# **Chapter 22:** Protists

# Protists

| | |
|---|---|
| Chlorophytes (green algae) | *Acetabularia, Chlamydomonas, Chlorella, Codium, Udotea, Ulva, Volvox, Scenedesmus* |
| Red algae | *Antithamnion, Porphyra* |
| Amoebozoans | *Amoeba, Dictyostelium, Physarum* |
| Stramenopiles | |
| Chrysophytes | *Emiliania, Mischococcus, Synura* |
| Diatoms | *Thalassiosira* |
| Brown Algae | *Laminaria, Macrocystis, Postelsia, Sargassum* |
| Oomycotes | *Phytophthora, Plasmopara, Saprolegnia* |
| Alveolates | |
| Ciliates | *Didinium, Paramecium, Stylonychia* |
| Dinoflagellates | *Gonyaulax, Gymnodinium, Karenia, Noctiluca* |
| Apicomplexans | *Plasmodium* |
| Foraminiferans | *Peneroplis, Spiroloculina* |
| Radiolarians | *Pterocorys, Stylosphaera* |
| Kinetoplastids | *Trypanosoma, Leishmania* |
| Euglenoids | *Euglena* |
| Diplomonads | *Giardia* |
| Parabasalids | *Trichomonas, Trichonympha* |

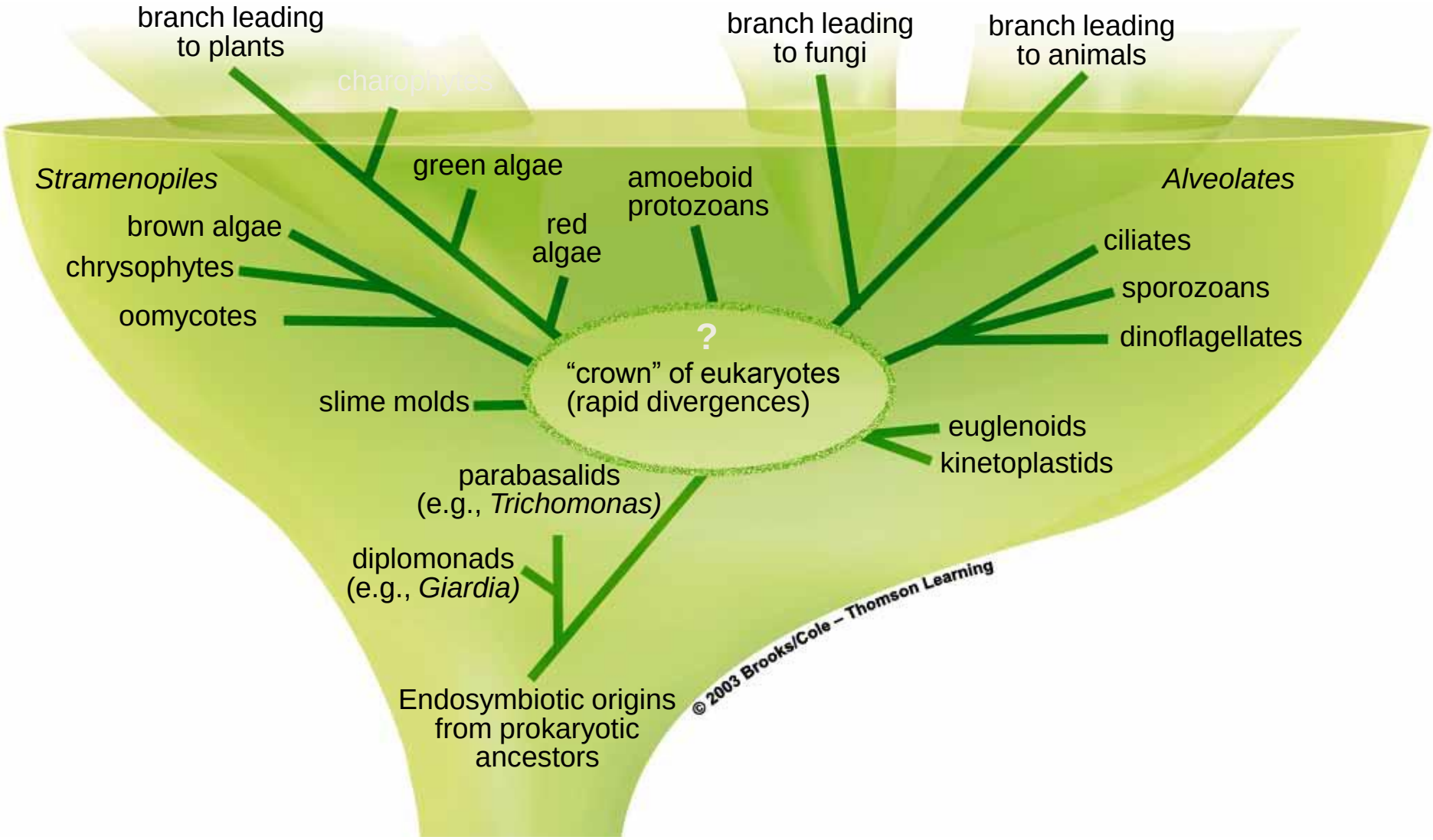
# Protistans are Unlike Prokaryotes

- Have a **nucleus and organelles**
- Have **proteins associated with DNA**
- Use **microtubules in a cytoskeleton, spindle apparatus, and cilia and flagella**
- May contain chloroplasts
- May divide by mitosis and meiosis

# Difficult to Classify

- **Historically a catch-all kingdom**
- **Differ enormously from one another in morphology and life-styles**
- Molecular and biochemical comparisons are clarifying the evolutionary picture
- Protistans are not a monophyletic group

# Evolutionary Tree



# Evolutionary Tree

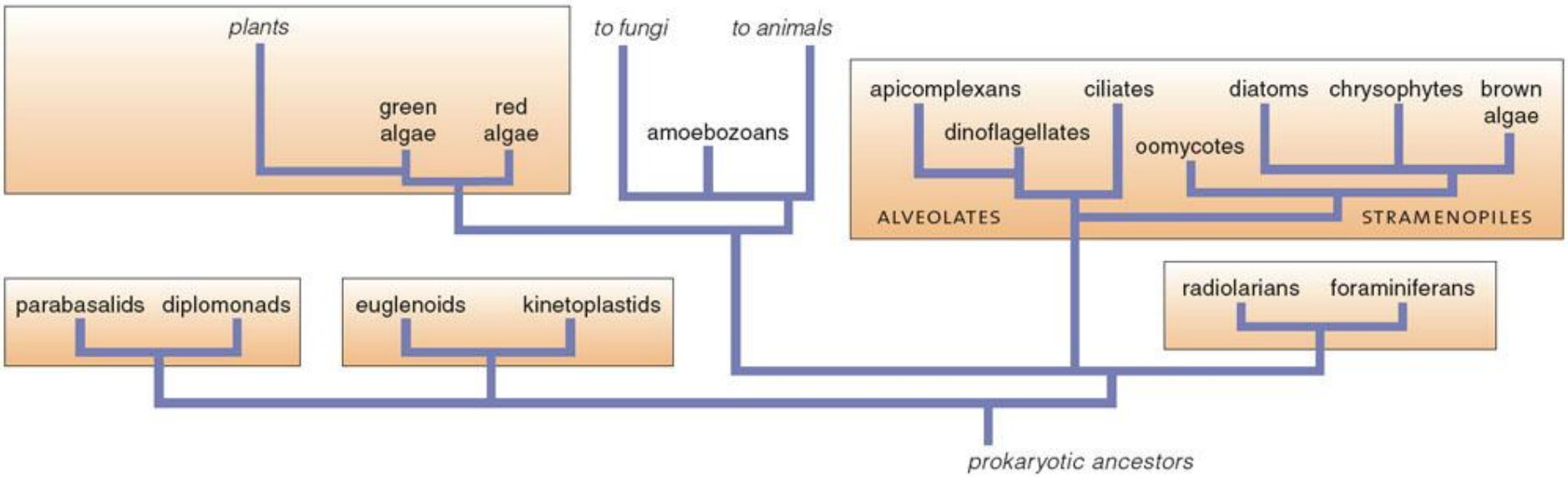


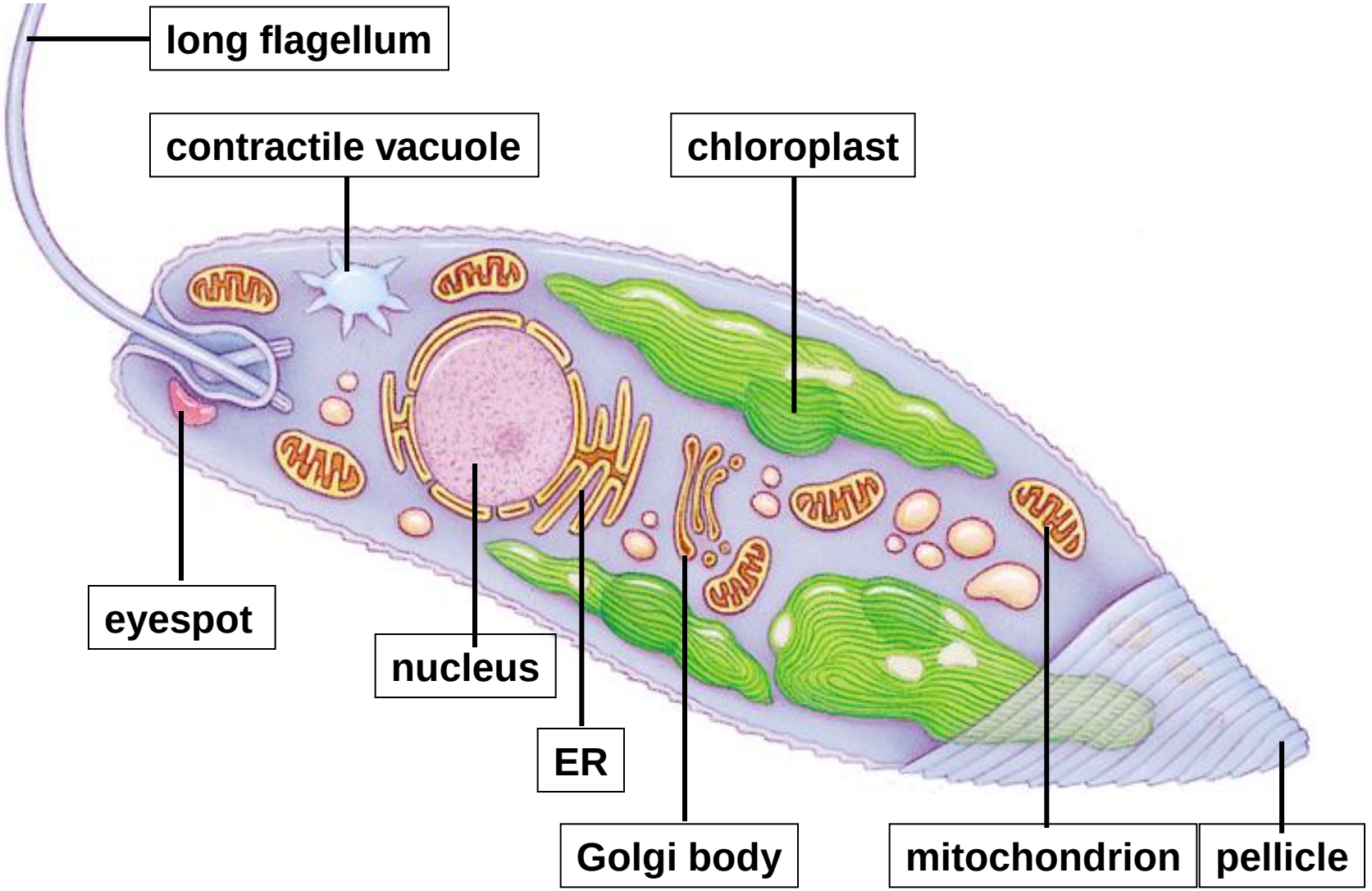



Fig. 22-2, p.352

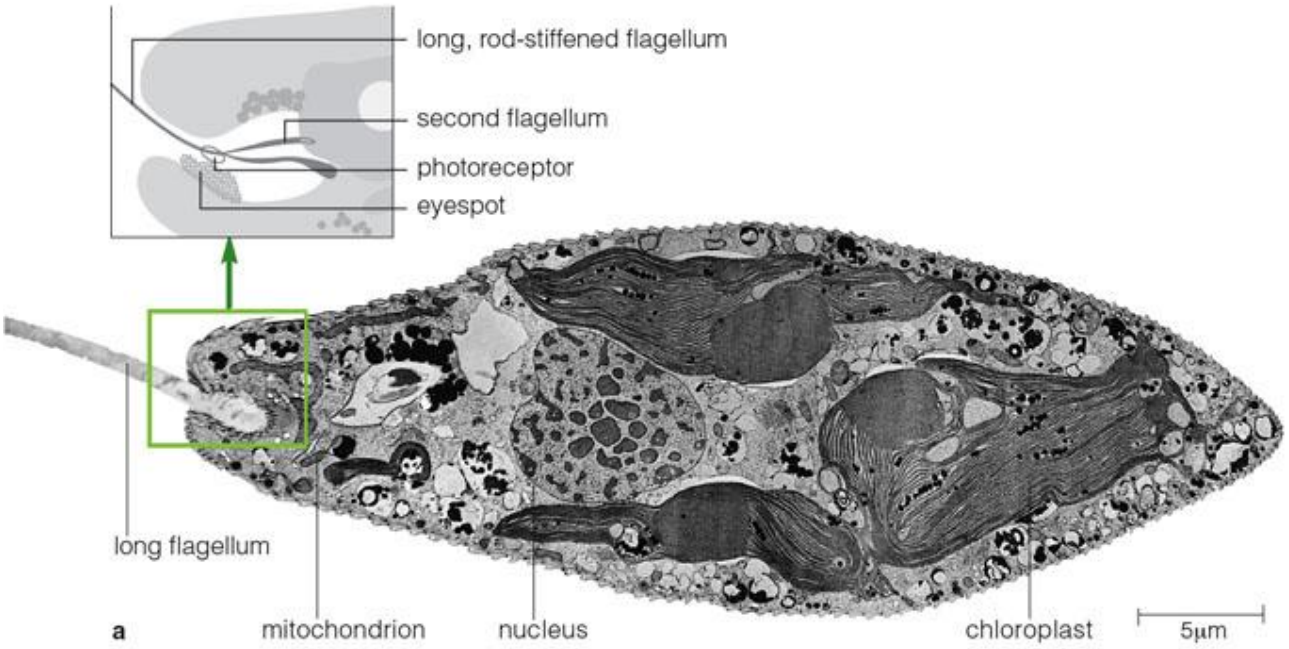
# Euglenoids: Evolutionary Puzzle

- **Some heterotrophs**
- **Most have chloroplasts like green algae and plants**
- **Have flagella like flagellated protozoans**
- **Related to flagellated protozoans**
- **Acquired chloroplasts by endosymbiosis**

# Euglenoid Body Plan



# Euglenoid Body Plan



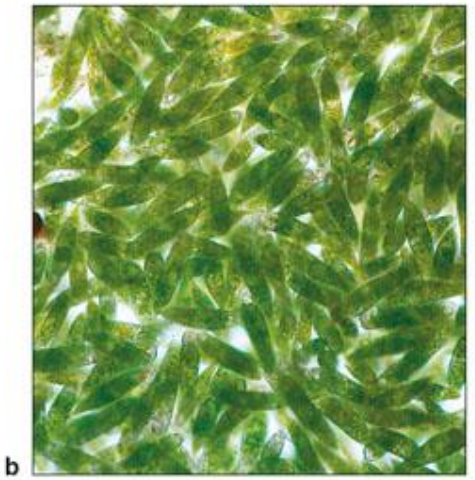
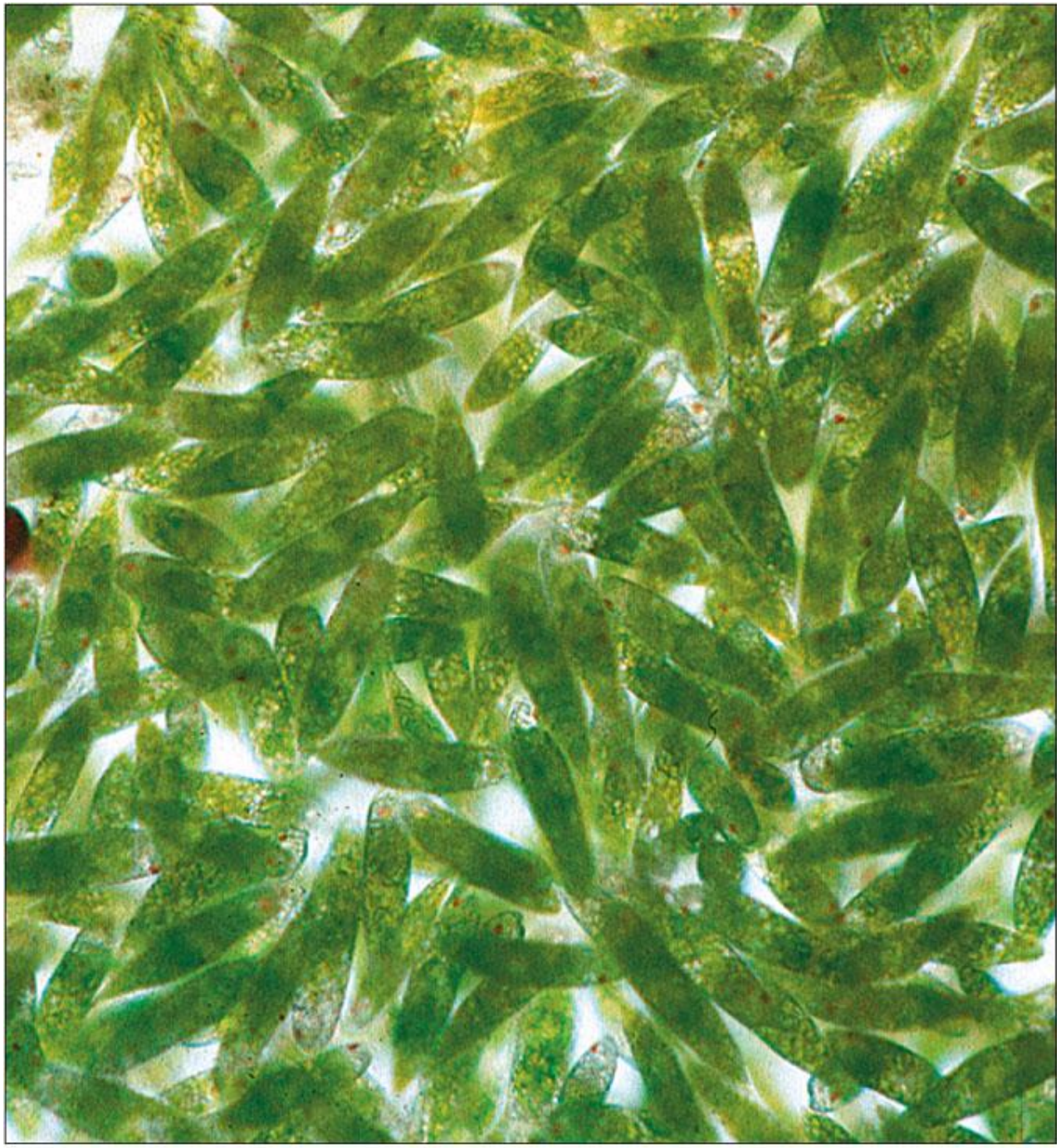






Fig. 22-4a, p.354



# Euglenoid Body Plan



Fig. 22-4b, p.354

# Euglenoids Are a Monophyletic Group

- Members share a common ancestor and derived traits that are present in no other group

- Unique traits
  - A storage carbohydrate
  - Type of eyespot

# Amoeboid Protozoans (Sarcodina)

- Move by means of cytoplasmic streaming and pseudopods
- Naked amoebas
- Foraminiferans

} Rhizopods

- Heliozoans
- Radiolarians

} Actinopods

# Naked Amoebas

- **Change shape constantly**
- **Most are free-living cells that engulf their prey**
- Some are symbionts in animal guts
- A few are opportunistic pathogens

# Other Amoeboid Protozoans

- Foraminiferans
  - Calcium carbonate shell
- Radiolarians and Heliozoans
  - Shells of silica

**A living heliozoan**

# Other Amoeboid Protozoans

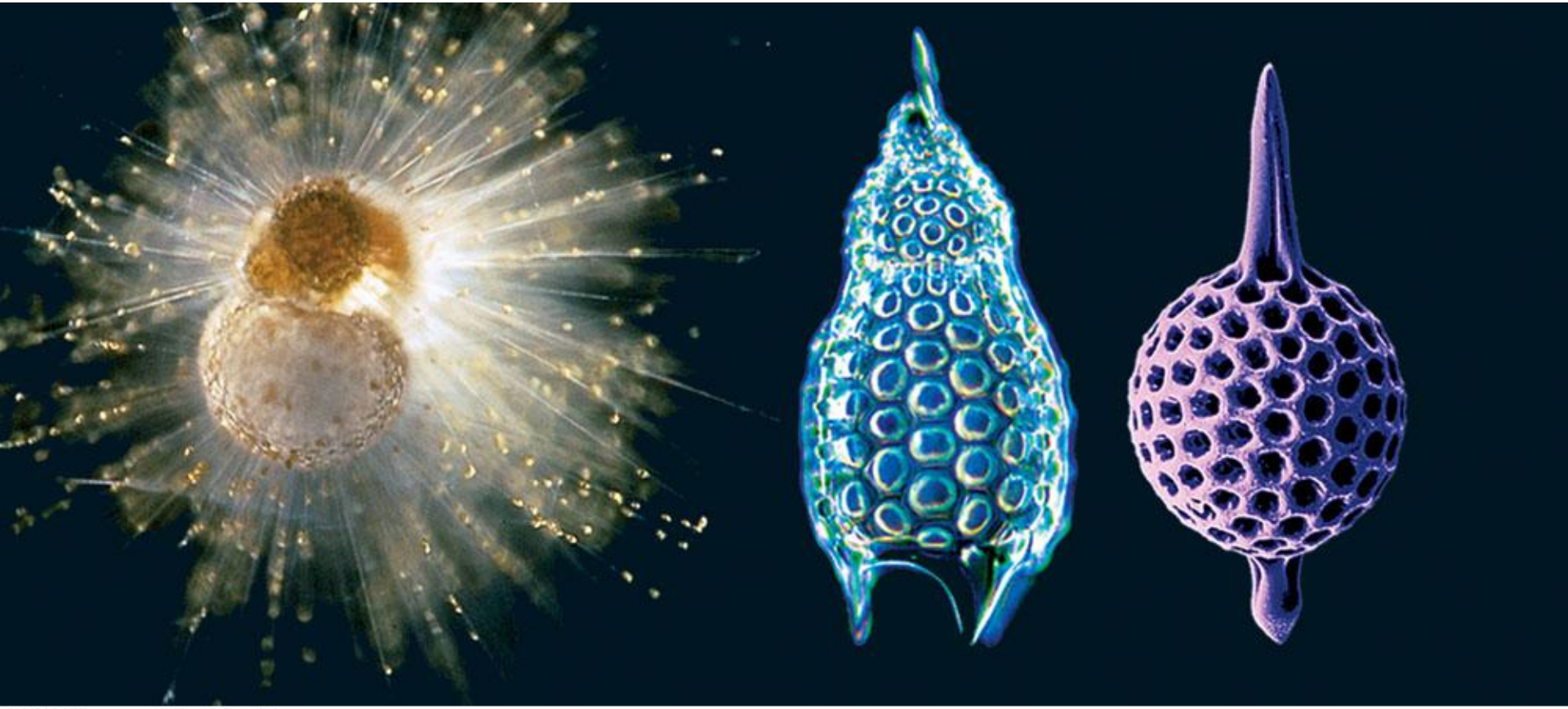
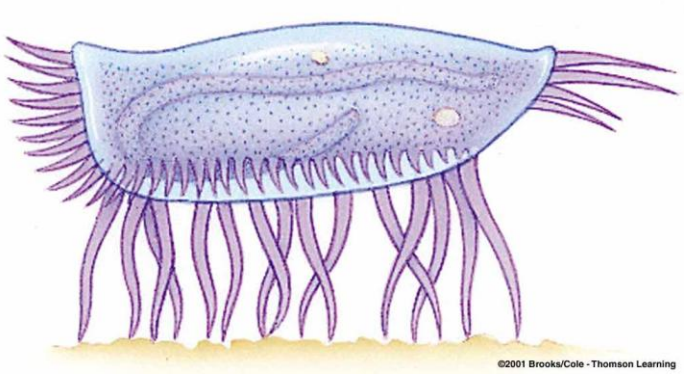




Fig. 22-6, p.355

# Ciliates (Ciliphora)

- **All heterotrophs**
- **Arrays of cilia allow movement and direct food into oral cavity**
- Diverse life-styles




Hypotrich


*Paramecium*

# Alveolates

- **Have tiny, membrane-bound sacs (alveoli) underneath their outer membranes**
- Ciliates
- Sporozoans
- Dinoflagellates

# Body Plan of *Paramecium*

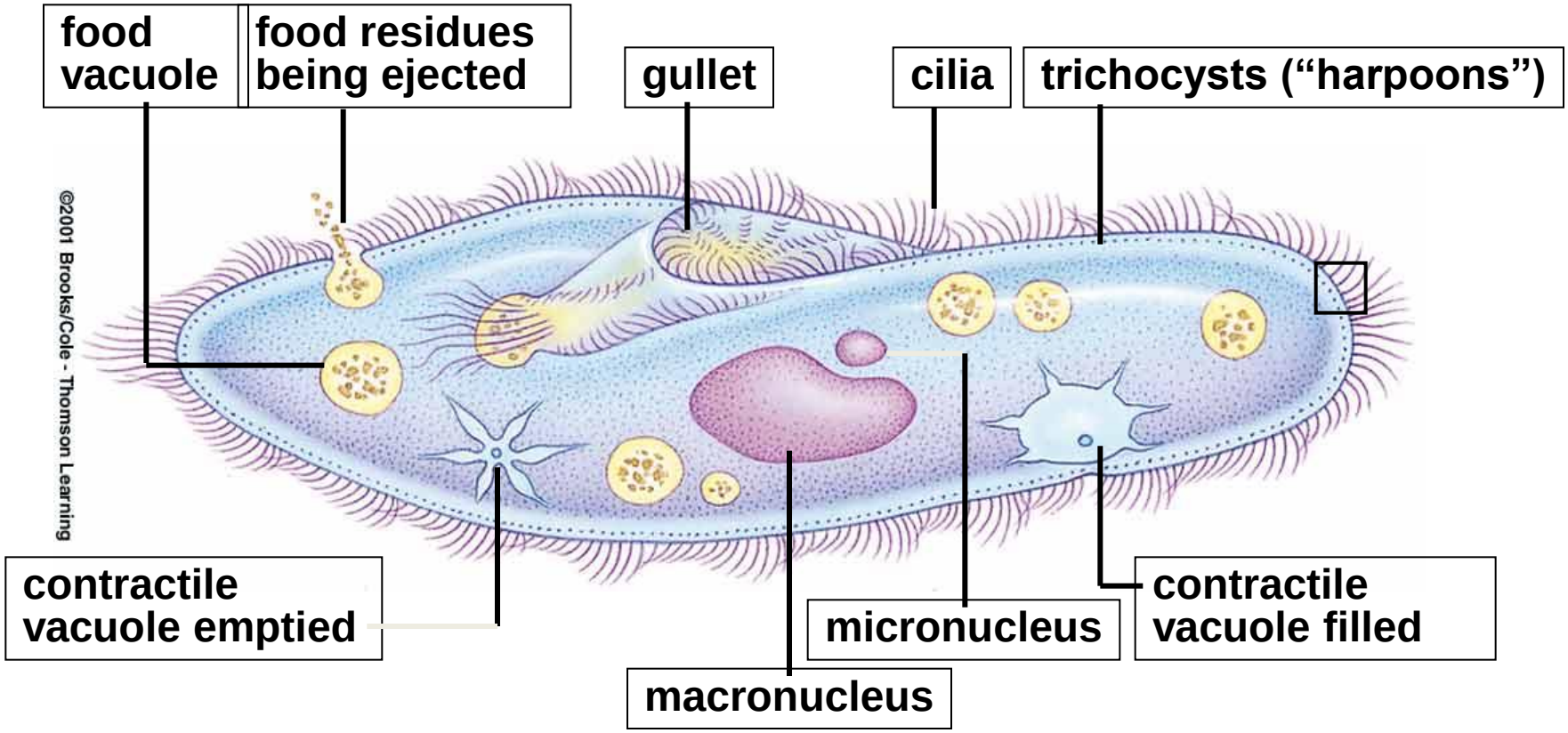



Fig. 22-7a, p. 356

# Ciliate Conjugation

- Most ciliates have two different nuclei
  - Large macronucleus
  - Smaller micronucleus
- Micronucleus participates in sexual reproduction (conjugation)
  - Partners exchange micronuclei

# Paramecium

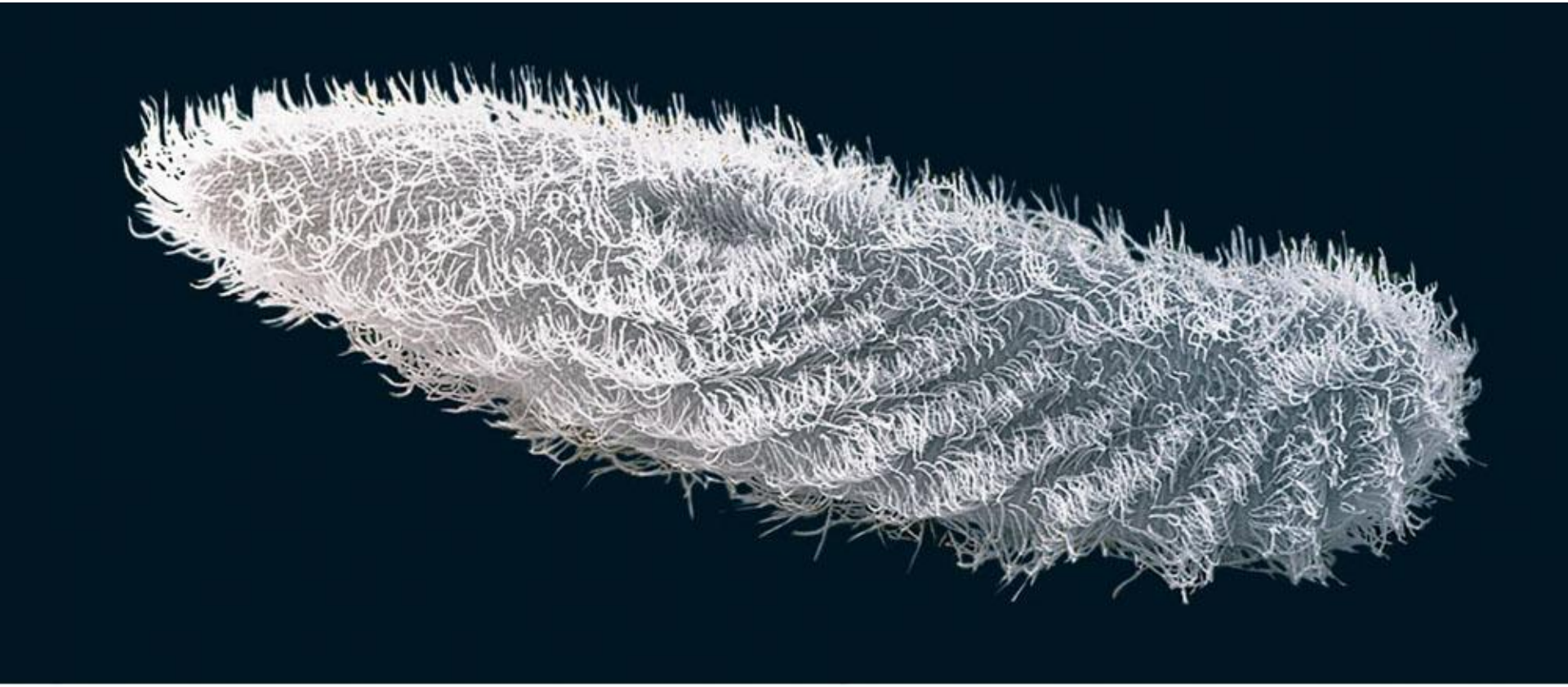
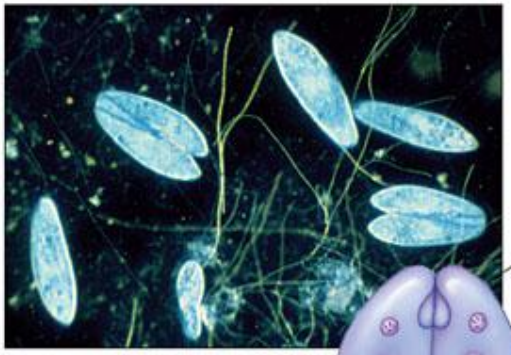




Fig. 22-7a1, p.356

# Protozoan Conjugation



a Prospective partners meet.

b Partners physically join up, most often at their oral depression.

c The two cells undergo cytoplasmic fusion. The micronucleus of each enters meiosis I.

d Meiosis II follows and results in four haploid micronuclei. The macronucleus of each cell starts to degenerate.

e In each cell, one haploid micronucleus stays intact; the other three degenerate.

f Each haploid micronucleus divides. Each cell will swap a daughter micronucleus with its partner.

g Two micronuclei in each cell fuse, forming a diploid micronucleus. Each cell now contains genetic material from the other.

h The conjugating cells disengage. The micronucleus of each divides.

i Micronuclei in each cell divide. Then the original macronucleus degenerates.

j Each cell now has four micronuclei.

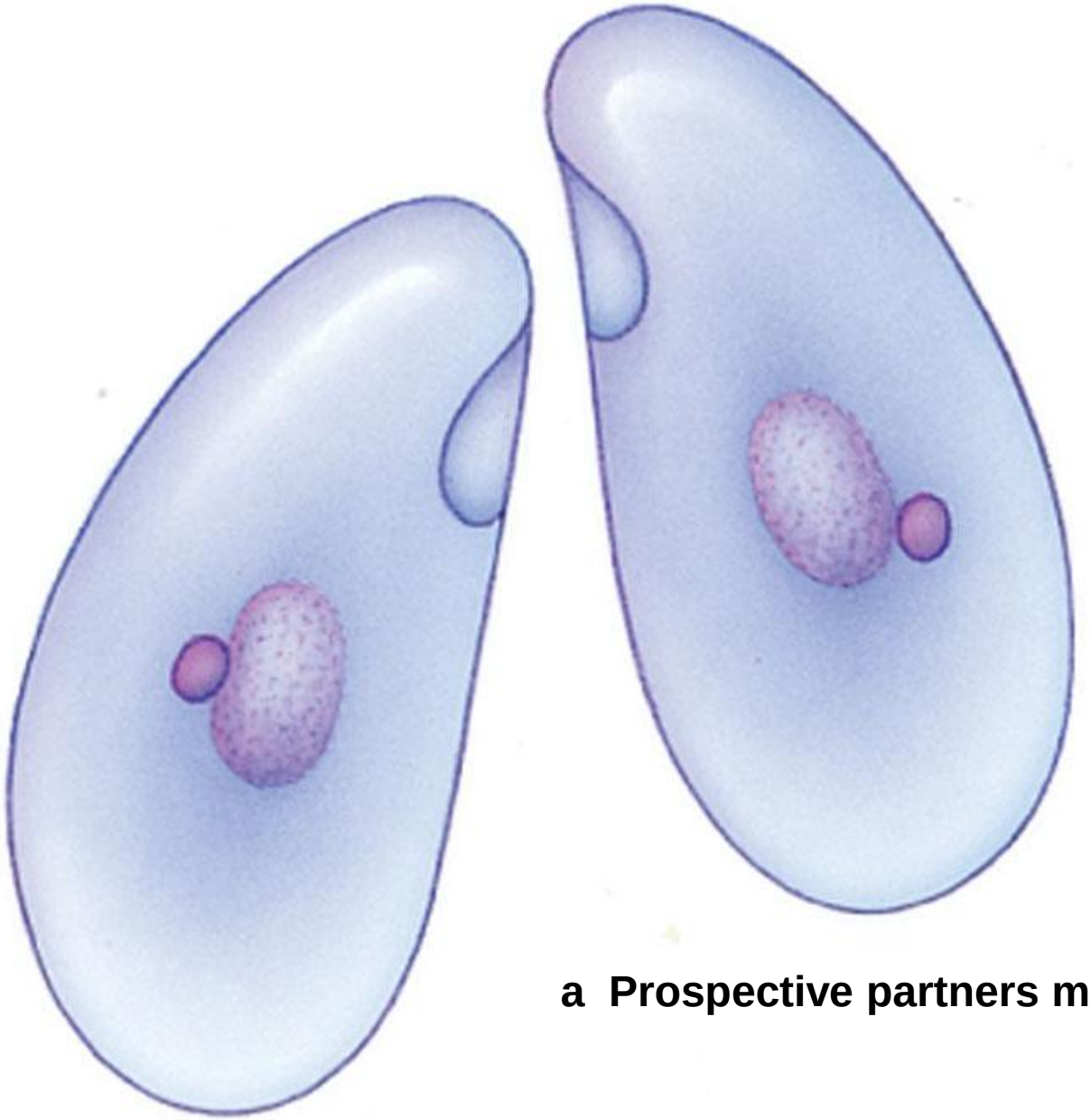
k Of the four micronuclei, two develop into macronuclei.

l Cytoplasmic division now begins, and two cells form.

m Each daughter cell contains one micronucleus and one macronucleus.



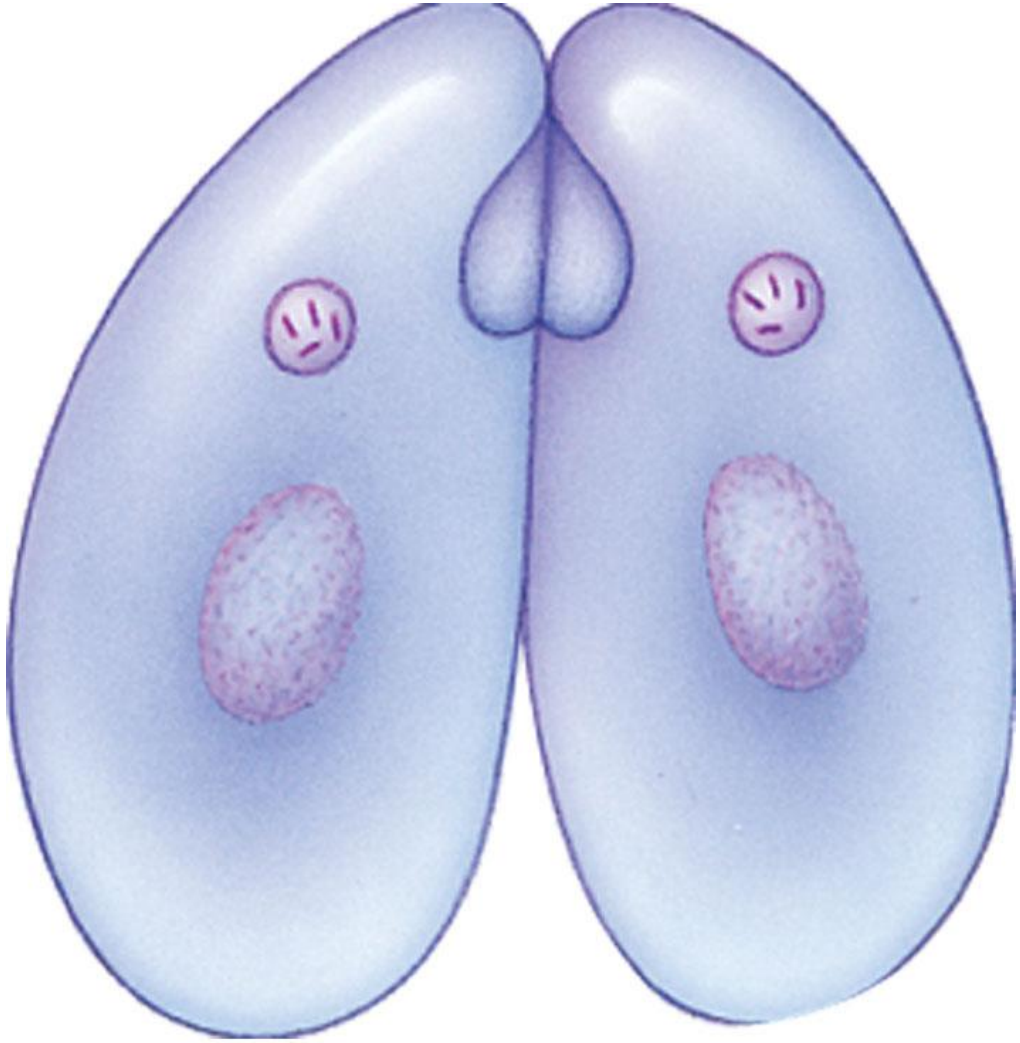
**Fig. 22-8, p.357**



**a Prospective partners meet.**



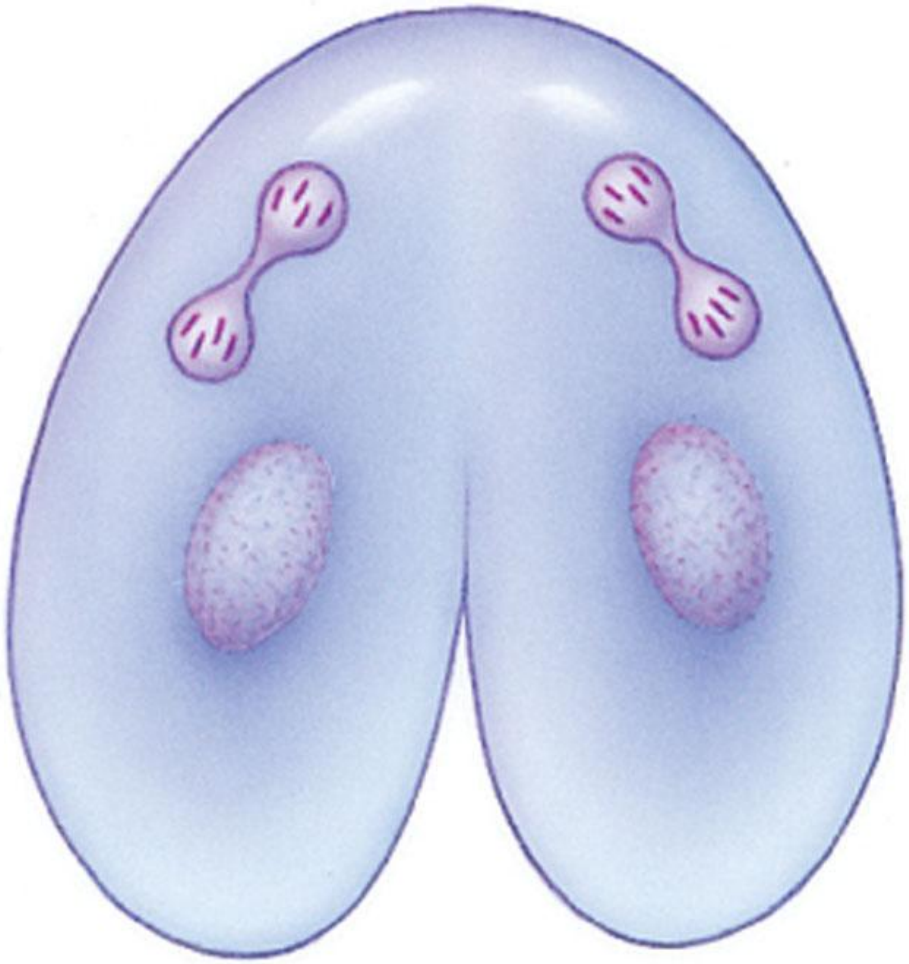
**Fig. 22-8a, p.357**





**b Partners physically join up, most often at their oral depression.**

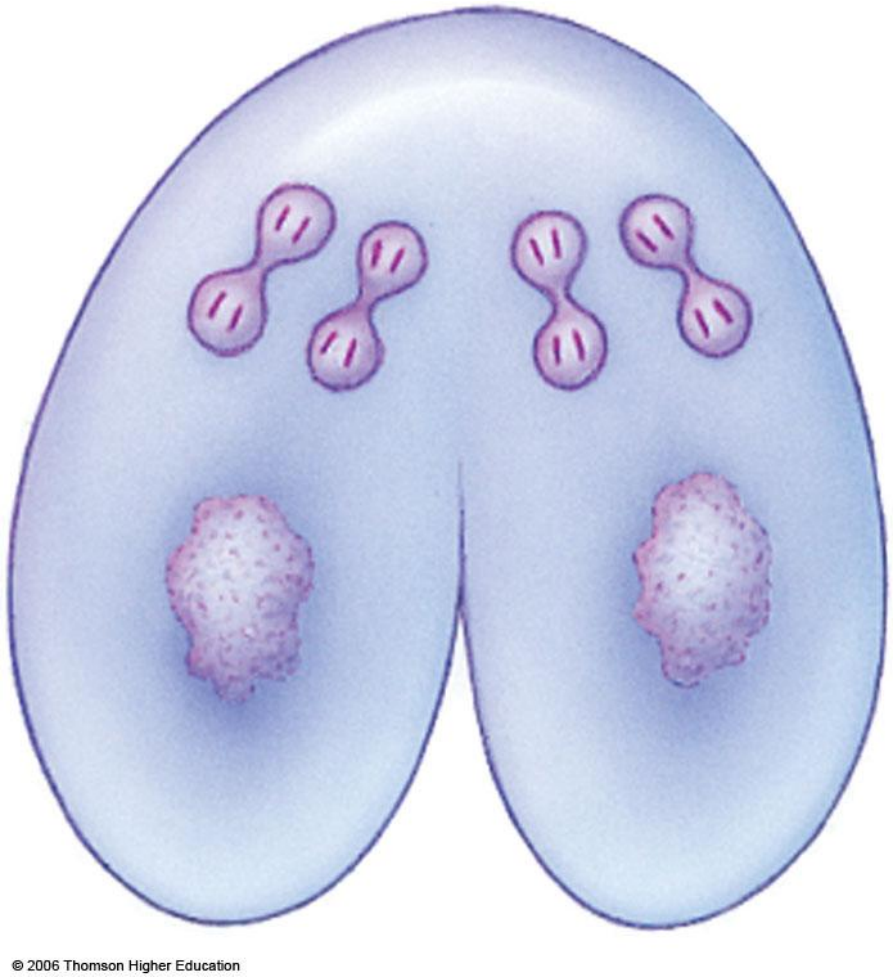
**Fig. 22-8b, p.357**





**c The two cells undergo cytoplasmic fusion. The micronucleus of each enters meiosis I.**

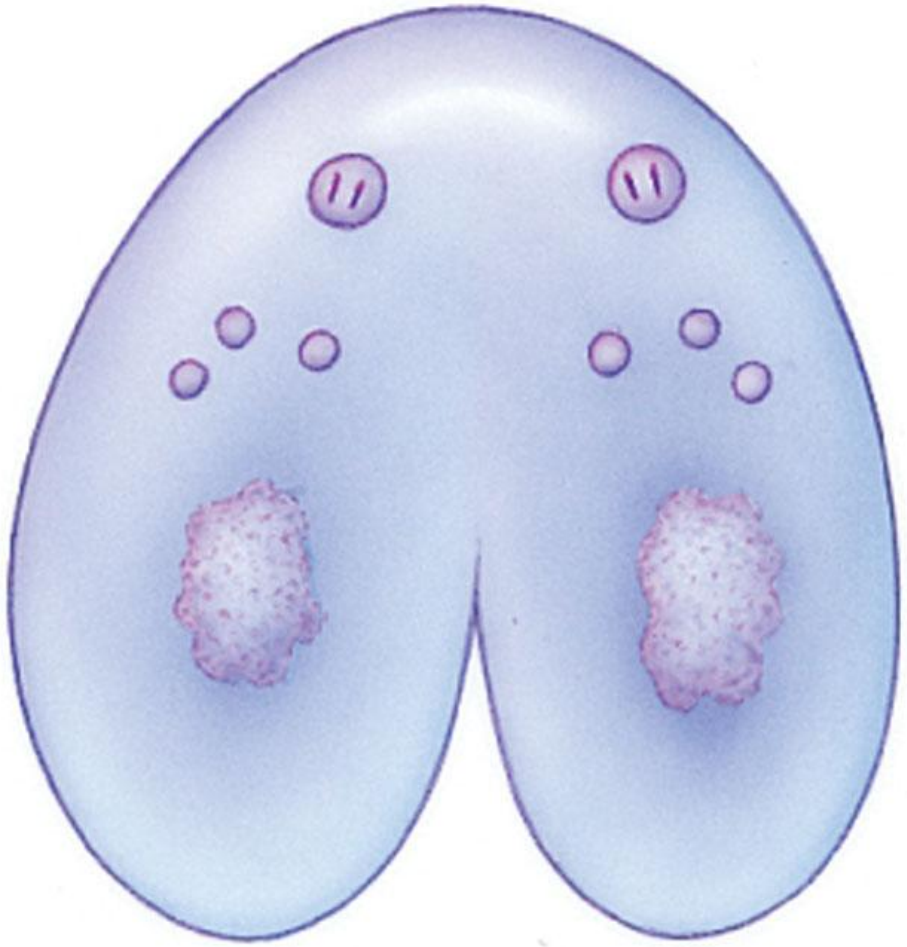
**Fig. 22-8c, p.357**





**d Meiosis II follows and results in four haploid micronuclei. The macronucleus of each cell starts to degenerate.**

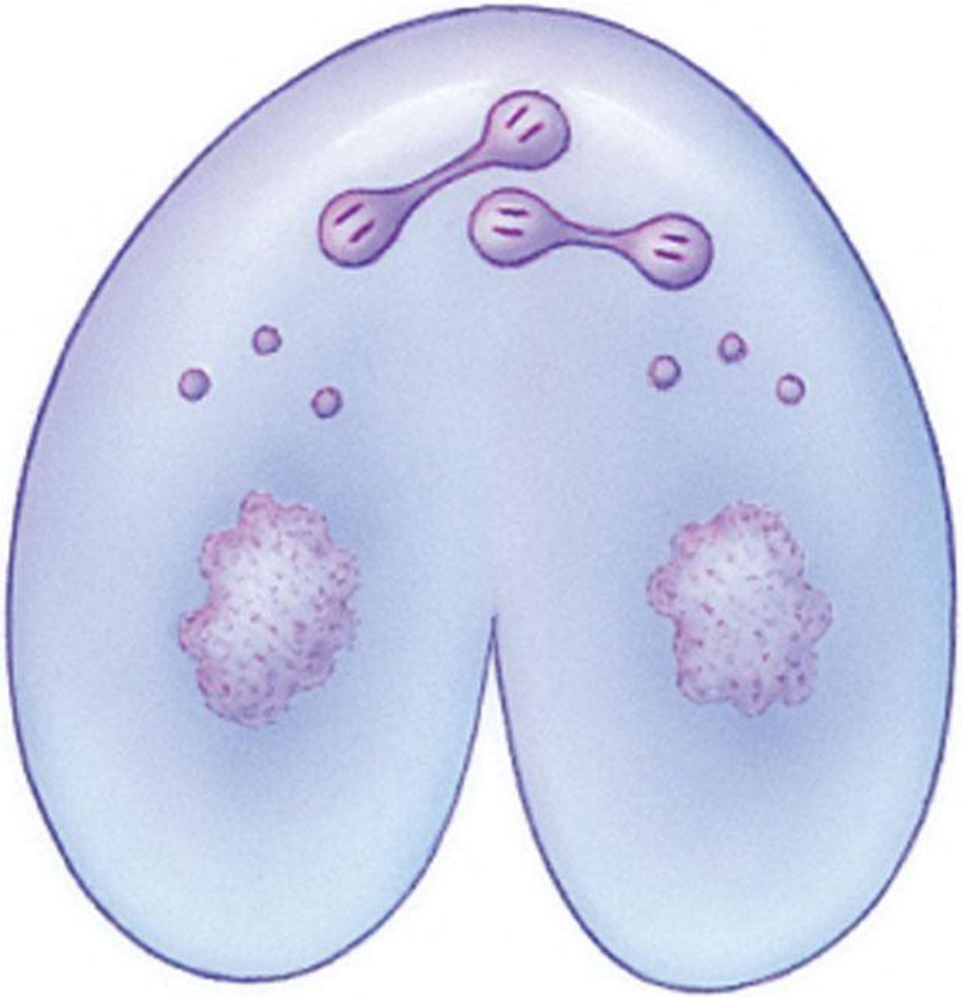
**Fig. 22-8d, p.357**





**e In each cell, one haploid micronucleus stays intact; the other three degenerate.**

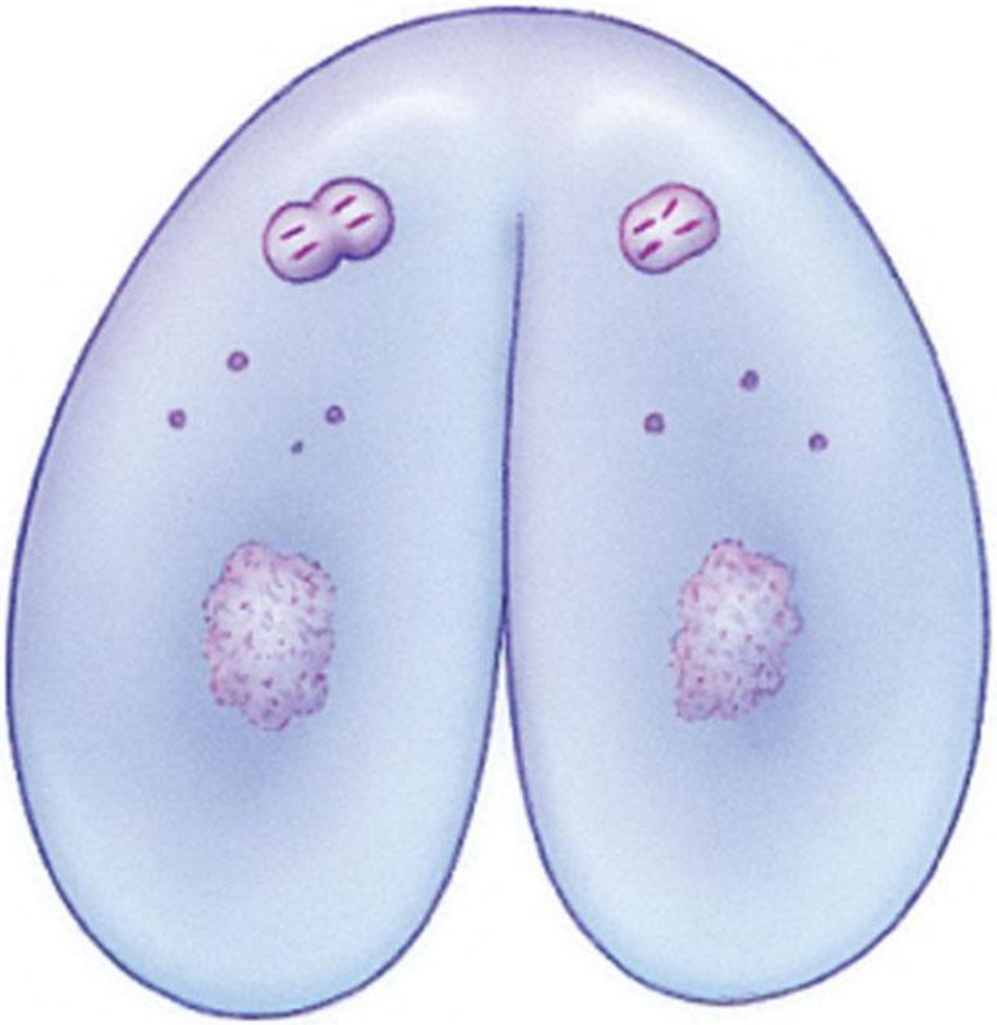
**Fig. 22-8e, p.357**





**f Each haploid micronucleus divides. Each cell will swap a daughter micronucleus with its partner.**

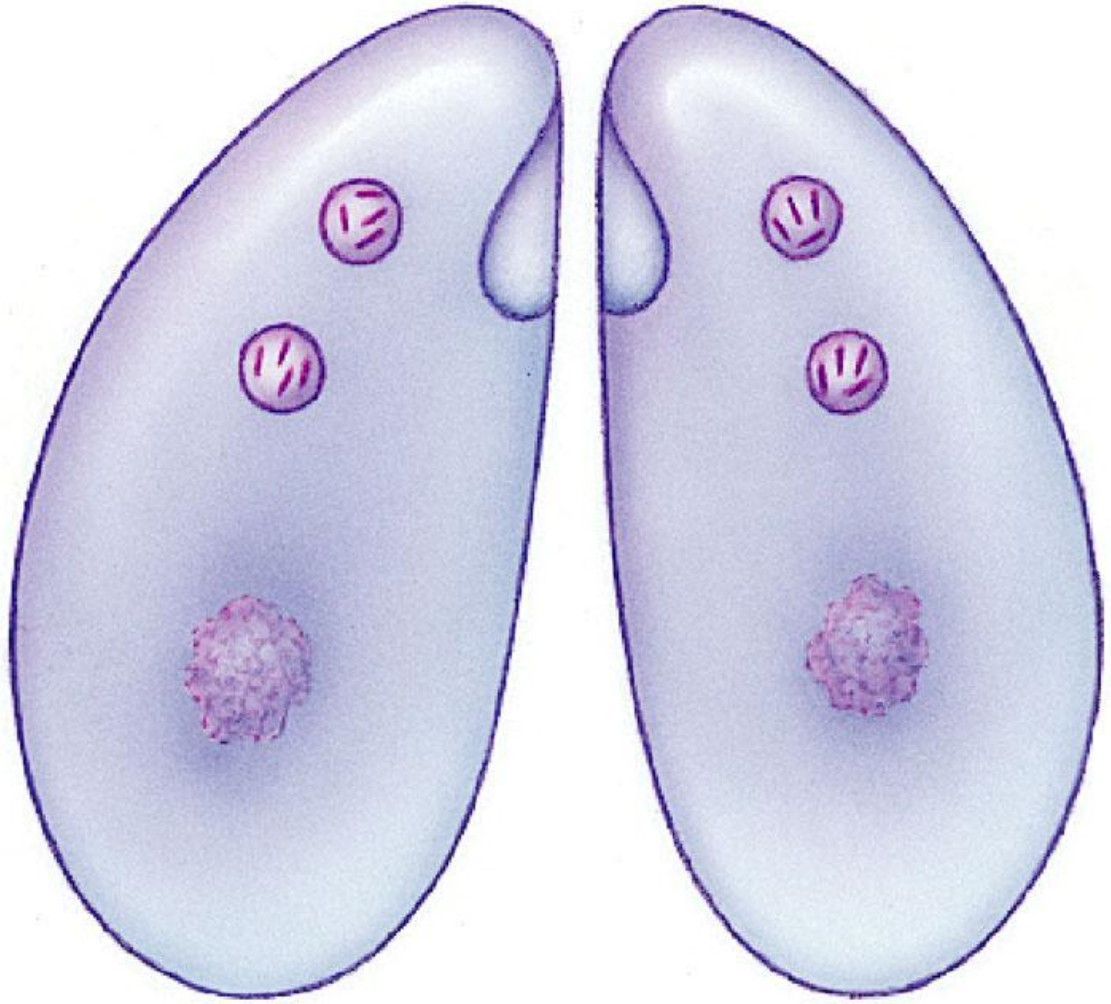
**Fig. 22-8f, p.357**





**g Two micronuclei in each cell fuse, forming a diploid micronucleus. Each cell now contains genetic material from the other.**

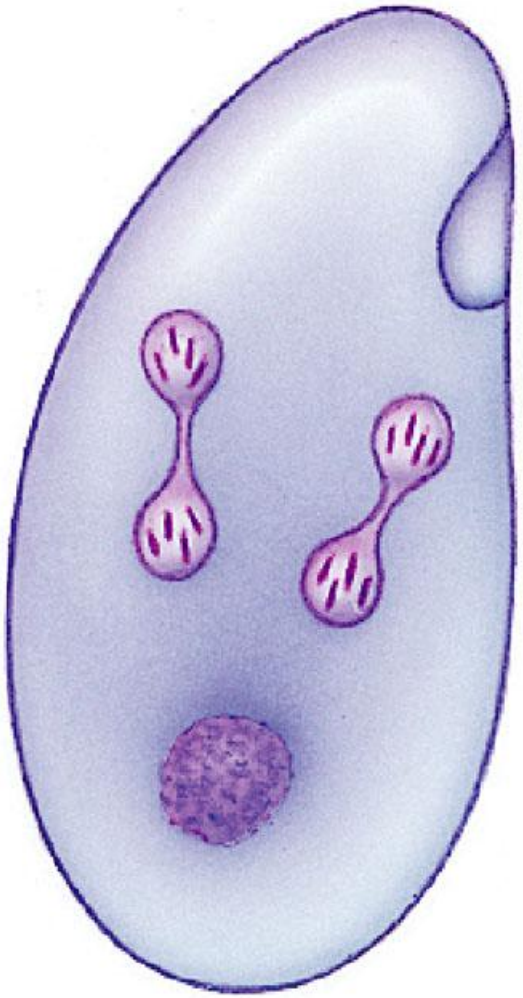
**Fig. 22-8g, p.357**





**h The conjugating cells disengage. The micronucleus of each divides.**

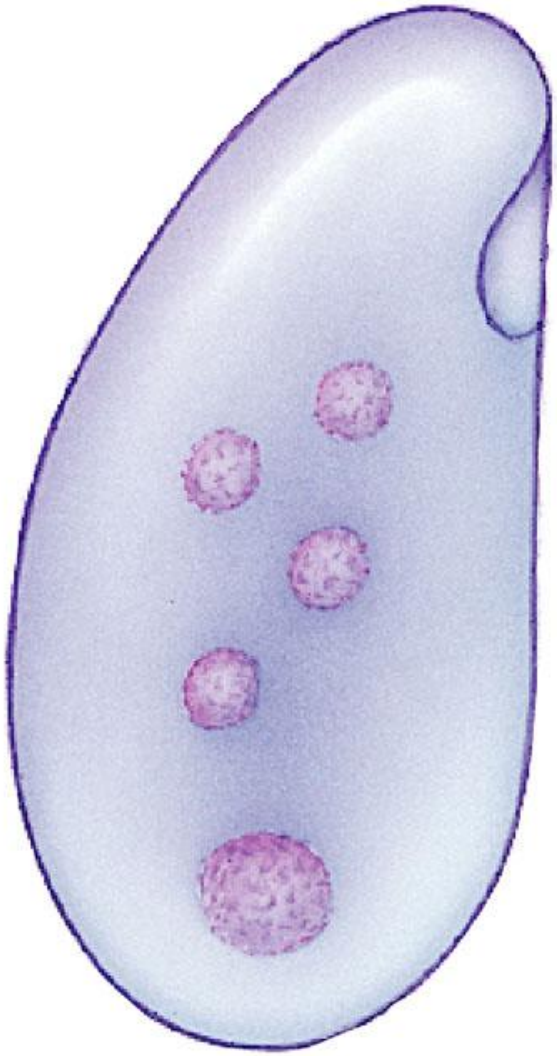
**Fig. 22-8h, p.357**





**i Micronuclei in each cell divide. Then the original macronucleus degenerates.**

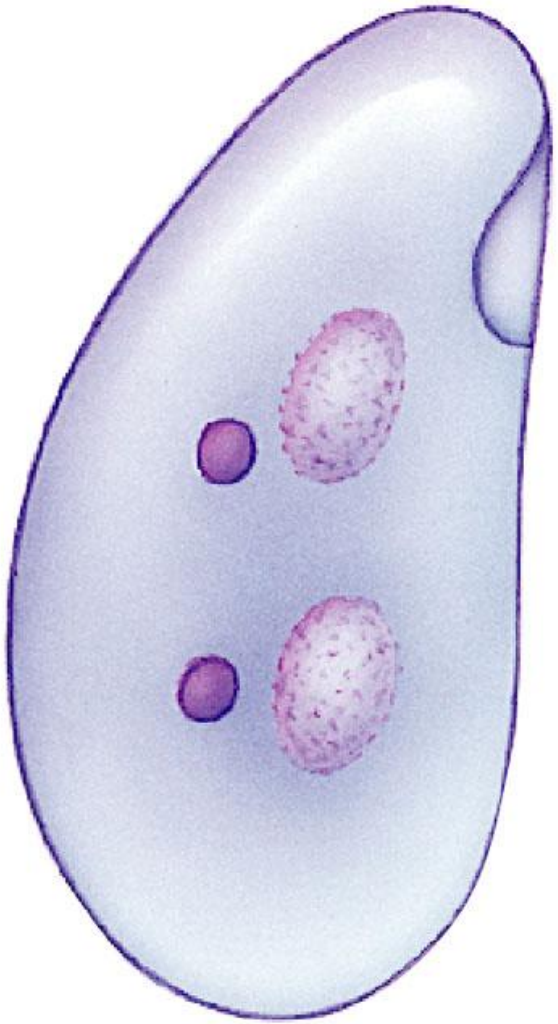
**Fig. 22-8i, p.357**





**j Each cell now has four micronuclei.**

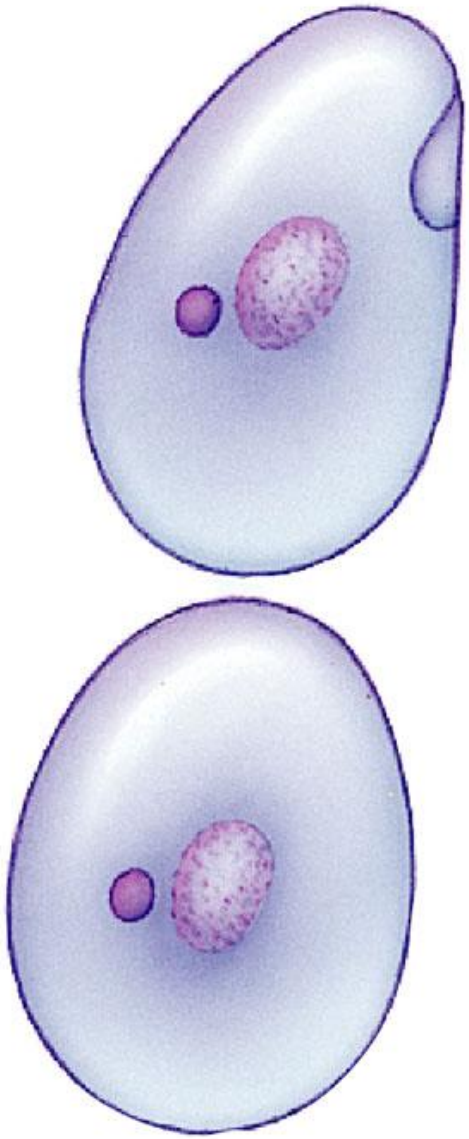
**Fig. 22-8j, p.357**





**k Of the four micronuclei, two develop into macronuclei.**

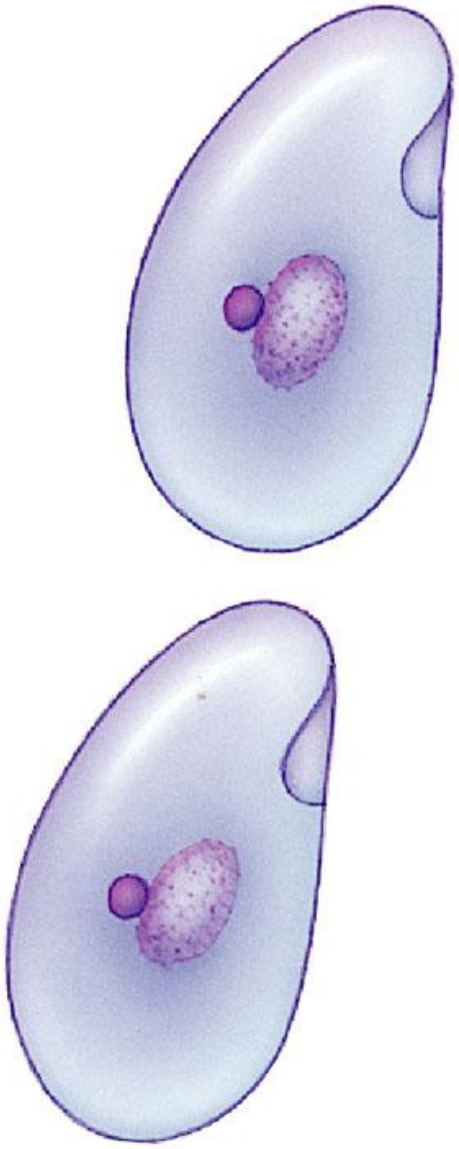
**Fig. 22-8k, p.357**





**l Cytoplasmic division now begins, and two cells form.**

**Fig. 22-8l, p.357**





**m Each daughter cell contains one micronucleus and one macronucleus.**

**Fig. 22-8m, p.357**

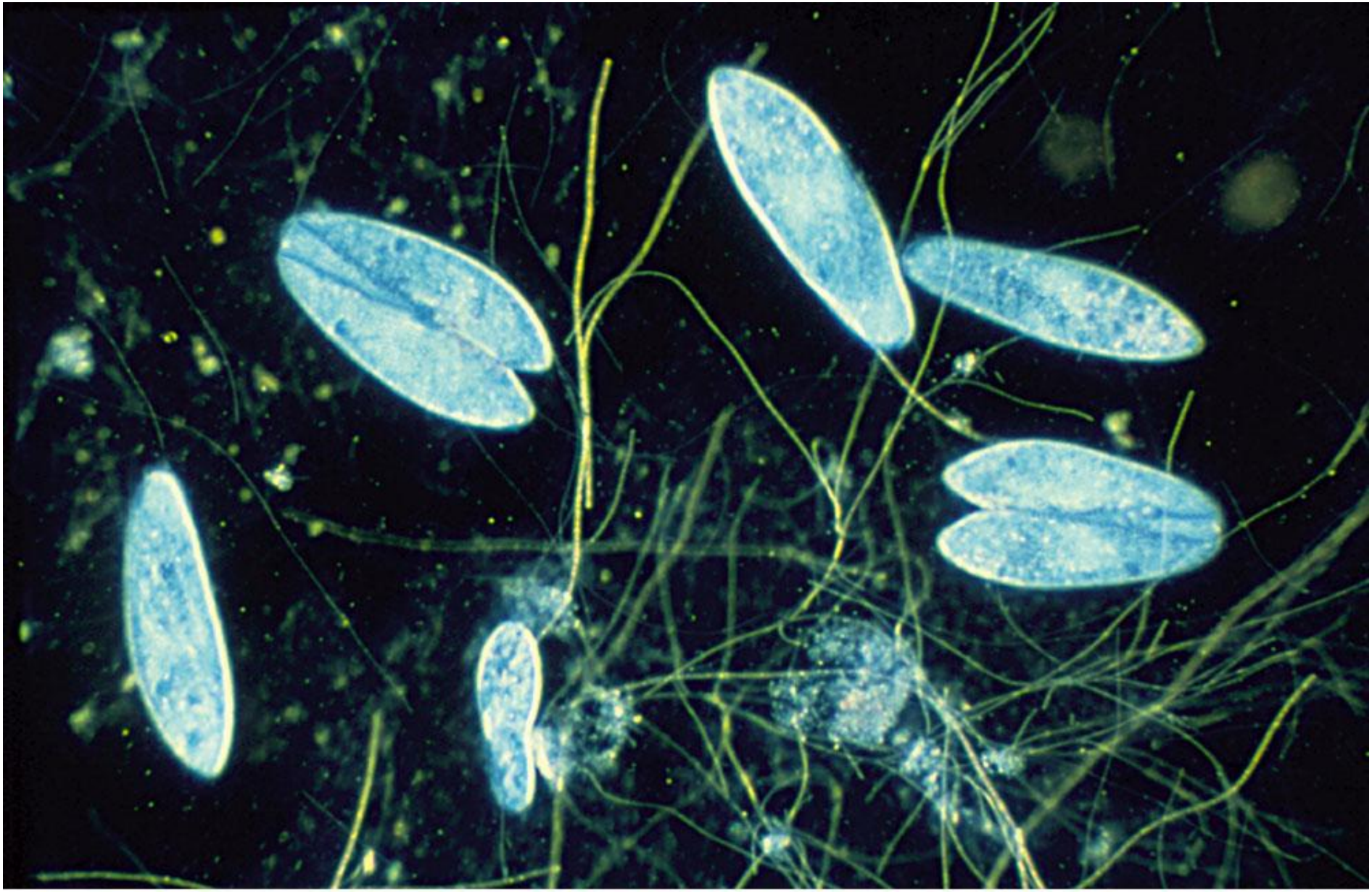
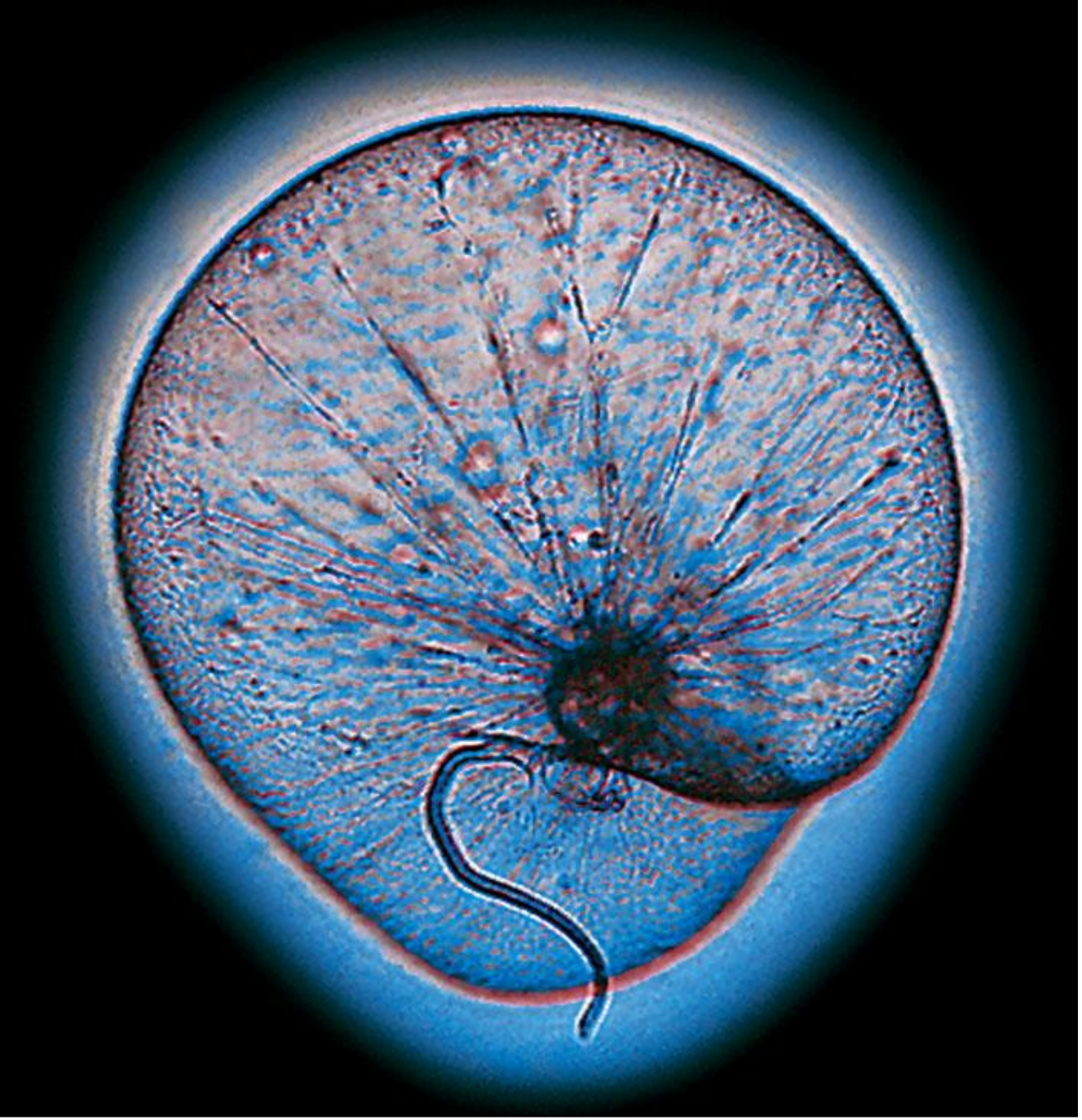




Fig. 22-8n, p.357

# Flagellated Protozoans

- Have one or more flagella
- All are heterotrophs
- Euglenoids
- Kinetoplastids (include trypanosomes)
- Parabasalids (include trichomonads)
- Diplomonads (include *Giardia*)



# Flagellated Protozoans



Fig. 22-9a, p.358

# Flagellated Protozoans



Fig. 22-9b, p.358

# Pfiesteria piscicida

- Associated with large fish kills
- Complicated life cycle
- Population explosions tied to water pollution

# Dinoflagellates

- **Most are single photosynthetic cells**
- **Important component of phytoplankton**
- **Each has two flagella**
- **Algal bloom is population explosion of dinoflagellates**

# Apicomplexans

- Parasitic
- Complete part of the life cycle inside specific cells of a host organism
- Many have elaborate life cycles that require different hosts
- Many cause serious human disease



Fig. 22-10, p.358

# Malaria

- Most prevalent in tropical and subtropical parts of Africa
- Kills a million Africans each year
- Caused by four species of *Plasmodium*
- Transmitted by *Anopheles* mosquitoes

# *Plasmodium* Life Cycle

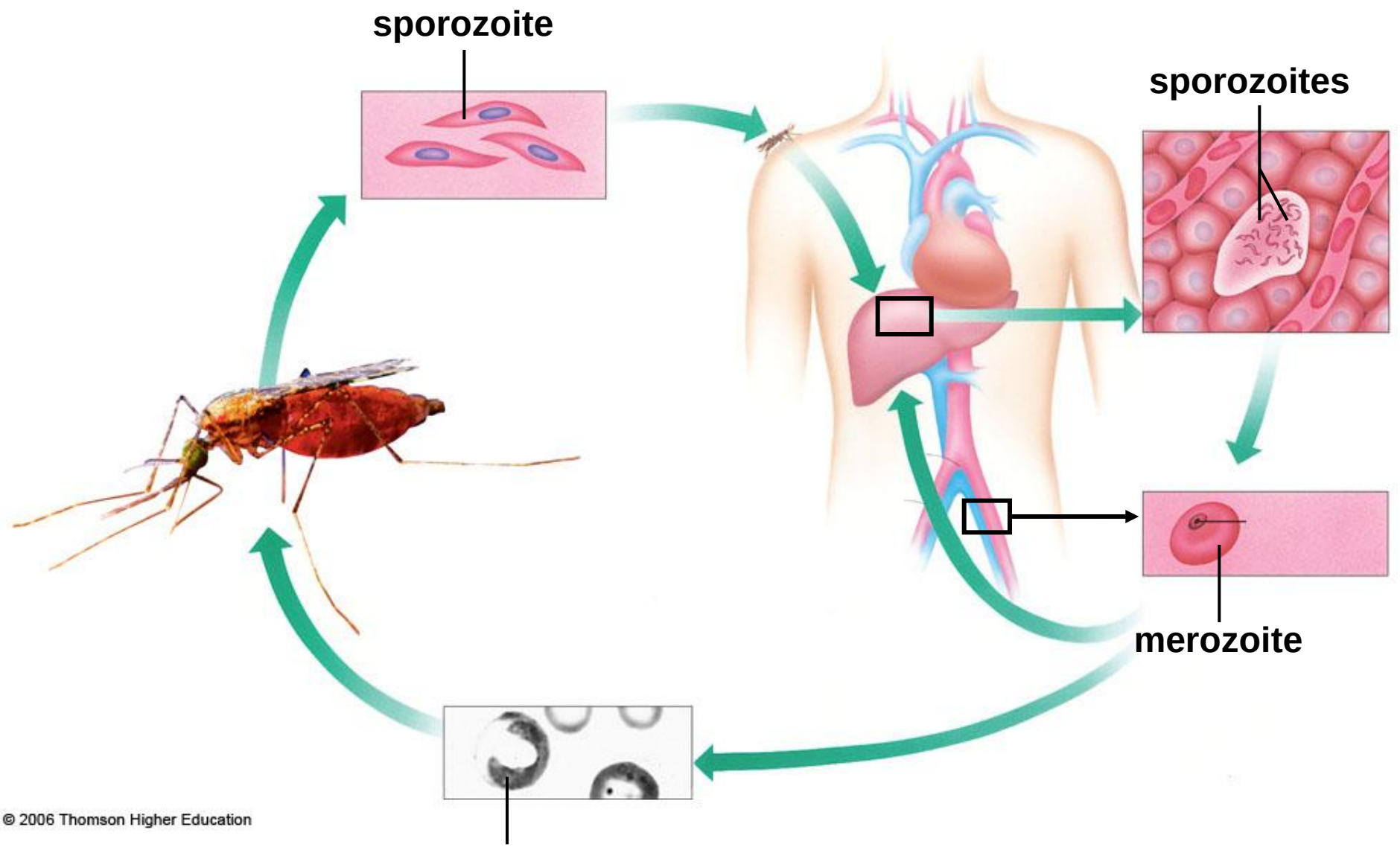
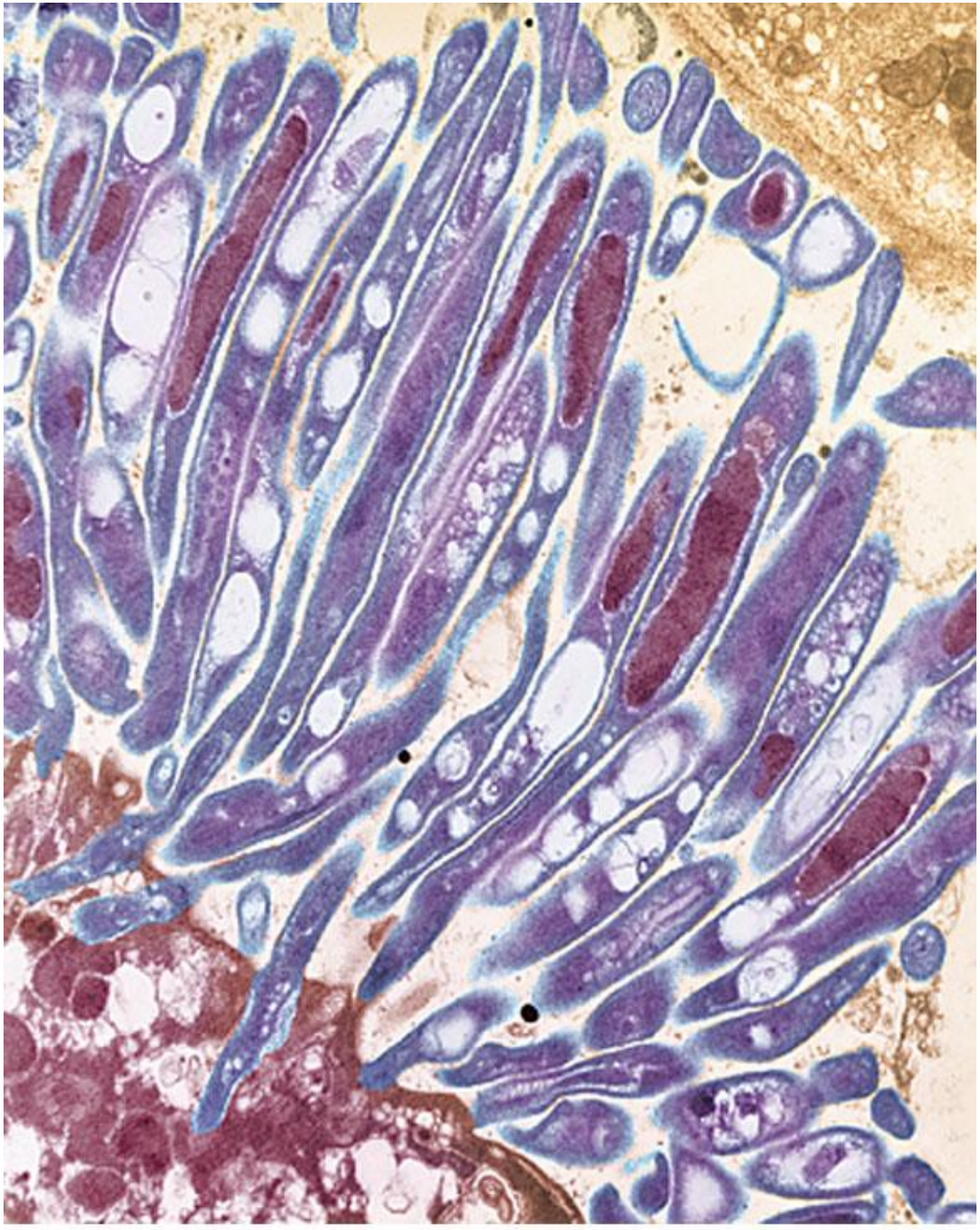





Fig. 22-11, p.359



# Toxoplasma

- Cysts may be ingested with raw or undercooked meat
- Exposure to cysts from cat feces
- Symptoms are usually mild in people with normal immune function
- Infection during pregnancy can kill or damage the embryo

# Stramenopiles

- Unique trait is one of their two flagella has thin filaments projecting from it
- Cells have four outer membranes
- Include
  - Oomycotes
  - Chrysophytes
  - Brown algae

# Chrysophytes (Chrysophyta)

- Mainly free-living photosynthetic cells
- Contain chlorophylls *a*, $c_1$, and $c_2$
- Four groups:

  - Golden algae
  - Yellow-green algae
  - Diatoms
  - Coccolithophores

# Chrysophytes (Chrysophyta)



Fig. 22-12b, p.360

# Diatoms

- Major component of the phytoplankton
- Silica shell of two overlapping parts
- Sediments rich in diatom remains quarried for many uses

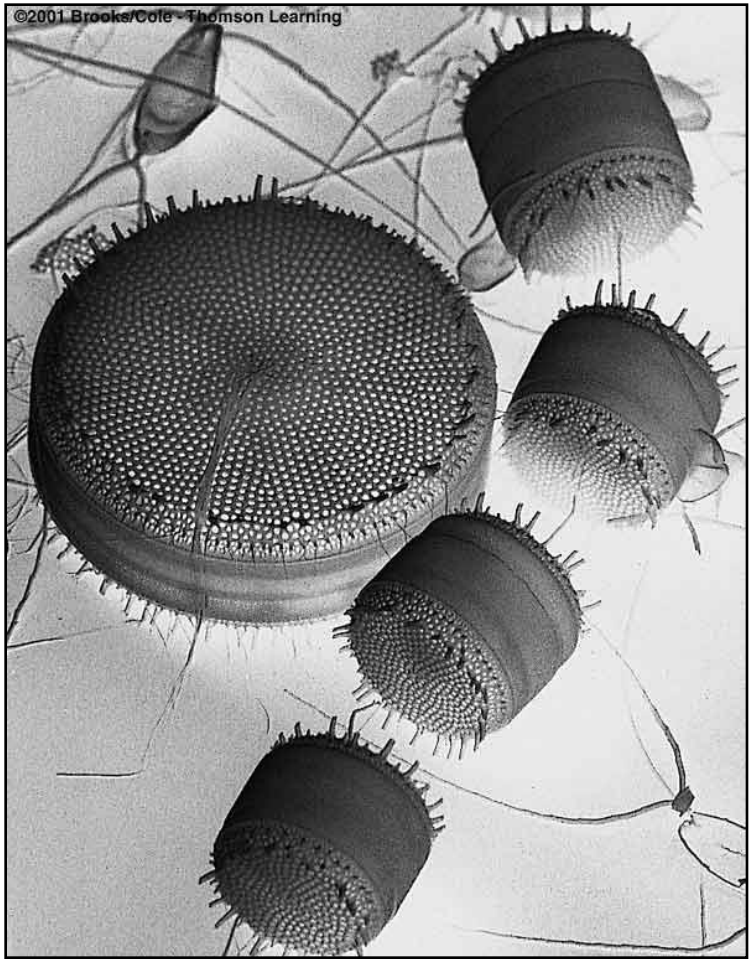



Fig. 22-12, p. 360

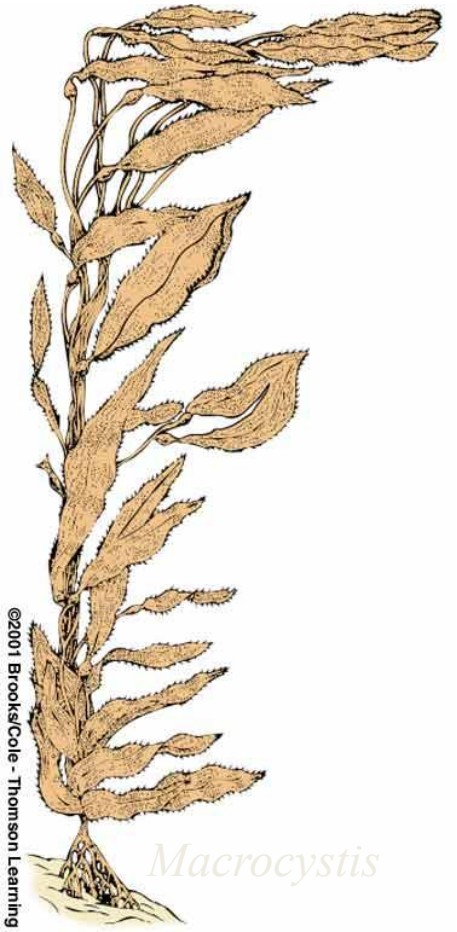
# Coccolithophores

- Major component of the phytoplankton
- Calcium carbonate shell
- Remains in chalk and limestone deposits


**Coccolithophore shell**

**Fig. 22-12, p. 360**

# Brown Algae (Phaeophyta)




- 1,500 species
- Most abundant in temperate seas
- Contain chlorophylls *a* and *c*, and fucoxanthin
- Range in size from tiny filaments to giant kelps

**Fig. 22-13, p. 361**

# Brown Algae (Phaeophyta)




Fig. 22-13a, p.361

# Brown Algae (Phaeophyta)



Fig. 22-13b, p.361

# Red Algae (Rhodophyta)

- 4,100 species
- Most abundant in tropical seas
- Can grow at great depths (phycobilins)
- Complex life cycles may include very different forms

# Red Algae

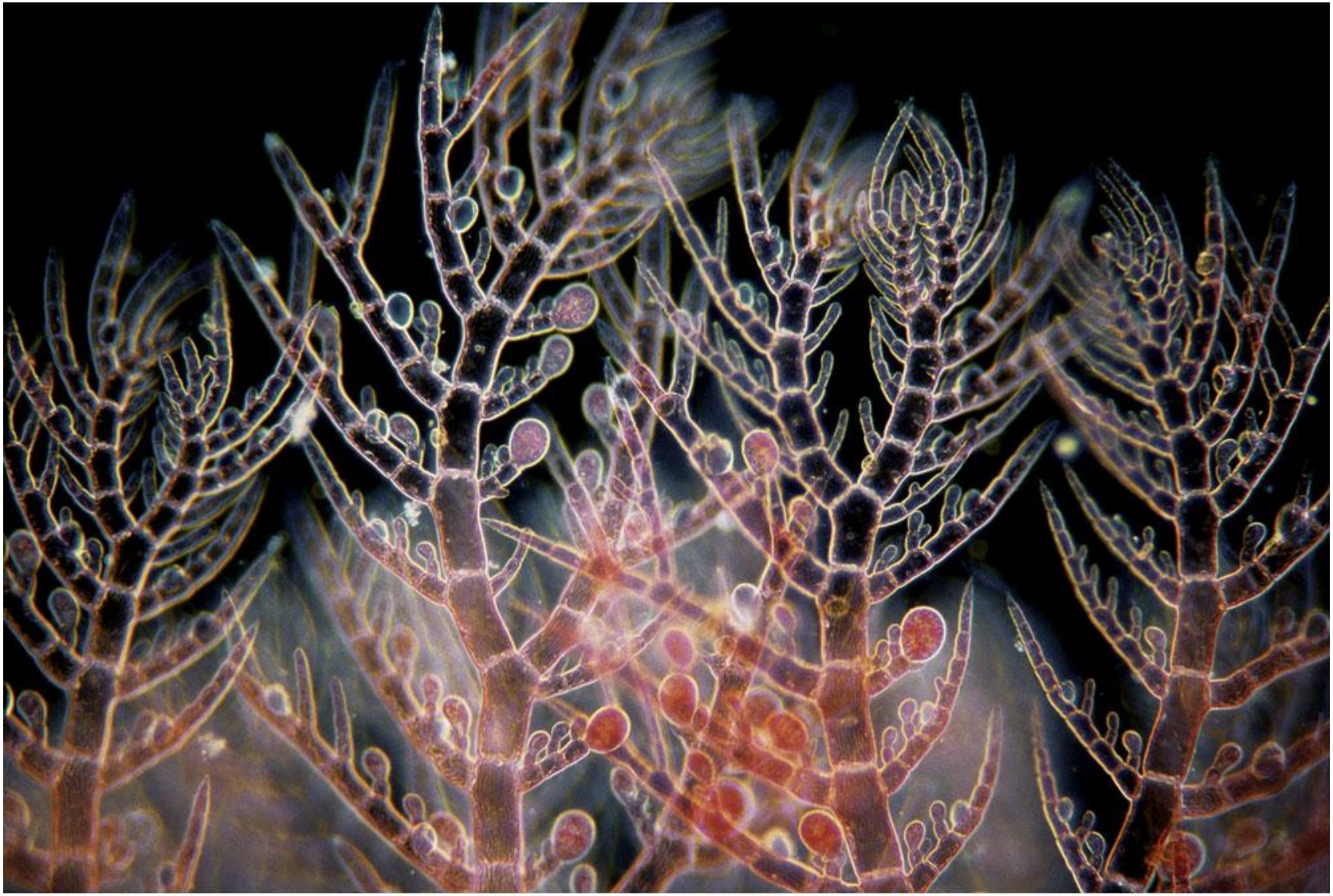
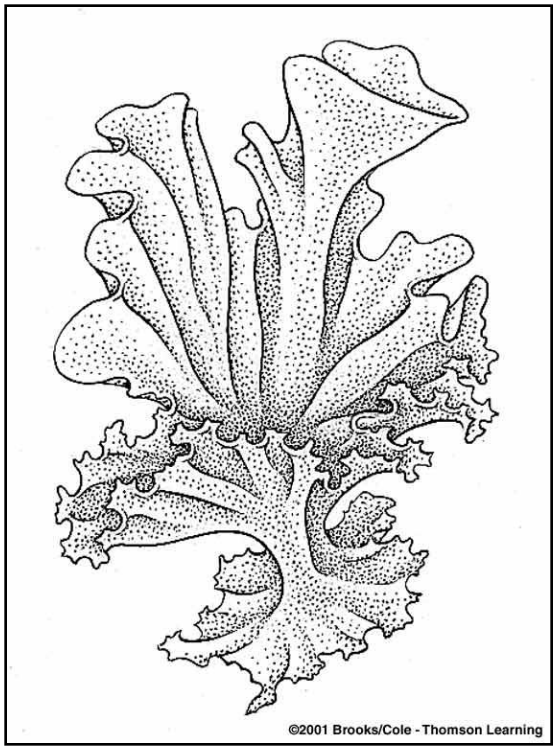




Fig. 22-18, p.363

# Green Algae (Chlorophyta)

- 7,000 species
- Resemble plants
  - Chlorophylls *a* and *b*
  - Starch grains in chloroplasts
  - Cell walls of cellulose, pectins




*Ulva*

# Green Algae (Chlorophyta)

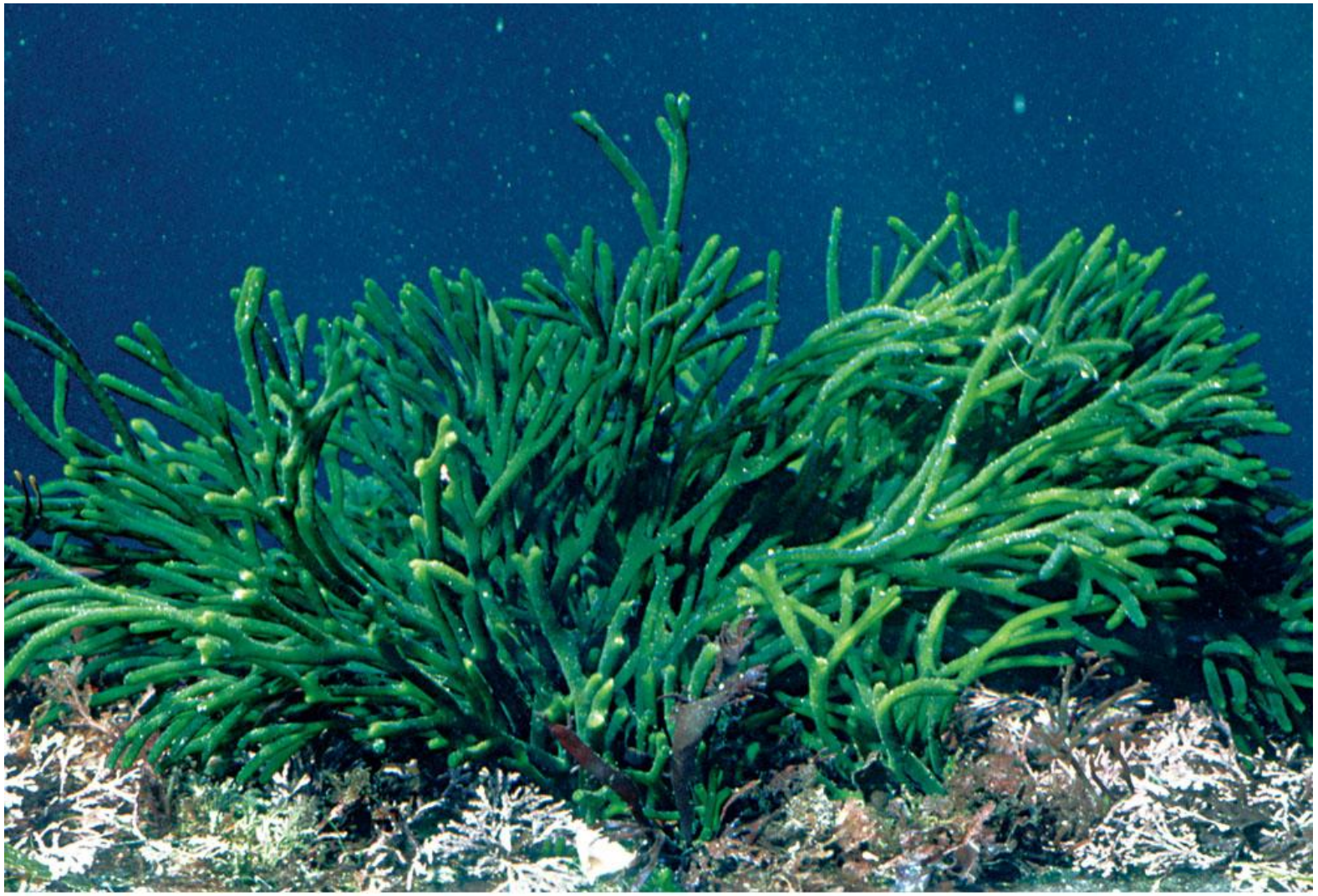




Fig. 22-19b, p.364

# Green Algae (Chlorophyta)

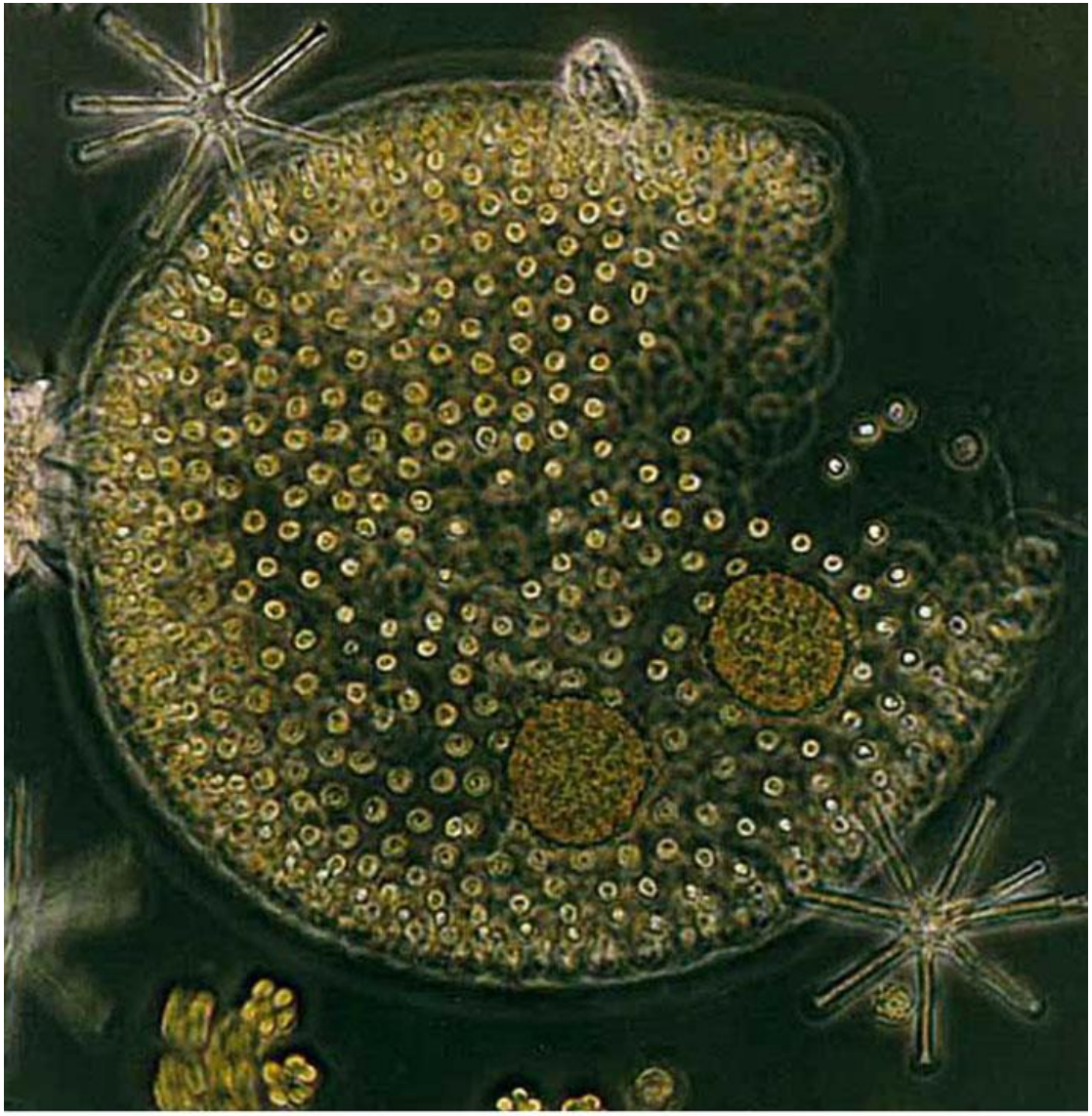




Fig. 22-19c, p.364

# Green Algae (Chlorophyta)

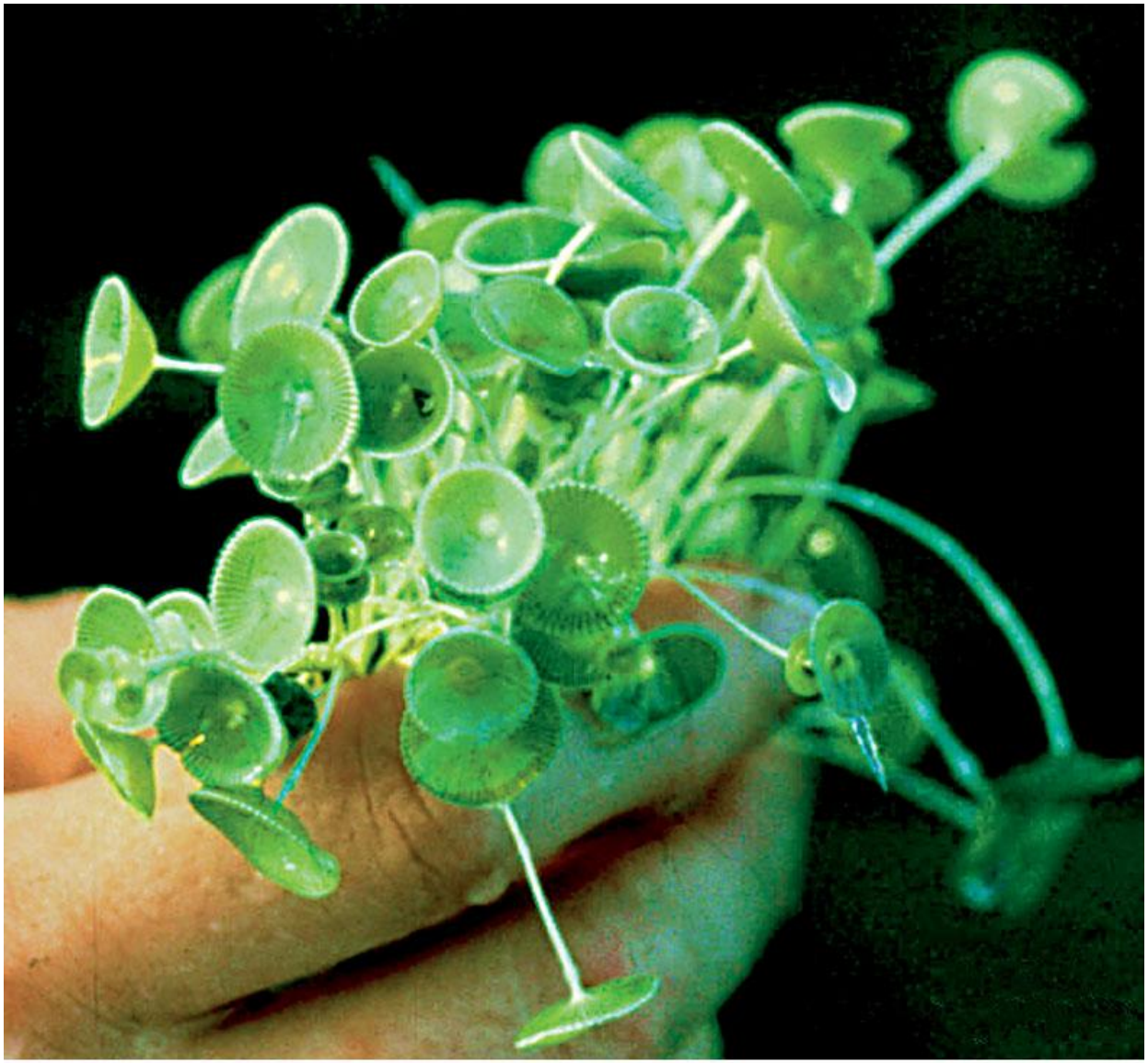




Fig. 22-19d, p.364

# Green Algae (Chlorophyta)



Fig. 22-19e, p.364

# Amoeba



Fig. 22-22a, p.366

# Amoeba



Fig. 22-22b, p.366

## Table 22.1 Comparison of Prokaryotes With Eukaryotes

| | Prokaryotes | Eukaryotes |
|---|---|---|
| Organisms represented: | Archaeans, bacteria | "Protists," plants, fungi, and animals |
| Ancestry: | Two major lineages that evolved more than 3.5 billion years ago | Equally ancient prokaryotic ancestors gave rise to forerunners of eukaryotes, which evolved more than 1.2 billion years ago |
| Level of organization: | Single-celled | Single-celled or multicelled with a division of labor among specialized cells; complex species have tissues and organ systems |
| Typical cell size: | Small (1–10 micrometers) | Large (10–100 micrometers) |
| Cell wall: | Most with no distinctive wall | Cellulose or chitin; none in animal cells |
| Membrane-bound organelles: | Rarely; no nucleus, no mitochondria | Typically profuse; nucleus present; most with mitochondria |
| Modes of metabolism: | Both anaerobic and aerobic | Aerobic modes predominate |
| Genetic material: | One chromosome; plasmids in some | Chromosomes of DNA plus many associated proteins in a nucleus |
| Mode of cell division: | Prokaryotic fission, mostly; some reproduce by budding | Nuclear division (mitosis, meiosis, or both) associated with one of various modes of cytoplasmic division, including binary fission |



Fig. 22-25, p.369