"I strongly encourage you to never use the word "bore" or "boring". It says a lot about a person. It's hard for me to imagine being "bored", ever. The world is so exciting and fascinating, yes?"
-Bill Nye

Protists

Chapter 28

"Protista" Characteristics

- Eukaryotic organisms that are not plants, animals, or fungi
- Most are unicellular
- Without _____
- First eukaryotes arose ~1.5 bya

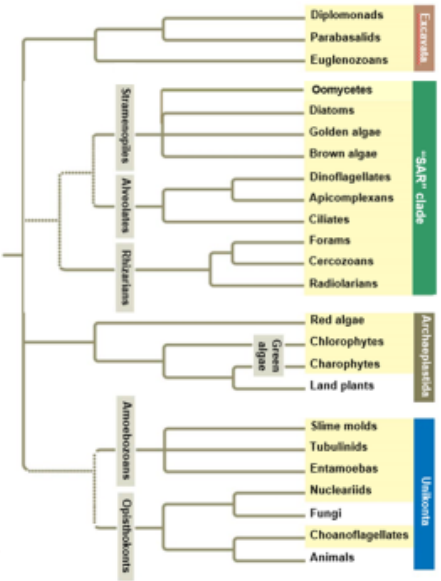
Protists: similar appearing but diverse phyla that are not related through an exclusive common ancestor, which have different life cycles, trophic levels, modes of locomotion and cellular structures.

*Cluster_____ that is under constant debate and revision

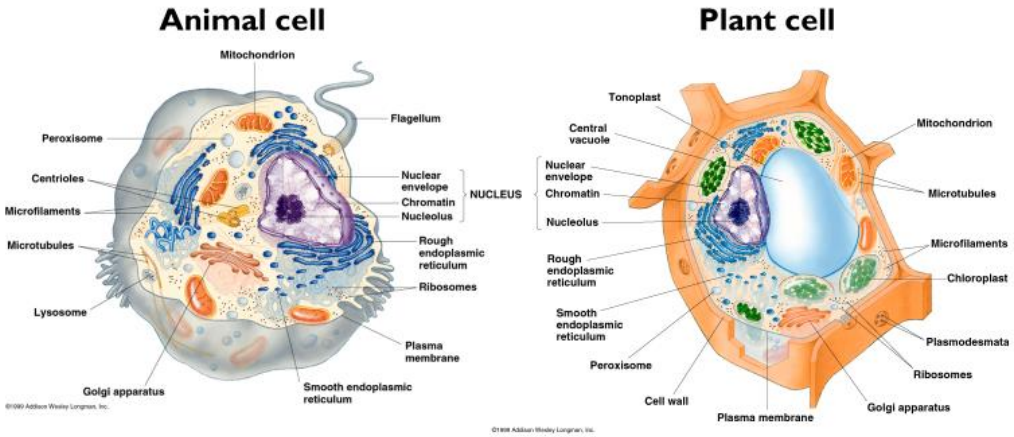
Four Supergroups:

- **Excavata**
- **SAR (Stramenopiles, Alveolata, Rhizaria)**
- **Archaeplastida**
  - Includes land plants
- **Unikonta**
  - Includes animals and fungi

***Need to know entire phylogeny for test and practicum**



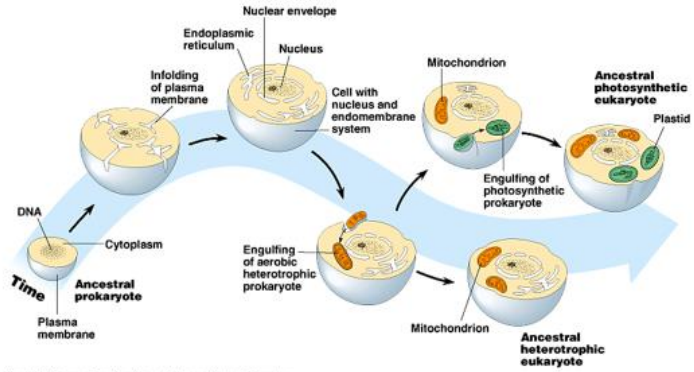
Eukaryotic Cells



Evolution of Eukaryotes

Autogenesis: _____ of prokaryote plasma membranes lead to compartmentalization

- Endoplasmic reticulum
- Golgi
- Nuclear membrane



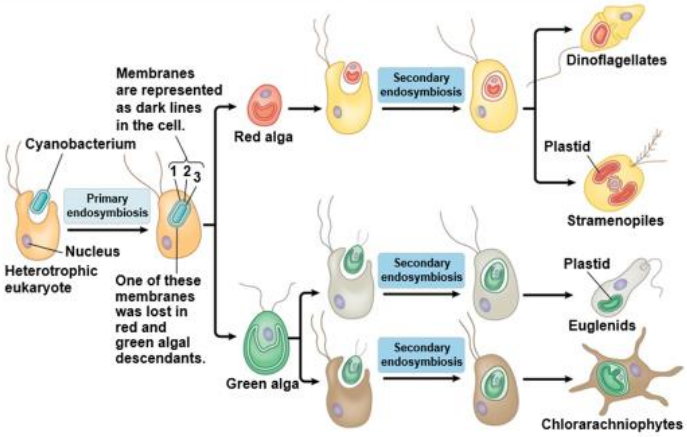
Evolution of Eukaryotes

_____: one organism lives inside the cell or cells of the other organism

- Mitochondria
- Chloroplast

Plastid: double membrane organelle

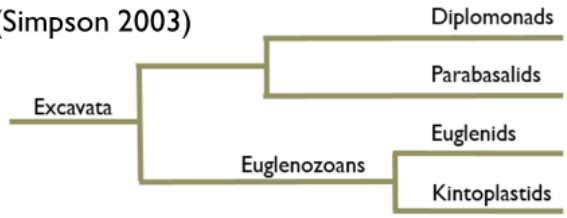
- Ex: Chloroplast



Supergroup: Excavata

Characteristics of Excavata:

- "Excavated" groove on side of cell body (some)
- Free living, symbiotic and parasitic forms
- Reduced or modified _____
- Multiple flagella
- Similar cytoskeleton elements (Simpson 2003)

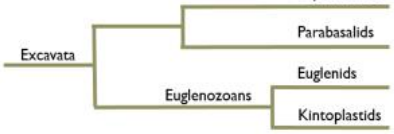


Simpson, A.G.B. 2003. Cytoskeletal organization, phylogenetic affinities and systematics in the contentious taxon Excavata (Eukaryota). International Journal of Systematic and Evolutionary Microbiology. 53, 1759-1777

Supergroup: Excavata
Clade: Diplomonads

Example: *Giardia lamblia*

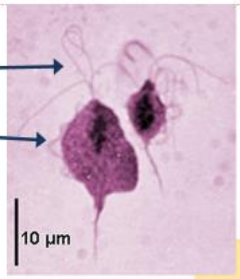
- Two equal sized, haploid nuclei
- Four flagella
- Reduced mitochondria
  - _____
- Internal parasite to vertebrates
- Giardiasis infection from drinking contaminated water

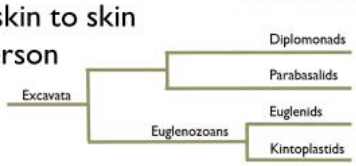


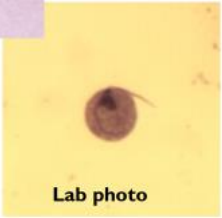
Supergroup: Excavata
Clade: Parabasalids

Example: *Trichomonas vaginalis*

- Multiple flagella
- _____ membrane
- Reduced mitochondria
  - _____
- Sexually transmitted disease
- Vaginitis infection from skin to skin contact with infected person



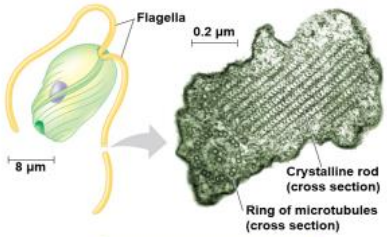


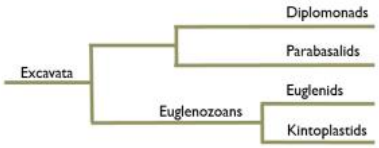


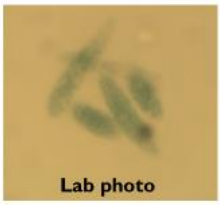
Supergroup: Excavata
Clade$_1$: Euglenazoans; Clade$_2$: Euglenids

Example: *Euglena sp.*

- Crystalline or spiral rod inside of flagella (all Euglenazoans)
- _____: photosynthesize when light is present, heterotrophic when its not
- Flagella emerge from _____



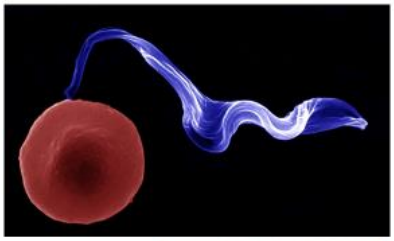


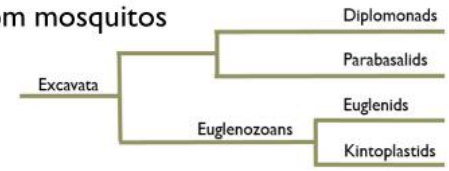


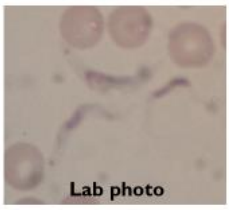
Supergroup: Excavata
Clade$_1$: Euglenazoans; Clade$_2$: Kinetoplastids

Example: *Trypanosoma sp.*

- Crystalline or spiral rod inside of flagella (all Euglenazoans)
- _____: Single, large mitochondrion
- African sleeping sickness from tsetse fly
- Chagas' disease from mosquitos







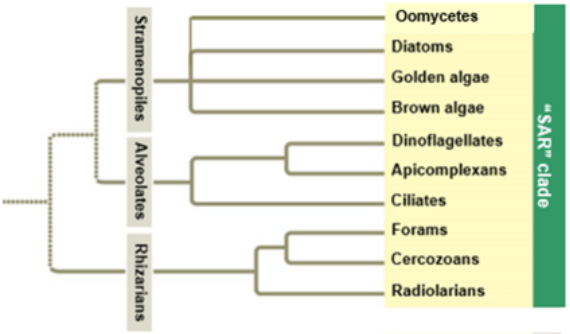
Supergroup: SAR

SAR

- Starmenopila
- Alveolata
- Rizaria

Characteristics of SAR:

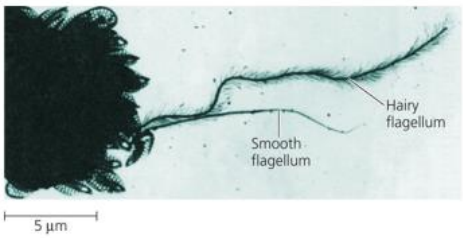
- Secondary endosymbiosis of red algae
- Similar DNA sequences



Supergroup: SAR
Clade$_1$: Stramenopila

Characteristics of Stramenopila:

- One hairy and one smooth _____ (most Stramenopiles)
  - *Stramen* = straw; *pilos* = hair



Includes:

- Oomycetes (water molds)
- Diatoms
- Golden algae (Chyrsophyta)
- Brown algae

Supergroup: SAR
Clade$_1$: Stramenopila; Clade$_2$: Oomycota

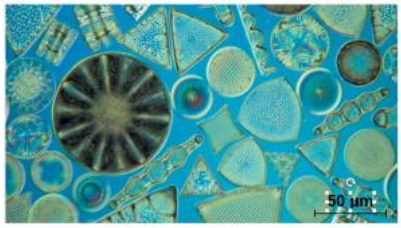
Example:Water molds

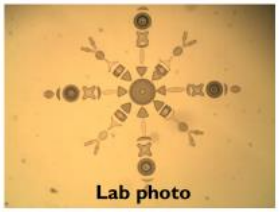
- Cellulose cell wall
- Coenocytic hyphae
- Heterotrophic decomposers
- Some parasitic
- Caused Potato Famine and French Wine Crisis

Supergroup: SAR
Clade$_1$: Stramenopila; Clade$_2$: Diatoms

Example: Diatoms

- Unicellular algae
- Silica cell wall
- Important photosynthetic organisms
- Fossilized diatoms form diatomaceous earth





Supergroup: SAR
Clade$_1$: Stramenopila; Clade$_2$: Chyrsophyta

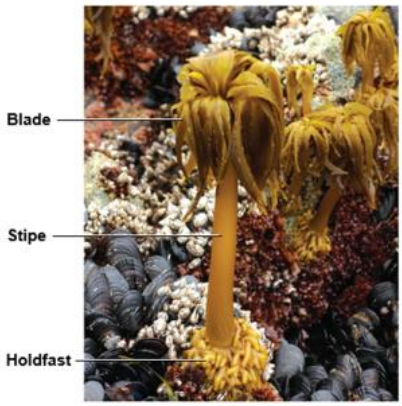
Example: Golden Algae

- Yellow and brown carotenoids
  - **Xanthophyll**
- Bi-flagellated cells
- Many planktonic
- Some are mixotrophic
- Most unicellular, some colonial

Supergroup: SAR
Clade$_1$: Stramenopila; Clade$_2$: Brown Algae

Example: Brown algae

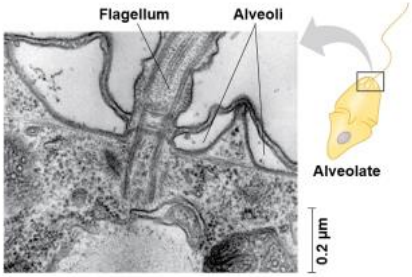
- Multicellular
- Most marine (temperate coasts)
- Brown and yellow carotenoids
  - **Fucoxanthin**
- Algin



Supergroup: SAR
Clade$_1$: Alveolata

Characteristics of Alveolata:

- Membrane bound sacs (alveoli)
- DNA similarities



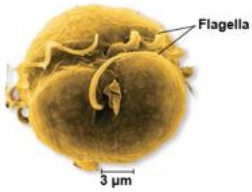
Includes:

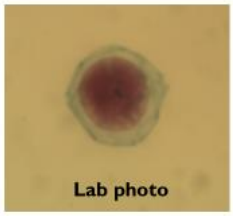
- Dinoflagellates
- Apicomplexans
- Ciliates

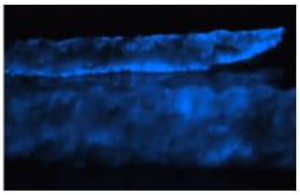
Supergroup: SAR
Clade$_1$: Alveolata; Clade$_2$: Dinoflagellates

Example: Dinoflagellates

- Reinforced cellular plates
- Move via flagella
  - Flagella in grooves
- Cause red tides



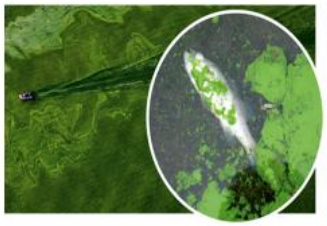


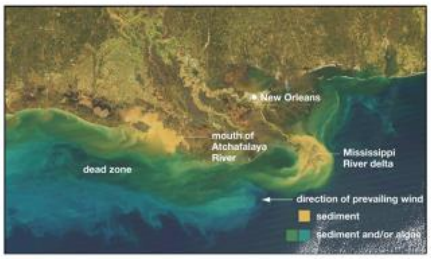


Algal Blooms

_____: excessive richness of nutrients in a body of water, frequently due to runoff from agricultural areas on land

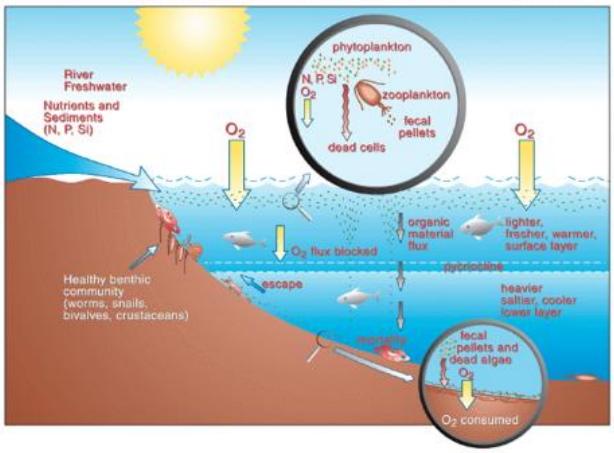
- Can cause algal blooms, which is the dense growth of algae and bacteria that can result in _____ where animals die from lack of oxygen (hypoxia).





What Causes Dead Zones?

1. During the summer months nutrient rich runoff from land enters the oceans resulting in eutrophication
2. Eutrophication along with abundant solar energy leads to massive algal blooms
3. Dead algae sink to the bottom where bacteria aid in decomposition
4. Heterotrophic bacteria deplete oxygen available to other organisms forming a hypoxic environment



Algal Blooms and Bioluminescence

- Bioluminescence in dinoflagellates is produced by a chemical reaction in the organism

$$\text{Luciferin} + O_2 \xrightarrow{\text{Luciferase}} \text{Oxyluciferin} + \text{Light}$$

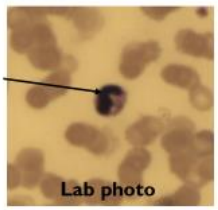
Algal Blooms and Toxins

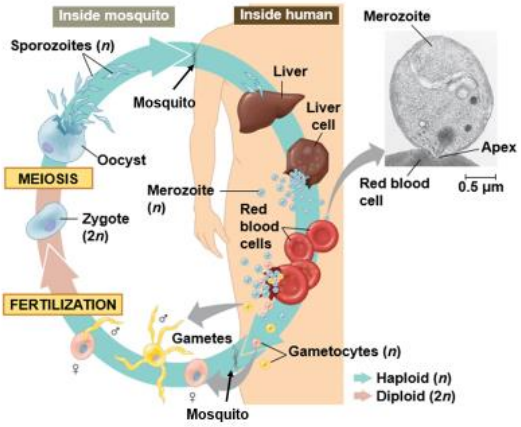
- **Paralytic Shellfish Poisoning** (PSP): caused by saxitonin produced by dinoflagellates
- **Neurotoxic Shellfish Poisoning** (NSP): caused by brevitoxin produced by dinoflagellates
- **Amnesic Shellfish Poisoning** (ASP): caused by domoic acid produced by diatoms

Supergroup: SAR
Clade$_1$: Alveolata; Clade$_2$: Apicomplexans

Example: *Plasmodium sp.*

- Animal parasites
- **Sporozoites:** infectious cells
- _____ structure
- Cause malaria

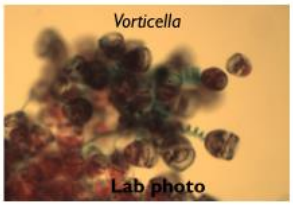




Supergroup: SAR
Clade$_1$: Alveolata; Clade$_2$: Ciliates

Examples: *Paramecium sp., Vorticella sp.*

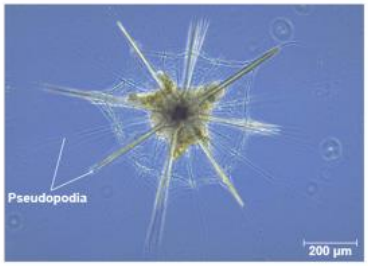
- Most are predatory
- Two types of nuclei
  - **Micronuclei and Macronuclei**
- **Conjugation**: exchange of micronuclei without reproduction
- Binary fission: asexual reproduction
- **Cilia**



Supergroup: SAR
Clade$_1$: Rhizaria

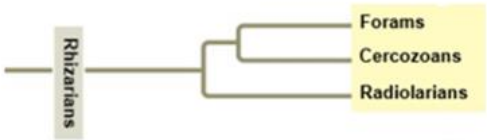
Characteristics of Rhizaria:

- Amoebas
  - Thread-like pseudopodia
- DNA similarities



Includes:

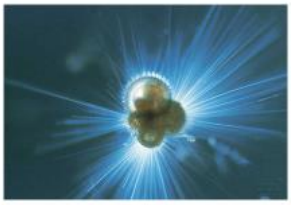
- Foraminiferans
- Cercozoans
- Radiolarians

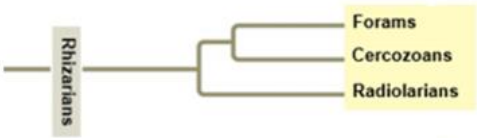


Supergroup: SAR
Clade$_1$: Rhizaria; Clade$_2$: Foraminiferans

Examples: Foraminiferans

- Porous, calcium carbonate tests
  - *Foramen* (little hole), *ferre* (to bear)
- Marine and freshwater
- Fossilized forams = sedimentary rock

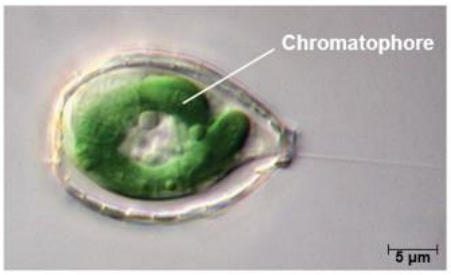


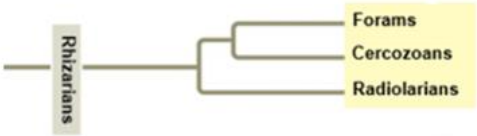


Supergroup: SAR
Clade$_1$: Rhizaria; Clade$_2$: Cercozoans

Examples: Cercozoans

- Thin pseudopodia
- **Chromatophore**: photosynthetic structure
- Marine, freshwater and soil

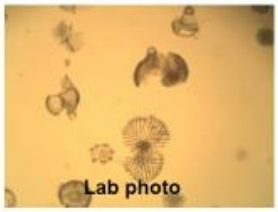


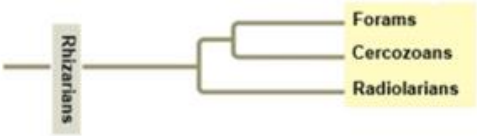


Supergroup: SAR
Clade$_1$: Rhizaria; Clade$_2$: Radiolarians

Examples: Radiolarians

- Silica tests
- Pseudopodia reinforced with microtubules
- Mostly marine
  - _____





Supergroup: Archaeplastida

Characteristics of Archaeplastida:

- Similar DNA sequences
- Endosymbiosis of cyanobacterium

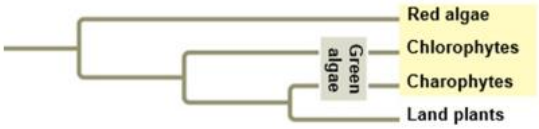
Includes:

- Red algae
- Chlorophytes
- Charophytes
- Land plants

Supergroup: Archaeplastida
Clade$_1$: Red algae

Examples: *Chondrus, Coralline*

- Multicellular
- Cellulose cell wall
- **Phycoerythrin:** photosynthetic pigment
- Mostly marine (warm tropical)
- Agar
- Lack flagellated gametes



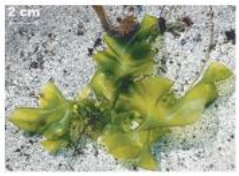
Supergroup: Archaeplastida
Clade$_1$: Chlorophytes

Example: *Ulva, Volvox, Ulothrix*

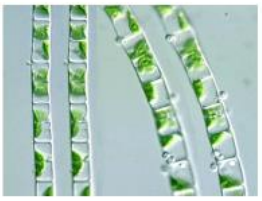
Unicellular, Multicellular, and Colonial

- Cellulose cell wall
- Pigments
  - **Chlorophyll A, B**
  - **Carotenoids**
- Mostly freshwater

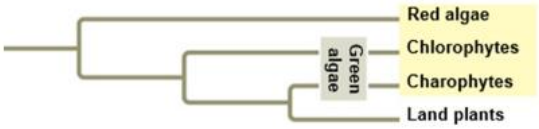
Ulva



Volvox



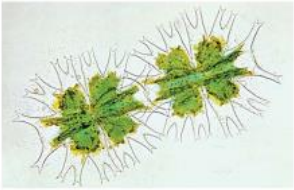
Ulothrix



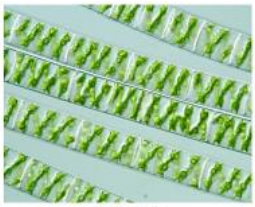
Supergroup: Archaeplastida
Clade$_1$: Charophytes

Sister taxa of land plants

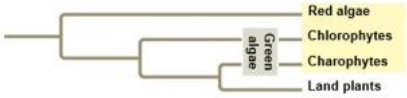
- Rings of cellulose synthesizing proteins
- Peroxisome enzymes
- Structure of flagellated sperm
- Formation of phragmoplast
- Cellulose cell wall
- Pigments
  - **Chlorophyll A, B**
  - **Carotenoids**
- Mostly freshwater



Desmid



Spirogyra

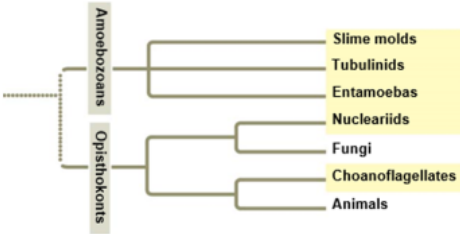


Supergroup: Unikonta

Characteristics of Unikonta:

Two major subgroups (Amoebazoans and Opisthokonts)

- Within group relationships support with DNA sequencing
- May have been first group to diverge from eukaryotes
- Single flagella
- Lobe or tube shaped pseudopodia
- Fusion of three genes



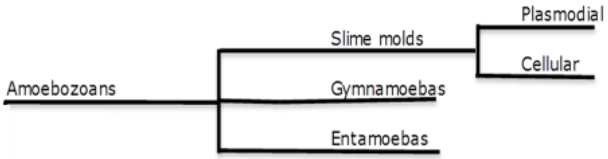
Supergroup: Unikonta
Clade$_1$: Amoebazoans

Characteristics of Amoebazoans:

- Lobe or tube-shaped pseudopod used for movement and feeding

Includes:

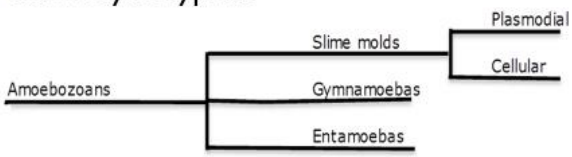
- Slime molds
  - Plasmodial
  - Cellular
- Gymnaoembas
- Entamoebas



Supergroup: Unikonta
Clade$_1$: Amoebazoans; Clade$_2$: Slime molds

Example: Plasmodial slime molds

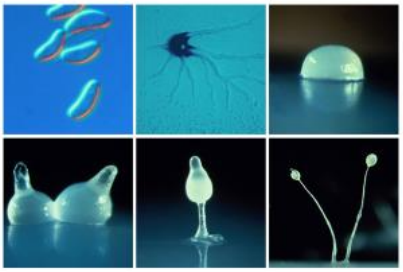
- Many are brightly colored
- **Plasmodium**: Single mass of cytoplasm
  - Supercell
- Single celled with multiple nuclei
- Coenocytic hyphae

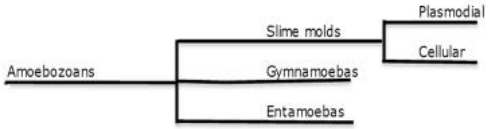


Supergroup: Unikonta
Clade$_1$: Amoebazoans; Clade$_2$: Slime molds

Example: Cellular slime molds

- Solitary feeding stage
- Form asexual fruiting bodies when food stressed
- _____ hyphae

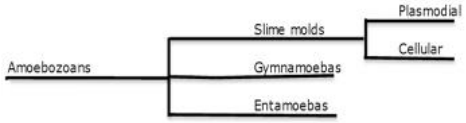




Supergroup: Unikonta
Clade$_1$: Amoebazoans; Clade$_2$: Gymnamoebas

Example: Tubulinids (Gymnamoebas)

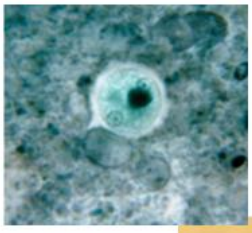
- Lobe or tube-shaped pseudopodia
  - _____ streaming
- Lack of test
- Unicellular
- Mostly heterotrophic
- Marine, freshwater, and soil

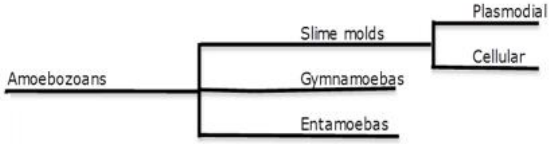


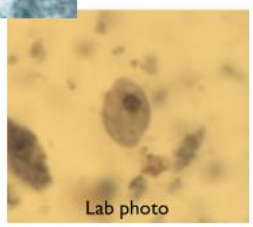
Supergroup: Unikonta
Clade$_1$: Amoebazoans; Clade$_2$: Entamoebas

Example: *Entamoeba histolytica*

- Parasitic
- Amoebic dysentery
  - Contaminated drinking water or food







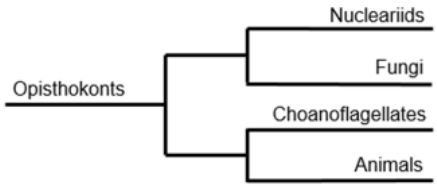
Supergroup: Unikonta
Clade$_1$: Opisthokonts

Characteristics of Opisthokonts:

- Unicellular or multicellular
- Posterior location of flagellum

Includes:

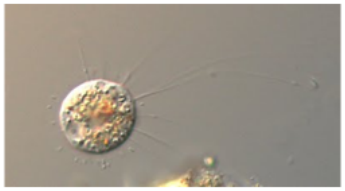
- Nucleariids
- Fungi
- Choanoflagellates
- Animals

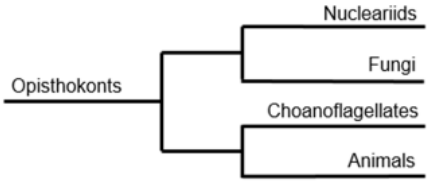


Supergroup: Unikonta
Clade$_1$: Opisthokonts; Clade$_2$: Nucleariids

Example: Nucleariids

- Lack distinctive characteristics
- Unicellular
- Posterior flagella
- Temporary pseudopods
- Feed on algae and bacteria
- Closely related to fungi

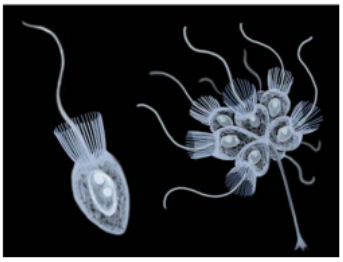


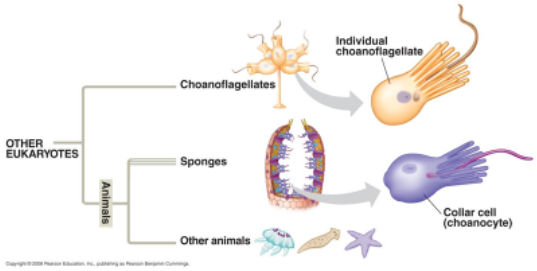


Supergroup: Unikonta
Clade$_1$: Opisthokonts; Clade$_2$: Choanoflagellates

Example: Choanoflagellates

- Unicellular or colonial
- Suspension feeders
- Closest relative to animals





Eukaryote Supergroup	Major Groups	Key Morphological Characteristics	Specific Examples
Excavata	Diplomonads and parabasalids	Modified mitochondria	*Giardia*, *Trichomonas*
	Euglenozoans Kinetoplastids Euglenids	Spiral or crystalline rod inside flagella	*Trypanosoma*, *Euglena*
"SAR" Clade	Stramenopiles Oomycetes Diatoms Golden algae Brown algae	Hairy and smooth flagella	Sargassum, diatoms
	Alveolates Dinoflagellates Apicomplexans Ciliates	Membrane-enclosed sacs (alveoli) beneath plasma membrane	*Plasmodium*, *Paramecium*
	Rhizarians Radiolarians Forams Cercozoans	Amoebas with threadlike pseudopodia	*Forms*
Archaeplastida	Red algae	Phycoerythrin (photosynthetic pigment)	Coralline, Chondrus
	Green algae	Plant-type chloroplasts	Chara, Ulva, Desmids
	Land plants	Dependent embryos, apical meristems	Mosses, ferns, conifers, flowering plants
Unikonta	Amoebozoans Slime molds Gymnamoebas Entamoebas	Amoebas with lobe-shaped or tube-shaped pseudopodia	*Amoeba*, *slime molds*
	Opisthokonts	Highly variable	Choanoflagellates, nucleariids, animals, fungi

Check Your Understanding

True or False: Organisms are classified as protists if they are multicellular organisms that are not plants, animals or fungi.

True or False: Chloroplast and mitochondria are theorized to have arisen through endosymbiosis

Check Your Understanding

Which of the following clades do **not** have a reduced or modified mitochondria?

a. Parabasalids
b. Kintoplastids
c. Cercozoans
d. Diplomonads
e. More than one of the above

Check Your Understanding

Which of the following are **not** one of the characteristics of organisms in the supergroup Unikonta?

a. Fusion of three genes

b. Secondary endosymbiosis of red algae

c. Single flagella

d. Excavated groove

e. More than one of the above