PROTOZOA

FISH310

CHAPTER 3

Protozoa – *Why do we care*?

- Besides being a **transitional** form between *plants and animals* and between *uni and multicellular* organisms they .....
  - Are often parasitic on shellfish and other invertebrates we are interested in
  - May be predators of shellfish larvae
  - May serve as food for planktotrophic shellfish larvae
    - In fact flagellates often cultured as a key food item in bivalve hatcheries
  - Some are commensals

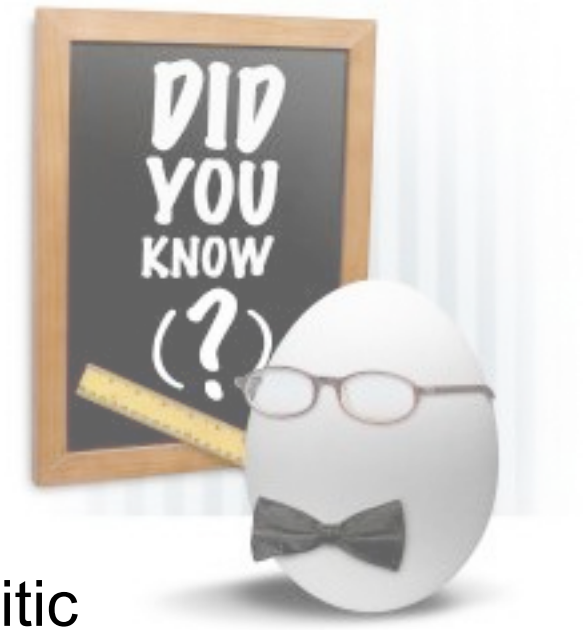
Defining Characteristics

- All are unicellular eukaryotes lacking collagen and chitinous cell walls
- All are nonphotosynthetic in the primitive condition

- Alveolates – possess membrane bound sacs under cell membrane called alveoli that surround each cilium or flagella
  - Phylum Ciliophora - ciliophorans or ciliates
    - Possess cilia at some stage in development
  - Phylum Dinozoa – dinoflagellates
    - Posses 2 flagella – one in sulcus and one in girdle
  - Phylum Apicomplexa (All are parasitic)
    - Possess apical complex
- (Phylum Mastigophora) - Flagellates
    - Possess one to several flagella
- (Phylum Rhizopoda) - Amoeba
    - Move by pseudopodia

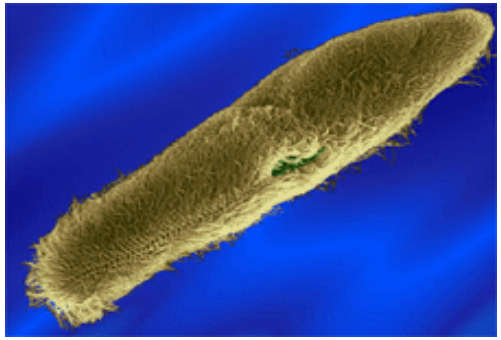
Protozoa: Fun Facts

- First discovered by Antony van Leeuwenhoek in 1674



- Occur in moist habitats
  - Freshwater, seawater, moist soil
  - Free-living, commensal, or parasitic

General Info

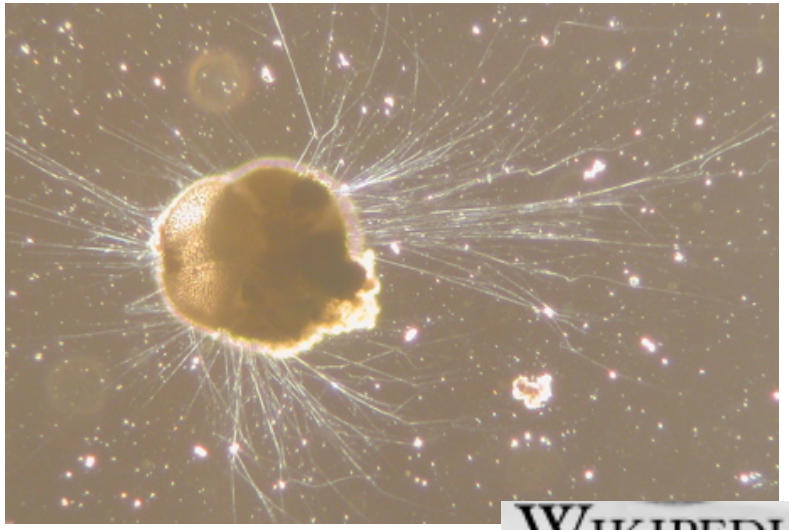


- ~82,000 species
  - >50% only known as fossils
- Simplest eukaryotic life forms but still amazingly complex in structure
- Despite most being unicellular still must:
  - Feed, digest, excrete, move, behave, and reproduce
    - Accomplished by organelles in lieu of tissues
    - Lack circulatory and excretory systems and use diffusion across cell surface for gas exchange and waste removal

www.edu.pe.ca/southernkings/Pictures/protozoa.jpg

Cell Characteristics

- Most microscopic 5-250 um
  - Largest rarely over 6-7 mm (e.g. foraminifera)



Protozoa 3 – Cell Characteristics

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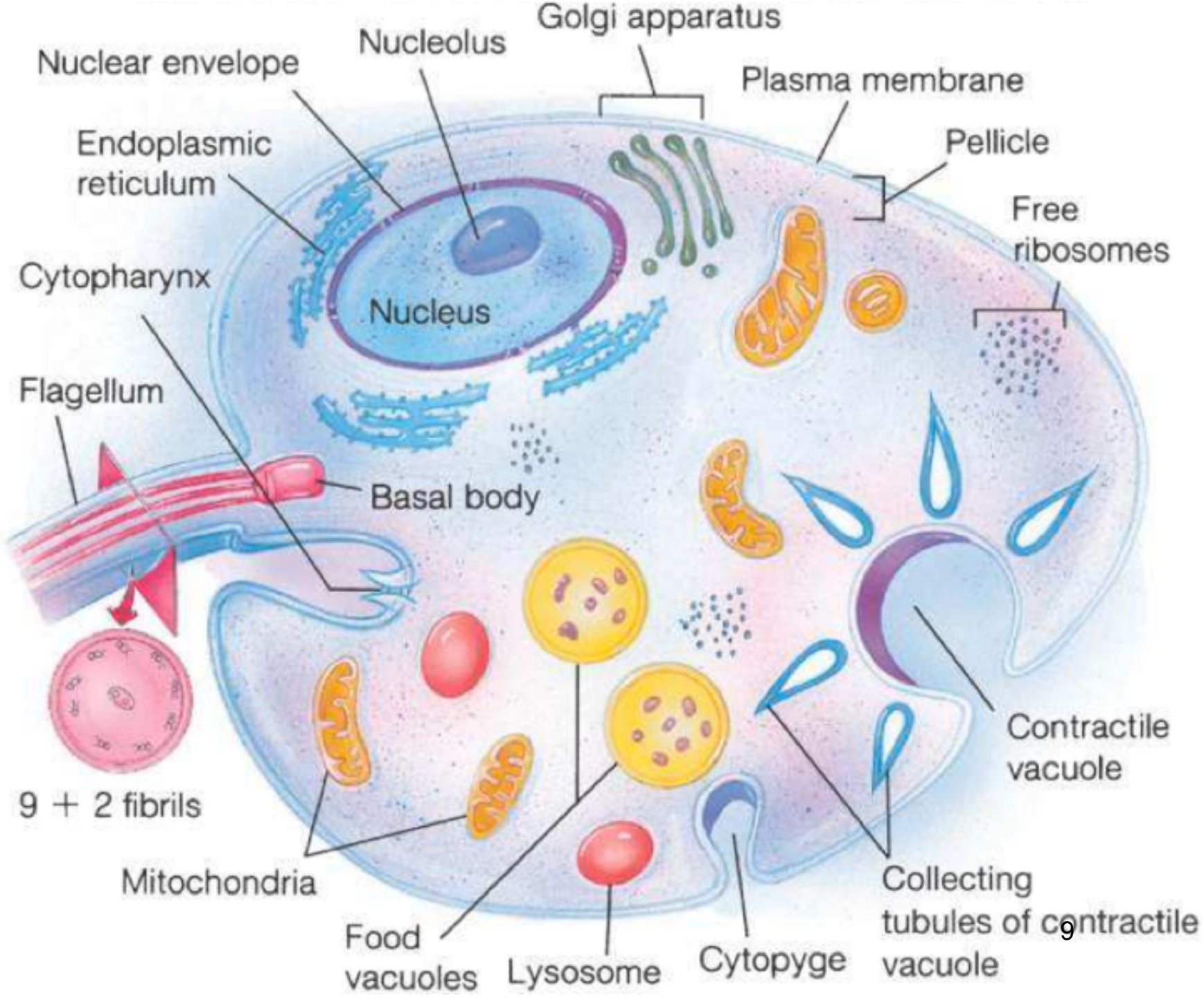
  - Essentially identical to metazoan cells in structure and chemical composition
- Cytoplasmic organelles; like those of eukaryotic cells
  - Such as what?

??????


Golgi apparatus
Nucleolus
Nuclear envelope
Plasma membrane
Endoplasmic reticulum
Pellicle
Free ribosomes
Cytopharynx
Nucleus
Flagellum
Basal body
Contractile vacuole
9 + 2 fibrils
Mitochondria
Collecting tubules of contractile vacuole
Food vacuoles
Lysosome
Cytopyge

Protozoa – Cell Characteristics

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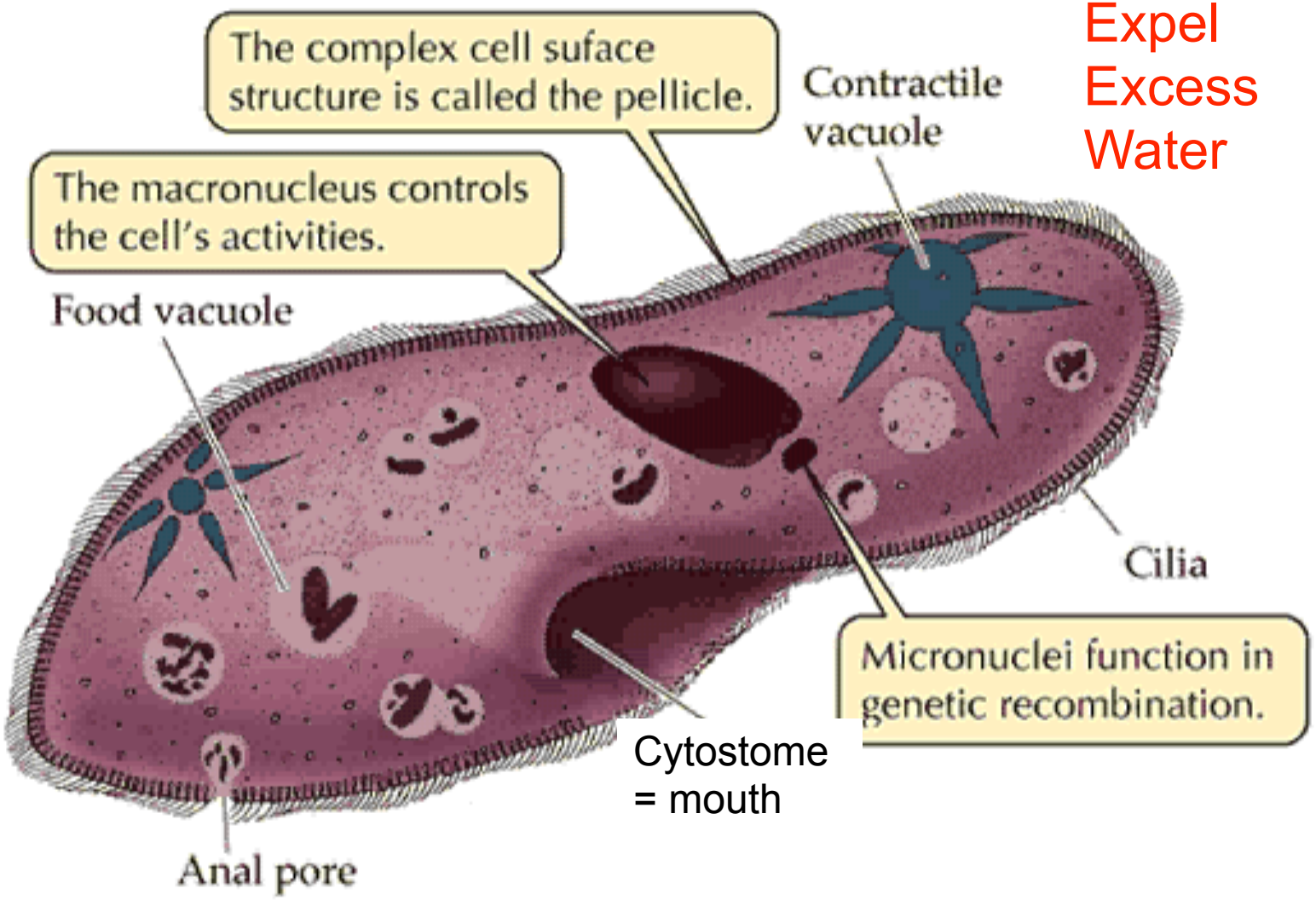
- Cytoplasmic organelles; like those of eukaryotic cells
  - Such as what?
- Also contain unique organelles **not** seen in metazoa
  - Contractile vacuoles
  - Trichocysts and Toxicysts
  - May possess complex arrays of microtubules or microfilaments

General Morphology

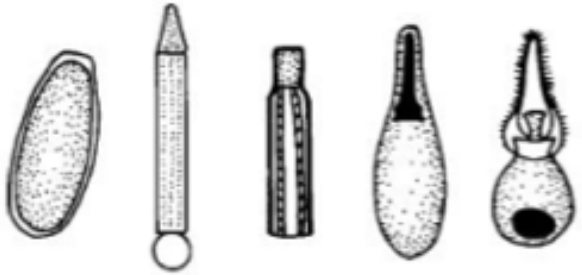


http://science.kennesaw.edu/biophys/biodiversity/protista/pictures/paramecium.gif

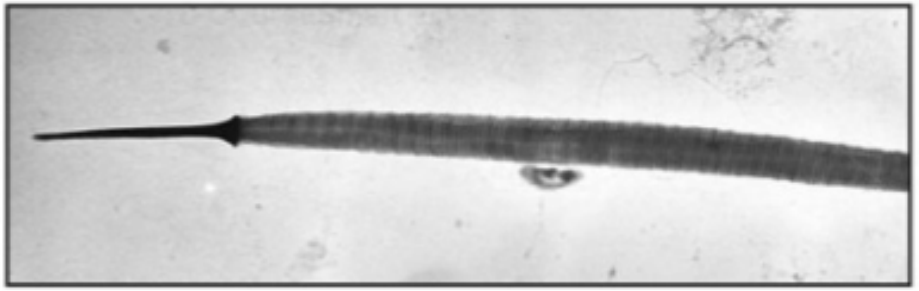
Protozoa: Unique organelles

- Contractile vacuoles (possess ≥ 1)
  - System of membranous vesicles and tubules to expel excess water from cytoplasm
  - Usually seen in freshwater protozoa….why?
- Trichocysts
  - Elongated capsules that discharge long thin filament when stimulated

What in the world are these for??



(a)

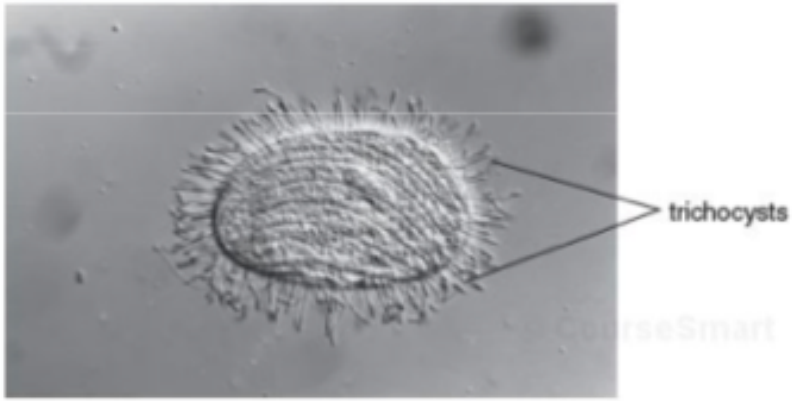


(b)

Figure 3.4

(a) Undischarged extrusomes of different types. At least 12 morphologically distinct types of extrusome have been described. Some expel mucus (left); others eject filaments of various lengths. Paralytic toxins are injected by one class of extrusome (toxicysts, not shown). Others (far right) are used primarily for adhering to prey during food capture. (b) Transmission electron micrograph of a trichocyst that has been discharged from *Paramecium* sp. (c) A ciliate, *Pseudomicrothorax dubis*, with its trichocysts extended.

(a) From Corliss, In *American Zoologist* 19:573, 1979. Copyright © 1979 American Society of Zoologists, Thousand Oaks, California. (b) Courtesy of M.A. Jakus, National Institutes of Health. (c) From S. Eperon and R. K. Peck. *The Journal of Protozoology* 35:280–86, fig. 1, p. 282, Allen Press, Inc. © 1988 Dr. Edna Kaneshiro, editor.



(c)

- Function is not known – protection or anchoring for feeding?

Protozoa 4: Unique organelles

- Contractile vacuoles (possess ≥ 1)
  - System of membranous vesicles and tubules to expel excess water from cytoplasm
  - Usually seen in freshwater protozoa….why?
- Trichocysts
  - Elongated capsules that discharge long thin filament when stimulated
  - Function is not known – protection or anchoring for feeding?
- Toxicysts
  - Related to trichocysts and used in predation – filaments contain toxin to paralyze prey and initiate digestion

Toxicysts

"Dileptus anser. This bizarre ciliate waves its "trunk" rather like an elephant and at the base of the trunk is the cytostome which has a grouping of **toxicysts** which it can discharge to stun potential prey."

www.microscopy-uk.org.uk/mag/imgdec06/P7.jpg

Actinobolina vorax: **toxicysts** on extensible tentacle-like projections of this freshwater protozoan; often extend tentacles at rest and retract when moving with cilia

www.protist.i.hosei.ac.jp

Protozoa: Locomotion

- Cilia
  - Phylum Ciliophora – fastest protozoa…move up to 2 mm/sec!
  - Locomotion, feeding, & likely gas exchange & waste removal

Protozoa 5: Locomotion

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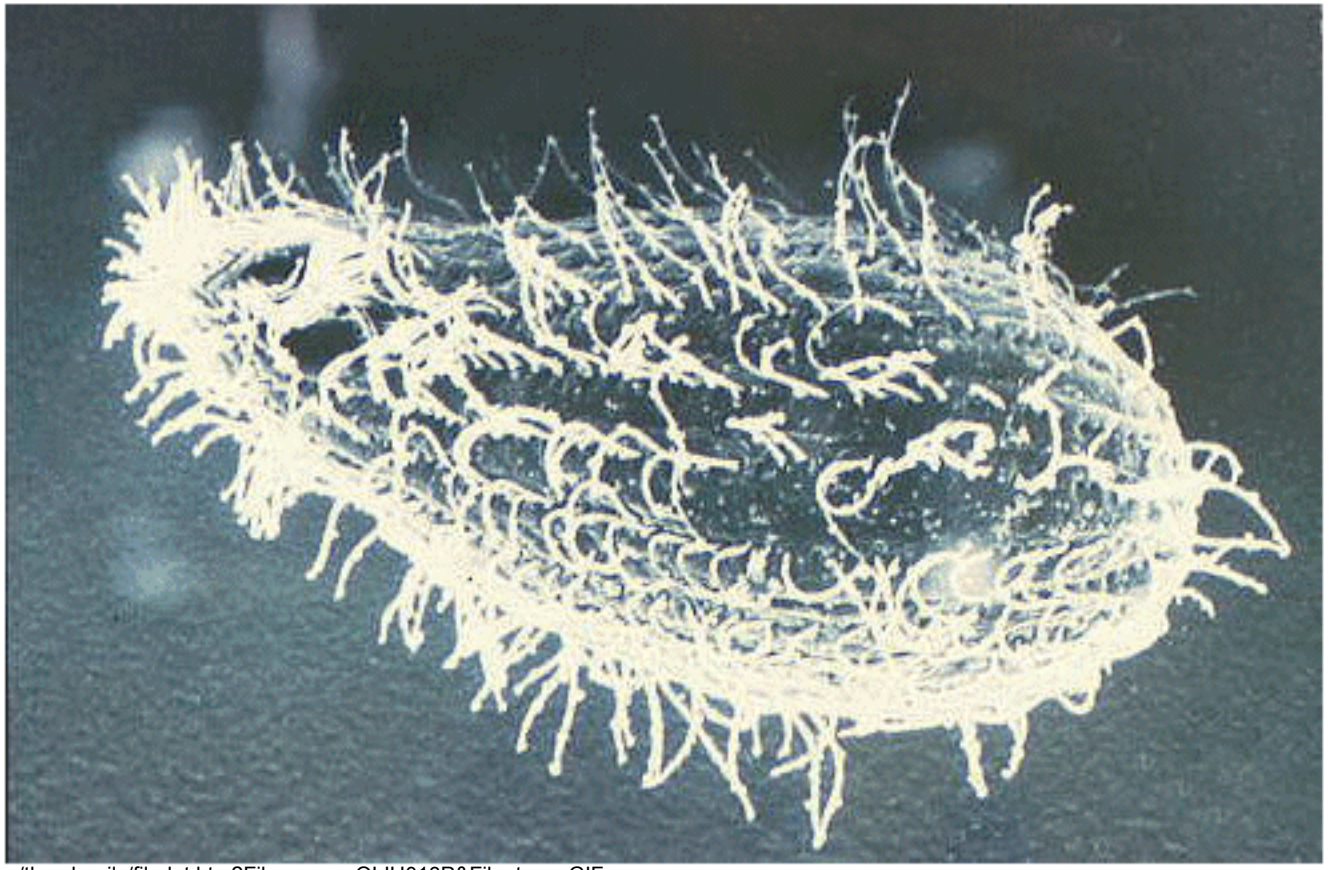

http://biodidac.bio.uottawa.ca/thumbnails/filedet.htm?File_name=OLIH013P&File_type=GIF

Protozoa: Locomotion

- Cilia
  - Phylum Ciliophora – fastest protozoa…move up to 2 mm/sec!
  - Locomotion, feeding, & likely gas exchange & waste removal
- Flagella
  - Phylum Dinozoa and Flagellates
  - Structure similar to cilia but have hair-like projections (mastigonemes) to increase surface area (and power)
  - Move up to 200 um per second
    - 1/10 as fast as ciliates but 40x faster than amoebae - move by pseudopodia

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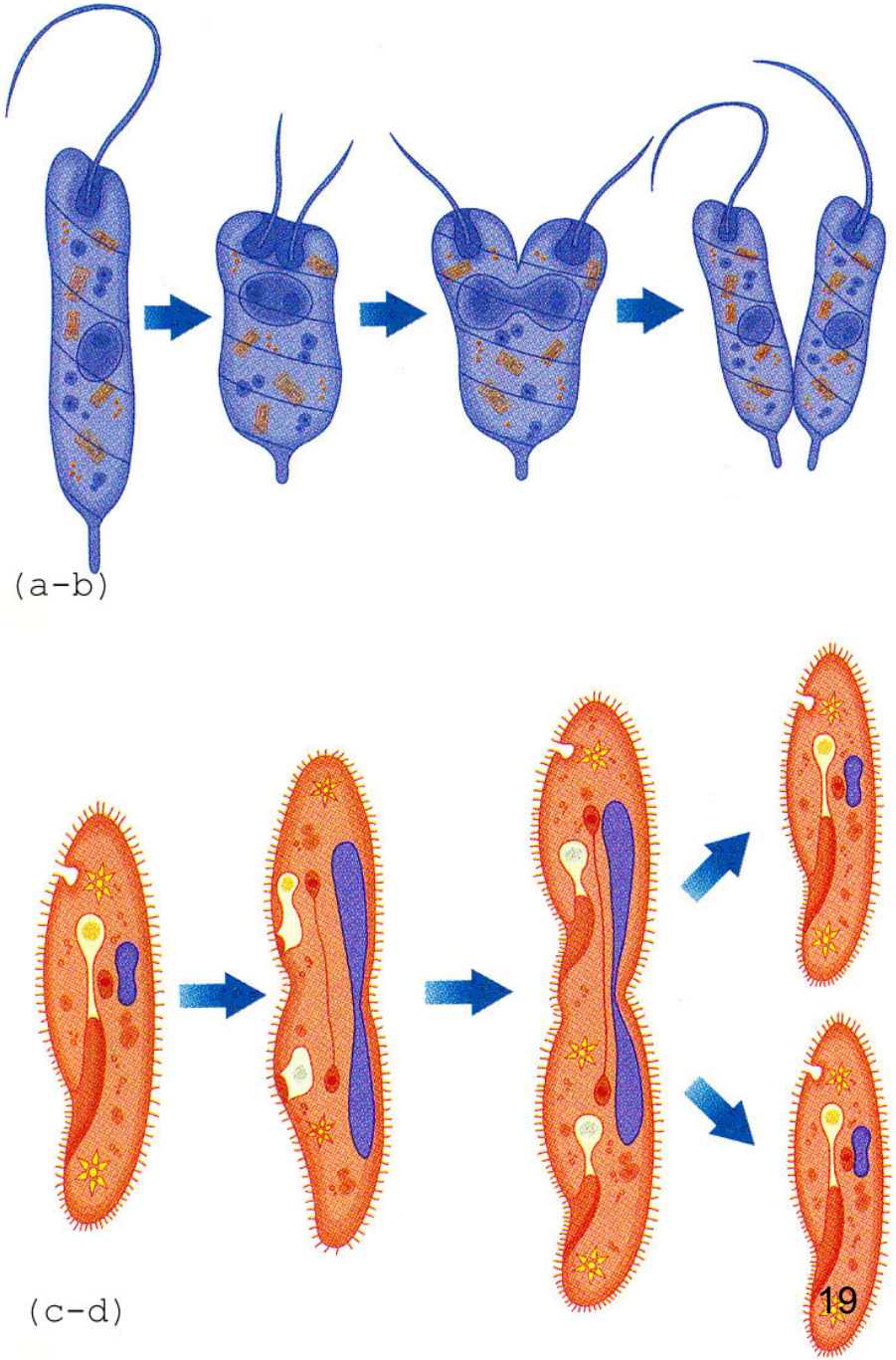
- Pseudopodia
  - Amoebozoa lack strict form (formless) and move slowly by ectoplasmic streaming (<300 um per minute)
  - Also used in feeding (phagocytosis) and drinking (endocytosis)

Protozoa: Reproduction

- Binary Fission
  - 2 equal sized cells result
- Budding
  - 2 cells result
- Schizogony
  - multiple cells after division of mother cell
- Sexual Reproduction
  - cells form haploid gametes which fuse

Binary Fission

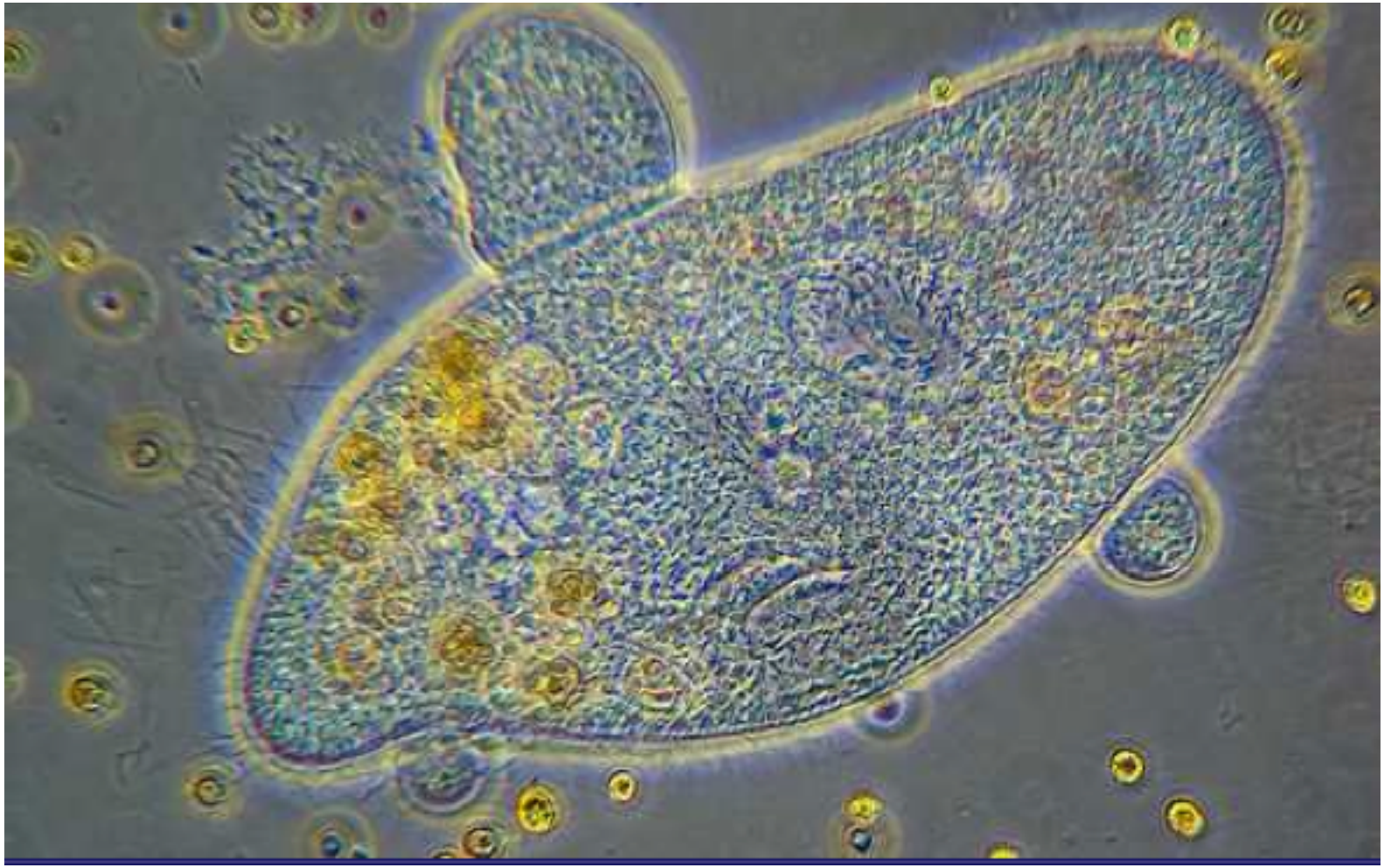


http://web.nkc.kku.ac.th/images/lean/3-7.jpg

Binary Fission in Ciliophora (transverse cleavage)

Figure 11. Binary fission in *Paramecium*. Image from http://biodidac.bio.uottawa.ca/thumbnails/filedet.htm?File_name=OLIH023P&File_type=GIF.

Budding



Protozoa 6: Reproduction

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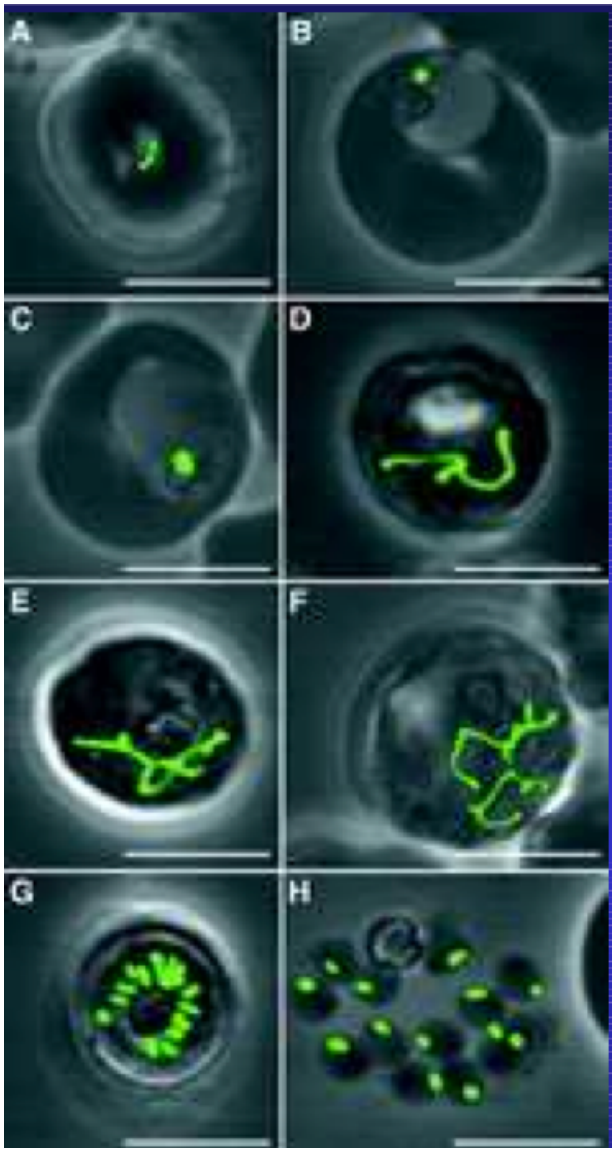
Scizogony



Plasmodium

Protozoa: Reproduction

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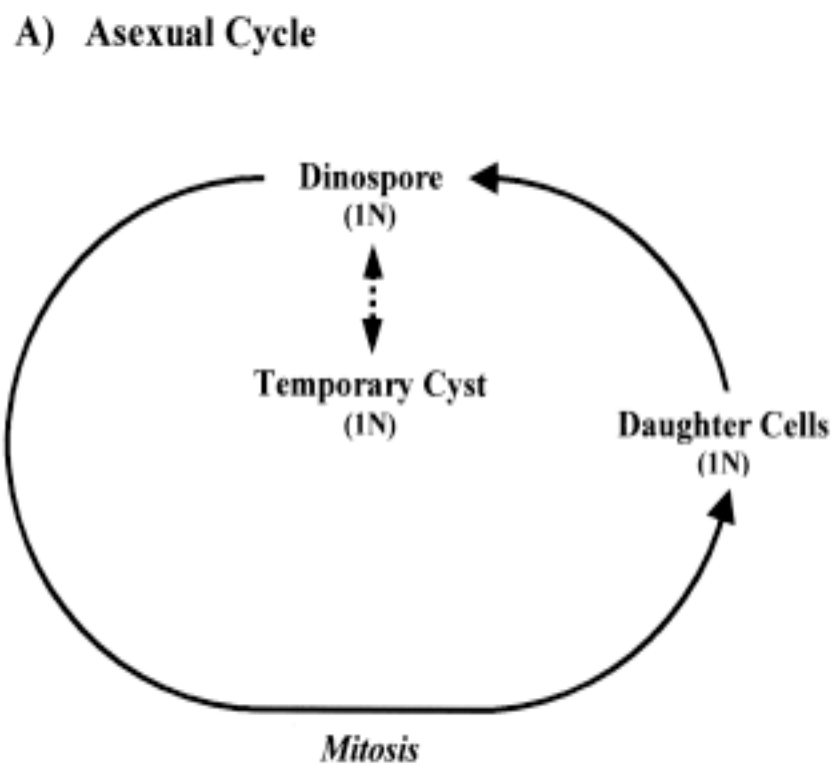
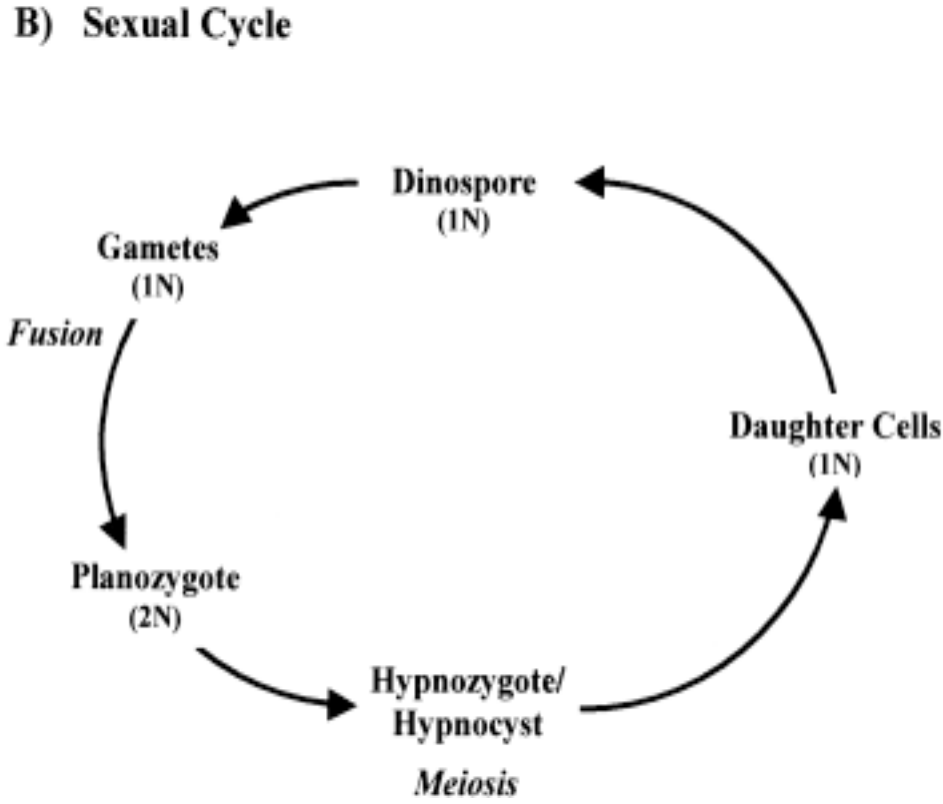
Flagellates: Dinoflagellates





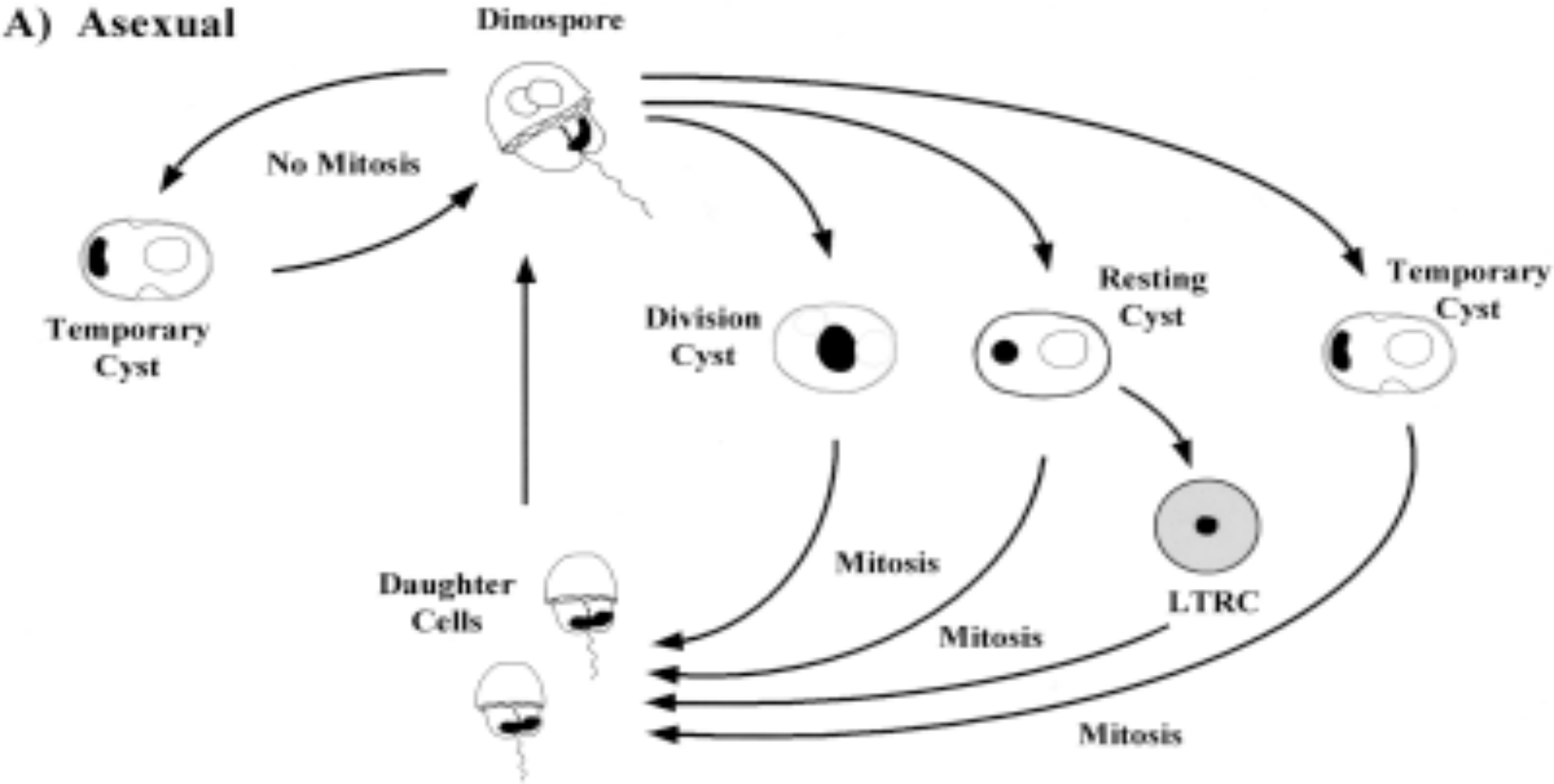


Fig. 9. (A) Schematic diagram showing paths of asexual reproduction and temporary cyst formation of *Pfiesteria piscicida.* Litaker et al. 2002

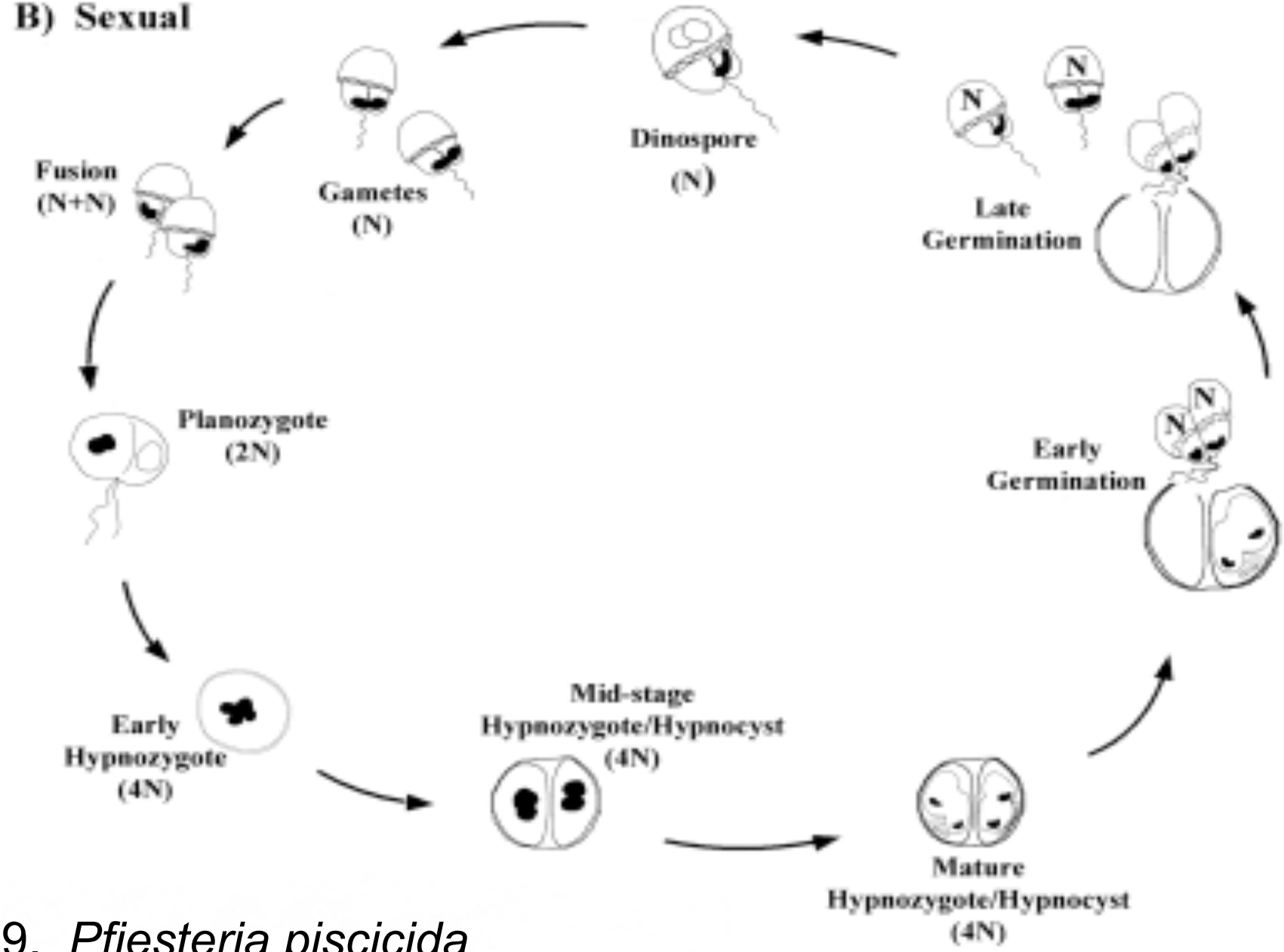


Fig. 9. *Pfiesteria piscicida*
Litaker et al. 2002

Ecological Implications?

Protozoan Examples

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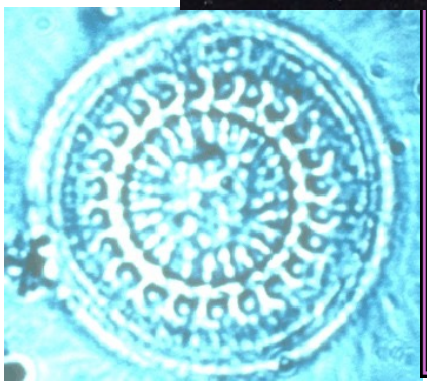
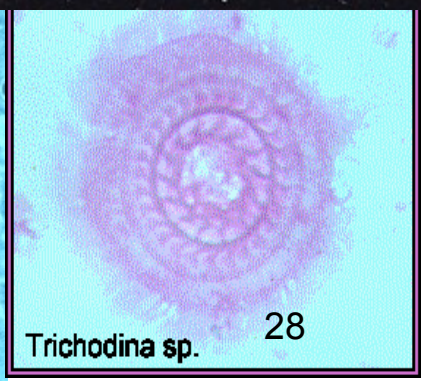
Alveolate: Phylum Ciliophora - Cilia

- Share
  - Macro and micronucleus
  - Division by binary fission
  - Feed with cytostome (mouth-like opening)
  - May be free living/symbiotic/parasitic
- Several families best known:
  - Ichthyophthiridae - “ich”
    - *Ichthyophthirius multifilis*
  - Trichodinidae - *Trichodina*





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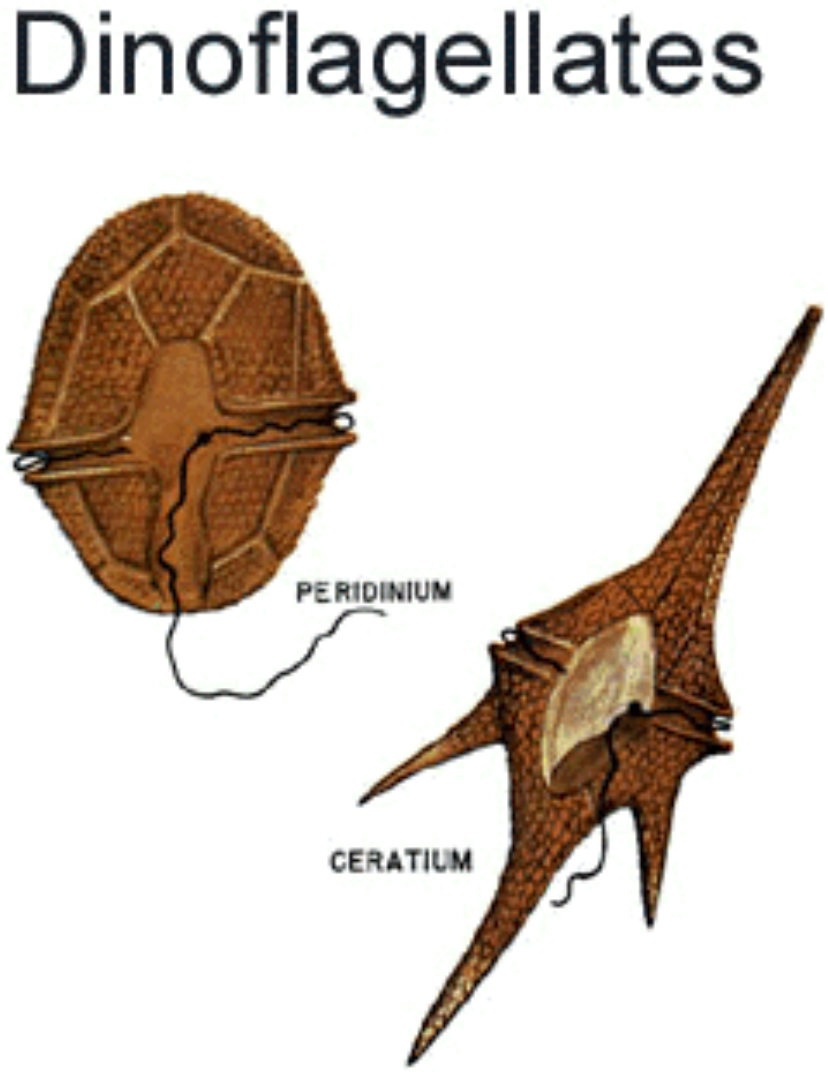
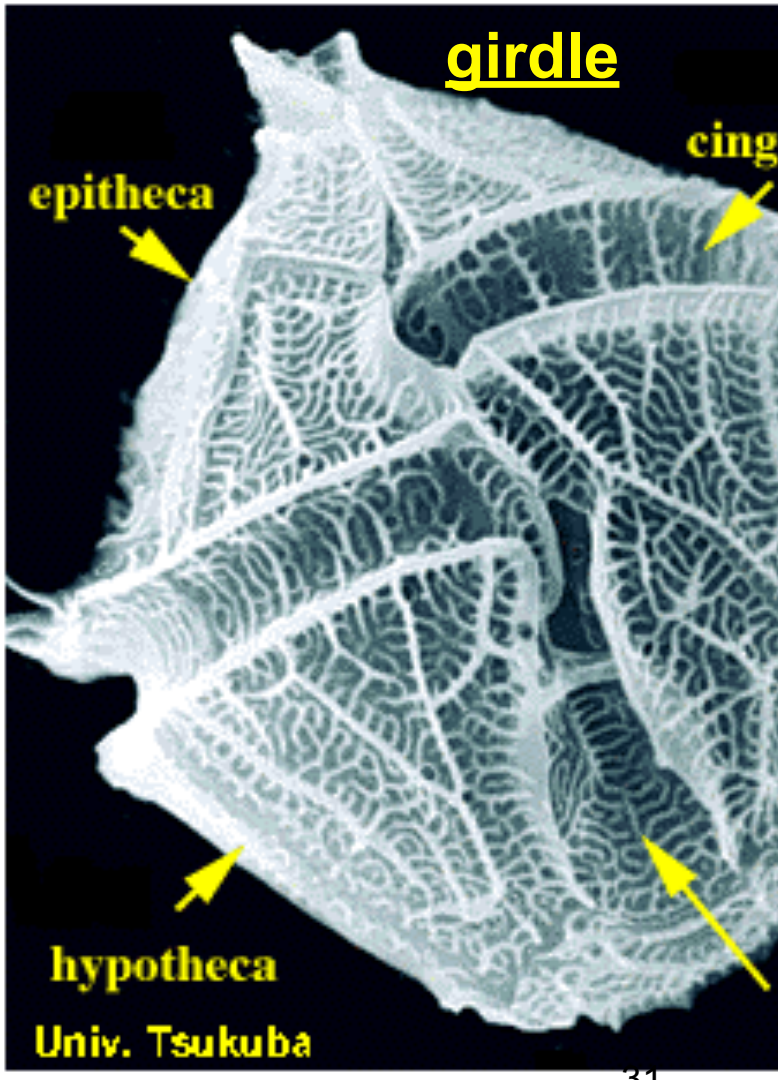
Alveolate: Phylum Dinozoa - Dinoflagellates

- Free-living, commensal or parasitic
- Marine and freshwater
- 2 unequal flagella
  - Located in equatorial and longitudinal grooves
- Membrane covering cell - reinforced by plates or theca (naked vs armored)
  - secreted by alveolar sacs
- Chloroplasts in 60% of species
- Sexual reproduction by gametes
- Some bioluminescent, some toxic

Dinoflagellate – Diagram and Scanning Electron Micrograph

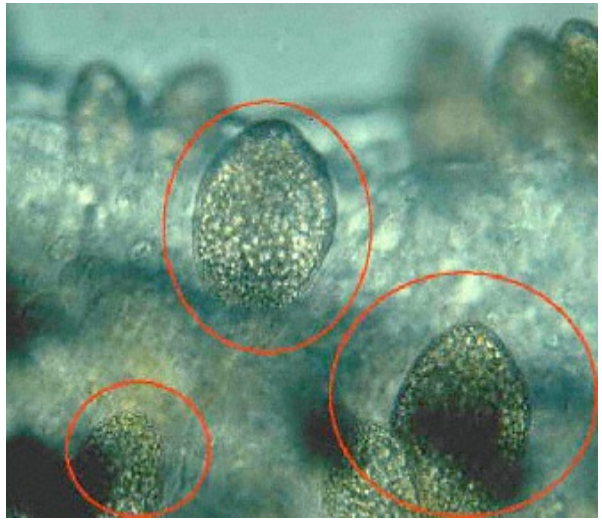




http://www.daviddarling.info/images/dinoflagellate.gif, http://www.botany.hawaii.edu/BOT201/Algae/Bot%20201%20Dinoflagellates%20page.GIF

Flagellates: Dinoflagellates

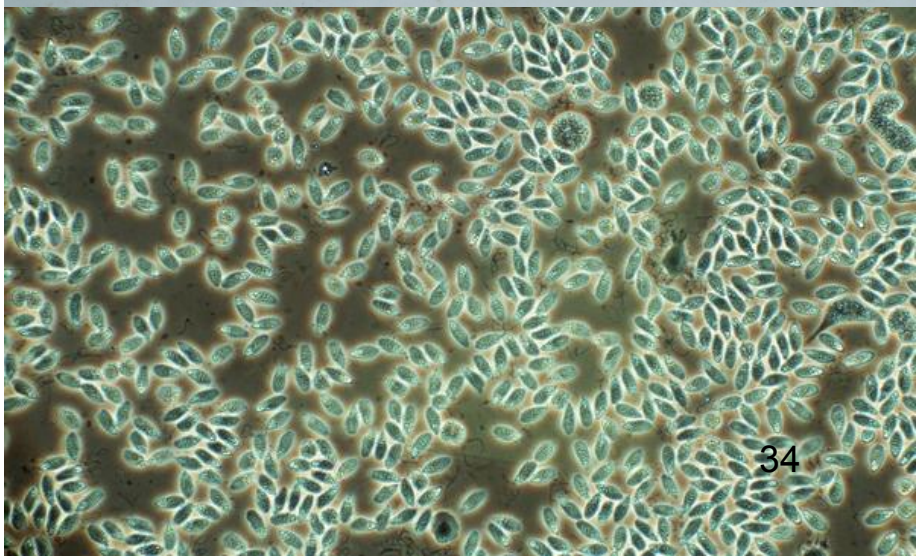
- Known as causes of red tides
- Several are parasitic on fish
  - *Pfiesteria* spp.
  - *Oodinium* spp.
- Attach and feed on host epidermis
  - Gills: causes anoxia and eventually death of fish
  - Skin: osmotic disruption



***Oodinium pilluris* in the skin mucous – velvet disease**

Parasitic Dinoflagellates – Bitter Crab Disease

- Caused by a dinoflagellate
  - *Hematodinium* spp.
- ***Geographic distribution:***
  - *North America*
  - *Arctic Ocean and Australia*
  - *UK and Europe*
- ***Host species: locally in PNW* = Tanner and snow crabs (***Chionoecetes*** spp.)** but infects wide variety of crustacea

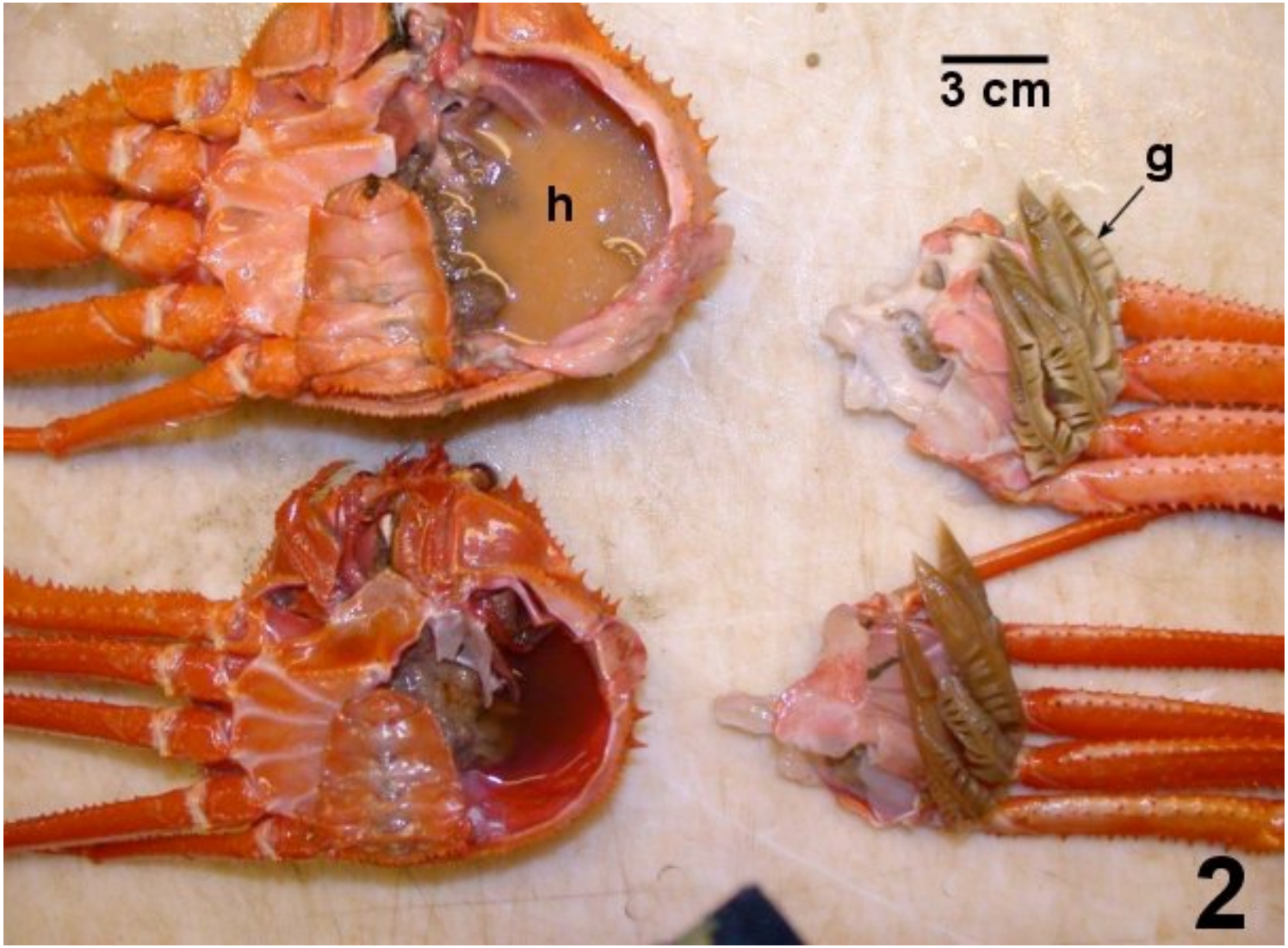


Bitter Crab Disease 2

- *Hematodinium* proliferates in hemolymph, consuming hemocyanin, essentially suffocating its host – **100%** fatal disease!

- ***Impact on the host:***
  - Drooping limbs and mouthparts
  - "cooked" appearance, muscle pulled back from exoskeleton, lethargic, discoloration of arthrodial membranes (translucent to opaque)
  - Milky-white hemolymph
  - When cooked, the muscle has a chalky texture and an astringent after-taste

- Severe economic losses of *Chionoecetes bairdi* (estimated up to $3 million US) in Alaska

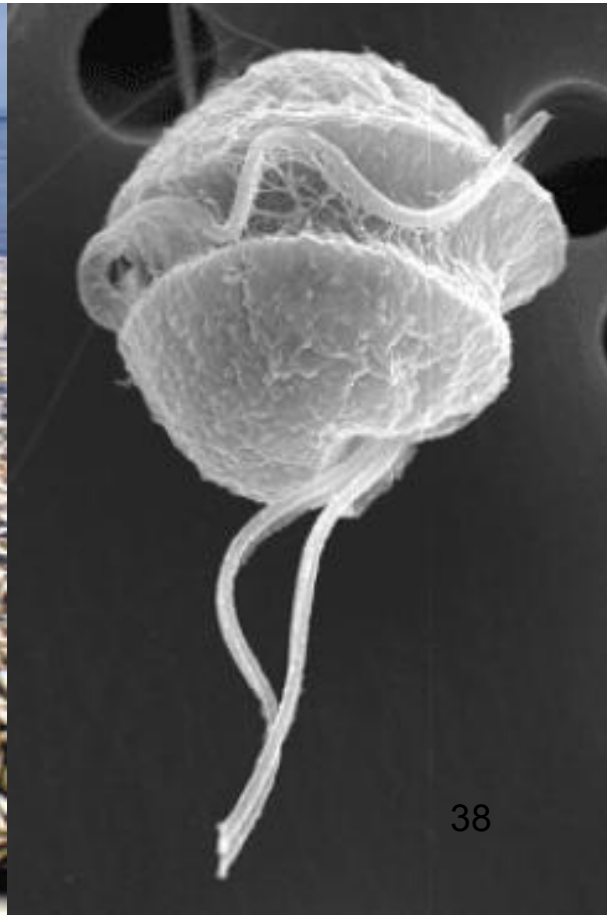


- Ventral surface of two commercial-size male *Chionoecetes tanneri* ; whitish dicoloration of the gills (g) and opaque hemolymph (h) pooled in the carapace of a specimen heavily infected with *Hematodinium* sp. (top) in comparison to an uninfected crab (bottom)

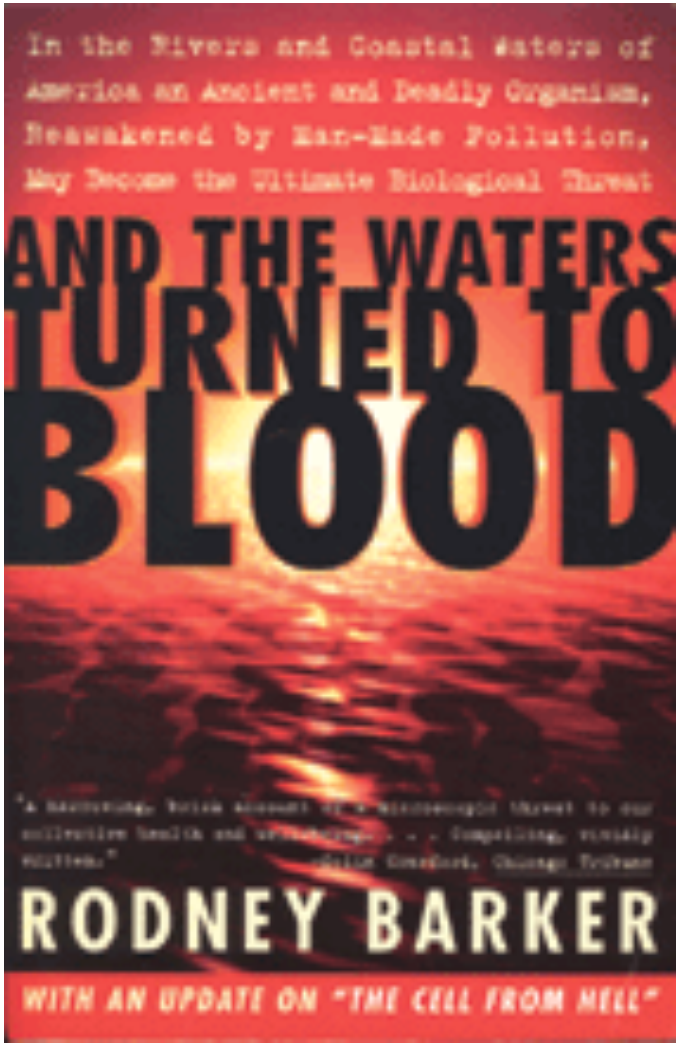
Image provided by Greg Workman, DFO Pacific.

Another “parasitic” dinoflagellate: actually = micropredator

Pfiesteria spp.



Alarm. A 1997 book fanned concerns about *Pfiesteria*'s neurotoxicity. CREDIT: TOUCHSTONE/SIMON & SCHUSTER



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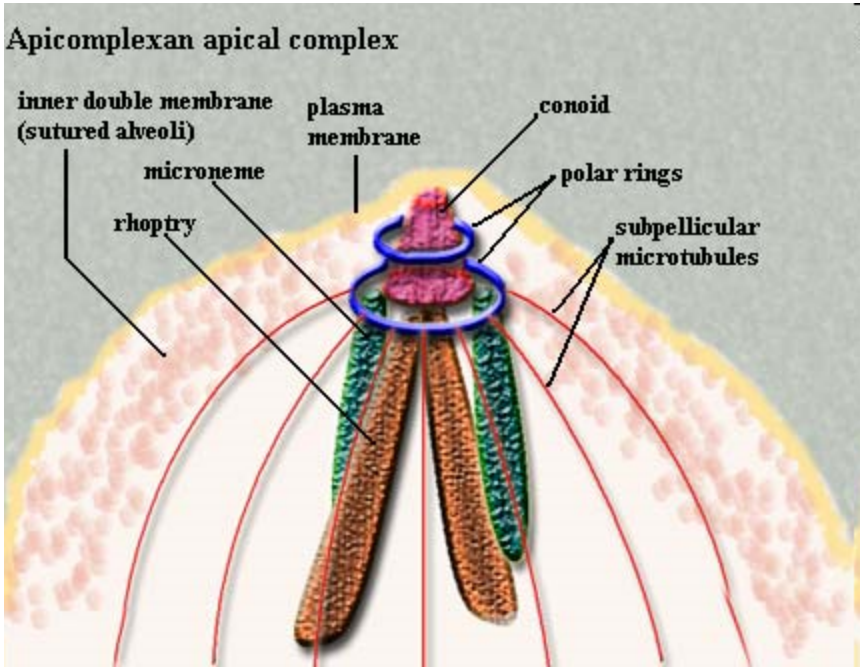
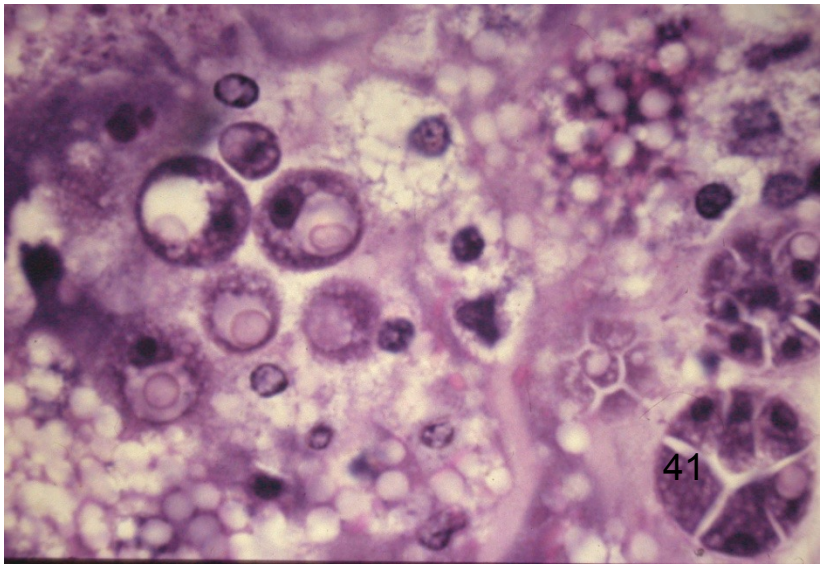
Alveolates - Phylum Apicomplexa (all parasitic)

- Characterized by apical complex in infective stage
- *Perkinsus* spp in abalone, clams, scallops, and oysters



www.palaeos.com/.../Images/ApicalComplex.jpg

(photos courtesy of J Handlinger)



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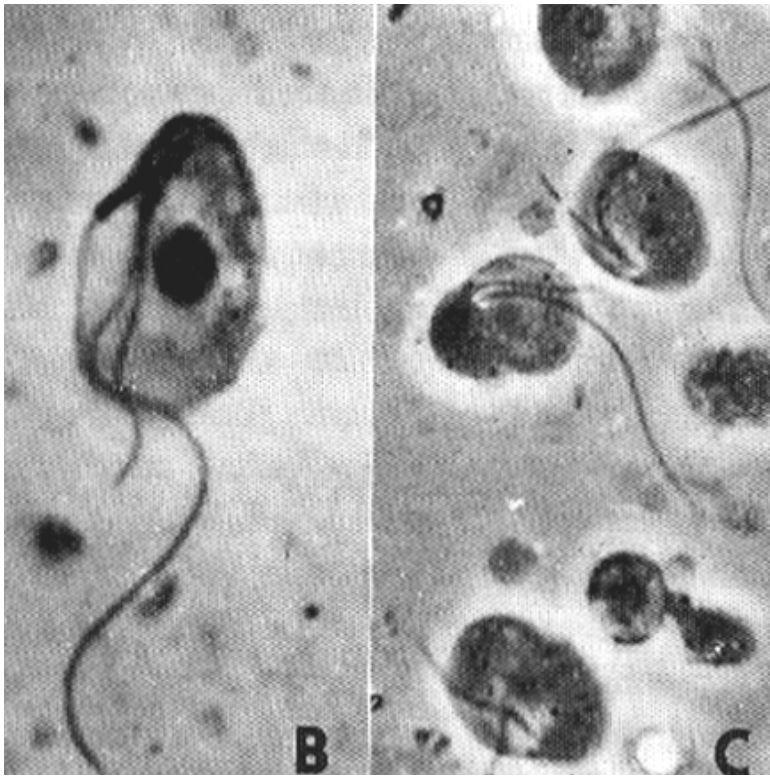
Flagellates

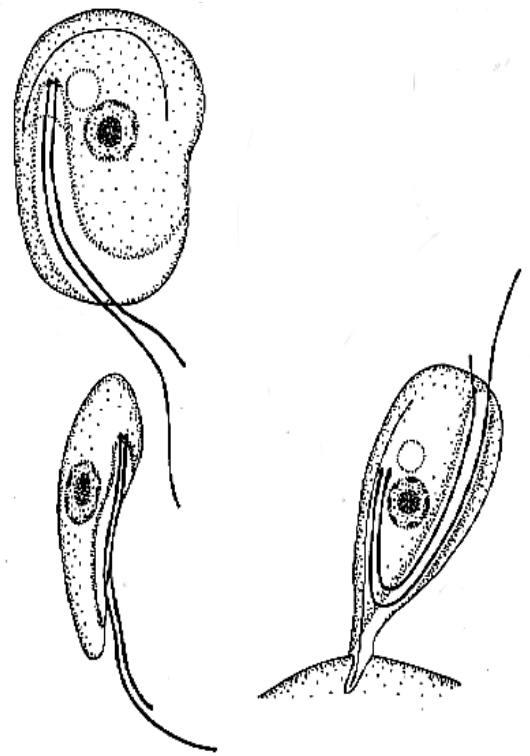
- >7500 species
- **Molecular data suggests = ancestors of amoebae**
- Characteristics
  - **≥ 1 flagella**
  - **Pellicle** – complex folded membranes covering cell (may =rigid or flexible)
  - **Most free living and some parasitic (trypanosomes) forms**
  - **Some photosynthetic (*Euglena*)**



Flagellates

- **Free swimming and attached forms**
- **Division by binary fission**

Swimming form



Attached form

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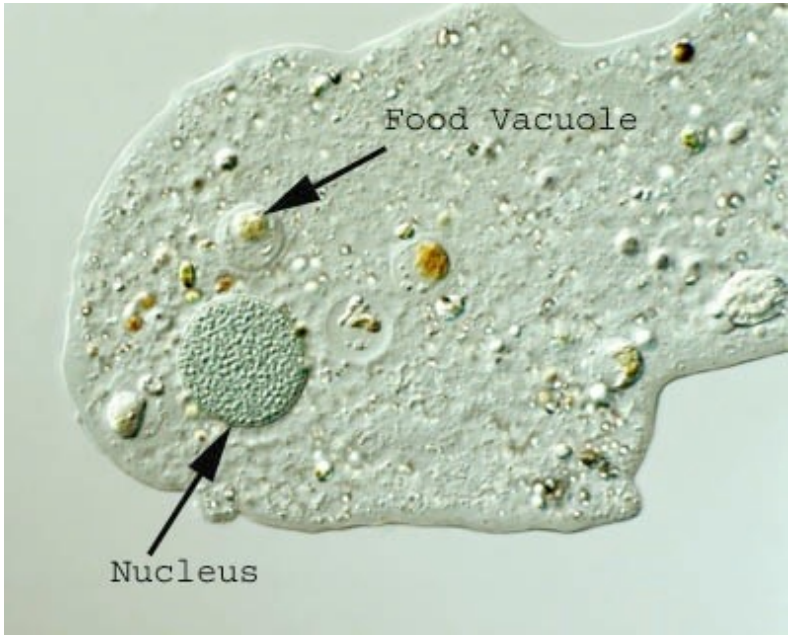
- (Phylum Mastigophora) - Flagellates
    - Possess one to several flagella
- **(Phylum Rhizopoda) - Amoeba**
    - Move by pseudopodia

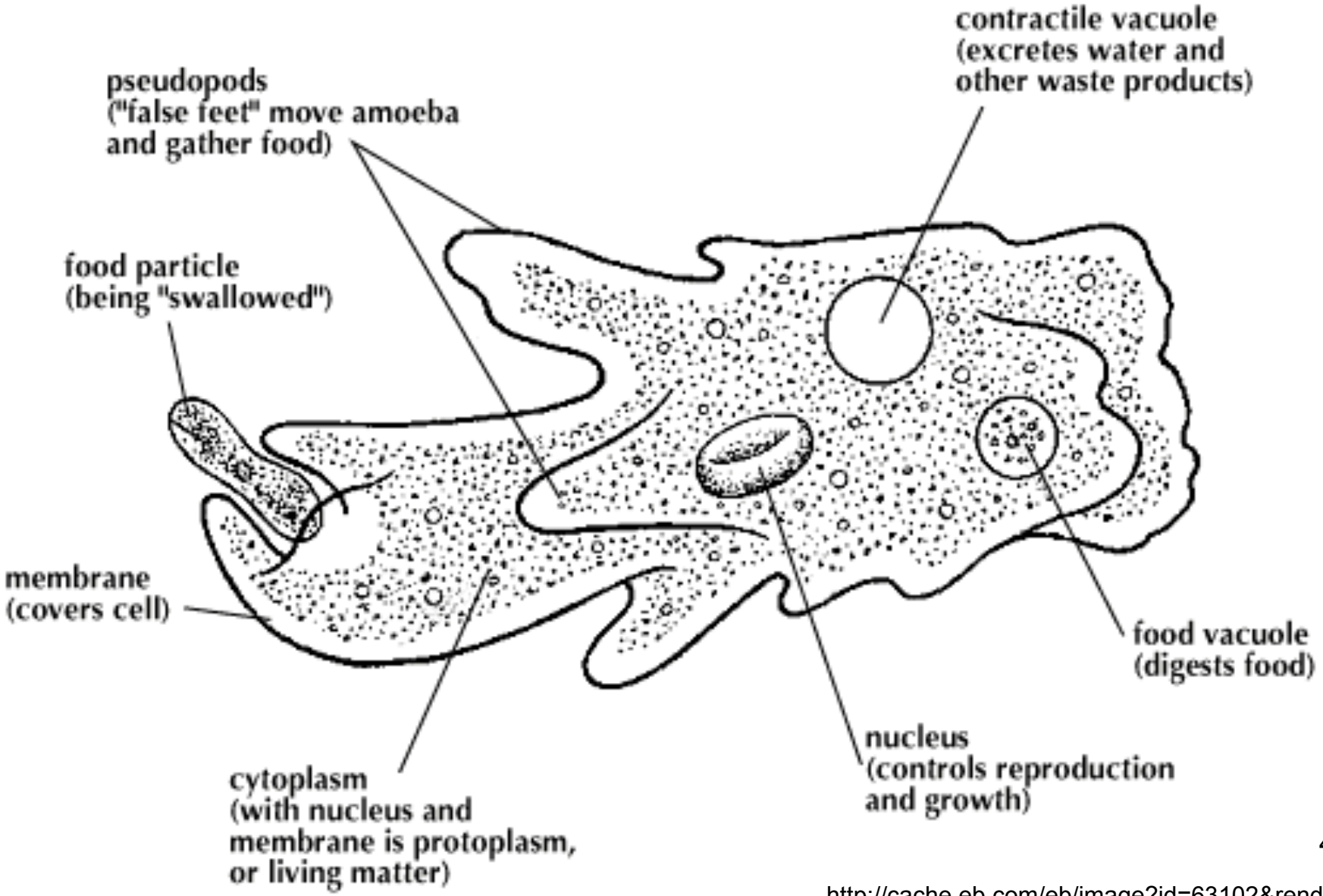
Amoebae: (Phylum Rhizopoda)

- Protists using pseudopodia
- Naked plasmalemma (no pellicle: thin protective membrane on some protozoa)
- Flagella present on some sexual stages
- Asexual reproduction via binary or multiple fissions
- Most free living, a few parasitic



http://www.btinternet.com/~stephen.durr/amoebanucleusvacuole.jpg

Amoebae: (Phylum Rhizopoda)



http://cache.eb.com/eb/image?id=63102&rendTypeId=4

Conclusions - Protozoans

- Diverse group of unicellular organisms
- Many free living but some important parasites of fish
- Divide by binary or multiple fission
- Have sexual stages
- Cause disease by destroying or disrupting functions of the epithelium of host