Branches On The Tree Of Life:
ALGAE

Produced by BioMEDIA ASSOCIATES @ 2004 -- 20 minutes
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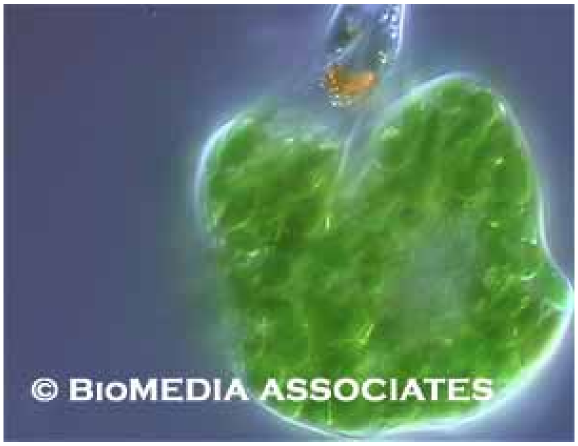


Euglena filled with green plastids (chloroplasts).
All illustrations in this study guide are from the video/DVD program.

WHAT ARE ALGAE?

"A rocky beach at low tide reveals a luxuriant garden of plant-like organisms. A drop of pond water swarms with single cells that are green and carry out photosynthesis. But there are also golden cells, cells encased in armor, colonies of various kinds, and long filaments. We lump all of these diverse organisms together under a familiar title—Algae. However, when their genetic material was compared, we discovered that these photosynthetic organisms were actually from deeply divergent evolutionary lines. In fact, some so-called algae groups are more different from each other— than plants are from animals."
(Comparing genetic material, DNA and RNA is a powerful way to determine evolutionary relationships. These studies, along with classical comparative anatomy approaches made possible by ever better microscopes, are yielding new and sometimes revolutionary classifications.

The term "algae" does not describe a particular branch of evolution, but refers to all those photosynthetic organisms that are neither plant nor bacteria. Algae are made up of eukaryotic cells, that is, cells with nuclei and organelles; and, they all have plastids, the bodies with chlorophyll that carry out photosynthesis. But the various lines of algae can have different combinations of chlorophyll molecules; some have just Chlorophyll A, some A and B, and other lines, A and C.

This program defines and examines the five deeply separated branches of life commonly referred to as algae:

Chromista is a line that includes the brown algae, golden brown algae, and diatoms. The plastids in these algae contain Chlorophylls A and C.
(The classification of microorganisms is being rearranged based on molecular data. This branch of life includes many non-photosynthetic organisms including water molds.)

The Red Line is an early branch of marine algae containing just
Chlorophyll A. Red algae can often be seen coating wave washed rocks.
(Red algae, seldom seen except along rocky seashores, are not treated in detail in this video program. A characteristic of red algae is that their plastids contain only one type of chlorophyll —

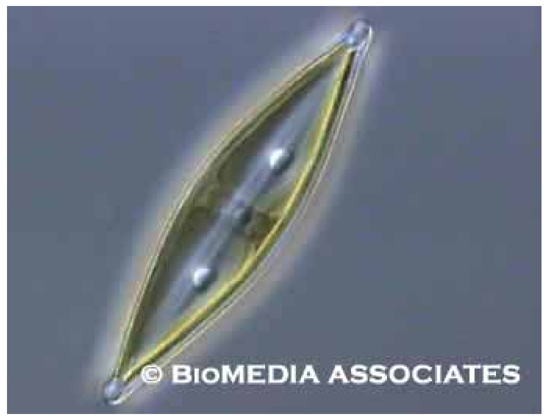
chlorophyll a. This is different from green algae and plants which have both chlorophyll a and b. In the plastids of healthy red algae, the green color of chlorophyll A is masked by molecules of bright red pigments. Like the multicellular green and brown algae of seashores , red algae have complex life cycles that switch back and forth between two completely different bodies. One body, called the sporophyte, has two sets of chromosomes. Through the process of meiosis the sporophyte produces microscopic spores, each with only a single set of chromosomes. These spores disperse in the ocean, settle, and then grow into a second body type with one set of chromosomes. This body is called a gametophyte, because it produces gametes – sperm or eggs. The fertilized egg settles to the bottom and then grows into a sporophyte body. Multicellular brown algae have similar alternation of generations in their life cycles.)

Dinoflagellates evolved on a separate line that includes, surprisingly, the ciliated protists. (*Dinoflagellates are more closely related to ciliated protests that other lines of algae.*)

The **Euglenids**, an independent line of single celled organisms that include both photosynthetic and non-photosynthetic species.

The **Green Line** (with chlorophylls A and B, is the evolutionary line of algae and plants.

CHROMISTA



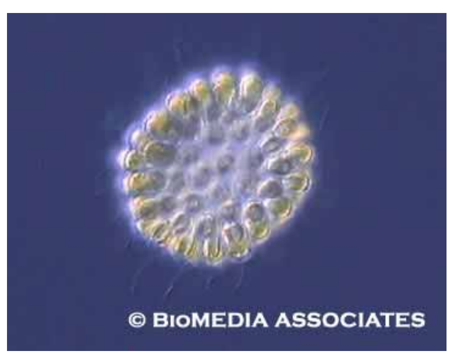
Chromista is a diverse branch of life that includes the brown sea weeds, diatoms, golden brown micro-algae and many nonphotosynthetic species.

Kelps and Other Brown Algae
Waves crashing into a rocky shore can be hazardous to life, but one group is particularly successful here, the brown algae. One brown alga, the sea palm, survives on wave-swept rocks, and this is the only place you find them. Sea palms can stake claim to this violent territory because of a striking set of evolutionary adaptations: a hold-fast anchor that glues the alga to the rock, sending fingers into every crevice; a flexible stalk that bends with the waves; and ribbon-like fronds that offer little resistance to the passing water.

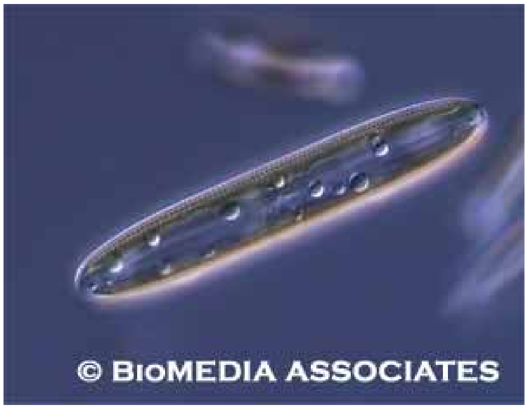
Other kinds of brown algae thrive along the rocky seashore, each species with its own unique set of adaptations. The common "rock weed", can tolerate total drying. Below the tide line, large brown algae dominate— their broad blades effectively harvesting the sun's energy.

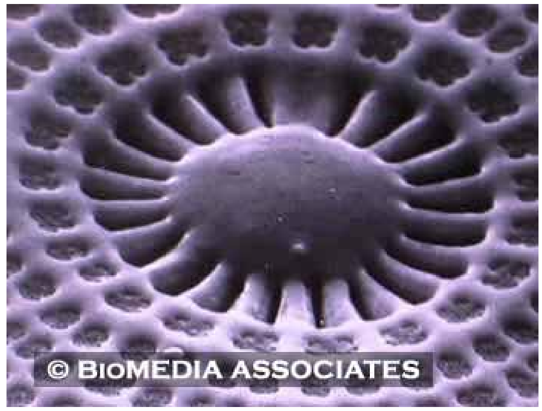
The Chrysophytes

This golden brown colonial microorganism (Synura) *belong to a branch of Chromista known as the Chrysophytes. Like the brown algae of seashores, they have chlorophylls A and C, plus accessory pigments that give them a golden hue.*



Diatoms

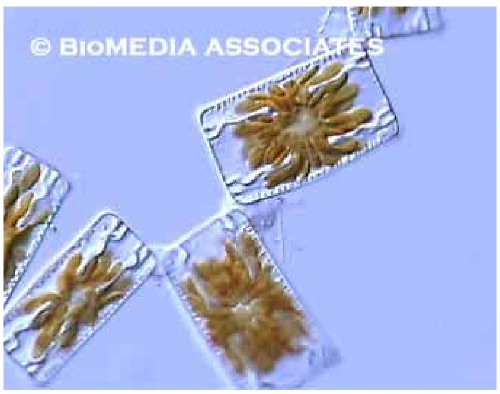




Seen with the scanning electron microscope, a diatom's glass house can seem like an elaborate castle.

A remarkable feature of every diatom cell is its protective glass house, built by extracting silica compounds from the surrounding water. The glass house is ribbed for strength, and divided into two sections, that fit together like the two halves of a Petri dish..

There are two basic types of diatoms — Centric and pinnate. Centric diatoms look circular from the top …and rectangular from the side. It's because they are short cylinders. Pinnate diatoms are oblong in shape, and they can have many different forms. Pinnate diatoms can link together in chains with side by side cells, or attach end to end. They form fans, or even grow like spokes in a wheel.



Although a glass house offers protection, there are plenty of organisms that successfully eat diatoms. In Diatoms the products of photosynthesis are stored as fat in the form of oil droplets. Being less dense than water, oil adds buoyancy, allowing planktonic diatoms to remain near the surface where there is plenty of light for photosynthesis.

Because they have no visible means of propulsion, diatom locomotion is somewhat of a puzzle. One hypothesis envisions a kind of conveyor-belt system. Pushed out through a slit on the lower surface, cytoplasm is thought to move over the surface and then reenter the cell, producing a tractor-like locomotion.
(The glass house puts certain requirements on diatom reproduction. Depending on light and nutrients, diatom cells can divide every day. During division, the cell produces a new lid and new bottom inside the existing house. The original bottom now becomes a lid for one of the daughter cells and the original lid gets a new bottom. You can imagine where this kind of asexual reproduction leads—ever smaller cells. Eventually, some descendants of the original cell become too small to function properly. At this point, sex kicks in. The small cells produce gametes through meiosis. Then, gametes from two different strains fuse together. The resulting cell escapes from its tiny hovel to build a new, full-sized glass palace.)

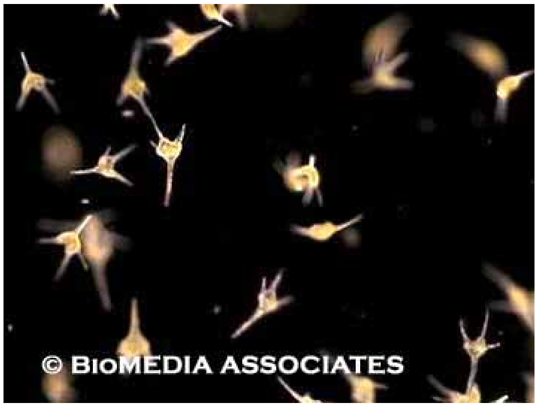
DINOFLAGELLATES

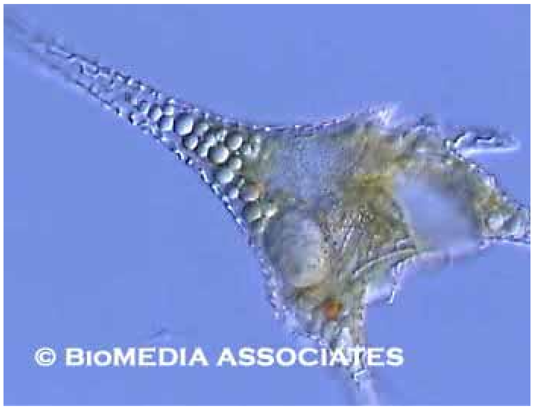
Dinoflagellates are single-cells, seldom noticed as they swim through the waters of pond or ocean. But when nutrient and light conditions are just right, some dinoflagellates multiply in astronomical numbers, causing an algal bloom. The cells become so abundant they turn the ocean various shades of red. Thus the name, RED TIDES.

Dinoflagellates color the water in a British Columbia bay.

Red tides can be dangerous, particularly to humans who enjoy eating shell fish. The problem is that molluscs feed on single-celled algae filtered from the water. If their food is a bloom of toxic dinoflagellates, they can store the toxin in their tissues. It doesn't hurt the mussel, but when the mussel is eaten, the results can be deadly.

Dinoflagellates, can also be found in almost any roadside pond. A posterior flagellum pushes the organism. A second flagellum is attached in a groove and spins the cell as it swims. Dinoflagellates have a very large nucleus and convert the products of photosynthesis into oil droplets as shown in the high magnification view of *Ceratium*.





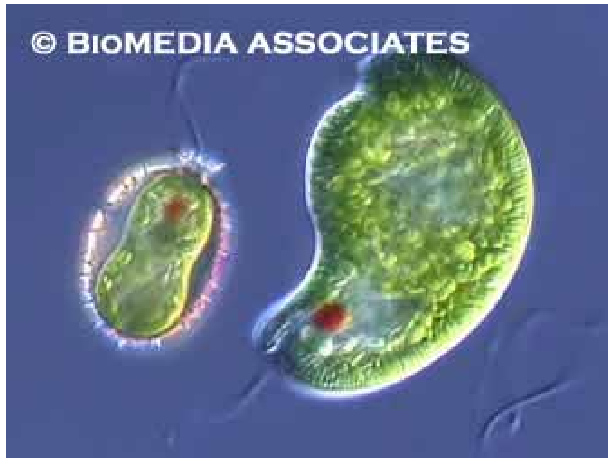
Ceratium, *a dinoflagellate adapted for living suspended in the open water.*

Not all dinoflagellates are free-swimming. In fact, some have taken up living inside of animals. These relationships are a form of symbiosis in which the dinoflagellates share food made by photosynthesis with the host animal. The productivity of coral reefs is due to the symbiotic dinoflagellates that live within the coral animals.

Although they are single celled, and mostly photosynthetic, Dinoflagellates are not closely related to any of the other algae groups. In fact, their DNA sequences show them to be more closely related to ciliates such as *Paramecium*, a surprising finding.

EUGLENIDS

Trachelomonas, *a shelled euglenid on the left and naked* Euglena *on the right, from pond water.*



When these green organisms were first observed, they posed a problem—were they plants or animals? They were green like plants yet they moved around like animals. These puzzling cells caused biologists to question the prevailing view—that there were only two kinds (kingdoms) of living things.

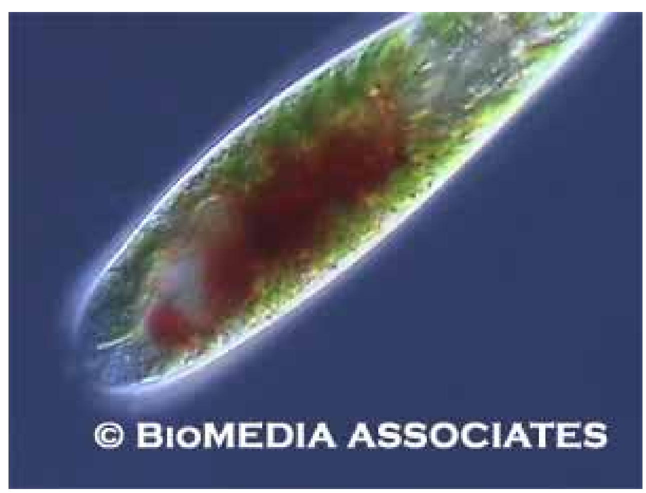
The DNA fingerprints of euglenids are so different from other evolutionary branches that some biologists now consider the euglenids to be a kingdom in their own right.

Euglena uses an undulating flagellum to push on the water, moving the cell forward. The red eyespot is actually a shield that shades a light sensitive region at the base of the flagellum. This arrangement makes it possible for a euglenid to swim toward the light—useful behavior for a photosynthetic organism.

A typical euglenid is filled with green chloroplasts, football shaped in some species, rounded in others. Euglenids also contain disc-shaped bodies where starch is stored.

But not all organisms in this line have chloroplasts. Field collections have shown that over half of living species in the euglenid line are non-photosynthetic.

Some euglenids can loose their chloroplasts and survive by absorbing nutrient molecules directly from its surroundings. Such individuals may continue to divide, leading to populations of non-green cells, potentially creating a new species of colorless euglenid.

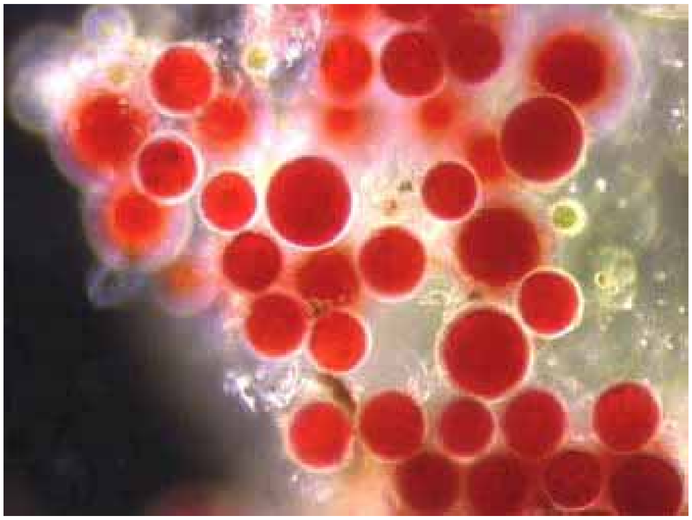


Euglena rubra *with pigment shield withdrawn.*

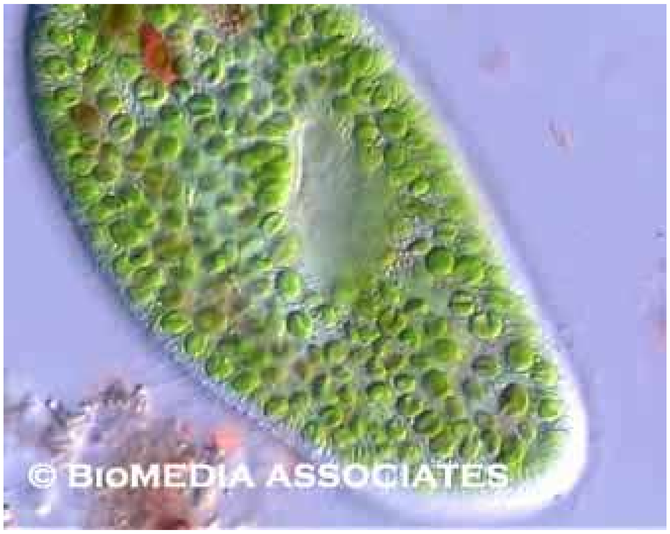
Euglena rubra, the "red Euglena" is a particularly interesting species due to its specialized ecological niche—life on the pond's surface in full sunlight. How does it avoid sunburn, often fatal to naked single cells? First the cell balls up, usually forming a raft with others. It avoids drying by producing a transparent plastic-like coating that seals in moisture. Sun exposure causes the red pigment to spread over the upper hemisphere of the cell, creating a parasol. These rafts often turn the surface of ponds red, that is until the sun goes behind a cloud. As the light dims, the red pigment is withdrawn and the pond's surface takes on a greenish appearance. At night the cells leave their plastic bubbles and dive to the pond bottom where they soak up nutrients, ready to return to the surface at first light for another day in the sun.

THE GREEN LINE OF EVOLUTION

Single cell green algae are found just about anywhere there is water. They coat surfaces, form bubbly scums on ponds, and drift about in the sunny upper water of lakes and oceans. They even live on snow banks—a condition called 'watermelon snow." In this case the green cells are protected from harmful ultra violet radiation by a parasol of red pigment (just like *Euglena rubra*). On cloudy days the pigment is partially withdrawn, giving the chloroplasts more light for photosynthesis.



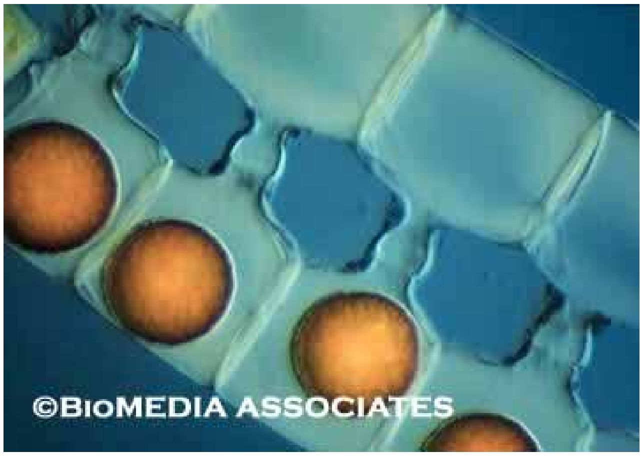
Red snow "watermelon snow" is a concentrated layer of Hematococcus a green alga with a red pigment sun shield.



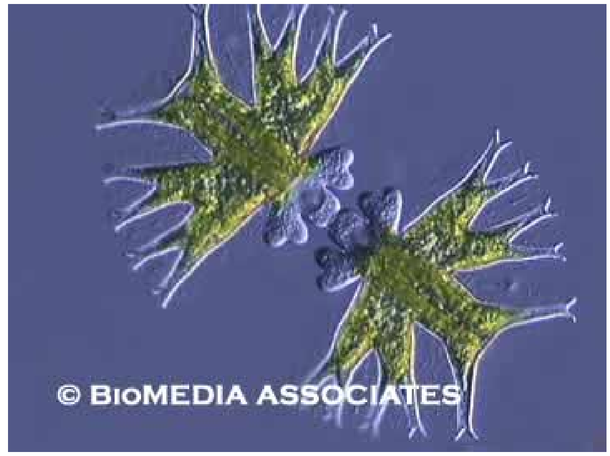
Paramecium bursaria *is an "algae farmer", culturing its small green guests and providing for their needs in exchange for a share of the products they make by photosynthesis.*

Symbiotic algae-farming is practiced by many kinds of water animals, including hydras and flatworms. Fungi also partner with green algae (and to a lesser extent with cyanobacteria) producing the combination organisms we call lichens, familiar coatings on rocks and tree trunks.

Floating green mats on ponds are composed of filamentous algae—long strands of cells bonded end to end. One of the most common is *Spirogyra*.



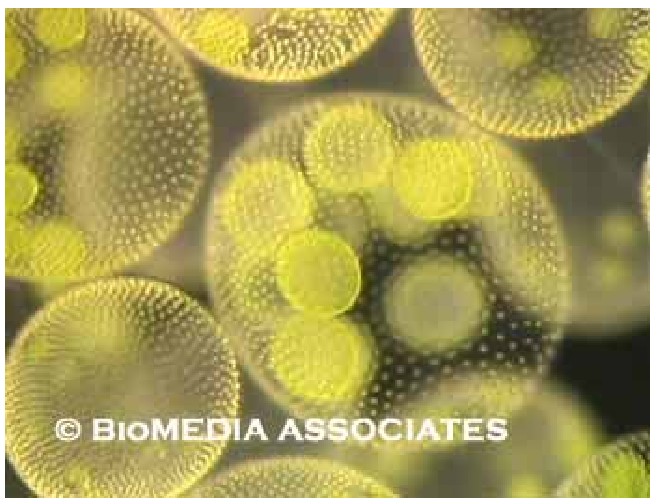
Spirogyra, conjugating strands and zygotes



Micrastarias *dividing. Note how the forked arms are already developing in the new cell halves.*

Like other freshwater algae, *Spirogyra* must deal with seasonal changes, such as drying and freezing. Survival involves a sexual process called conjugation. As conditions deteriorate, mating strands line up. Connections form and the cell contents merge producing Zygotes. Resistant to freezing and drying, these zygotes will produce the next generation of *Spirogyra* when favorable conditions return.

Colonial Algae



Volvo*x colonies with daughter colonies inside.*

Fresh water plankton often swarms with *Volvox* colonies. Inside are daughter colonies in various stages of development. When mature, the daughters break out, leaving the mother an empty sac, her reproductive mission accomplished.

Like *Spirogyra*, *Volvox* responds to deteriorating conditions through sexual reproduction. Some colonies develop packets of sperm, others—eggs. The sperm break out and fertilize another colony's eggs, which develop into tough, drought resistant zygotes, spore-like structures that will carry the species through a freezing winter, or baking summer.

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