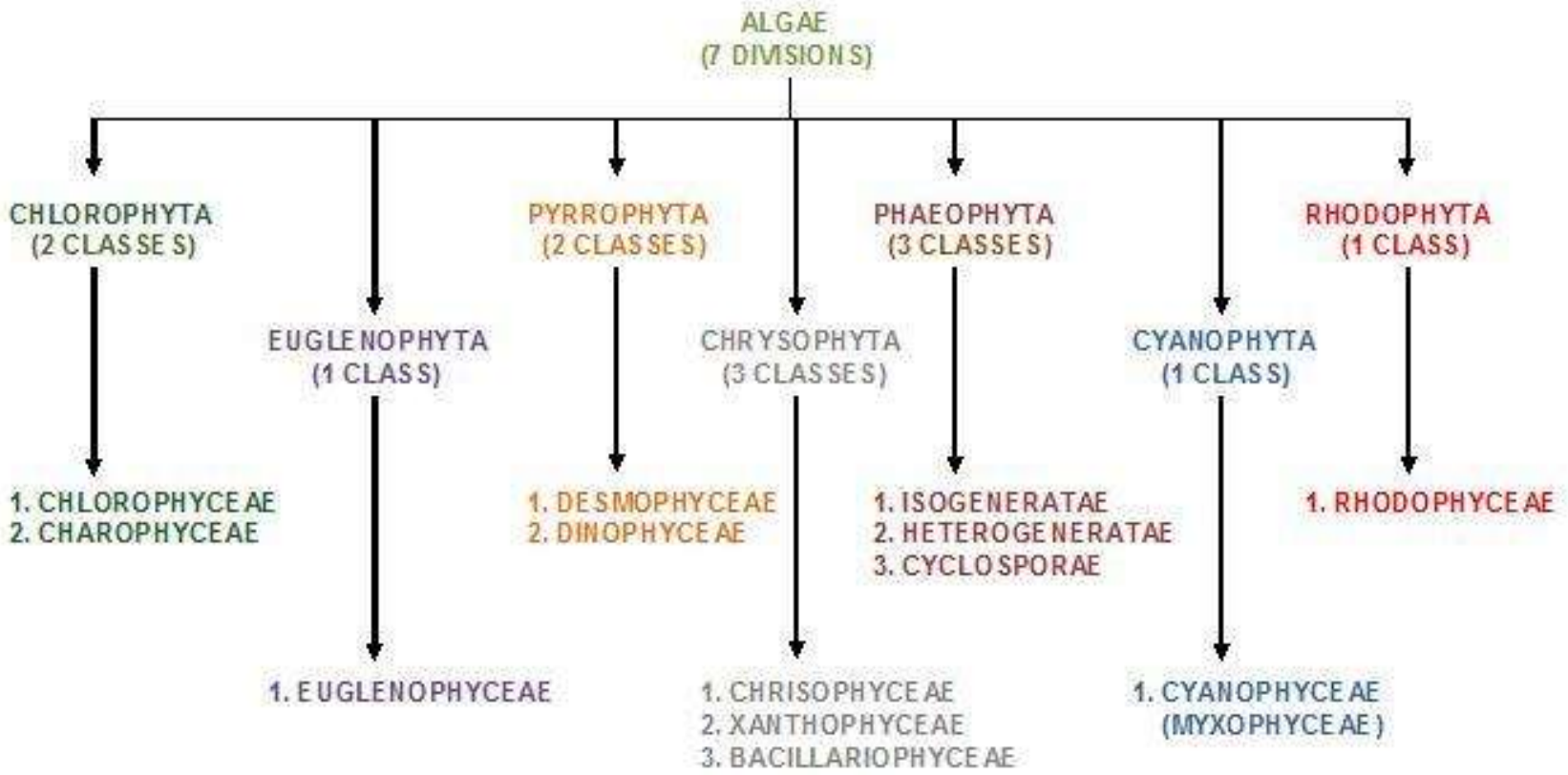
SMITH'S SYSTEM OF CLASSIFICATION OF ALGAE



phylum: Cyanobacteria or Cyanophyta (Blue green algae)

Called blue-green bacteria(Cyanobacteria) because there are similarities between Cyanobacteria and bacteria, including:

1 - Prokaryotic nucleus

2-coverd by mucilage sheath

3 - absent sexual reproduction

4-bacteria are unicellular forms and some cyanobacteria are unicellular forms.

5-motils spores are not seen in both groups .

The principal Characteristics of the Cyanophyta

1-there are unicellular ,colonial , filamentous and simple paranchymatous form .

2- Flagellate cells **never** at any stage in the life cycle .

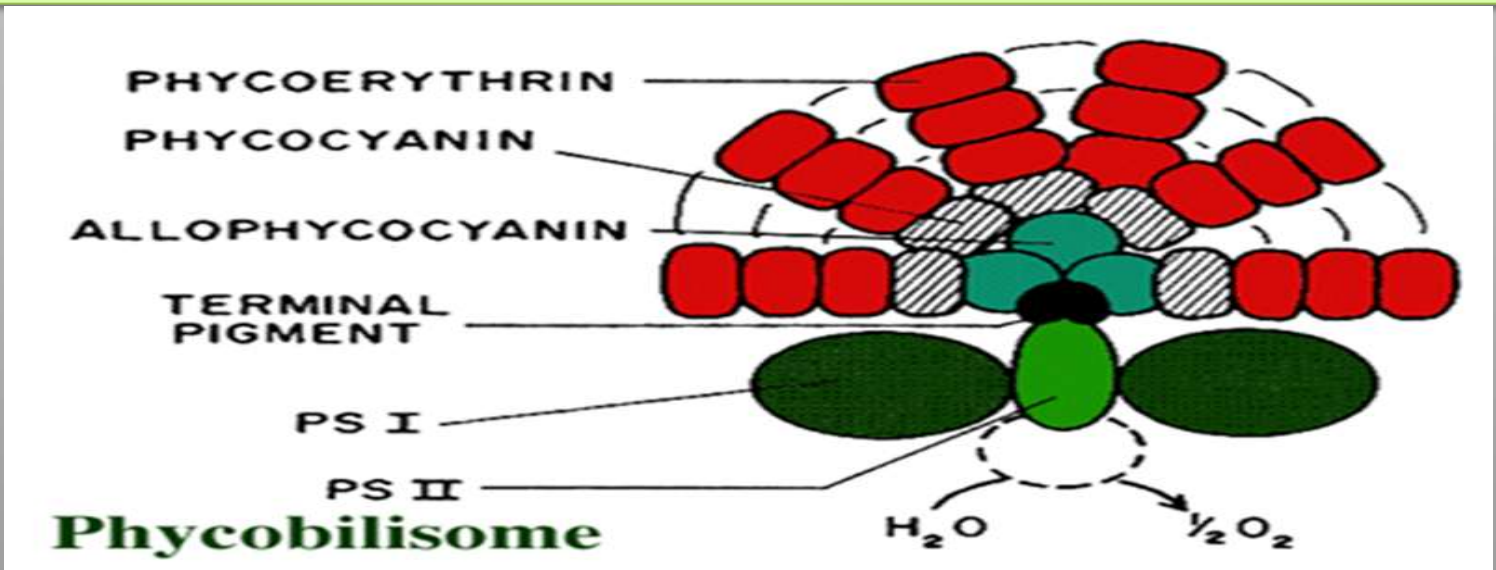
3- lack a nucleus and organelles (chloroplast, mitochondria)

4-The DNA lie bundled up in the center of the protoplasm .

5-cell wall consists of **peptidoglycan** , the cell are often embedded in sheaths of mucilage **.**

6- foods storage as Cyanophycean starch alpha-1,4 linked glucan

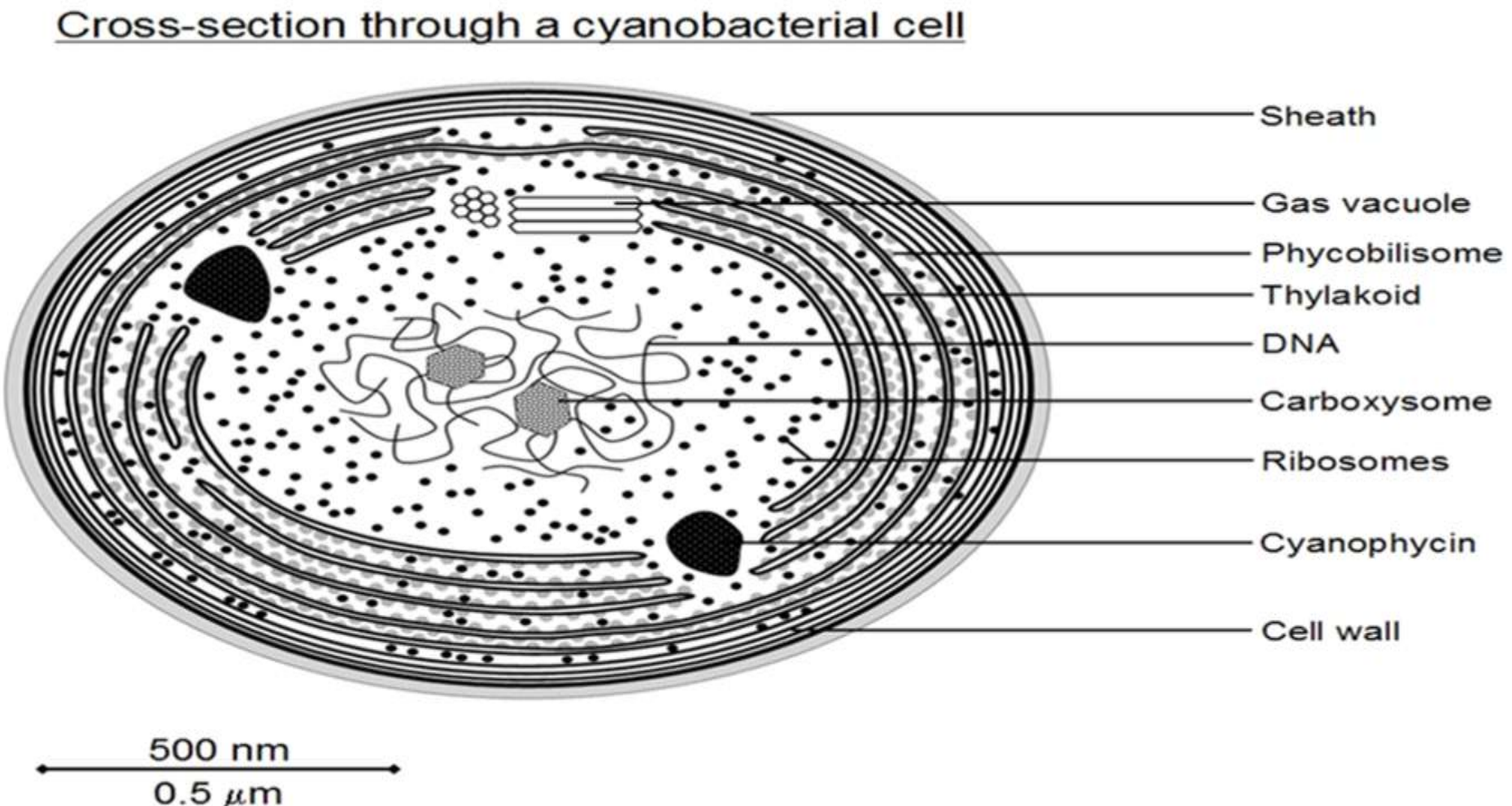
6-The photosynthetic pigments are located in thylakoids , which lie free in the cytoplasm .the thylakoids contain Chlorophyll a. Each outer facing into the cytosol of each thylakoid is studded with particles called phycobilisomes, which consist of chlorophyll and accessory pigments, called phycobiliproteins, such as phycoerythrin (red) , phycocyanin and allophycocyanin . The accessory pigments protect the chlorophyll from damaging UV light and also trap photons and funnel them to the chlorophyll, acting as antennae.



7-Reproduce asexually ,sexual reproduction is **absent.**

8-Reserve food is cyanophycin.

9- Gas vacuoles are often present in aquatic forms. These act to regulate buoyancy.

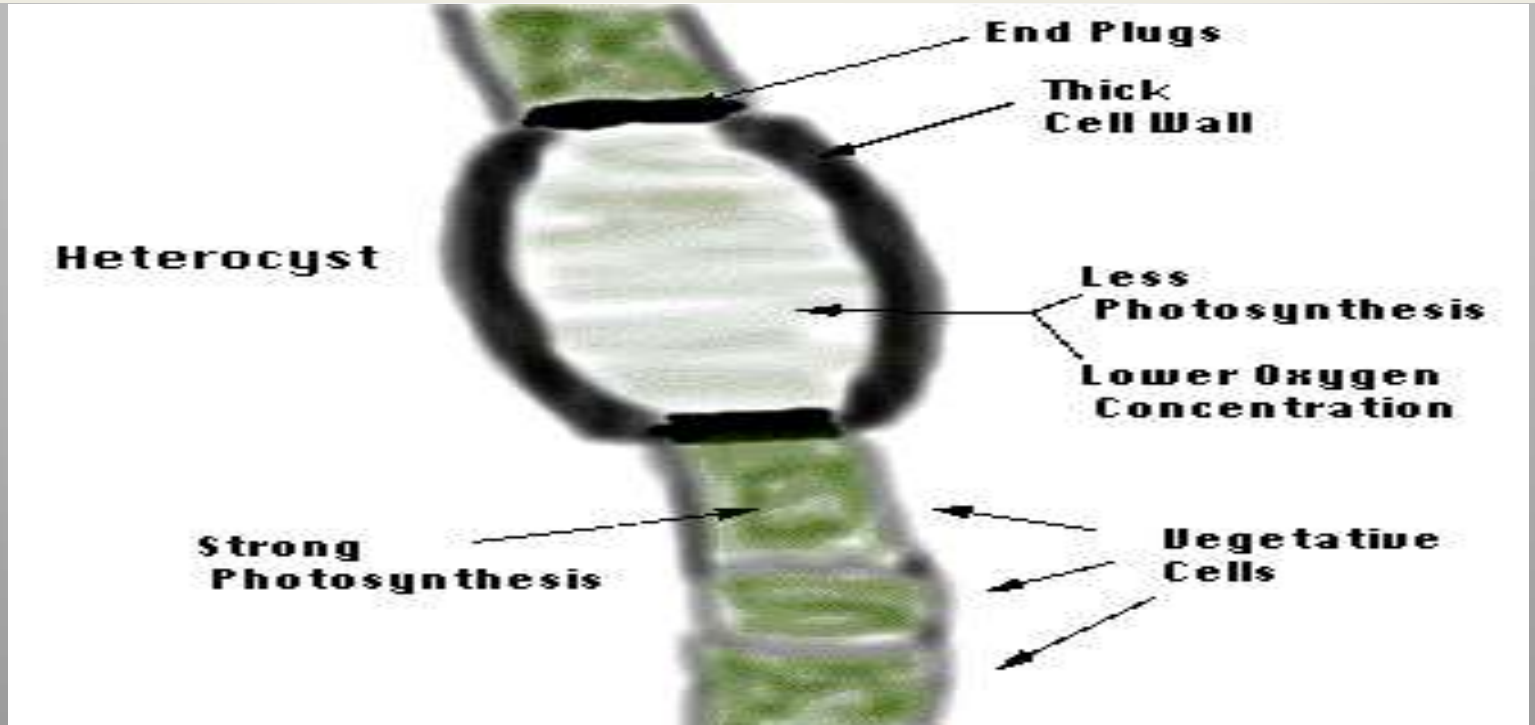


Heterocysts and nitrogen fixation

Heterocysts: specialized cells containing nitrogenase enzyme able to convert gaseous nitrogen (N_2) to ammonium (NH_4+)

- They are mostly found along the filaments of some algae such as *Nostocales* and *Stigonematales*.

- Heterocysts : thick cell wall, low oxygen concentration, photosystem II (light reaction) inactive but photosystem I active to provide ATP; and absent of granular reserve materials and gas vacuoles, connected to vegetative cells by cell wall pores

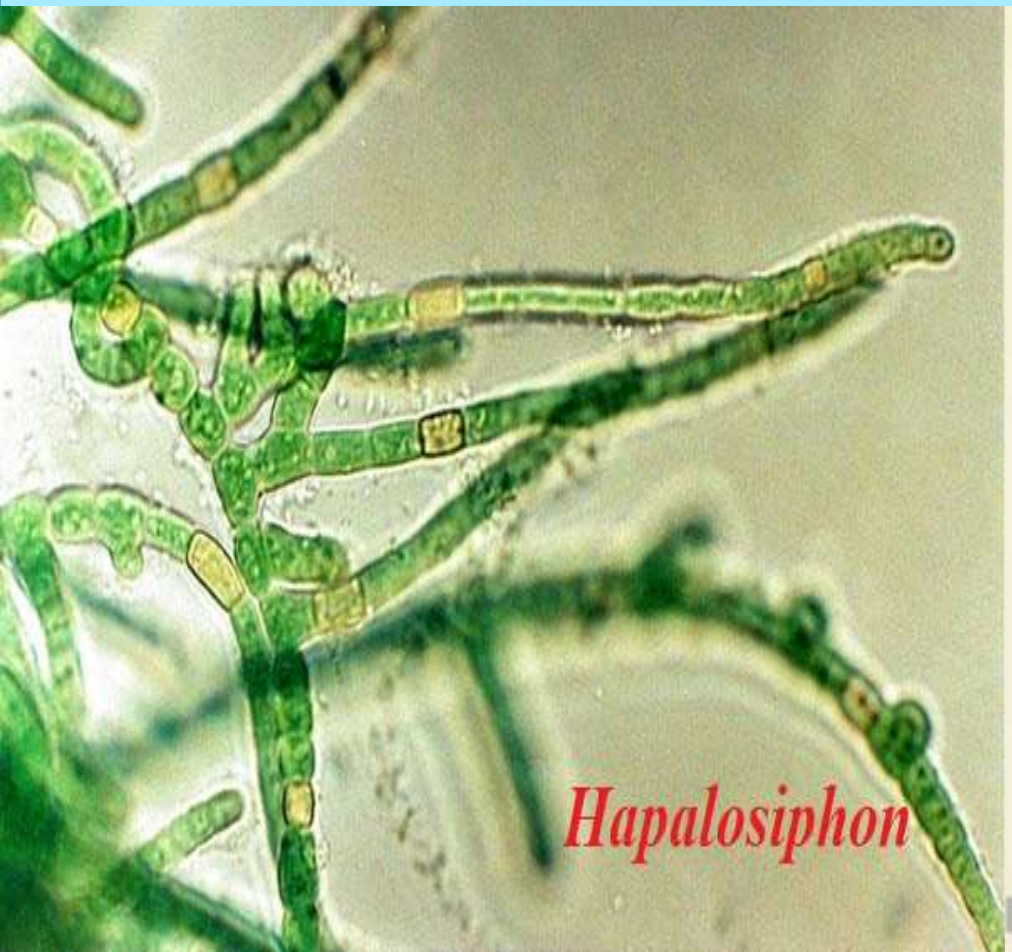


Shape of Heterocysts

1- They are **identical** to the vegetative cells.

2- They are also **round** ***Nostoc, anabena , Rivularia***

3- Some time **rectangular** in ***Scytonema.***



Position of Heterocysts in the trichomes :

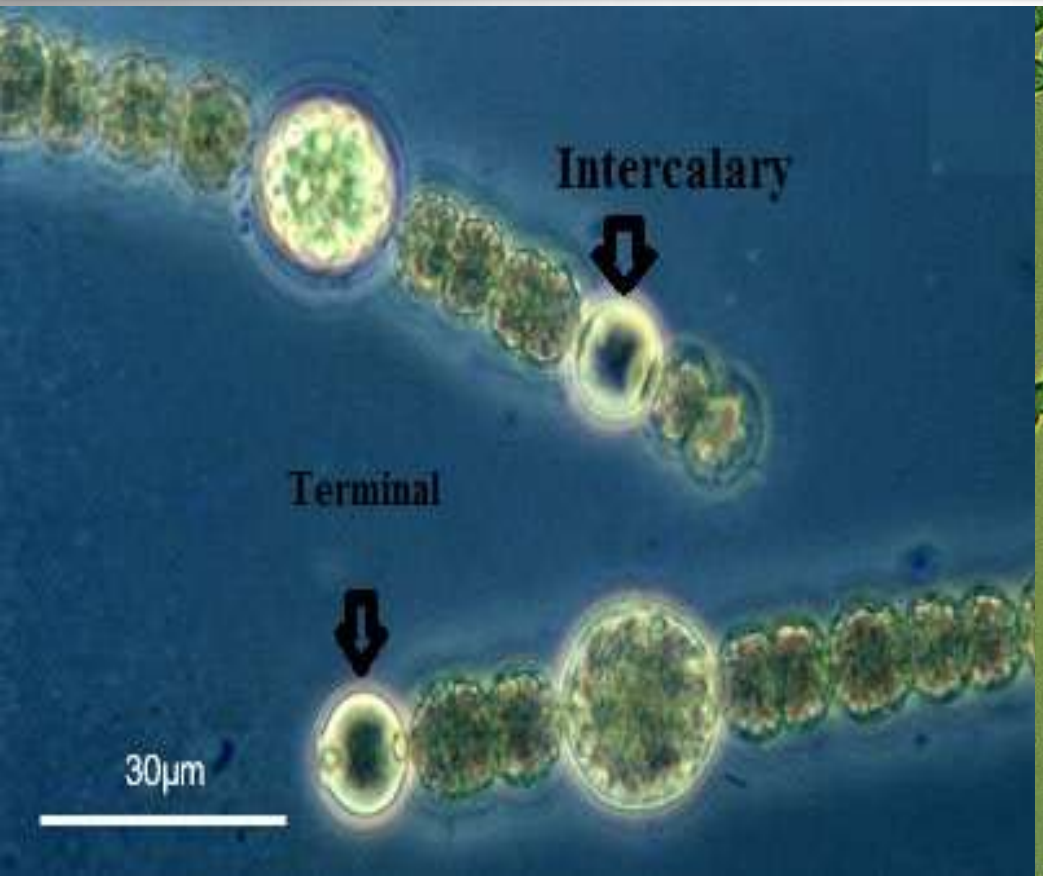
The Heterocysts usually occur singly.

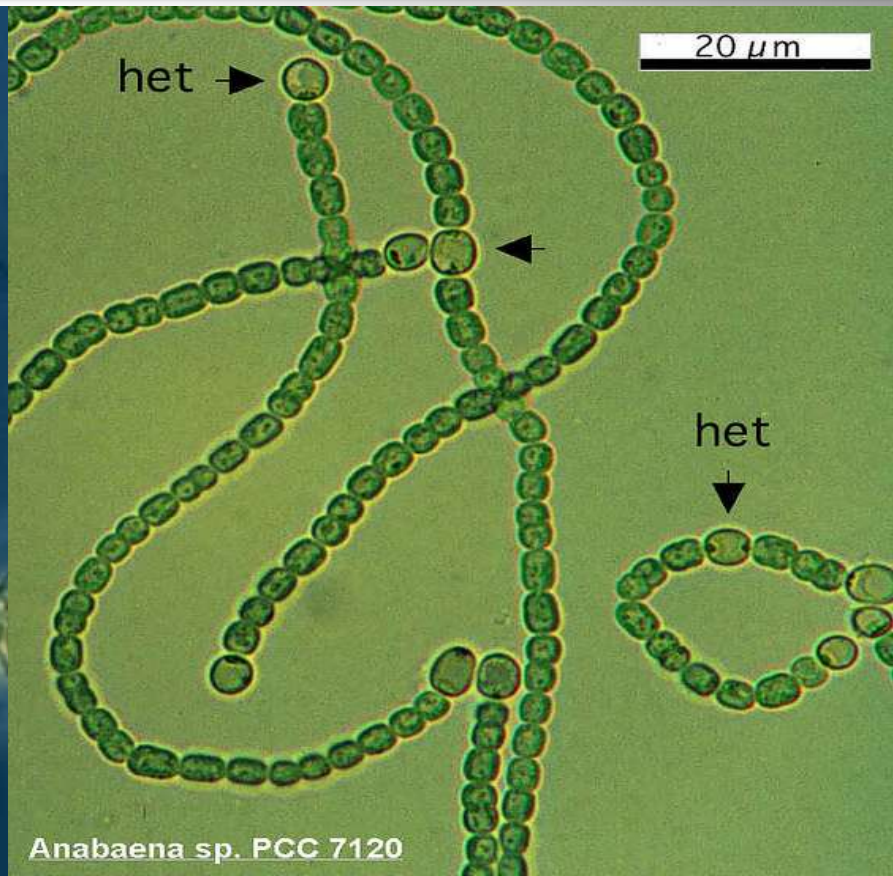
1- Terminal in position (*Gloeotricia*).

2- Intercalary in position(Nostoc).

3- Lateral in position (*Nostochopsis*).

4- In some genera they occur in pairs(*Anabaenopsis*).





Features

Mucilaginous Sheath –

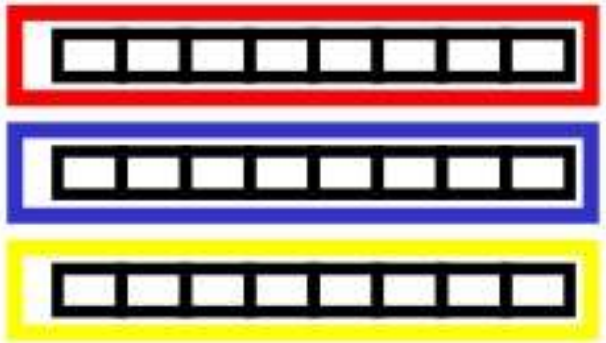
Function – protects cells from drying and involved in gliding.

Sheath is often colored:

Red = acidic

Blue = basic

Yellow/Brown = high salt



Reproduction

They are tow type for reproduction :

1-Vegetative reproduction

a-Binary fission (order Chroococcales)

b-Fragmentation .

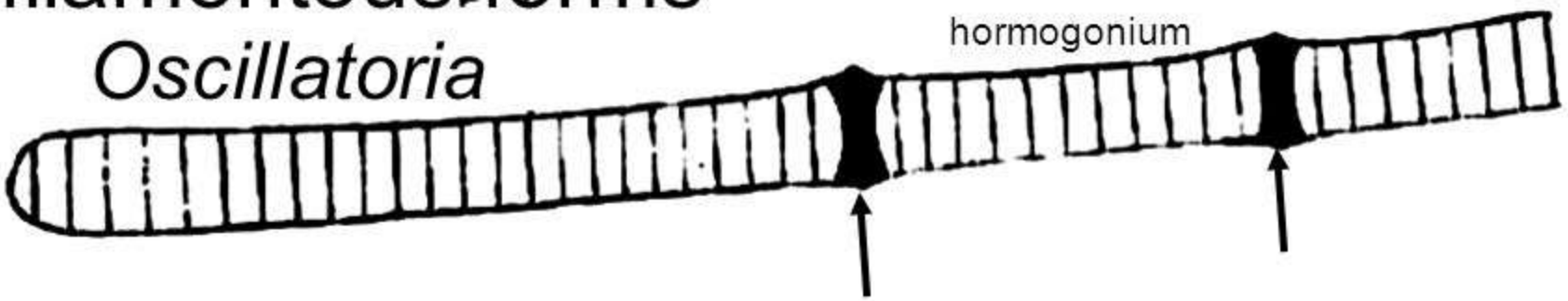
c- Hormogonia: which are characteristic of all truly filamentous cyanobacteria, are short pieces of trichome that become detached from the parent filament and move away by gliding, eventually developing into a separate filament(many Nostocales.).

Cyanobacteria: systematic characters

Vegetative reproduction:

by hormogonia, only in some filamentous forms

Oscillatoria



"separation discs" (necridia)

Lyngbya

2-Asexual reproduction

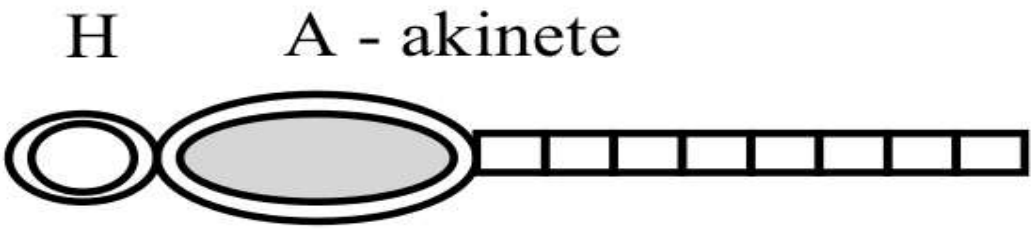
a-Akinetes : are large thick walled cells , full large amount of cyanophycin , which enable the algae to survive periods when environmental conditions are not favorable to growth (drought ,cold, nutrient deficiency etc...) they develop from vegetative cells.

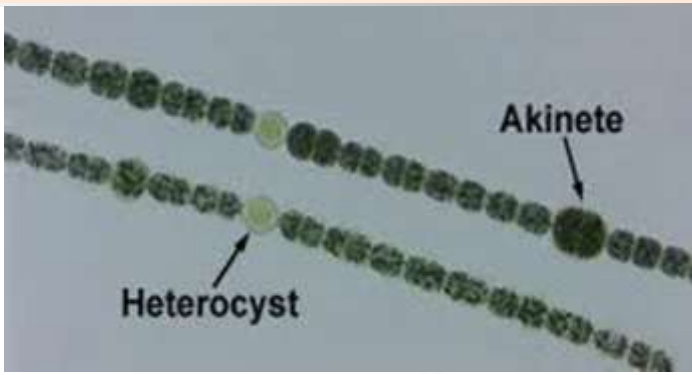
Asexual Reproduction

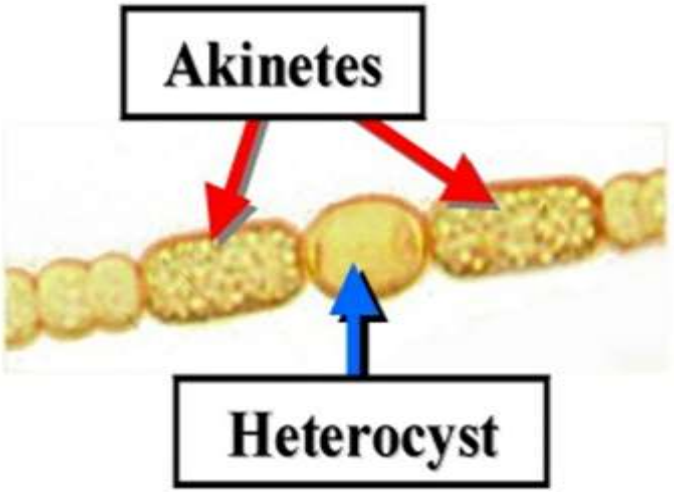
Akinete – thick walled resting spore

Function – resistant to unfavorable environmental conditions.

Appear as larger cells in the chain and different than heterocyst. Generally lose buoyancy







b-**Endospores**: spores that form following division of the protoplast , enclosed within the parent cell wall.

c-**Exospores**: spores produced by budding

d-Nannocysts; cells may divide into many parts without any change in shape, such as Microcystis.

Taxonomic diversity

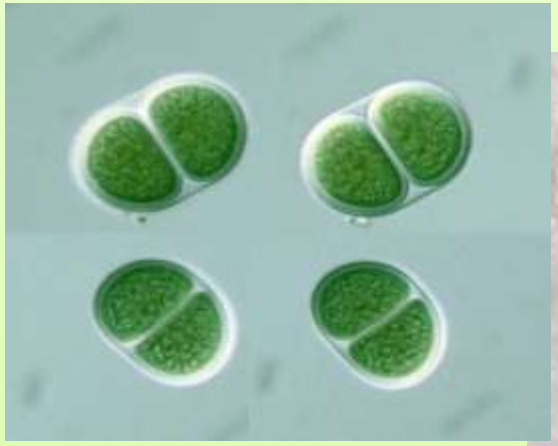
Freshwater cyanophyta can be divided into four main groups in relation to general morphology :

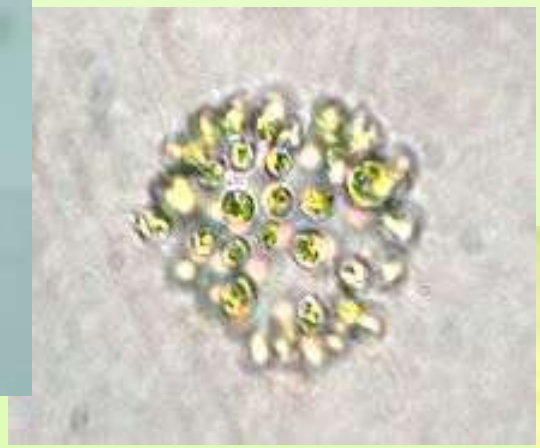
1-Chroococcales

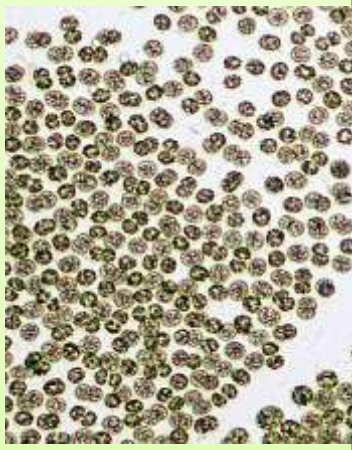
-solitary cells (no filaments form).

-enclosed by a thin layer of mucilage .

- the cells may remain as single cells or be aggregated into plate like or globular colonies e.g. Chroococcus , Gloeocapsa , microcytis

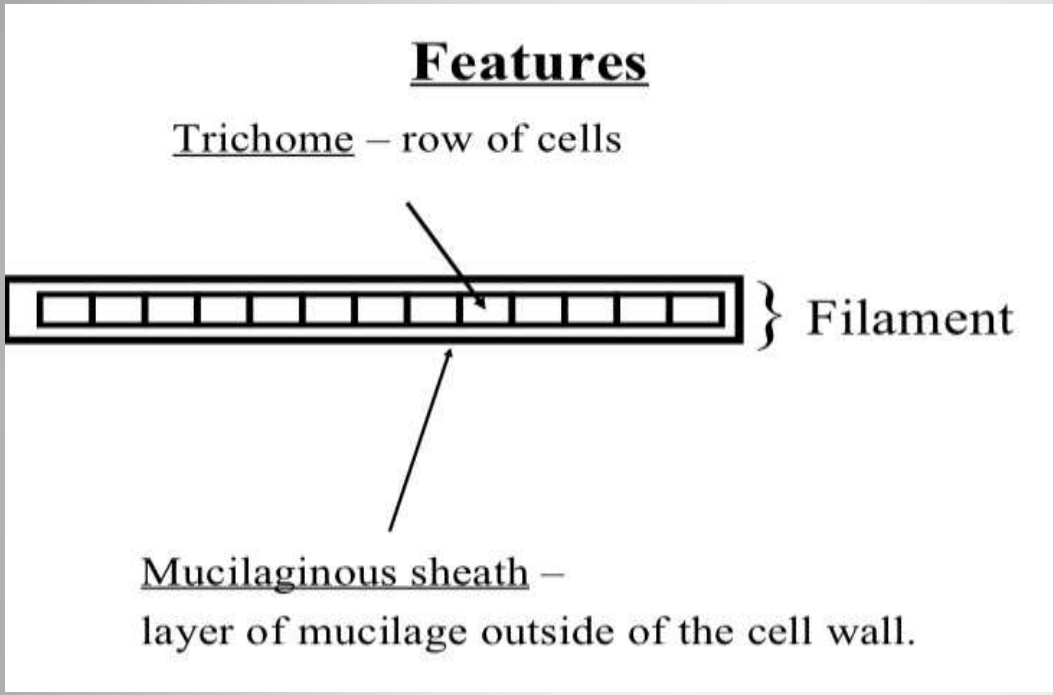


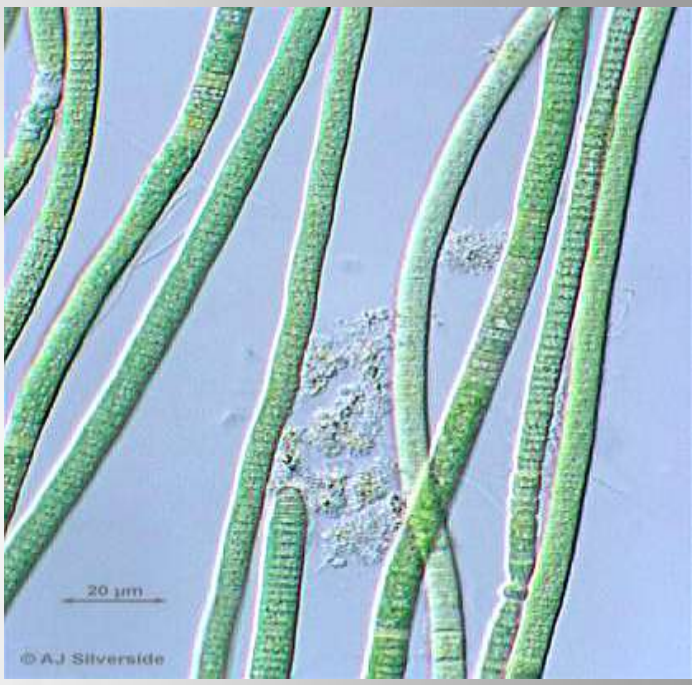




2-Oscillatoriales;

single filamentous forms consisting of a trichome . **is a chain of vegetative cells; a cyanobacterial trichome is often surrounded by a slimy sheath**.





lacking heterocysts and akinetes .

these relatively simple algae occur as planktonic or benthic aggregations.

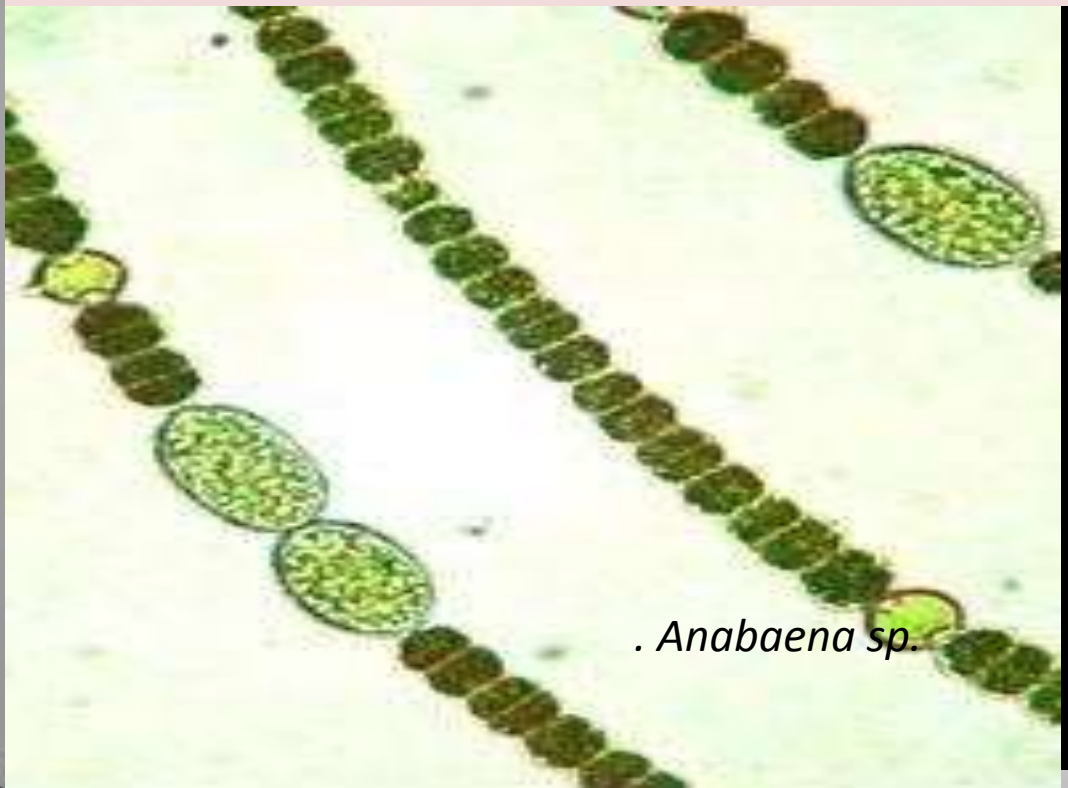
In some cases they form dense mats on mud or rocky substrata. Such as *Oscilatoria sp.*

Trichome : a row of cells without the sheath in the cyanobacteria.
filament: one or more trichomes enclosed in a sheath.

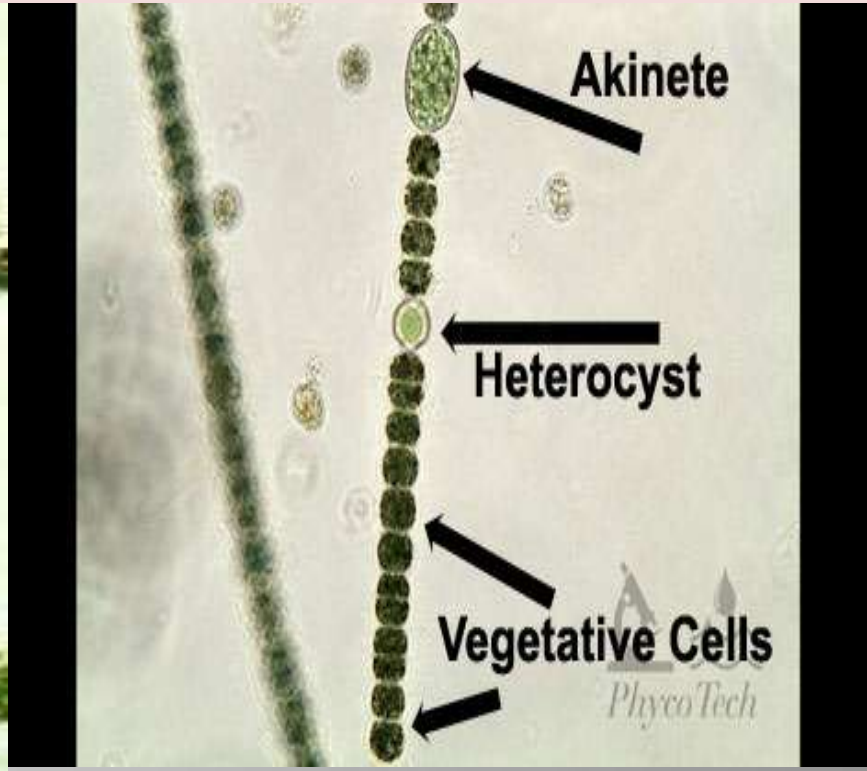
3-Nostocales

-filamentous algae . planktonic or benthic.

uniseriate trichomes, with akinetes or heterocysts unbranched or false-braching .*ex. Anabaena sp.*



. *Anabaena sp.*



4-Stigonematales;

- Uni or multiseriate trichomes,

with akinetes and heterocysts, True branching

- such *stigonema*

stigonema

5-Pleurocapsales: coccoidal cells (clusters of cells) via 3-dimensional divisions.

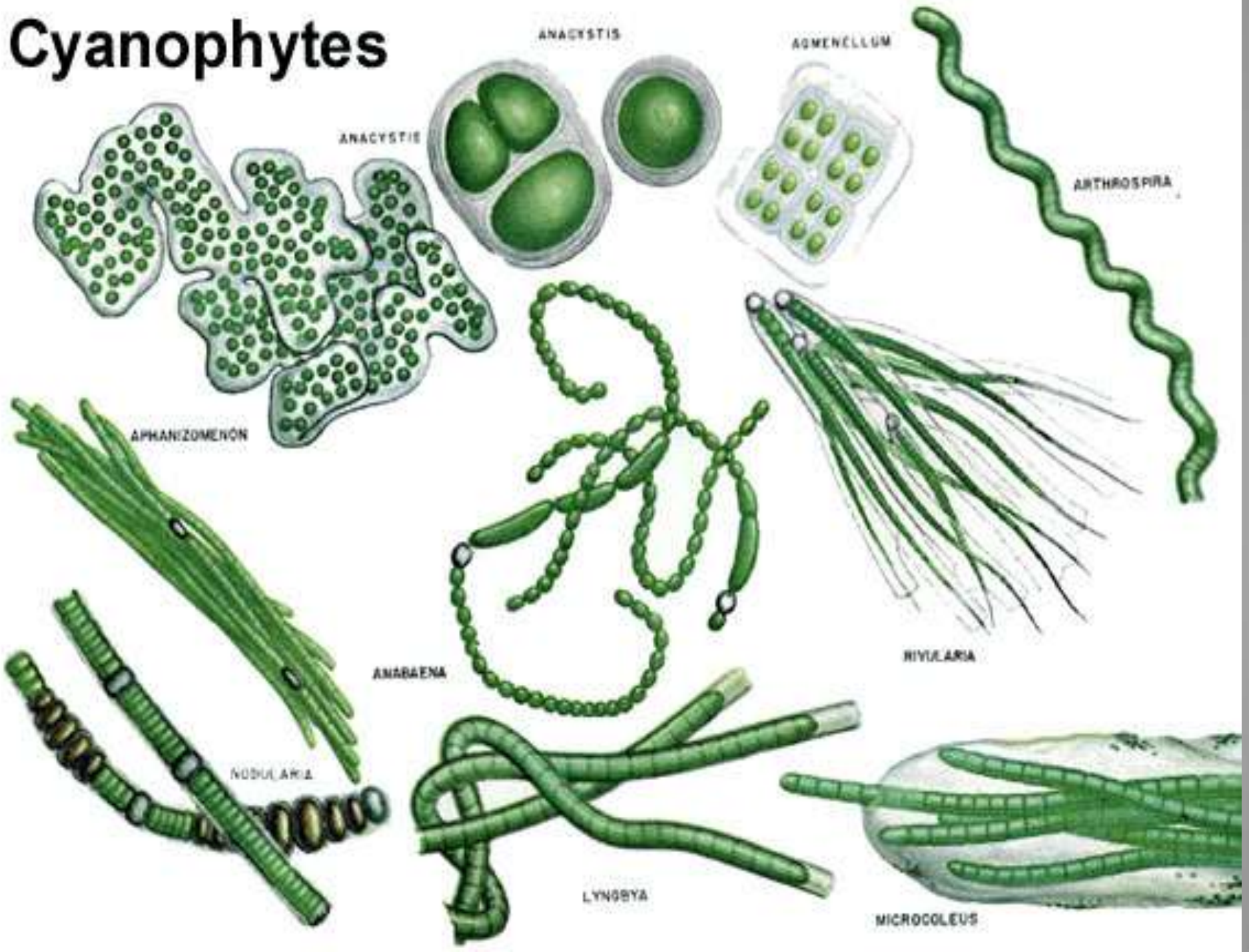
1-Order Chroococcales — Unicells, as individual cells or colonies. Spores may occur, never akinetes or heterocysts

2. Order Oscillatoriales — Uniseriate trichomes, never akinetes and heterocysts. Unbranched or false-braching

3. Order Nostocales — Uniseriate trichomes, with akinetes or heterocysts unbranched or false-braching

4. Order Stigonematales — Uni- or multiseriate trichomes, with akinetes and heterocysts. True branching

Cyanophytes



Blue-green algae as bio-indicators

The presence or absence of particular species can be a useful indicator of ecological statue .

the dominant presence of colonial blue-green forming dense summer blooms .has been useful as an indicator of high nutrient status .

Algal blooms are natural phenomena that occurred before human development in response to changes in temperature, light, rainfall, or changes in limiting nutrients. agriculture and urban discharges, which add more nutrients, light and organic matter have led to increased frequency and duration of algal bloom and in some cases a switch to more toxic species. Persistent and widespread blooms lead to loss of biological function of the waterway.

Competition with other algae

Why The ability of blue greens to out- compete other freshwater algae has been attributed to arrange of characteristics including;

- Optimum growth at high temperatures
- Low light tolerance
- Tolerance of low N/P ratios
- Depth regulation by buoyancy
- Resistance to zooplankton grazing
- Tolerance of high pH and low CO_2 concentration
- Symbiotic association with aerobic bacteria

Eutrophication: is a major problem that is associated with algal blooms in lakes. A direct result of human interference, eutrophication is caused by the addition of excess nutrients (runoffs of phosphate and nitrate from chemical fertilizers and sewage disposal) to the water that encourage algae to grow abundantly. As the algae die and sink to the bottom, most of the water's oxygen is consumed in breaking down the decaying plant matter. Fish and other animals that require large amounts of oxygen can no longer survive and are replaced by organisms with lower oxygen demands.

fertilisers wash into a lake or river

algae grow faster

plants shaded by algae

algae die

some plants die

dead algae and plants decomposed by microbes

microbes respire and use up oxygen

dissolve oxygen levels fall

aquatic animals suffocate and die

Overuse of nitrogenous fertilisers can harm the environment. Lakes and rivers can suffer from **eutrophication**.

OK

dissolved O_2

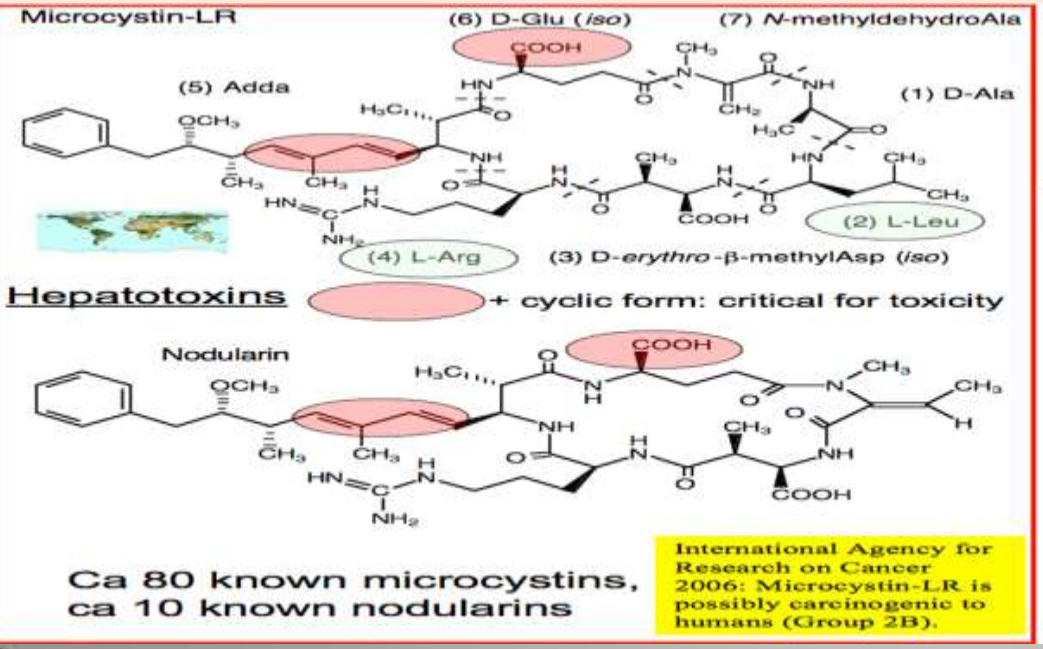
too low

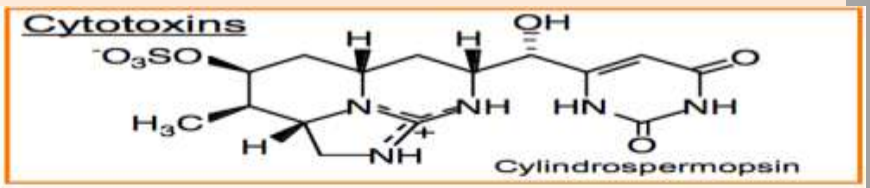
Cyanotoxins are toxins produced by cyanobacteria

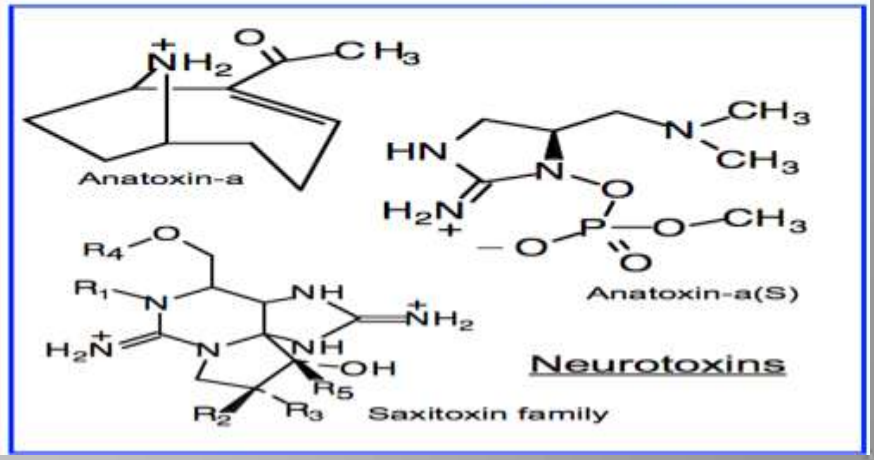
there are two types of cyanotoxins: Neurotoxins and Hepatotoxins

Neurotoxins :toxins that affect the nervous system which can cause lethargy, muscle aches, confusion, memory impairment, and at high concentrations leading to death.

The neurotoxins are alkaloids(nitrogen-containing compounds of low molecular weight)The two neurotoxins produced by cyanobacteria are anatoxin and saxitoxin Excreted by : anabaena , aphanizomenon , oscillatoria





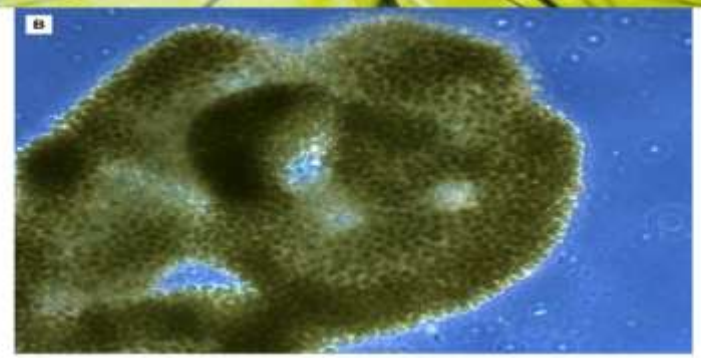


Hepatotoxins : toxins that affect the liver, The heptatotoxins are inhibitors of protein phosphatases. which can cause weakness, vomiting, diarrhea and cold extremities.

The two neurotoxins produced by cyanobacteria are Microcystins and Nodularins

Microcystis(Excreted by :Anabaena , Nostoc, Oscillatoria)

Nodularins (Excreted by : Nodularia).



phylum:Chlorophyta(Green algae)

The principal Characteristics of the Chlorophyta:

1- Flagellate cells are isokont.

2-the chlorophyll **a** and **b** present , also have accessory pigments including B-carotene and Xanthophylls .

3-Pyrenoids, where present , Each is surrounded starch grains.

4- Food stores as **starch** , is similar in the seed plants.

5-Chloroplast vary in shape ,size and number , in unicellular species they tend to be cup-shaped but in filamentous form may be annular ,reticulate ,discoid or ribbon-like .

6- motile species an eyespot is present.

7- Cell walls mainly cellulose, but some marine forms add $CaCO_3$.

8- Habitat may be freshwater, moist surfaces, or marine environments.

Chlorophyta includes tow classes:

1-Class:Chlorophyceae

2-Class:Charaphyceae

Class : Chlorophycaea

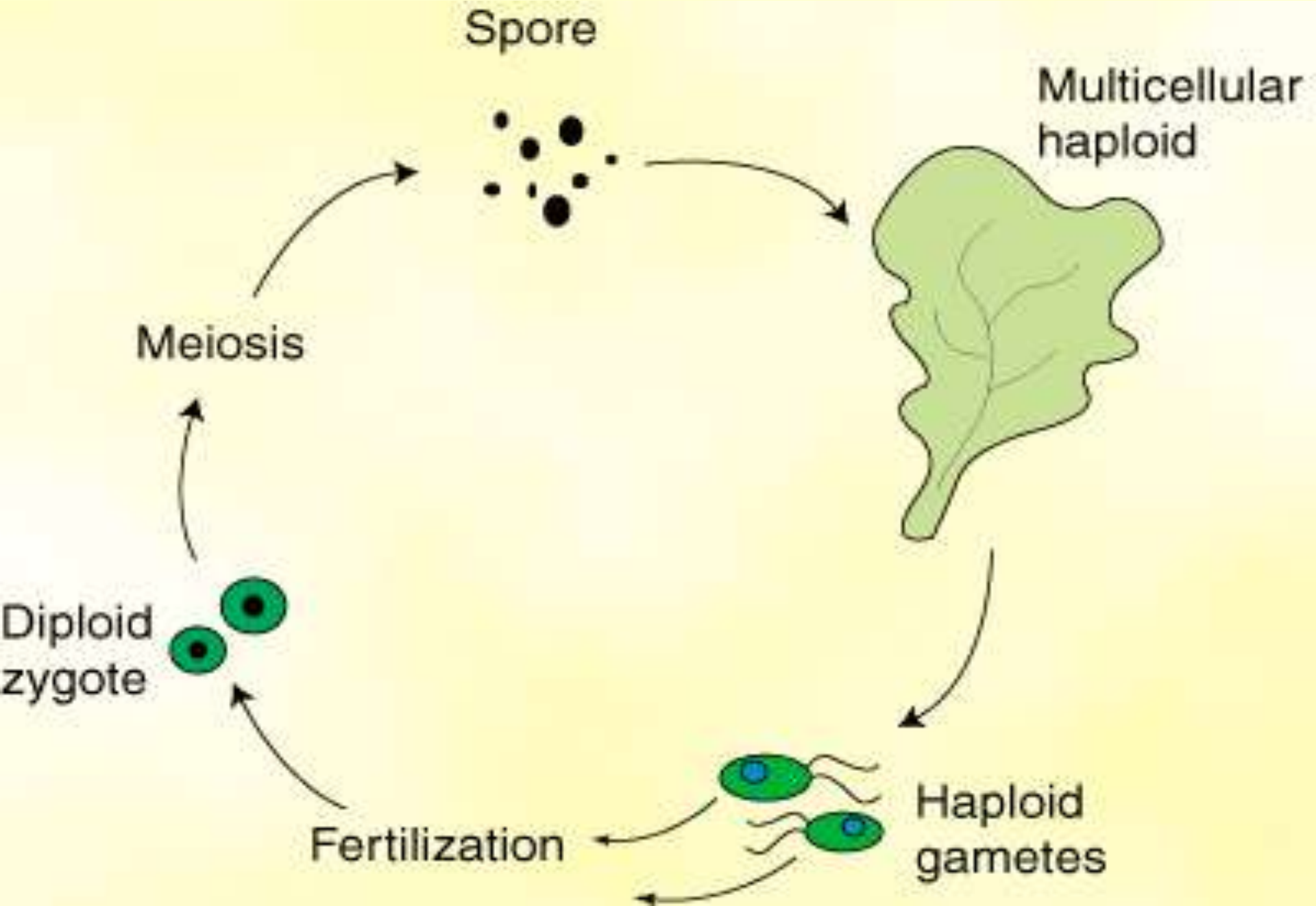
1-Order:Volvocales 2-Tetrasporales 3-Ulotrichales 4-Ulvales 5-Schizogoniales 6-Cladophorales 7-Oedogoniales 8-Zygnematales 9-Chlorococcales 10-Siphonales 11-Siphonocladiales

The Chlorophyceae are a large and important group of freshwater. that are important both ecologically and scientifically.

They come in a wide variety of shapes and forms, including free-swimming unicellular species, colonies, non-flagellate unicells, filaments.

all have a **haploid life-cycle**, in which only the zygote cell is diploid. The zygote will often serve as a resting spore, able to resist environmental changes such as desiccation.

Life cycle of the Green Algae - Haploid life cycle



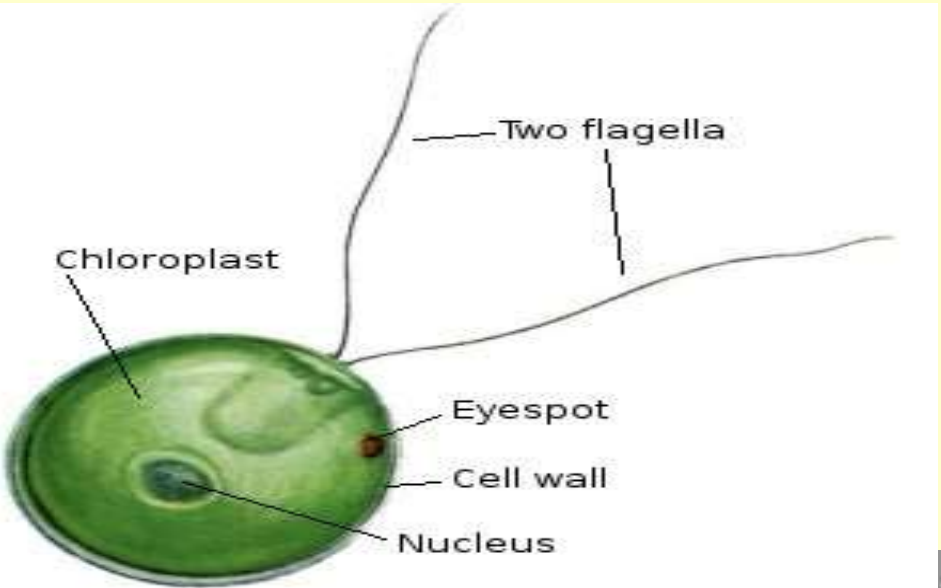
Most famous and important Chlorophyceae :

Chlamydomonas:

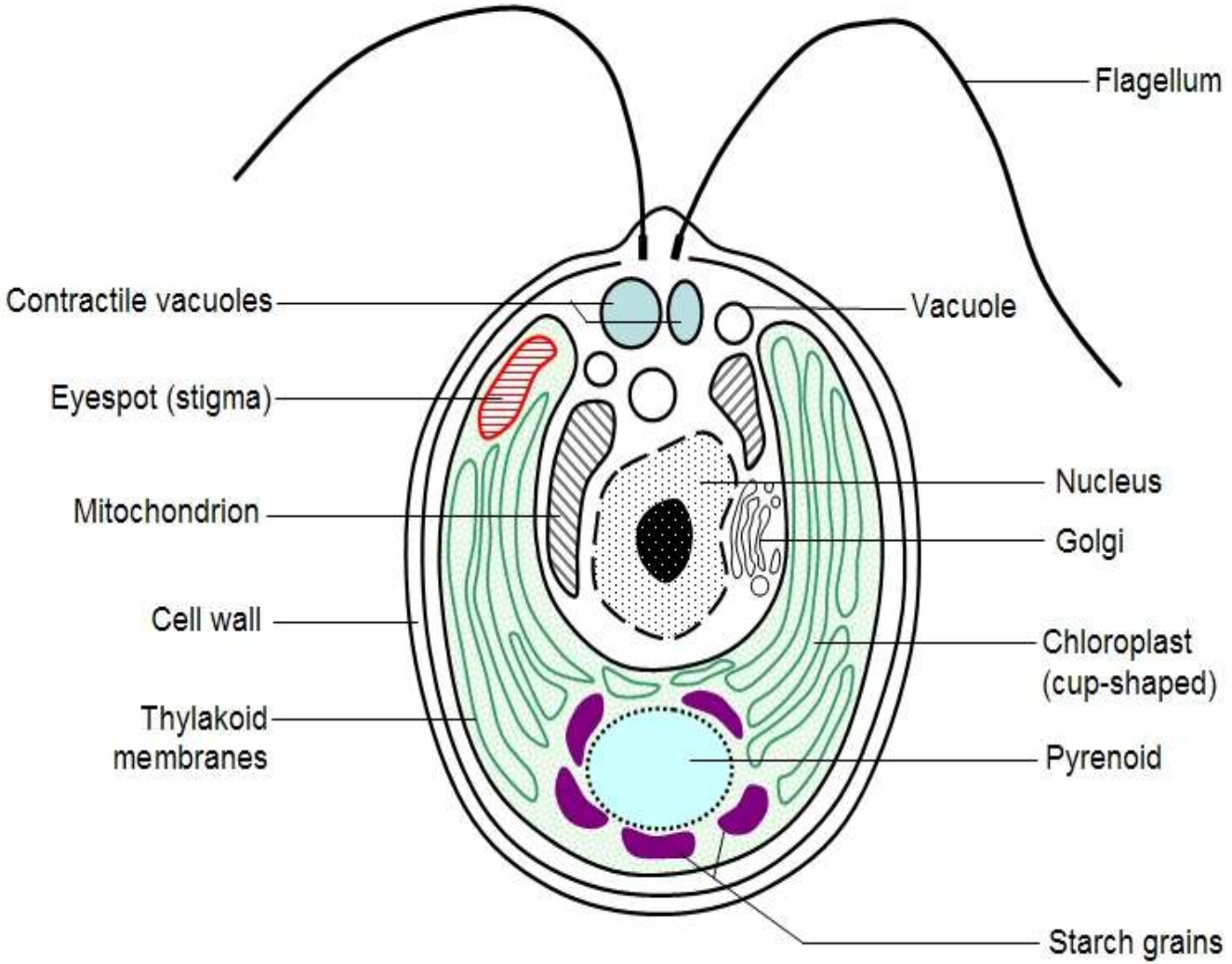
Chlamydomonas:is a genus of green algae from order vovocales consisting of unicellular flagellates .

occurring in stagnant water ,damp soil, freshwater, seawater, snow as "snow algae". It is generally found in habitat rich in **ammonium salt**.

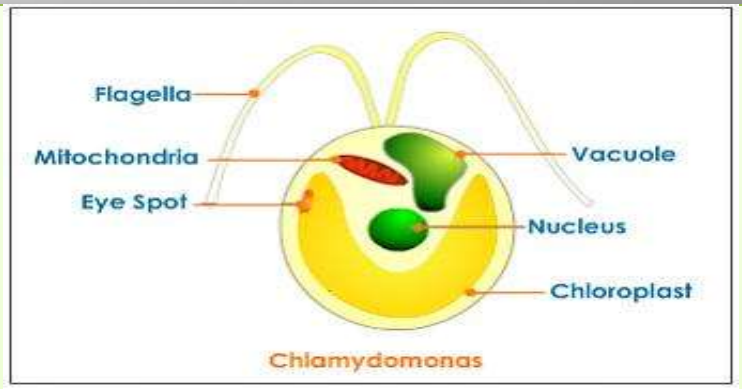
Chlamydomonas is used as a model organism for molecular biology, especially studies of flagella motility ,chloroplast dynamics, biogenesis, and genetics such as *Chlamydomonas nivalis*



Chlamydomonas



Morphology



Motile unicellular algae.
Generally oval in shape.
Cell wall is made up of glycoprotein
Two anteriorly flagella.
Contractile vacuoles found at near the bases of flagella.
cup shaped chloroplast is present, which has a single large pyrenoid.
Eye spot present for photosensitivity

Reproduction:

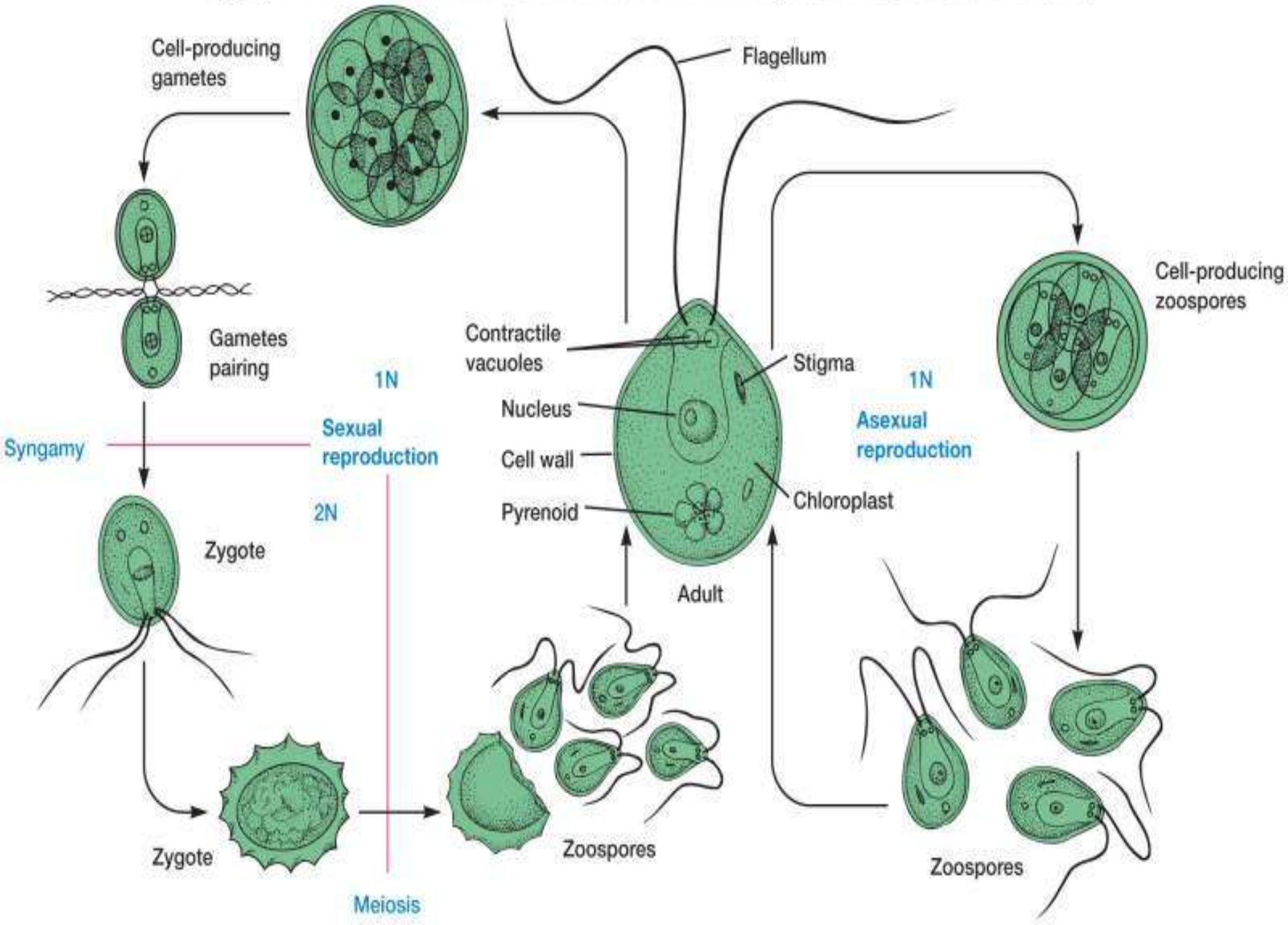
-Asexual reproduction :by producing **zoospores**.

-Sexual reproduction

reproduce sexually by forming **gametes** via cell divisions

- the water-borne gametes fuse to form a four-flagellated zygote
- zygote loses its flagella and enters a resting phase
- meiosis generates four haploid cells at the end of the resting phase

which give rise to new haploid vegetative algae;



Volvox

- spherical colonies Each mature *Volvox* colony is composed of numerous flagellate cells similar to *Chlamydomonas*, up to 50,000 in total, and embedded in the surface of a hollow sphere containing an extracellular matrix made of a gelatinous glycoprotein called Intercellular gel .

The cells have eyespots, more developed near the anterior, which enable the colony to swim towards light.

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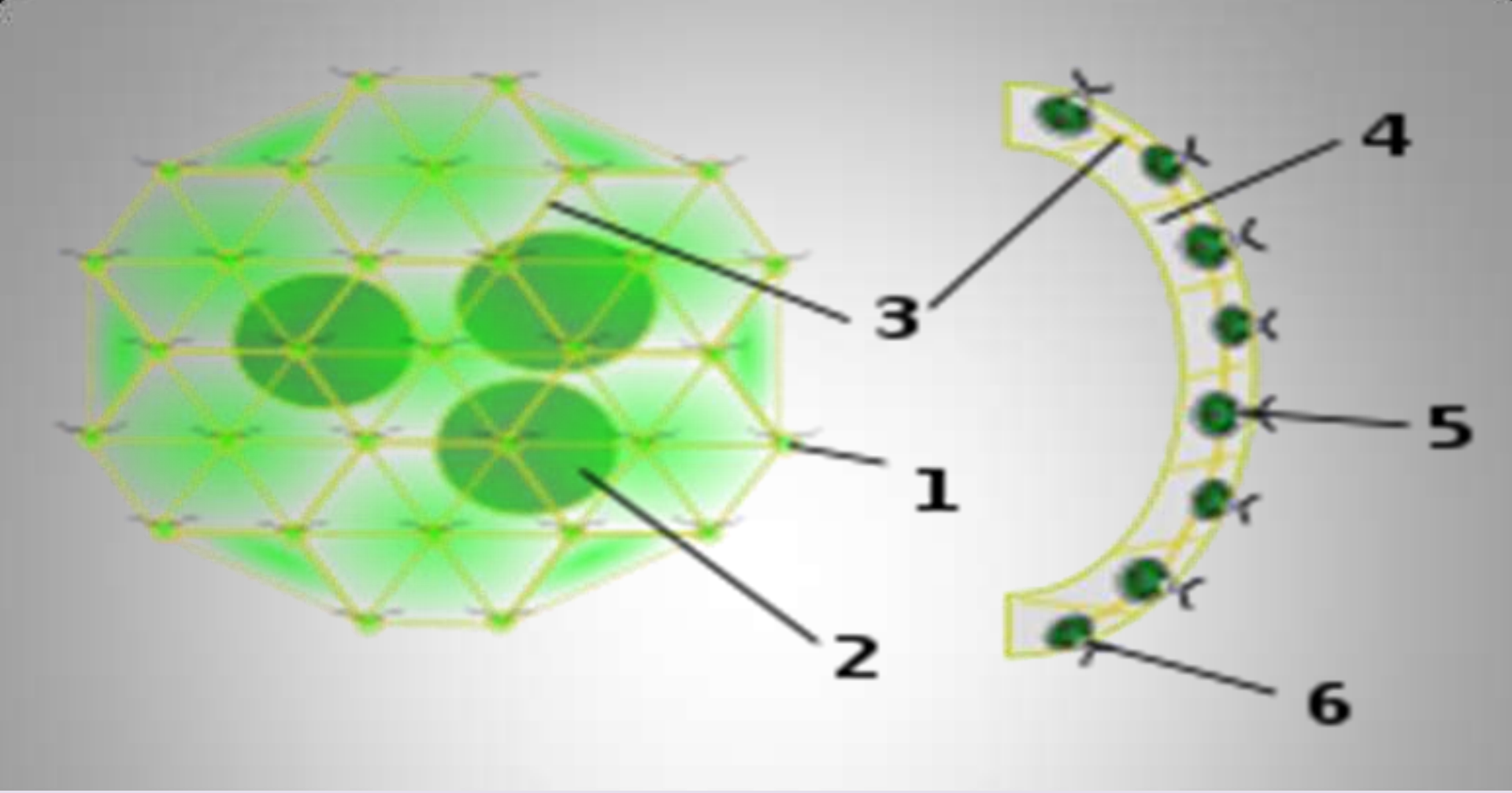


Volvox colony structure

1) Chlamydomonas -like cell
2) Daughter colony
3) Cytoplasmic bridges
4) Intercellular gel,
5) Reproductive cell
6) somatic cell

Reproduction

Asexual reproduction (Gonidia)

sexual reproduction (Oogamous)

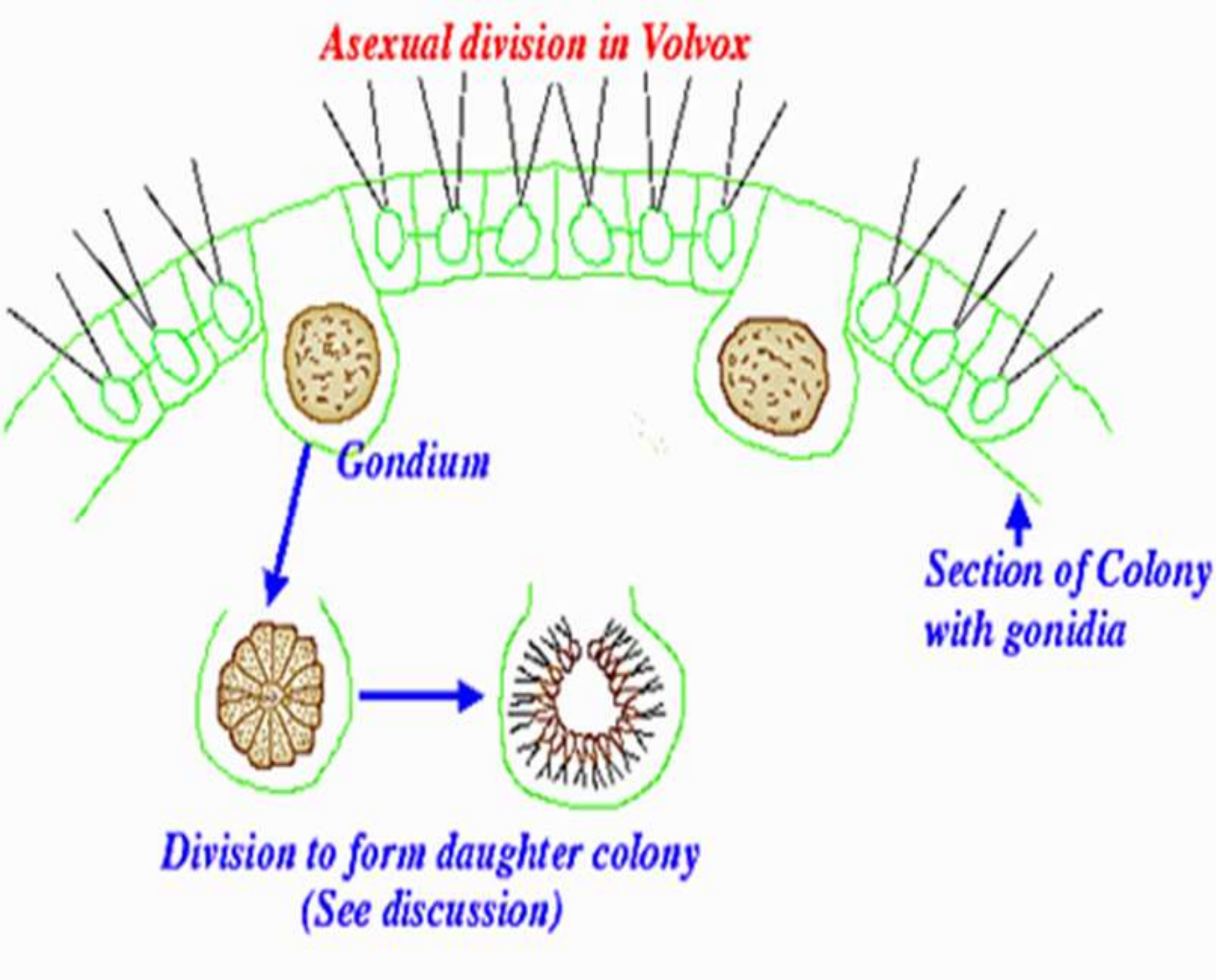
Asexual reproduction

Asexual colonies have reproductive cells known as **gonidia**,

-few cells in posterior half are pushed back into hollow cavity

-cells withdraw their flagella, increase in size, become round shaped.

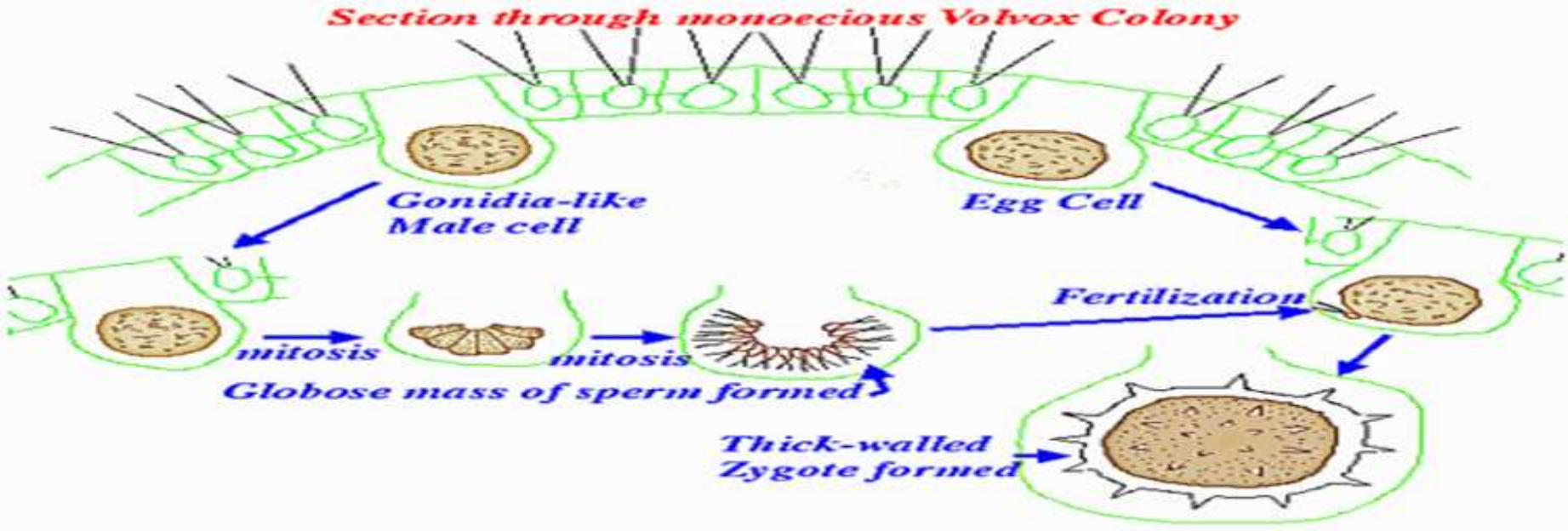
The protoplasm of cells divides by successive longitudinal divisions & forms daughter coenobium

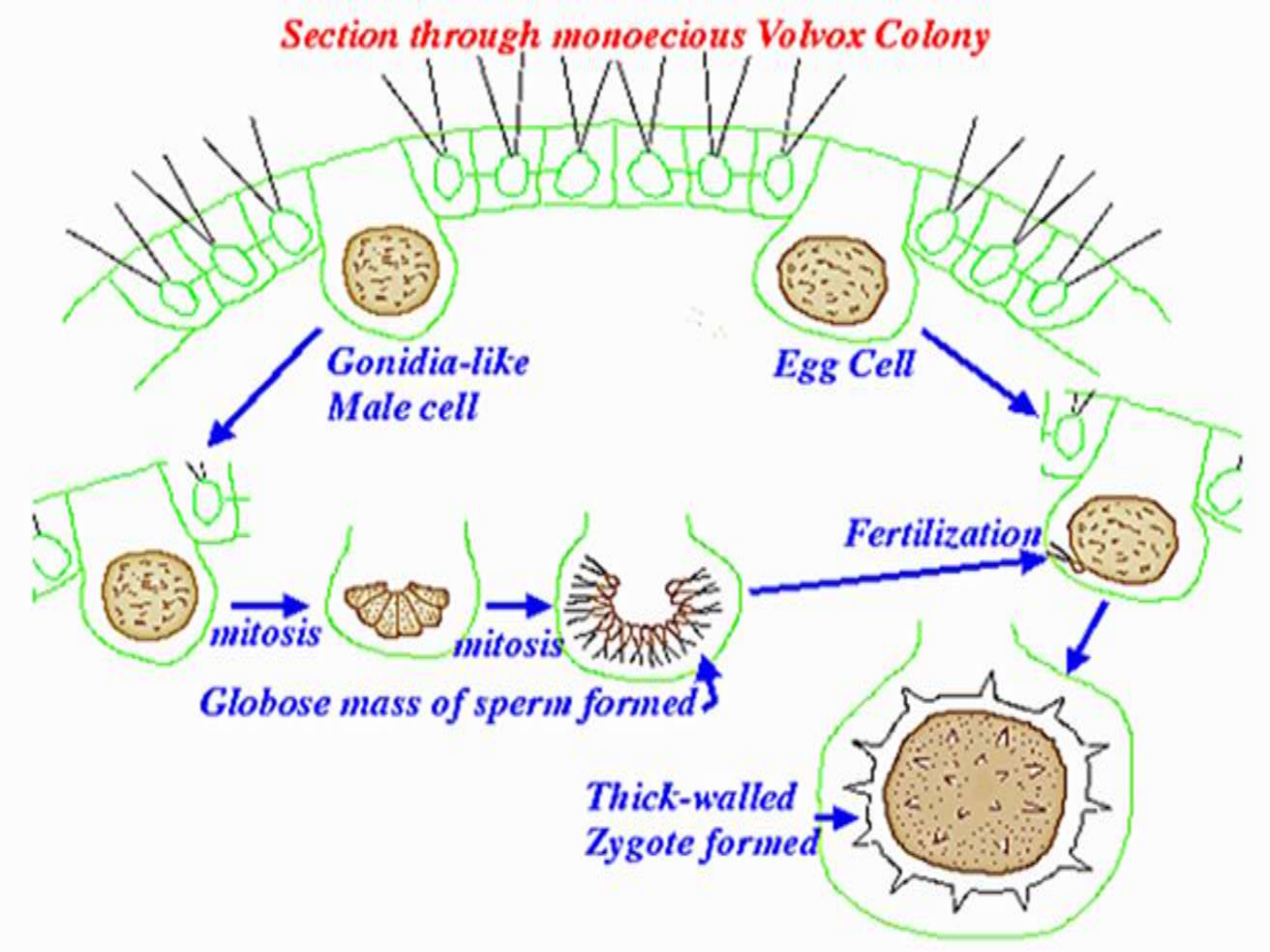

Asexual division in Volvox
Gondium
Section of Colony with gonidia
Division to form daughter colony
(See discussion)

Sexual reproduction :

Two types of gametes are produced: Male sex organs, (Antheridia) Female sex organs(Oogonia).

fusion of sperms and egg cells. The fertilization of male and female gametes in sexual reproduction leads to the formation of **zygotes**. After fertilization, a zygote with a hard protective layer is formed which helps to withstand harsh conditions and survive through the winter, that volvox can be monoecious or dioecious.




Section through monoecious Volvox Colony
Gonidia-like
Male cell
Egg Cell
Fertilization
mitosis
mitosis
Globose mass of sperm formed
Thick-walled
Zygote formed

Chlorella

Chlorella is a of single-cell green algae. It is spherical in shape, about 2 to 10 μm in diameter, and is without flagella. *Chlorella* contains the green photosynthetic pigments chlorophyll a and b .it plays an important role as **endosymbionts** inside the tissues of other organisms. Sponges, polyps, ciliates, *Chlorella* internally, providing a home for the alga in exchange for its photosynthetic.

In recent years, researchers have use of *Chlorella* as an experimental organism because it lacks a sexual cycle , the research advantages of genetic and source of food .

Top 7 Chlorella Benefits

1. Heavy Metal Detox
2. Detox Radiation
3. Immune Support
4. Weight Loss
5. Younger Appearance
6. Prevents Cancer
7. Blood Sugar/Cholesterol

Dr. Axe

FOOD IS MEDICINE

Oedogonium.

Oedogonium: is epiphytic on other aquatic algae or water plants. it may also be attached to stones or free floating objects.

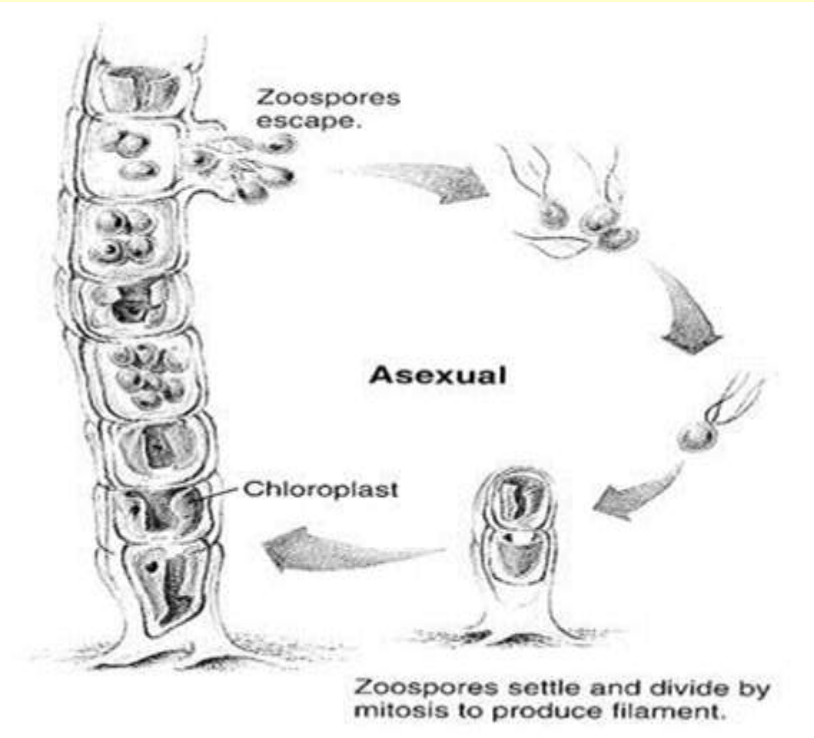
Reproduction

1-Vegetative reproduction : is by **Fragmentation**

2-Asexual reproduction :is through **Zoospore** under favorable conditions, **multi flagellated zoospores** are formed inside zoosporangium, The zoospores are ovoid, each with a ring of flagella at the anterior end.

On germination, the zoospore anchors itself to the substratum

Asexual reproduction may also take place through **aplanospores** and **Akinete**: under unfavorable conditions, formation of red walled, thick .

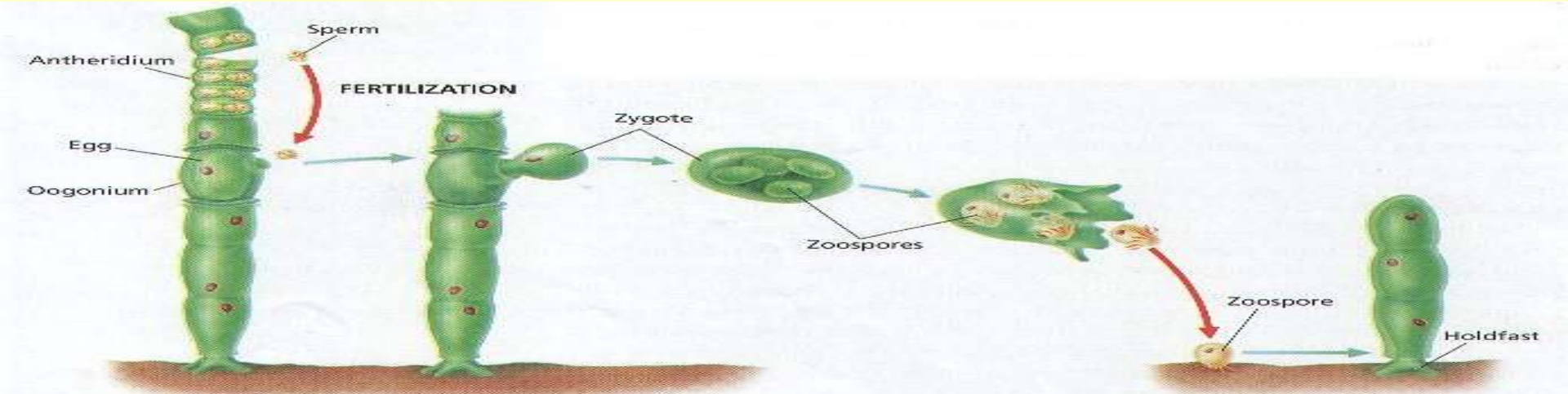


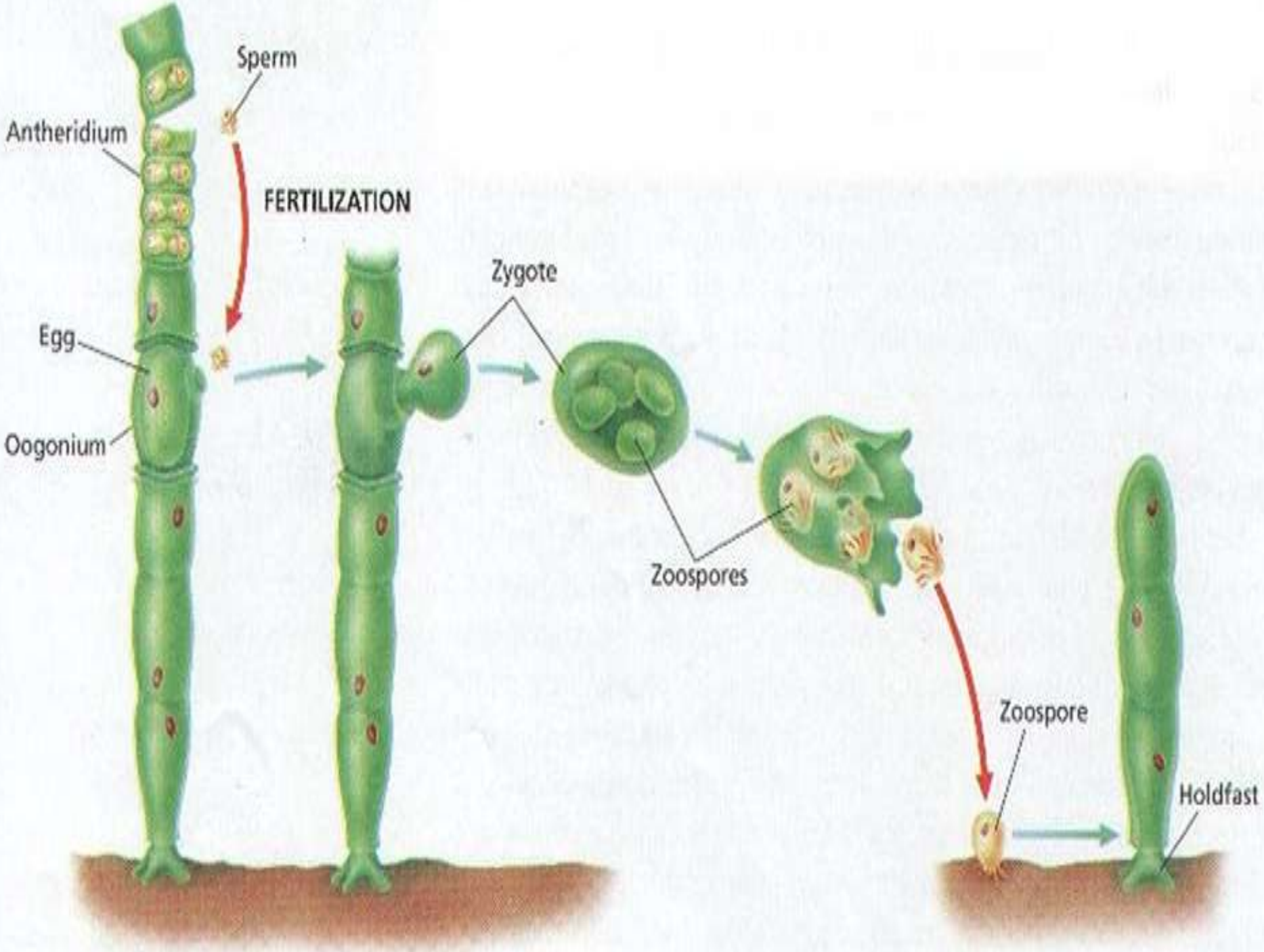
3-Sexual reproduction :is **Oogamous**, and depending on the behavior of the male filaments.

Macrandrous(the male gametophytes similar to female in size) if the male filament forms the sperm directly

Nannandrous (produce androsporangia that attaché and form small male gametophytes near oogonium called dwarf male) if a sperm are produced in a special dwarf male filament.

The zygote becomes resting Oospore and usually releases four zoospore via meiosis. Zoospores undergo meiosis so one cell attaches to the bottom & develops a holdfast while the other zoospores divide & form a filament Thalli are monoecious or dioecious forming antheridium and/or oogonium




Sperm
Antheridium
FERTILIZATION
Egg
Oogonium
Zygote
Zoospores
Zoospore
Holdfast

Cladophora

Growing attached to rocks ,in appearance regular-branching filaments that have cross walls separating multinucleate segments, *Cladophora* grows in the form of a tuft or ball with filaments that may range up to 13 cm (5 inches) in length .

Asexual reproduction ,by **biflagellate or quadriflagellate zoospore**

sexual reproduction in cladophora is **Isogamous** the biflagellate gametes normally unite, although they sometimes develop into new plants without union.

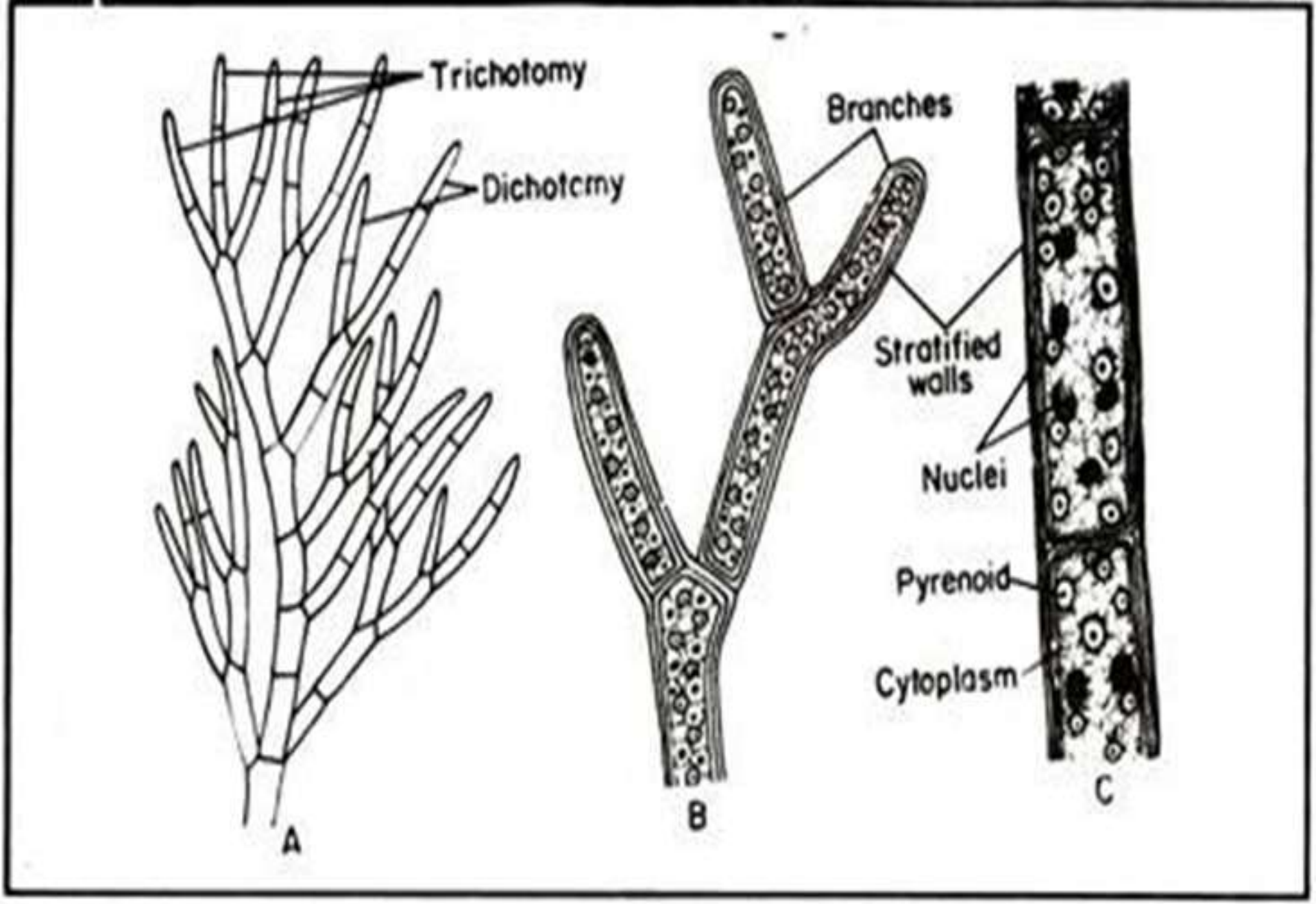


Fig 2.19. Cladophora Sp. A - Filament, B - Enlarged view of filament, C - Cell contents.

Order :Zygnematales

1-family : Zygnemaceae

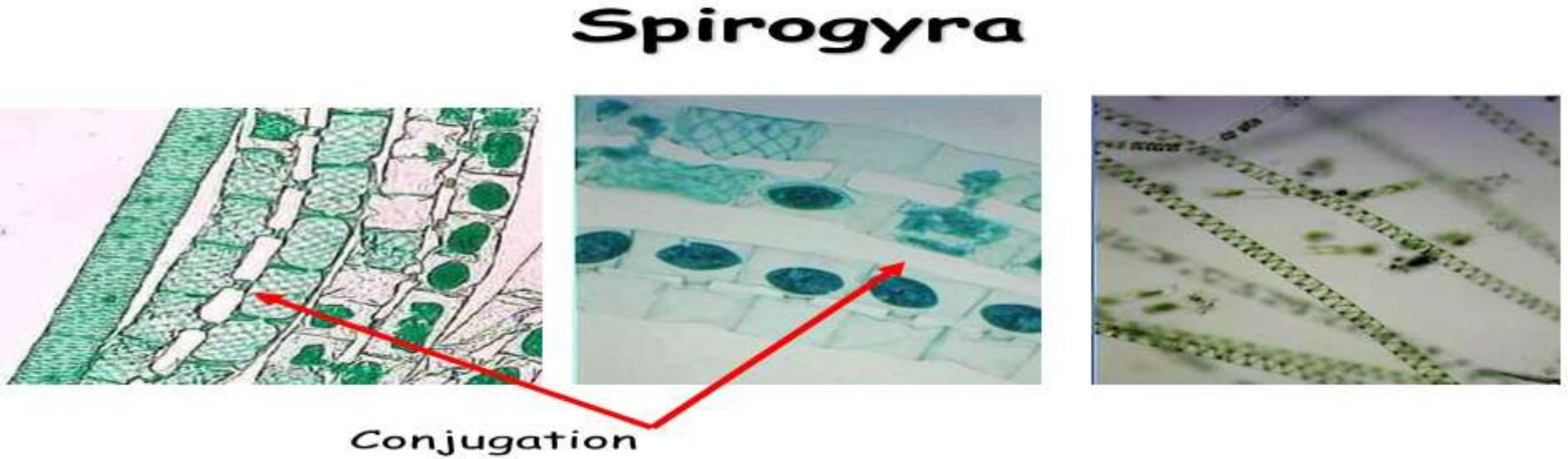
1-The family **Zygnemaceae** consist several thousand different species in genera such as **Zygnema** and **Spirogyra**

2- this group develop into unbranched filaments.

3- diversely shaped chloroplast , such as **stellate** in zygnema ,**helical** in Spirogyra

4-Most live in Freshwater , and grows on or near plants, rocks.

5- Sexual reproduction in Zygnematales takes place through a process called **conjugation.**



2-the family: Desmidaceae(Desmids)

1-Mostly freshwater such as ponds, rivers, and lakes.

2- Most desmids are unicellular, some species grow as long filamentous colonies.

3- No flagella

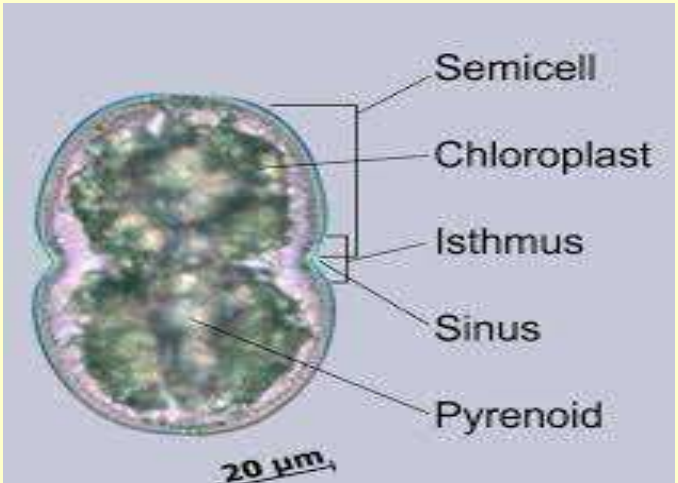
4-Two, mostly ornamented **semi-cells** are joined by a narrow connection called the **isthmus**. The shape of the half-cells (semi cells) is most various: ranging from more or less globular to disc- or spindle-like

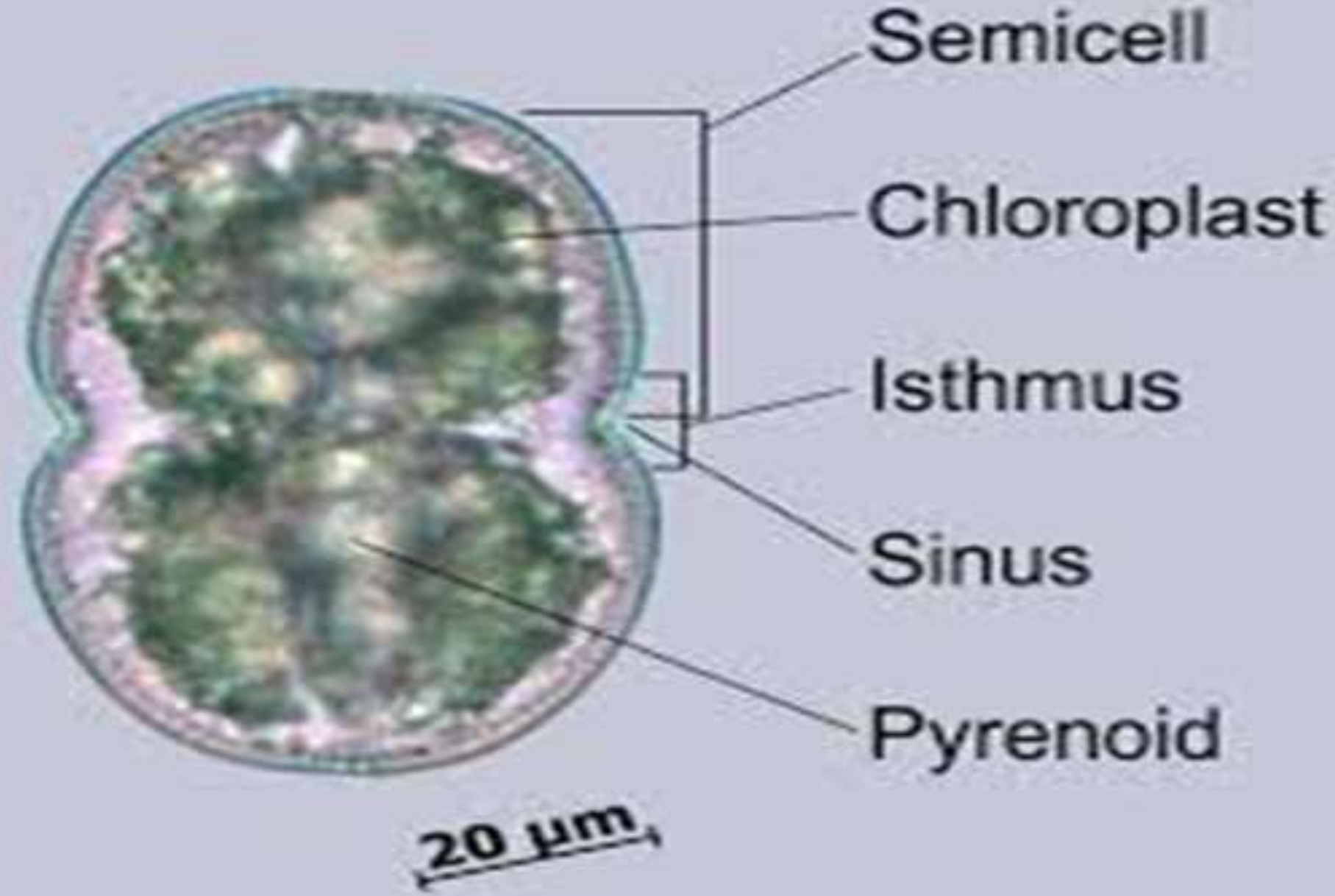
5-the spherical nucleus is situated. Each semi-cell houses a large, often folded chloroplast. One or more pyrenoids can be found

6-Reproduction: Asexual: division along the isthmus, each new cell regrows its sister semi cell.

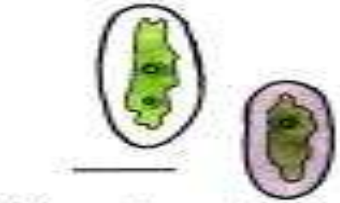
Sexual: conjugation

Desmids are not to be expected in polluted waters




Semicell
Chloroplast
Isthmus
Sinus
Pyrenoid
20 µm

CONJUGALES – Desmids

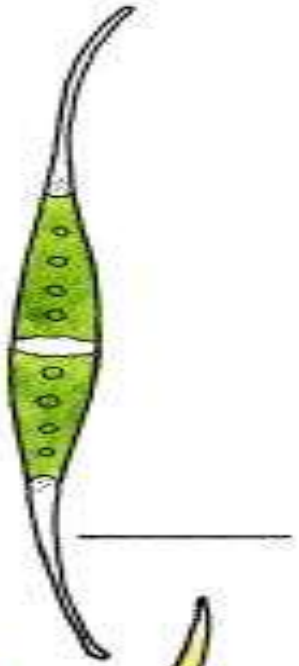


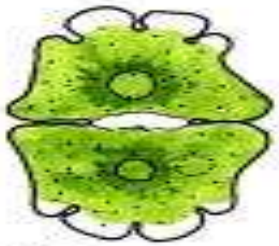
Mesotaenium

Cylindro-
cystis

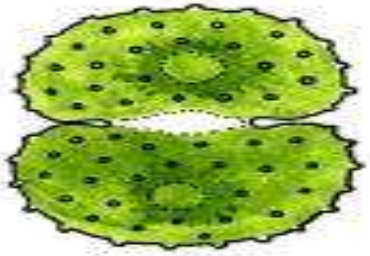
Netrium

Closterium



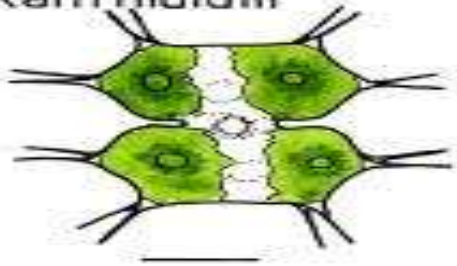


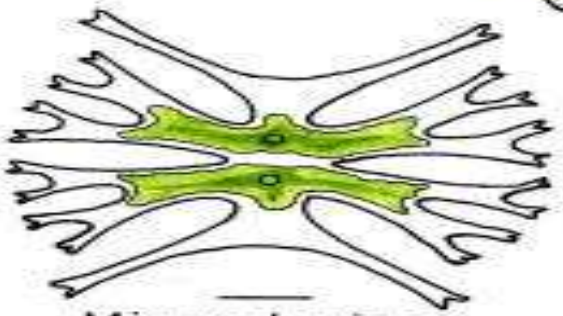
Euastrum



Cosmarium

Xanthidium

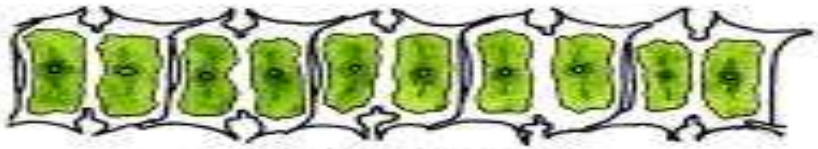




Micrasterias

zyg.

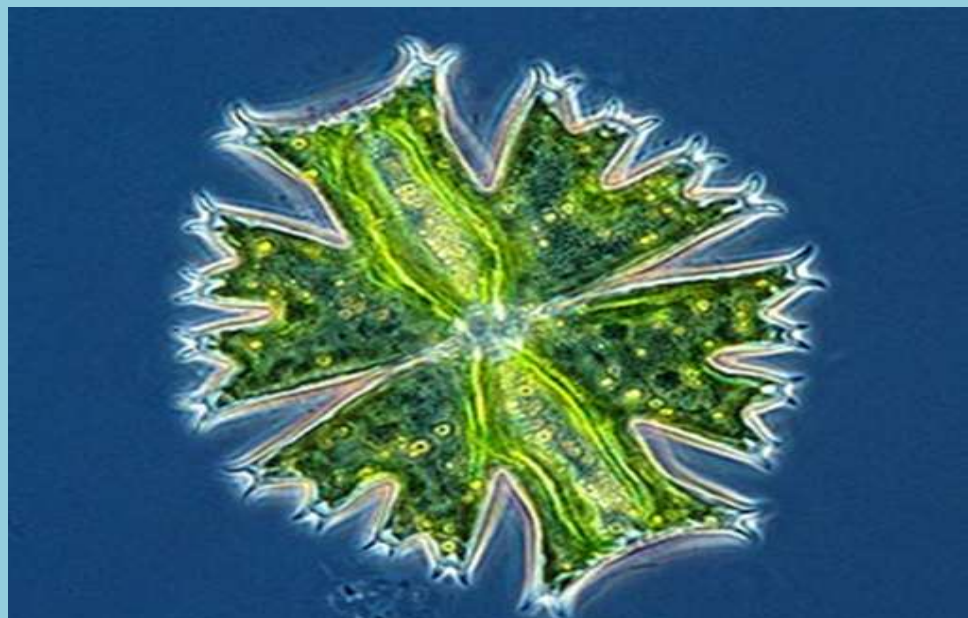
Staurastrum zyg.



Onychonyma

Micrasterias:

unicellular organism's nucleus sits on a narrow isthmus linking its two mirror image "semi-cells." A single large, space-filling chloroplast is housed within each semi-cell ,these form carbohydrates for energy storage.



2) Class: Charaphycae (Stone worsts,الحشائش الحجرية)

The members of this class of algae greens As a link between the rest of the algae and mosses

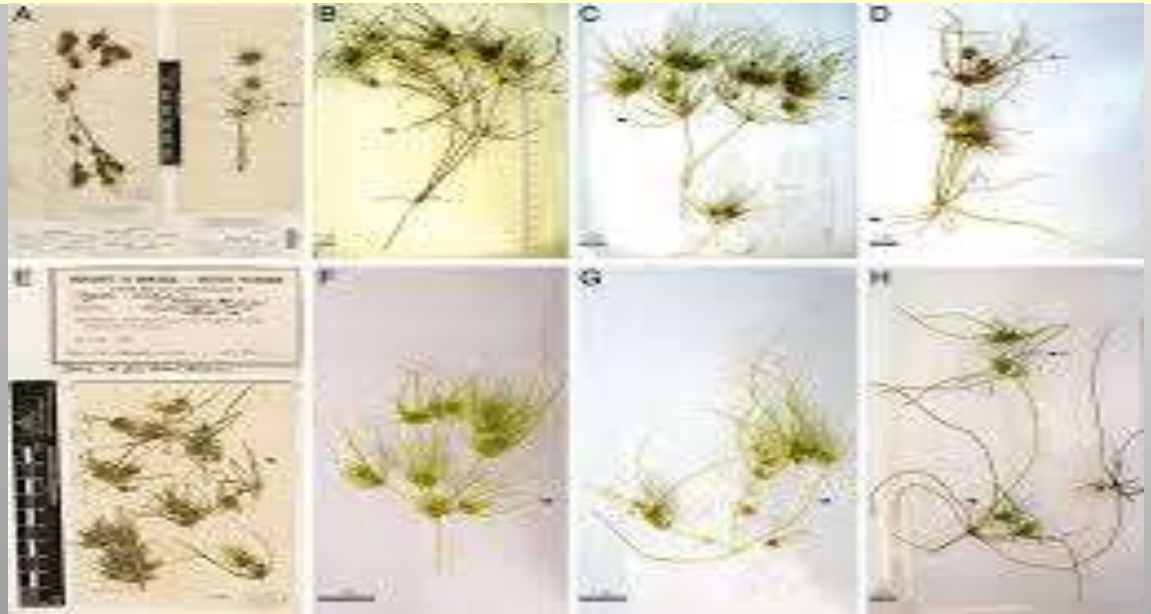
And differs from the class algae greens with features the following: -

1-consist of **erect axis** is divided into nodes and internodes.

2- reproduction complex is surrounded by **sterile tissue**

3-Vary the male gametes

4-Zygote grow to give **Protonemal stage** then grows into an adult plant.



The principal Characteristics of the Charophyceae (stonewort)

1-These algae can occur in fresh or brackish waters, and they have cell walls that contain large concentrations of **calcium carbonate**.

2- Cells of this class are **asymmetrical**.

3-The thallus is attached to the mud by a **rhizoidal system**. The plant body is erect and possesses **nodes and internodes**. Secondary laterals, also called 'leaves' arise from the nodes which are of limited growth. The leaves may or may not be differentiated into nodes and internodes.

4-The reproduction (An envelope of sterile cells)

Asexual reproduction is absent.

Vegetative reproduction takes place by **bulbils, secondary protonema**,

Sexual reproduction: is **Oogamous** each female sex organ (Oogonium) contains one large, immobile egg, and each male sex organ (antheridium) produces small, biflagellate sperm.

In sexual reproduction each female sex organ (oogonium) contains one large, immobile egg, and each male sex organ (antheridium) produces one small, biflagellate sperm. An envelope of sterile cells surrounds the reproductive structures.

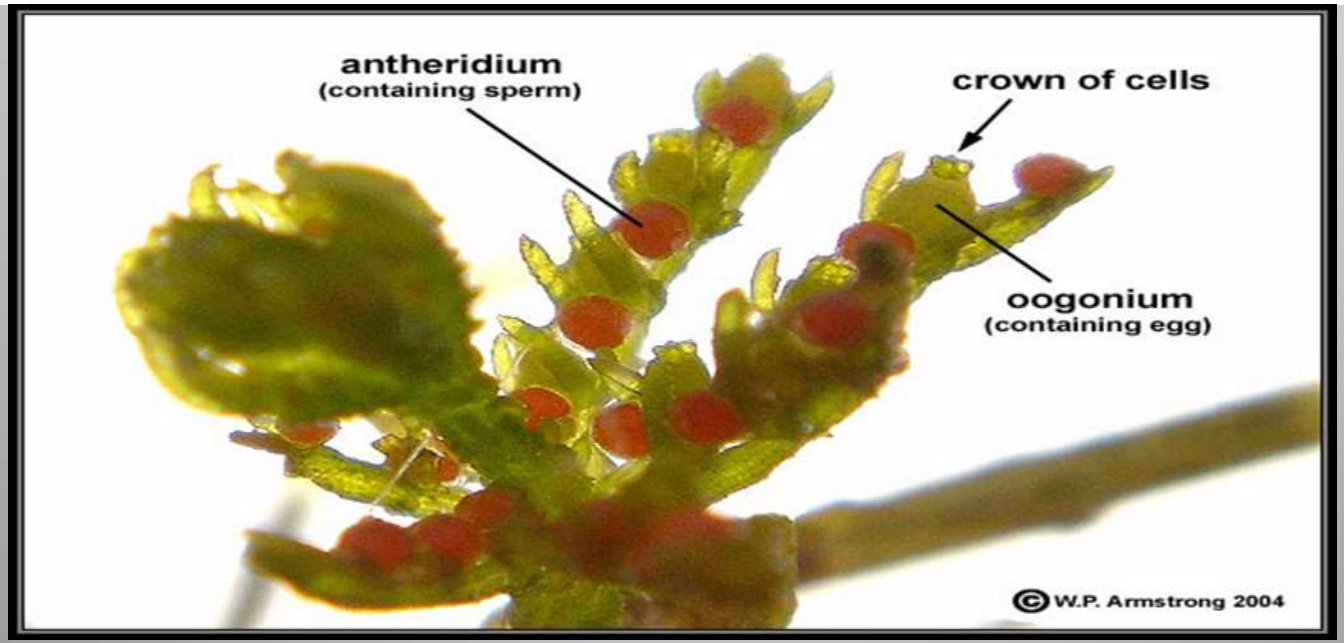
Chara sp. Morphology

The plant body is a gametophyte. Chara species is branches derived from apical cells ,It consists of a main axis (differentiated into nodes and internodes), dimorphic branches (long branch of unlimited growth and short branches of limited growth), rhizoids (multicellular with oblique septa) and stipulates (needle shaped structures at the base botany classes.

Chara plants are rough to the touch because of deposited calcium carbonate on the cell wall. Chara plants a distinctive and unpleasant smell of hydrogen sulfide.

Reproduction

the sex organs can be readily identified by their shape and color. The sperm-bearing antheridia are bright orange, while the egg-bearing oogonium is green with a distinctive crown of cells. This is an excellent alga for studying life cycles in general biology and botany classes.

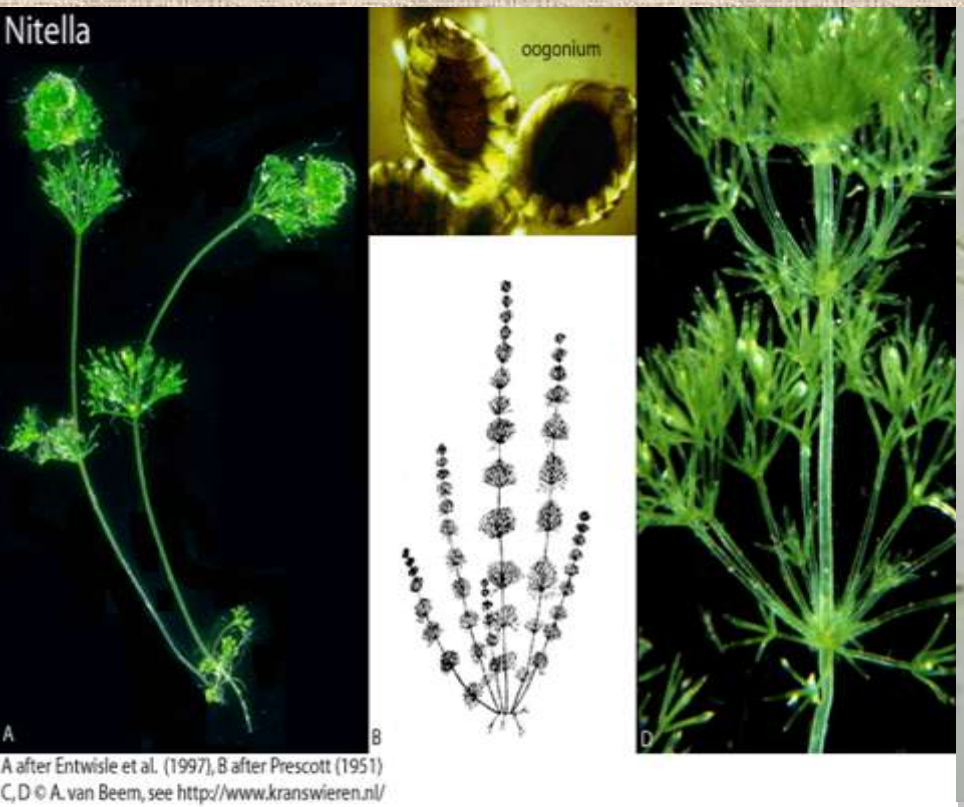


Nitella

- Light to dark green color
- Less than 8 cm to 2 m long
- Forked bushy branches
- Soft to touch
- No odor
- Fresh water
- Prefers slightly acidic water

Chara

- Grey-green color
- 5 cm to 1 m long
- Cylindrical whorled branches
- rough to the touch (Calcium deposits)
- Musty, garlic, like odor
- Fresh to brackish water
- Prefers slightly alkaline water



A after Entwisle et al. (1997), B after Prescott (1951)
C, D © A. van Beem, see http://www.kranswieren.nl/