BIOL 1202
General Biology II Lecture

CHAPTER 28
Protists
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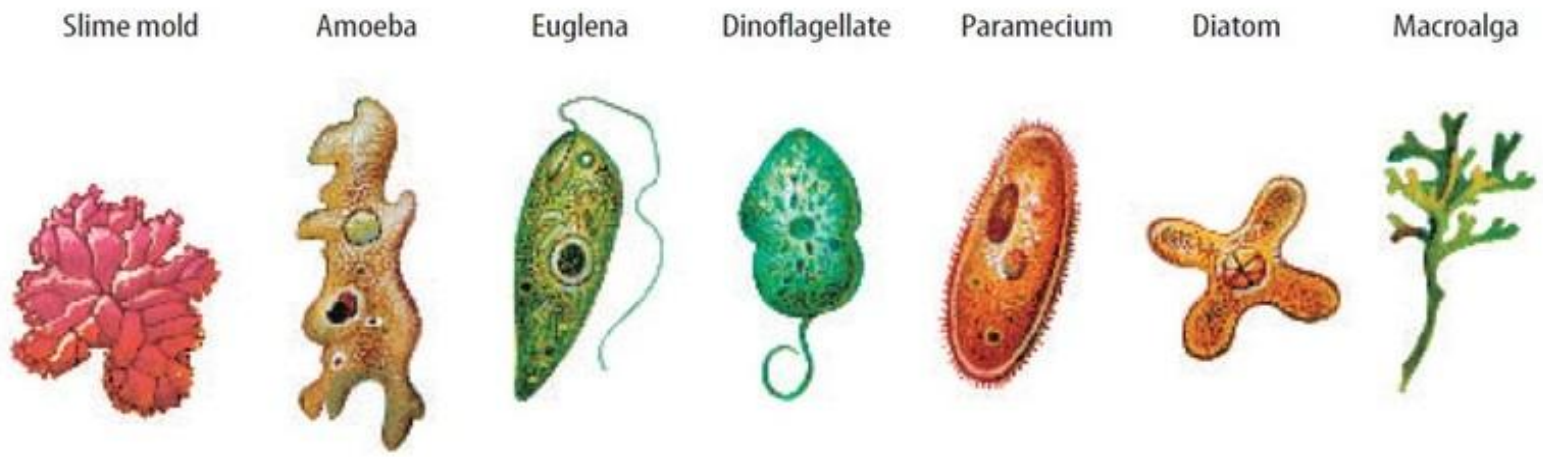
CH 28 Learning Objectives

1. Describe the process of secondary endosymbiosis and explain its role in eukaryotic history.
2. Characterize the excavates.
3. Give examples of the protists classified in SAR.
4. Describe characteristics of red and green algae.
5. Identify and describe the closest eukaryotic relatives of fungi and animals.
6. Give examples of ecological roles played by protists.

I would suggest completing the crossword puzzle to help you understand the terminology and correlate how the terms relate to topics covered in this chapter.

Concept 28.1: Most eukaryotes are single-celled organisms

- Protists are eukaryotes
- Eukaryotic cells have organelles and are more complex than prokaryotic cells
- Important characters include
  - the organisms in most eukaryotic lineages are protists
  - most protists are unicellular



Structural and Functional Diversity in Protists

- Protists exhibit more structural and functional diversity than any other group of eukaryotes
- Though most protists are unicellular, there are some colonial and multicellular species
- Protists can be very complex, even as single cells
- Protists, the most nutritionally diverse of all eukaryotes, include
  - **Photoautotrophs**: contain chloroplasts
  - **Heterotrophs**: absorb organic molecules or ingest food
  - **Mixotrophs**: contain photosynthesis & heterotrophism
- They use both sexual and asexual reproduction

Four Supergroups of Eukaryotes

- Our understanding of the evolutionary relationships among protist groups continues to change rapidly
- Several hypotheses have been proposed and discarded
- One current hypothesis divides all eukaryotes (including protists) into four supergroups

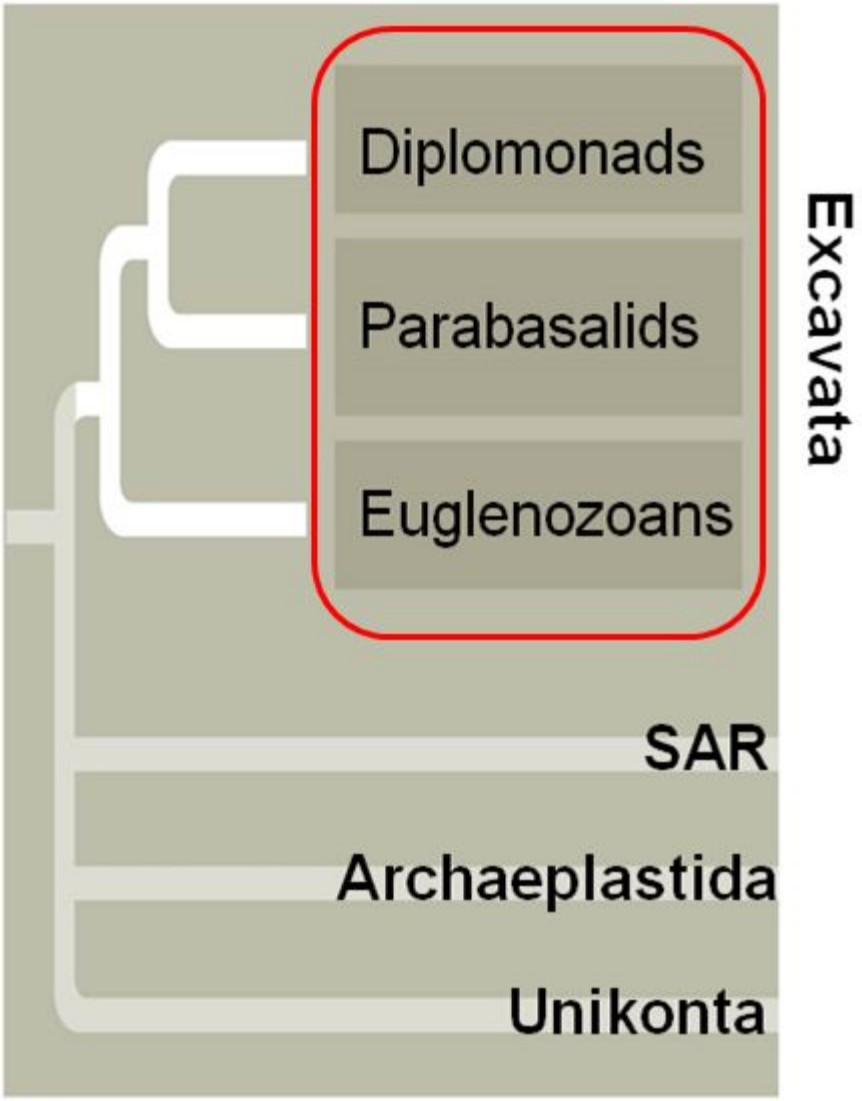
1. Excavata
2. **SAR** (**S**tramenopiles, **A**lveolates, and **R**hizarians)
3. Archaeplastida
4. Unikonta

Endosymbiosis in Eukaryotic Evolution

- There is now considerable evidence that much protist diversity has its origins in endosymbiosis
- **Endosymbiosis** is a relationship between two species in which one organism lives inside the cell or cells of the other organism (the host)
- Mitochondria and plastids are derived from prokaryotes that were engulfed by the ancestors of early eukaryotic cells, possibly a lokiarchaeote (newly discovered group of archea)
- Mitochondria evolved once by endosymbiosis of an alpha proteobacterium
- Plastids evolved later by endosymbiosis of a photosynthetic cyanobacterium

Concept 28.2: Excavates include protists with modified mitochondria and protists with unique flagella

- The clade **Excavata** is characterized by its cytoskeleton
- Some members have an "excavated" feeding groove on one side of the body
- The excavates include three monophyletic groups: the diplomonads, parabasalids, and euglenozoans

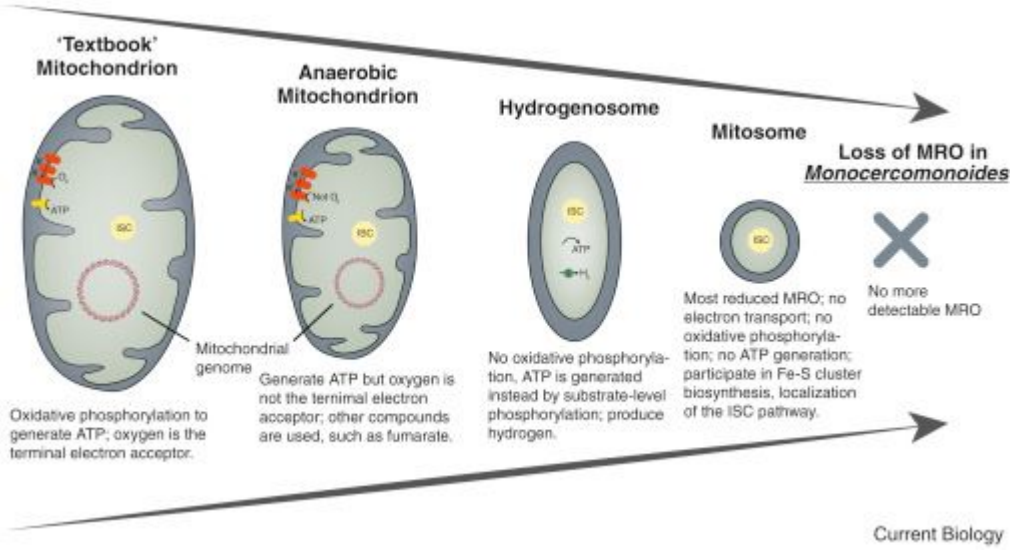


EXCAVATA: Diplomonads and Parabasalids

- These two groups ***lack plastids*** and have ***modified mitochondria***, most live in anaerobic environments
- **Diplomonads**
  - have reduced mitochondria called **mitosomes**
  - derive energy from anaerobic biochemical pathways
  - have two equal-sized nuclei and multiple flagella
  - are often parasites, EX: *Giardia intesinalis*
- **Parabasalids**
  - have reduced mitochondria called **hydrogenosomes** that generate some energy anaerobically
  - include *Trichomonas vaginalis*, a sexually transmitted parasite

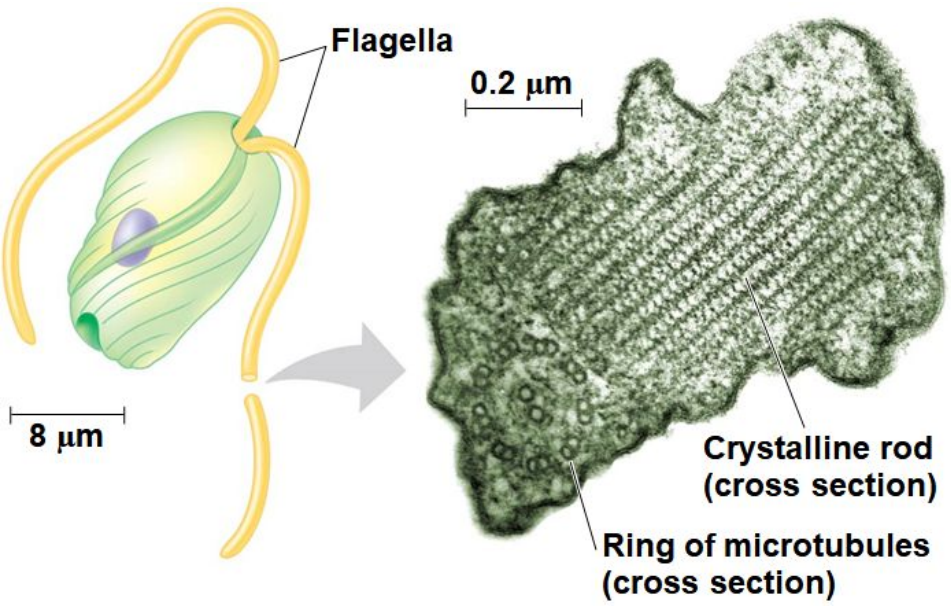
mitochondrion vs hydrogenosome vs mitosome

it gets smaller



EXCAVATA: Euglenozoans

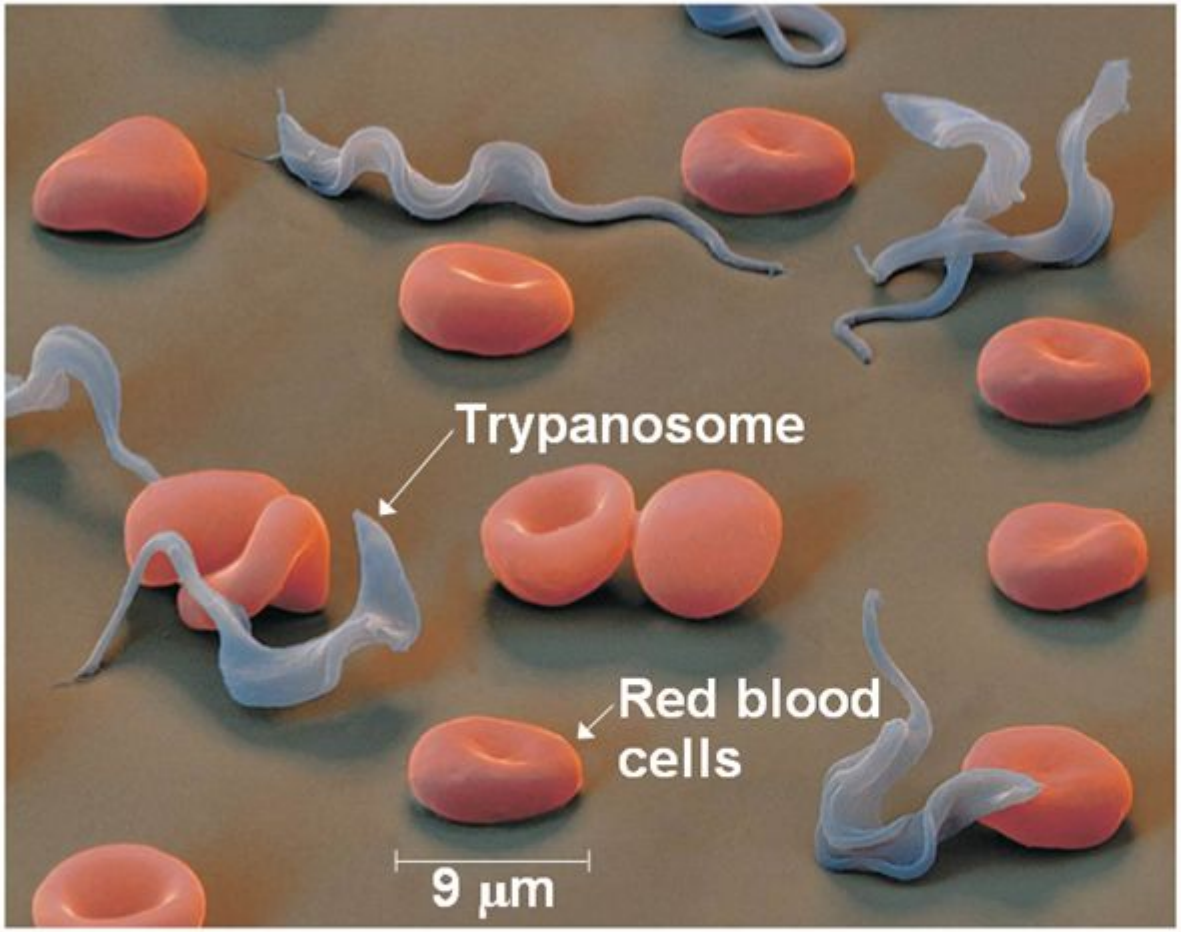
- **Euglenozoa** is a diverse clade that includes predatory heterotrophs, photosynthetic autotrophs, mixotrophs, and parasites
- The main feature distinguishing them as a clade is a **spiral** or **crystalline rod** inside their flagella
- This clade includes the **kinetoplastids** and **euglenids**



Kinetoplastids

- **Kinetoplastids** have a single mitochondrion with an organized mass of DNA called a **kinetoplast**
- Free-living species are consumers of prokaryotes in freshwater, marine, and moist terrestrial ecosystems
- Some species parasitize animals, plants, and other protists
  - EX: Kinetoplastids in the genus *Trypanosoma* cause sleeping sickness in humans
  - EX: Another pathogenic trypanosome causes Chagas' disease ("Kissing Bug disease")
- Trypanosomes evade host immune responses by producing cell-surface proteins with different molecular structures in each generation

Figure 28.7

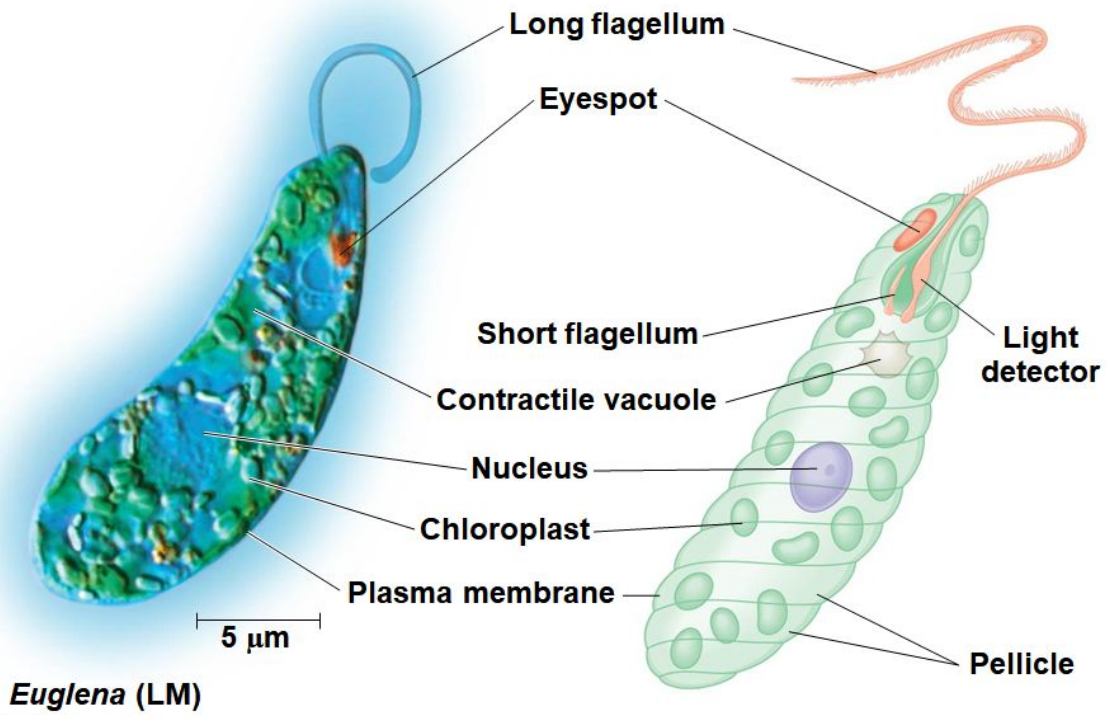


Sleeping Sickness

Kissing Bug bite causes Chagas' Disease

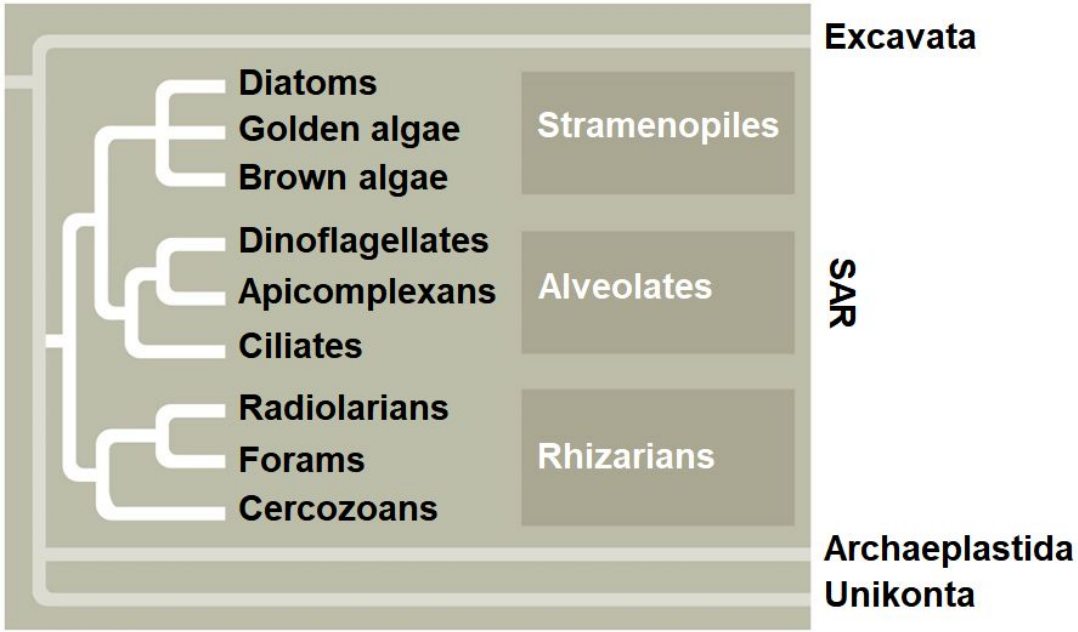
Euglenids

- **Euglenids** have one or two flagella that emerge from a pocket at one end of the cell
- Some species are mixotrophs; they can be autotrophic or heterotrophic depending on the environmental conditions



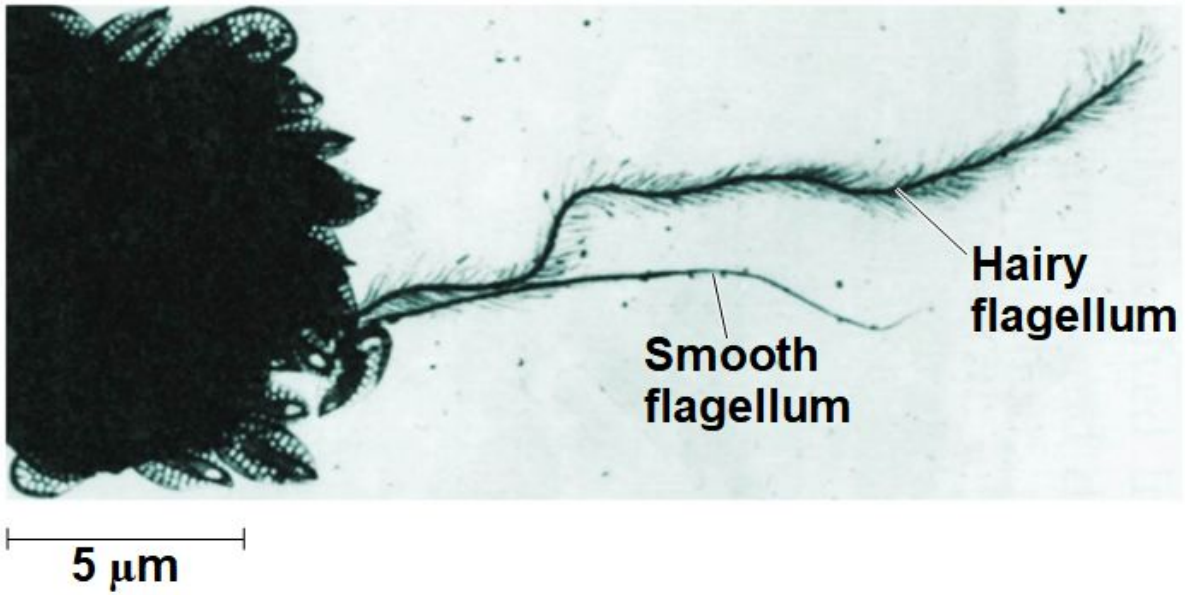
Concept 28.3: SAR is a highly diverse group of protists defined by DNA similarities

- **SAR** is a monophyletic supergroup named for the first letters of its three major clades: **S**tramenopiles, **A**lveolates, and **R**hizarians
- This group is one of the most <u>controversial of the four supergroups</u>



Stramenopiles

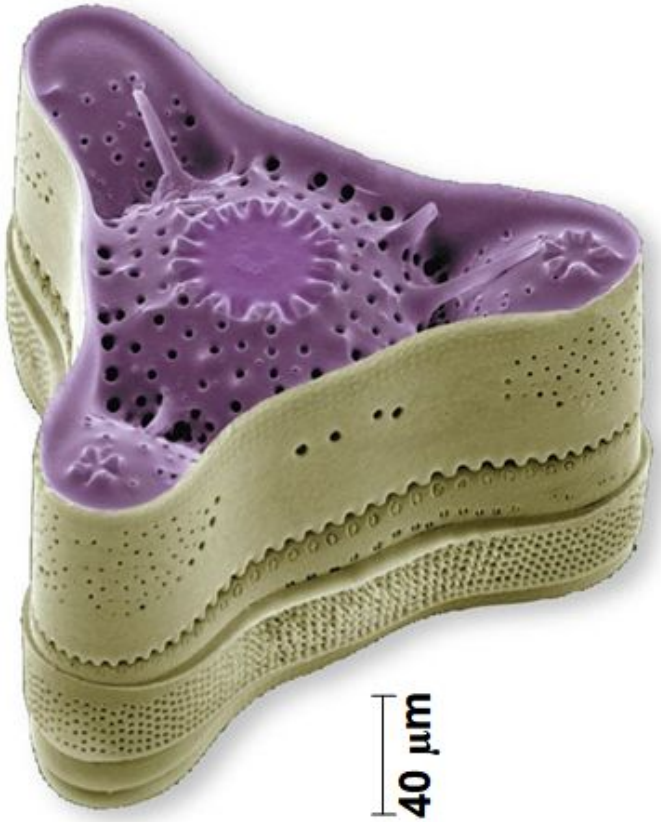
- **Stramenopiles** includes some of the most important photsynthetic organisms on Earth
- Most have a "hairy" flagellum paired with a "smooth" flagellum
- Stramenopiles include **diatoms**, **golden algae**, and **brown algae**



Stramenopiles: *Diatoms*

- **Diatoms** are unicellular algae with a unique two-part, glass-like wall of silicon dioxide
- Diatoms are a major component of phytoplankton and are highly diverse
- After a diatom bloom, many dead individuals fall to the ocean floor, where decomposition is slow
- The carbon they took up from the atmosphere and incorporated into their biomass is sequestered on the ocean floor for decades to centuries
- Some scientists advocate fertilizing the ocean with iron to promote diatom blooms and facilitate movement of CO_2 to the bottom of the ocean

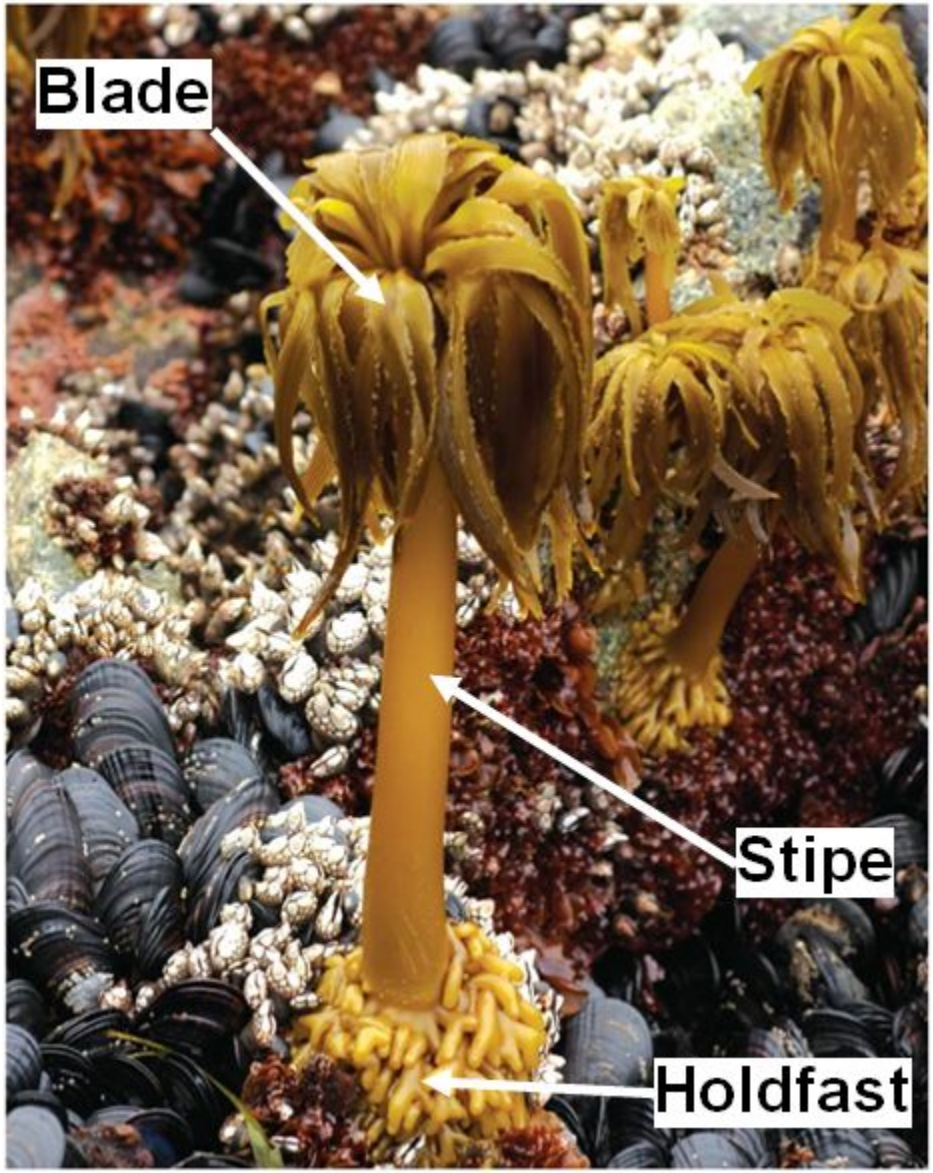
Various Diatom species



Stramenopiles: *Brown Algae*

- **Brown algae** are the largest and most complex algae
- All are multicellular, and most are marine
- Brown algae include many species commonly called "seaweeds"
- Brown algal seaweeds have plantlike structures: the rootlike **holdfast**, which anchors the alga, and a stem-like **stipe**, which supports the leaflike **blade**
- Some have gas-filled, bubble-shaped floats to keep their photosynthetic structures near the water surface
- However, unlike plants, brown algae **lack** true tissues and organs

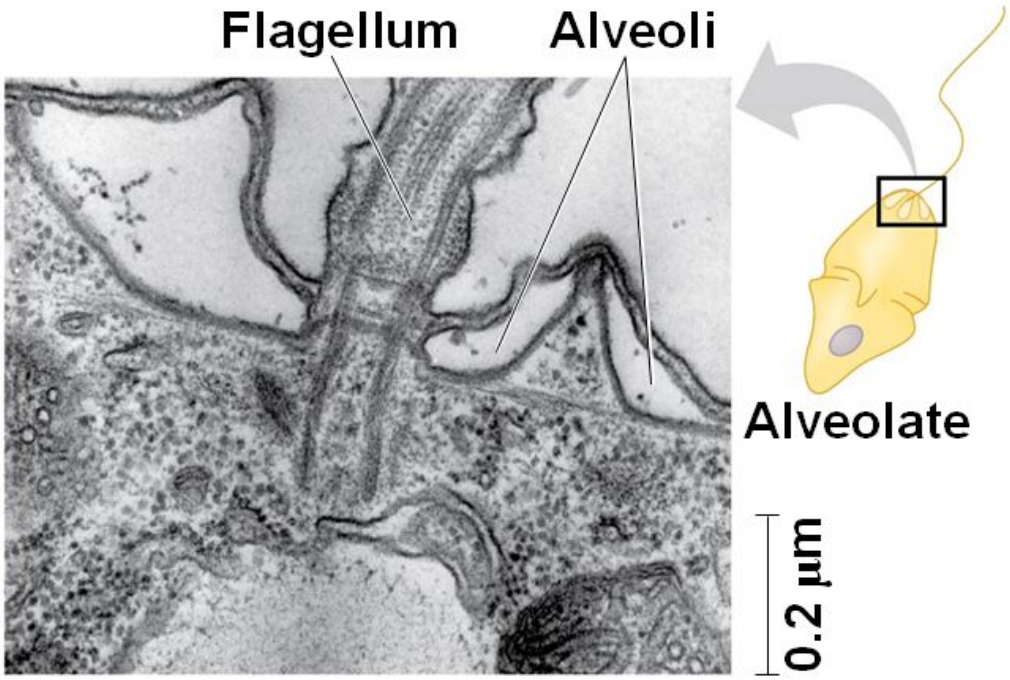
Figure 28.12



Commercial brown algae products

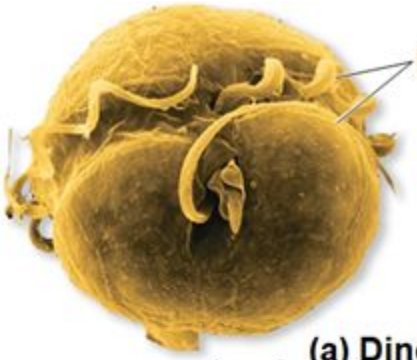
Alveolates

- **Alveolates** have membrane-enclosed sacs (alveoli) just under the plasma membrane
- The alveolates include
  - Dinoflagellates
  - Apicomplexans
  - Ciliates



Alveolates: *Dinoflagellates*

- **Dinoflagellates** have two flagella, and each cell is reinforced by cellulose plates
- They are abundant components of both marine and freshwater phytoplankton
- They are a diverse group of aquatic phototrophs, mixotrophs, and heterotrophs
- Toxic "red tides" are caused by dinoflagellate blooms



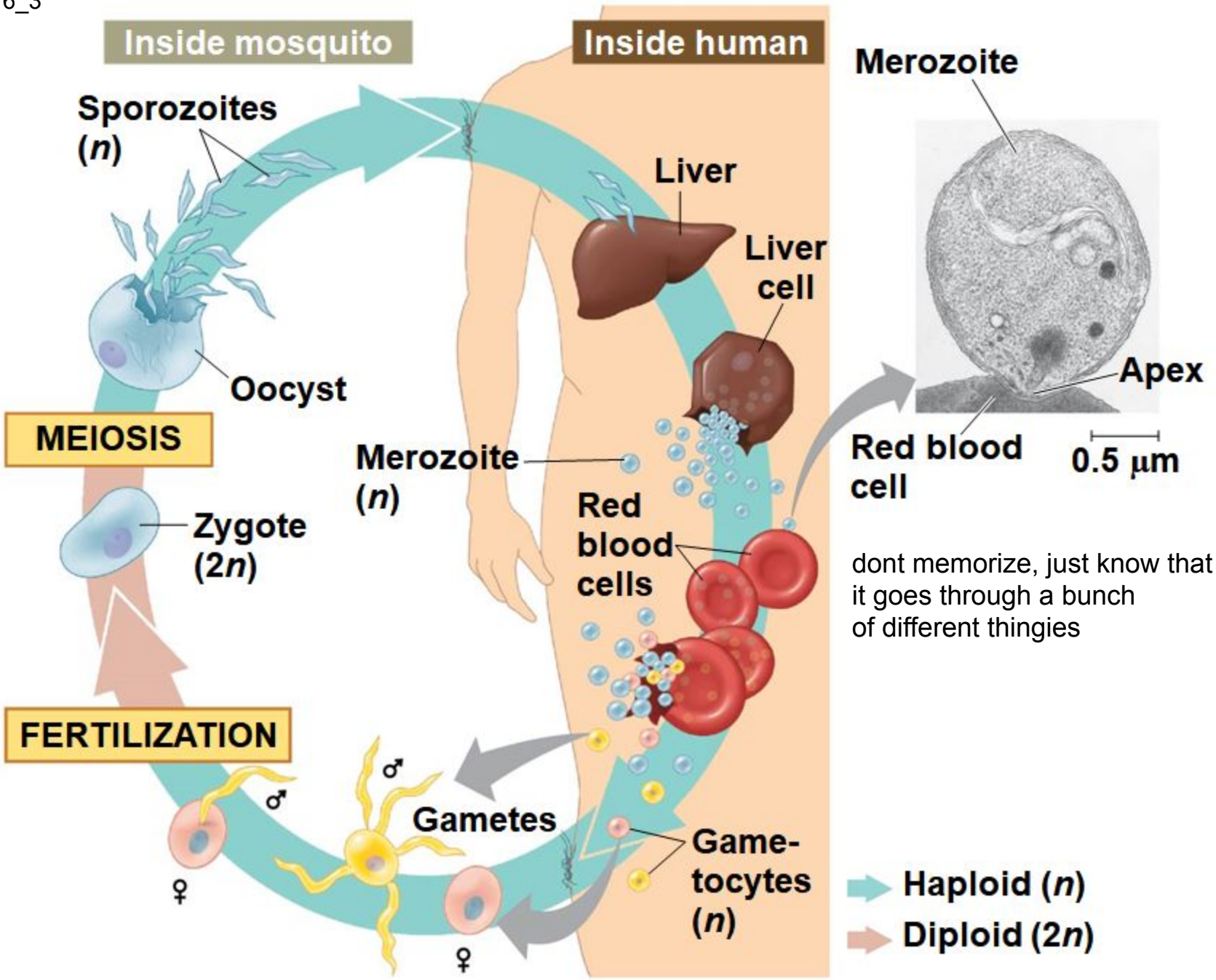
(a) Dinoflagellate flagella

(b) Red tide in the Gulf of Carpentaria in northern Australia

Alveolates: *Apicomplexans*

- Most **apicomplexans** are parasites of animals; some cause serious human diseases
- They spread through their host as infectious cells called sporozoites (designed to penetrate host cells)
- The life cycles of most species have sexual and asexual stages and require 2+ different hosts
- *Plasmodium* is the parasite that causes malaria
  - *Plasmodium* requires both mosquitoes and humans to complete its life cycle
  - ~200 million infected yearly and 600,000 die annually
- The first malarial vaccine was approved in Europe in 2015, but it provides only partial protection

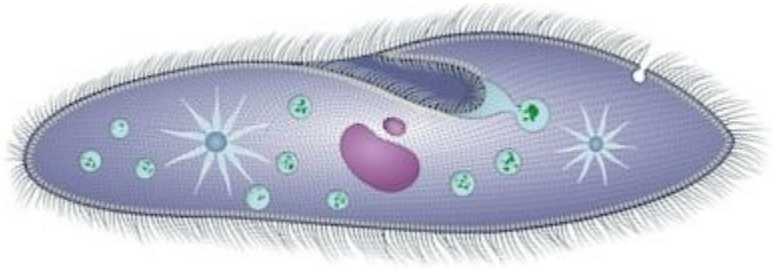
Figure 28.16_3



dont memorize, just know that it goes through a bunch of different thingies

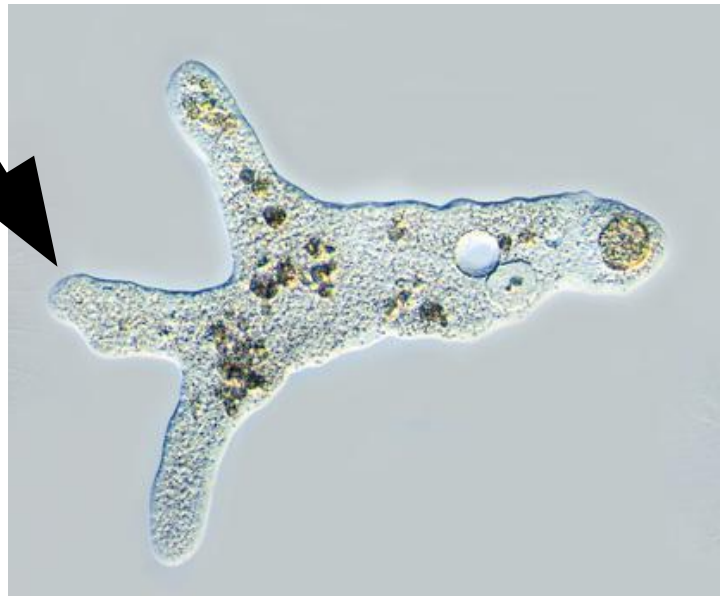
Alveolates: *Ciliates*

- **Ciliates**, a large varied group of protists, are named for their use of cilia to move and feed
- Most ciliates are predators of bacteria or protists
- A distinctive feature is two types of nuclei
- Genetic variation results from **conjugation**, in which two individuals exchange haploid micronuclei
- Conjugation is a sexual process and is separate from reproduction, which generally occurs by binary fission
- EX: *Paramecium*



Rhizarians

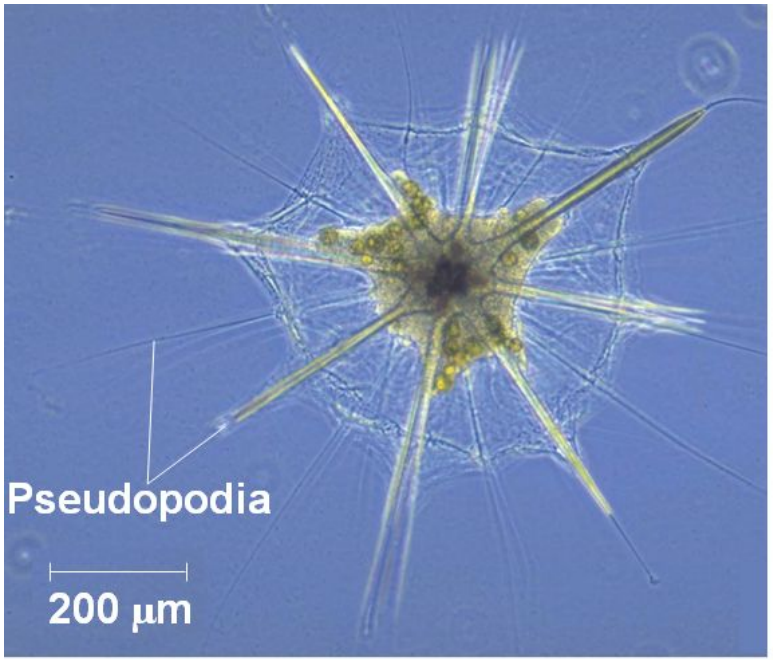
- Many species of rhizarians are **amoebas**
- Amoebas are protists that move & feed by structures called **pseudopodia**, extensions of the cell surface

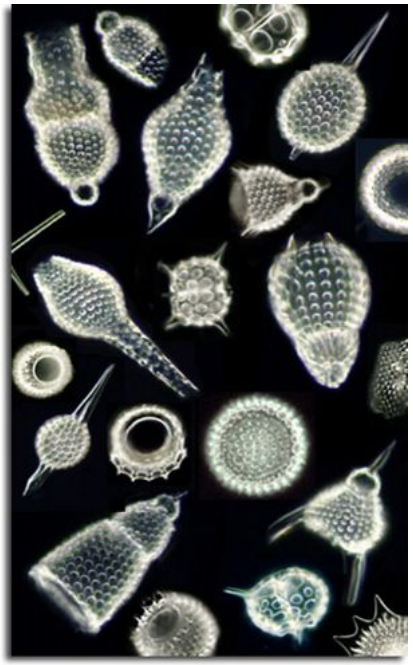


- Rhizarian amoebas differ from amoebas in other clades by having threadlike pseudopodia
- Rhizarians include radiolarians, forams, cercozoans

Rhizarians: *Radiolarians*

- **Radiolarians**, mostly marine protists, have delicate, symmetrical internal skeletons made of ***silica***
- Pseudopodia reinforced by microtubules radiate from the central body of radiolarians
- Cytoplasm covering the microtubules engulf prey that become attached to the pseudopodia



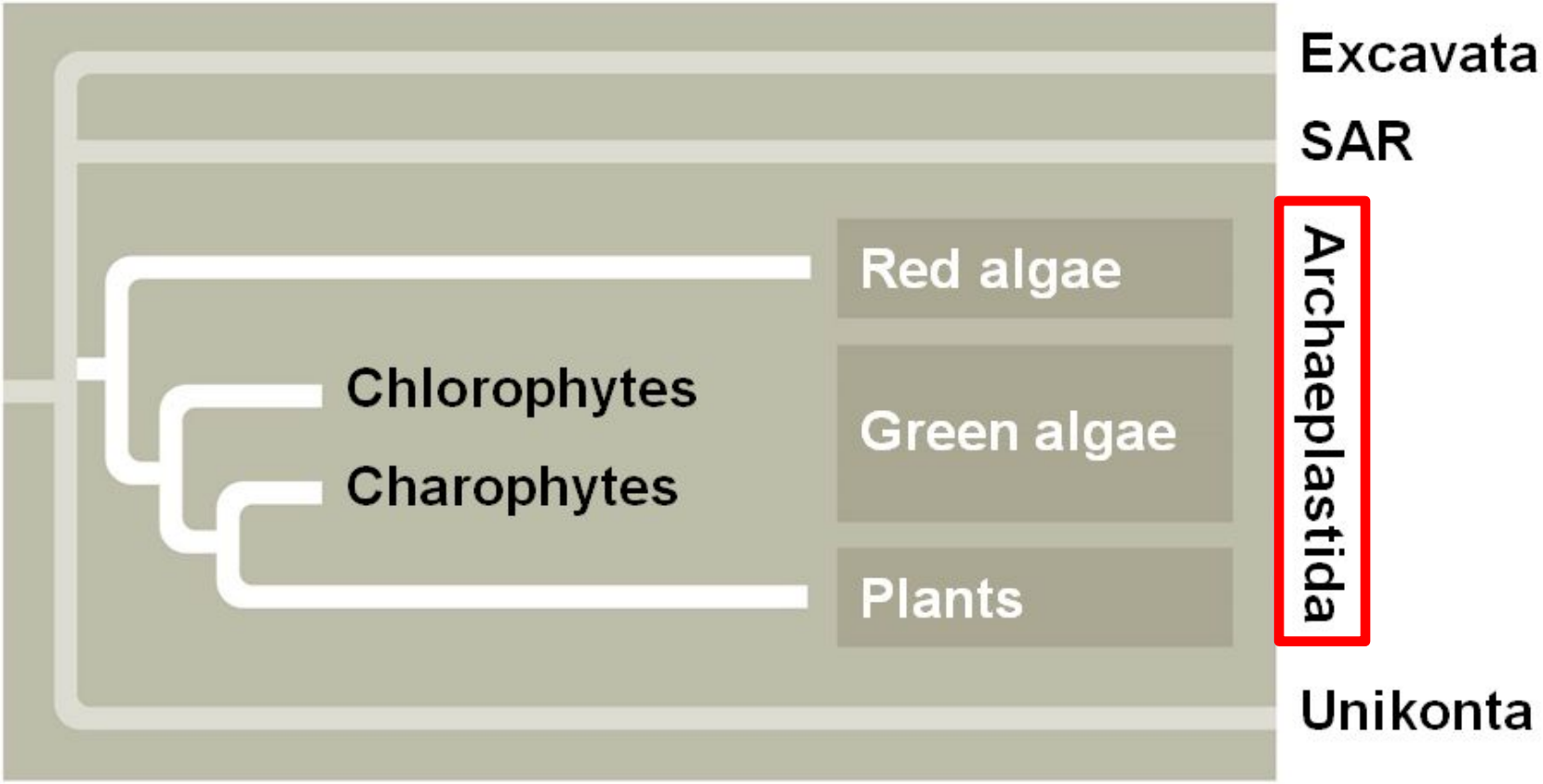


Rhizarians: *Foraminiferans (or Forams)*

- Named for their porous shells, called **"tests"**, made of calcium carbonate
- Pseudopodia extend through the pores in the test
- Some house photosynthetic algae in their tests
- Both freshwater and marine forms are known
- Magnesium content in fossilized forams can be used to estimate changes in ocean temperature over time

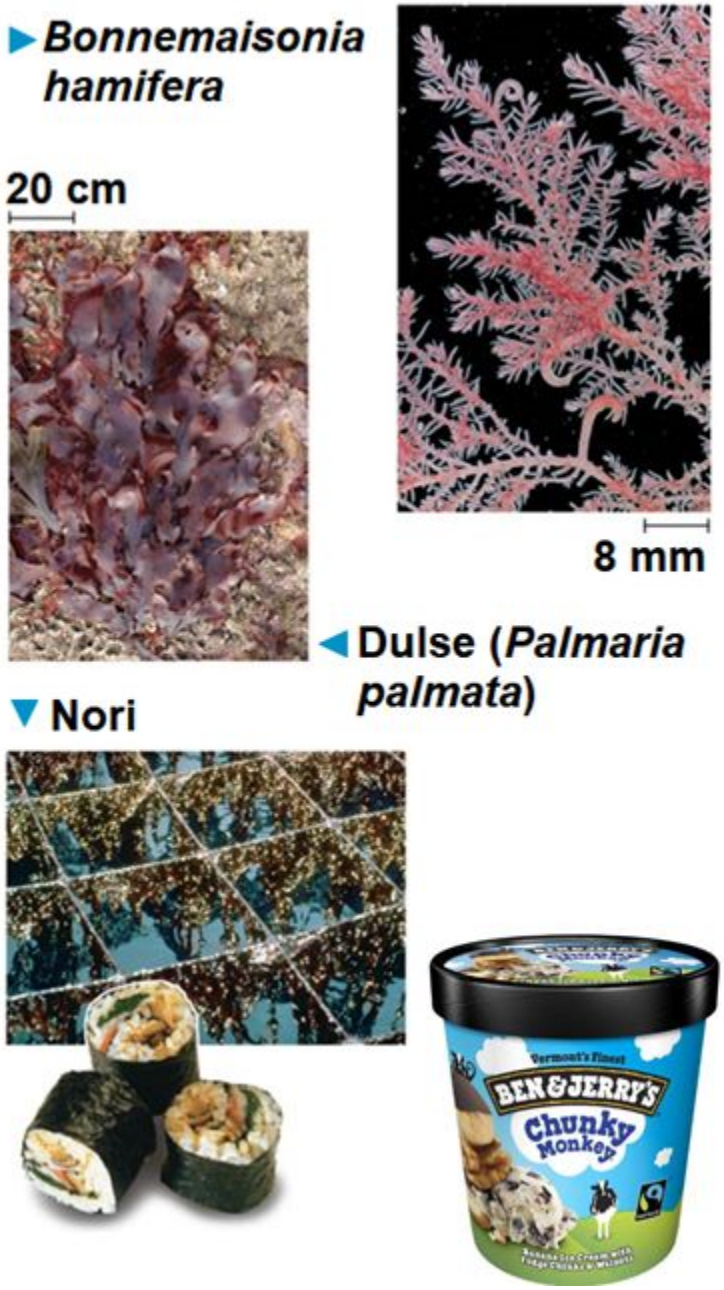
Concept 28.4: Red algae and green algae are the closest relatives of plants

- **Archaeplastida** is the supergroup that includes red algae, green algae, and plants



Red Algae

- **Red algae** are reddish in color due to an accessory pigment called phycoerythrin, which masks the green of chlorophyll
- The color varies from greenish-red in shallow water to dark red or almost black in deep water
- Red algae are usually multicellular; the largest are seaweeds
- Red algae are the most abundant large algae in coastal waters of the tropics



Green Algae

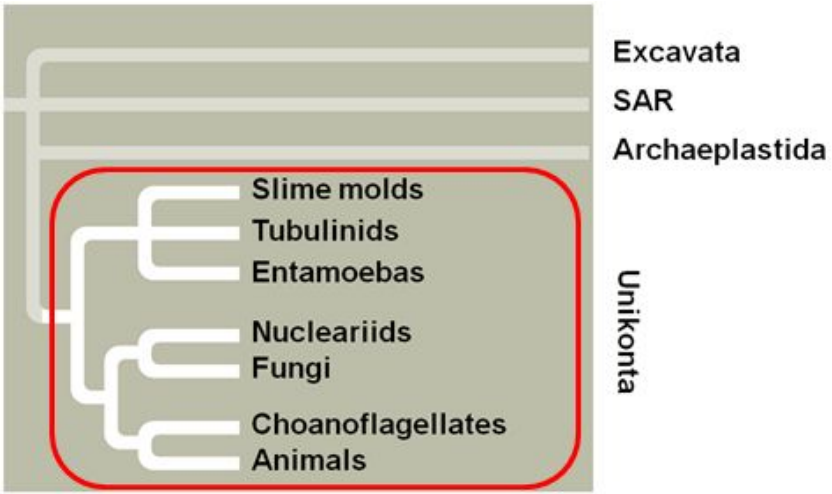
- **Green algae** are named for their grass-green chloroplasts
- Plants and green algae are closely related
- Green algae are a paraphyletic group
- The two main groups are the charophytes and the chlrophytes
- Charophytes are most closely related to plants
- Most chlorophytes live in fresh water, although many are marine
- Other chlorophytes live in damp soil, as symbionts in lichens, or in environments exposed to intense visible and ultraviolet radiation

- Larger size and greater complexity evolved in green algae by
  1. formation of colonies from individual cells
  2. formation of true multicellular bodies
  3. repeated division of nuclei with no cytoplasmic division
- Most chlorophytes have complex life cycles with both sexual and asexual reproductive stages
- Alternation of generations has evolved in some chlorophytes, including *Ulva*

(b) *Ulva*, or sea lettuce

Concept 28.5: Unikonts include protists that are closely related to fungi and animals

- The supergroup **Unikonta** includes animals, fungi, and some protists
- This group includes two clades: the amoebozoans and the opisthokonts
- It is unclear whether unikonts separated from other eukaryotes relatively early or late



Amoebozoans

- **Amoebozoans** are amoebas that have lobe- or tube-shaped, rather than threadlike, pseudopodia
- They include slime molds, tubulinids, and entamoebas

Amoebozoans: *Slime Molds*

- Slime molds, or mycetozoans, were once thought to be fungi due to their spore-producing fruiting bodies
- This resemblance between slime molds and fungi is a result of convergent evolution
- Slime molds include two lineages

A. Plasmodial slime molds: unicellular feeding mass (plasmodium)

B. Cellular slime molds: motile stage, forms fruiting body

A   B

Amoebozoans: *Tubulinids*

- Tubulinids are a diverse group of amoebozoans with lobe- or tube-shaped pseudopodia
- They are common unicellular protists in soil as well as freshwater and marine environments
- Most tubulinids are heterotrophic and actively seek and consume bacteria and other protists

Amoebozoans: *Entamoebas*

- *Entamoeba* are parasites of vertebrates and some invertebrates
- *Entamoeba histolytica* causes amebic dysentery, the third-leading cause of of human death due to eukaryotic parasites

Concept 28.6: Protists play key roles in ecological communities

- Protists are found in diverse aquatic and moist terrestrial environment
- Protists play two key roles in their habitats
  1. Symbiont
  2. Producer

1. Symbiotic Protists

- Some protist symbionts benefit their hosts
  - Dinoflagellates nourish coral polyps that build reefs
  - Wood-digesting protists inhabit the gut of termites
- Some protists are parasitic
  - *Plasmodium* causes malaria
  - *Phytophthora ramorum* causes sudden oak death
  - *P. infestans* causes potato blight (1800s irish famine)

2. Photosynthetic Producer Protists

- Many protists are important **producers** that obtain energy from the sun to convert CO_2 to organic compounds
- In aquatic communities, photosynthetic protists and prokaryotes are the main producers
- Photosynthetic protists are limited by nutrients; populations can explode when limiting nutrients are added