Discipline Courses-I
Semester-I
Paper: Phycology and Microbiology
Unit-VII
Lesson: Chlorophyceae- Introduction
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Chapter: Chlorophyceae

Introduction

Divison Chlorophyta includes a diverse assemblage of photosynthetic organisms commonly known as green algae. These organisms are largely aquatic and are present in marine (seawater) and fresh waters. The organisms can be unicellular, multicellular, coenocytic (more than one nucleus in a cell) or colonial representatives. Chlorophytes are eukaryotes with an organised (membrane enclosed) cell nucleus containing DNA and organised plastids (chloroplasts containing abundant green pigments- chlorophyll *a* and *b* and various carotenes and xanthophyll). Photosynthesis occurs in chloroplasts.

In this unit you will study the Division **Chlorophyta** and its Class **Chlorophyceae**. The objectives of this chapter are to learn about:

1. Ecological and scientific relevance of Chlorophytes.
2. Where do they occur?
3. Range of thallus organization among Chlorophyta.
4. General characters of form and function with special reference to Chlorophyceae.
5. What are the key similarities between Chlorophyta and land plants?
6. Classification: old and new classification systems, what are the various criteria for classification, what is 'Core Chlorophyta', "UTC clade" and its three classes with special reference to the class "Chlorophyceae".
7. The five orders within Chlorophyceae with special reference to Chlamydomonadales and Oedogoniales.

Why are they important to us?

Due to their role as **primary producers** in aquatic food webs, Chlorophytes have a high ecological relevance, being thus of great scientific importance. They generate oxygen through photosynthesis and sequester large amounts of atmospheric CO_2 in the ocean interior (Field et al., 1998) and provide food for other organisms. Some of the green algae such as *Chlamydomonas*, *Chlorella, Volvox*, *Acetabularia* etc. are also being used as **model organisms** in laboratories.

Some well-known Chlorophytes

- *Ostreococcus taurii* is the smallest known free living eukaryote.
- *Chlorella* was used by Melvin Calvin for the elucidation of light-dependent reactions of photosynthesis (Calvin cycle).
- *Acetabularia* was used by Joachim Hammerling for the transplantation experiments to demonstrate the role of nucleus in carrying genetic information and cellular development.
- *Chlamydomonas reinhardtii* has been used as a model system for studying chloroplast biogenesis, photosynthesis, flagellar assembly and function, cell cycle control and circadian rhythms.
- The colonial green alga *Volvox* has served as a model for the evolution of multicellularity, cell differentiation, and colony motility (Kirk, 1998; Kirk, 2003; Herron and Michod, 2008; Herron et al., 2009).

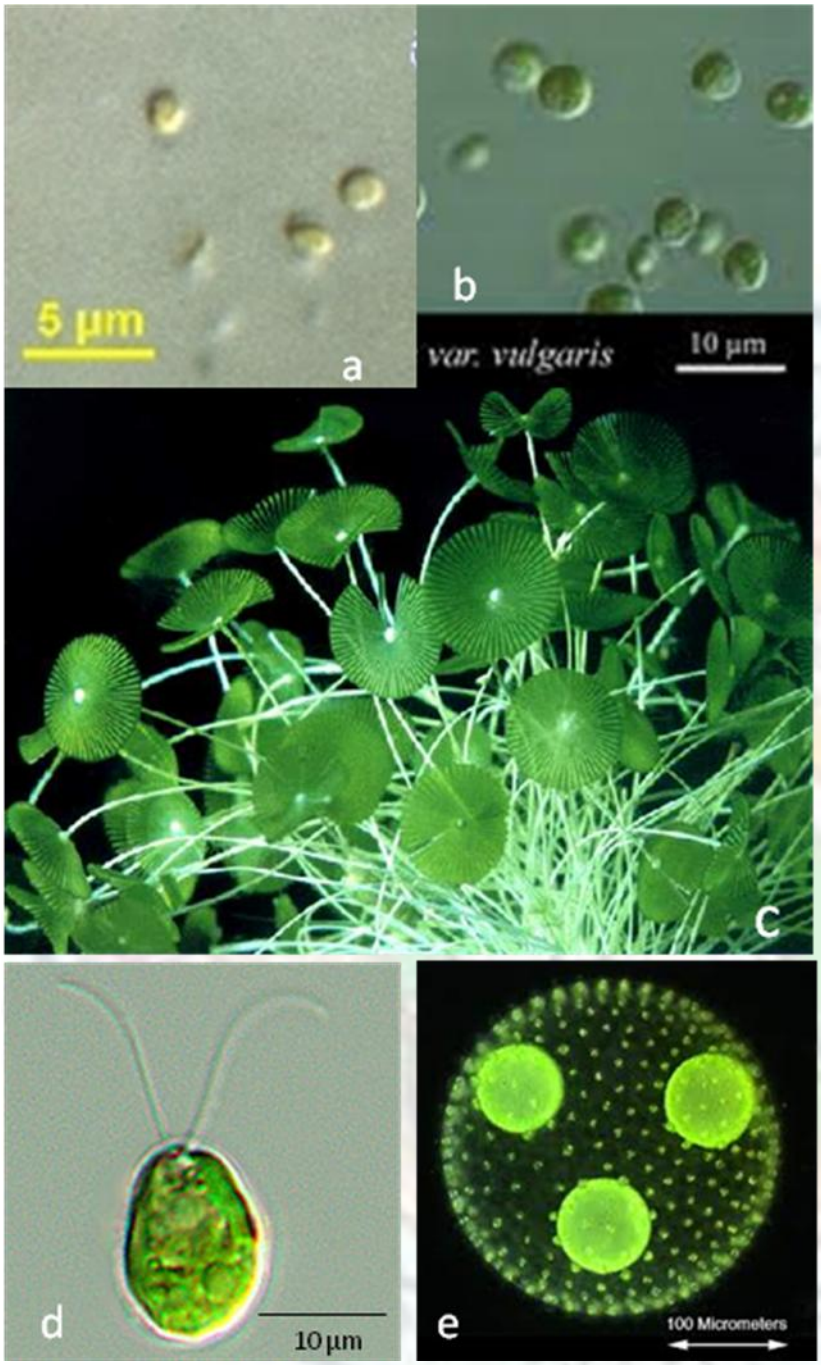

Figure: (a) *Ostreococcus,* **(b)** *Chlorella,* **(c)** *Acetabularia,* **(d)** *Chlamydomonas*, **(e)** *Volvox*

Source: http://www.marinespecies.org/aphia.php?p=taxdetails&id=345497

http://plantphys.info/plant_biology/labaids/zygnemophyceae.shtml

https://wiki.umn.edu/IBS8102/030410-Molnar

http://deptsec.ku.edu/~ifaaku/jpg/Inouye/Inouye_01.html

http://www.flickr.com/photos/algreer/17087738/

Habitat: where do they occur?

Most of the Chlorophytes are **aquatic** and are predominantly freshwater; only about 10% of the aquatic forms are marine. Some Chlorophytes are **terrestrial** as well.

Among the aquatic forms, most of the Ulotrichales have freshwater forms whereas members of Caulerpales are predominantly marine. Oedogoniales have exclusively freshwater forms. *Spirogyra* and *Hydrodictyon* frequently form noticeable but harmless **blooms** that may cover the surface of freshwater ponds. A few members of Chlorophyta commonly occur in nearshore marine environments forming nuisance macroscopic growths e.g. *Ulva* (sea lettuce), *Codium* (dead man's fingers), *Enteromorpha, Cladophora.*

Species of *Ulothrix,* and *Zygogonium* are sub-aerial, and are usually found on damp soil in the form of sheets. *Trentepohlia* forms orange-red growths on moist rocks or cliff faces due to the accumulation of carotenoid pigments which obscure chlorophyll. Species of *Protococcus* and *Trentepohlia* are **epiphytic** on sea weeds or on the bark of trees, whereas *Chlorella* (Figure **g**) is **endophytic** i.e. they live inside a host organism. *Cephaleuros* and *Rhodochytrium* are **parasitic**, and they lack green colour. *Cephaleuros* is a parasitic form which causes red-rust disease of tea leaves. Some species occur in unusual habitats; for example, *Chlamydomonas yellowstonensis, Chlamydomonas nivalis* and *Haematococcus nivalis* occur on the snow covered mountain tops and can impart a characteristic colour (which varies from red to orange to yellow) to the snow due to the accumulation of carotenoid pigments. ***Chlamydomonas nivalis*** is cryophilic (cold loving) and flourishes in freezing waters. It contains a red carotenoid pigment known as **astaxanthin** in addition to chlorophyll and imparts a red colour to the snow referred to as **watermelon snow.** Some green algae in association with certain fungi form lichens.

Figure: *Cladophora* branched thalli that break off and generate noxious (harmful) odor during decay

Source: http://aquariumpoetry.blogspot.in/

Figure: (a-f) Occurrence and distribution of a few Chlorophytes **(g)** *Chlorella* cells inside the cytoplasm of *Paramecium bursaria*

Source:http://emilyd47.blogspot.in/2011/07/freshwater-algae.html; https://en.wikipedia.org/wiki/Algal_bloom;http://www.fastcompany.com/1527858/algae-maybe-not-miracle-biofuel-we-all-thought-it-was;http://www.topnews.in/usa/algae-knew-about-quantum-mechanics-2-bln-yrs-humans-23400;http://protist.i.hosei.ac.jp/pdb/images/ciliophora/paramecium/bursaria/sample_4.jpg

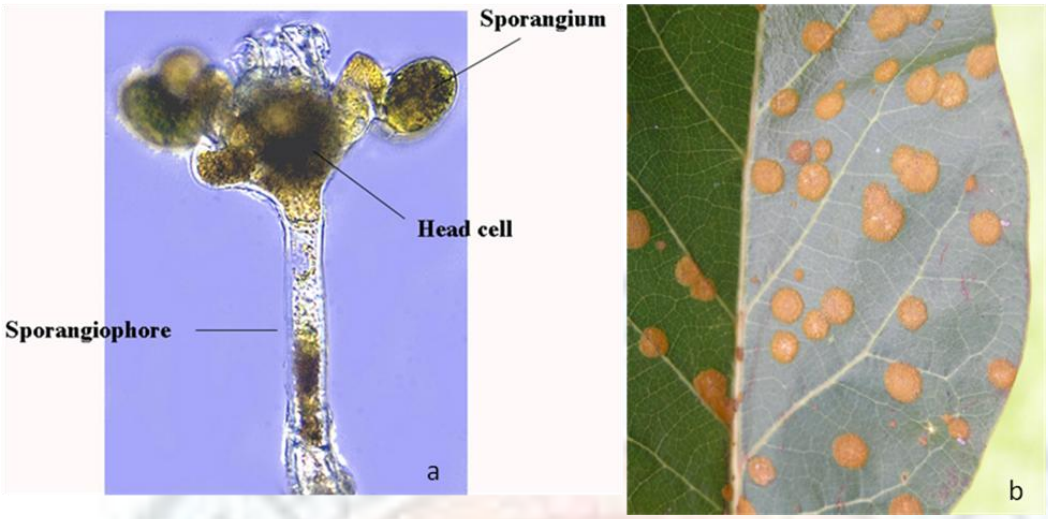

Figure: (a) *Cephaleuros virescens,* a parasitic alga causing red rust on tea leaves; **(b)** "red rust of tea"

Source:http://ucjeps.berkeley.edu/constancea/83/lopez_etal/trent_fig15.jpg,http://growables.org/information/TropicalFruit/avocadoalgalspotnew.htm

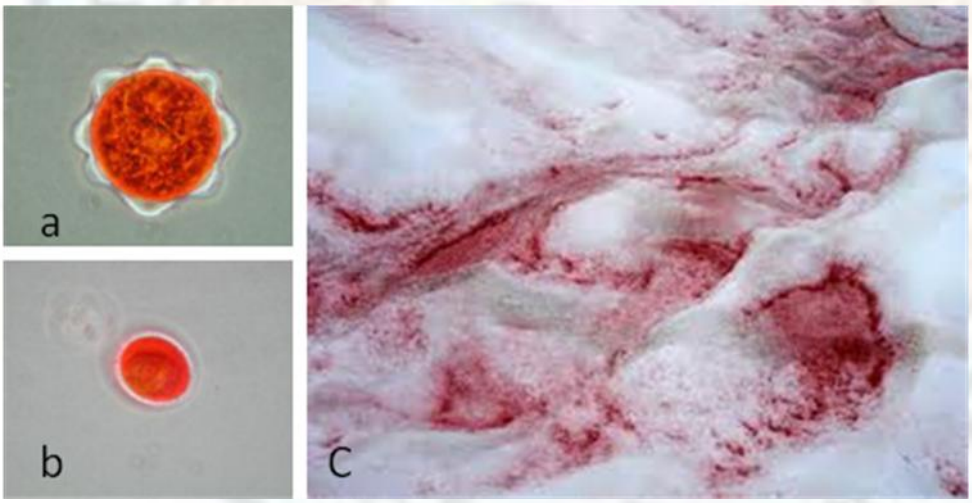

Figure: a,b *Chlamydomonas nivalis* an alga that accumulates red carotenoid pigments **c,** **"**Watermelon snow"- red colour of the snow is due to *Chlamydomonas nivalis*

Source:http://lacienciaysusdemonios.com/2010/01/11/psicrofilos-amantes-del-frio/, http://countryroostgardens.blogspot.in/2010/12/10-things-about-snow.html

Habit and structure: Range of thallus organization

In Chlorophytes there is no differentiation of root, stem and leaves; hence the plant body is **thalloid** in nature. The thallus may be single-celled or many-celled and shows **evolutionary progression** from simple to more complex types of construction. Chlorophytes are a heterogenous group exhibiting a wide range in their thallus structure and morphology beginning from simple microscopic motile unicellular forms through multicellular flagellated or non flagellated colonies, palmeloid forms, dendroid forms, filamentous forms, heterotrichous forms, siphonous forms to well developed parenchymatous thalli.

I. Unicellular thallus

It is the **simplest type** of construction within Chlorophyta. Unicellular thallus is of two types:

(i) Unicellular **motile** thallus: Vegetative cells have two or four flagella and are motile (e.g., *Chlamydomonas, Tetraselmis, Sphaerella*)

(ii) Unicellular **non-motile** thallus: These cells do not possess flagella, eyespot etc., meant for locomotion. (e.g., *Chlorella, Chlorococcus*).

Figure: *Chlamydomonas* cell- unicellular motile thallus

Source: http://content62.eol.org/content/2012/07/30/05/99002_580_360.jpg

II. Colonial thallus

The colonial habit is achieved by aggregation of the products of cell division within a mucilaginous mass, by aggregation of motile cells or juxtaposition of cells subsequent to cell divisions.

(i) **Coenobium**: A colony with a **definite** shape, size and arrangement of cells. The number of cells in a coenobium is determined at the juvenile stage and subsequently there is only increase in size. Coenobia may be motile with flagellated cells (e.g., *Eudorina, Pandorina, Volvox*) or non-motile having cells without flagella (*Pediastrum, Hydrodictyon*).

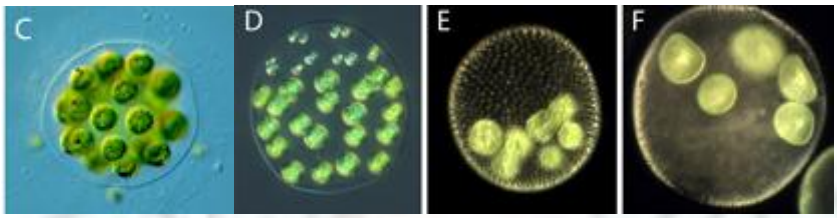

Figure: Coenobia of *Eudorina, Pandorina* and *Volvox*

Picture courtesy:Dr. Frederik Leliaert

Figure: *Hydrodictyon*-the water net

Source:http://hydrodictyon.eeb.uconn.edu/people/llewis/hydrodictyonB.jpg;http://commons.wikimedia.org/wiki/File:Hydrodictyon_reticulatum.jpg

(ii) **Palmelloid**: In contrast to coenobial forms, in a palmelloid colony the number of cells, their shape and size is **not definite**. The cells remain irregularly aggregated within a common mucilaginous matrix, but they are independent and function as individuals. In some palmelloid forms it is a temporary phase (e.g. *Chlamydomonas*), whereas in others it is a permanent feature (e.g., *Tetraspora*)

(iii) **Dendroid**: The colony appears like a microscopic tree. The number, shape and size of cells is indefinite and a mucilaginous thread is present at the base of each cell. Threads of different cells are united to form a branched structure (e.g., *Ecballocystis*).

III. Filamentous forms

(i) Filamentous **unbranched**: Simple unbranched filaments may be free floating (e.g., *Spirogyra*) or attached to some substartum (e.g., *Ulothrix, Oedogonium*)

(ii) Filamentous **branched**: In *Cladophora* simple branched filaments remain attached to the substratum by a basal cell. In such filamemnts branches arise just below the septa between any two adjacent cells except the basal cell.

(iii) **Heterotrichous**: The thallus is very much evolved and differentiated into prostrate and erect systems (e.g., *Fritschiella, Coleochaete, Stigeoclonium, Draparnaldiopsis*). Both the prostrate and the erect systems may be well developed or there is progressive elimination of prostrate or erect systems.

(iv) **Siphonaceous**: The thallus is made up of branched, aseptate, coenocytic, tubular filaments as the nuclear divisions are not accompanied by wall formation (e.g. *Protosiphon, Codium*)

(v) **Parenchymatous**: Thallus is formed by the divisions of cells in two or more planes. The daughter cells do not separate from the parent and give rise to parenchymatous thalli of various shapes (e.g., *Ulva, Enteromorpha*). Leaf like or foliaceous thallus as seen in *Ulva* has evolved due to transverse as well as longitudinal septation in the filament.

Figure: Range of thallus structure in Chlorophyta. A: *Pterosperma* B: *Nephroselmis* C: *Palmophyllum* D: *Tetraselmis* E:*Chlorella* F: *Oocystis* G: *Haematococcus* H:*Pediastrum* I: Bulbochaete J: *Chaetophora* K: *Ulothrix* L: *Ulva* M:Cladophora ´ N: Boergesenia O: Acetabularia P: Caulerpa Q: Klebsormidium R: Spirotaenia T: Micrasterias U: Coleochaete

Source: Photo courtesy Dr. Frederik Leliaert

Table: Thallus organization in different genera

Source: Author

Thallus organisation	Genera
Motile unicells	*Chlamydomonas*
Motile colourless unicells	*Polytoma*
Nonmotile unicells	*Chlorella*
Encapsulated unicells	*Phacotus*
Motile colony	*Pandorina*
Dendroid colony	*Tetraselmis*
Palmelloid colony	*Tetraspora*
Coccoid (Zoosporic)	*Chlorococcum*
Coccoid (Azoosporic)	*Chlorella*
Simple filament	*Ulothrix*
Heterotrichous filament	*Stigeoclonium*
Discoid (prostrate type)	*Coleochaete*
Crusts or cushions	*Pseudopringsheimia*
Erect type	*Draparnaldia*
Pseudoparenchymatous (uniaxial)	*Dasycladus*
Pseudoparenchymatous multiaxial	*Codium*
Foliose, parenchymatous	*Ulva*
Tubular, parenchymatous	*Enteromorpha*

General characters of Form and function (with special reference to Chlorophyceae)

Division Chlorophyta and Class Chlorophyceae share the same general features of form and function.

1. Plant body has a simple construction and shows no differentiation into true root, stem and leaves. For this reason plant body is called a **thallus**.
2. The cells constituting the thallus are **eukaryotic** and thus contain all the cell organelles such as the definitely organized nucleus; membrane bound plastids, mitochondria, Golgi bodies, endoplasmic reticulum, and true vesicles.
3. **Starch** is the main reserve food.
4. The cell wall is stable and generally has **cellulose** as the main structural polysaccharide.
5. The protoplast is bounded by a thin and semi permeable plasma membrane.
6. The cytoplasm possesses many small vacuoles or there is a large central vacuole.
7. The pigments are localized in the green plastids known as **chloroplasts**.
8. The main pigments are **chlorophyll *a*** and ***b***, but **α** and **β carotenes** and **xanthophylls** are also present.
9. The chloroplasts normally contain the **pyrenoids** surrounded by a **starch sheath**.
10. The shape of chloroplast shows much variation; it is cup shaped, (*Chlamydomonas*), girdle shaped (*Ulothrix*), reticulate (*Cladophora, oedogonium*), stellate, spiral (*Spirogyra*) or discoid.
11. Usually there is a single nucleus in each cell, but the members of Siphonales and Cladophorales are coenocytic. The position, size and shape of the nuclei are quite variable. The nucleoli and chromosomes remain suspended in the granular matrix of the nucleus. In general, there is a single nucleolus per nucleus but in Conjugales, there are several nucleoli in a nucleus.
12. Most of the flagellate cells have a photosensitive red **eye spot** or **stigma** in the anterior portion, near the flagellar base.
13. The motile vegetative or reproductive cells (zoospores and gametes) have two (rarely four) equal, whiplash type flagella inserted ate the anterior end. However, in Oedogoniales the motile cells have a **ring** or crown of flagella.
14. The plant body is unicellular or multicellular. The former may be solitary or colonial. The multicellular forms show a considerable range of variation in the form and structure of the plant body.

15. All cells of Chlorophyta contain **at least one plastid**, though these do not always display photosynthetic pigments. Most of the Chlorophytes are considered to be **autotrophic**. However, Chlorophytes exhibit a surprising level of nutritional variation.
16. Some forms (Prasinophyceans) are known to feed on particles and therefore exhibit **phagotrophy** and **mixotrophy**. A few forms are colourless and contain a reduced plastid, they have completely lost their ability to carry out photosynthesis and are thus obligately heterotrophic. Some forms are capable of complementing photosynthesis by uptake and utilization of exogenous carbon i.e., sugars, amino acids etc. (Neilson and Lewin, 1974; Tuchman, 1996), thus they exhibit mixotrophy. Some green algae are photoheterotrophic, i.e., they utilize organic carbon when their photosynthesis becomes limited by the availability of dissolved inorganic carbon (Graham, et al., 1994; Lewitus and Kana, 1994).
17. They reproduce by **vegetative**, **asexual** and **sexual** methods. The vegetative propagation takes place by cell division and fragmentation. **Akinetes**, **zoospores** and **aplanospores** are the main **asexual** spores. Zoospores are often formed during night and are then liberated in the morning.
18. **Sexual reproduction** occurs in all members except some Chlorococcales and Chlorodendrales. It may be **isogamous**, **anisogamous** or **oogamous**.
19. The **zygote** or oospore secretes a thick wall and undergoes a resting period. It germinates under favourable conditions and forms a new thallus.
20. The sex organs are always unicellular.
21. Zygote generally is the **only diploid structure** in the life cycle.
22. **Life history**: Most of the members are haploid showing **haplontic** life cycle. Some members are diploid (Siphonales) showing **diplontic** life cycle while a few others show isomorphic alternation of generations between haploid and diploid plants (e.g. *Cladophora*)- called **diplohaplontic** life cycle.
23. Chlorophytes are better represented in **fresh water** than in salt water.

Key similarities between Chlorophytes and land plants

- Chloroplasts of both Chlorophyta and land plants contain photosynthetic pigments Chlorophyll a and Chlorophyll b.
- Similar arrangements of membrane bound thylakoids.
- Cell wall is similar in structure and composition
- Chloroplasts synthesize starch which is the main reserve food.

Classification

The classification of algae into taxonomic groups relies upon their **morphological**, **ultrastructural**, and **molecular characters**. Classification of green algae has undergone considerable changes over the years. Earlier workers entirely relied upon colour and form. Later, cytological information and types of life histories were added. The development of further techniques helped a wider understanding of the cell wall and flagellar structures and the physiology and biochemistry of functions, all of which proved useful in classifying different taxa. The introduction of molecular studies which are especially comparative provided a new framework for the phylogenetic relationships among the green lineage. For many algal groups, form alone can still be used for differentiation. For some algae form combined with function will prove useful. A detailed knowledge of the life-history is essential to understand the concept of taxa. Molecular, physiological and ecological characters likewise are useful in algal taxonomy.

From early times algae have been variously classified. As far back as 1836, Harvey recognized 3 algal groups- Chlorospermae, Melanospermae, Rhodospermae and placed all green algae into Chlorospermae. Subsequently many flagellates were discovered and described and even today changes are being made to accommodate these forms properly. Some of the important systems of classification of algae are those of Engler (1924), Fritsch (1935), Smith (1938), Round (1965), Prescott (1969), Chapman and Chapman (1973), Stewart and Mattox (1975) and Pickett-Heaps (1975, 76).

Fritsch (1935) classified algae into **11 classes** and placed **all green algae** in the class Chlorophyceae. Fritsch sub-divided **Chlorophyceae** into **9 orders**, Volvocales, Chlorococcales, Ulotrichales, Cladophorales, Chaetophorales, Oedogoniales, Conjugales, Siphonales, and Charales. Fritsch considered the following characters while classifying algae:

- Structure of plant body
- Habitat or occurrence
- Nature of photosynthesizing pigment
- Type of reserve food material
- Method of reproduction etc.

However *Charales (Charophytes) have been removed from Chlorophyceae as majority of modern phycologists favour the independent status for Charophytes. This view has been followed in this text.

Figure: Fritsch system of classification detailed for Chlorophyceae

Source: Author

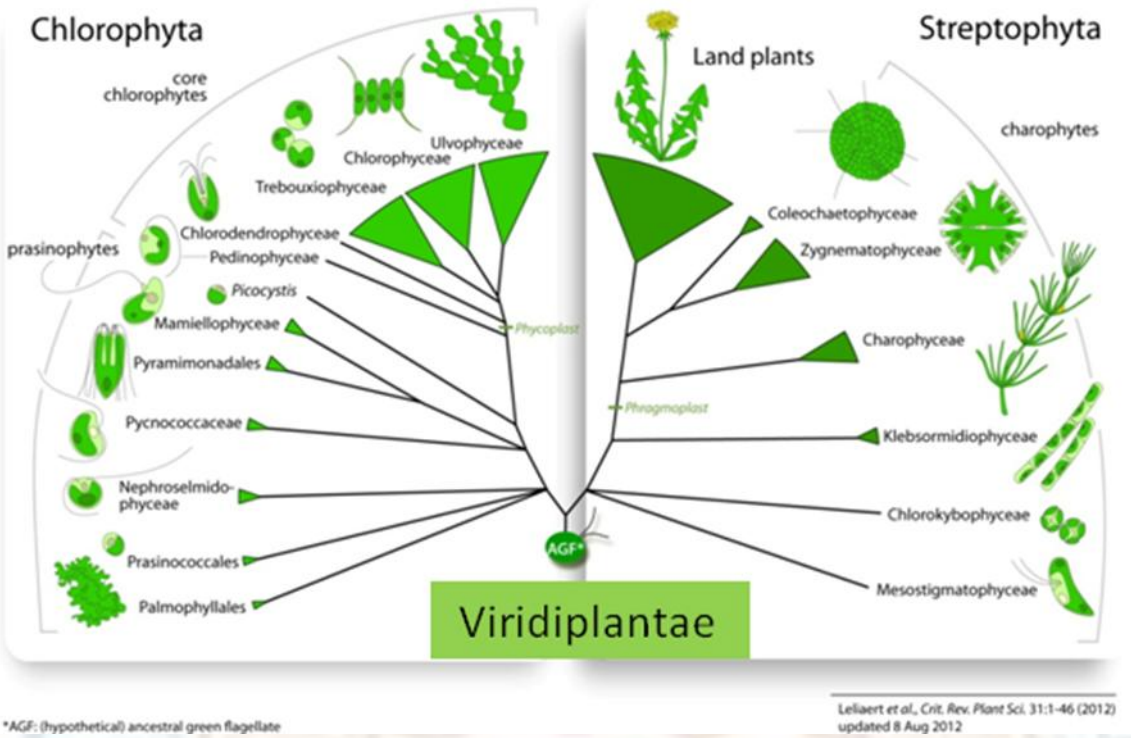

Figure: Early divergence of two lineages of the Kingdom Viridiplantae* (an expansion of the traditional plant kingdom to include green algae): **Chlorophyta** and Streptophyta. The Chlorophyta comprises most of the described species of green algae. The Streptophyta includes charophytes, a few freshwater algae, and the land plants.

Sources:Leliaert *et al.* (2012), http://www.uniprot.org/taxonomy/33090,

http://comenius.susqu.edu/biol/202/archaeplastida/viridiplantae/default.htm

In **newer classifications** Chlorophyta (all green algae except Charophytes) is a division (Phylum) of the kingdom **Viridiplantae***. Viridiplantae is the expansion of the traditional **Plant Kingdom** to include **green algae** (Chlorophyta + Charophyta).

*Viridiplantae has two divisions, Chlorophyta and Streptophyta (land plants and Charophytes). Hence Viridiplantae includes: (a) Chlorophytes (b) Charophytes (c) land plants. They contain chlorophyll *a* & *b* and certain other distinguishing characters. It has been generally accepted now that early chlorophytes gave rise to the land plants. The ancestors of land plants most likely resembled modern-day members of the division Chlorophyta. Earlier chlorophytes were placed as a division in the kingdom **Protista** but

according to recent classifications Chlorophyta along with Streptophyta (land plants and Charophytes) has been placed in the kingdom Viridiplantae.

According to the new classification systems the division Chlorophyta includes only about **4,300 species** and includes the classes Prasinophyceae, Chlorodendrophyceae, Trebouxiophyceae, Ulvophyceae and Chlorophyceae.

Prasinophytes represents the "early diverging Chlorophyta". Ulvophyceae (**U**), Trebouxiophyceae (**T**) and **Chlorophyceae** (**C**), are together known as **UTC clade.** The UTC clade along with Chlorodendrophyceae are known as **'The Core Chlorophyta'**.

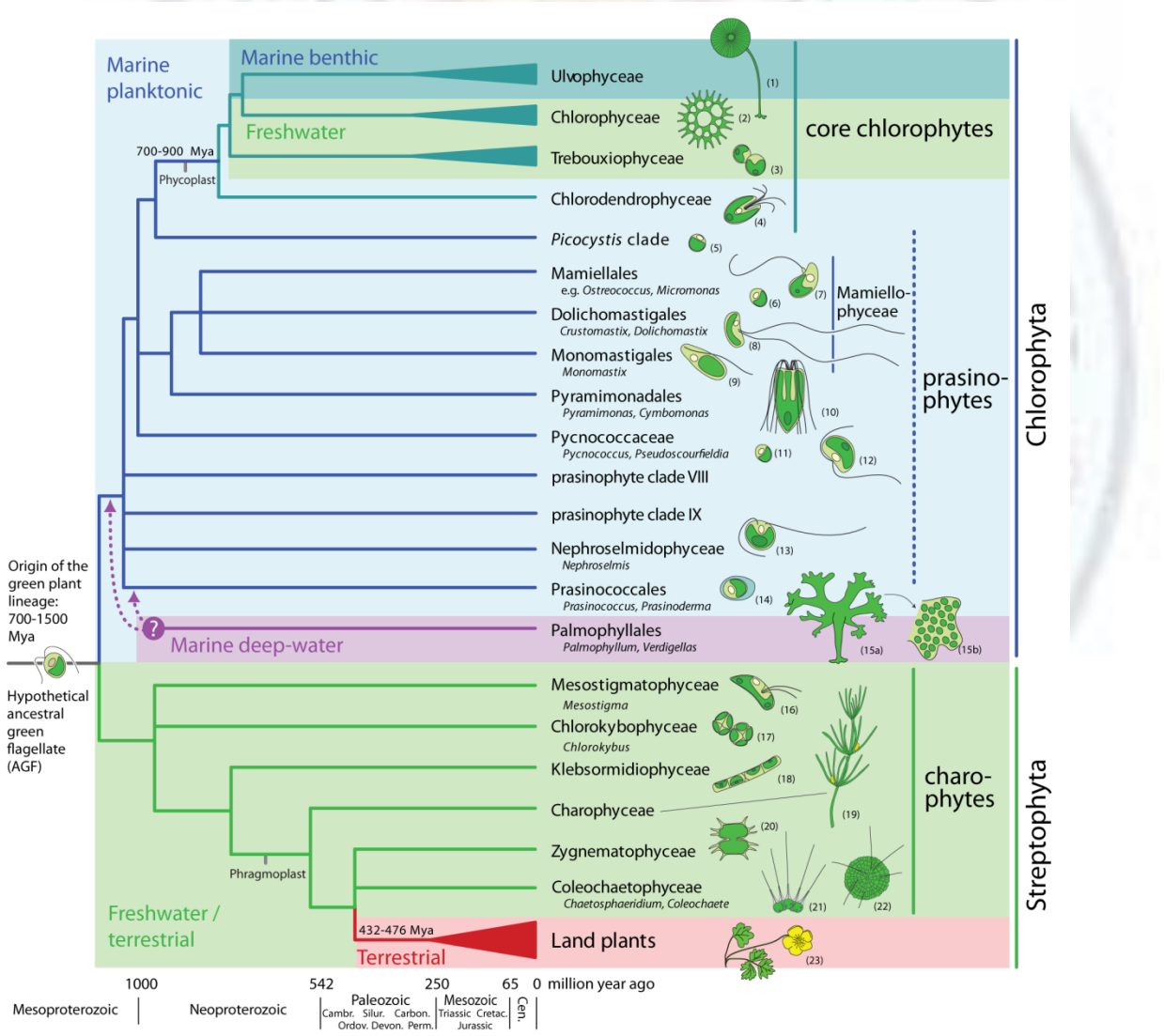

Figure: Main groups of green plants and their phylogenetic relationships. Drawings exemplify representatives of each group.

Picture courtesy: Dr. Frederik Leliaert

Class Chlorophyceae: (with special reference to the orders Chlamydomonadales & Oedogoniales)

Chlorophyceae are a morphologically diverse group of photosynthetic organisms which include non-motile and motile unicellular organisms having two or four flagella, cells that are embedded in a mucilaginous envelope, colonies of biflagellates, blade-like thalli, branched or unbranched filaments. Reproduction is likewise diverse, including vegetative, asexual and sexual modes. Members of Chlorophyceae are abundant in freshwater although a few occur in terrestrial habitats as well. The class Chlorophyceae is characterized by the occurrence of closed mitosis during cell division and a phycoplast-mediated cytokinesis. In Chlorophyceae the nuclear envelope persists throughout mitosis, this is known as **closed mitosis**. In Chlorophyceae cytokinesis occurs by simple furrowing. Members of Chlorophyceae have a well developed cell wall and produce a set of microtubules that lie parallel to the plane of cytokinesis. This parallel set of microtubules is known as **phycoplast**.

Molecular phylogenetic analyses have considerably reshaped the classification of Chlorophyceae. Five major clades (orders) have been identified within the class: **Chlamydomonadales**, Sphaeropleales, Chaetophorales, Chaetopeltidales and **Oedogoniales**.

The **Chlamydomonadales** constitute the largest group of the Class Chlorophyceae. The Chlamydomonadales mainly include freshwater and terrestrial green algal forms, including several salt tolerant or halotolerant species and/or psychrophilic species (*Dunaliella* and *Chlamydomonas nivalis*). Since the Chlamydomonadales include unicellular forms (e.g., ***Chlamydomonas***) as well as colonial forms (e.g., *Volvox*), its members have been extensively studied as models of multicellular evolution.

The **Oedogoniales** includes the filamentous genera ***Oedogonium***, *Oedocladium* and *Bulbochaete*. The Oedogoniales are characterized by zoospores and meiozoospores with an anterior ring of numerous flagella (stephanokont). They are characterized by a unique form of cytokinesis and a specialized form of oogamous sexual reproduction involving the production of stephanokont motile cells.

In the next three chapters we will study the Class **Chlorophyceae** in detail.

Summary

In Chlorophyta, the plant body is thalloid in nature and shows no differentiation into root stem and leaves. Thallus may be unicellular or multicellular exhibiting a wide range in form and function. Cells may be motile (flagellate) or non-motile. The motile cells have 2 or 4 equal flagella at the anterior end. Sometimes, flagella are several. Most of the members are aquatic and predominant in freshwaters, only a few forms are marine. The reserve carbohydrate is starch, composed of amylose and amylopectin. The pigments are confined to green plastids known as chloroplasts. Chloroplasts contain chlorophyll a, chlorophyll b, β carotene and xanthophylls approximately in the same proportion as in higher plants. Starch is the reserve food. Pyrenoids are commonly surrounded by starch sheath. Cellulose is the main component of the cell wall. Sexual reproduction is by isogamy, anisogamy or oogamy. Most of the members are haploid but some are diploid (Siphonales) while a few others show isomorphic alternation of generations between haploid and diploid plants. Chlorophyta includes the classes Prasinophyceae, Chlorodendrophyceae, Ulvophyceae, Trebouxiophyceae and **Chlorophyceae**.

Exercise/ Practice

1. Which algal division is characterized by the presence of chlorophyll *a* and chlorophyll *b*, cellulosic cell walls, starch as the main energy storage material, and lives in freshwater and marine habitats?
2. Describe the salient features of Chlorophyta.
3. Name the reserve food material in the cells of Chlorophyta.
4. What is a coenobium?
5. Describe the range of thallus structure/growth forms exhibited within Chlorophyta.
6. Name a green alga which is parasitic.
7. Describe the range of habitat where members of Chlorophyta are usually found.
8. What are the various criteria for classification of algae.
9. Fill in the blanks:

   (i) The colony of *Volvox* having a definite number of cells arranged in a specific manner is called…….

   (ii)……causes red snow/watermelon snow.

   (iii)……causes red rust of Tea.

   (iv) Members of Chlorophyta are most abundant in……water.

   (v)……is an epiphytic chlorophyte.

(vi)……occurs endophytically inside the cytoplasm of *Paramecium*.

(vii) The algae growing in seawater is known as……algae.

(viii)……..is an example of a colonial green alga in Chlorophyta.

(ix)……is an example of a filamentous green alga in Chlorophyta.

(x) The ancestors of land plants most likely resembled modern-day members of the division……

(xi) Plant body showing no differentiation into true root, stem and leaves is called…….

(xii) In …….. the coenobium is net-like.

Glossary

Autotroph: not needing an external source of organic compounds as an energy source. Energy is obtained from light or inorganic chemical reactions.

Bloom: heavy growth of planktonic algae in a body of water

Carotenoid: yellow, orange, or red hydrocarbon fat-soluble pigment

Cellulose: polysaccharide composed of -1, 4 linked glucose molecules that forms the main skeletal framework of most algal cell walls.

Chlorophyll: fat soluble, green pigment

Chloroplast: plastid with chlorophyll

Coccoid: spherical

Coenobium: colony of algal cells in a specific arrangement and number that does not increase once mature.

Dendroid: a type of nonmotile colony that usually forms a stalk and produces mucilage in one area.

Eukaryotic: a cell having membrane-enclosed organelles such as the nucleus and mitochondria.

Eyespot: red to orange area in a cell, composed of lipid droplets

Marine: refers to sea or ocean or other saltwater environments

Palmelloid: term describing colony of an indefinite number of single, nonmotile cells in mucilaginous matrix.

Phototaxis: movement of a whole organism toward (positive) or away from (negative) light.

Plankton: organisms that float or swim to maintain a constant position against a water current.

Pyrenoid:proteinaceous area of the chloroplast associated with the formation of storage product.

Siphonaceous: large multinucleate cells without cross walls except when reproductive bodies are formed.

Stellate: star-shaped

Stigma or eyespot: group of pigmented lipid bodies that are associated with phototaxis.

Xanthophyll: a carotenoid composed of an oxygenated hydrocarbon.

Zygote: product of the fusion of two gametes

References/ Bibliography/ Further Reading

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Links

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3. http://books.google.co.in/books?id=hOa74Hm4zDIC&pg=PA133&lpg=PA133&dq=fritsch+classification+of+algae&source=bl&ots=wHdP_Q0oqG&sig=KbejfL9BMnivM5UuluuBVf1WTdY&hl=en&sa=X&ei=F4ykUbmPF4eurAeD4IDYDA&ved=0CDgQ6AEwAQ#v=onepage&q=fritsch%20classification%20of%20algae&f=false

4. http://acoi.ci.uc.pt/image_gallery.php

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