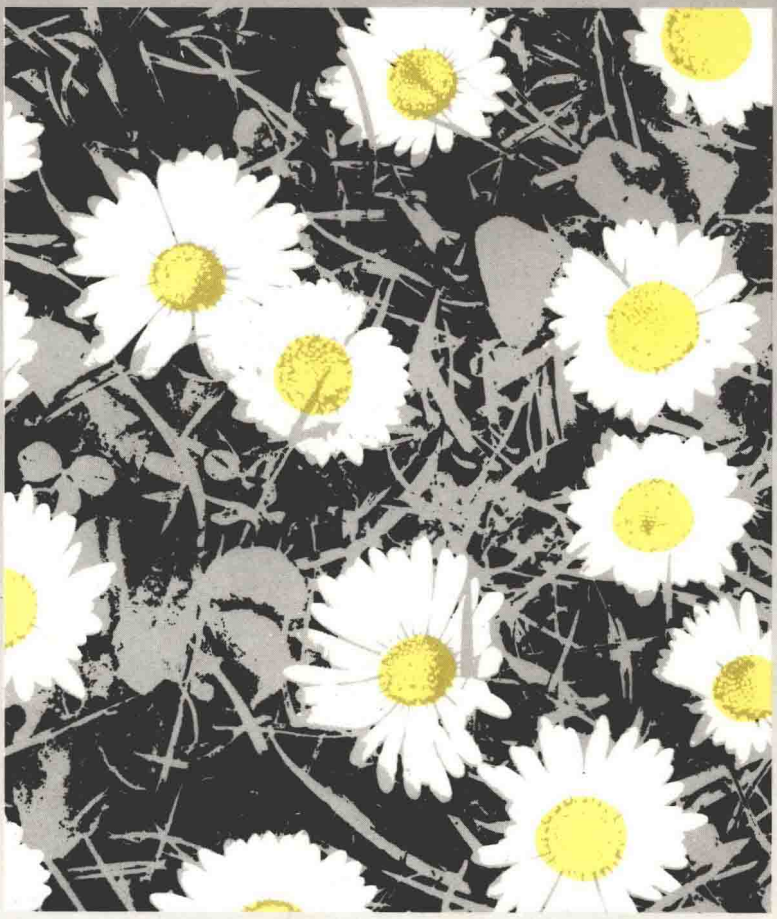
Handbook of PLANT TYPES



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Preface

The purpose of this book is to provide a guide to the classification and structure of the plant types that appear on most advanced level biology and botany syllabuses, and in other courses of this level.

The plant types are illustrated by means of annotated diagrams, each with a classification of the plant and notes on its habitat, reproduction, and other details which vary from plant to plant. Drawings are of a simple line type, showing features of biological interest, in the style required by the examining boards, and that could be reproduced by students. Plant classification includes the main group (division or phylum), the class, and one or two other subgroups. The plant may be illustrated by a generalised diagram of the genus, or of one particular species. The plant divisions considered are the Algae, Fungi, Lichenes, Bryophyta, Pteridophyta, and Spermatophyta. Life cycles are given where appropriate, and each flowering plant is shown as the half flower, floral diagram, floral formula, and fruit, with notes on pollination and fruit dispersal. The flowers are followed by sections on seeds and vegetative propagation. Bacteria are not considered because they cannot be seen clearly with the optical microscope. Scale is not given on the diagrams since it is expected that students will study actual specimens, and because some plants show considerable variation in size.

The plants chosen are those with which urban students will be familiar. The flowers illustrated are common and in bloom in early summer, or are those with a fruit which students would be expected to have studied. The moss shown is the very common wall moss, *Tortula*, not the rarer *Funaria* of the textbooks, and the mushroom described is the cultivated, not the field species. Seeds and seedlings are discussed in relation to man with, for example, the parts of the wheat grain used in various types of bread, and notes on the differences in the amino acids stored in cereals and legumes. There are sections on the economic importance of algae and fungi, and a list of food plants on our supermarket shelves, each with its Latin name, family, and the nature of the part eaten.

Classification has been kept as simple as possible with regard to A-level requirements, but accounts of the divisions include groups relevant to a study of evolution (such as *Rhynia, Ginkgo* and the cycads) and to ecology (such as the characteristics of all ten classes of algae), as well as the plants required for a study of the diversity of plant life.

Since syllabuses vary, each annotated diagram and life cycle can be read more or less in isolation without sifting through unwanted material, but emphasis is placed on evolutionary relationships and the concept of alternation of generations in the life cycles of plants. In the classification sections, characteristics are given in note form; for all levels bellows that of a division, characteristics are listed as numbered points and can be made into comparison tables by students. Botanical terminology is defined in the glossary. Where there are alternative names for a structure, one term is used consistently in the text and the alternatives are included in the glossary.

It is intended that this book will fill the gap between the modern comprehensive functional approach type of textbook and the older structural botanical tomes which provide far more detail than is required in today's syllabuses.

Introduction: plant classification

The main categories used in plant classification are:

Kingdom
Division (or phylum)
Class
Order
Family
Genus (plural genera)
Species

The term subdivision is sometimes used between division and class, especially in seed plants, and the term subclass is used between class and order.

A species has two names, the genus (generic) name and the specific epithet. This is known as a binomial or binominal. The naming of species is called binomial nomenclature, and follows a system worked out by the Swedish botanist Linnaeus in the eighteenth century, so it is also called the Linnaean system. The names of species and genera are printed in italics and underlined in manuscript. All other categories are printed in Roman type and are single words, known as uninomials.

There are certain rules and conventions governing the naming (nomenclature) of plants. These rules are codified in the International Code of Botanical Nomenclature (I.C.B.N.) which is updated every few years. The I.C.B.N. has laid down rules for the endings (suffixes) of the categories, so that the level of a group can easily be recognised. For example, orders end in -ales, such as Agaricales, Filicales, and families end in -aceae, such as Ranunculaceae, Liliaceae. From the order level downwards, these suffixes are the same for all plants, but above the order level they are different for algae, fungi, and all other plants. The suffixes are:

	Algae	**Fungi**	**Other plants**
Division	-phyta	-mycota	-phyta
Subdivision	-phytina	-mycotina	-phytina
Class	-phyceae	-mycetes	-opsida
Subclass	-phycidae	-mycetidae	-idae
Order	-ales	-ales	-ales
Family	-aceae	-aceae	-aceae

Although most families end in -aceae, there are nine exceptions in flowering plants, sanctioned by long usage. The Compositae, Gramineae, Labiatae, Leguminosae and Palmae are some of these exceptions.

The above system has only been introduced quite recently and was finalised in the 1970s. There are two main problems with using it; firstly that old and varied terminology is still frequently used, and secondly that there is disagreement among experts about the status of plant groups. For example, if the Algae is considered to be a division, it should be renamed Phycophyta; green algae are then a class called Chlorophyceae, brown algae are Phaeophyceae, etc. But some experts think that Algae should be given an indeterminate status above a division but below a kingdom, and the classes should be raised to division status as Chlorophyta, Phaeophyta, etc. The same problem arises with the Fungi. In some systems the Fungi are considered to form a division, sometimes called Mycophyta, while in other systems the Fungi are given a status above that of a division, sometimes even that of a kingdom, and the slime moulds and true fungi are then given division status as Myxomycota and Eumycota.

Among the other plants, these new suffixes make well known groups difficult to recognise. For example, the mosses, formerly known as Musci, have been renamed Bryopsida, and the dicotyledons should now be called Magnoliopsida. Ferns are properly called Filicopsida or Polypodiopsida, or sometimes Pteropsida, but the old name of Filicineae is still seen. The term Pteropsida is confusing because it is sometimes used for a group which includes ferns, gymnosperms and angiosperms on the grounds that they are closely related. Angiosperms are properly called Magnoliophytina and Gymnosperms are Coniferophytina.

In the text, an intermediate course is taken between the correct new system and the old familiar one. The terms Angiosperms, Gymnosperms, Dicotyledons and Monocotyledons are used as proper classification terms, but Bryopsida and Hepaticopsida are used for mosses and liverworts. In the fungi, subgroups commonly used are given subclass status but the proper subclass suffix is not used. This is because students are more likely to meet the terms Discomycetes, Pyrenomycetes, etc., than Discomycetidae, Pyrenomycetidae, especially since the status of the groups vary, and the former terms are sometimes used as common names.

The formation of common names from the Latin is complex and somewhat arbitrary. We are familiar with it in everyday life. The genus *Antirrhinum* is printed in italics and with a capital letter, but the term is also used as a common name, antirrhinum. Both forms are correct and their use depends on context. The same is true of rhododendron, delphinium and many other plant names. It is also true, with a little more subtlety for algae, fungi, angiosperms, gymnosperms, monocotyledons and dicotyledons. When discussing ''the division Algae'' a capital letter is used, but when discussing ''freshwater algae'' it is not. Most names both lose their capital letter and change their ending when used as common names, as in the case of the division Bryophyta which becomes bryophytes, and a member of the Ascomycetes which becomes an ascomycete, and so on. In general, when a term is used with its category name, a capital letter and the correct suffix are found; when a term is used as a common name, a lower case first letter and an anglicised ending are used. Both are seen in the text here, as occasion demands. Students can be confused about this, especially as common names are used on some syllabuses.

Quite recently, two new and very important terms have come into general use. These are Prokaryota (prokaryotes, procaryotes) and Eukaryota (eukaryotes, eucaryotes). The Prokaryota includes those organisms which do not have a true nucleus with a nuclear membrane and whose DNA is not organised into chromosomes. It comprises the bacteria and blue-green algae only. The Eukaryota includes those organisms whose DNA is found in a nucleus, surrounded by a nuclear membrane and organised into chromosomes during cell division. The Eukaryota comprises all organisms except bacteria and blue-green algae, i.e. all other plants and animals. The distinction between pro- and eukaryotes is thought to be the most basic among living organisms. The flagellates, from which plants and animals are thought to have evolved, arose from eukaryotic organisms. Since bacteria and blue-green algae are considered to be closely related, they are often placed together in a division called the Schizophyta, where the blue-green algae are called Schizophyceae and the bacteria are called Schizomycetes.

Besides the great differences between prokaryotes and eukaryotes, some authorities consider that the differences between members of the Eukaryota are so important

that there should be more than the two kingdoms of plants and animals. As mentioned above, fungi are often placed in a third and separate kingdom, but a number of classification systems for living organisms have been proposed, with suggestions ranging from three to six kingdoms. One of these suggestions, that of a five-kingdom system, has received much support. This was originally proposed by R. H. Whittaker of Cornell University in papers written in 1959 and 1969, modified by L. Margulis and K. V. Schwartz in 1982, and sometimes called the Margulis 1974 classification.

The five-kingdom system is as follows:

1 Kingdom Monera
Prokaryotic organisms.
(a) Bacteria
(b) Blue-green algae

2 Kingdom Protoctista or Protista
Eukaryotic unicellular organisms and their immediate descendents.
(a) All eukaryotic algae (including seaweeds)
(b) Flagellated fungi, i.e. water moulds, slime moulds
(c) Protozoa

3 Kingdom Fungi
Fungi without flagellated stages.

4 Kingdom Animalia
Multicellular animals including sponges.

5 Kingdom Plantae
Multicellular green plants.
(a) Bryophyta
(b) Pteridophyta
(c) Spermatophyta

There are a number of other classification terms in common use.
Thallophyta: a group whose body is not divided into roots, stems and leaves. Originally this group included algae, fungi, lichens and bacteria, but its constituents have varied in the course of time.
Cormophyta: a group whose body is divided into roots, stems and leaves. This group includes the pteridophytes and spermatophytes, and sometimes the bryophytes.
Archegoniatae: a group whose female sex organs are archegonia. This group always includes bryophytes and pteridophytes, and sometimes the gymnosperms since they have reduced but definite archegonia.
Embryophyta: a group which produce a multicellular embryo within the parent plant. This group includes the bryophytes, pteridophytes and spermatophytes.
Tracheophyta: the plants with vascular tissue (i.e., tracheids). This group includes the pteridophytes and spermatophytes.
Cryptogamia and Phanerogamia: these are two obsolete terms still sometimes seen. Cryptogams are plants which reproduce by spores, and phanerogams are plants which reproduce by seeds.

Division Algae

Characteristics

Photosynthetic plants in which the plant body is unicellular, colonial, thalloid, or parenchymatous, but does not form root, stem and leaves.

Possess a range of carotenoid and biloprotein (phycobilin) accessory pigments which are important in classification, as well as chlorophyll.

Mainly aquatic, marine or fresh water; a few live in damp places on land.

Reproduce by spores.

Sex organs are not surrounded by sterile tissue, i.e. are not archegonia, except in the Charophyceae (which is often included in the Chlorophyceae).

Zygote does not develop into a multicellular embryo inside the female sex organ.

Summary classification of the division

Division Algae

Class Cyanophyceae	Class Chrysophyceae
Class Euglenophyceae	Class Pyrrophyceae
Class Chlorophyceae	Class Cryptophyceae
Class Xanthophyceae	Class Phaeophyceae
Class Bacillariophyceae	Class Rhodophyceae

Some authorities reduce or increase the number of classes.

In some systems of classification, the Algae is considered to be a group of above division status. The classes are then raised to division level and known as Cyanophyta (Myxophyta), Euglenophyta, Chlorophyta, Xanthophyta, Bacillariophyta, Chrysophyta, Pyrrophyta, Cryptophyta, Phaeophyta, Rhodophyta.

Class Cyanophyceae or Myxophyceae (blue-green algae)

1 Possess chlorophyll and the accessory biloprotein (phycobilin) pigments phycocyanin (blue) and phycoerythrin (red) usually with more phycocyanin, giving the blue colour.
2 Cell wall is made of peptidoglycan (mucopeptide).
3 Food reserves are cyanophycean starch and cyanophycin (protein).
4 Includes unicellular, colonial and filamentous forms.
5 No flagella.
6 Much smaller than other algae.

e.g. *Nostoc, Oscillatoria*.

This group is prokaryotic, while all other algae are eukaryotic. Blue-green algae are thought to be more closely related to bacteria, and may be placed with bacteria in the division Schizophyta. The bacteria are then considered to be a class of Schizophyta called Schizomycetes, and the blue-green algae are a class called Schizophyceae.

Class Euglenophyceae (euglenoids)

1 Possess chlorophyll and carotenoids.
2 Cell wall is absent, and they are also classified as flagellate protozoans.
3 Food reserve is paramylum.
4 Most are unicellular, a few colonial.

e.g. *Euglena*.

Euglenoids are claimed as both plants and animals and are probably intermediate organisms from which plants and animals evolved.
Plant characteristics: (1) photosynthetic; (2) similar to green algae like *Chlamydomonas,* except that they do not have cell walls.
Animal characteristics: (1) can live heterotrophically; (2) similar to flagellates like *Trypanosoma,* except that they can photosynthesise; (3) no cell walls; (4) food reserves not starch.

When classified as animals, euglenoids are placed in the phylum Protozoa, class Flagellata, subclass Phytoflagellata or Phytomastigina.

Class Chlorophyceae (green algae)

1 Possess chlorophyll and some carotenoids, and appear green.
2 Cell wall is usually made of cellulose, but some are without cell walls and are also considered to be protozoans.
3 Food reserve is true starch.
4 Includes unicellular, colonial, filamentous and parenchymatous forms. Some unicellular forms are members of the phytoplankton, especially a group called desmids. Filamentous forms may be rooted, or attached to a surface, or free floating, and larger parenchymatous forms are green seaweeds.

e.g. *Chlorella, Chlamydomonas, Pleurococcus,* which are all unicellular, *Volvox* which is colonial, *Cladophora, Spirogyra,* which are filamentous, *Ulva* (sea lettuce) which is parenchymatous.

The Chlorophyceae is one of the largest groups of algae. It is sometimes divided into two classes, the Chlorophyceae and the Charophyceae. The Charophyceae includes the stoneworts such as *Chara,* which look rather like horsetails and are somewhat different from other algae.

Class Xanthophyceae (yellow-green algae)

1 Possess chlorophyll and many carotenoid pigments, giving them a yellowish colour.
2 Cell wall may be absent, and some members are considered to be flagellate protozoans; if a wall is present, it has much pectic material and is often silicified.
3 Food store is oil or fat.
4 Mostly unicellular or filamentous, some amoeboid; very common in phytoplankton.

e.g. *Botrydium, Chloramoeba.*

Class Bacillariophyceae (diatoms)

1 Possess chlorophyll with several xanthophylls, especially fucoxanthin.
2 Cell wall is made of pectin and silica, and is composed of two halves, overlapping like a date box or petri dish, and called a frustule.
3 Food reserves are chrysolaminarin and fat.
4 Unicellular or colonial; common in phytoplankton.

There are two subgroups:
Order Pennales (pennate diatoms): shaped like a date box, e.g. *Pinnularia.*
Order Centrales (centric diatoms): shaped like a petri dish, e.g. *Coscinodiscus.*

Class Chrysophyceae (golden algae)

1 Possess chlorophyll and the brown pigments fucoxanthin and diadinoxanthin.
2 Cell wall is always absent, but cell membrane may become silicified.
3 Food reserves are oil and chrysolaminarin.
4 Mostly unicellular; very common in phytoplankton.
e.g. *Chromulina* and the coccolithophorids whose skeletons formed the sediment that was compressed to form chalk.

Class Pyrrophyceae (dinoflagellates)

1 Possess chlorophyll and special carotenoids unique to the group.
2 Cell wall is made of plates or valves, or may be absent, and these members are also considered to be protozoans.
3 Food reserves are mannitol and starch.
4 Unicellular, and more rarely palmelloid and filamentous forms; the unicellular forms are called dinoflagellates, and are common in the phytoplankton.
e.g. *Ceratium, Gymnodinium, Peridinium*.

Class Cryptophyceae

This is a very small class which was once included in the Pyrrophyceae. Members usually have no cell walls, and have been considered to be protozoans.
e.g. *Cryptomonas*.

Class Phaeophyceae (brown algae)

1 Possess chlorophyll and the brown pigment fucoxanthin, so appear brown.
2 Cell wall contains alginic acid and fucinic acid.
3 Food reserve is laminarin.
4 Plant body is more complex than in any other group except red algae, and includes filamentous, thalloid and parenchymatous forms; mostly large, marine, brown seaweeds.
e.g. *Ectocarpus*, which is filamentous, *Ascophyllum* (wrack), *Fucus* (wrack), *Laminaria* (kelp or oarweed), *Pelvetia*, all of which are thalloid seaweeds.

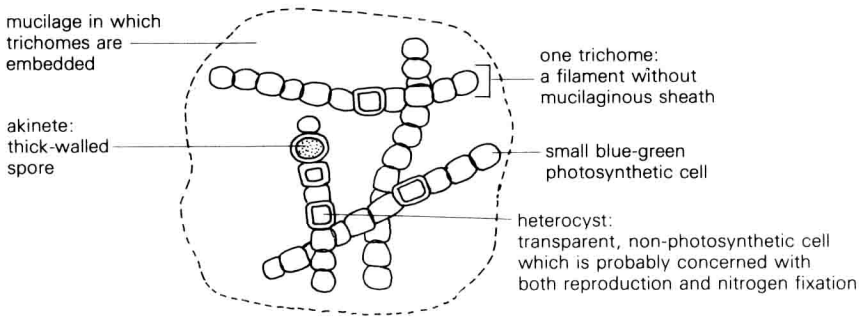
Class Rhodophyceae (red algae)

1 Possess chlorophyll and the accessory biloprotein (phycobilin) pigments phycocyanin and phycoerythrin so they appear red.
2 Cell wall includes cellulose and polysulphate esters.
3 Food reserves are floridean starch and floridoside.
4 Usually thalloid, but also unicellular, filamentous and parenchymatous types are known; mainly marine red seaweeds, some impregnated with lime.
5 No flagella (only group of eukaryotic algae with none).
6 Very complex life cycles.
e.g. *Bangia, Chondrus* (carragheen), *Porphyra* (laver), *Rhodymenia* (dulse).

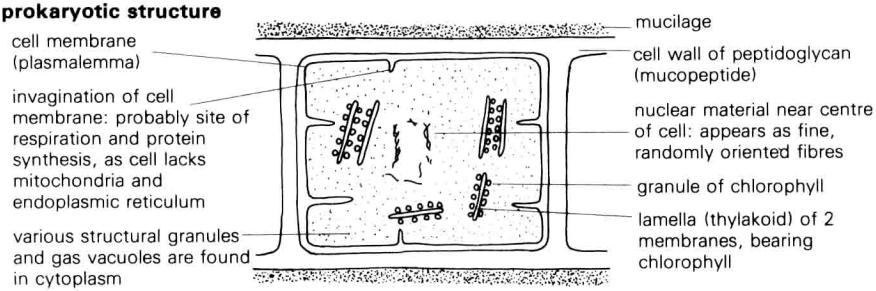
Division	Algae
Class	Cyanophyceae
Order	Nostocales
Genus	*Nostoc*

Nostoc

Several trichomes of *Nostoc* embedded in a common mass of mucilage



Simplified diagram of one cell of a trichome of a generalised blue-green alga with mucilage sheath, as seen under electron microscope to show prokaryotic structure



Habitat: ponds, streams, ditches, damp rocks; some species form the algal partner of some lichens, or have a symbiotic association with the roots of certain higher plants, where they are concerned with nitrogen fixation.

Non-sexual reproduction

(1) By fragmentation of filaments; specialised hormogonia (short lengths of trichome with rounded ends) are formed and give rise to new trichomes. In some genera, trichomes are formed by breaks at heterocysts (see glossary).

(2) By special thick-walled spores called akinetes (see glossary).

Sexual reproduction: has not been observed in blue-green algae, but a parasexual process called genetic recombination has been found in some genera.

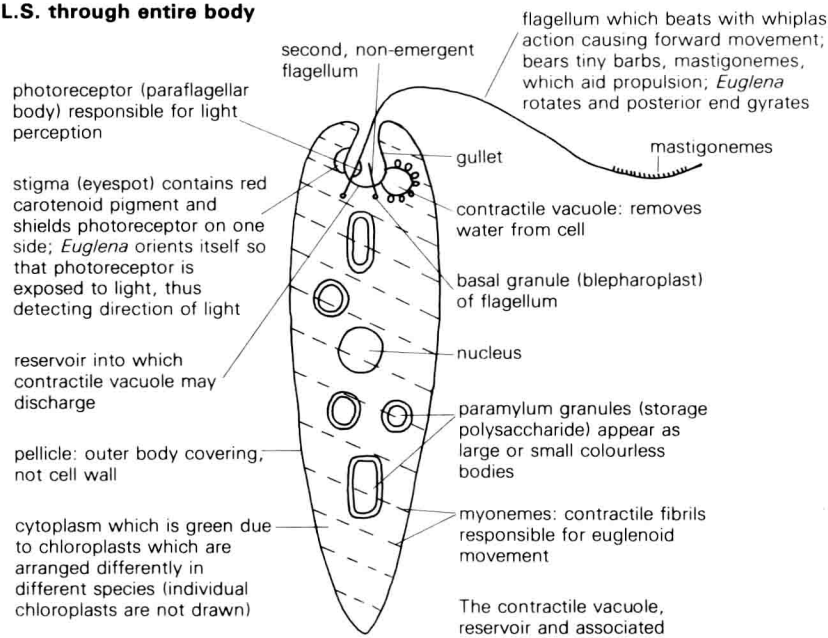
Notes: *Nostoc* is capable of nitrogen fixation in the soil, converting nitrogen gas to ammonia. Heterocysts may be the site of nitrogen fixation, which probably cannot occur in the presence of oxygen produced in photosynthesis since it requires reducing conditions. Nitrogen fixation by *Nostoc* is important in Asia in rice paddy fields.

In some genera, each trichome is surrounded by mucilage, e.g. *Oscillatoria;* in others there may be many parallel trichomes surrounded by a common sheath, e.g. *Microcoleus,* while in *Nostoc* the trichomes are contorted and embedded in a mucilage mass to form a spherical shape.

Euglena

Division	**Algae**
Class	**Euglenophyceae**
Order	**Euglenales**
Genus	***Euglena***

L.S. through entire body



Diagrams to show euglenoid movement

Changes in shape of the cell.

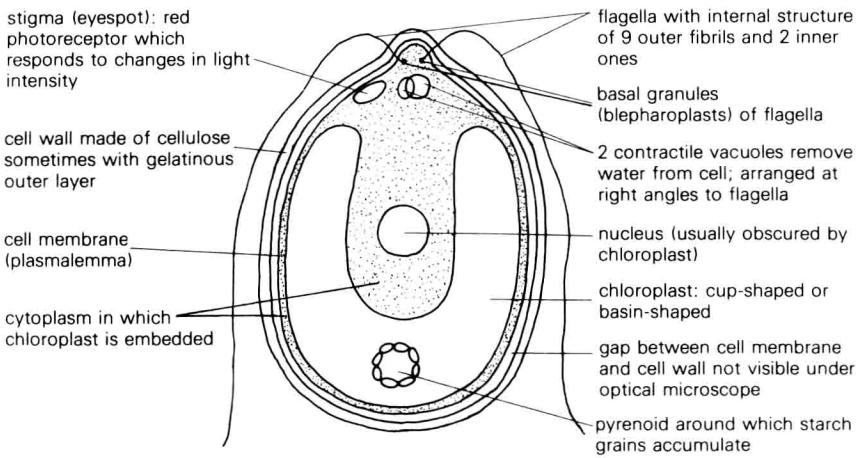
These changes in shape are clearly visible in live specimens under the microscope, and are brought about by contraction of myonemes.

Habitat: ponds, ditches and puddles, especially in water containing organic matter.
Reproduction: non-sexual only, by longitudinal binary fission. It can also form a temporary palmella stage (see *Chlamydomonas*, page 15).
Nutrition: in the light, it usually photosynthesises, but in the dark it can undergo saprophytic nutrition, using organic molecules in the water. Unlike most plants, it cannot make vitamins B_1 or B_{12}.
Behaviour: *Euglena* swims towards light of moderate intensity (positive phototaxis) but away from very bright light (negative phototaxis), enabling it to move to optimum light intensity for photosynthesis.
Notes: *Euglena* is considered to be both a plant and an animal, and is probably similar to the ancestral eukaryotic flagellate organisms from which both plants and animals are thought to have evolved (see page 11).

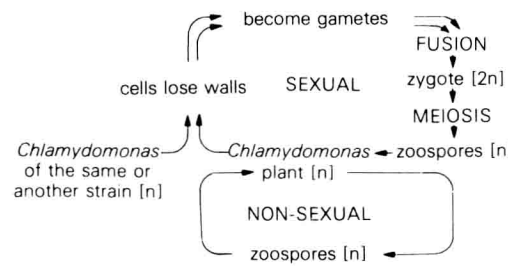
Division	**Algae**
Class	**Chlorophyceae**
Order	**Volvocales**
Genus	***Chlamydomonas***

Chlamydomonas

L.S. through pear-shaped motile unicellular structure



Haplontic life cycle



Gametes may be isogametes or anisogametes, depending on species.

Habitat: fresh water as part of the phytoplankton. A few species live in the sea and brackish water; one on snow, some on waterlogged soil.

Non-sexual reproduction

(1) By zoospores: flagella are withdrawn and the plant divides into two or more daughter cells within the wall of the parent. Daughter cells develop flagella and cell walls, and are called zoospores. They break free and form new plants.

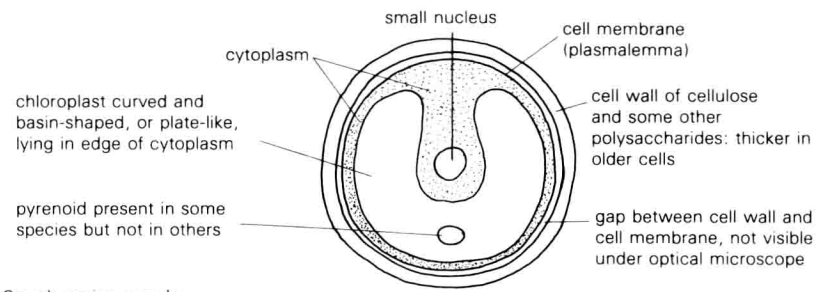
(2) In unfavourable conditions, particularly when water is scarce, the release of daughter cells is delayed and they go on dividing inside the parent envelope, which becomes mucilaginous. This is called the palmella stage.

Sexual reproduction

Individuals of different (or sometimes the same) mating types come together; they shed their cell walls and become gametes. Then pairs of gametes fuse to form zygotes. Each zygote develops a coat, and undergoes meiosis to form four zoospores which grow into new *Chlamydomonas* plants. This is a haplontic life cycle; only the zygote is diploid, all other stages are haploid.

Chlorella		
	Division	Algae
	Class	Chlorophyceae
	Order	Chlorococcales
	Genus	*Chlorella*

L.S. through non-motile, unicellular, spherical structure



Starch grains may be present in older cells.

Production of autospores

parent cell with 2 autospores

parent cell with 4 autospores

parent cell releasing autospores

Up to 16 autospores may be produced in one parent cell.

Habitat: stagnant water, forming a green suspension; some species live symbiotically in *Hydra* and in some protozoans, e.g. *Stentor*.
Reproduction: is non-sexual only. Cells divide inside the parent wall to form non-motile spores called autospores or aplanospores, which are released by breakdown of the parent wall. Sexual reproduction has not been observed.
Use: (1) *Chlorella* is used in physiological experiments on carbon dioxide in photosynthesis, as it is thought to have chlorophyll similar to that of higher plants. It is good laboratory material in that it is easy to grow, and can be used in easily measurable quantities. (2) Attempts have been made to grow *Chlorella* as food since it has a high protein content, but production is too expensive for commercial exploitation.
Notes: *Chlorella* appears rather similar to *Pleurococcus* in vegetative form, but *Chlorella* is in the order Chlorococcales and *Pleurococcus* is in the Chaetophorales (see *Pleurococcus,* page 17).