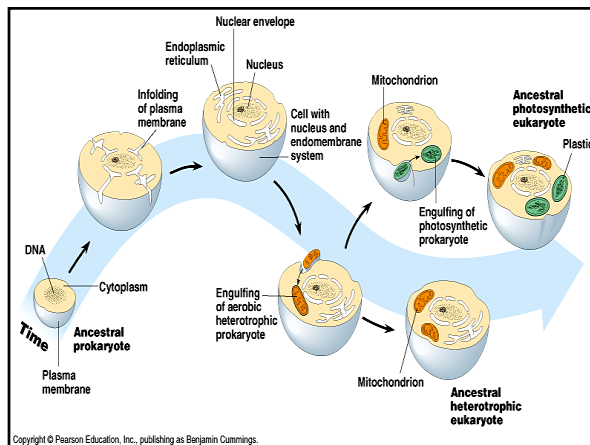


# Protists



## The Eukaryotic cell probably originated as a community of prokaryotes

- The fossil record indicates that they first evolved more than 1.7 bya.
- The endomembrane system is thought to have evolved by membrane infolding. This infolding of prokaryotic plasma membrane and the specialization of internal membranes into membrane-bounded organelles accounts for the origin of eukaryotic organelles, except mitochondria and chloroplasts.
- Endosymbiosis is the likely basis of the origin of mitochondria and chloroplasts, with mitochondria evolving first. The ancestral mitochondria may have been small heterotrophic prokaryotes and, similarly, the ancestral chloroplasts may have been small photosynthetic prokaryotes.



- Several lines of evidence support the endosymbiotic hypothesis. Mitochondria and chloroplasts are similar in size and shape to prokaryotes and include bacterial-type DNA, RNA, and ribosomes. These organelles replicate in eukaryotic cytoplasm in a manner resembling binary fission. The inner, but not the outer, membranes of these organelles contain enzymes and electron transport molecules characteristic of prokaryotes, not eukaryotes.

- Endosymbiosis is common today between protists and prokaryotes.

## Protists, unicellular eukaryotes and their close multicellular relatives, probably represent multiple kingdoms

- Protists (literally means 1<sup>st</sup> creature) are diverse and likely represent several kingdoms within domain eukarya.
- As a group protists are nutritionally diverse. Photosynthetic protists are referred to as "algae," a term with no taxonomic meaning. Heterotrophic protists are referred to as protozoans.
- Colonial and multicellular protists whose immediate ancestors were unicellular are also considered protists.

- Protists are found in all habitats but are most common in aquatic ones.

- As eukaryotes, their cells are more complex than prokaryotes, with many kinds of organelles.

- Evolutionarily, protists are pivotal because it was ancestral protists that evolved into ancestral plants, fungi, and animals.

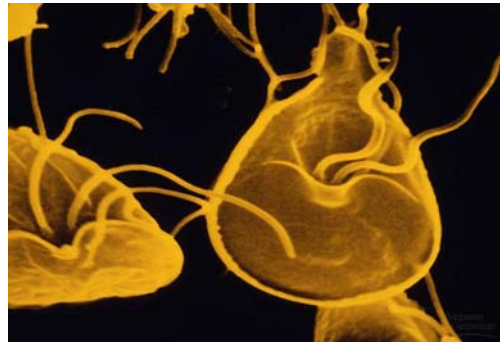
- Studies of protistan nucleic acid sequences provide evidence that suggests that these eukaryotic cells evolved from several different eukaryotic ancestors.

**Protozoans are protists that ingest their food**

•Most species are free-living inhabitants of watery environments. A few are causes of diseases of humans and other animals.

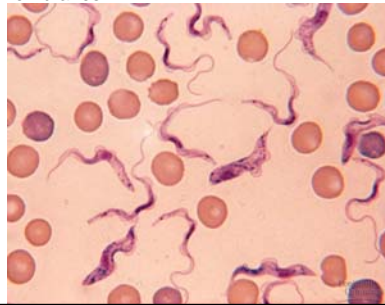
**Note:** Most protozoans have cells that lack cell walls, although some have relatively rigid protein skeletons below their plasma membranes.

•Flagellates move by one or more flagella. *Giardia* is a flagellate that can cause abdominal cramps and severe diarrhea. What makes *Giardia* particularly interesting is its two haploid nuclei and lack of mitochondria. The presence of vestiges of mitochondrial genes in its genome suggests it once had mitochondria.



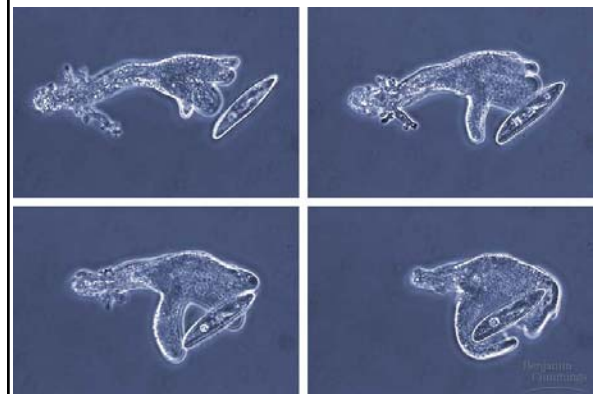
*Giardia*

•Another interesting flagellate is a species of *Trypanosoma* that is spread by tsetse flies and causes African sleeping sickness when it grows among blood cells. Trypanosomes escape a host's immune response by changing the molecular appearance of the proteins in the membranes

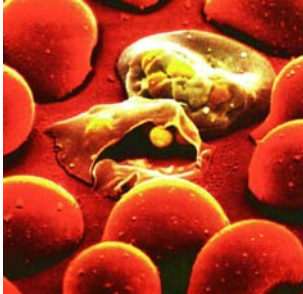


*Euglena*

•Amoebas move and feed by means of pseudopodia.



•**Apicomplexans** are all parasites, some causing serious human disease. *Plasmodium* species are spread by mosquitoes and cause malaria when they reproduce in red blood cells.



**Plasmodium that causes malaria**

•Ciliates are common, free-living forms that use cilia to move and feed. Daily activity is controlled by a polyploid macronucleus, and sexual recombination involves as many as 80 diploid micronuclei.

**Cilia**- numerous, short, flagellalike structures arranged in more complex patterns than flagella.

## Common Ciliates



**Stentor**

**Paramecium**

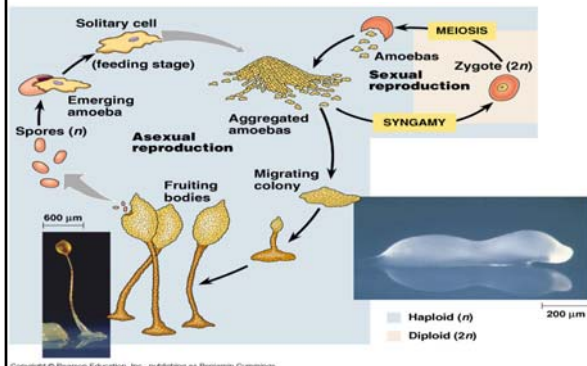
**Cellular slime molds have both unicellular and multicellular stages**

•The unicellular stage exists as individual, amoeboid cells that feed on bacteria in rotting vegetation, increasing their population by mitotic cell division.

•When their food supply runs out, the individual cells mass into a sluglike, multicellular colony.

•The slugs wander about, moving to an advantageous location to reproduce. Some cells form a stalk below, and other reproductive spores above.

•Because they are eukaryotes with a simple developmental sequence, cellular slime molds have played a role in research of cellular differentiation.

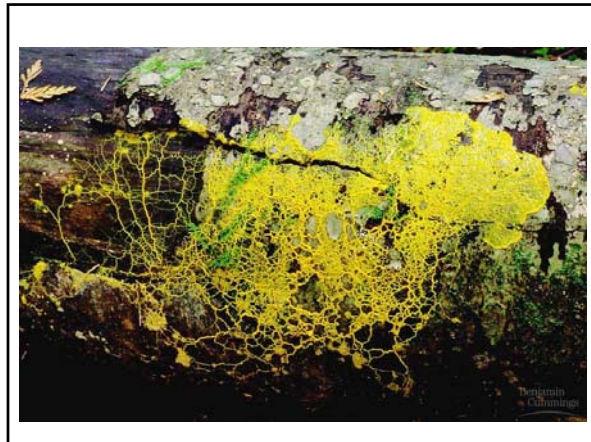


**Plasmodial slime molds have brightly colored stages with many nuclei**

•These protists exist in several different forms, including single cells, multinucleate feeding webs, resistant bodies, and multicellular reproductive structures.

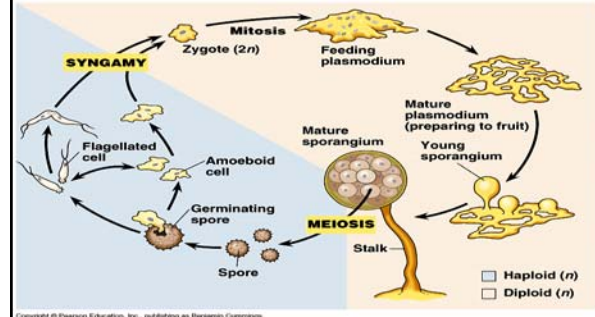
•They are common inhabitants of moist, rotting leaves and dead logs.

•Life starts as individual amoeboid or flagellated cells (that can change back in forth, depending on availability of water). As these cells ingest bacteria, they grow into amoeboid plasmodium (a single undivided mass of protoplasm containing many nuclei).



•When food runs out, the plasmodium mounds up into reproductive structures.

**Note:** Because the nuclei in the feeding stage all divide by mitosis at exactly the same time, some plasmodial slime molds were used in early research on the chemistry of mitosis.



### Photosynthetic protists are called algae

- Most algae have chloroplasts with chlorophyll *a*, as do plants.

**Note:** The variety of accessory photosynthetic pigments cause many algae to be other colors than the typical grass-green color of chlorophyll *a*.

- Some heterotrophic protists are considered algae.
- The morphology of species varies considerably, from single cells to colonial filaments to plantlike bodies (seaweeds).

•Dinoflagellates are uniquely shaped and move by two flagella in perpendicular grooves. Some dinoflagellates are responsible for toxin-releasing blooms in warm coastal waters that are known as red tides. Nutritionally, some dinoflagellates are photoautotrophs, others chemoautotrophs, and others chemoheterotrophs.

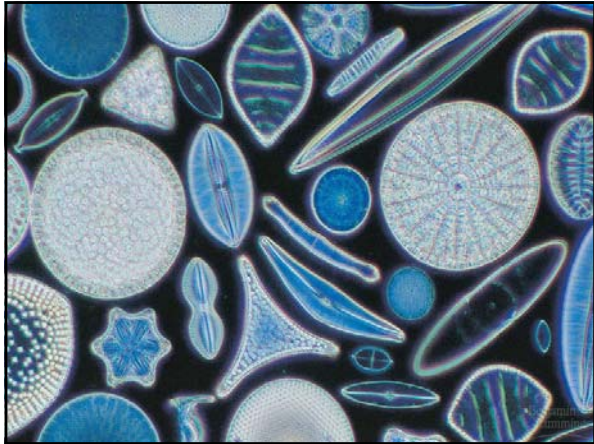


*Pfiestria piscicida*- produces toxins that are lethal to fish and dangerous to humans. Red-tides result from population explosions of Pfiestria and several other Marine dinoflagellates.

## Diatoms

•Diatoms are unicellular, with uniquely shaped and sculptured silica walls. They are common components of watery environments. In terms of being a food source, diatoms are to marine animals what plants are to land animals. Fossilized diatoms make up thick sediments of diatomaceous earth, which can be used either for filtering or as an abrasive.

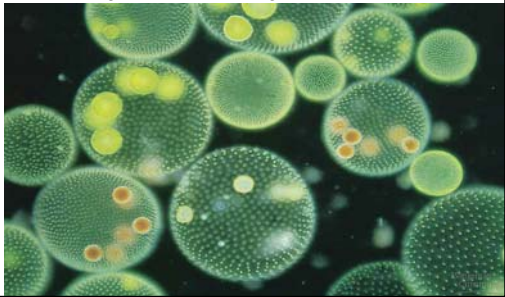
•All diatoms are enclosed in a frustule that is made of two valves fitted together by a connective zone known as a girdle.



## Green Algae

- The green algae are common inhabitants of fresh water and include a large variety of forms. Green algae share some features with higher plants and are considered either the plant kingdom's ancestors or members of the plant kingdom.

**Volvox** is a colonial green alga common in freshwater. Each *Volvox* colony is a hollow ball composed of hundreds or thousands of biflagellate cells. The cells are connected by strands of cytoplasm; if isolated, these cells cannot reproduce. The large colonies will eventually release the small green and red daughter colonies within them.

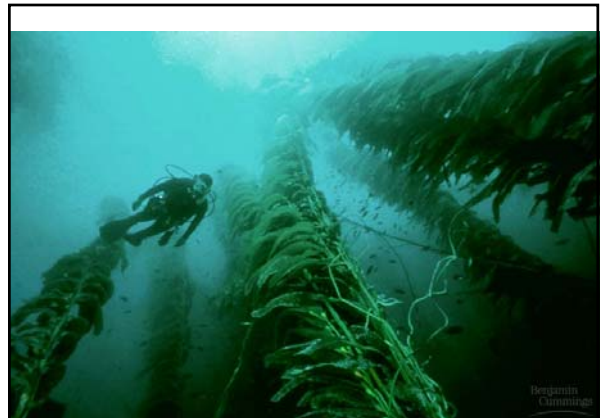


### Seaweeds are multicellular marine algae

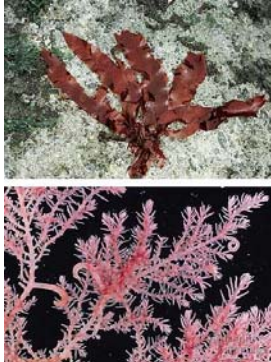
- Seaweeds are the most complex of the photosynthetic protists. Some have complex bodies with leaflike, stemlike, and rootlike structures, all analogous (no common ancestry) rather than homologous (common ancestry) to similar structures in higher plants

- Molecular and cellular studies suggest that there maybe three groups of seaweeds , with brown algae, red algae, and multicellular green algae each being placed in different kingdoms.

- Brown algae include the most complex seaweeds. Some can grow to lengths of 100 m, forming kelp "forests" that bare rich with other life. Similarities of molecules used in photosynthesis suggests that brown algae and diatoms may be members of the same kingdom.



- Red algae are most common in tropical marine waters. Most are soft-bodied, but encrusted species are important in building coral reefs.



- Some multicellular green algae are seaweeds, such as *Ulva*. The reproductive pattern of algae involves alternation of generations, alternating between haploid gametophytes that give rise to gametes directly by mitosis and diploid sporophytes that give rise to spores by meiosis

#### **Multicellular life may have evolved from colonial protists**

- Most multicellular organisms, including seaweeds, slime molds, fungi, plants, and animals, are characterized by differentiation of cells that perform different activities within one organism.
- Multicellularity undoubtedly evolved several times within the kingdom Protista. Some of these kingdoms evolved further into ancestors of the plant, fungus, and animal kingdoms.

- A hypothetical scenario for the evolution of a multicellular plant or animal from an early protist: (a) formation of ancestral colonies, with all the cells the same; (b) specialization and cooperation among different cells within the colony; (c) delimitation of specialized sexual cells from somatic cells.

#### **Multicellular life has diversified over hundreds of millions of years**

- The oldest fossils of multicellular organisms (red algae and invertebrate animals) date back 700 mya. These organisms were red algae and animals resembling corals, jellyfish, and worms. Other kinds of multicellular algae probably existed as well, but their remains are yet to be found in the fossil record.
- A mass extinction occurred between the Precambrian and Paleozoic eras.

- Up until 500 mya to 475 mya, life was aquatic and represented by diverse animals and multicellular algae, along with ancestral protists and prokaryotes.