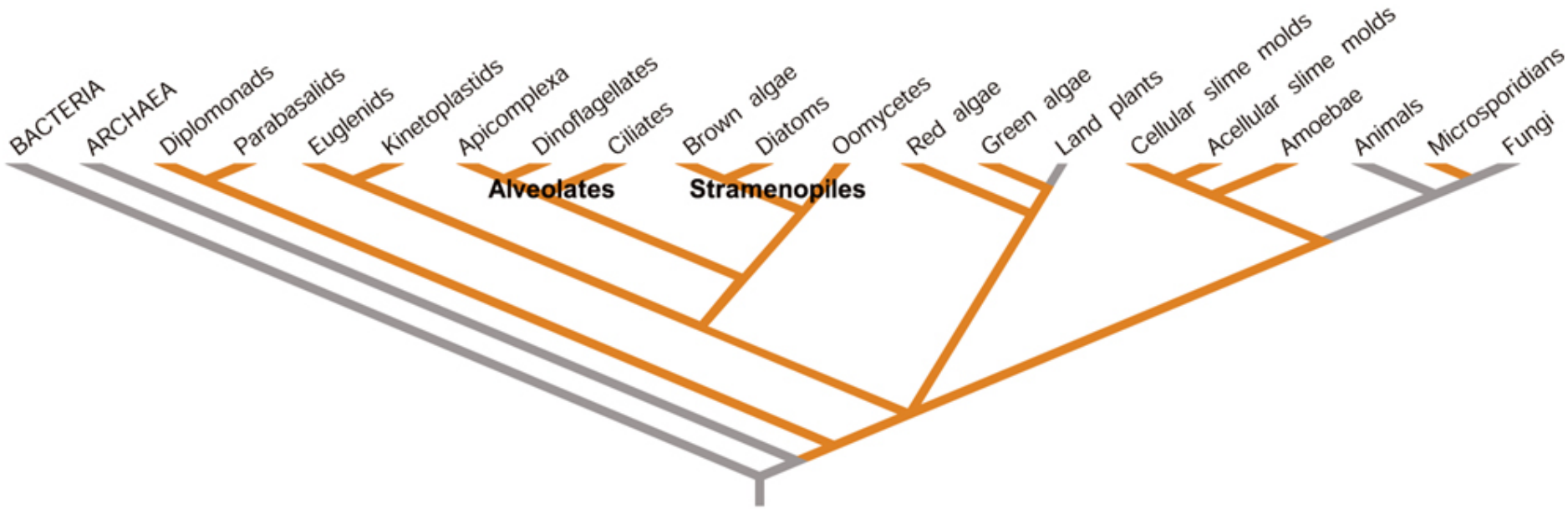
Protists

What Are the Protists?

- Protists are all the eukaryotes that are not fungi, plants, or animals.
  - Protists are a paraphyletic group.
  - Protists exhibit wide variation in morphology, size, and nutritional strategies.
  - All protists live in water, or moist soil, or moist interiors of other organisms.

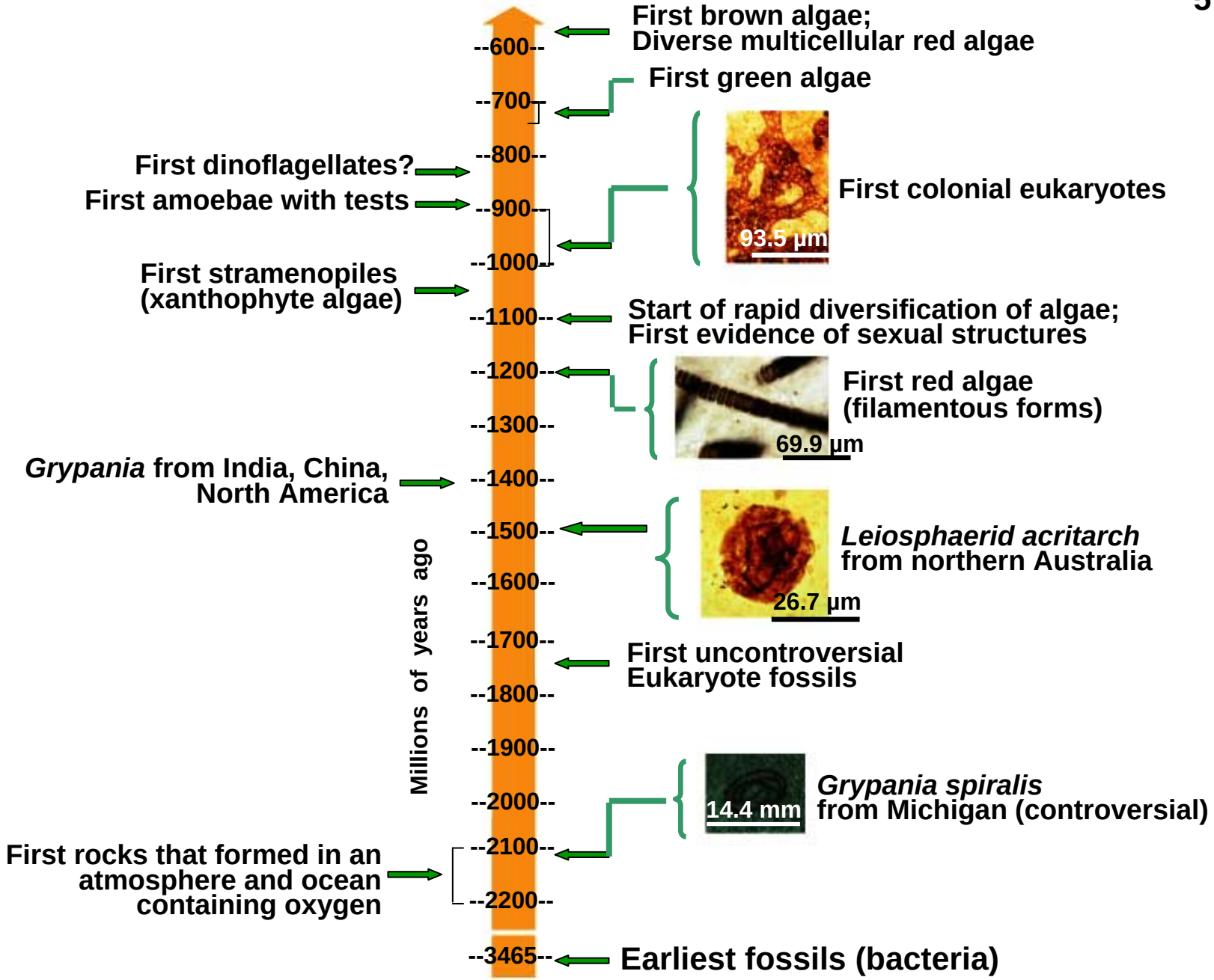
Recent phylogeny of eukaryotes



- The tree of life groups protists based on molecular data.
- The molecular data for protists supports much of the historical groupings of protists based on their morphology.

What Are the Protists?

- Timeline of early eukaryotic evolution
  - Eukaryotes appear to have evolved close to, or soon after, the time that O_2 became abundant in the atmosphere and oceans.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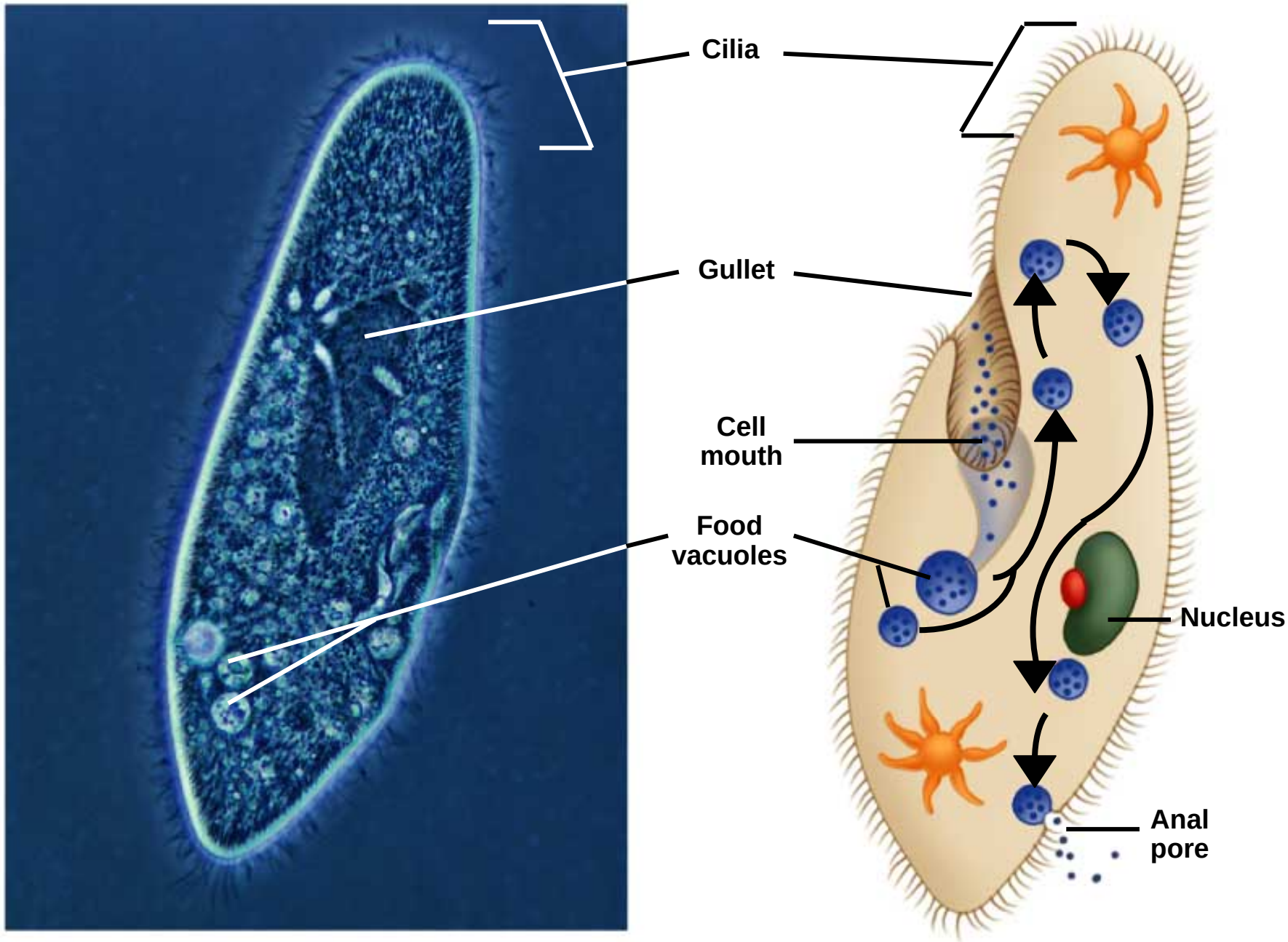
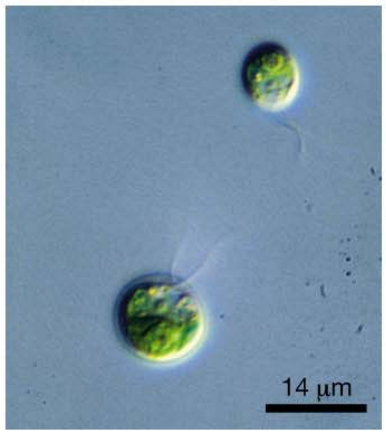
Millions of years ago
First brown algae;
Diverse multicellular red algae
First green algae
First dinoflagellates?
First amoebae with tests
93.5 µm
First colonial eukaryotes
First stramenopiles
(xanthophyte algae)
Start of rapid diversification of algae;
First evidence of sexual structures
69.9 µm
First red algae
(filamentous forms)
Grypania from India, China,
North America
26.7 µm
Leiosphaerid acritarch
from northern Australia
First uncontroversial
Eukaryote fossils
14.4 mm
Grypania spiralis
from Michigan (controversial)
First rocks that formed in an
atmosphere and ocean
containing oxygen
Earliest fossils (bacteria)

Organization

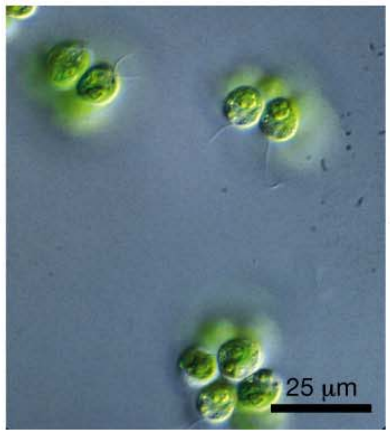
- The earliest eukaryotes solved the problem of increasing cell size (10 times larger than avg. prokaryote).
  - As cell increases volume increases more rapidly than surface area; hence there is a lack of synchronicity between metabolism and transport and exchange of energy and nutrients. In order to cope with this:
    - Compartmentalization into organelles increased the available surface area in the interior of cells, facilitating food and waste transport in and out of the cell.
  - Larger cells make possible the evolution of diverse structures and functions.
  - Unicellular, colonies, multicellular.


Cilia
Gullet
Cell mouth
Food vacuoles
Nucleus
Anal pore

Volvocales species range from unicellular to colonial to multicellular.

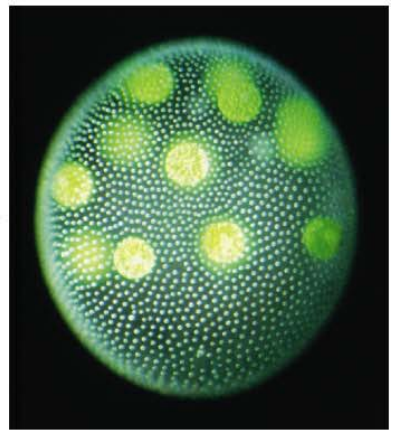


Chlamydomonas



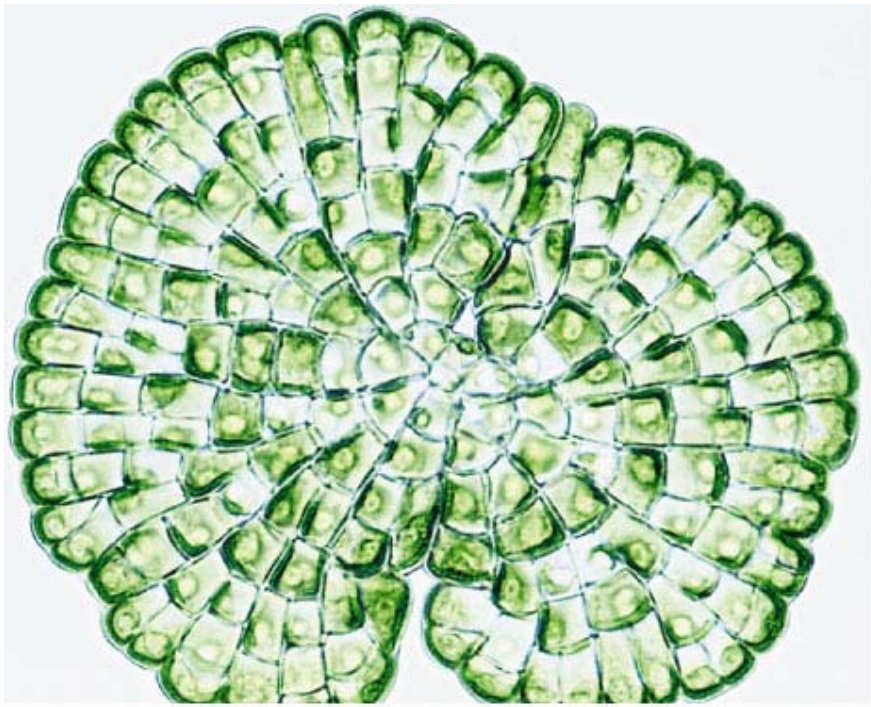
Gonium

Pandorina



Volvox

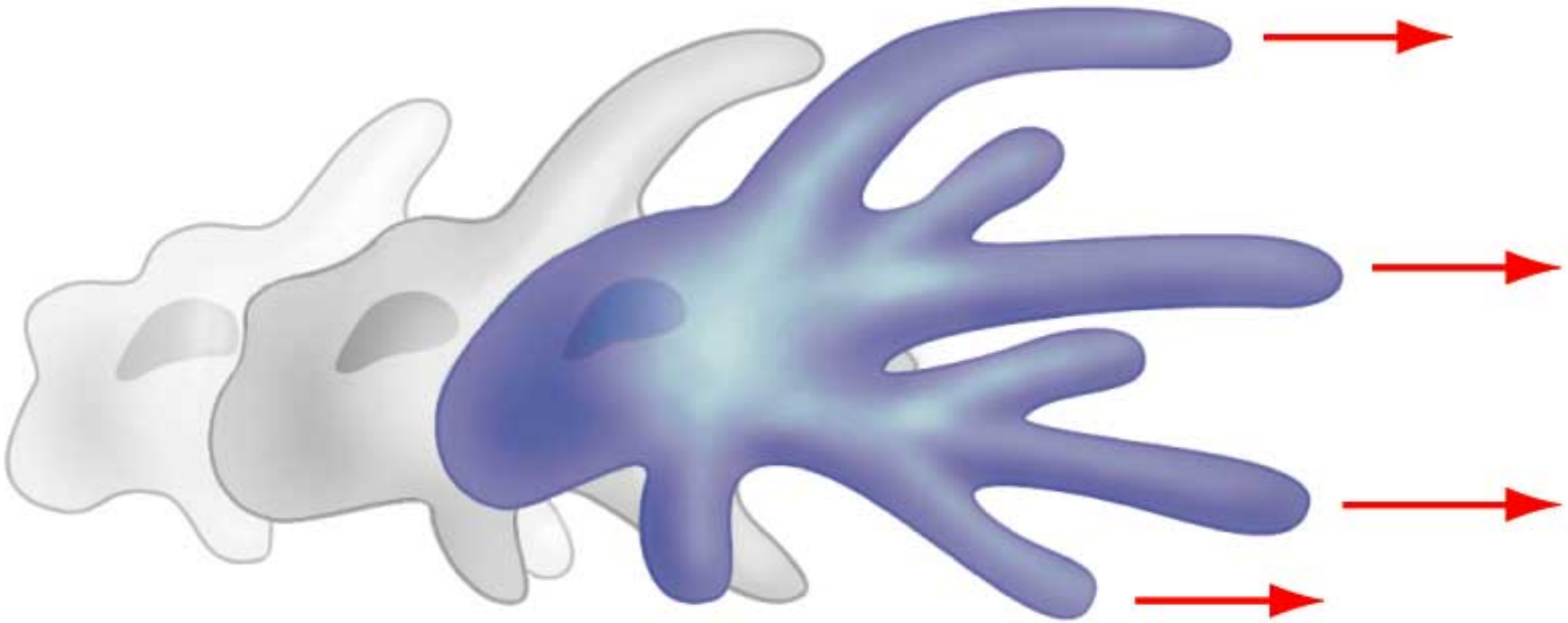
Some protists are clearly multicellular.



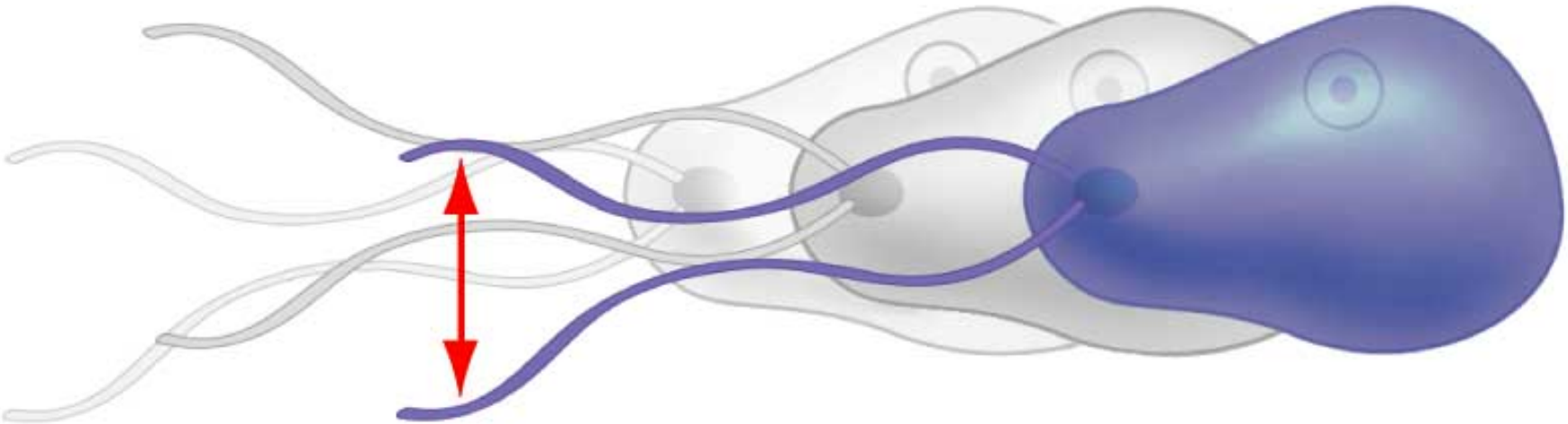
Homeostasis

- Methods of locomotion, support, and protection
  - Protists can be motile by means of cilia or flagella.
  - Support and protection are provided by hard external tests or shells, or by rigid internal structures.

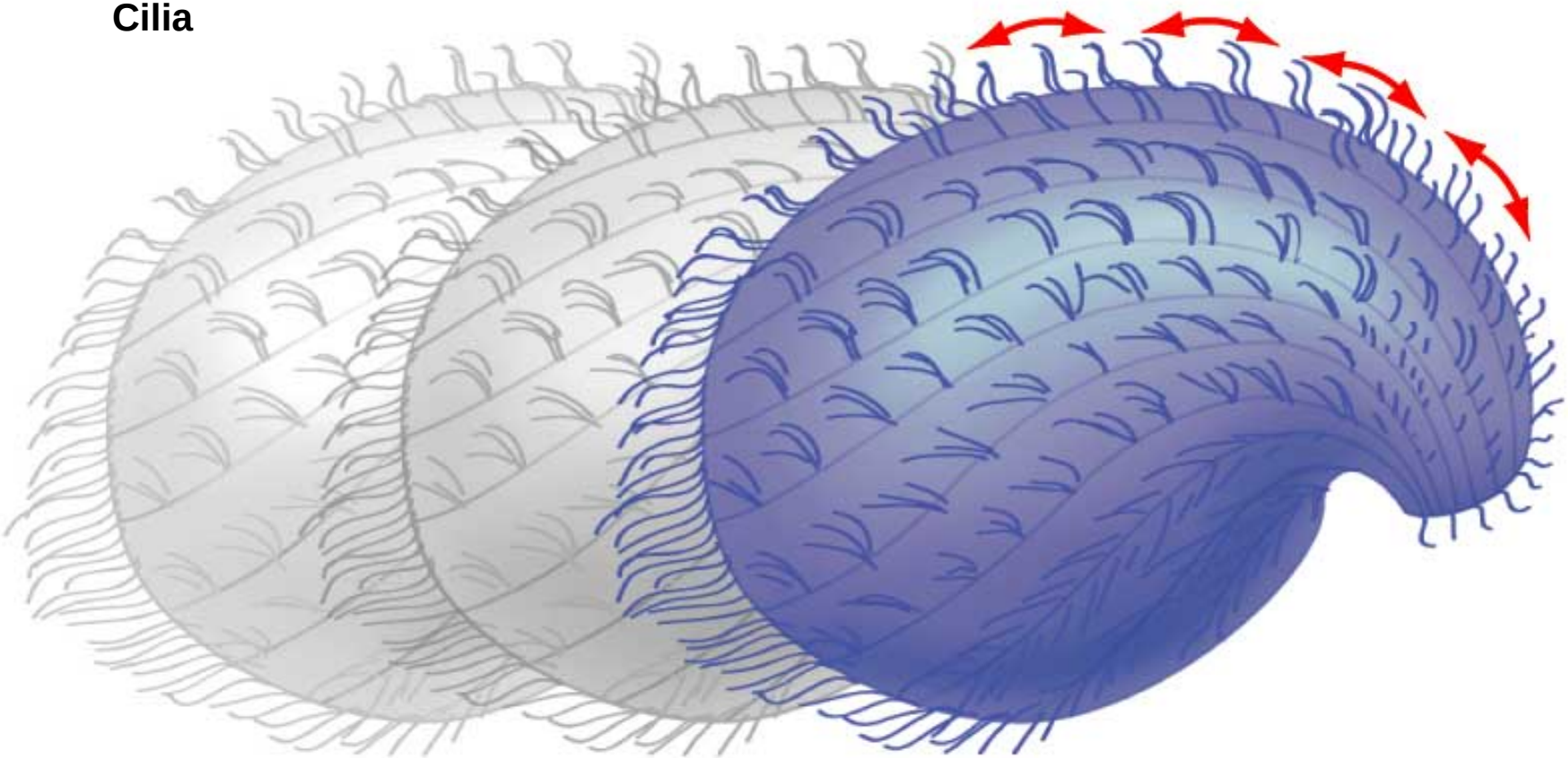
Pseudopodia



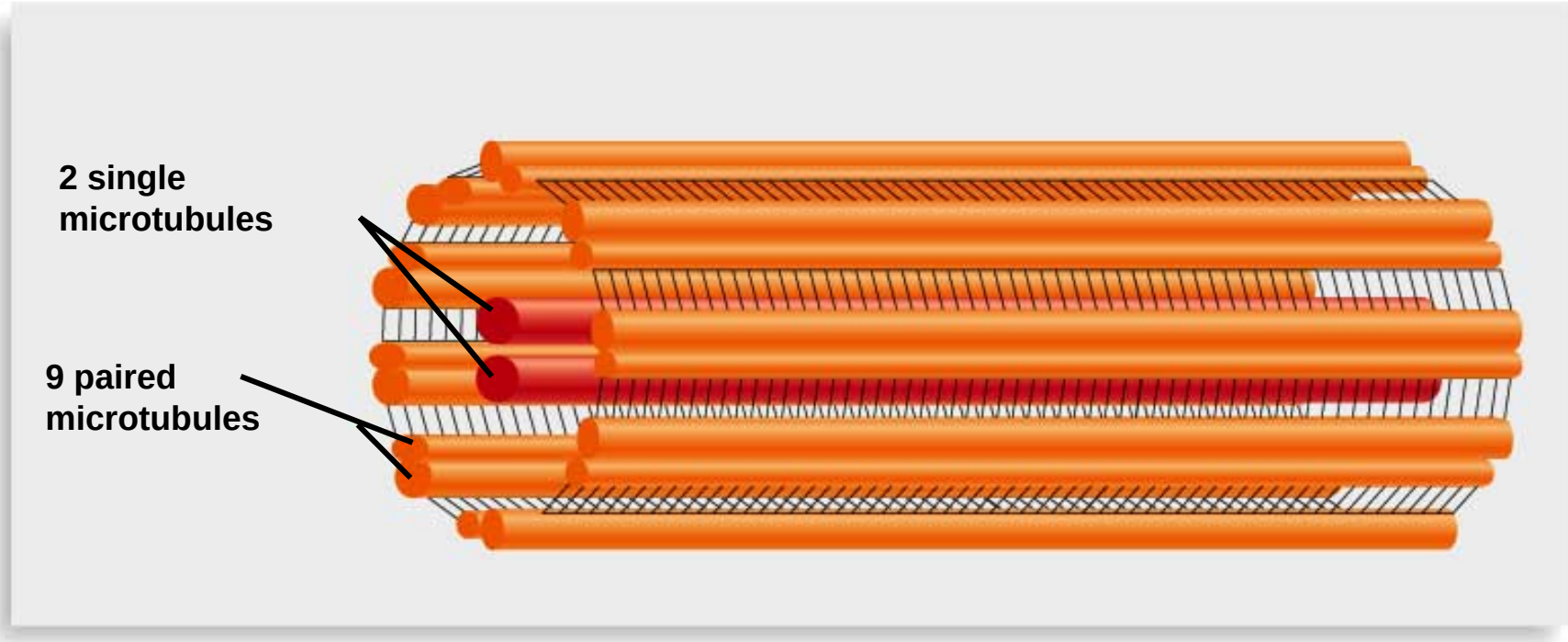
Flagella



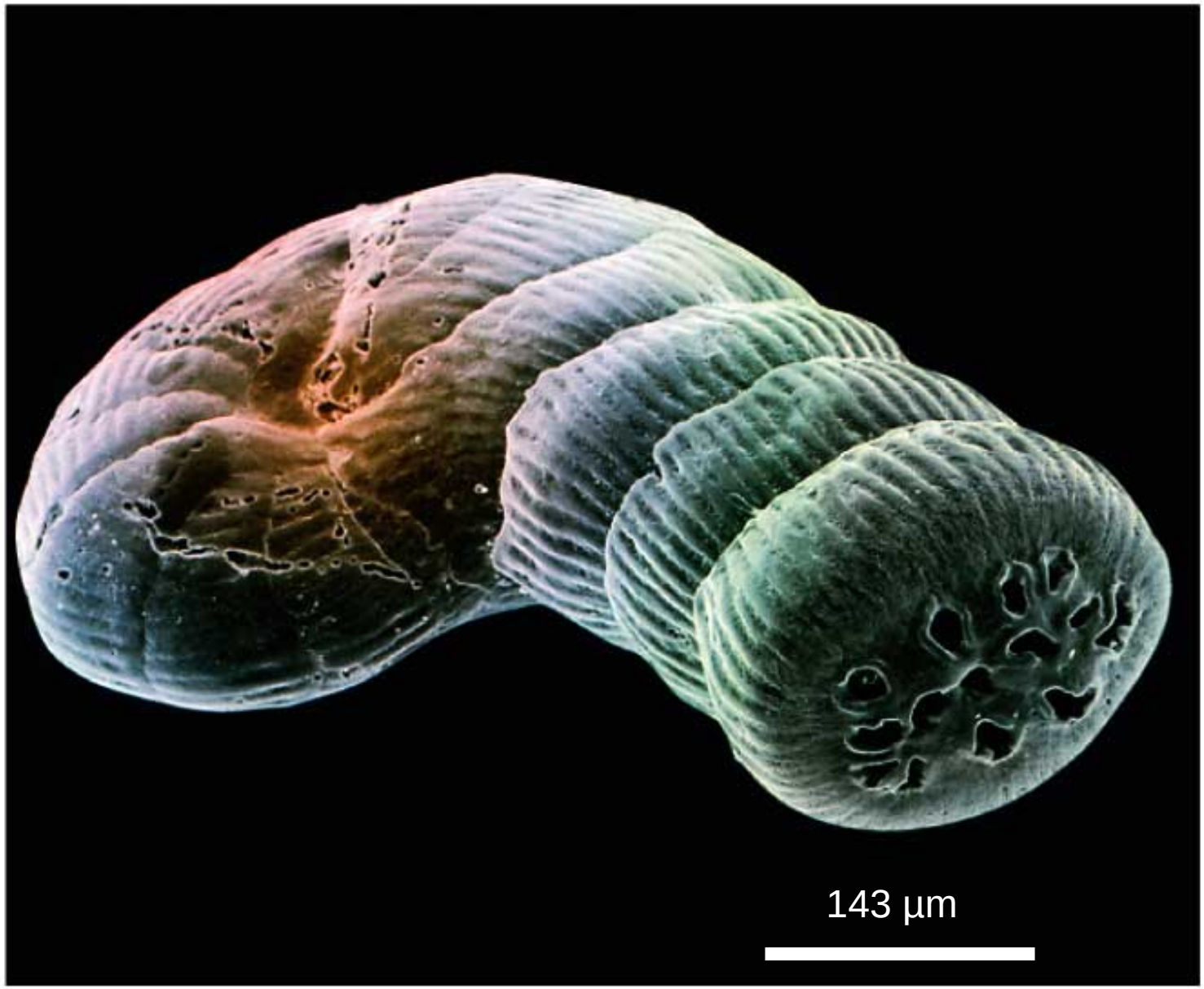
Cilia



Structure of microtubules in cilia and flagella

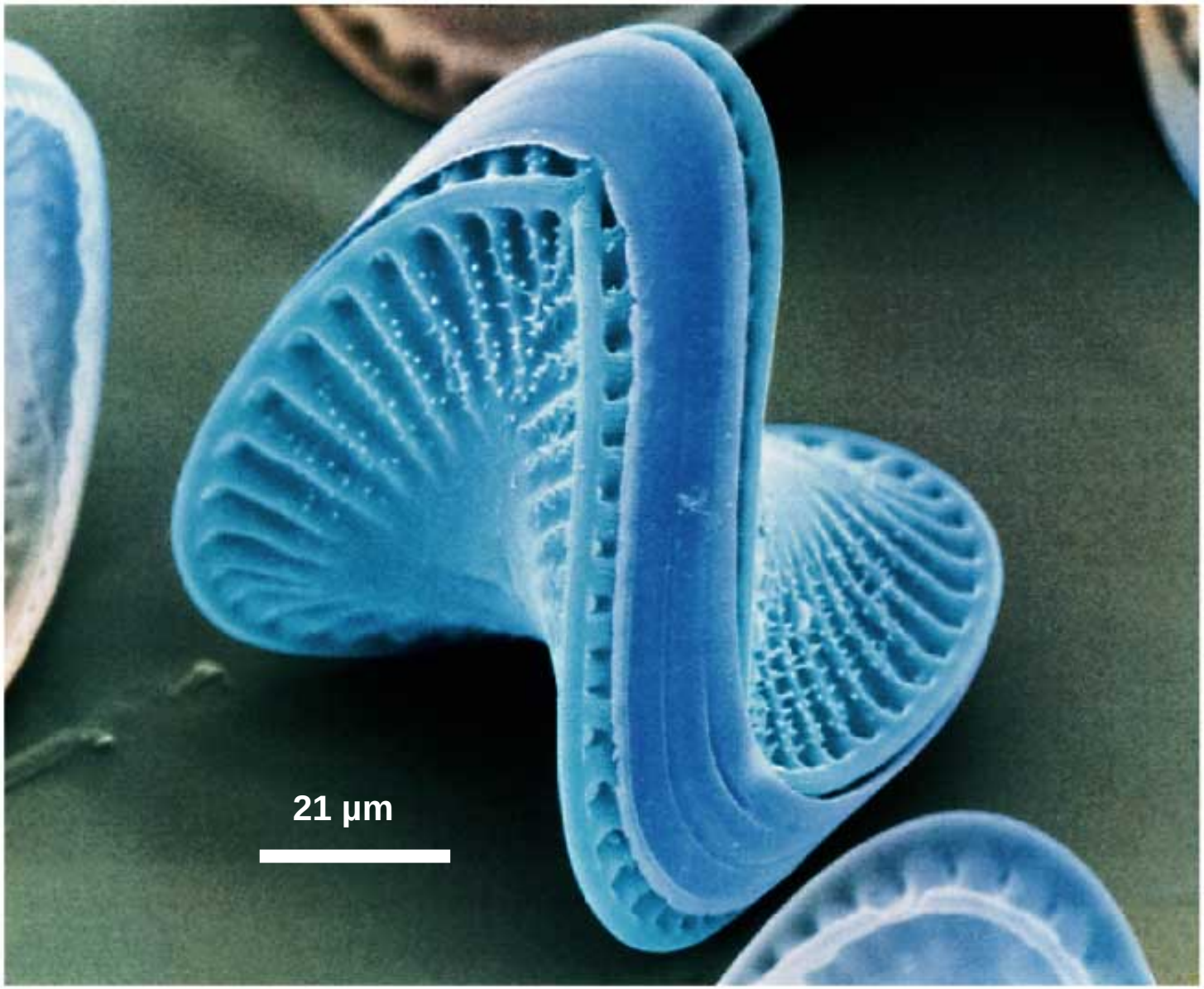


Foraminifera



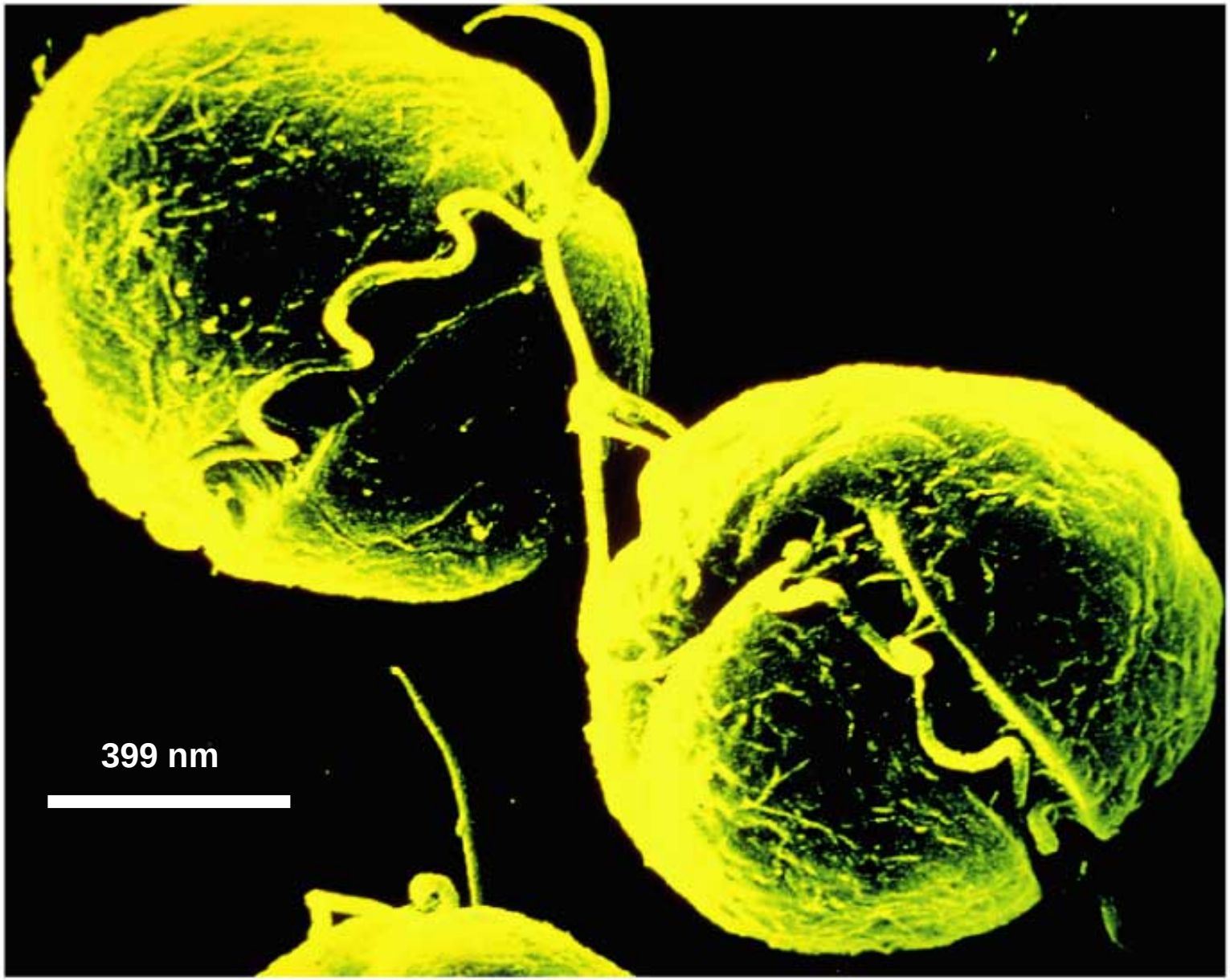
Calcium carbonate test, with chambers

Diatom



Test made of silicon oxides

Dinoflagellate



Plates made of cellulose

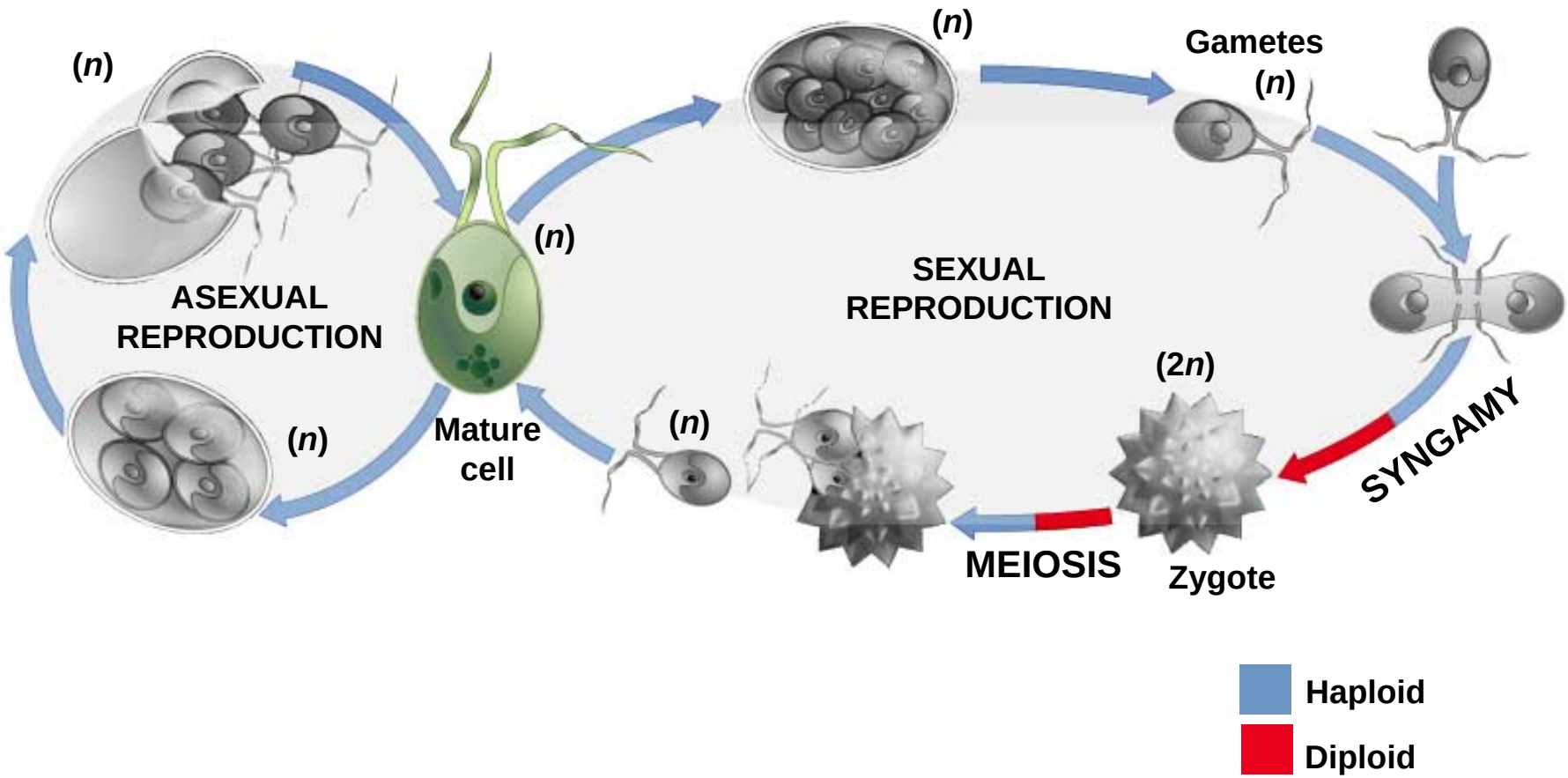
Reproduction and Heredity

- Meiosis makes eukaryotic sexual reproduction possible.
  - Meiosis reduces the diploid chromosome number to haploid and introduces genetic variability through crossover and independent assortment.
- Asexual reproduction is also observed
- Advantages of meiosis/sexual reproduction

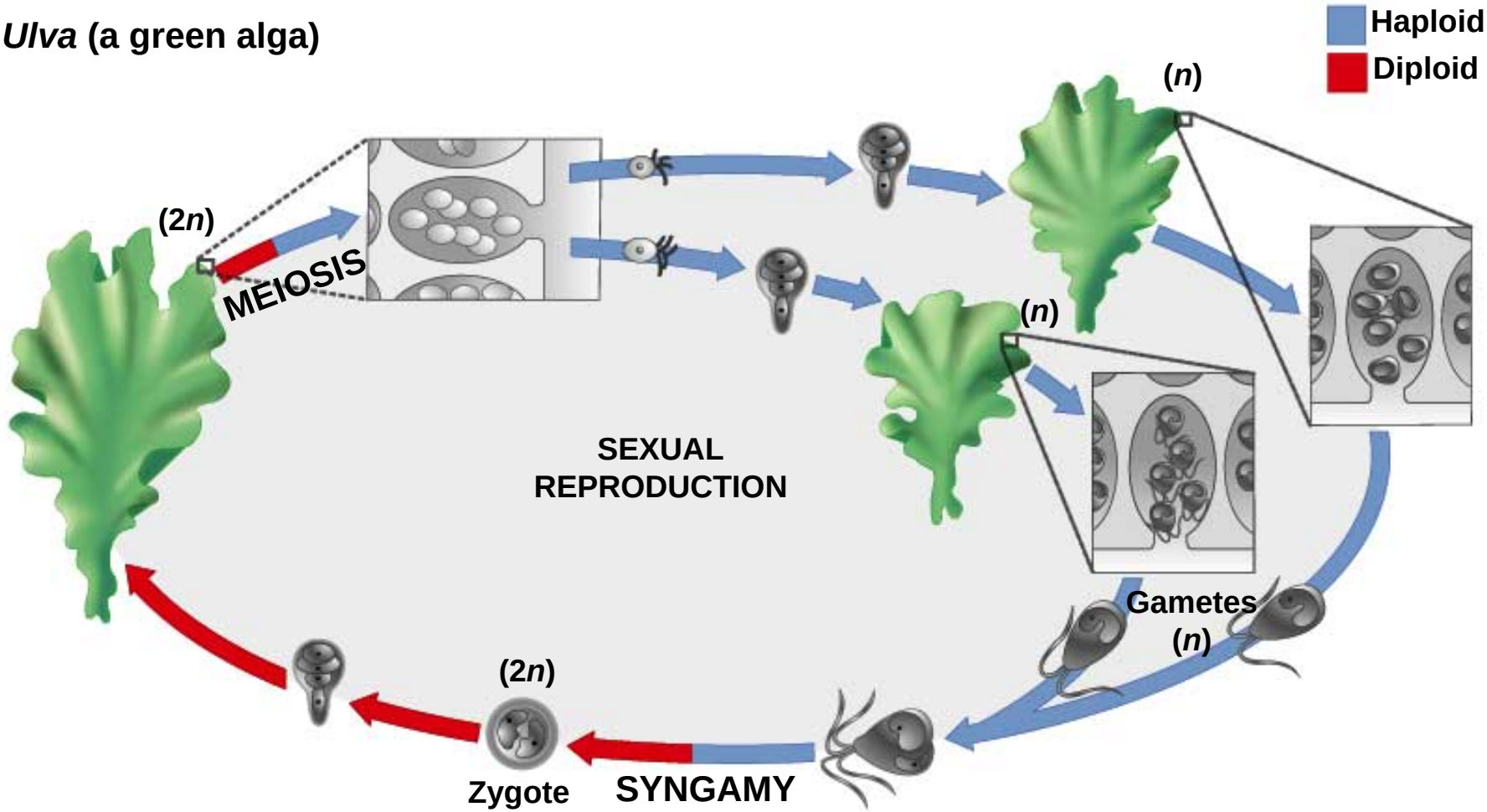
Growth and Development

- Diversity in the timing of meiosis and sexual reproduction has led to a wide variety of life cycles in the protists.
  - Growth of cells and development of multicellular entities is observed for the first time in evolutionary history

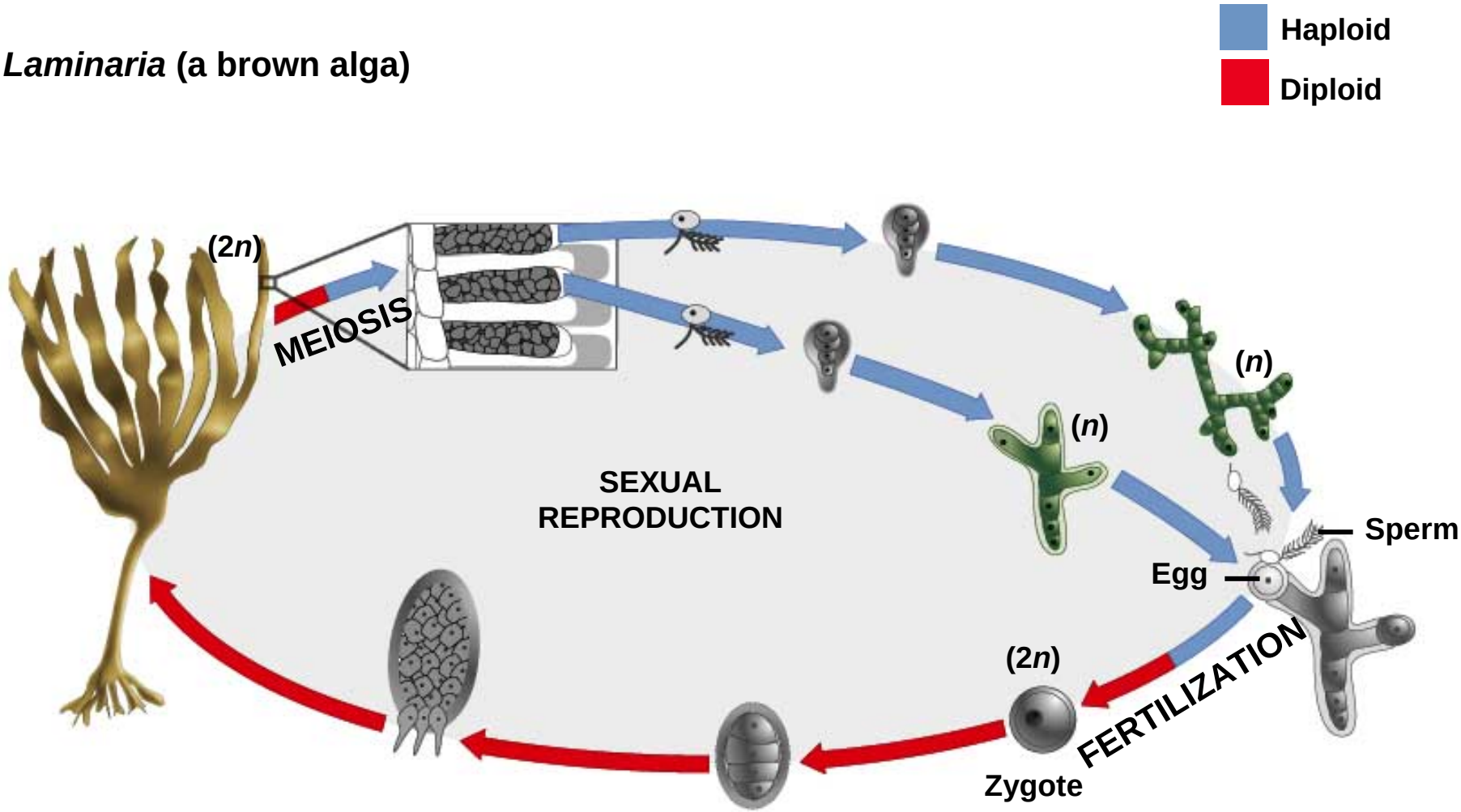
Chlamydomonas



***Ulva* (a green alga)**



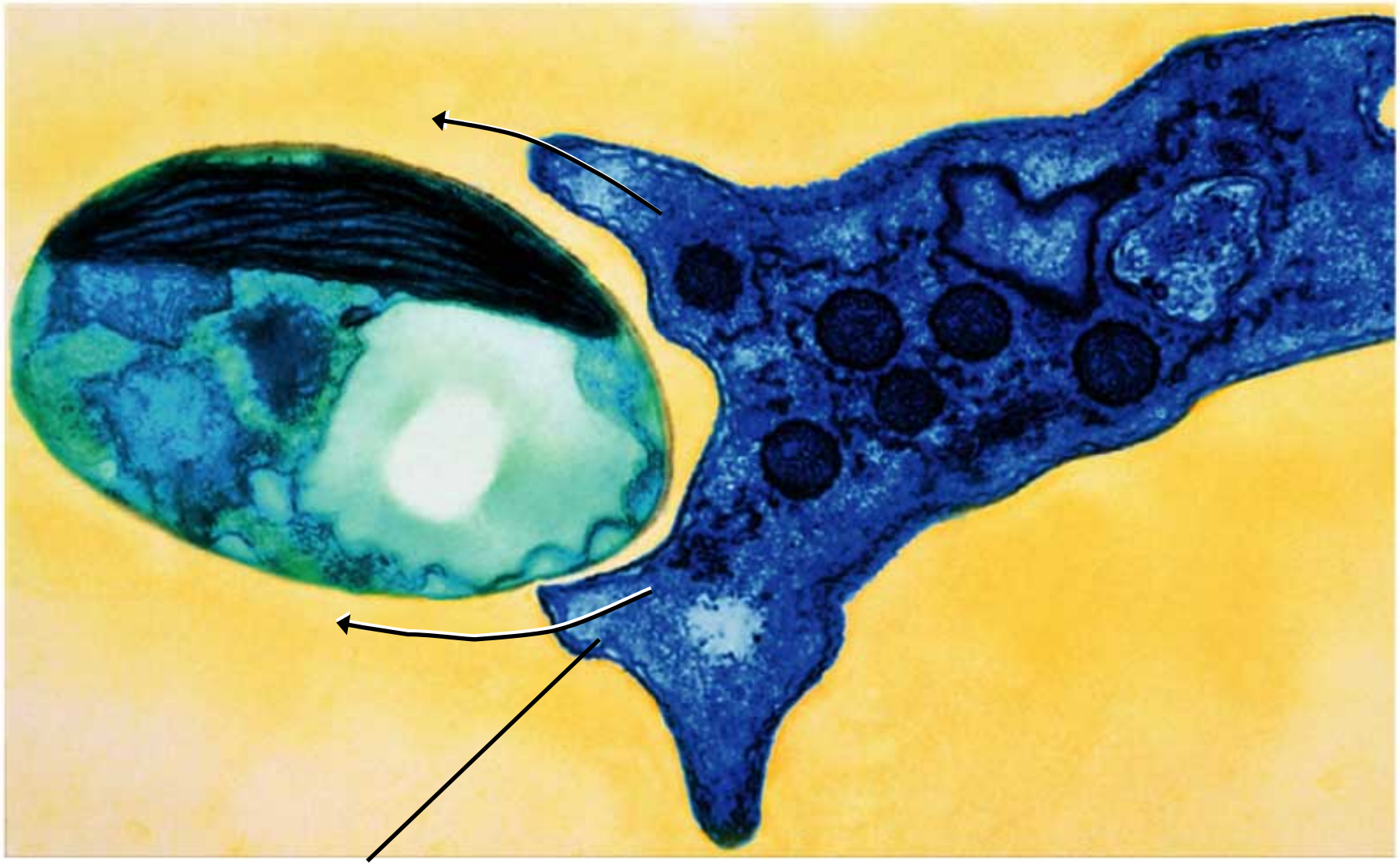
Laminaria **(a brown alga)**



Metabolism

- Protists are either chemoheterotrophs (most of them) or photoautotrophs
- Chemoheterotrophs developed novel nutritional strategies facilitated by innovations in cell structure.
  - Ingestive heterotrophs engulf bacteria and other food materials in pseudopods. Hence predation evolved.
  - Scavenging is facilitated by ciliated structures
  - Also absorptive lifestyles occur: decomposers and parasites
- Nutritional strategies may vary widely within any one phylogenetic group.

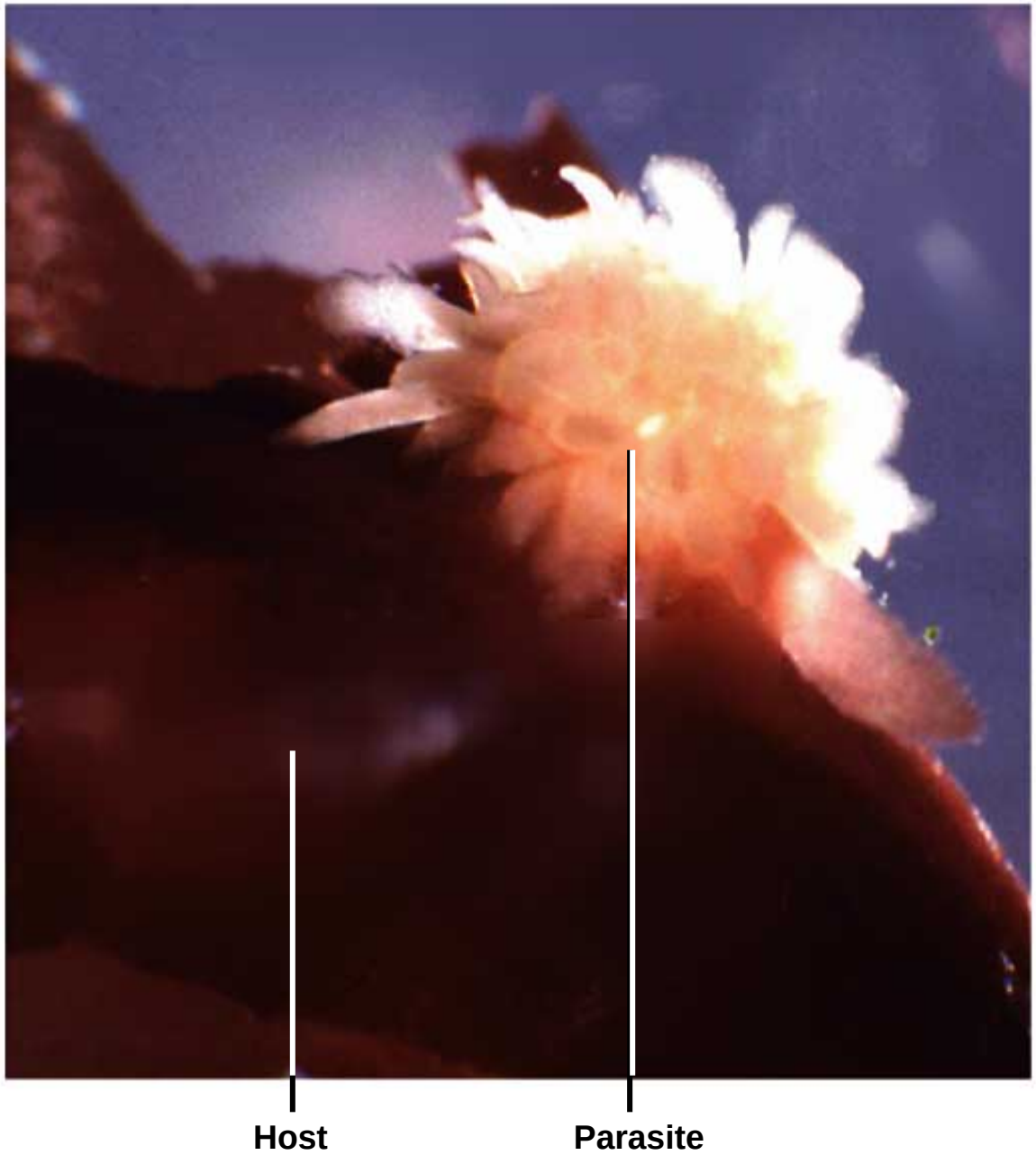
Predation and scavenging



Pseudopodia engulf food

Ciliary currents sweep food into a gullet

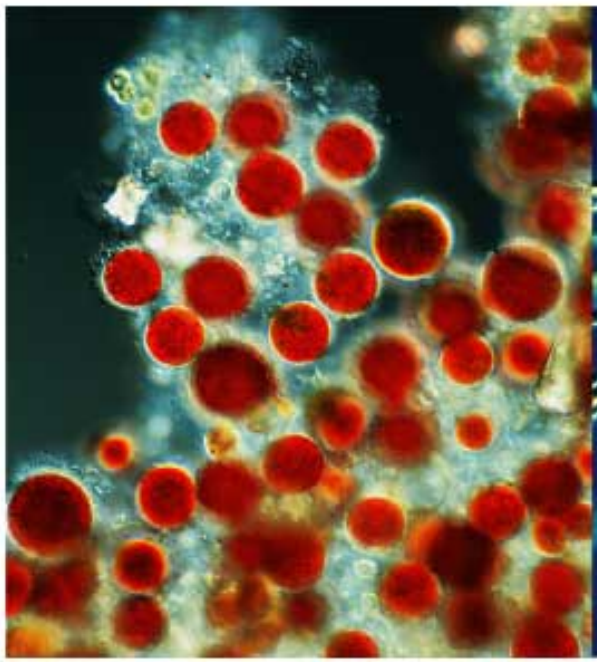
Parasitism



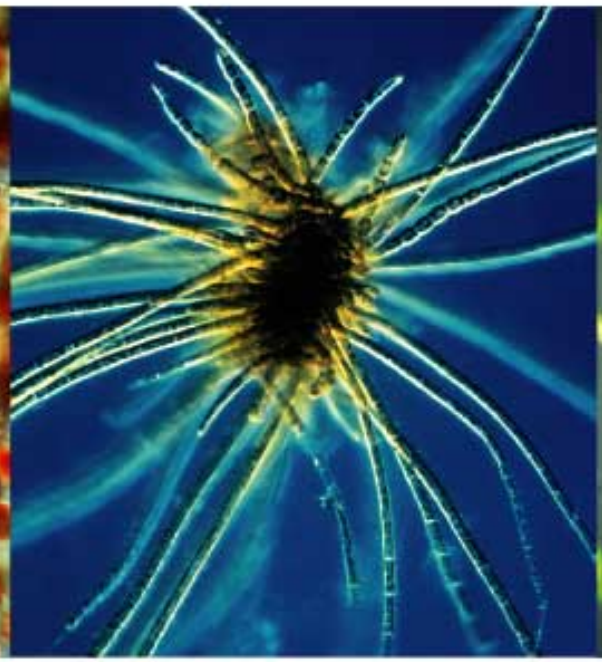
Ecology

- Predation: *Paramecium*
- Parasitism: *Plasmodium falciparum*
- Mutualism: most marine ciliates contain dinoflagellates that engage in photosynthesis
- Decomposers: water molds (oomycetes)
- Competition in photosynthetic autotrophs:
  - variation in their photosynthetic pigments, which enables different species to utilize different wavelengths of light and reduce competition.

Photosynthetic pigments

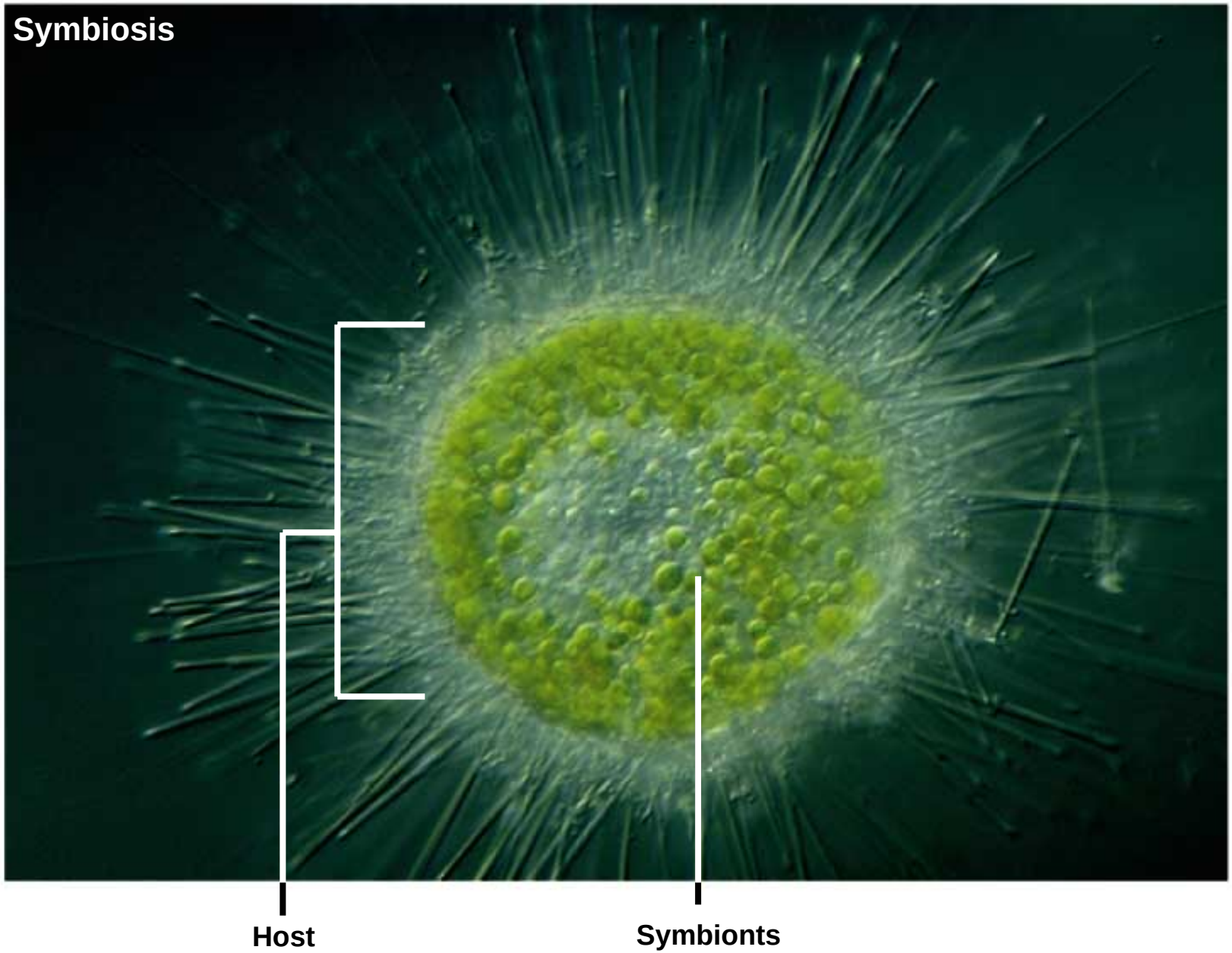


Red: chlorophyll *a* and phycobilins



Brown: chlorophyll *a* and chlorophyll *c*

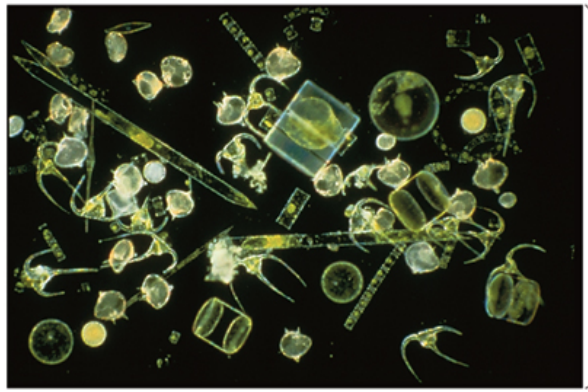
Green: chlorophyll *a* and chlorophyll *b*


Symbiosis
Host
Symbionts

Ecology

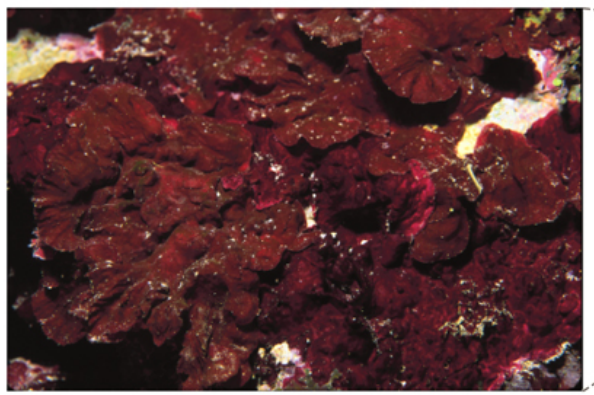
- All protists live in water, or moist soil, or moist interiors of other organisms.
- Species diversity is low (only 10 percent of all known eukaryotes); however abundance is extremely high (a single teaspoon of pondwater can contain over 1000 flagellated protists)

Surface waters teem with microscopic protists



In some near-shore areas, gigantic protists form underwater forests

Protists are particularly abundant in tidal habitats

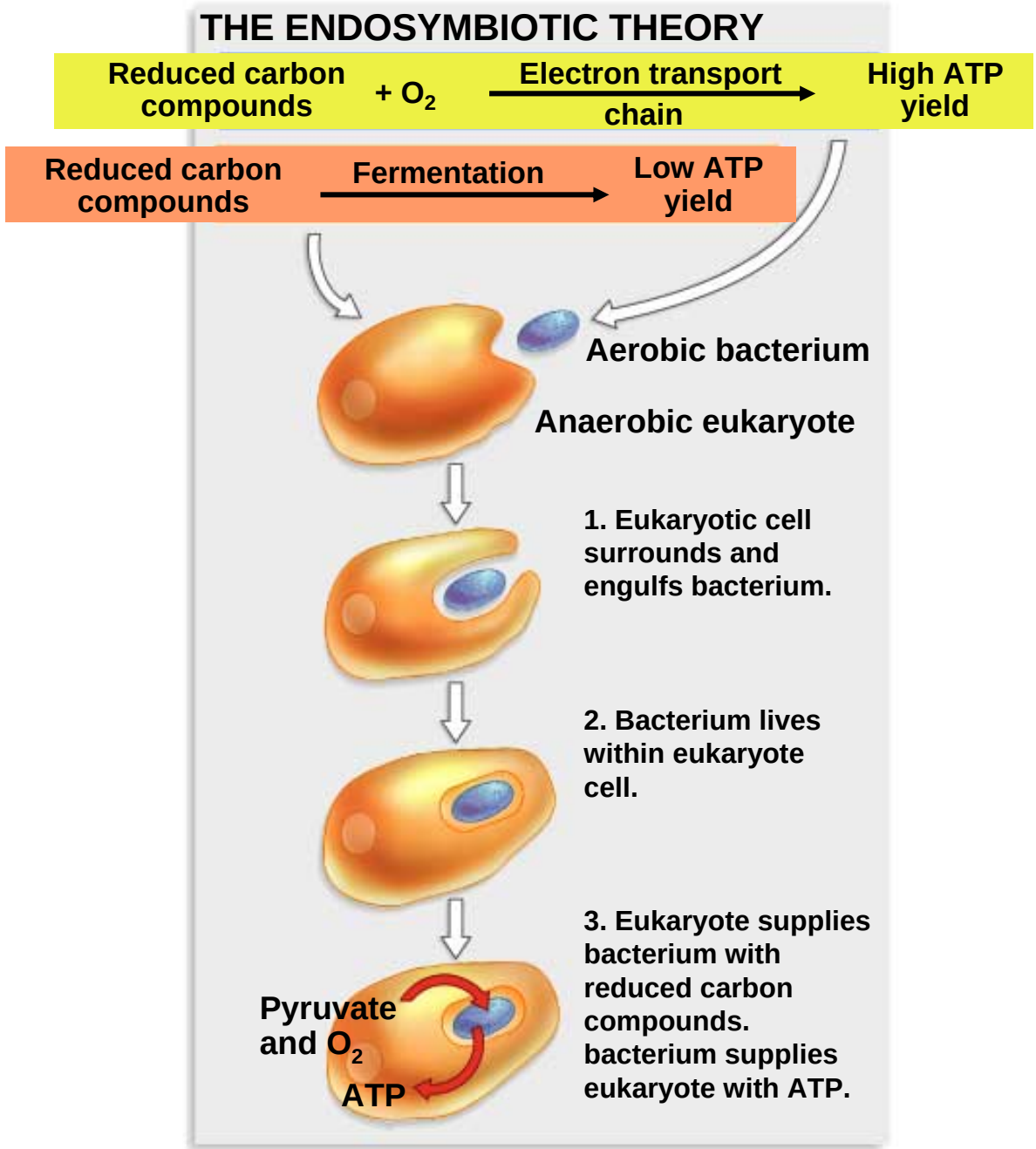


Adaptation

- Meiosis, sexual reproduction, and the diversity of eukaryotes.
  - The effect of potentially debilitating mutations is lessened since only half of the daughter cells of meiosis will receive a particular mutant allele.
  - Fusion of haploid gametes from two parents creates genetically different offspring, some of which may be more resistant to environmental changes and pathogens than the parents.

The Origin of Mitochondria and Chloroplasts

- The endosymbiotic theory
  - Mitochondria evolved by larger anaerobic eukaryotes engulfing aerobic prokaryotes, which became endosymbionts that enabled the host cell to become aerobic.
  - Chloroplasts evolved in an analogous way. In this case a photosynthetic, endosymbiotic bacteria provided its eukaryotic host with oxygen and glucose in exchange of protection.


THE ENDOSYMBIOTIC THEORY
Reduced carbon compounds
+ O_2
Electron transport chain
High ATP yield
Reduced carbon compounds
Fermentation
Low ATP yield
Aerobic bacterium
Anaerobic eukaryote
1. Eukaryotic cell surrounds and engulfs bacterium.
2. Bacterium lives within eukaryote cell.
3. Eukaryote supplies bacterium with reduced carbon compounds. bacterium supplies eukaryote with ATP.
Pyruvate and O_2
ATP

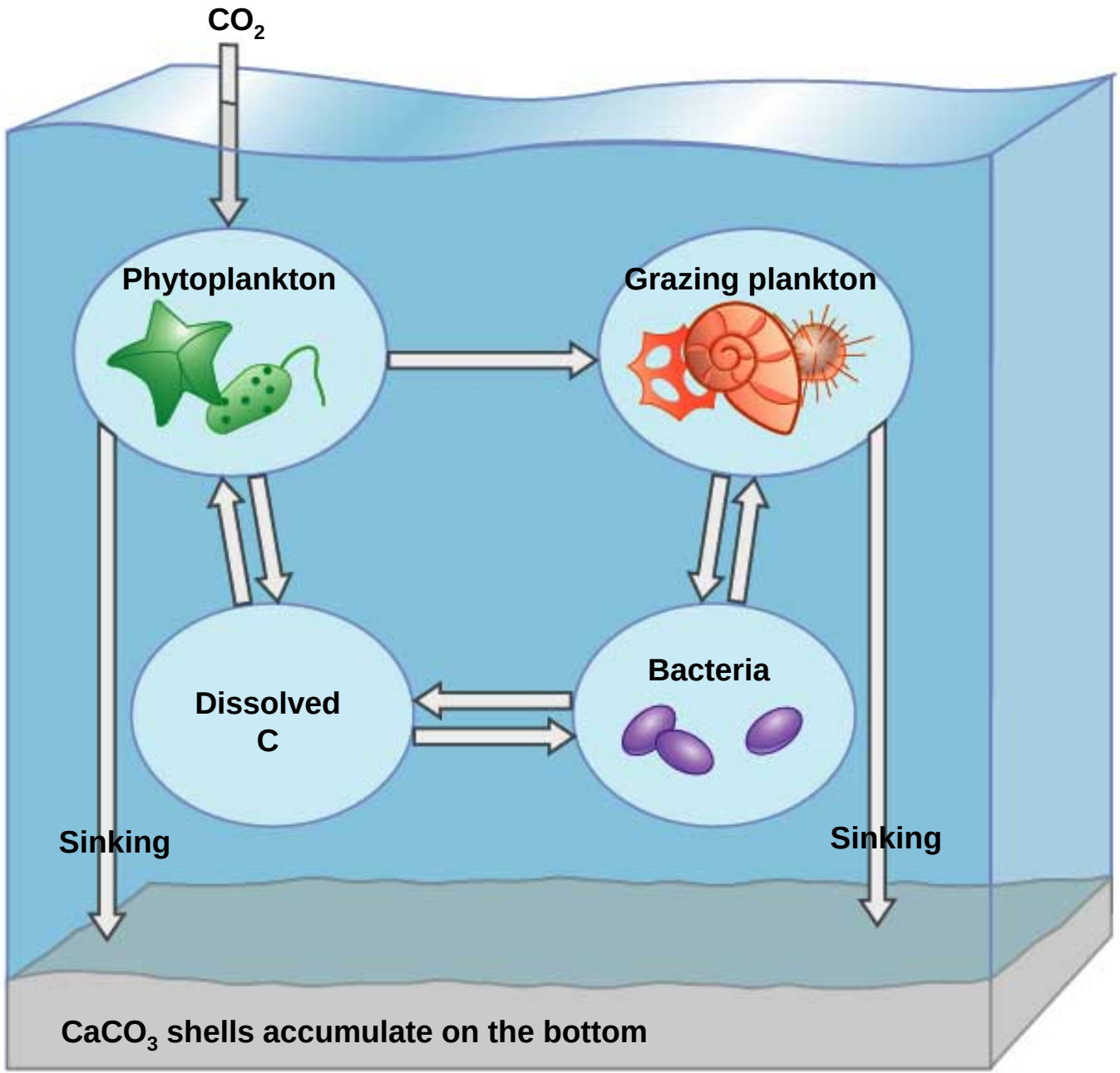
The Origin of Mitochondria and Chloroplasts

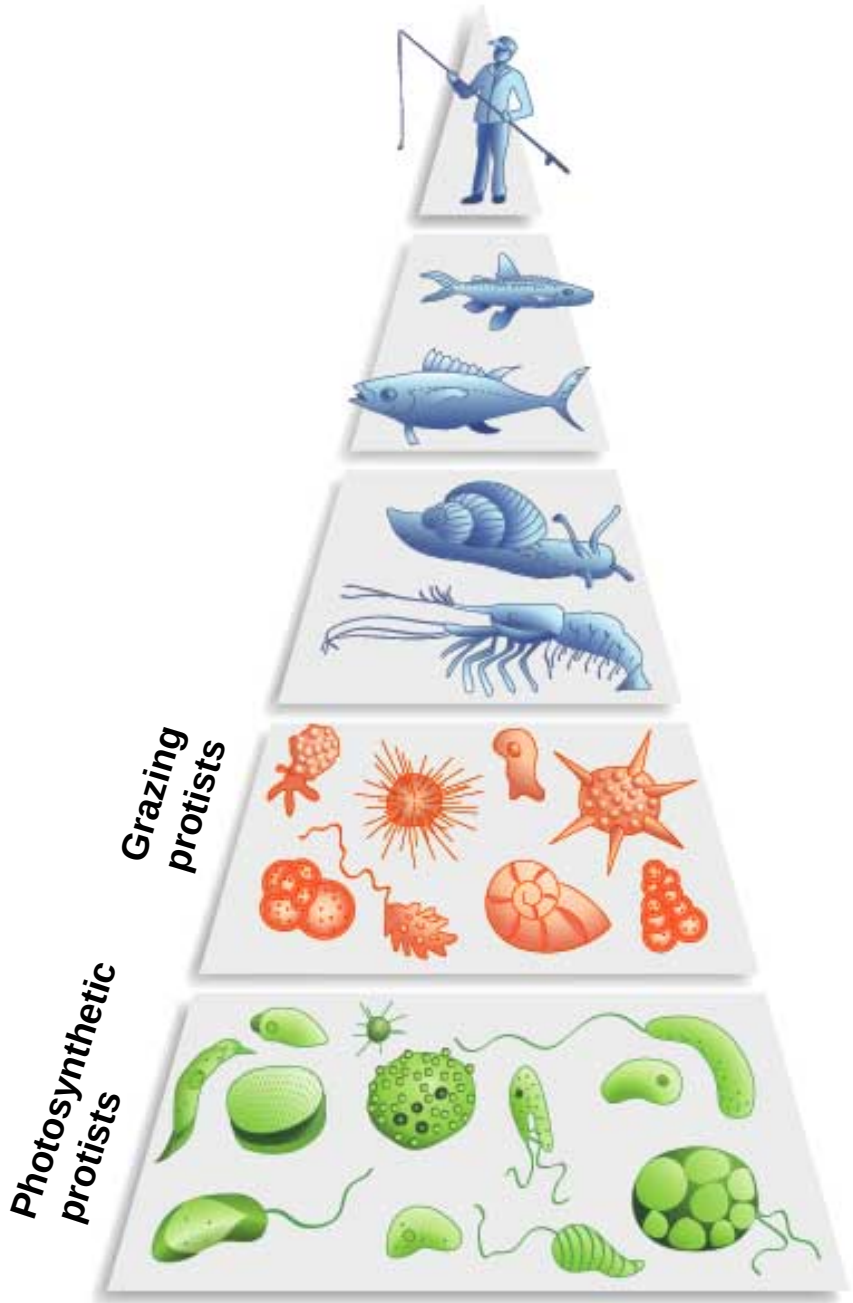
- The endosymbiotic theory
  - Evidence that supports the theory of endosymbiosis:
    - Physical similarities exist between mitochondria, chloroplasts, and prokaryotes.
    - Molecular data indicates mitochondria and chloroplasts are prokaryotic in origin.

Importance

- Many protists are responsible for human diseases, such as malaria (*Plasmodium falciparum*), diarrhea (*Giardia*), reproductive tract infections (*Trichomonas*), chagas disease (*Tripanosoma cruzi*).

- Protists are the leading primary producers in oceans and are the basis for marine and freshwater food chains.


CO_2
Phytoplankton
Grazing plankton
Dissolved C
Bacteria
Sinking
Sinking
$CaCO_3$ shells accumulate on the bottom


Grazing protists
Photosynthetic protists