

Protista: nature's superstore

The world of protists

In just a few drops of pond water, you can find an thousands of protists. Some will be moving (looking for that all important snack), some will be using photosynthesis to make their food (the less ambitious ones), and still others will be decomposing organic matter (truly the bottom feeders of protist society). You will learn about the great diversity in the protist kingdom and why biologists group them all together.

What in the heck is a protist?

Kingdom Protista contain the most diverse organism of all the kingdoms. Protists may be unicellular or multicellular, microscopic or meters long, heterotrophic or autotrophic. In fact, there is no such thing as a typical, garden-variety protist. When you look at different protists you may wonder how they could be even in the same kingdom. The characteristic that all protists share is that, unlike bacteria, they are all eukaryotes (remember the membrane around organelles thing).

Although there are no typical protists, some resemble animals in their method of nutrition. The animal like protists are called **protozoa** (sing. Protozoan). Unlike animals, though, all protozoans are unicellular. Other protists are plant like autotrophs, using photosynthesis to make food. This group is called the **algae** (sing. Alga). Unlike plants, algae do not have organs such as roots, stems, and leaves but they do have pigments that carry on photosynthesis. Still other protists are more like fungi. The fungus like protists are able to move at some point in their lives and do not have cell walls made of chitin. These yucky protists that aspire to on day be fungi are called **slime molds**.

It might surprise you to learn how much protists affect other organisms. The really cool ones cause diseases such as malaria and sleeping sickness. These protists result in millions of human deaths throughout the world every year. Unicellular algae produce much of the oxygen in Earth's atmosphere and are the basis of aquatic food chains. Slime molds and water molds decompose a significant among of organic material, recycling nutrients for others to use.

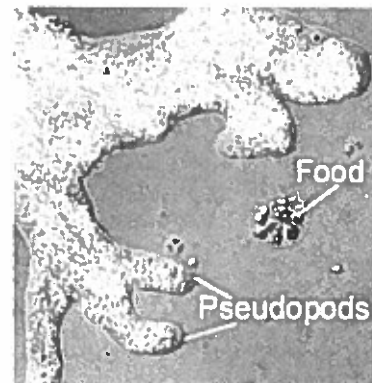
Part A: What is a protozoan?

If you sat by a pond, you might notice clumps of dead leaves at the water's edge. Under the microscope, a piece of those wet decaying leaves reveals a small world, probably inhabited by animal-like protists.

Although a diverse group, all protozoans are unicellular heterotrophs that feed on other organisms or dead organic matter. They usually reproduce asexually, and some also reproduce sexually.

Diversity of Protozoans: so many protist dances, so little time....

Many protozoans are grouped according to the way they move or in one group's case lack of movement. The four main groups of protozoans are: the sarcodines, the flagellates, the ciliates, and the sporozoans.

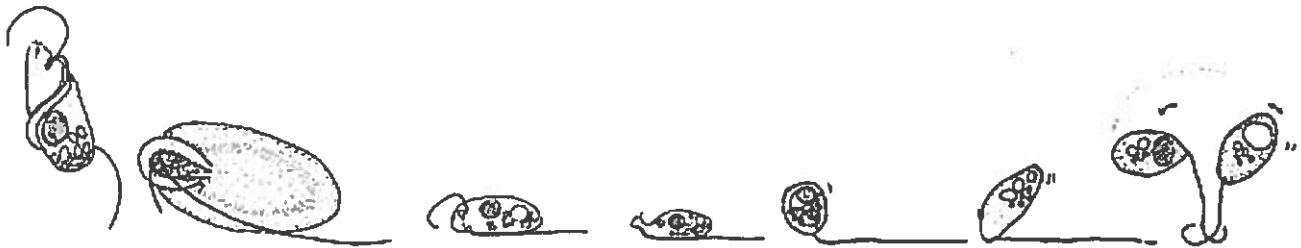


The **sarcodines** are members of the phylum Rhizopoda that includes hundreds of species of amoebas and amoeba like organisms. Amoebas have no cell wall and they move using structures called pseudopods. A **pseudopod** is a cytoplasm containing extension of the plasma membrane. The organism moves its cytoskeleton in the direction it wishes to go. This pulls the membrane around it and the cytoplasm fills the membrane. Then the rest of the organism catches up. As the pseudopod forms, the shape of the cell changes and the **amoeba** moves. Amoebas form pseudopodia around their food, as you can see in the picture to the right.

Although most amoebas live in salt water, there are freshwater ones that live in the ooze of ponds, in wet patches of moss, and even in moist soil. Because amoebas live in moist places, nutrients dissolved in the water around them can diffuse directly through their cell membranes. However, because freshwater amoebas live in hypotonic environments, they constantly take in water. They have structures called contractile vacuoles that are constantly collecting and pumping out excess water.

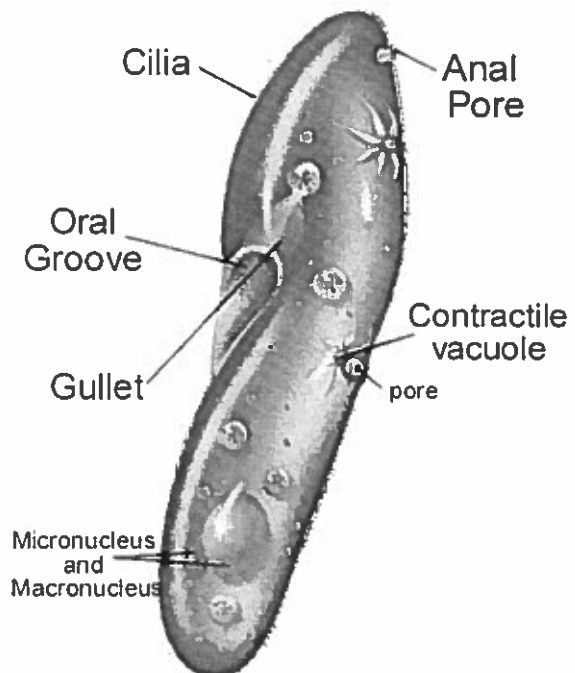
Most sarcodines commonly reproduce by asexual reproduction. When environmental conditions become unfavorable, some types of amoebas form cysts that can survive extreme conditions.

The **flagellates** belong to the phylum Zoomastigina. All flagellates have a tail like appendage that aids in its movement. Because it moves by a whipping action, these



organisms do not have a smooth movement but more or less jerk from side to side. Some flagellates are parasites that cause diseases in animals, such as African sleeping sickness in humans. Other flagellates are helpful. For example, termites survive on a diet of wood. Without the help of certain species of flagellate that lives in the digestive tract of termites, some termites could not survive on such as diet. In a mutualistic relationship, flagellates convert cellulose from wood into a carbohydrate that both they and their termite hosts can use.

The roughly 8000 members of the protist phylum ciliophora, known as **ciliates**, use tiny hair like appendages that cover their bodies to move. Ciliates live in every kind of aquatic habitat—from ponds and streams to oceans and sulfur springs. A typical ciliate, the paramecium, is pictured to the right.

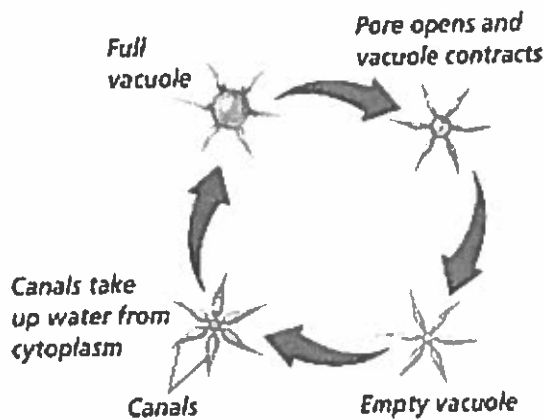


Paramecia have an outer covering called a pellicle through which thousands of cilia are sticking. The paramecium beats these little hair like appendages and move like many rowers on a crew boat. The oral groove is where food (mostly bacteria) enters the paramecium and is put in a vacuole in the gullet. **Paramecia** are so special; one nucleus is not enough for them. NOOO!!!! They have a micronucleus that is involved in sexual reproduction and a macronucleus that controls the day-to-day activity of the cell.

Because fresh water is a hypotonic solution for the paramecium, water is

constantly moving in by osmosis. In order to avoid bursting (OUCH!), the paramecium has

evolved **contractile vacuoles**. These are special canals that funnel water into the central vacuole they surround. When the vacuole is full as seen to the left, it moves to the cell membrane and empties its contents.



Many structures found in ciliates' cells may work together to perform just one important life function. For example, Paramecium uses its cilia, oral groove, gullet, and food vacuoles in the process of digestion.

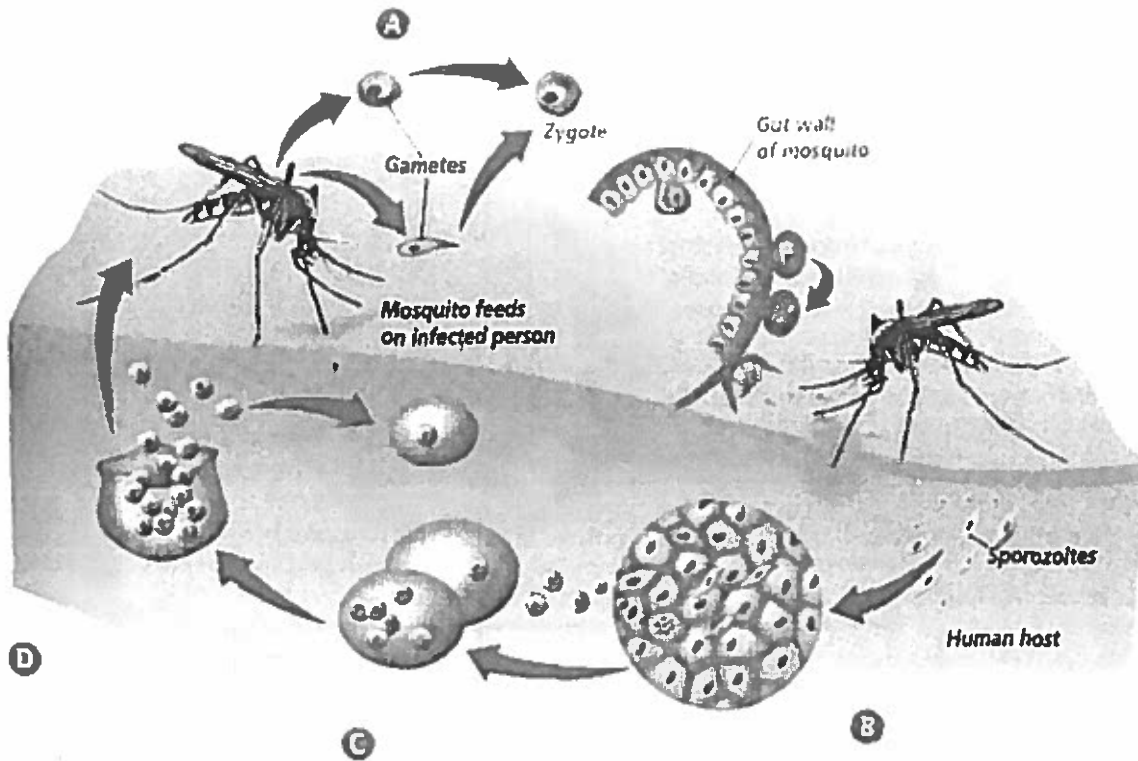
A paramecium usually reproduces

asexually by fission and separating into two daughter cells. When their food supplies dwindle or their environmental conditions change, paramecia usually undergo a form of conjugation. This complex process involves two paramecia join and exchange genetic material. Then they separate; each divides asexually, passing on its new genetic composition.

Sporozoans: The house guest that comes to visit and stays....forever.

Protists in the phylum Sporozoa are often called **sporozoans** because most produce spores. A **spore** is a reproductive cell that forms without fertilizations and produces a new organism. All sporozoans are parasites and most of the adult forms don't move on their own. They live as internal parasites in one or more hosts and have complex life cycles. Sporozoans are usually found in a part of a host that has a ready food supply, such as an animal's blood or intestines. Plasmodium, members of the sporozoans genus, are organisms that cause the disease malaria in humans and in other mammals and in birds.

Throughout the world today, more than 300 million people have malaria, a serious disease that usually occurs in places that have tropical climates. The *Plasmodium* that mosquitoes transmit to people causes human malaria. As you can see in the diagram of the life cycle below, the *Plasmodium* lives in both humans and mosquitoes.



At A you can see the spores of Plasmodium are entering the mosquito from infected human blood. These spores, without fertilization, produce zygotes which develop in the mosquito's digestive tract. The zygote, when mature, releases cells called sporozoites. As shown in B, these sporozoites find their way to the mosquito's salivary glands where they are injected into a new human when the mosquito bites. At C in the diagram, the sporozoites reproduce asexually in the human liver. The spore-like cells then enter the human's red blood cells and multiply rapidly. Eventually, the red blood cells rupture as seen at D. The rupturing releases toxins into the human blood that cause the symptoms of malaria. New spores are also released into the blood, infecting more red blood cells and waiting for a mosquito to bite to continue the cycle.

Until World War II, the drug quinine was used to treat malaria. Today, a combination of drugs chloroquine and primaquine are most often used to treat this disease because they cause few serious side effects in humans. But, some species of Plasmodium have begun to resist these drugs. Therefore, quinine is once again being used to treat the resistant strains.

Part B: Algae- Upon this alga, you build your ecosystem

Each time you inhale, you breathe in oxygen, much of which is being produced by plant like protists. The algae are important in the world of living things. Just about every living thing depends either on these protists for oxygen for food.

What are Algae?

Photosynthesizing protists are called algae. All algae contain up to four kinds of chlorophyll as well as their photosynthetic pigments. These pigments produce a variety of colors in algae, including purple, rusty-red, olive-brown, yellow and golden-brown. Thus, color is a good way to classify algae.

Algae include both unicellular and multicellular organisms. The photosynthesizing unicellular protists, known as phytoplankton, are so numerous that they are one of the major producers of nutrients and oxygen in aquatic ecosystems in the world. It's been estimated that algae produce more than half of the oxygen generated by Earth's photosynthesizing organisms. Although multicellular algae may look like plants because they are large and sometimes green, they have no roots, stems, or leaves.

Different types of Algae

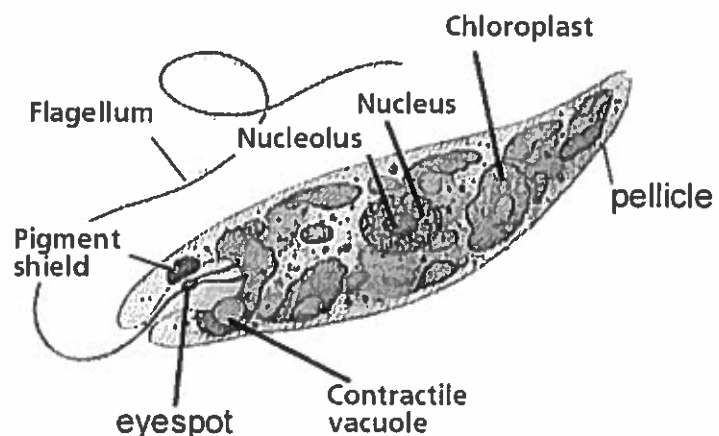
Algae are classified into seven phyla. Three of these phyla—the euglenoids, diatoms, and dinoflagellates—include only unicellular species. However, in three other phyla, which are green (chlorophyta), red (Rhodophyta) and brown (Phaeophyta) algae, most species are multicellular. One phylum the golden algae (chrystophyta) are mostly unicellular but some live as colonies.

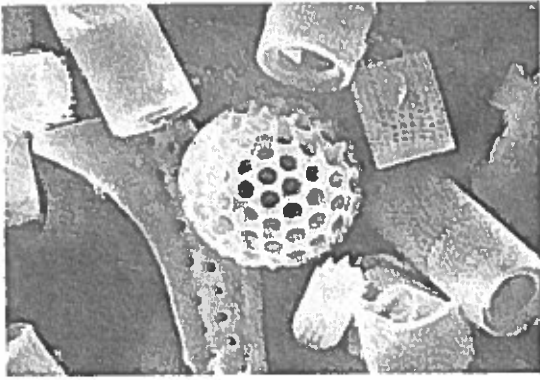
Euglenoids: Autotrophs and Heterotrophs (The best of both worlds)

Hundreds of species of euglenoids make up the phylum Euglenophyta.

Euglenoids are unicellular, aquatic protists that have both plant and animal characteristics. Unlike plant cells, they lack a cell wall made of cellulose. However, they do have a flexible pellicle made of protein that surrounds the cell membrane. Euglenoids are plantlike in that most have chlorophyll and photosynthesize. However they are also animal-like because, when light is not available, they can ingest

food in ways that might remind you of some protozoans. In other words, euglenoids can be heterotrophs. The picture to the right shows the body features of a typical euglenoid. Euglenoids might also remind you of protozoans because they have one or more flagella to move. They use their flagella to move toward light or food.





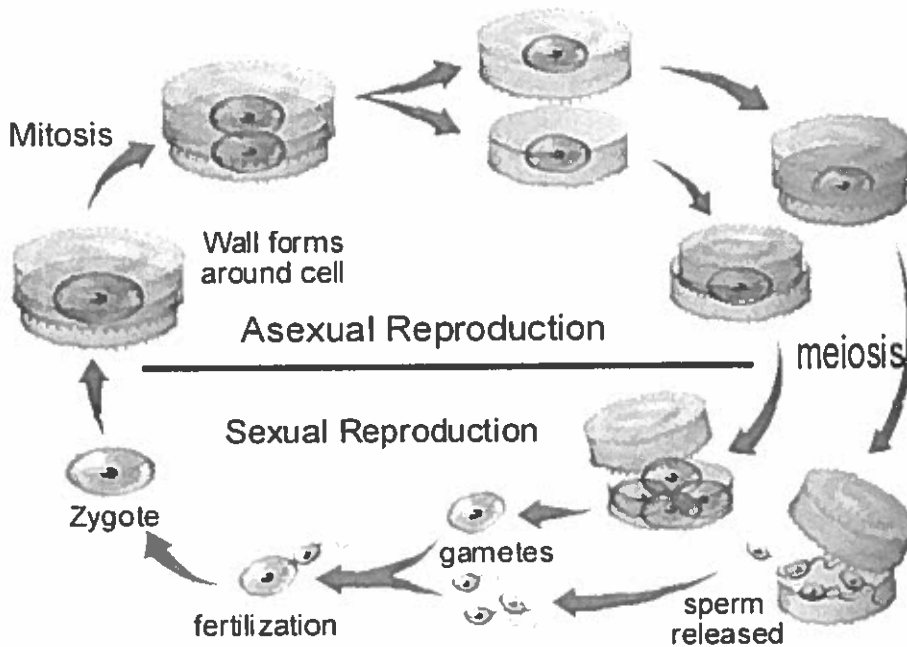
Diatoms- Protist geometry

Diatoms, members of the phylum Bacillariophyta, are unicellular photosynthetic organisms with shells made of silica. There are abundant in both marine and freshwater ecosystems, where they are a large part of the phytoplankton. The delicate shells of diatoms, like those you see in the picture to the left, remind you of boxes with lids. Each species has its own unique shape, decorated with grooves and pores.

Diatoms contain chlorophyll as well as other pigments called **carotenoids** that usually give them a golden-yellow color. The food that diatoms make is stored as oils rather than starch. These oils give fishes that feed on diatoms an oily taste. They also give diatoms buoyancy so they float near the surface where light is available.

When diatoms reproduce asexually, the two halves of the box separate; each

half then produces a new half to fit inside itself. This means that half of each generation's offspring are smaller than the parent cells. When diatoms are about one quarter of their original size, they reproduce sexually by producing gametes that fuse to form zygotes. The zygote develops into a full-sized diatom, which will divide asexually for a while. You can see both the



asexual and sexual reproductive processes of diatoms in the picture below.

When diatoms die, their shells sink to the ocean floor. The deposits of diatom shells—some of which are millions of years old—are dredged or mined, processed, and used as abrasives in tooth and metal polishes, or added to paint to give the sparkle that makes pavement lines more visible.

Dinoflagellates: to every alga, turn, turn, turn....

Dinoflagellates, members of the phylum dinoflagellata, have cell walls that are made of thick cellulose plates. They come in a great variety of shapes and styles—some even

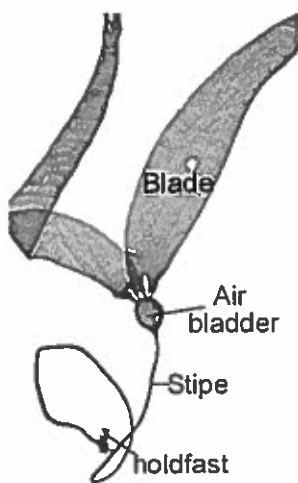


resemble helmets, and others look like suits of armor. Dinoflagellates contain chlorophyll, carotenoids, and red pigments. They have two flagella located in grooves at right angles to each other. The cell spins slowly as the flagella beat. A few species of dinoflagellates live in freshwater, but most are marine and, like diatoms, are a major component of phytoplankton. Many species live symbiotically with jellyfish, mollusks, and corals. Some free-living species are bioluminescent, which means they emit light.

Several species of dinoflagellates produce toxins. One toxin-producing dinoflagellate, *Gonyaulax catanella*, produces an extremely strong nerve toxin that can be lethal. In the summer, these organisms may become so numerous that the ocean takes on a reddish color. This population explosion is called **red tide**. Because shellfish harbor the toxin from the dinoflagellates that they eat, shell-fishing sites where red tide has been found are closed. When humans eat infected shellfish, they quickly become very ill. The disease is called paralytic shellfish poisoning. If not diagnosed in a short time, death results.

Red Algae

Red algae, members of the phylum Rhodophyta, are multicellular marine seaweeds. The body of seaweed, as well as that of some plants and other organisms, is called a thallus and lack roots, stems, or leaves. Red algae use structures called holdfasts to attach to rocks. They grow in tropical waters or along rocky coasts in cold water. In addition to chlorophyll, red algae also contain photosynthetic pigments called **phycobilins**. These pigments absorb green, violet, and blue light- the only part of the light spectrum that penetrates water below depths of 100 m. Therefore, the red algae can live in deep water where most other seaweeds cannot thrive.



Brown Algae: that icky stuff you find dried up on the beach

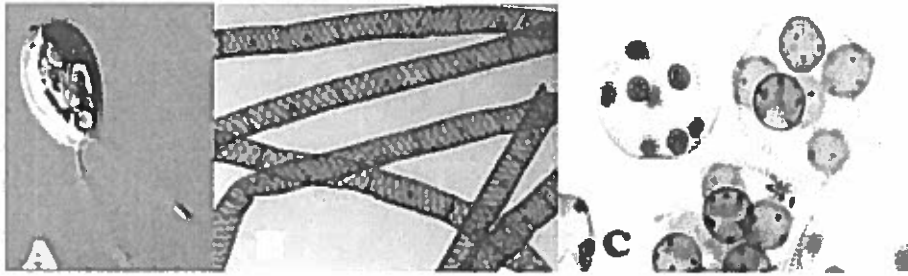
About 1500 species of multicellular **brown algae** make up the phylum Phaeophyta. Almost all of these species live in salt water along rocky coasts in cool areas of the world. Brown algae contain chlorophyll as well as a yellowish brown carotenoid called fucoxanthin, which gives them their brown color. Many species of brown algae have air bladders that keep their bodies floating near the surface, where light is available.

The largest and most complex brown algae are kelp. In **kelp**, the thallus is divided into the holdfast, stipe and blade as seen in the picture to the left. The holdfasts anchor kelp to rocks or the sea bottom. Some giant kelps may grow up to 60 meters long. In some parts of the world, such as off the California coast, giant kelps form dense, underwater forests. These kelp forests are rich ecosystems that provides a wide variety of marine organisms with their habitats.

Green Algae: How green are my algae

Green algae make up the phylum Chlorophyta. The green algae are the most diverse algae, with more than 7000 species. The major pigment in green algae is

chlorophyll, but some species also have yellow pigments that give them a yellow-green color. Most species of green algae live in freshwater, but some live in the oceans, in moist soil, on tree trunks, in snow, and even in the fur of sloths—large, slow-moving mammals that live in the tropical rain forest canopy.



Green algae can be unicellular, colonial, or multicellular in organization. Picture A is *Chlamydomonas* is a unicellular and flagellated green alga. Picture B is *Spirogyra* is

a multicellular species that forms slender filaments. The third picture shows *Volvox*, a green alga that can form a colony, a group of cells that lives together in close association.

A *Volvox* colony is composed of hundreds, or thousands, of flagellated cells arranged in a single layer forming a hollow ball-shaped structure. The cells are connected by strands of cytoplasm, and the flagella of individual cells face outward. The flagella can beat in a coordinated fashion, spinning the colony through the water. Small balls of daughter colonies form inside the large sphere. The wall of the large colony will eventually break open and release the daughter colonies.

Green algae reproduce both asexually and sexually. For example, *Spirogyra* reproduces asexually by fragmentation. During fragmentation, an individual breaks up into pieces and each piece grows into a new individual. Green algae and some other types of algae, have a complex life cycle. This life cycle consists of individuals that alternate between producing reproductive cells called spores and producing gametes. This pattern is called alternation of generations. An organism that has this pattern alternates between producing haploid and diploid generation.

The haploid form of an organism is called the gametophyte because it produces gametes. The gametes fuse to form a zygote from which the diploid form of the organism (the sporophyte) develops. Certain cells in the sporophyte undergo meiosis. Eventually these cells become haploid spores that can develop into a new gametophyte.

Golden Algae (Algae with the Midas touch)

The phylum Crystophyta contain about 850 species of organisms commonly called **golden algae**. Most of the golden algae live in fresh water, but a few are found in marine environment. The cells form highly resistant cysts that enable them to survive beneath frozen surfaces of lakes in winter and dry lakebeds during the summer. Two flagella of unequal length are located at one end of each cell.

Most species placed in this phylum are some shade of yellow or brown due to the presence of large amounts of carotenoids. They also have two types of chlorophyll. Golden algae store much of their surplus energy as oil and are important in the formation of petroleum deposits.

Part C: Slime molds, water molds, and downy molds: It came from the woodpile?

Certain groups of protists, the slime molds, the water molds and the down mildews, consist of organisms with some fungus like features. Recall that fungi are heterotrophic organisms that decompose organic material to obtain energy. Like fungi, the fungus like protists decompose organic materials.

There are three phyla of fungus like protists. Two of these phyla consist of slime molds. Slime molds have characteristic of both protozoans and fungi and are classified by the way they reproduce. Water molds and down mildews make up the third phylum of fungus like protist. Although fungus like protists are not an everyday part of human lives, some disease-causing species damage vital crops.

Slime molds: the name says it all

Many slime molds are beautifully colored, ranging from brilliant yellow to orange to rich blue, violet, and just black. They live in cool, moist shady places where they grow on damp, organic matter such as rotting leaves or decaying tree stumps and logs.

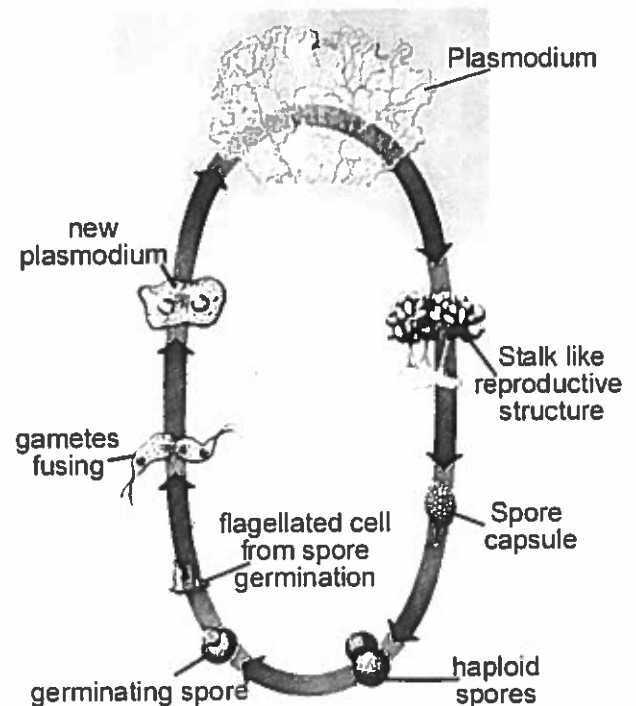
There are two major types of slime molds--plasmodial slime molds and cellular slime molds. The plasmodial slime molds belong to the phylum Myxomycota and the cellular slime molds make up another grouping, the phylum Acrasiomycota.

Slime molds are animal-like during much of their life cycle, moving about and engulfing food in a way similar to that of amoebas. However, like fungi, slime molds make spores to reproduce.

Plasmodial slime molds- speed demon of fungus like protists

Plasmodial slime molds get their name from the fact that they form a plasmodium, a mass of cytoplasm that contains many diploid nuclei but no cell walls or membranes. This slimy, multinucleate mass, as show in the picture to the left, is the feeding stage of the organisms. The plasmodium creeps like an amoeba over the surfaces of decaying logs or leaves. Some plasmodiums move at the blazing fast 2.5 cm/hour, engulfing microscopic organisms and digesting them in food vacuoles. At that rat, a plasmodium would cross this piece of paper in about 8 hours. Wow!!!!

A plasmodium may reach more than a meter in diameter and contain thousands of nuclei. However, when moisture and food become scarce in its surroundings, a plasmodium transforms itself into many



separate, stalked, spore-producing structures. Meiosis takes place within these structures and produces haploid spores, which the wind disperses. A spore germinates into either a flagellated or an amoeboid cell, or a gamete that can fuse with another cell to form a zygote. The diploid zygote grows into a new plasmodium. This life cycle can be seen in the picture to the right.

Cellular slime molds

Unlike plasmodial slime molds, **cellular slime molds** spend part of their life cycle as an independent amoeboid cell that feeds, grows and divides by cell division. When food becomes scarce, these independent cells join with hundreds or thousands of others to reproduce. Such an aggregation of amoeboid cells resembles a plasmodium. However, this mass of cells is multicellular—made up of many individual amoeboid cells, each with a distinct cell membrane. Cellular slime molds are haploid during their entire life cycle.

Water molds and downy mildews

Water molds and down mildews are both members of the phylum Oomycota. Most members of this large and diverse group of fungus-like protists live in water or moist places. Some feed on dead organisms and others are plant parasites.

Most water molds appear as fuzzy white growths on decaying matter. They resemble some fungi because they grow as a mass of threads over the food source, digest it, and then absorb the nutrients. But at some point in their life cycle, water molds produce flagellated reproductive cells—something that fungi never do. This is why water molds are classified as protists rather than fungi.

One economically important member of the phylum Oomycota is a downy mildew called *Phytophthora infestans* that causes a disease in potato plants. This downy mildew was the cause of the Irish Potato Famine in the mid-1800's. Because the Irish economy relied heavily on its potato crop, when the mildew infested the island, the economy went sour. Many people faced starvation in Ireland or immigration to America. Many chose immigration and have populated our large east coast cities of Boston, New York and Philadelphia.