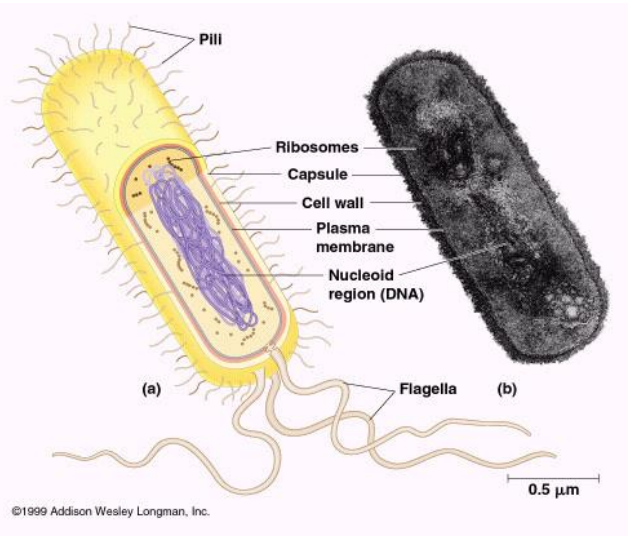
Prokaryotes

1. **General Characteristics and structures** – The prokaryotic Cell contains a single circular chromosome, ribosomes (70S), and a cell wall made up of peptidoglycan. They have no membrane bound organelles.
2. **Natural History** – Prokaryotes appear in the fossil record 3.5 billion years ago as fossilized Stromatolites (a thin layer of rocks that form when certain prokaryotes bind thin films of sediment together). They were the sole inhabitants until about 2.1 billion years ago (for 1.4 billion years).
3. **Biogeography** – They are present in most habitats on the planet, growing in soil, water, acidic hot springs, radioactive waste, and deep in the Earth's crust, as well as in organic matter and the live bodies of plants and animals. They have been found living in the cold and dark in a lake buried a half-mile deep under the ice in Antarctica and in the upper atmosphere.

Era	System & Period	Series & Epoch
CENOZOIC	Quaternary	Recent
		Pleistocene
	Tertiary	Pliocene
		Miocene
		Oligocene
		Eocene
		Paleocene
MESOZOIC	Cretaceous	
	Jurassic	
	Triassic	
PALEOZOIC	Permian	
	Carboniferous	Pennsylvanian
		Mississippian
	Devonian	
	Silurian	
	Ordovician	
	Cambrian	
	Precambrian	

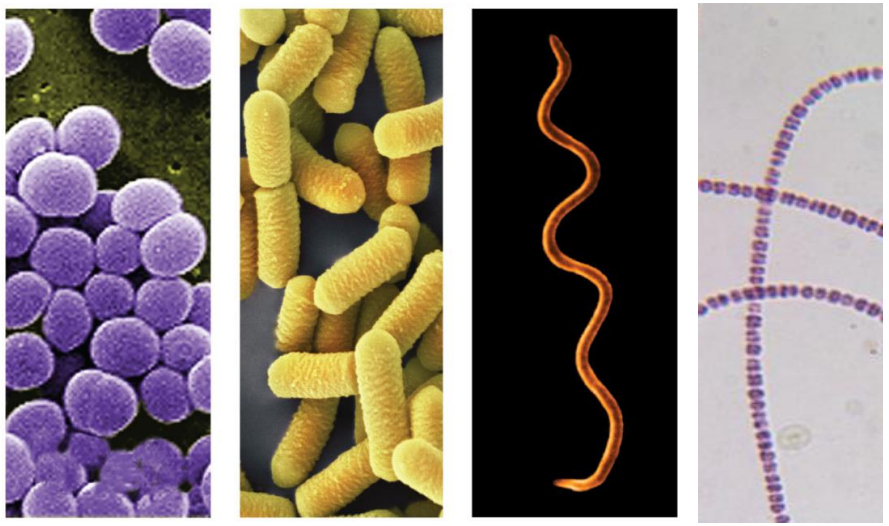


Prokaryotes – General Characteristics

Morphology

Most prokaryotes are unicellular but have a variety of shapes.

1. **Cocci** - Round or Spherical in shape.
2. **Bacilli** - Rod-shaped.
3. **Helical** – Spiral-shaped.
4. **Filamentous** – Cells that continue to elongate instead of dividing.



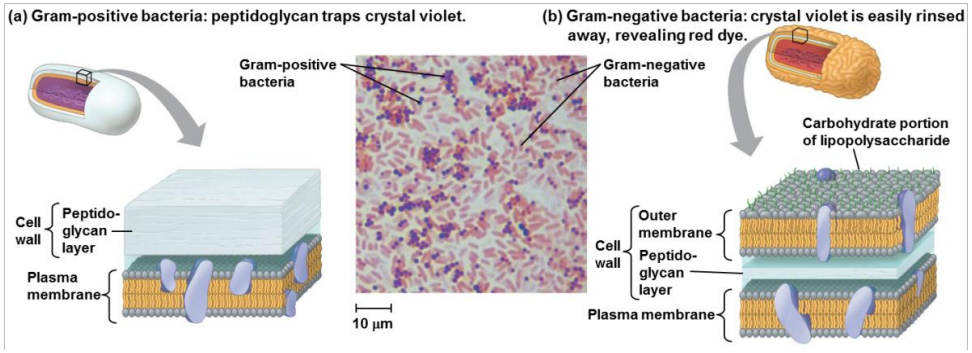
Prokaryotes – General Characteristics

Cell-Surface Structure

A key feature of nearly all prokaryotes is the cell wall. The cell wall contains peptidoglycan (a polymer of sugars cross-linked by short polypeptides). Using a technique called the Gram stain, bacterial species can be separated into two groups based on the differences in cell wall composition. Gram staining is a technique used to identify bacteria.

The procedure is as follows:

1. *Application of crystal violet*
2. *Application of iodine*
3. *Alcohol wash*
4. *Application of safranin*



1. **Gram-positive – Violet in Color**

   A simple structure with a large amount of peptidoglycan that retains the violet color in the cytoplasm.

2. **Gram-negative – Red in Color**

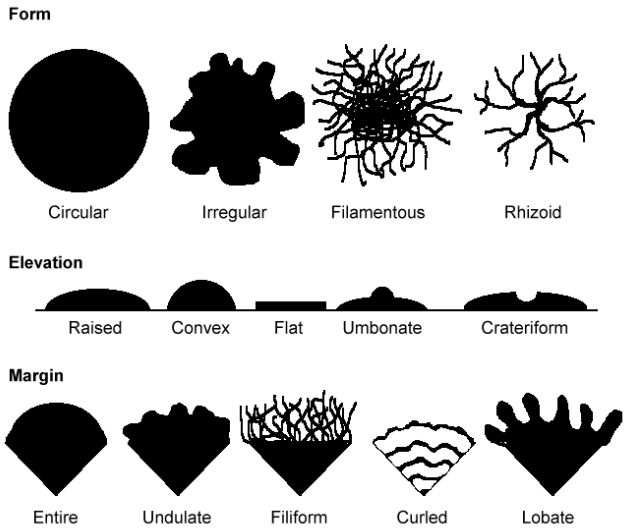
   A small amount of peptidoglycan sandwiched in between two membranes. The violet dye easily washes away to expose the red dye.

Prokaryotes – General Characteristics

Bacterial Colonies

A bacterial colony grows from a single bacterium and is composed of millions of cells. Each colony has a characteristic size, shape, consistency, texture, and color, all of which may be useful in preliminary species identification. At this station you have examples of different bacterial colonies.

Be able to identify the Petri dishes only as bacterial colonies and realize that their shapes, margins, and surface characteristics (as illustrated on the left) are used as a tool.

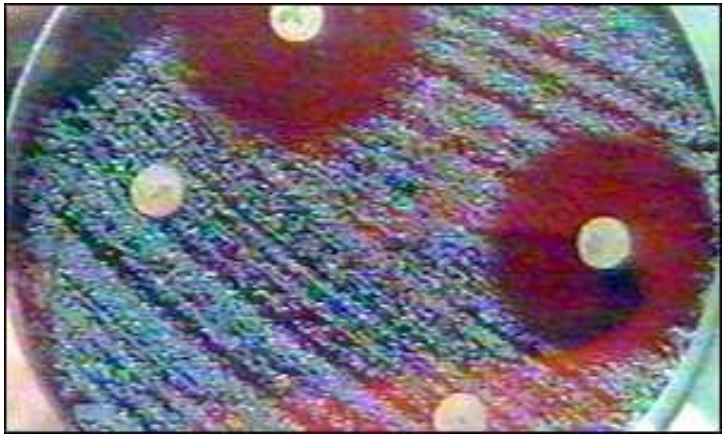


Prokaryotes – General Characteristics

Bacteria and Antibiotics

It is comparatively easy to find or develop drugs that are effective against prokaryotic cells and that do not affect eukaryotic cells. These two types of cells differ in the presence or absence of cell walls, their ribosome structure, and details of their metabolism.

Differences between different bacterial cells allow certain antibiotics to work on certain bacteria and not on others. Therefore it is impossible to have one antibiotic fight all bacterial diseases.



Spectrum of Microbial Activity (Range)

Narrow Spectrum – works on either gram negative or gram-positive bacteria
(ex. Penicillin – gram positive)

Broad Spectrum – works on **both** gram negative and gram positive bacteria
(ex. Tetracycline)

Prokaryotes – General Characteristics

Bacteria Pigments

Some bacteria can be identified by their colorful pigments. Pigments are used for several reasons:

Photosynthesis: certain pigments are used to collect light energy and convert it into sugars for the bacteria

Protection: certain pigments are used to protect the bacteria from the damage of Ultraviolet light

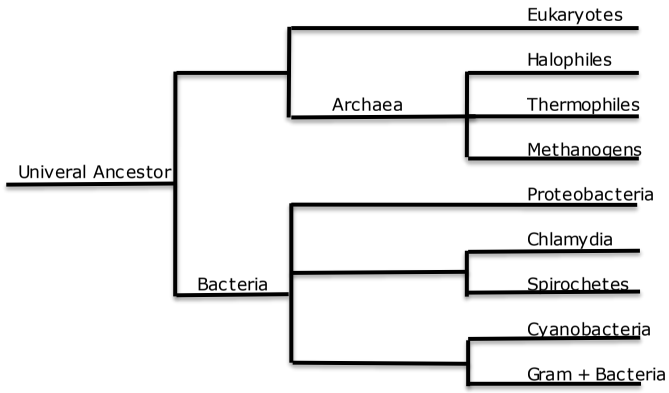
Be able to recognize the pigmented bacteria at this station.

Prokaryotes – General Characteristics

Luminescent Bacteria

Microbial luminescence (or light emission) is found in deep sea environments and in soils. These organisms have an enzyme called luciferase that releases light during cellular respiration (the making of ATP). These type of bacteria are being used in industry to: detect the progression of plant infections, antibiotics in milk, toxic pollutants, and bacteria in food.

Prokaryotes – Classification



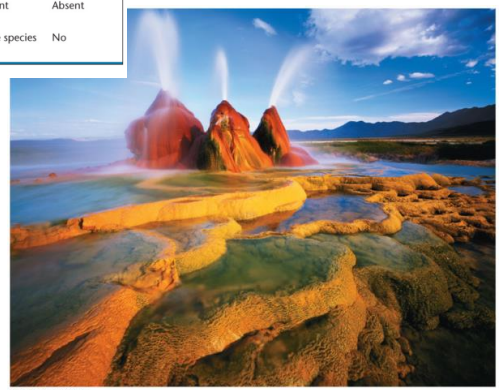
The kingdom Monera (in the five kingdom system) contained all the prokaryotes. This taxonomic grouping was polyphyletic and was based only on cellular structure and not on any molecular evidence. Using molecular biology (small subunit ribosomal RNA), Carl Woese suggested that some prokaryotes are more closely related to eukaryotes. He suggested that even though they are all made up of prokaryotic cells, one group of bacteria replicated their DNA and made proteins more like Eukaryotes and should be separated into a separate Domain.

The Domain Bacteria includes the vast majority of prokaryotic species which include five major groups: 1) the Proteobacteria, 2) the Chlamydias, 3) the Spirochetes, 4) the Cyanobacteria, and 5) the Gram-positive Bacteria.

The Domain Archaea can is being worked out but the first Archaea were called extremophiles due to the extreme conditions they were found in. These include two types: 1) the halophiles, and 2) the thermophiles. A third group has been identified and they are found in more moderate environment release methane and are called 3) methanogens.

Table 27.2 A Comparison of the Three Domains of Life

CHARACTERISTIC	DOMAIN		
	Bacteria	Archaea	Eukarya
Nuclear envelope	Absent	Absent	Present
Membrane-enclosed organelles	Absent	Absent	Present
Peptidoglycan in cell wall	Present	Absent	Absent
Membrane lipids	Unbranched hydrocarbons	Some branched hydrocarbons	Unbranched hydrocarbons
RNA polymerase	One kind	Several kinds	Several kinds
Initiator amino acid for protein synthesis	Formyl-methionine	Methionine	Methionine
Introns in genes	Very rare	Present in some genes	Present in many genes
Response to the antibiotics streptomycin and chloramphenicol	Growth inhibited	Growth not inhibited	Growth not inhibited
Histones associated with DNA	Absent	Present in some species	Present
Circular chromosome	Present	Present	Absent
Growth at temp-eratures > 100°C	No	Some species	No

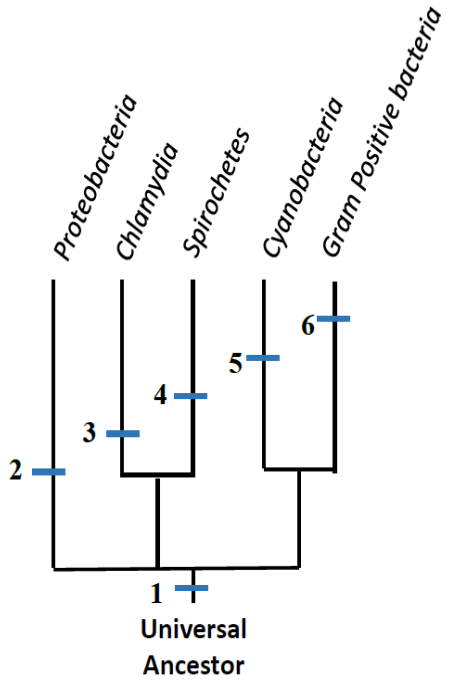


Domain Bacteria – Classification

Classification Systems

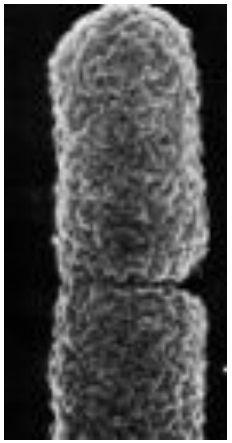
The Scientists interested in the evolution of microorganisms are more interested in taxonomic techniques that allow for the comparison of highly conserved genes among different species. In the 1980's. researchers began using PCR (polymerase chain reaction) to analyze bacterial genes. As a result of these comparisons, a phylogenetic tree can be developed that displays the degree of relatedness of different organisms. Making relationships difficult is the ability of prokaryotes to do horizontal gene transfers that make up an average of 75% of a bacteria's genome.

The classification of bacteria serves a variety of different functions. Because of this variety, bacteria may be grouped using many different typing schemes. The critical feature for all these classification systems is an organism identified by one individual (scientist, clinician, epidemiologist), is recognized as the same organism by another individual. At present the typing schemes used by clinicians and clinical microbiologists rely on phenotypic typing schemes. These schemes utilize the bacterial morphology and staining properties of the organism, as well as O2 growth requirements of the species and nutrition requirements combined with a variety of biochemical tests. For clinicians, the environmental reservoir of the organism, the vectors and means of transmission of the pathogen are also of great importance.



Classification Characteristics: 1) Gram negative. 2) DNA Sequence. 3) Lack Peptidoglycan. 4) Axial filaments in flagella. 5) Photosynthetic. 6) Gram Positive.

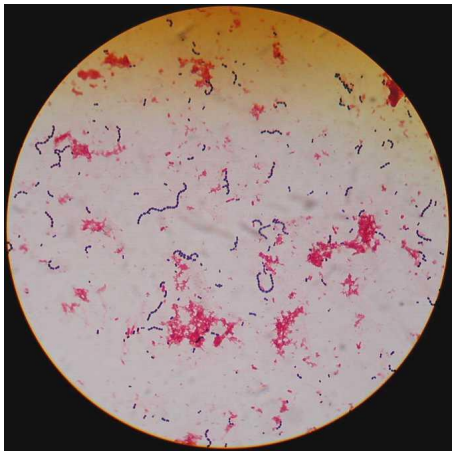
Domain: Bacteria
Group: Proteobacteria



The group proteobacteria is the most diverse group of bacteria. It is broken down into three main subgroups depending on their major nutritional modes and the source of their energy. The groups are:

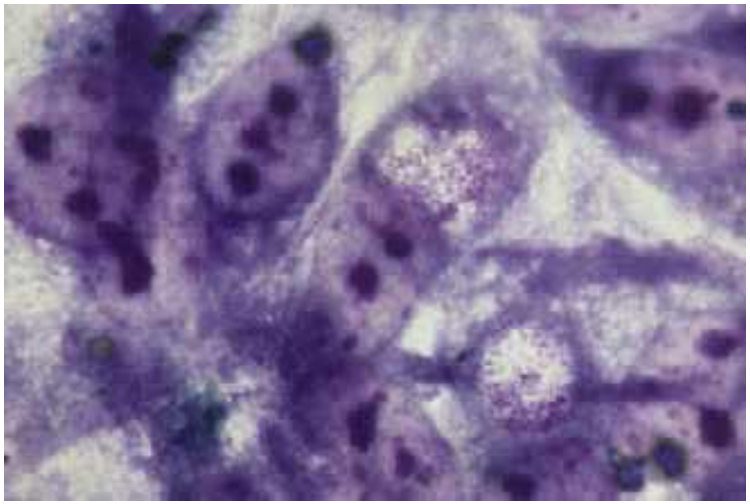
1. Photoautotrophic (use light and CO_2)
2. Photoheterotrophic (use light and organic molecules)
3. Chemoautotrophic (use inorganic molecules and CO_2)
4. Chemoheterotrophic (use organic molecules for both)

The example for this group is *Escherichia coli* (*E. coli*). *E. coli* is a rod-shaped, gram negative, facultative anaerobe. This is one of the most prolific microorganisms in the human intestinal tract. *E. coli* is normally harmless but certain strains are pathogenic. Some of these have specialized fimbrae (fingers) that allow them to bind to the intestinal wall. These produce toxins that cause diarrhea and, in a few cases, death. Several outbreaks in the United States have been linked to raw milk or undercooked hamburger.



Domain: Bacteria
Group: Chlamydia

This group of cocci bacteria are obligate intracellular parasites of animals that obtain all their ATP from host cells. They are transmitted to humans by interpersonal contact or by airborne respiratory routes. When using gram stain on this organism, you will get a gram negative result. This is due to their unusual cell wall which lacks peptidoglycan.

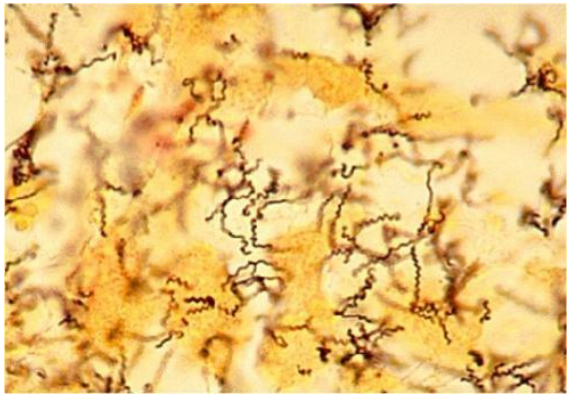


There is no lab example for this group because of their small size (can't be seen with our microscopes) but you should know about the following species.

Chlamydia trachomatis is the most common cause of blindness in the world and is the most common sexually transmitted infection.

Domain: Bacteria
Group: Spirochetes

The spirochetes are helical chemoheterotrophs. They have a unique morphology and mechanism of motility. They are typically slender, long and helical in shape. They contain fibrils (axial filaments) that are attached to the cell poles and wrapped throughout the body. (In a sense, they are bacterial flagella in a protoplasmic sheath). They are found in aquatic environments and in the bodies of animals. Some of them may cause disease.



The example for this group is *Treponema pallidum*. This is the organism that causes syphilis. This organism is frail and cannot survive drying or chilling. Since it dies within a few seconds on being exposed to air (essentially anaerobic), it must be transmitted by sexual intercourse, kissing, or other intimate body contact. It requires warm, moist skin or mucous membrane surfaces to penetrate the body.

Syphilis occurs in four stages

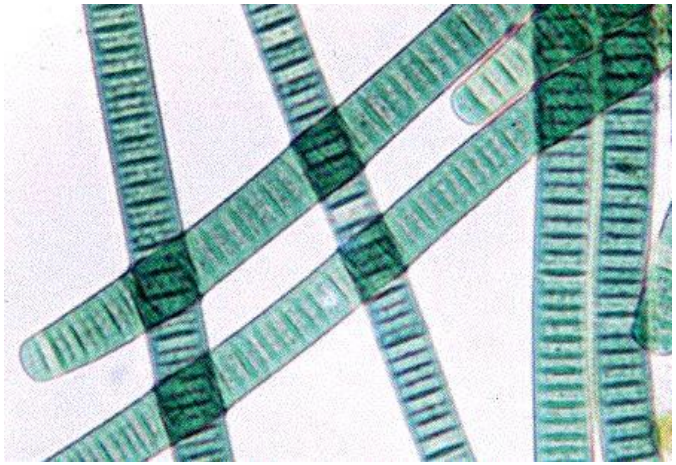
- Primary stage (top photo) is a pink to red, raised painless sore called a chancre which disappears in 3-6 weeks.
- Secondary stage (bottom photo) occurs 1-6 months after the chancre disappears. It is a rash that doesn't itch.
- Latent stage lasts for a few months to a lifetime. There are no external symptoms.
- Tertiary stage is characterized by permanent damage to vital organs and death.

Domain: Bacteria
Group: Cyanobacteria

The cyanobacteria are aerobic, photoautotrophic bacteria. They were once called blue-green algae but they are made up of prokaryotic cells and are not a true algae. They have unicellular, colonial and filamentous forms. They contain the pigment phycocyanin which give them their blue-green color.

They are unique on this planet because they are the only organisms known to both release oxygen **and** fix nitrogen. They mostly inhabit fresh water, but they are also found in marine environments and some symbiotic relationships.

The example for cyanobacteria is *Oscillatoria*. *Oscillatoria* is a filamentous form that is found in large numbers in fresh water. They can be a problem in areas where there is chemical pollution in the form of synthetic detergents. The detergents contain phosphates that allow the cyanobacteria to multiply rapidly and whey they die, it causes decomposing bacteria to bloom, which in turn removes all the oxygen from the water and results in the death of other organisms (fish, insects, etc.).

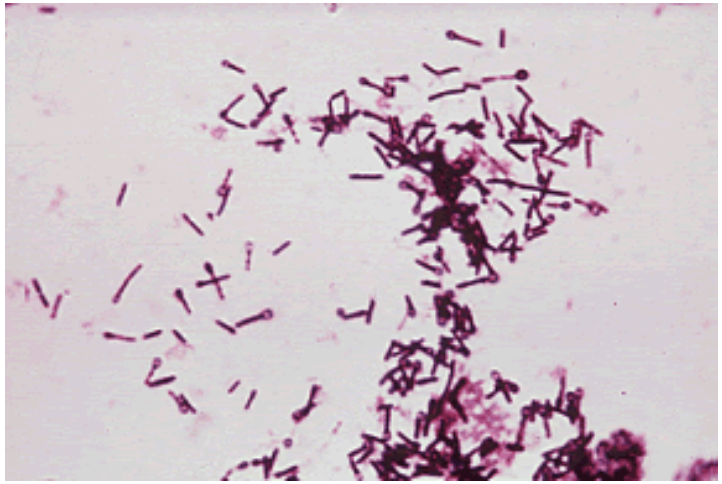


Domain: Bacteria
Group: Gram Positive Bacteria

Most of the bacteria in this group are gram positive. There are a few gram negative members but are grouped in this taxa due to molecular systematics. Some are photosynthetic, but most species are chemoheterotrophs.

The example for this group is *Clostridium tetani*. This is an obligate anaerobe , endospore-forming gram –positive rod.

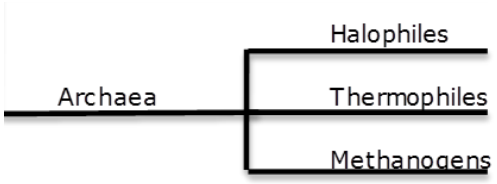
The endospores make the bacteria resistant to harsh conditions. (Notice the round ends on some of the rod-shaped individuals). It is common in soil contaminated with animal fecal wastes. The species releases an exotoxin (neurotoxin) that blocks the relaxation pathway of the muscles and causes them to contract. The muscles in the jaw are affected early and the condition is often known as lockjaw. An amount of the neurotoxin weighing as much as the ink in a period of this page can kill 30 people.



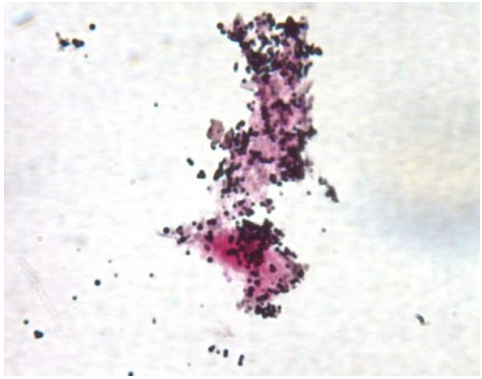
Domain: Archaea

Group: Methanogens (methane releasing)
Group: Halophiles (lives in high salt areas)
Group: Thermophiles (lives in extreme temperatures)

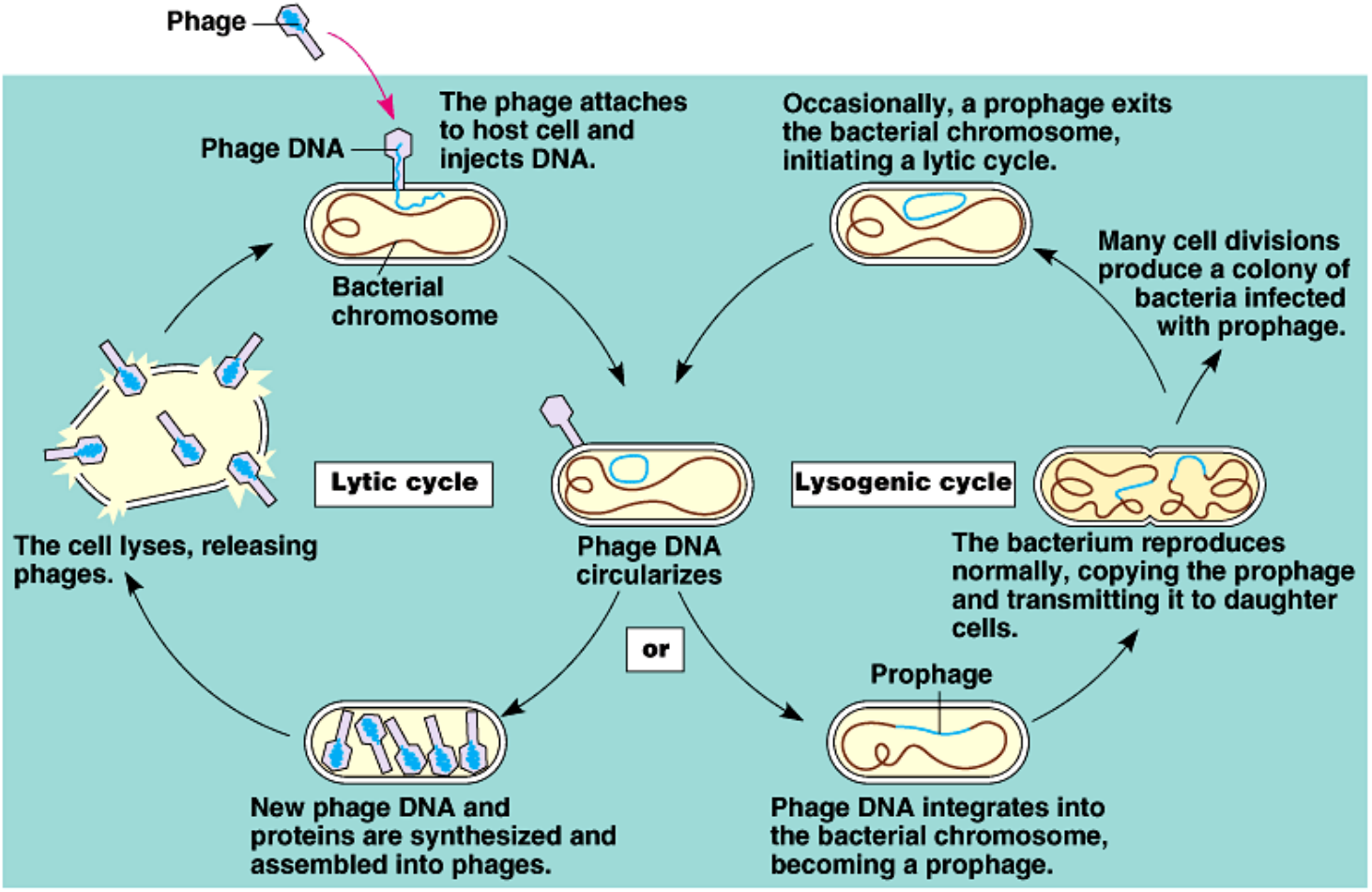
This domain is made up of prokaryotic cells but are quite different than the true bacteria. They do share some characteristics with the eukaryotes and are thought to be more closely related to the eukaryotes than the bacteria of today. The shared characteristics with eukaryotes include:



DNA introns present
RNA polymerase
Start Amino Acid for protein synthesis
Response to antibiotics



Viruses



Viruses

Viruses are made up of genomes (DNA or RNA) enclosed in a protective coat called a capsid (protein). The tiniest viruses are only 20 nm in diameter (smaller than a ribosome).

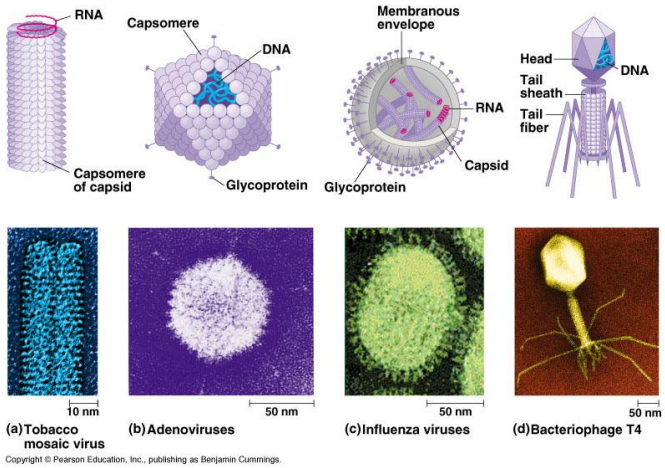


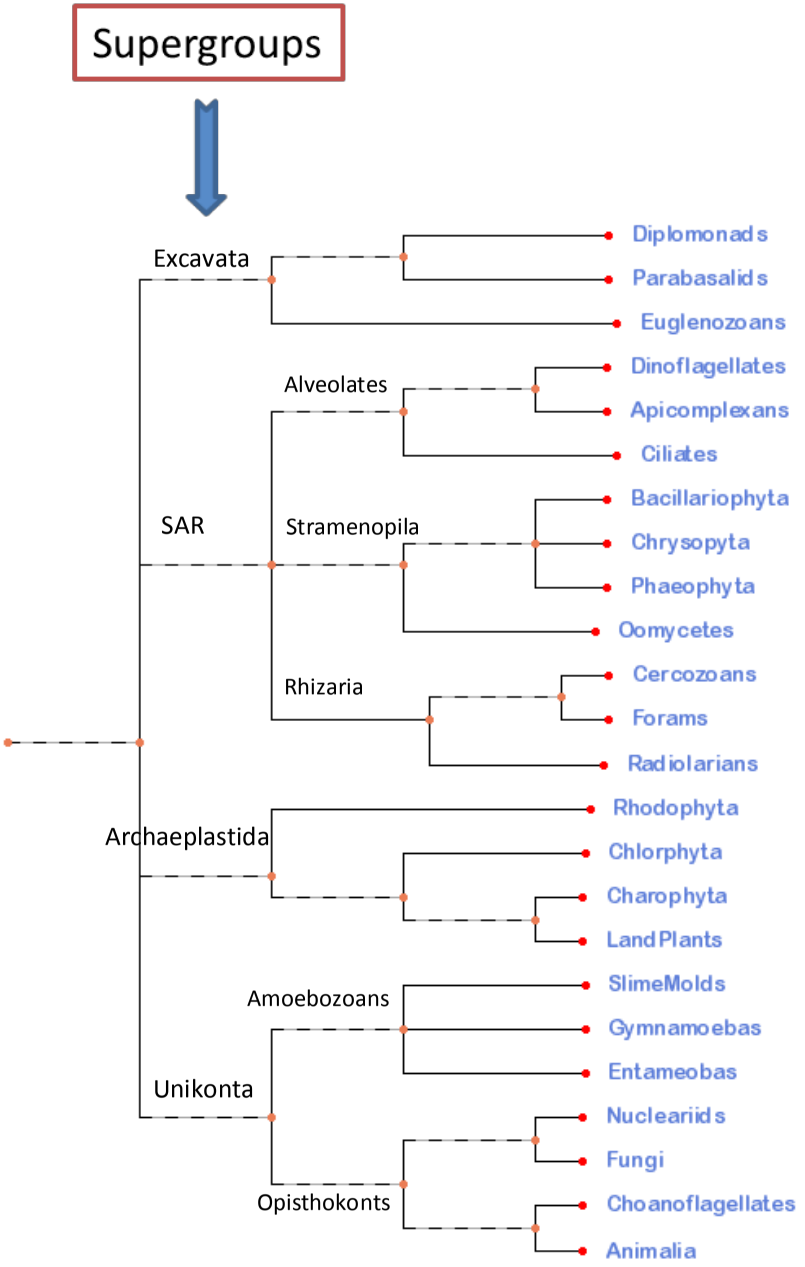
Table 18.1 Classes of Animal Viruses, Grouped by Type of Nucleic Acid

Class*	Examples/Diseases
I. dsDNA**	
Papovavirus	Papilloma (human warts, cervical cancer); polyoma (tumors in certain animals)
Adenovirus	Respiratory diseases; some cause tumors in certain animals
Herpesvirus	Herpes simplex I (cold sores), herpes simplex II (genital sores); varicella zoster (chicken pox, shingles); Epstein-Barr virus (mononucleosis, Burkitt's lymphoma)
Poxvirus	Smallpox; vaccinia, cowpox
II. ssDNA	
Parvovirus	Roseola; most parvoviruses depend on co-infection with adenoviruses for growth
III. dsRNA	
Reovirus	Diarrhea; mild respiratory diseases
IV. ssRNA that can serve as mRNA	
Picornavirus	Poliovirus; rhinovirus (common cold); enteric (intestinal) viruses
Togavirus	Rubella virus; yellow fever virus; encephalitis viruses
V. ssRNA that is a template for mRNA	
Rhabdovirus	Rabies
Paramyxovirus	Measles; mumps
Orthomyxovirus	Influenza viruses
VI. ssRNA that is a template for DNA synthesis	
Retrovirus	RNA tumor viruses (e.g., leukemia viruses); HIV (AIDS virus)

*The subclasses within each class differ mainly in capsid structure and in the presence or absence of a membranous envelope.
**ds = double-stranded; ss = single-stranded.

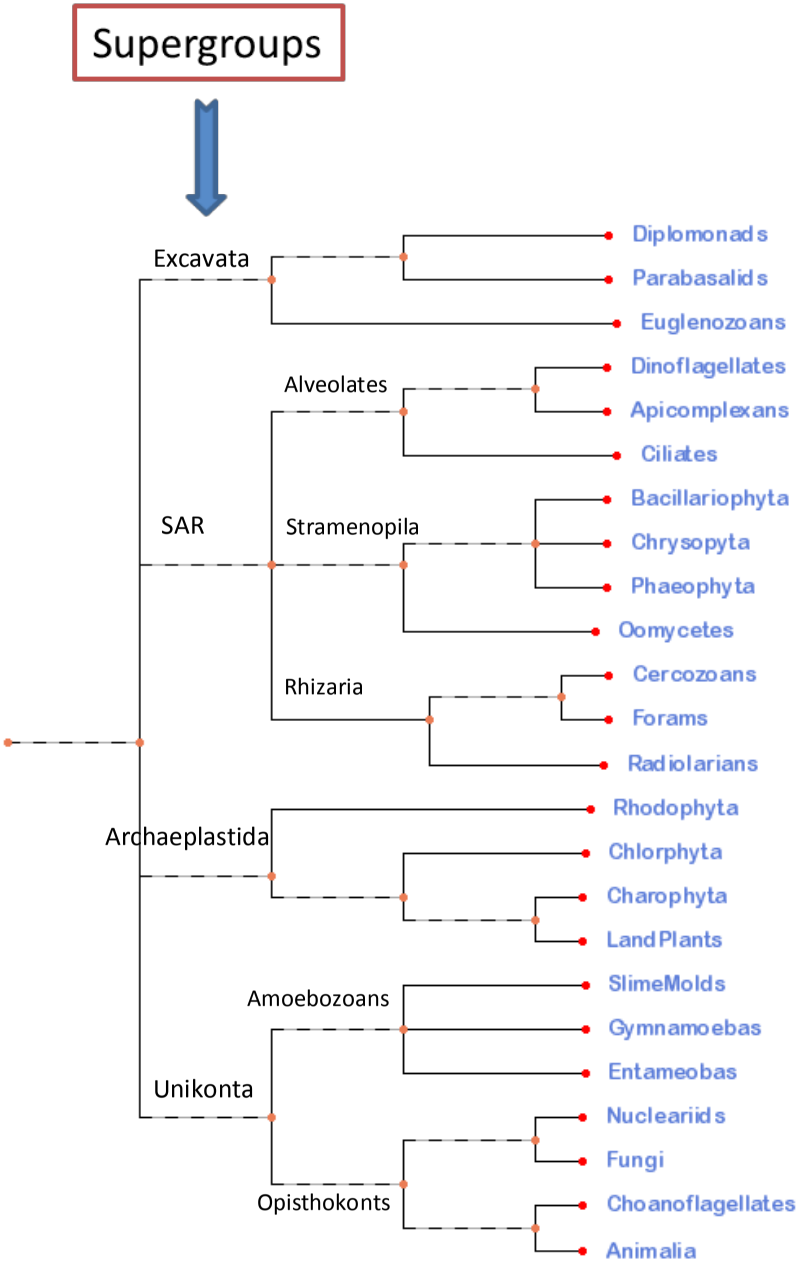
Protista Classification

The kingdom Protista (in the five kingdom system) contains mostly unicellular eukaryotes. This taxonomic grouping is polyphyletic and based only on cellular structure and life styles not on any molecular evidence. Using molecular biology and detailed comparison of cell structure, scientists are now beginning to see evolutionary history in the protists. The ongoing changes in the protest phylogeny are rapidly changing with each new piece of evidence. The following classification suggests 4 "supergroups" within the original Protista kingdom and the taxonomy is still being worked out. This lab is looking at one current hypothesis shown on the right. Some of the organisms are grouped together because of very strong support and others are controversial. It is important to focus on the characteristics of each clade which explains why they are grouped together. This lab will only look at the groups that were once included in the Protista kingdom and the other groups (higher plants, fungi, and animals) will be examined in future labs.



Protista Classification

Starting with the four "Supergroups", we will divide the rest into different levels called clades. A Clade is defined as a group of biological taxa (as species) that includes all descendants of one common ancestor. Too simplify this process, we have included a cladogram we will be using throughout the course. We will divide or expand parts of the cladogram to emphasize evolutionary relationships. For the protists, we will divide the supergroups into smaller clades assigning them artificial numbers (clade1, clade2, clade3) to establish a grouping at a specific level.



CLASSIFICATION:

Domain: Eukarya

Supergroup: Excavata
- Clade$_2$: Diplomonads
- Clade$_2$: Parabasalids
- Clade$_2$: Euglenozoans
  - Clade$_3$: Euglenids
  - Clade$_3$: Kinetoplastids

Supergroup: SAR
- Clade1: Alveolates
  - Clade$_2$: Dinoflagellates
  - Clade$_2$: Apicomplexans
  - Clade$_2$: Ciliates
- Clade1: Stramenopila
  - Clade$_2$: Bacillariophyta
  - Clade$_2$: Chrysophyta
  - Clade$_2$: Phaeophyta
  - Clade$_2$: Oomycetes
- Clade 1: Rhizaria
  - Clade$_2$: Cercozoans
  - Clade$_2$: Forams
  - Clade$_2$: Radiolarians

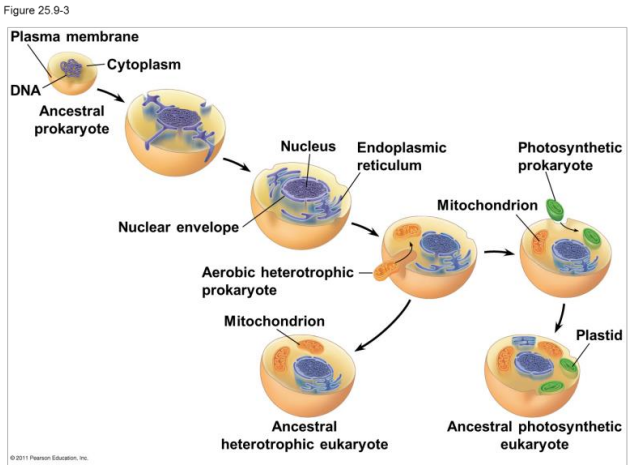
Supergroup: Archaeplastida
- Clade$_2$: Rhodophyta
- Clade$_2$: Chlorophyta
- Clade$_2$: Charophyta

Supergroup: Unikonta
- Clade$_1$: Amoebozoans
  - Clade$_2$: Slime Molds
    - Clade$_3$: Plasmodial
    - Clade$_3$: Cellular
  - Clade$_2$: Gymnamoebas
  - Clade$_2$: Entamoebas
- Clade$_1$: Opisthokonts
  - Clade$_2$: Nucleariids
  - Clade$_2$: Choanoflagellates

Protista Classification

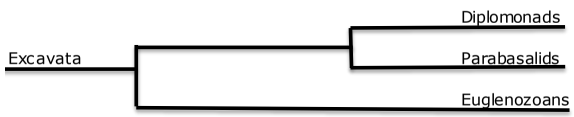
1. **General Characteristics and structures** – These organisms once were placed in a single kingdom but with new genetic information, it now appears this kingdom is polyphyletic. The individuals included in this new clade are all eukaryotes (with a nucleus and membrane-bound organelles) and most are single-celled.
2. **Natural History** – The first protist (eukaryotic) organism appears in the fossil record about 2.1 billion years ago during the Precambrian. It is believed the first protist was probably a non-pigmented heterotrophic form. It is believed that mitochondria and plastids were small prokaryotes that lived within other prokaryotes giving rise to new organelles. The serial endosymbiosis hypothesis suggests that mitochondria evolved before plastids through a series of endosymbiotic events.
3. **Biogeography** – The distribution of protists is worldwide; as a group, these organisms are both cosmopolitan and ubiquitous. Every individual species, however, has preferred niches and microhabitats, and all protists are to some degree sensitive to changes in their surroundings. The availability of sufficient nutrients and water, as well as sunlight for photosynthetic forms, is, however, the only major factors restraining successful and heavy protist colonization of practically any habitat on Earth.

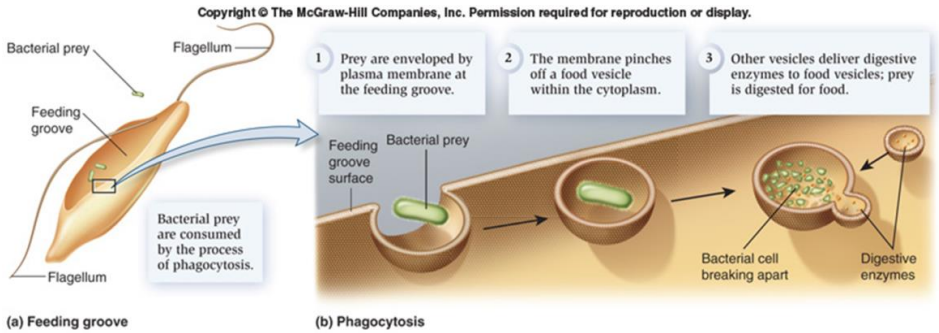
Era	System & Period	Series & Epoch
CENOZOIC	Quaternary	Recent
		Pleistocene
	Tertiary	Pliocene
		Miocene
		Oligocene
		Eocene
		Paleocene
MESOZOIC	Cretaceous	
	Jurassic	
	Triassic	
PALEOZOIC	Permian	
	Carboniferous	Pennsylvanian
		Mississippian
	Devonian	
	Silurian	
	Ordovician	
	Cambrian	
	Precambrian	



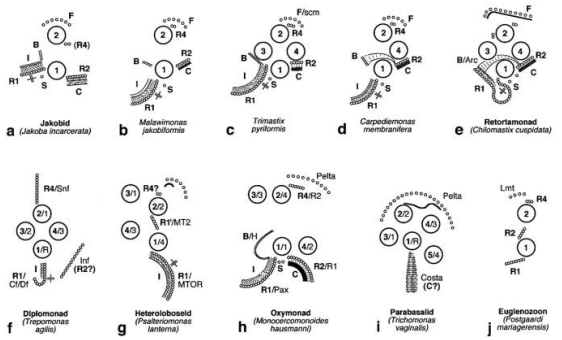
Supergroup: Excavata

1. **General Characteristics and structures** – The members of this supergroup have similar cytoskeletal features and some members have an "excavated" groove on one side of their body.
2. **Natural History** – Each of the clades within the supergroup are monophyletic, but it is difficult to determine if this supergroup is monophyletic because the characteristics they have may have been found in the common ancestor of all eukaryotes.
3. **Biogeography** – The Excavata includes taxa that are photosynthetic, parasitic, symbiotic and heterotrophic. The three clades are the Diplomanads, the Parabasalids and the Euglenozoans.



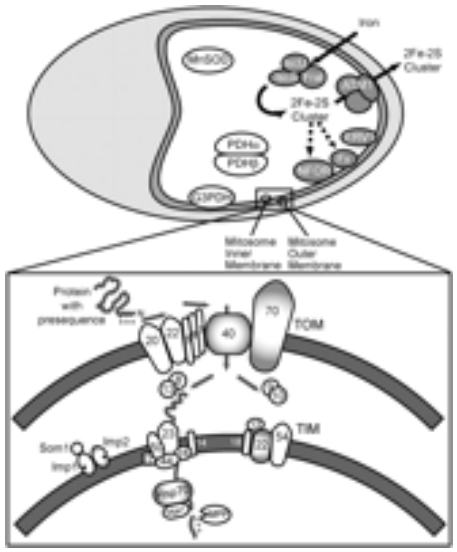


Era	System & Period	Series & Epoch
CENOZOIC	Quaternary	Recent
		Pleistocene
	Tertiary	Pliocene
		Miocene
		Oligocene
		Eocene
		Paleocene
MESOZOIC	Cretaceous	
	Jurassic	
	Triassic	
PALEOZOIC	Permian	
	Carboniferous	Pennsylvanian
		Mississippian
	Devonian	
	Silurian	
	Ordovician	
	Cambrian	
	Precambrian	

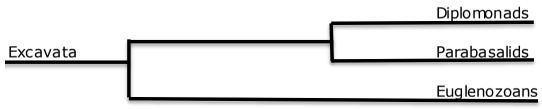


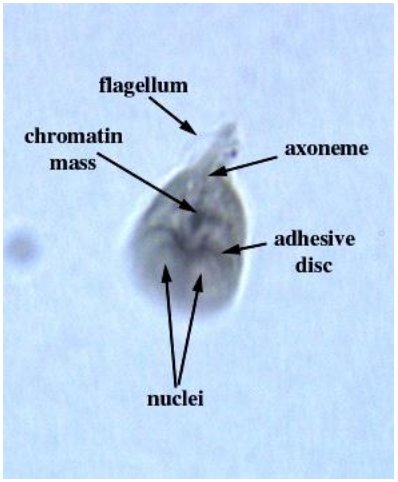
Diagrammatic representations of the proximal cytoskeletons of Excavata

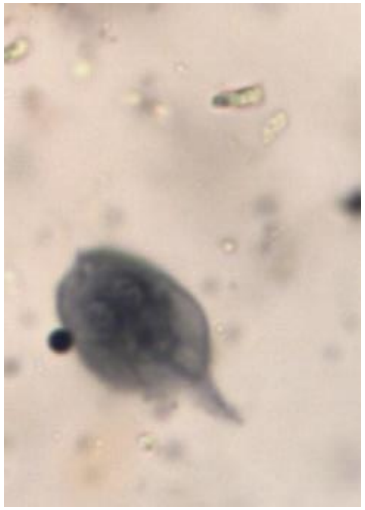
Supergroup: Excavata
Clade$_2$: Diplomonads



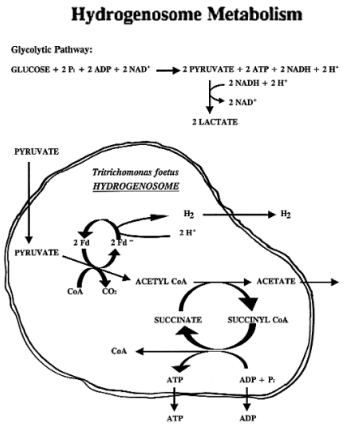
1. **General Characteristics and structures** – The members of this clade have modified mitochondria called mitosomes. They lack functional electron transport chains and cannot use oxygen to make ATP. They are anaerobic. They also have two equally sized haploid nuclei.
2. **Biogeography –** Many Diplomonads are parasitic. Our Example is *Giardia lamblia* which parasitize the intestines of mammals. In California, It can be found in the highest streams in the Sierras.
3. **Unique Characteristics** - It can infect people when they drink contaminated water. It can cause cramps and severe diarrhea.



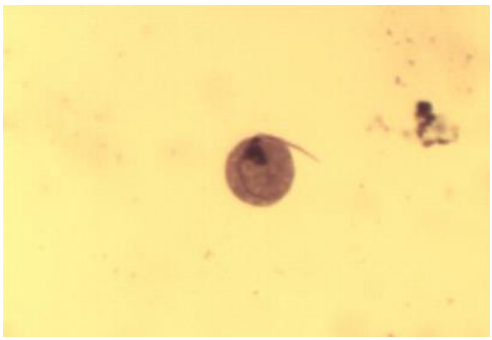




Supergroup: Excavata
Clade$_2$: Parabasalids



1. **General Characteristics and structures** – The members of this clade have reduced mitochondria called hygrogenosomes. They are anaerobic and release hydrogen peroxide as a by-product. They also have a modified flagella with an undulating membrane.
2. **Biogeography –** Many parabasalids are parasitic. Our Example is *Trichomonas vaginalis*.
3. **Unique Characteristics:** It causes Vaginitis by infecting the vagina and urethral mucus membranes and can be transmitted by sexual intercourse. Males often have no symptoms when infected.

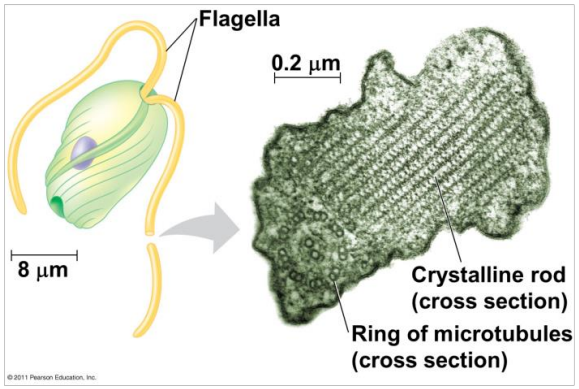


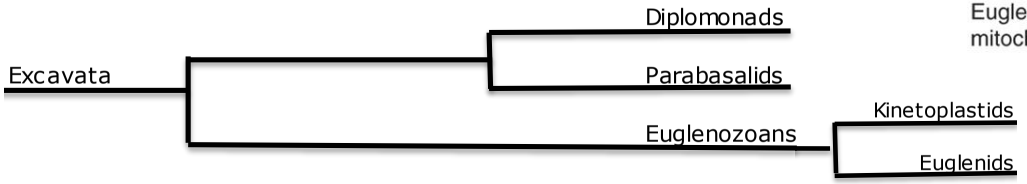
Supergroup: Excavata

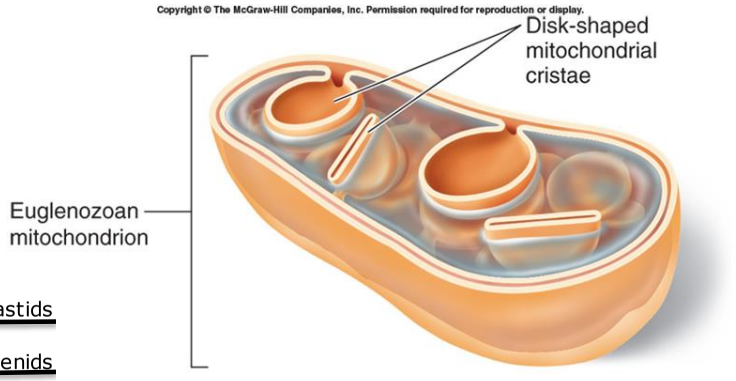
Clade$_2$: Euglenozoans

1. **General Characteristics and structures** – The members of this clade all have a rod with either a spiral or a crystalline structure inside each of their flagella. They also have a disc-shaped cristae.
2. **Biogeography** – The members of this clade are very diverse including predators, heterotrophs, photosynthetic autotrophs and parasites. The two best known groups are in the clades: Kinetoplastids and Euglenids.

Figure 28.5

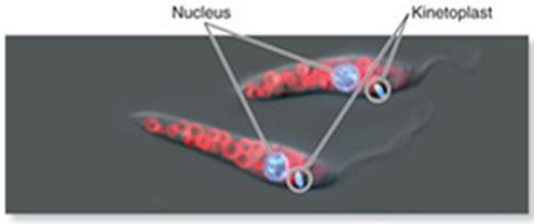




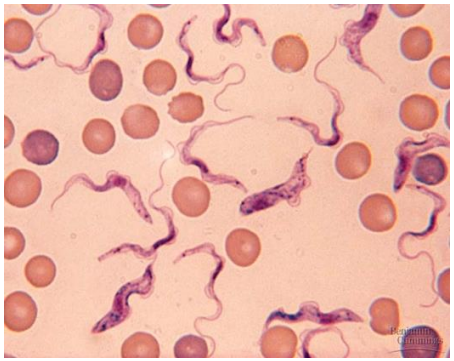


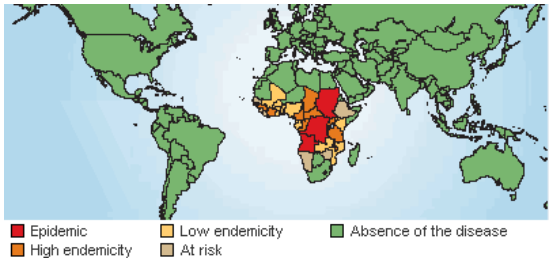
Supergroup: Excavata
Clade$_2$: Euglenozoans
Clade$_3$: Kinetoplastids

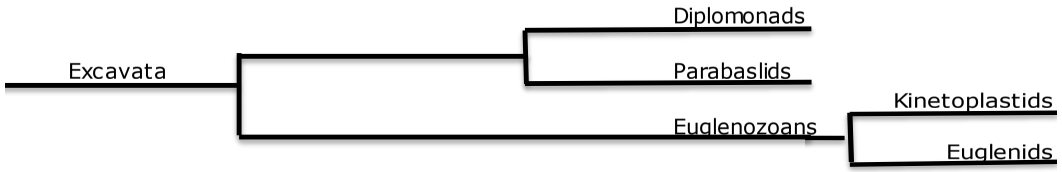
1. **General Characteristics and structures** – The members of this clade have a single, large mitochondrion that contains a large mass of DNA called a kinetoplast.
2. **Biogeography –** The members of this clade include species that feed on prokaryotes in freshwater, marine and most terrestrial habitats. There are also species that parasitize animals, plants, and other protists.
3. **Unique Characteristics:** Our example is a *Trypanosoma* which is a human pathogen that causes African Sleeping Sickness in Africa spread by the TseTse Fly and Chagas Disease in South America spread by the Kissing Bug.



(b) *Leishmania*

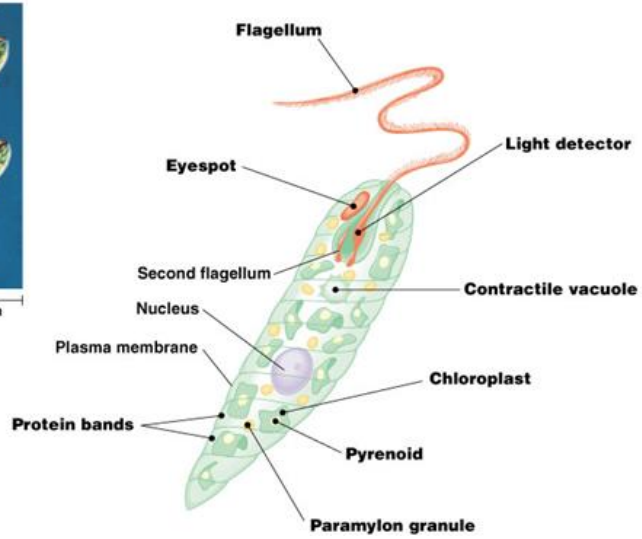


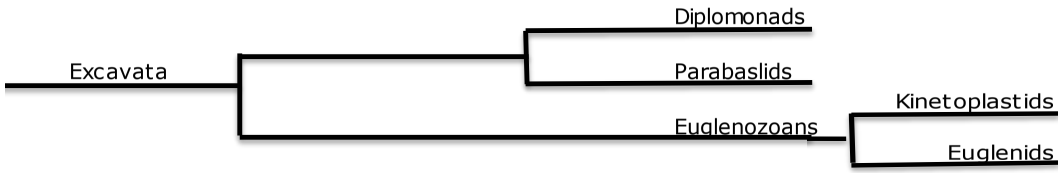




Supergroup: Excavata
Clade$_2$: Euglenozoans
Clade$_3$: Euglenids

1. **General Characteristics and structures** – The members of this clade have an anterior pocket with one or two flagella emerging from the pocket.
2. **Biogeography –** They are commonly found in freshwater especially when it is rich in organic materials, with a few marine and endosymbiotic members.
3. **Unique Characteristics -** Many members of this clade are called mixotrophs because they are autotrophic in sunlight but when unavailable, they can become heterotrophic.

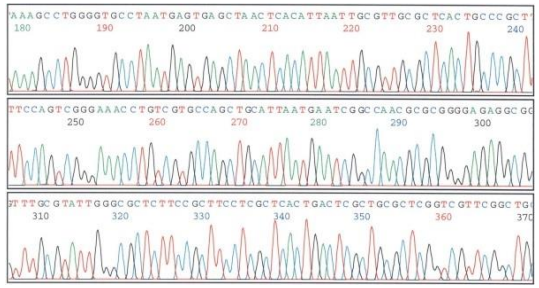


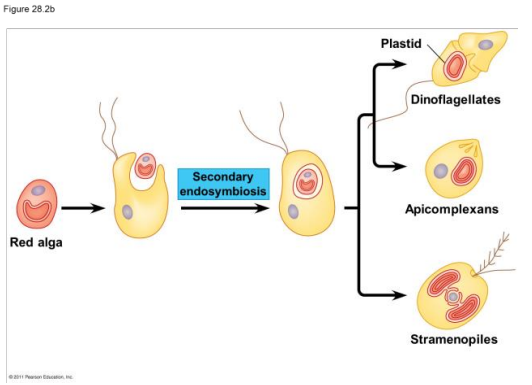


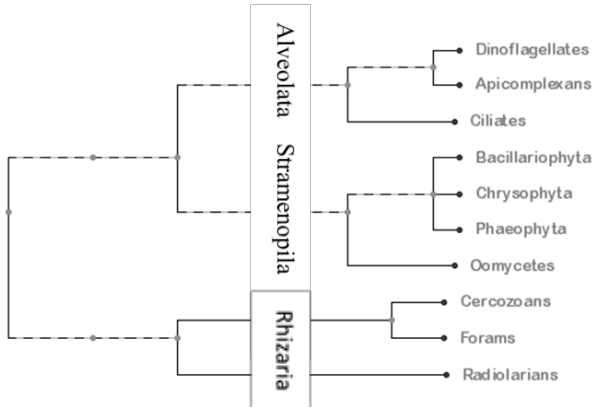
Supergroup: SAR

1. **General Characteristics and structures** – The members of this supergroup are grouped together based on two pieces of evidence: 1) DNA Sequence Data and 2) the secondary endosymbiotic relationship with a red algae
2. **Natural History** – Evidence suggests this supergroup evolved over a billion years ago with the incorporation of plastids from a red algae although some lack plastids and it is believed these were lost later in their evolutionary history.
3. **Biogeography** – The SAR include taxa that are very diverse including some of the most important photosynthetic organisms on Earth. It also includes organisms that make up our large kelp forests and some important pathogens. This supergroup can be divided into three clades: the Alveolates, the Stramenopiles, and the Rhizaria.

Era	System & Period	Series & Epoch
CENOZOIC	Quaternary	Recent
		Pleistocene
	Tertiary	Pliocene
		Miocene
		Oligocene
		Eocene
		Paleocene
MESOZOIC	Cretaceous	
	Jurassic	
	Triassic	
PALEOZOIC	Permian	
	Carboniferous	Pennsylvanian
		Mississippian
	Devonian	
	Silurian	
	Ordovician	
	Cambrian	
	Precambrian	

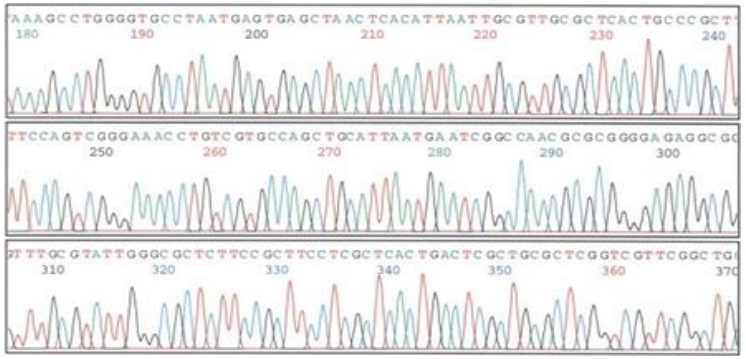


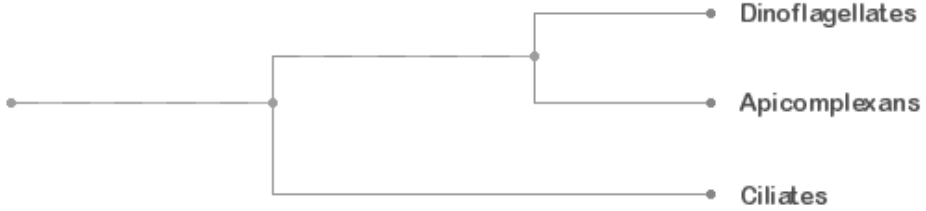


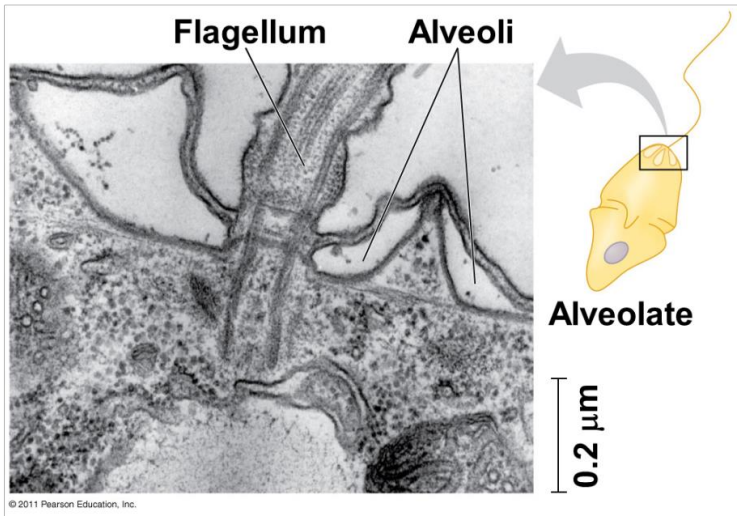


Supergroup: SAR
Clade$_1$: Alveolates

1. **General Characteristics and structures** – The monophyletic grouping for this clade is well supported by DNA similarities. The members of this clade also include species with membrane-bound sacs (alveoli) just under the plasma membrane.
2. **Biogeography –** The Alveolates include three different clades: 1) the Dinoflagellates, 2) the Apicomplexans, and 3) the Ciliates.

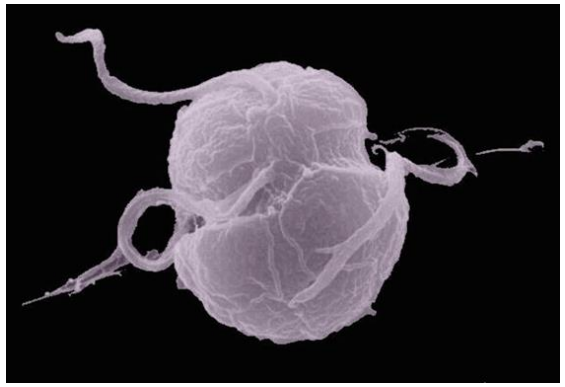


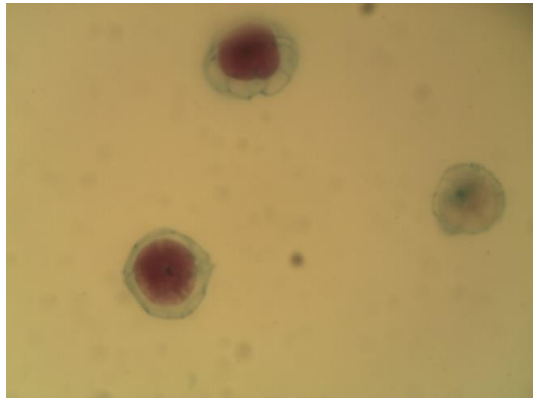


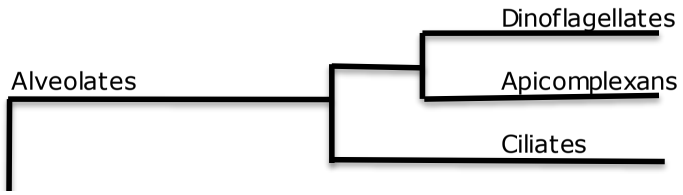


Supergroup: SAR
Clade$_1$: Alveolates
Clade$_2$: Dinoflagellates

1. **General Characteristics and structures** – This clade is identified by the reinforced cellular plates with two flagella, one apical and one in a groove within the plates.
2. **Biogeography –** The dinoflagellates are abundant in both marine and freshwater plankton.
3. **Unique Characteristics –** In California, these organisms are responsible for Red Tides. These organisms release a neurotoxin that can be magnified in filter feeding shellfish and can cause respiratory distress or even death. Many of the species are mixotrophs.

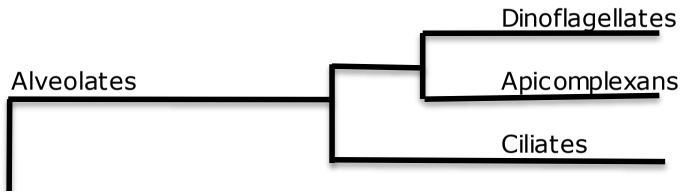


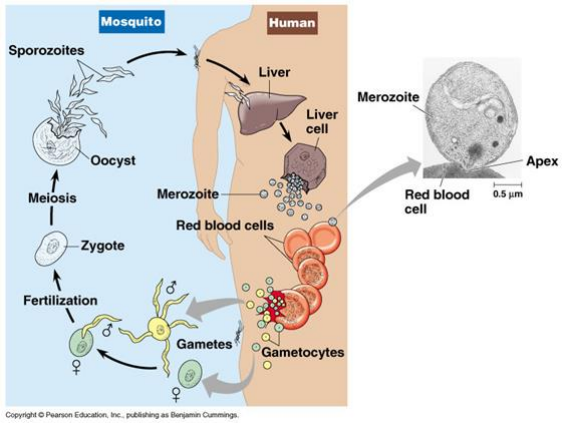


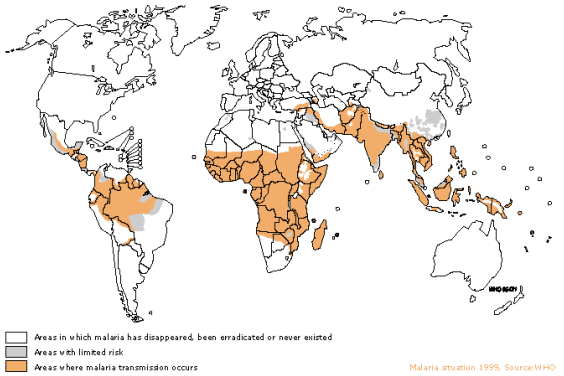


Supergroup: SAR
Clade1: Alveolates
Clade$_2$: Apicomplexans

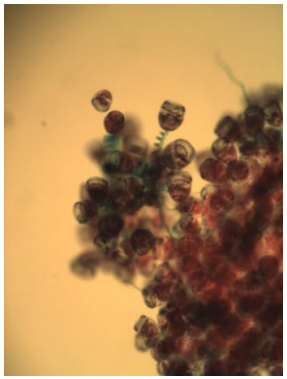
1. **General Characteristics and structures** – This clade is identified by the apical structure of the sporozoite. This apical complex is used to penetrate their host.
2. **Biogeography –** The Apicomplexans are all internal parasites of animals. The pathogenic species are now mainly confined to Africa, Asia and Latin America in tropical and subtropical areas where the Anopheles mosquito can breed.
3. **Unique Characteristics** – One of the best know species is *Plasmodium sp.* which causes Malaria. The host species of this disease is the *Anopheles* mosquito. It attacks a human's red blood cells.



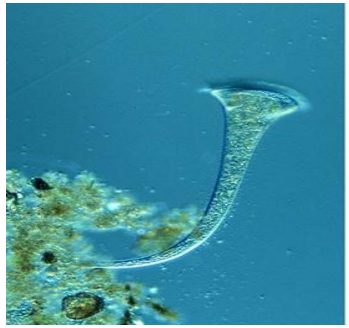
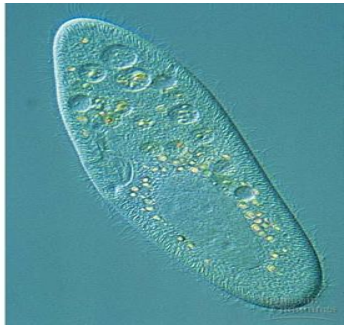




Supergroup: SAR
Clade1: Alveolates
Clade$_2$: Ciliates

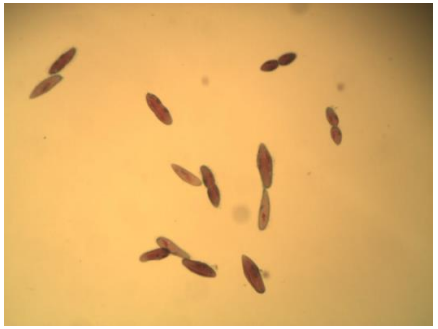
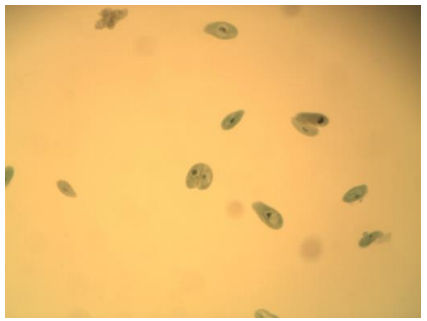



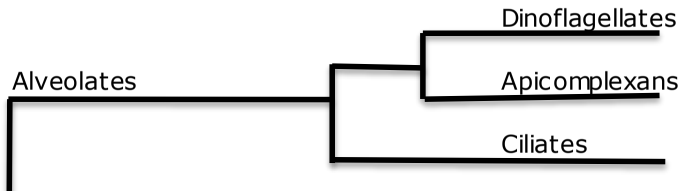
1. **General Characteristics and structures** – This clade is identified by cilia which is used for movement or feeding. They also have two distinct nuclei, a macro and a micronuclei.
2. **Biogeography –** The Ciliates are a diverse group that is common almost everywhere there is water — in lakes, ponds, oceans, rivers, and soils. Ciliates have many ectosymbiotic and endosymbiotic members, as well as some obligate and opportunistic parasites.
3. **Unique Characteristics –** The macronuclei control the functions of the cell and the micronuclei are exchanged during conjugation (sexual reproduction) where the organisms are side by side. They reproduce asexually through transverse binary fission (end to end).

Asexual

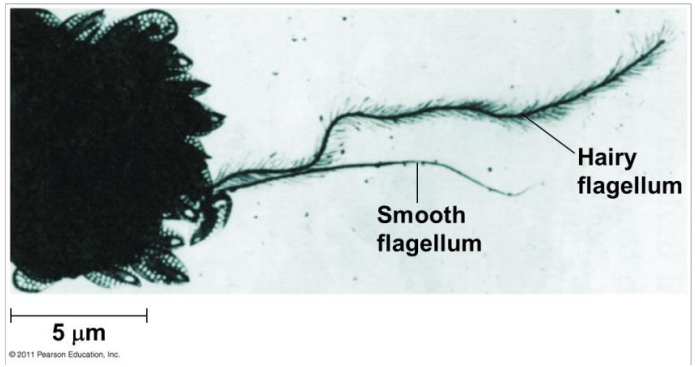
Sexual

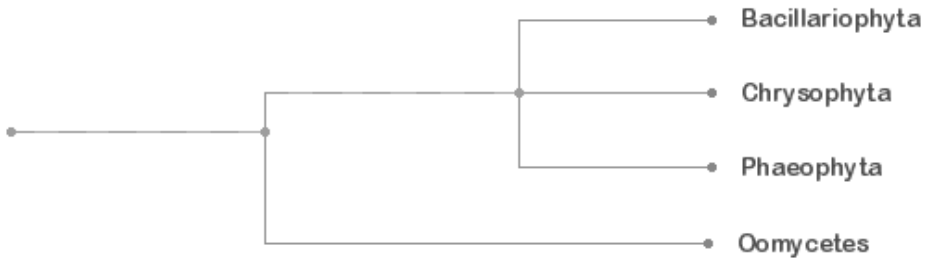





Supergroup: SAR
Clade$_1$: Stramenopiles

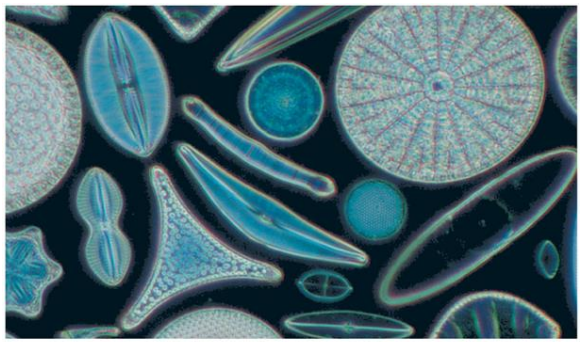
1. **General Characteristics and structures** - members of this group include members that have flagellum with numerous fine, hair like projections.
2. **Biogeography –** This is the clade that includes some of the most important photosynthetic organisms on the planet. It also includes several clades of heterotrophs. The Stramenopiles include four different clades: 1) the Diatoms, 2) the Golden Algae, 3) the Brown Algae and 4) the Oomycetes (Water Molds).

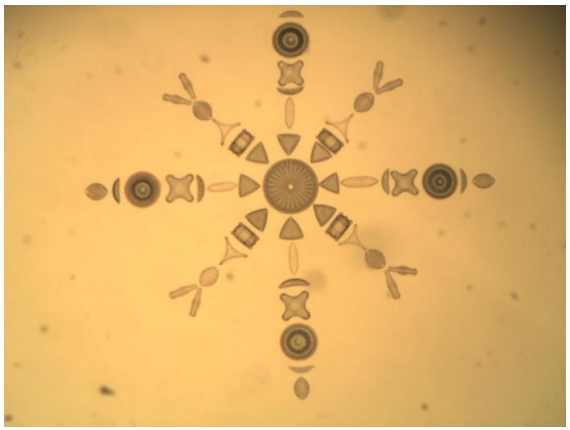


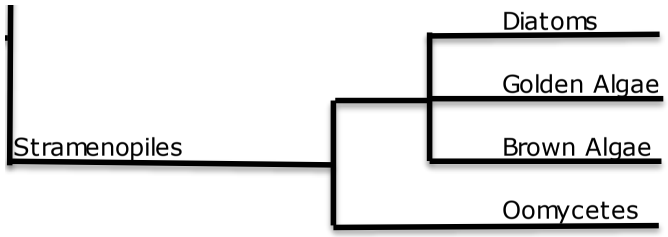


Supergroup: SAR
Clade$_1$: Stramenopiles
Clade$_2$: Diatoms

1. **General Characteristics and structures** – This clade is identified by cell walls made up of overlapping silica tests called a frustule.
2. **Biogeography –** The diatoms are unicellular algae that are a large component of phytoplankton in oceans and lakes.
3. **Unique Characteristics –** Fossilized diatoms accumulate in sediments known as diatomaceous earth. These sediments are mined to use as a filtering medium and can be found in products like paints and toothpastes. After a bloom, many diatoms die and are left un-decomposed on the ocean floor which removes their carbon from the carbon cycle. This acts as a carbon sink, a natural way of reducing carbon dioxide omissions that contribute to global climate change.

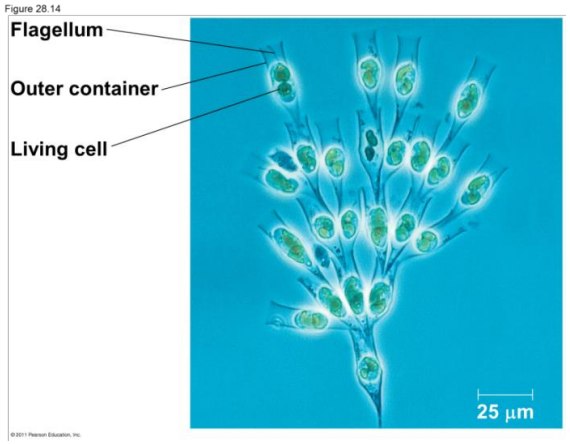


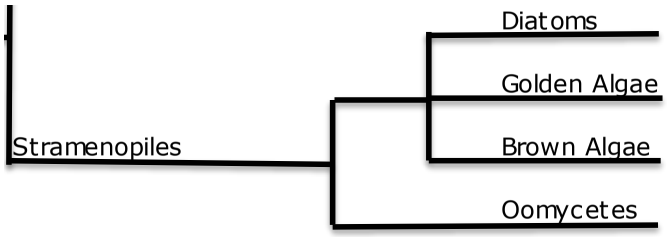


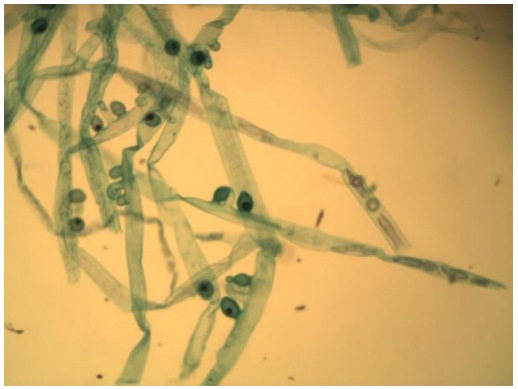


Supergroup: SAR
Clade$_1$: Stramenopiles
Clade$_2$: Golden Algae

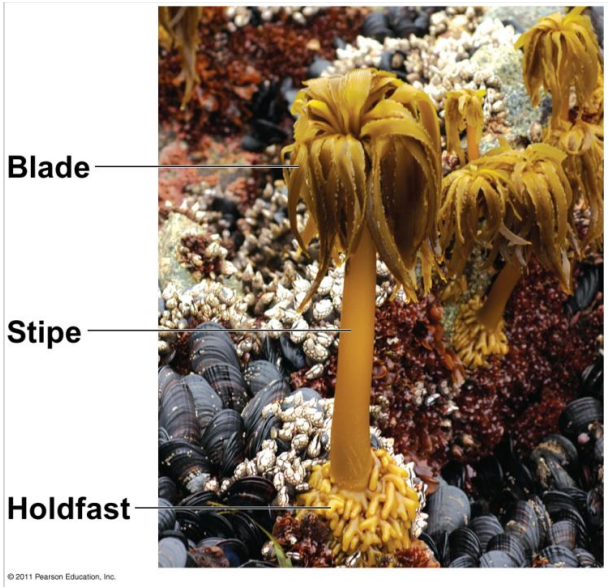
1. **General Characteristics and structures** – This clade is identified by their color due to yellow and brown carotenoids (xanthophyll). The cells of these organisms are typically bi-flagellated, with both flagella near one end of the cell.
2. **Biogeography –** The Golden Algae are components of fresh water and marine plankton.
3. **Unique Characteristics –** While most species are photosynthetic, some species are mixotrophic. Most species are unicellular but the one in lab is colonial. They can form protective cysts under extreme conditions and can survive for decades.



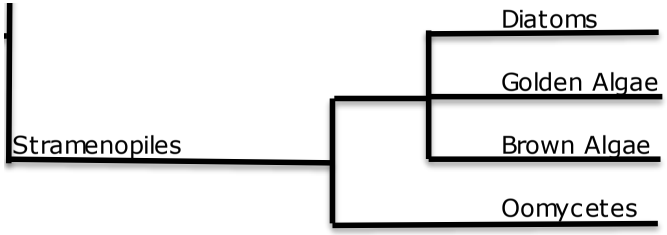




Supergroup: SAR
Clade$_1$: Stramenopiles
Clade$_2$: Brown Algae

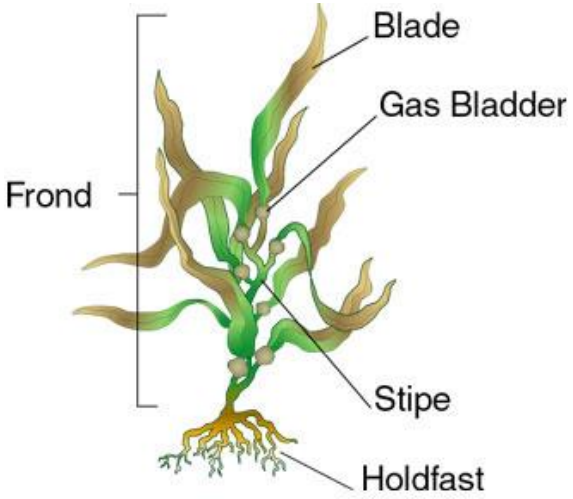


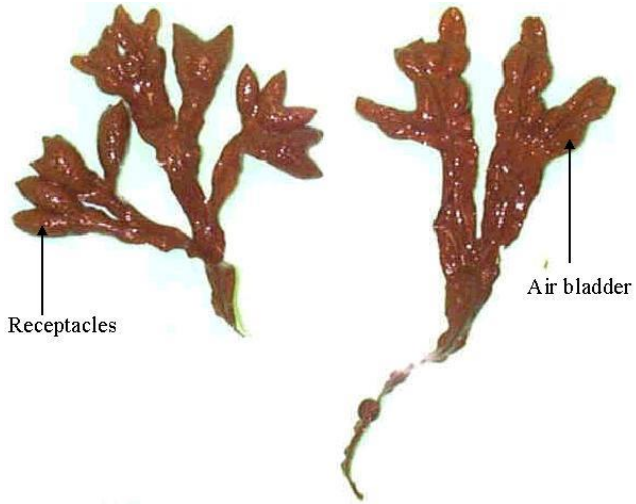
1. **General Characteristics and structures** – This clade is the largest and most complex multicellular algae. They get their color from the brown or olive color (pigments: carotene, fucoxanthin) in their plastids. The intertidal species are subject to desiccation and wave action and have evolved a cell-wall with cellulose and a gel-like substance called algin (a polysaccarhide) to reduce drying and help cushion them from waves.
2. **Biogeography –** The Brown Algae are mostly marine found along temperate coasts where the water is cool.
3. **Unique Characteristics –** The algin is used to thicken processed foods such as ice cream, pudding, salad dressing and other products like paint.



Supergroup: SAR
Clade$_1$: Stramenopiles
Clade$_2$: Brown Algae

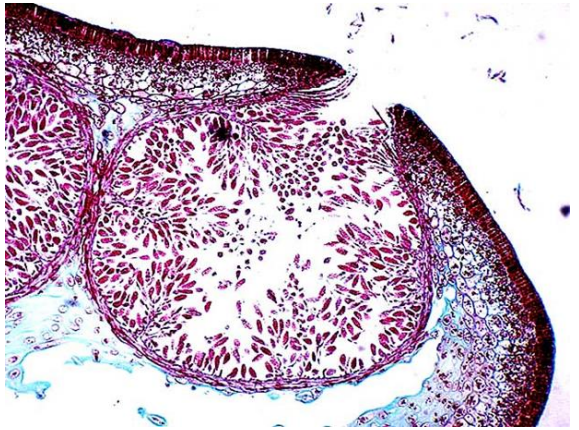
External Structures – A representative of the brown algae is the common seaweed, *Fucus*, often called **kelp or rockweed**. It occurs in the rocks along seashores. Seaweeds are multicellular and made up of differential tissues and organs that resemble those we find in plants. They lack true roots, stems and leaves and are called a thallus. A thallus consists of a holdfast (used for attachment), a stem-like stipe, and leaf-like blades. On the blades are air bladders that are used to help the blades float and on the ends are receptacles that are swollen areas at the ends of the blades that contain the reproductive components for the algae. The small pores that enter the receptacles are called ostioles.

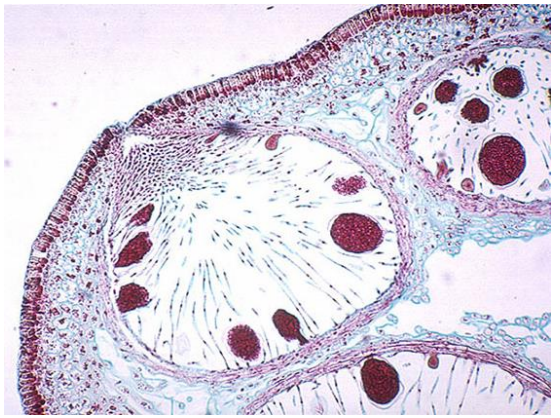




Supergroup: SAR
Clade$_1$: Stramenopiles
Clade$_2$: Brown Algae

Internal Structures – The ostioles in the *Fucus* receptacles lead into chambers called conceptacles. Observe both the male and female conceptacles, which are available on prepared slides. In the male, find the branched antheridia and the sperm. Surrounding the antheridia, there are sterile hairs called paraphyses, which are used for protection (top picture). In the female, observe the oogonia and its eggs along with the paraphyses (bottom picture).

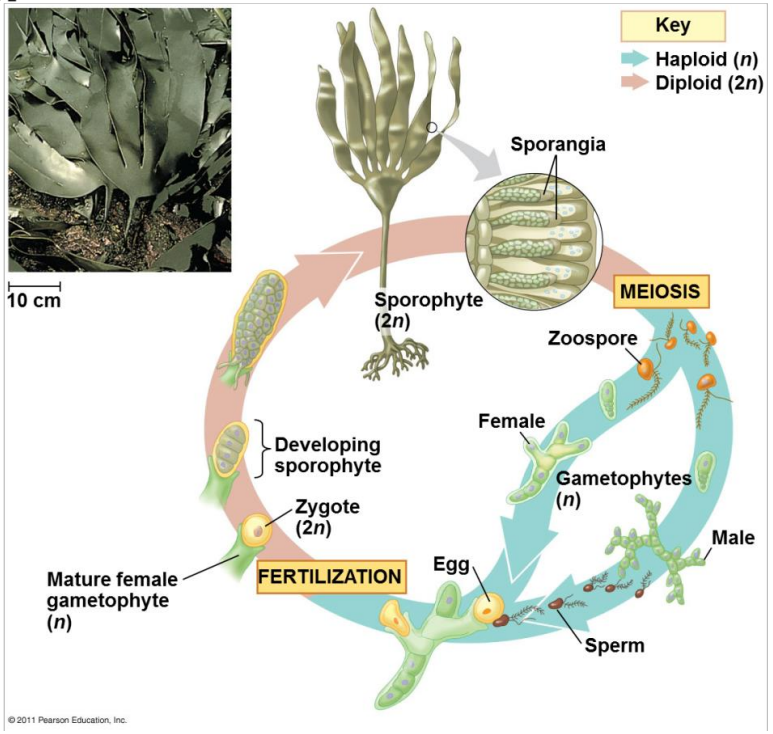




Supergroup: SAR
Clade$_1$: Stramenopiles
Clade$_2$: Brown Algae

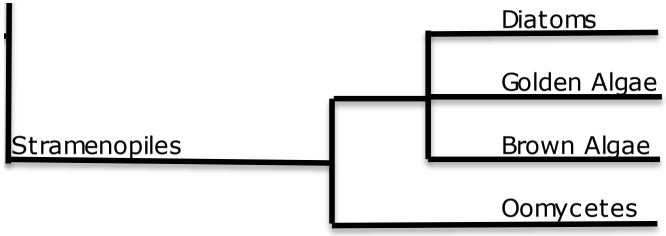
Alternation of Generation – The brown algae life cycle consists of a cycle with multicellular haploid and diploid forms. This term refers to the fact that both forms are multicellular. This pattern will also be seen in higher plants. The structure most people identify as "algae" is a sporophyte structure that is diploid.

Figure 28.16-2

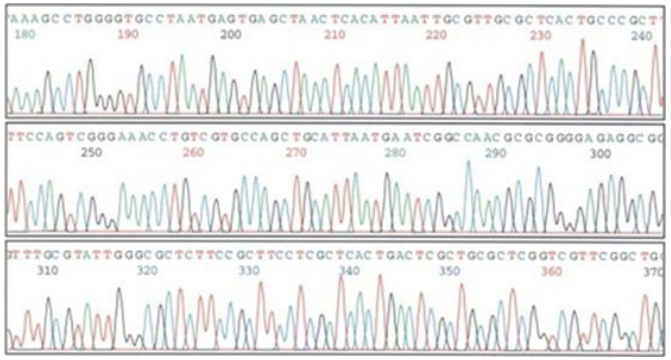


Supergroup: SAR
$Clade_1$: Stramenopiles
$Clade_2$: Oomycetes

1. **General Characteristics and structures** –They have hyphae like a fungus (and at one point they were thought to be a fungus) but their cell walls are made of cellulose (fungus cell walls are made of chitin). This clade includes the water molds, the white rusts, and the downy mildews.
2. **Biogeography –** The Oomycetes have lost their plastids and are therefore either decomposers or parasites. Water molds are usually parasites on dead algae and animals in fresh water and the white rusts and downy mildews are usually plant parasites.
3. **Unique Characteristics –** The Oomycetes are responsible in the 19th century for the French Wine Crisis and for the Potato Famine in Ireland causing the Irish to migrate to North America and Russia.

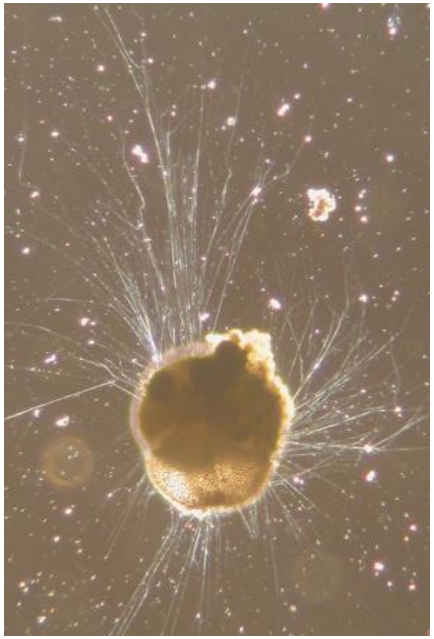


Supergroup: SAR Clade$_1$: Rhizaria



1. **General Characteristics and structures** – The members of this clade have similar DNA sequences even though they vary greatly in morphology. Many of the former amoebas were included with this clade but we now know they are distinctly differen and belong in this clade and are characterized by thin like pseudopodia.
2. **Natural History** – Each of the clades within the larger clade are monophyletic. The three clades are the Cercozoans, the Forams and the Radiolarians.
3. **Biogeography** – The Rhizaria are found in marine, freshwater or soil ecosystems.

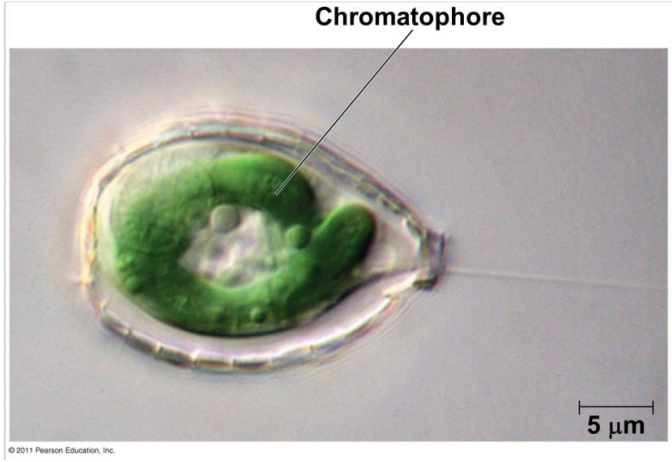
Era	System & Period	Series & Epoch
CENOZOIC	Quaternary	Recent
		Pleistocene
	Tertiary	Pliocene
		Miocene
		Oligocene
		Eocene
		Paleocene
MESOZOIC	Cretaceous	
	Jurassic	
	Triassic	
PALEOZOIC	Permian	
	Carboniferous	Pennsylvanian
		Mississippian
	Devonian	
	Silurian	
	Ordovician	
	Cambrian	
	Precambrian	

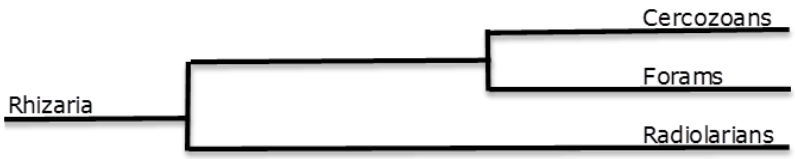


Supergroup: SAR
Clade$_1$: Rhizaria
Clade$_2$: Cercozoans

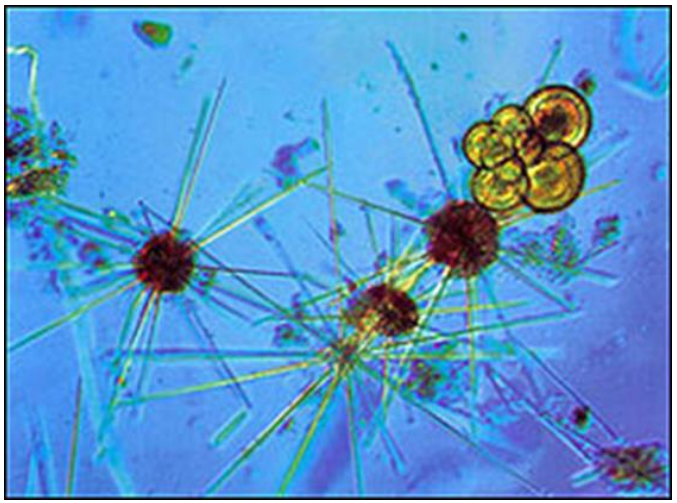
1. **General Characteristics and structures** – This clade includes most of the amoeboid-shaped Protista with thin pseudopodia.
2. **Biogeography –** The Cercozoans are predators, and parasites found in freshwater, marine, and soil ecosystems.
3. **Unique Characteristics –** They have evolved a sausage-shaped internal structure through endosymbiosis of a cyanobacteria for photosynthesis (a chromoatophore) which is different from the cyanobacteria that produced plastids in other organisms.

Figure 28.19

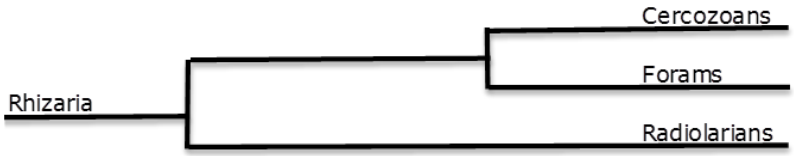


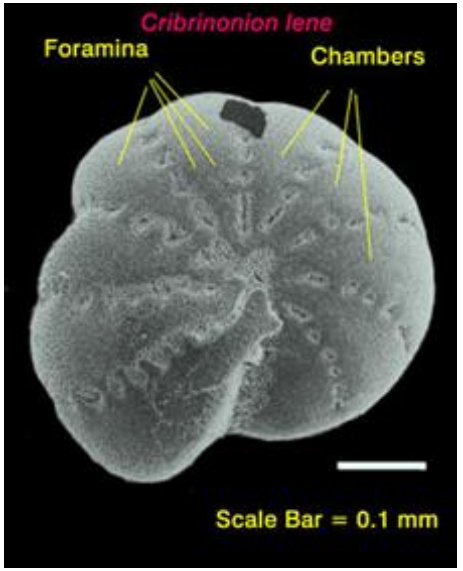


Supergroup: SAR
Clade1: Rhizaria
Clade2: Forams



1. **General Characteristics and structures** – This clade includes the amoebas with thin pseudopodia and a calcium carbonate test. (Foramen is Latin for little hole).
2. **Biogeography –** The Forams are found in both ocean and freshwater habitats attached to sand, rocks or algae. Others are found in plankton.
3. **Unique Characteristics –** Most Forams are known from fossils and make up sedimentary rock. They also are symbiotic with photosynthetic algae that can live in their calcium carbonate test and provide them with nourishment.





Supergroup: SAR
Clade1: Rhizaria
Clade2: Radiaolarians

1. **General Characteristics and structures** – This clade includes the amoebas with thin pseudopodia and a delicate silica skeleton.
2. **Biogeography –** The Radiolarians are common as marine plankton.
3. **Unique Characteristics –** Most Radiolarians are planktonic and when they die, their skeletons sink to the bottom and form a radiolarian ooze covering much of the sea floor.