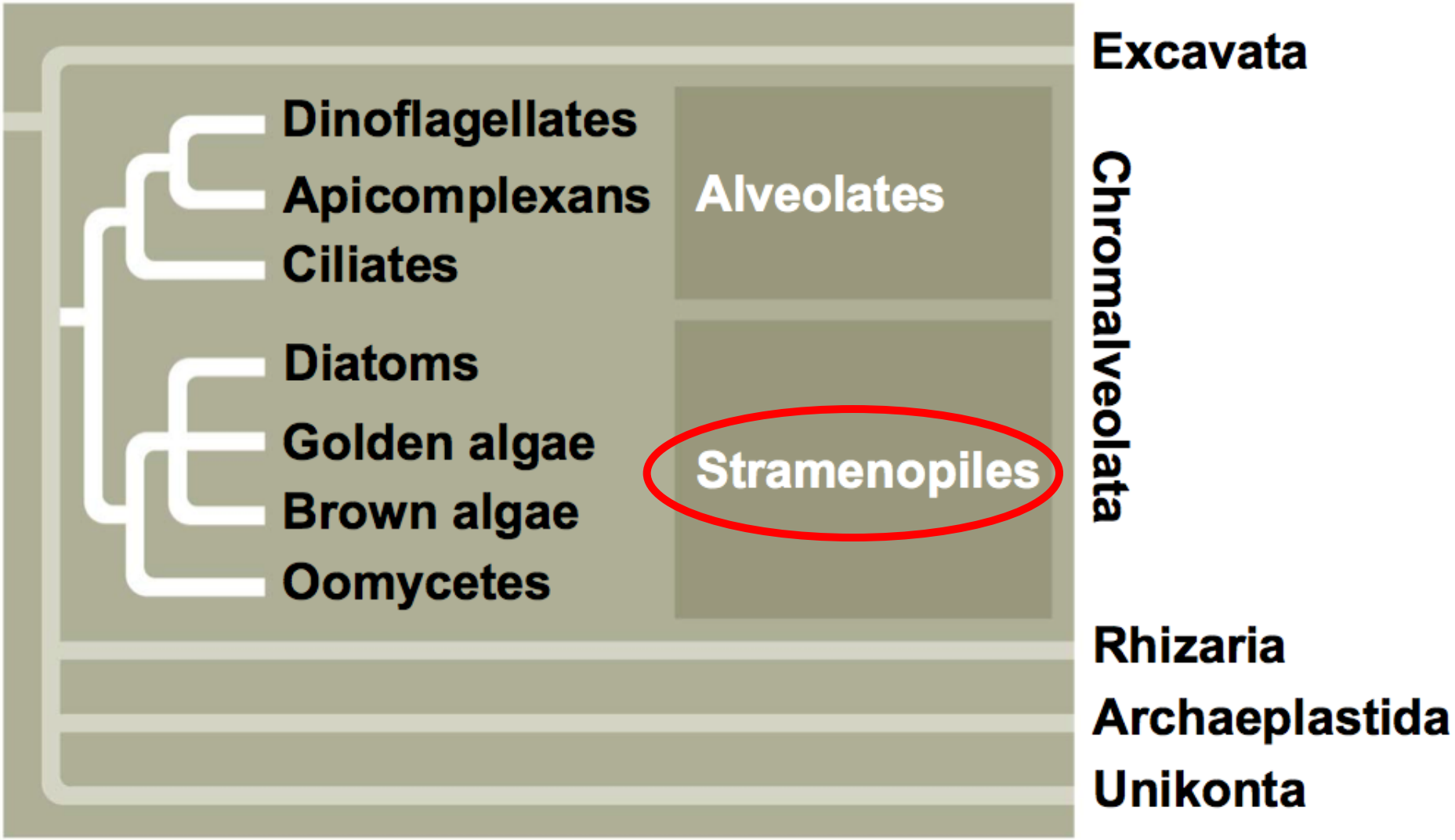
Diploid (2*n*)

AP Biolo

vertebrate mosquito

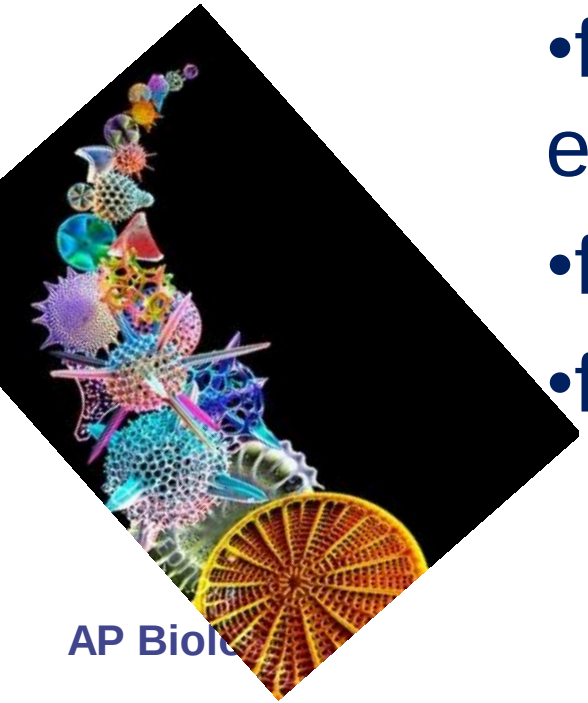


Supergroup: Chromalveolata



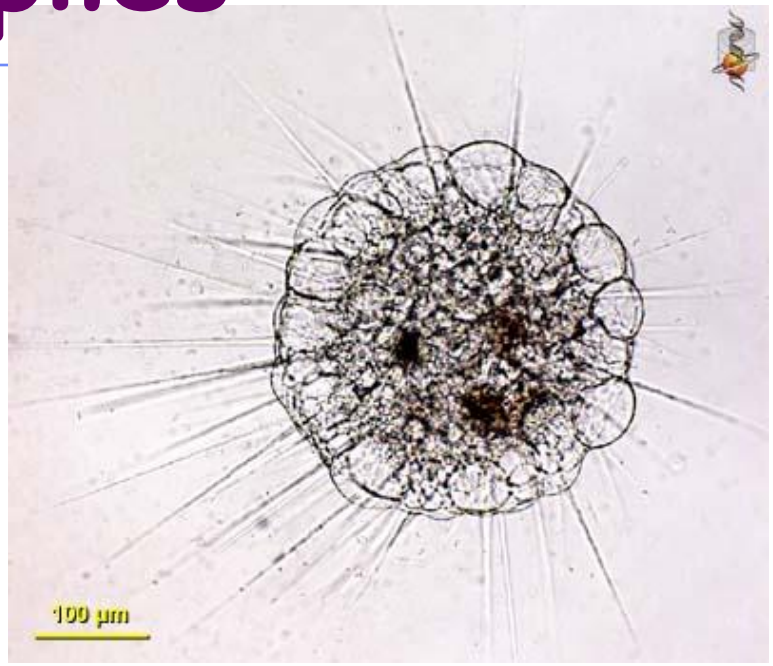
Diatoms

- major **producer**
- single-celled algae
- produce glass-like shells or "**tests**" made of silica
  - fossilized diatoms = diatomaceous earth
  - filtering agents or abrasives
  - found in toothpaste



Clade: Stramenopiles

Actinosphaerium



"heliozoan"

- no test/shell
- hair-like axopods supported by microtubules
  - capture prey
  - adhere to surfaces for movement

Oomycetes

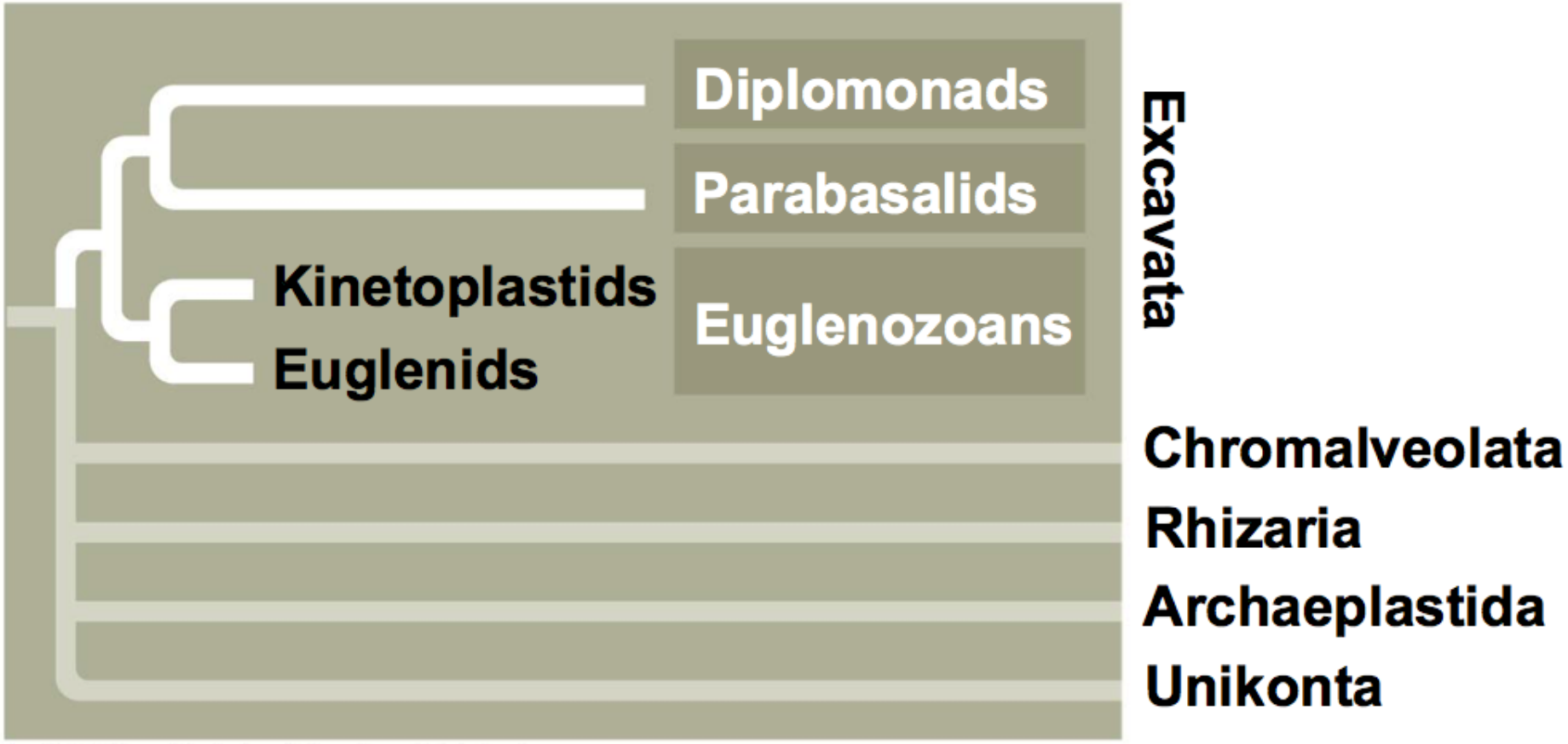
fish "fungus" (not a fungus!)

potato blight Irish potato famine (1840s)

- **Water molds, rusts, mildews**
- contain plastids related to red algae but non-photosynthetic
- decomposers & parasites
- filamentous multinucleate hyphae resemble fungi
- cell walls contain cellulose
- (not related to fungi)

Key Concept/Eukaryote Supergroup	Major Clades	Key Morphological Characteristics	Specific Examples
Concept 28.3 **Chromalveolates** may have originated by secondary endosymbiosis	**Alveolates** Dinoflagellates Apicomplexans Ciliates	Membrane-bounded sacs (alveoli) beneath plasma membrane	*Pfiesteria*, *Plasmodium*, *Paramecium* 
	Stramenopiles Oomycetes Diatoms Golden algae Brown algae	Hairy and smooth flagella	*Phytophthora*, *Laminaria* 

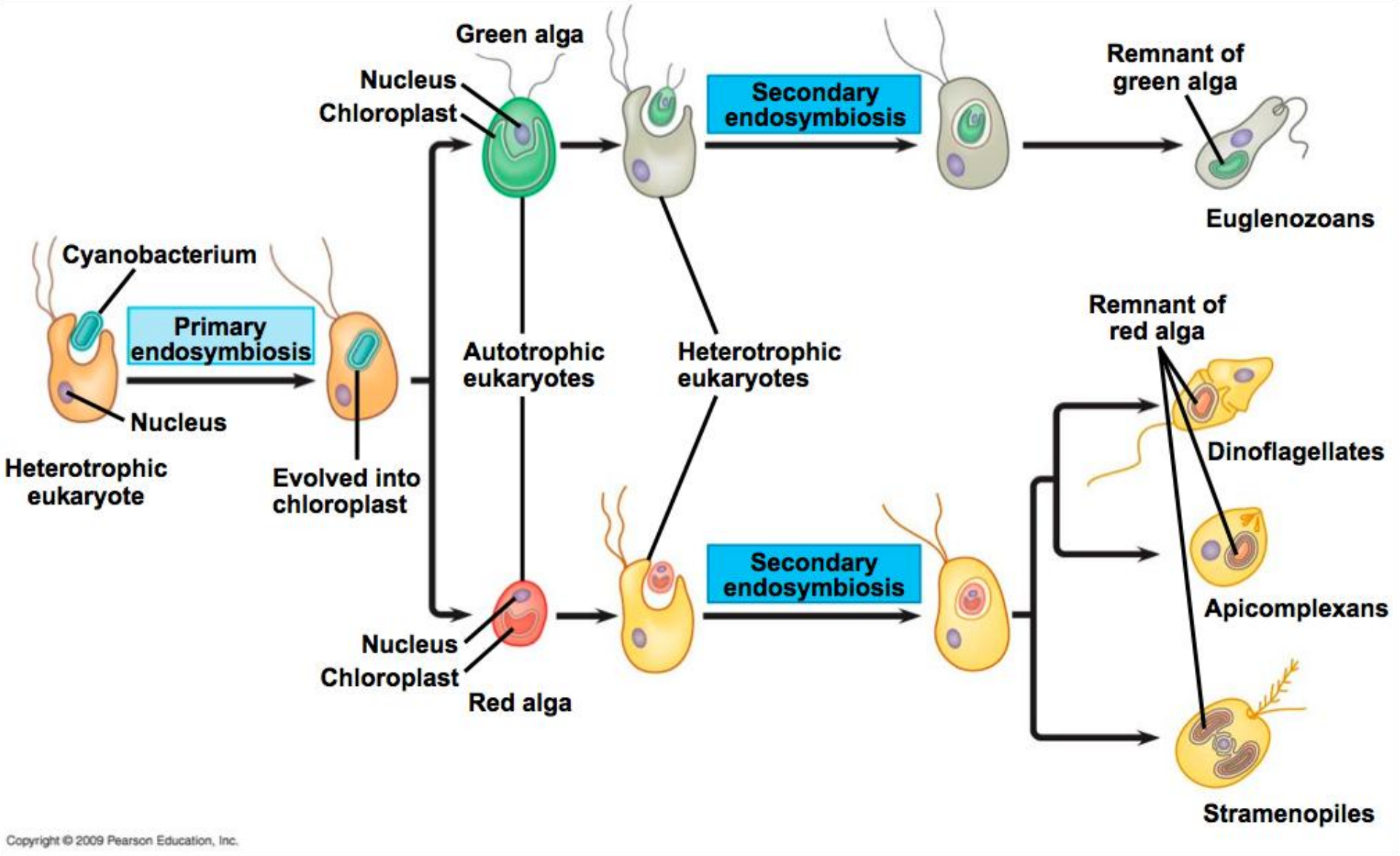
Supergroup: Excavata



Supergroup: Excavata

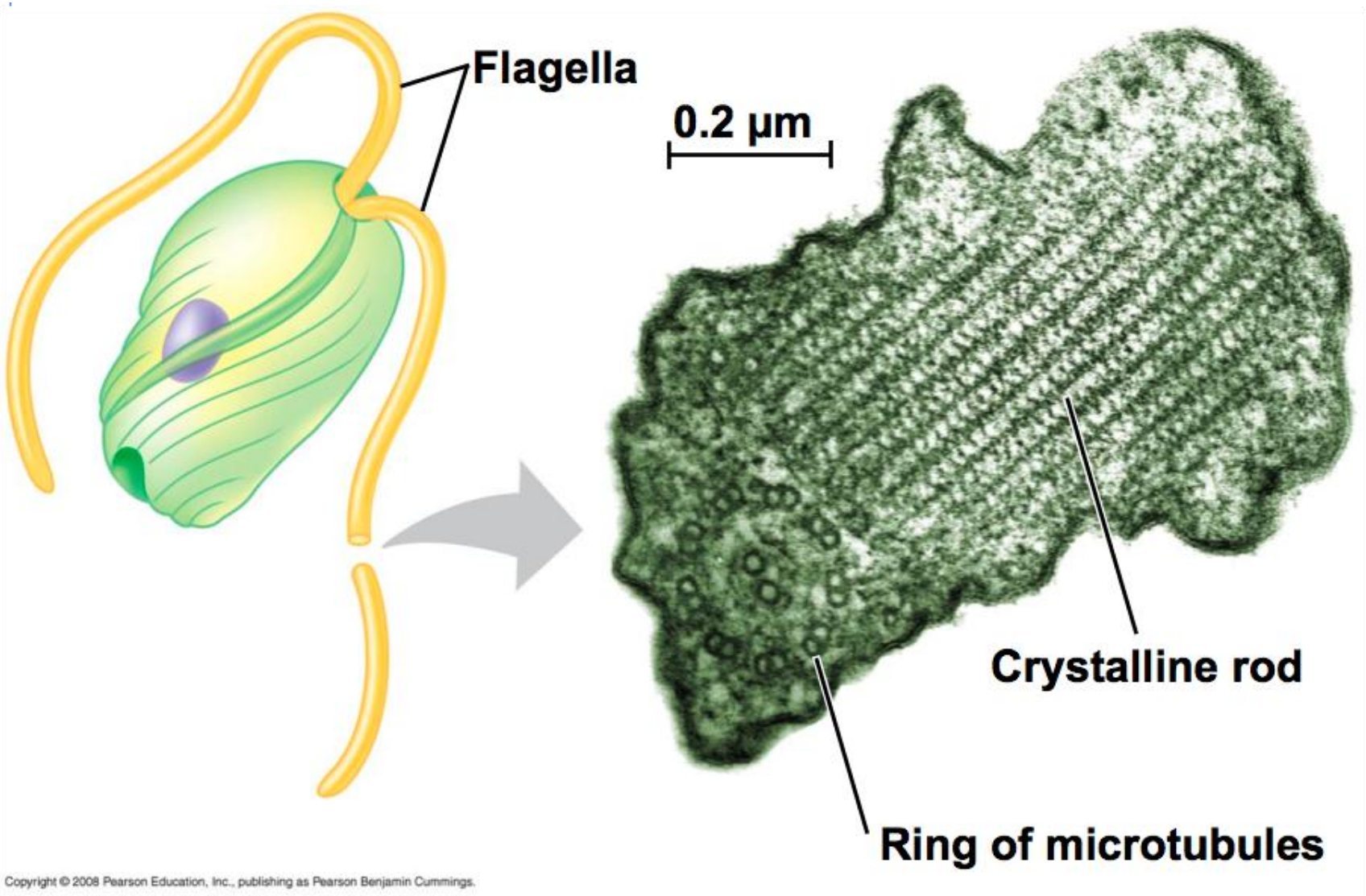
- monophyletic group likely originated from ancient 2˚ endosymbiosis

- many members have excavated feeding "groove" on one side of body
  - subgroups
  - **Diplomonads**
  - **Parasabalids**
  - **Euglenozoans**



Euglenozoans

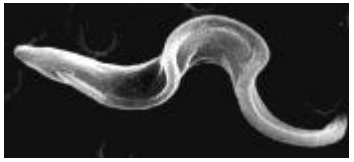
- diverse group
  - predatory heterotrophs
  - photosynthetic autotrophs
  - parasites
- **spiral or crystalline rod in flagella**
- include...
  - **Kinetoplastids**
  - **Euglenids**



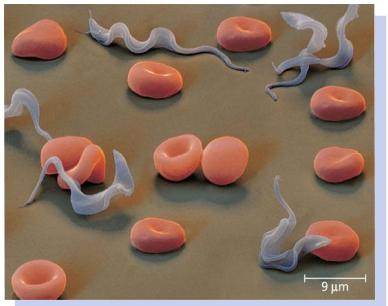
Euglenozoans: Kinetoplastids

- members contain atypical single large mitochondrion called **kinetoplast**

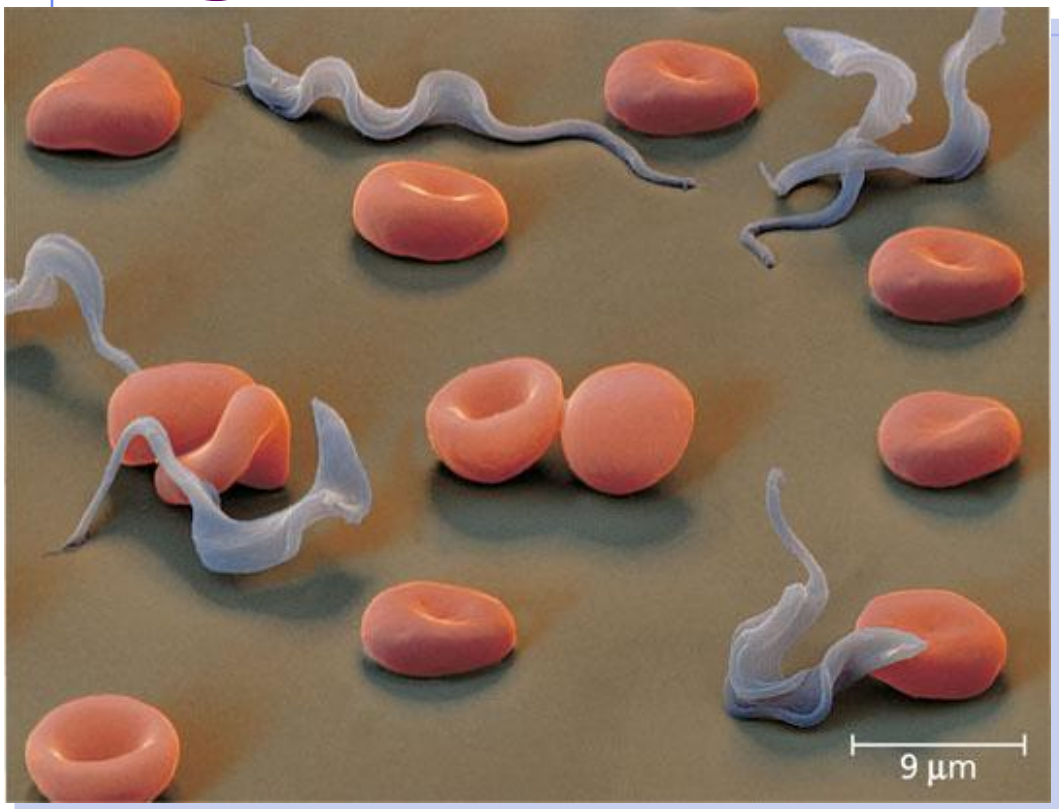
- free-living & parasitic species



- **Trypanosomes (African Sleeping Sickness)**
- obligate parasite of humans
- **cause disease**



Euglenozoans: Kinetoplastids



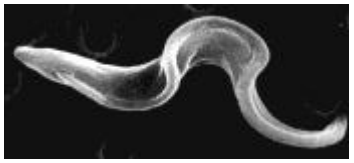
Trypanosomes cause...

African sleeping sickness

South American Chagas disease

Euglenozoans: Kinetoplastids

Trypanosoma



Similarities to *Plasmodium*...

(recall, plasmodium causes malaria)

- **complicated life cycle**
- **vector is insect**
- **cell surface proteins change every 3 weeks to avoid host immune system**

Euglenozoans: Kinetoplastids

Trypanosoma causes disease in humans.

African sleeping sickness

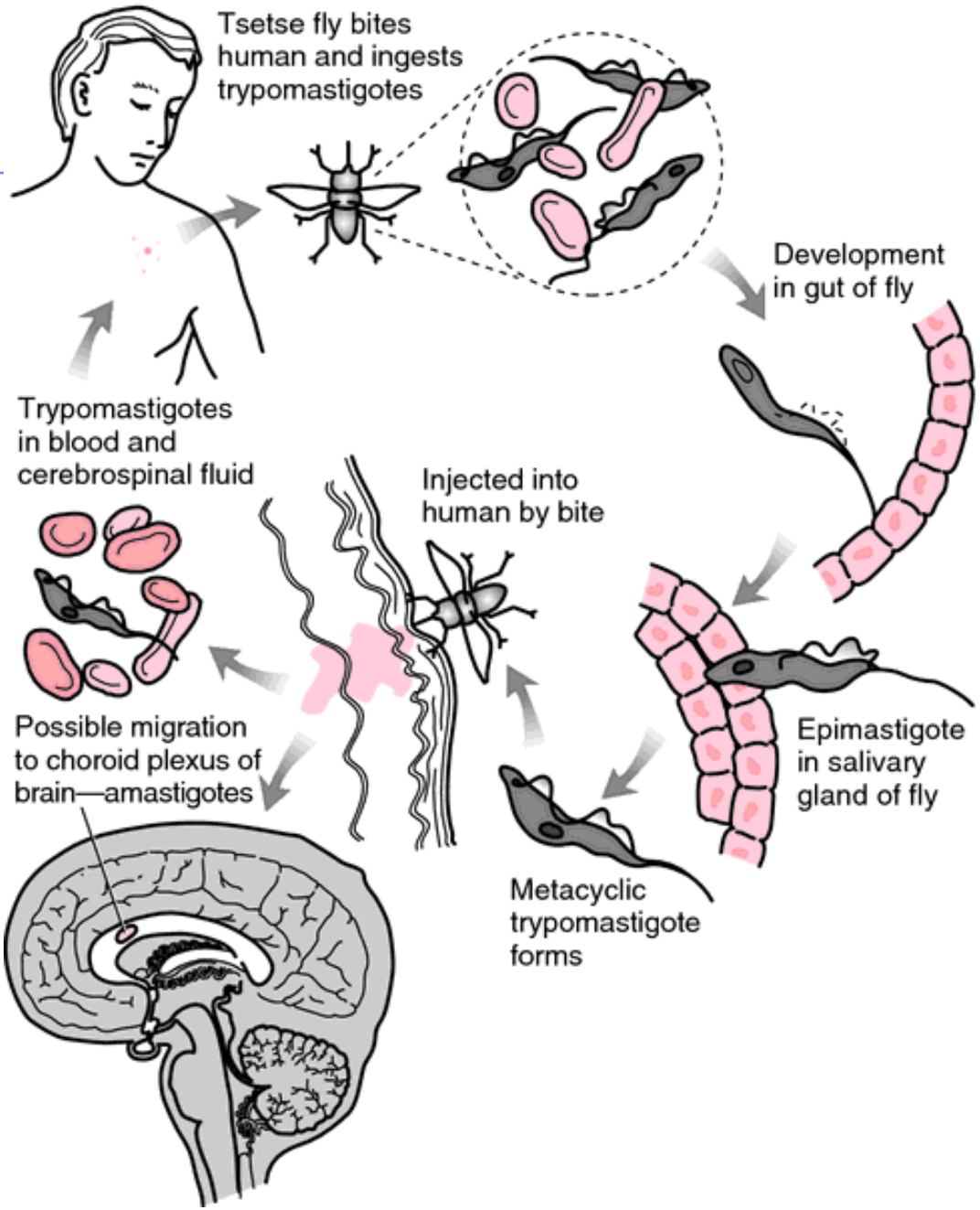
- **vector = tsetse fly**
- affects nervous system
- classic sleeping symptoms

South American Chagas disease

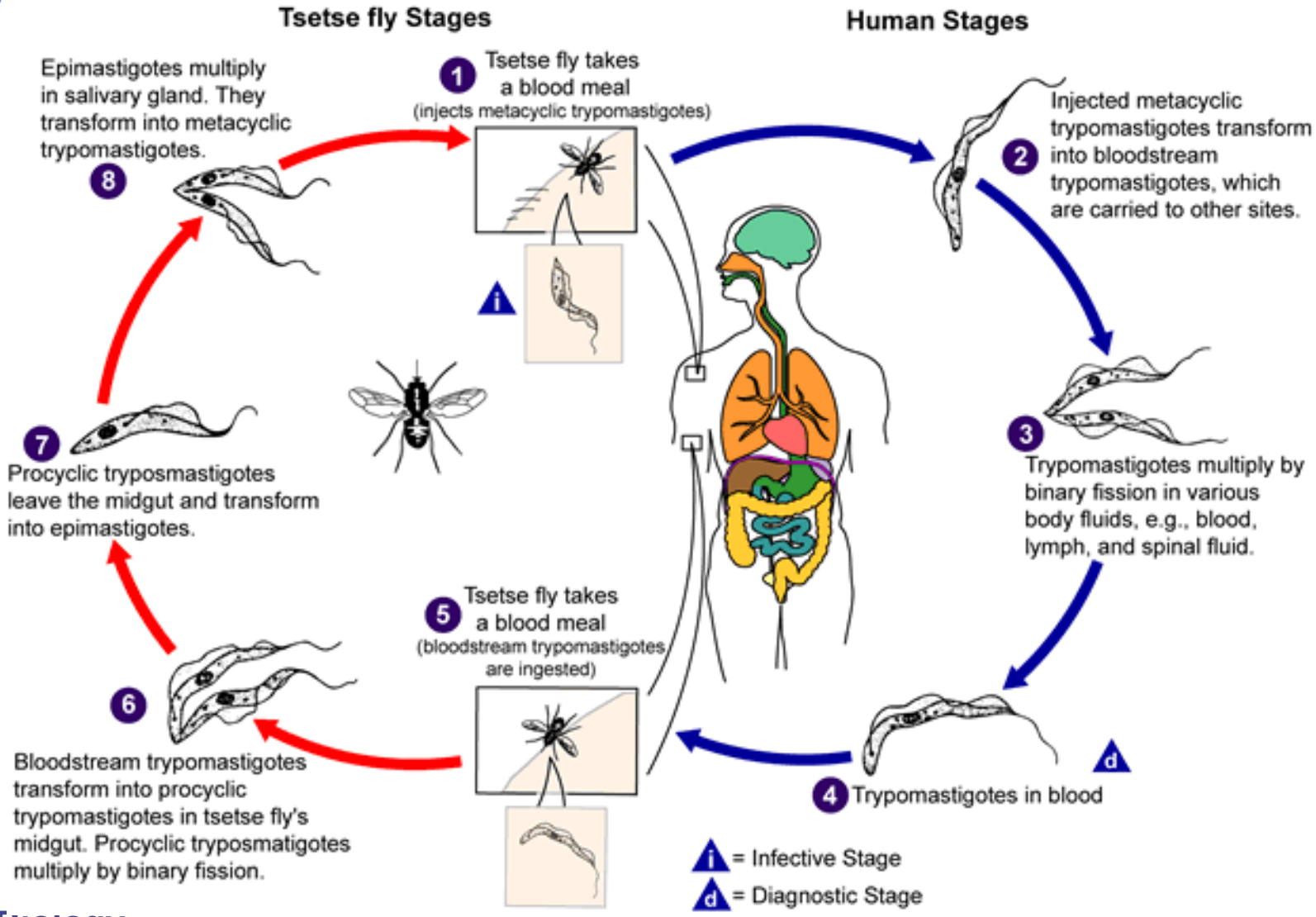
- **vector = blood-sucking assassin bu**
- over years leads to heart failure

Trypanosomes

- Life Cycle



Euglenezoans - Trypanosomes



Trypanosoma

AFRICAN SLEEPING SICKNESS

A 3-IN-1 MEDICAL REFERENCE

Medical Dictionary

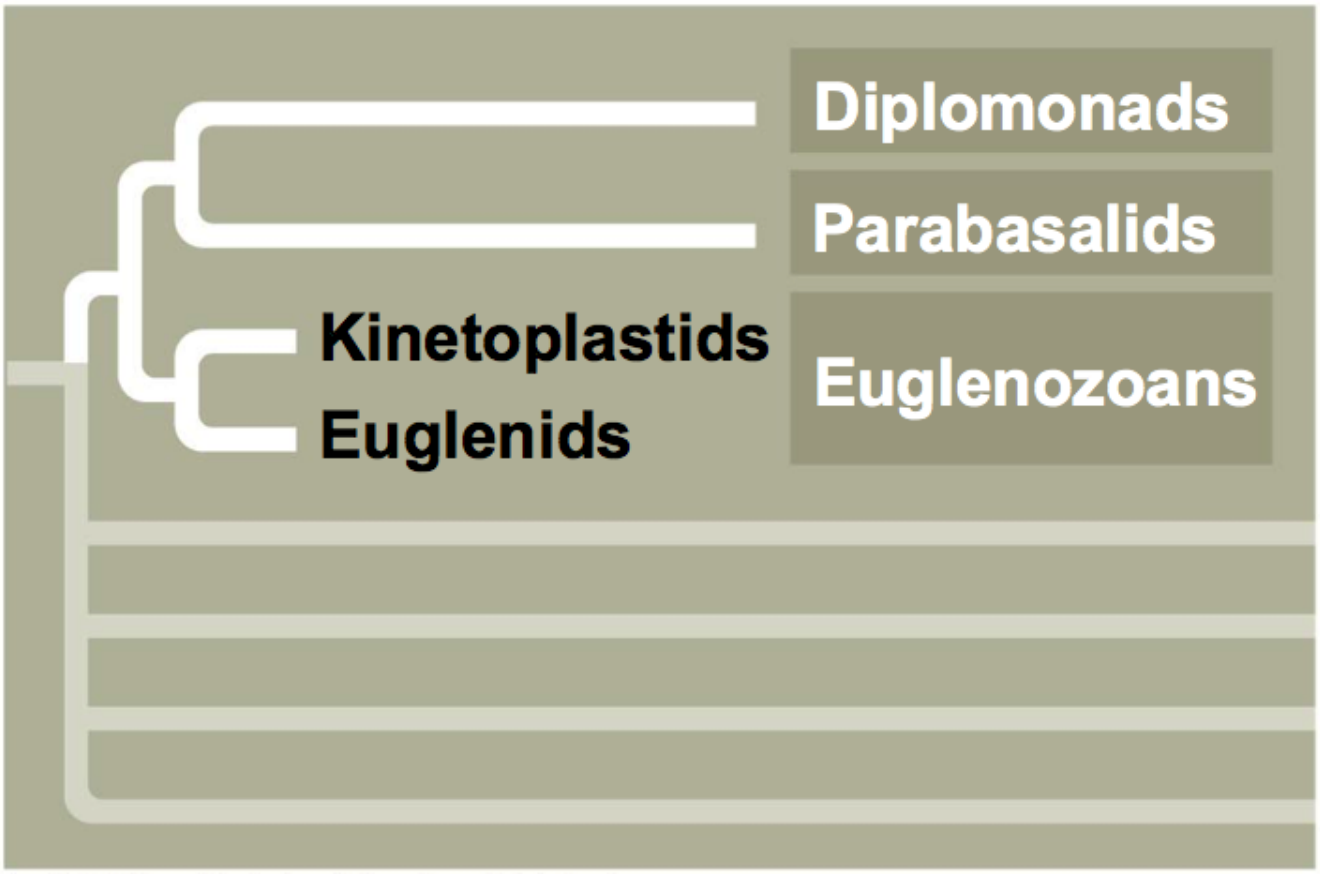
Bibliography &

Annotated Research Guide

TO INTERNET REFERENCES

ICON Group International, Inc.

http://animal.discovery.com/tv-shows/monsters-inside-me/videos/african-sleeping-sickness.htm

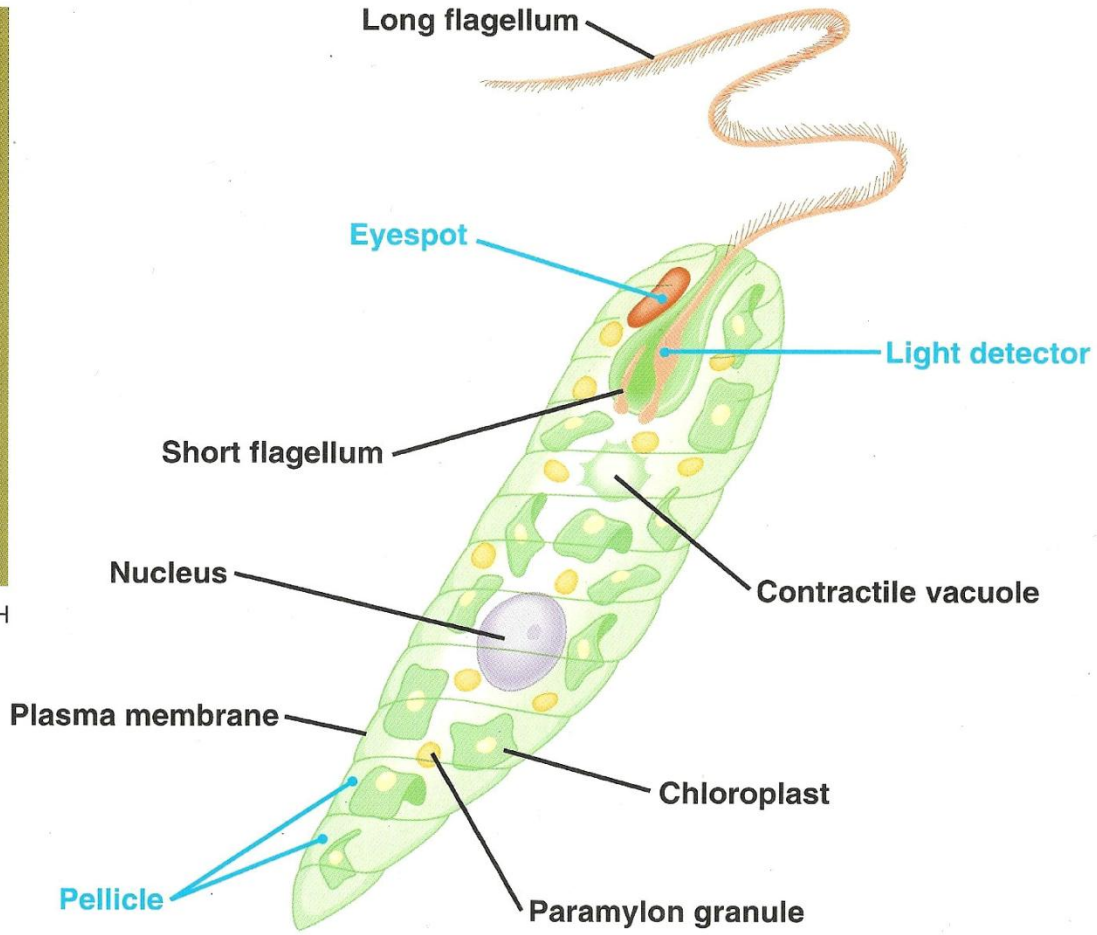


Euglenozoans: Euglenids

Euglena (LM)

5 μm

Euglena



Euglenozoans: Euglenids

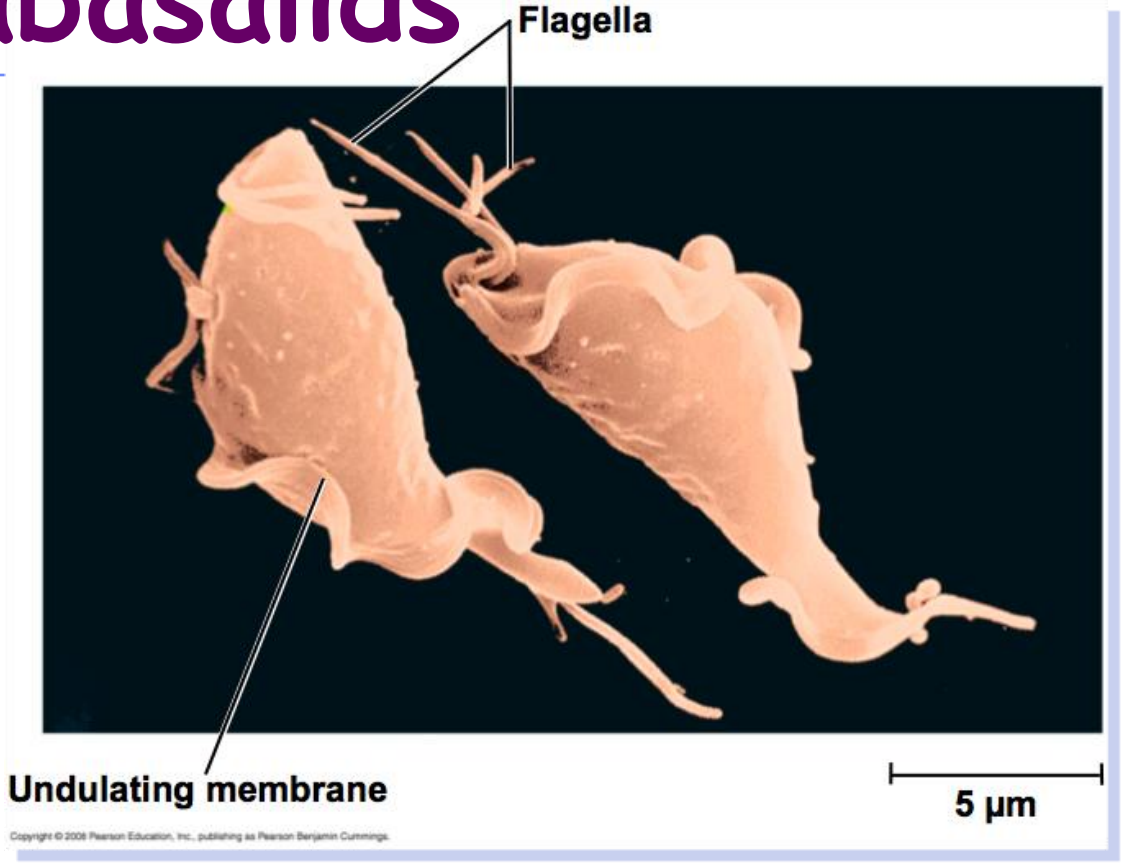
Euglena

- mixotroph
- red “eyespot” called stigma is light sensitive
- positive phototropism
- pellicle
- contractile vacuole

Diplomonads & Parabasalids

- live in anaerobic environments
- atypical mitochondria
    - no aerobic cellular respiration
- lack plastids

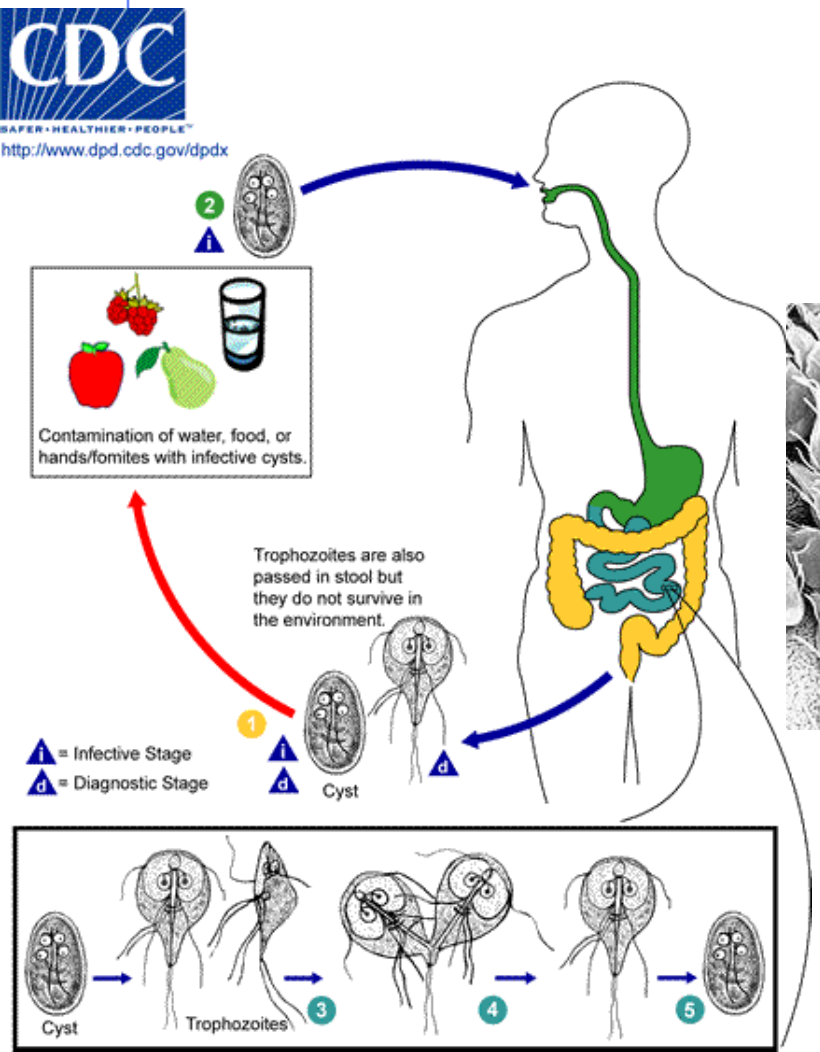
Parabasalids

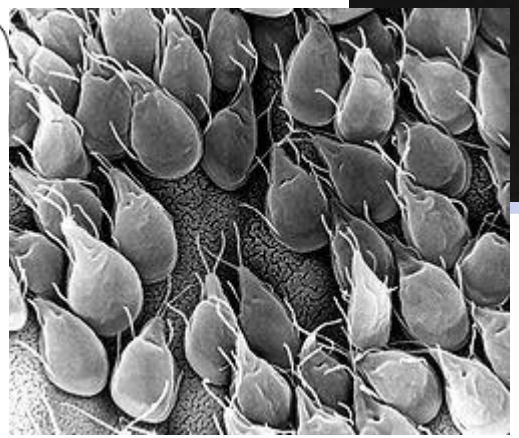


Trichomonas vaginalis

- obligate parasite of humans
- causes STD

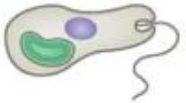
Diplomonads





Giardia intestinalis

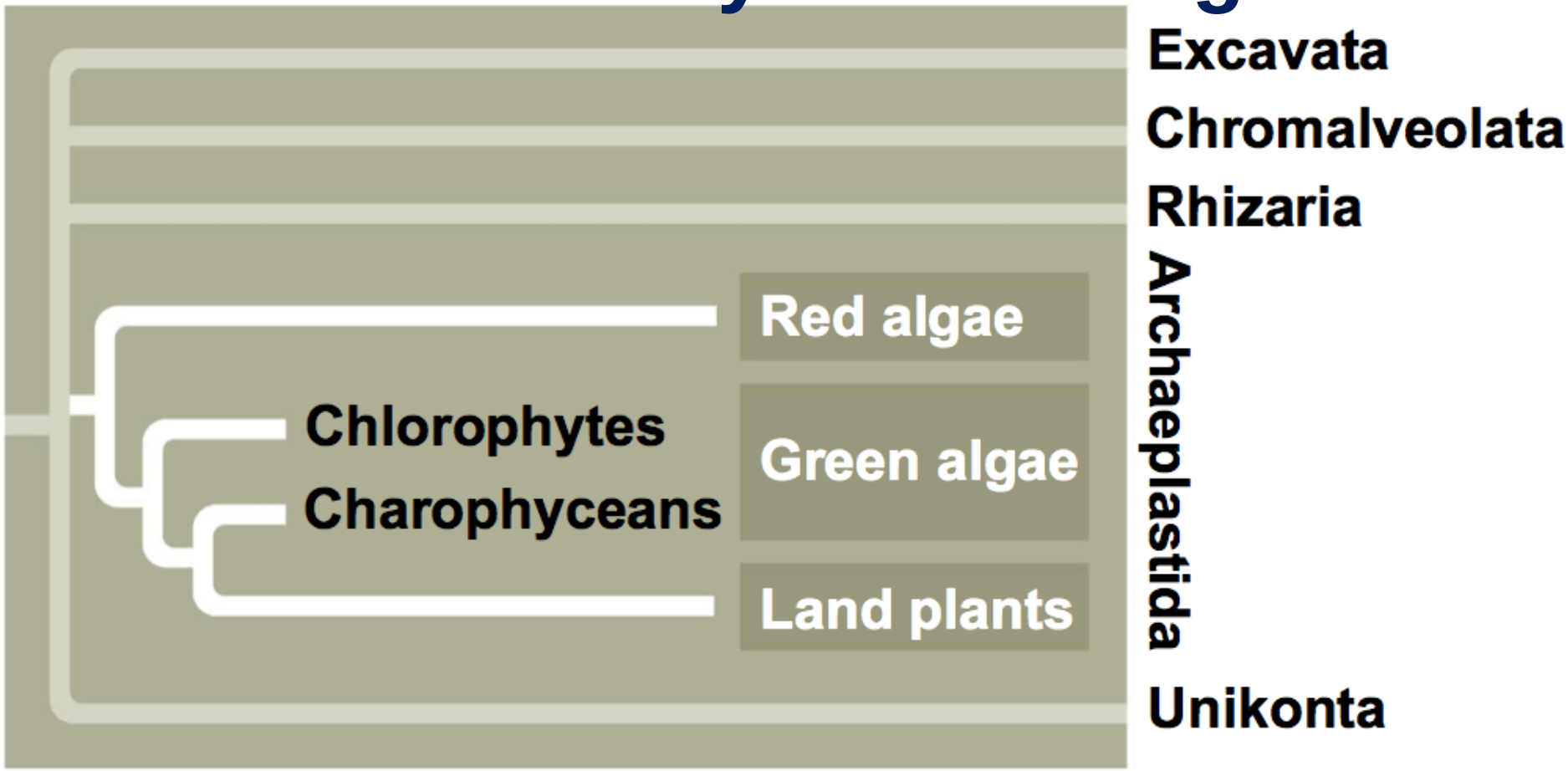
causes “hiker’s diarrhea”

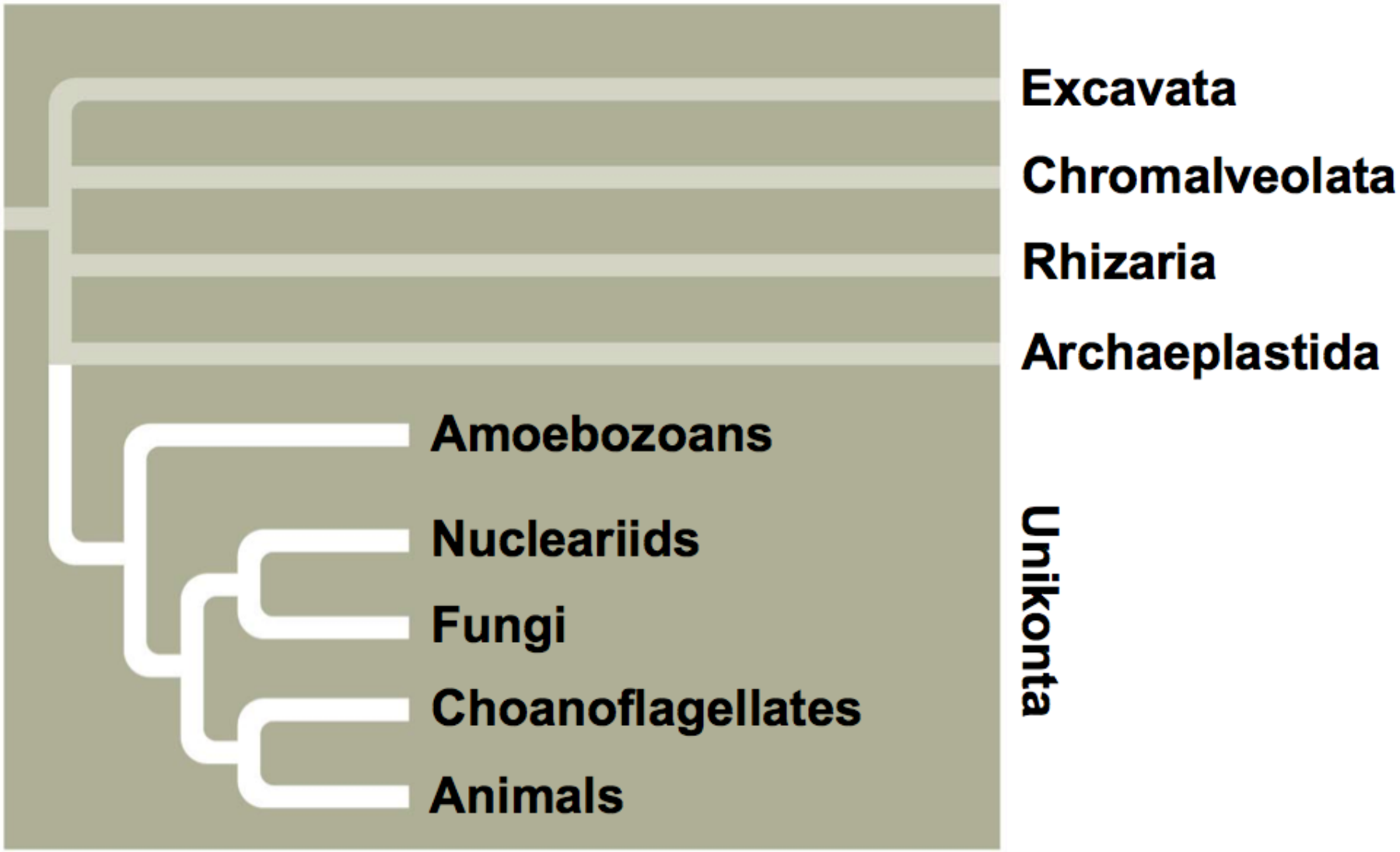
Key Concept/Eukaryote Supergroup	Major Clades	Key Morphological Characteristics	Specific Examples
Concept 28.2 **Excavates** include protists with modified mitochondria and protists with unique flagella	**Diplomonads and parabasalids**	Modified mitochondria	*Giardia*, *Trichomonas* 
	Euglenozoans Kinetoplastids Euglenids	Spiral or crystalline rod inside flagella	*Trypanosoma*, *Euglena* 

Supergroup: Archaeplastida

closest relatives of plants

will do later in year with algae





Supergroup: Unikonts

- includes Animals, Fungi and related protists

- includes amoebas with lobe or tube shaped pseudopods

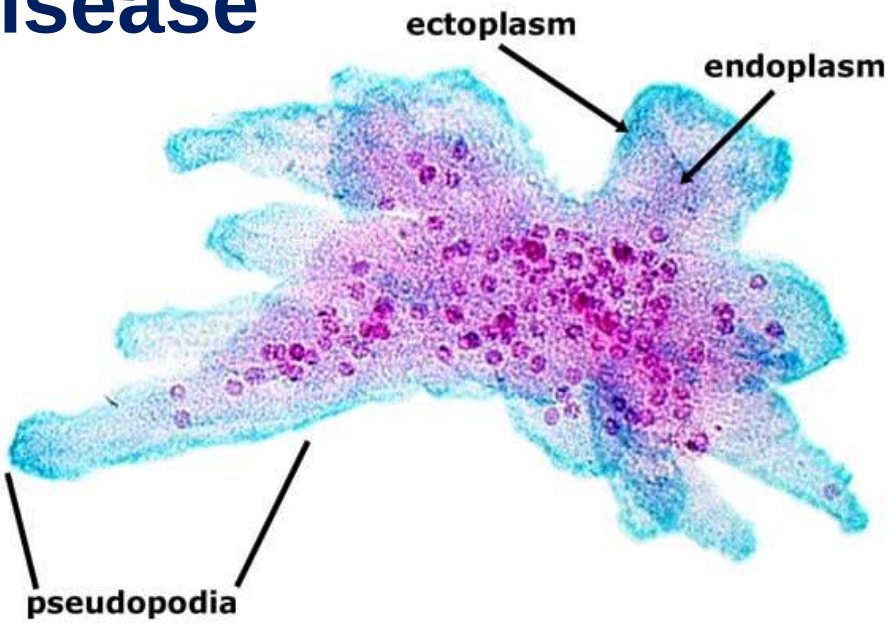
- protist clades...
  - **Amoebozoans**
  - **Choanoflagellates**

Amoebozoans

- include...
  - gymnamoebas
    - live in soil, water
    - most ingestive heterotrophs
  - entamoebas
    - parasites of animals
  - slime molds
    - absorptive heterotrophs

Gymnamoebas & Entamoebas

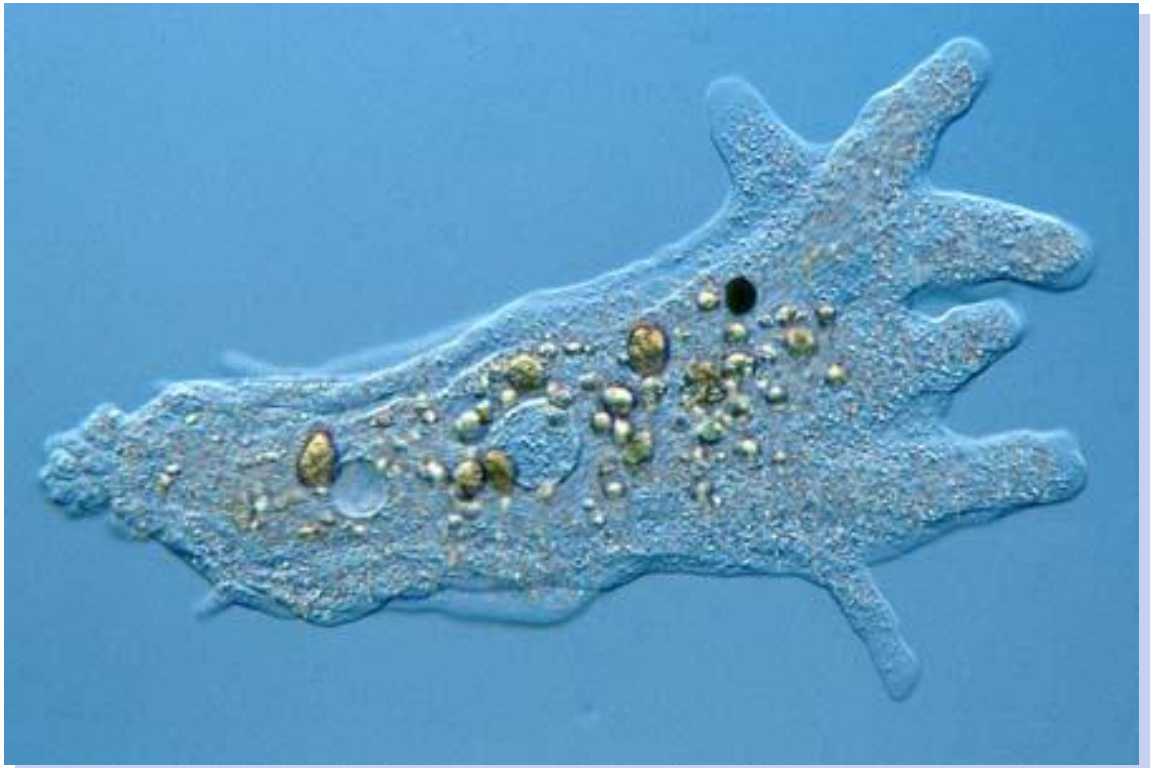
- have lobe- or tube-shaped pseudopods
- amoeboid-like movement (actin + myosin)
- eat by phagocytosis
- some cause human disease



Gymnamoebas

Amoeba proteus

http://www.youtube.com/watch?v=7pR7TNzJ_pA&feature=player_detailpage



- free living
- senses light & moves away

Amoebozoans

Entamoeba histolytica

- anaerobic
- obligate parasite of humans
- cause of amebic dysentary

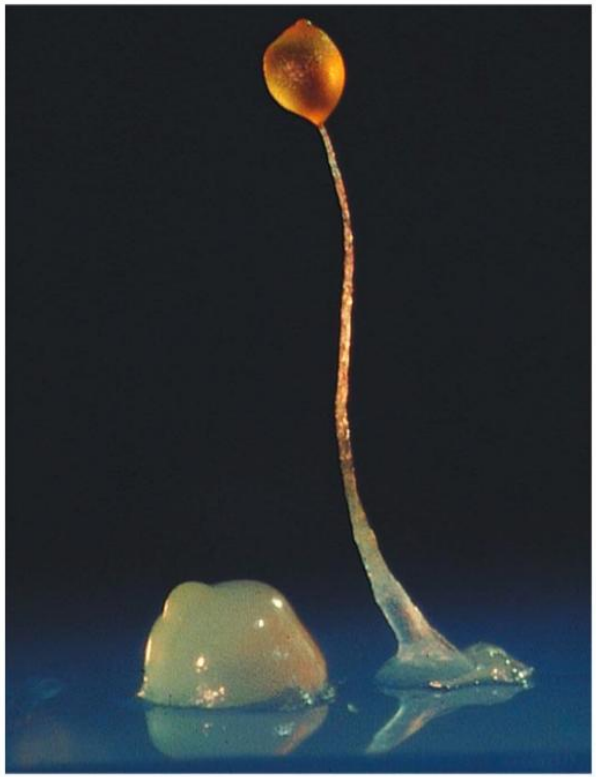
Slime molds

http://www.youtube.com/watch?v=bkVhLJLG7ug

- absorptive heterotrophs
- decomposers & recyclers

- complex life cycle
- may be cellular or plasmodial
  - cellular
    - cells feed individually but can aggregate for form fruiting body
  - plasmodial
    - feeding stage is multinucleate

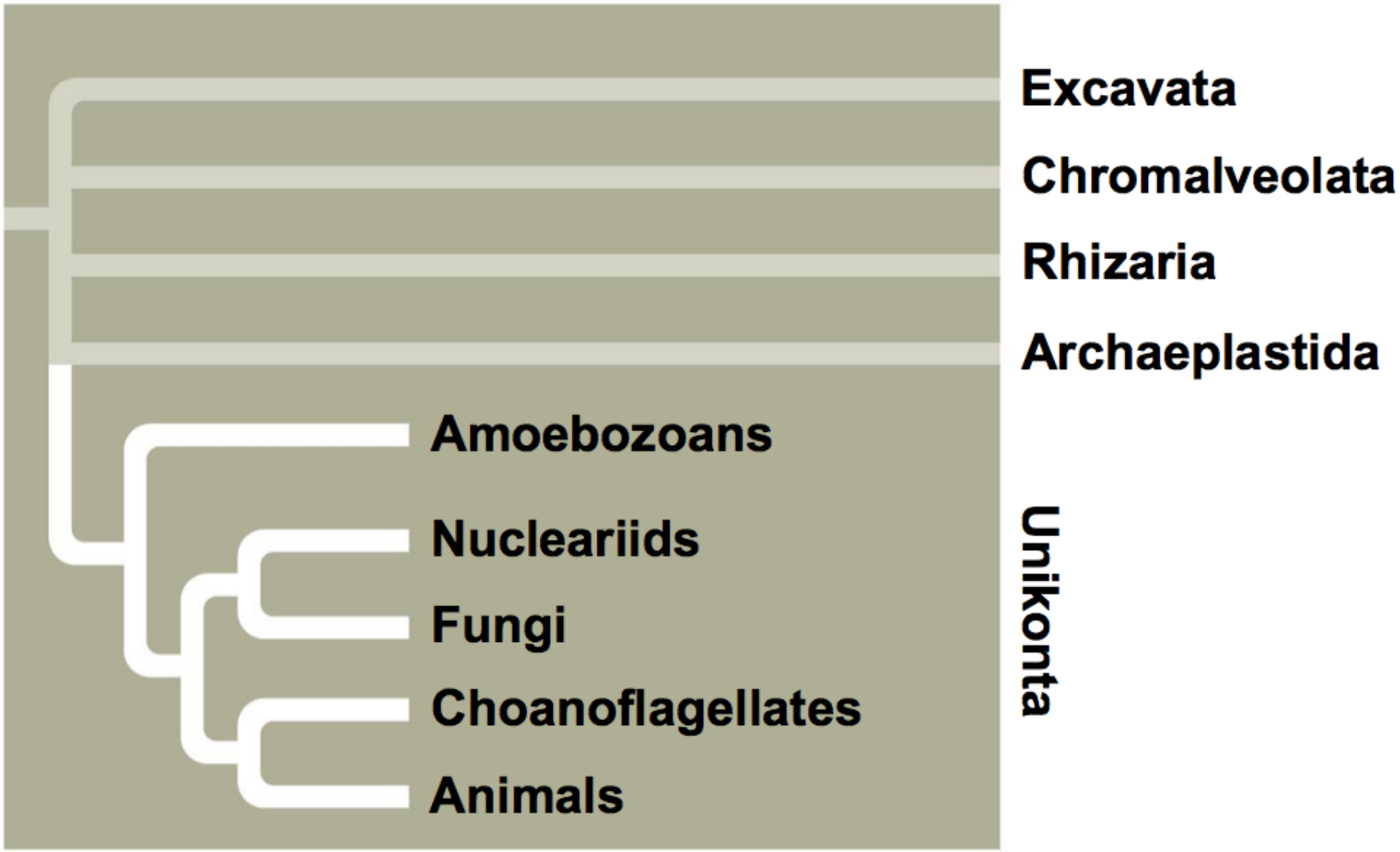
Cellular slime mold: *Dictyostelium*



Plasmodial slime mold

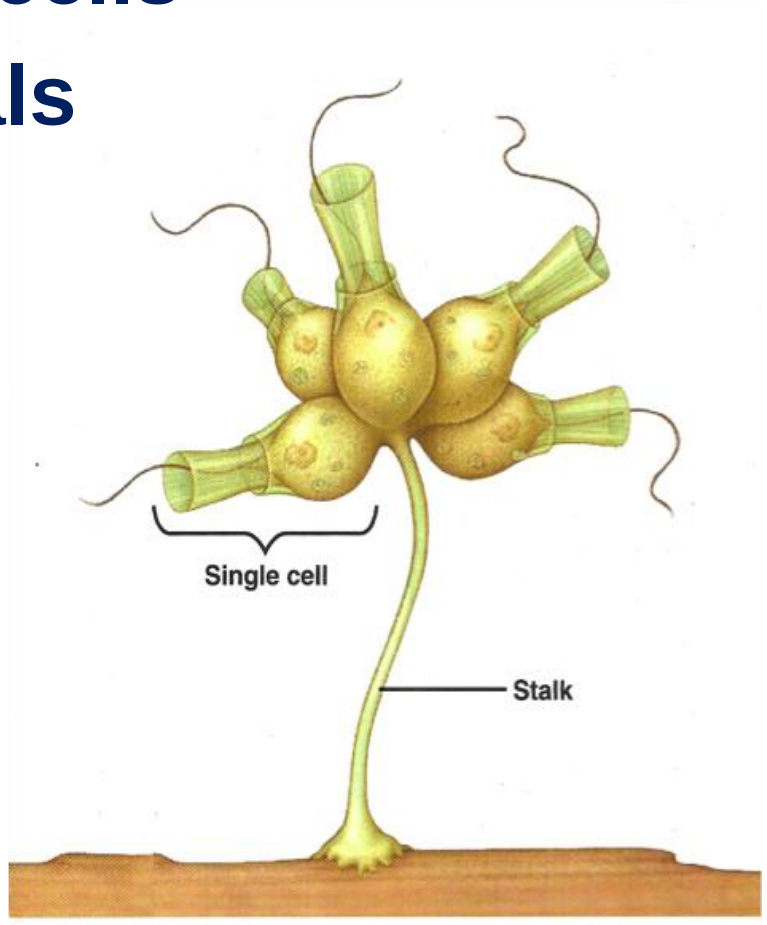
fruiting body

plasmodium stage

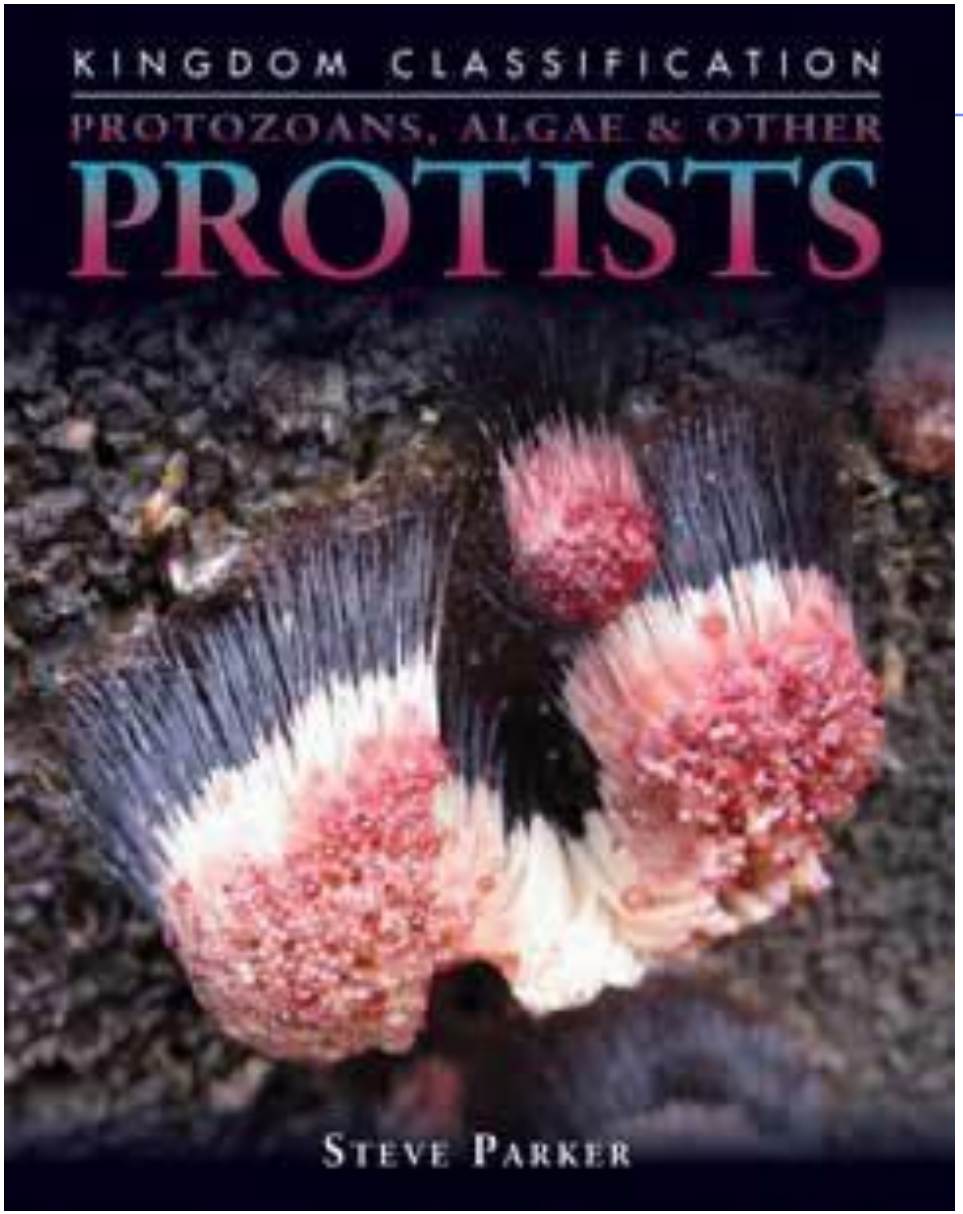


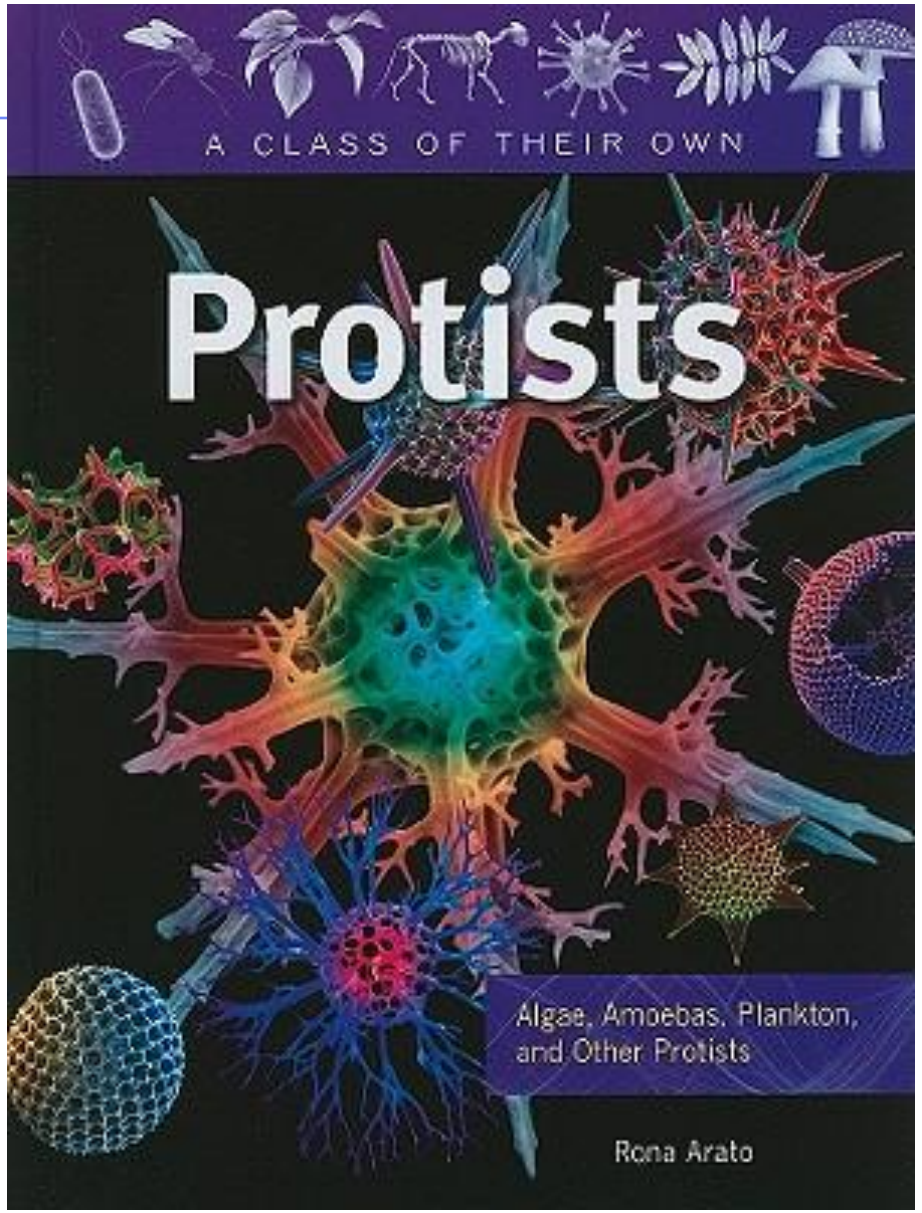
Choanoflagellates

- colonial
- resemble some sponge cells
- likely ancestral to animals



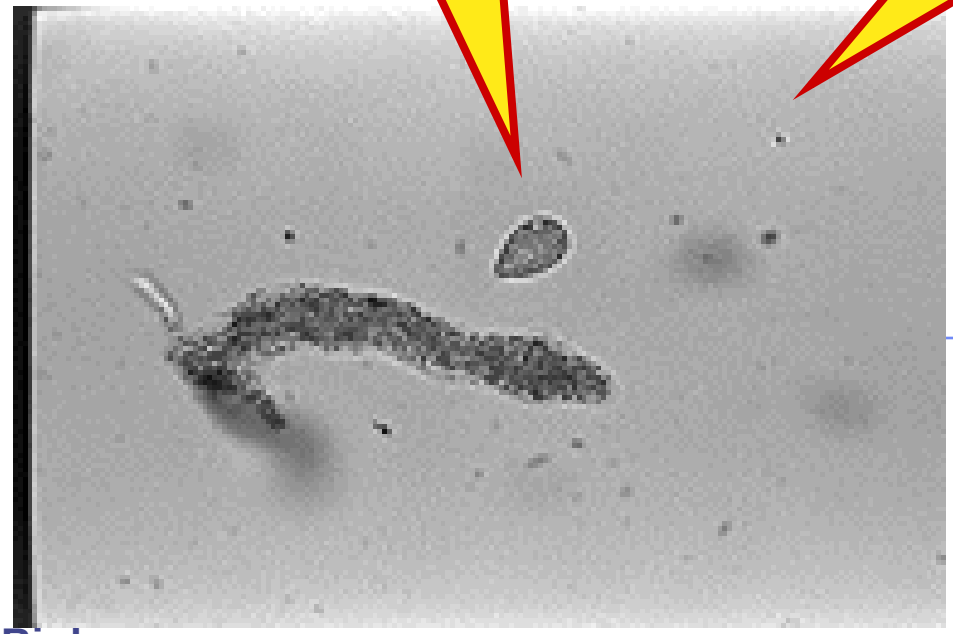
Key Concept/Eukaryote Supergroup	Major Clades	Key Morphological Characteristics	Specific Examples
Concept 28.6 **Unikonts** include protists that are closely related to fungi and animals	**Amoebozoans** Slime molds Gymnamoebas Entamoebas	Amoebas with lobe-shaped pseudopodia	*Amoeba*, *Entamoeba*, *Dictyostelium* 
	Opisthokonts	(Highly variable; see Chapters 31–34.)	Nucleariids, choanoflagellates, animals, fungi 


KINGDOM CLASSIFICATION
PROTOZOANS, ALGAE & OTHER
PROTISTS
STEVE PARKER

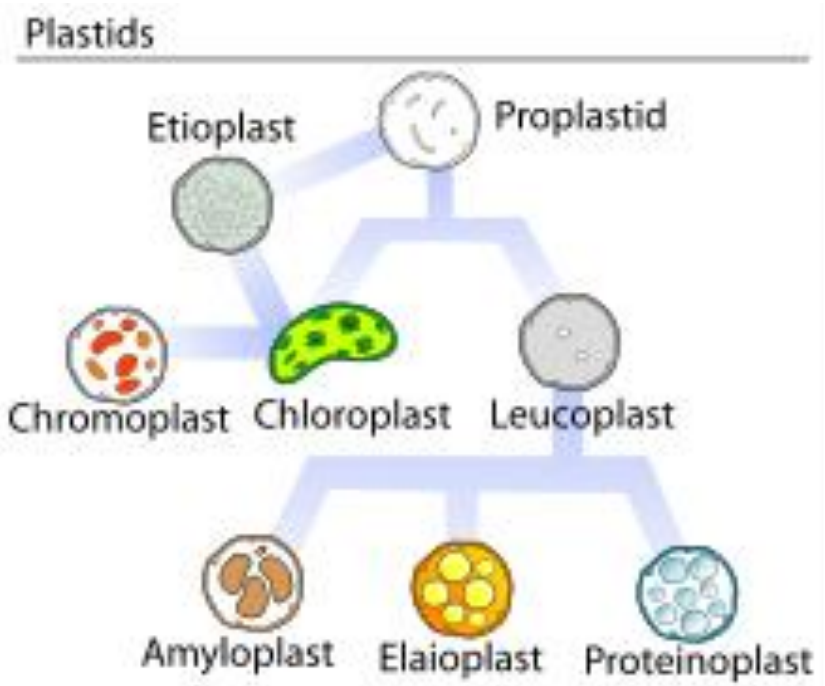

A CLASS OF THEIR OWN
Protists
Algae, Amoebas, Plankton, and Other Protists
Rona Arato

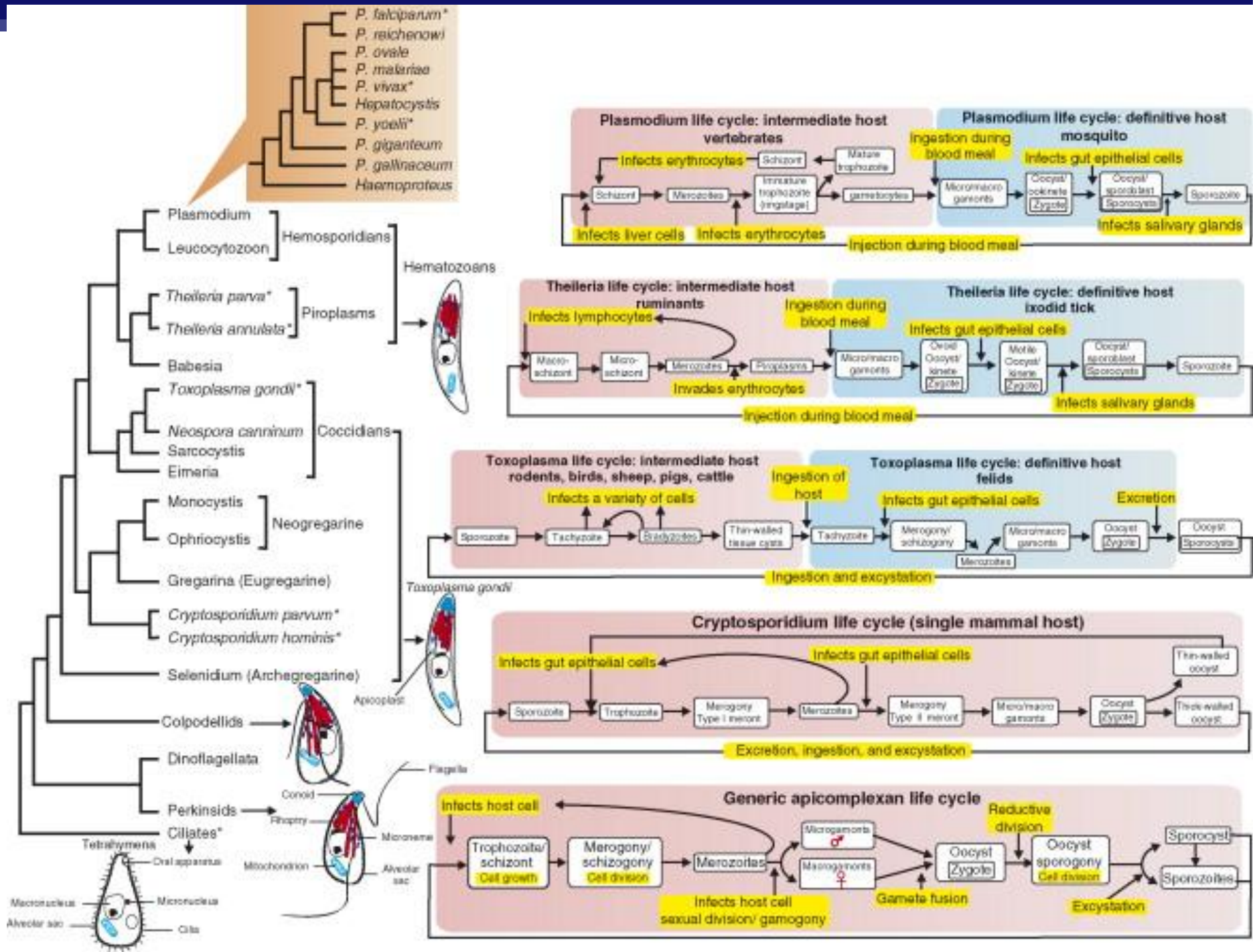
Oh No!

Any Questions?? Yum!



plastids


Plastids
Etioplast
Proplastid
Chromoplast
Chloroplast
Leucoplast
Amyloplast
Elaioplast
Proteinoplast


P. falciparum*
P. reichenowi
P. ovale
P. malariae
P. vivax*
Hepatocystis
P. yoelii*
P. giganteum
P. gallinaceum
Haemoproteus
Plasmodium
Leucocytozoon
Hemosporidians
Theileria parva*
Theileria annulata*
Piroplasms
Babesia
Hematozoans
Toxoplasma gondii*
Neospora caninum
Sarcocystis
Eimeria
Coccidians
Monocystis
Ophriocystis
Neogregarine
Gregarina (Eugregarine)
Cryptosporidium parvum*
Cryptosporidium hominis*
Selenidium (Archegregarine)
Colpodellids
Dinoflagellata
Perkinsids
Ciliates*
Tetrahymena
Oral apparatus
Macronucleus
Micronucleus
Alveolar sac
Cilia
Apicoplast
Toxoplasma gondii
Conoid
Rhoptry
Micronema
Mitochondrion
Alveolar sac
Flagella
Plasmodium life cycle: intermediate host vertebrates
Infects erythrocytes
Schizont
Mature trophozoite
Schizont
Merocytes
Immature trophozoite (ring stage)
gametocytes
Infects liver cells
Infects erythrocytes
Plasmodium life cycle: definitive host mosquito
Ingestion during blood meal
Micro/macro gametes
Zygote
Infects gut epithelial cells
Oocyst/ ookinete
Oocyst/ sporoblast
Sporocysts
Sporozoite
Infects salivary glands
Injection during blood meal
Theileria life cycle: intermediate host ruminants
Infects lymphocytes
Macro-schizont
Micro-schizont
Merocytes
Piroplasms
Invades erythrocytes
Theileria life cycle: definitive host ixodid tick
Ingestion during blood meal
Micro/macro gametes
Infects gut epithelial cells
Zygote
Infects salivary glands
Injection during blood meal
Toxoplasma life cycle: intermediate host rodents, birds, sheep, pigs, cattle
Infects a variety of cells
Sporozoite
Tachyzoite
Bradyzoites
Thin-walled tissue cysts
Ingestion and excystation
Toxoplasma life cycle: definitive host felids
Ingestion of host
Infects gut epithelial cells
Tachyzoite
Merogony/ schizogony
Merozoites
Micro/macro gametes
Excretion
Oocyst
Zygote
Sporocysts
Cryptosporidium life cycle (single mammal host)
Infects gut epithelial cells
Infects gut epithelial cells
Sporozoite
Trophozoite
Merogony Type I meront
Merozoites
Merogony Type II meront
Micro/macro gametes
Oocyst
Zygote
Thin-walled oocyst
Thick-walled oocyst
Excretion, ingestion, and excystation
Generic apicomplexan life cycle
Infects host cell
Trophozoite/ schizont
Cell growth
Merogony/ schizogony
Cell division
Merozoites
Microgamonts
Macrogamonts
Infects host cell
sexual division/ gamogony
Gamete fusion
Oocyst
Zygote
Reductive division
Oocyst sporogony
Cell division
Sporocyst
Sporozoites
Excystation