COURSE NAME-BIOLOGY AND DIVERSITY OF ALGAE, BRYOPHYTA AND PTERIDOPHYTA (PAPER CODE: BOT 502)

UNIT –6 : GENERAL CHARACTERS OF CYANOPHYTA

UNIT –7 : GENERAL CHARACTERS OF SOME GENERA OF XANTHOPHYTA AND BASCILLARIOPHYTA

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GENERAL CHARACTERS OF CYANOPHYTA

1. The individual cells are prokaryotic in nature. The nucleus is incipient type and they lack membrane bound organelles.
2. Both vegetative and reproductive cells are non-flagellate.
3. Cell wall is made up of microfibrils and is differentiated into four (4) layers. The cell wall composed of mucopeptide, along with carbohydrates, amino acids and fatty acids.
4. Locomotion is generally absent, but when occurs, it is of gliding or jerky type.
5. The principal pigments are chlorophylls a (green), c-phycocyanin (blue) and c-phyco-erythrin (red). In addition, other pigments like β-carotene and different xanthophylls like myxoxanthin and myxoxanthophyll are also present.
6. Membrane bound chromatophore are absent. Pigments are found embedded in thylakoids.
7. The reserve foods are cyanophycean starch and cyanophycean granules (protein).
8. Many filamentous members possess specialized cells of disputed function (supposed to be the centre of N_2 fixation) known as heterocysts.
9. Reproduction takes place by vegetative and asexual methods. Vegetative reproduction takes place by cell division, fragmentation etc. Asexual reproduction takes place by endospores, exospores, akinetes, nannospores etc.
10. Sexual reproduction is completely absent. Genetic recombination is reported in 2 cases.

OSCILLATORIA

Scientific classification

Division: Cyanophyta

Phylum: Cvanobacteria

Class: Cyanophyceae

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Oscillatoria*

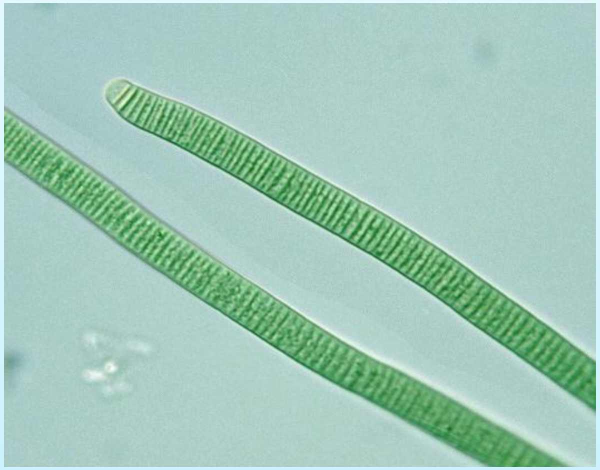


Fig. *Oscillatoria* filaments

Fig. Hormogonia

Oscillatoria is a genus of filamentous cyanobacteria. It has more than 100 species. Some of the species are *O.amoena* (Kützing) Gomont, *O.anguiformis* (P. González Guerrero) Anagnostidis, *O.anguina* Bory, *O. prolific* and *O. formosa*. It is named for the oscillation in its movement. Filaments in the colonies can slide back and forth against each other. Thus the whole mass is reoriented to its light source. It is very common in moist places rich in decaying organic matter. It is commonly found in watering-troughs waters like streams, roadside ditches, drains and sewers. It is mainly blue-green or brown-green. It forms thin blue green mucilaginous coating on the surface of flowing water. It's one species is found in hot springs. Some species like *O. formosa* and *O. princeps* are symbiotic. They form association with the nitrogen fixing bacteria.

Vegetative structure

Its body is composed of single row of cells. These cells form trichomes. Its trichomes are unbanched filaments. The trichome shows polarity. Some species have narrow trichome. Filaments may be either attached or free floating and rarely occur singly. The filaments may be interwoven or arranged in parallel rows. All cells of a trichome are similar in shape except apical cells. The apical cells are convex at the tip. It may be cap like (capitate) or covered by a thick membrane called calyptra. The apical cell may also be conical, dome shaped, acuminate, oval, flattened convex or coiled and accordingly to the shape of the cap cell, the species are identified.

Cell Structure

The cells show prokaryotic organization. All cells in the trichome are similar in structure. The cell can be differentiated into two parts: Cell wall and protoplasm. Cell wall is made of mucopeptide. Under an ordinary microscope the protoplasm is distinguishable into a peripheral chromoplasm and a central colourless centroplasm or central body.

Ultrastructure of cell shows that the chromoplasm contains photosynthetic lamellae or single thylakoid which often run parallel to one another. The thylakoids contain photosynthetic pigments like chlorophyll a, carotenes, xanthophyll's and phycobilins (C-phycocyanin, allophycocyanin, c-phycoerythrin). The centroplasm represents the incipient nucleus called gonophore. It is represented by DNA fibrils. The cell contains many ribosomes but mitochondria, plastids, endoplasmic reticulum and Golgi bodies are absent. Reserve food material is in the form of cyanophycean starch, lipid, globules and cyanophycin. The protoplasm also contains two types of granules α and β, α granules contain proteins and polysaccharides while β granules have lipid. Planktonic species of *Oscillatoria* possess gas vacuoles or pseudovaculoles which are devoid of any membrane. It is made of a number of 'hexagonal' structures called 'gas vesicles'.

Reproduction in *Oscillatoria*:

Oscillatoria reproduces only be vegetative methods. These are:

1-**By fragmentation:** It occurs due to accidental breakage of the filament, biting of some insects or animals. Filament divides into small pieces or fragments. Each of these fragments is capable of developing into new individual.

2-**By hormorgonia:** Hormogonia or hormogones are short segments of trichome which consists of few cells. Hormogones are formed due to formation of separation discs. These discs are mucilaginous, pad like and biconcave in shape. These are formed by death of one or more cells of the filament. These mucilage filled dead cells are also called necridia.

Movement in *Oscillatoria*: The name *Oscillatoria* (oscillate, to swing) is given to this alga due to the peculiar movement shown by the trichome. It is called 'oscillatory movement'. These are the jerky, pendulum-like movements of the apical region of the trichome. Some other movements shown by the trichomes of *Oscillatoria* are:

Gliding or creeping movement: The trichome moves forward and backward along its long axis.

Bending movement: The tip of the trichome shows bending.

ANABAENA

Division: Cyanophyta
Class: Cyanophyceae
Order: Nostocales
Family: Nostocaceae
Genus: *Anabaena*

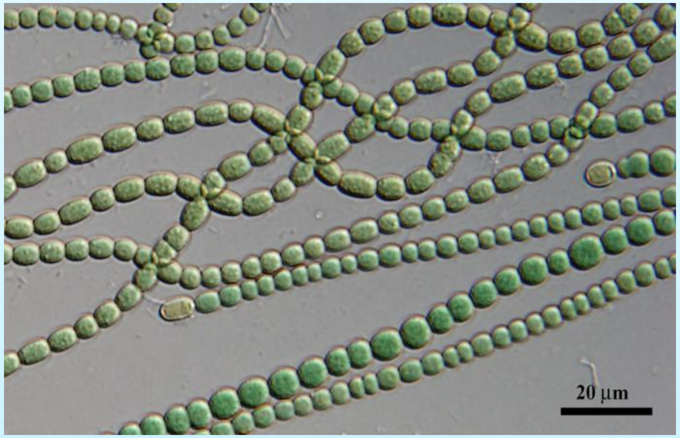


Fig. Filaments of *Anabaena*

Anabaena is a genus of filamentous cyanobacteria. It is found as plankton. Many species are known worldwide as major components of the freshwater plankton and also of many saline lakes. Others occur as tychoplankton. There are at least 15 gas-vacuolate species in freshwater, and *A. spiroides, A. circinalis, A. aequalis, A. affinis, A. angstumalis angstumalis, A. angstumalis marchita* and *A. flos-aquae* are the most common in the plankton. *Anabaena flos-aquae*, has invaded brackish marine environments such as the low-salinity portions of the Baltic Sea. It is known for its nitrogen fixing abilities. They form symbiotic relationships with certain plants, such as the mosquito fern. Some species of *Anabaena* are **endophytes.** They live in the roots of *Cycas* and *Azolla*. Anabaena is found in all types of water. **Blooms** or massive growths can occur in waters with a lot of nutrients. These blooms discolor the water and give it a bad odor when the cells die and decay.

They are one of four genera of cyarlobacteria that produce **neurotoxins.** These toxins are harmful to local wildlife, as well as farm animals and pets. Production of these neurotoxins is part of its symbiotic relationships. It protects the host plant from grazing pressure. Certain species of *Anabaena* have been used on rice paddy fields. They act as natural fertilizer.

Vegetative thallus/Structure

It has filamentous structure. Its filament resembles the filament of *Nostoc*. Sometimes it becomes difficult to differentiate between trichomes of *Nostoc* and *Anabaena*. There is only one difference. The filaments of *Nostoc* are covered by mucilage and form a colony. It is absent in *Anabaena*. The filament of *Anabaena* consists of string of **beaded** cells. Heterocysts are of same shape as of vegetative cell. The filaments are ordinarily straight but they may be circinate or irregular. Filaments occur singly within a sheath.

Trichomes may be straight, curved or helically (spirally) formed. The cells are cylindrical, spherical or ovoid (barrel- shaped) and not shorter than broad (or only slightly so), usually ranging in width from about 2 to 10 µm but in some species to over 20 µm.

The terminal cells may be rounded, tapered or conical in shape. Heterocysts are intercalary or terminal or both. Intercalary heterocysts are nearly spherical to cylindrical with rounded ends; terminal heterocysts are similar or sometimes conical. Akinetes are usually formed, and their position in trichomes differs with the species. A firm individual sheath is absent, but a soft mucilaginous covering is often present. Trichomes, when free of adhesive mucilage, are normally motile and colonies are not formed.

Gas vesicles occur in many species; however, they occur mainly in those that are planktonic. Protoplasm is composed of ‘Soo riafts. The peripheral part is called chromoplasm. It contains pigments hence it is colored. The central colourless part of protoplasm contains nucleus like material called **central body** or **chromatin granules. H**eterocysts are of same shape as of vegetative cell. Golgi bodies, endoplasmic reticulum and mitochondria are absent in their cells.

Nitrogen fixation by *Anabaena*

During times of low environmental nitrogen, about one cell out of every ten differentiates into a heterocyst. The heterocyst then supply neighboring cells fixed nitrogen in return for the products of photosynthesis. Such nitrogen fixing cell cannot perform photosynthesis now. This separation of functions is essential. The nitrogen fixing enzyme in heterocysts is **nitrogenase.** It is unstable in the presence of oxygen. Nitrogenases are kept isolated from oxygen. Therefore, heterocysts have developed elements to maintain a low level of oxygen within the cell. The developing heterocyst builds three additional layers outside the cell wall. These layers prevent the entrance of oxygen into the cell. It gives heterocyst its characteristic enlarged and rounded appearance. Due to these adaptations, the rate of oxygen diffusion into heterocysts is 100 times lower than of vegetative cells. Heterocyst cells are terminally specialized for nitrogen fixation. Carbohydrate, probably in the form of glucose, is synthesized in vegetative cells and moves into heterocysts. In return, nitrogen fixed in heterocysts moves into the vegetative cells, at least in part in the form of amino acids.

Reproduction

Only vegetative propagation is found which takes place by

- **Fragmentation** of "parental" trichomes into shorter trichomes indistinguishable in cell dimensions from the former trichome.
- **Hormogonia:** these are frequently formed due to breaking up of trichomes into smaller pieces at the region of heterocysts. On germination, they develop heterocyst and grow into long filaments. They are motile in many species.
- **Akinetes :** they are formed during unfavorable conditions. **Akinetes are thick walled spores with a large amount of reserved food material.** Their wall is two to three layers thick. They have granular protoplasm. Akinetes are capable of forming new filaments. The Akinetes can survive in dry conditions. On germination, akinetes form new thallus. Nitrogen deficiency appears to be one factor leading to production of akinetes.
- **By germination of heterocysts:** In a few species, heterocyst germinates to form new thallus.
- **Endospore formation is** rare in *Anabaena.*

Fig. 4.3.2.c. Akinete in *Anabaena*

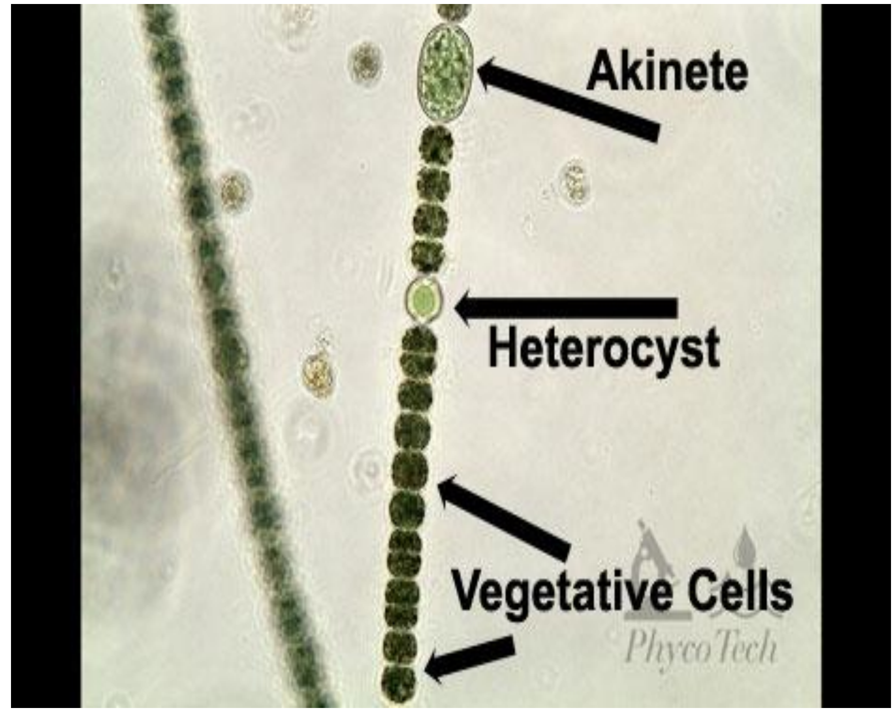
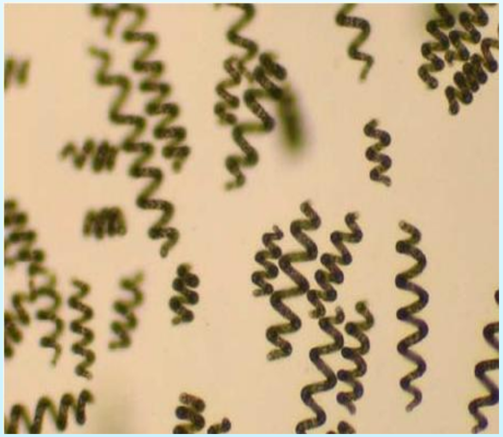


Fig. Akinete and heterocyst in *Anabaena*

SPIRULINA / ARTHROSPIRA

Division: Cyanophyta
Class : Cyanophyceae
Order : Oscillatoriales
Family : Spirulinaceae
Genus : *Spirulina*



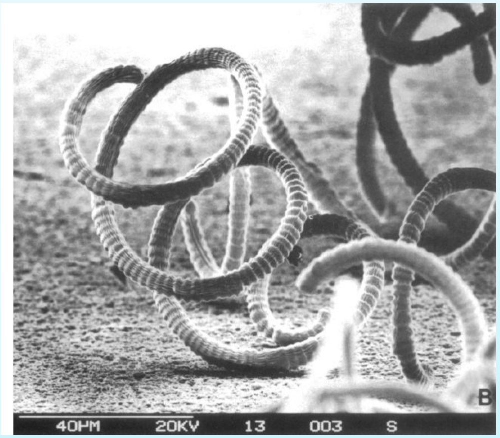


Fig. Microphotograph of *Spirulina*

Spirulina is a genus of filamentous cyanobacteria (commonly called blue-green algae), with a coil-like shape. 13 species are known some of them are *S. abbreviate, S. albida*, *S. baltica*, *S. magnifica*, *S. abbreviate*. *S. agilis*, etc. *Spirulina* is also the commercial name for the species *Arthrospira platensis* (previously known as *Spirulina platensis)*, which is cultivated around the world as a food source. It is a very rich source of nutrition. In fact, it was a staple of Aztec cuisine. The genus is also responsible for the flamingo's pink plumage. It is currently popular as a health food in the U.S. and Europe, often taken as a dietary supplement in the form of powder or tablet.

It has 55 - 70 % protein, vitamin A, B1 (thiamine), B2 (riboflavin), B3 (niacin), B6 (pyridoxine), B12 (cobalamin), vitamin C, vitamin D, vitamin E, folate, vitamin K, biotin, pantothenic acid, beta carotene (source of vitamin A), inositol, minerals as calcium, manganese, iron, chromium, phosphorus, molybdenum, iodine, chloride, magnesium, sodium, zinc, potassium, selenium, germanium, copper, boron.

Vegetative thallus/structure

Spirulina is a multicellular, filamentous cyanobacterium. Under the microscope it appears as blue green filaments composed of cylindrical cells arranged in ubranched, helicoidal trichomes. The filaments are motile, gliding along their axis. Heterocysts are absent. The helical shape of the trichome is characteristic of the genus but the helical parameter (i.e. pitch, length and helix dimensions) vary with the species and even within the same species. The helical shape is maintained only in liquid media.

Cell structure

The diameter of the cells ranges from 1-3 µm in the smaller species and from 3-12 µm in the larger. The larger species have a granular cytoplasm containing gas vacuoles and septa. The cell wall is made up of four layers. The cells contains phycocyanin, chlorophyll, carotenoids, myxoxanthophyll, zeaxanthin, cryptoxanthin, echinenone and other xanthophylls, gamma linolenic acid, glycolipids, sulfolipids and polysaccharides.

Reproduction

The life cycle of *Spirulina* in laboratory culture is simple by hormogonia. A mature trichome is broken in several pieces through the formation of specialized cells, necridia, that undergo lysis, giving rise to biconcave separation disks. The fragmentation of the trichome at the necridia produces gliding, short chains (2-4 cells), the hormogonia, which give rise to a new trichome.

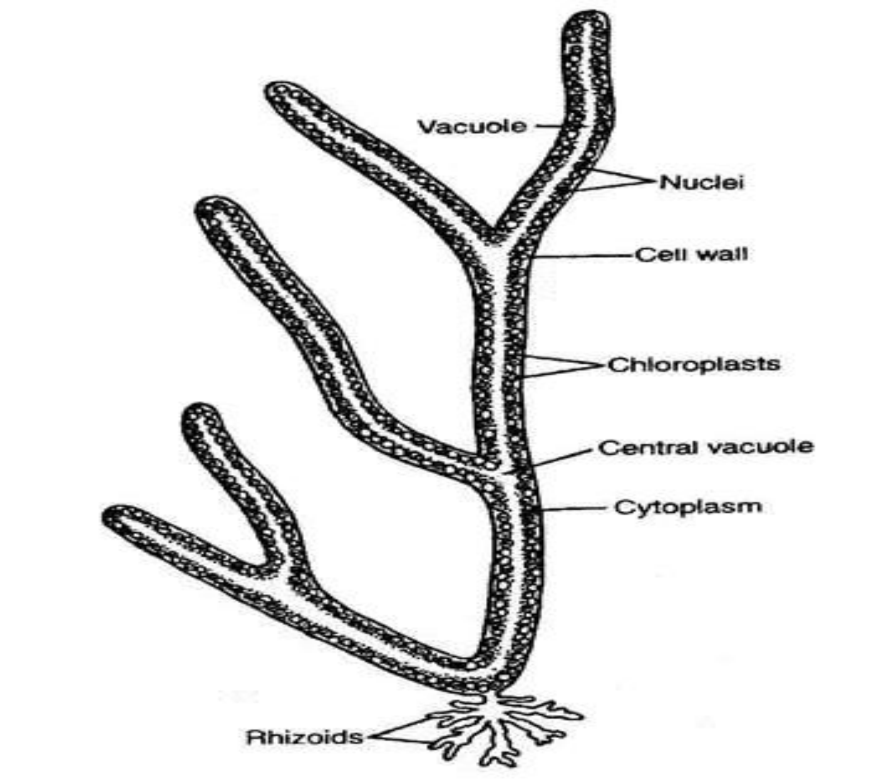
During this process, the cytoplasm appears less granulated and the cells assume a pale blue-green color. The number of cells in hormogonia increases by cell fission while the cytoplasm becomes granulated and the cells assume a brilliant blue-green color. By this process trichomes increase in length and assume the typical helicoidal shape.

GENERAL CHARACTERS OF XANTHOPHYTA

- The members of Xanthophyta are also known as Yellow-Green Algae.
- The members of this group are primarily freshwater and terrestrial, few are marine.
- This class is characterized by the motile cells having anteriorly directed **tinsel** flagellum and a posteriorly directed **whiplash** flagellum.
- The chloroplast consists of chlorophyll a, and c, and appear yellowish-green. The major carotenoids found in this group are diadinoxanthin, heteroxanthin and vaucheriaxanthin.
- In the chloroplast, the thylakoids group in to bands of three. In many genera, there is a single pyrenoid in the chloroplast. The eyespot in motile cells are always present in the chloroplast. The chloroplast is surrounded by the two membranes of **chloroplast-endoplasmic-reticulum** (c.e.r). The outer membrane of c.e.r. is usually continuous with outer nuclear membrane.
- The reserve food material in this group of the algae are mannitol, ß-1,3 linked glucans similar to the paramylon and lipids.
- Vegetative and asexual reproduction takes place by fragmentation and by zoospore, aplanospore or by akinete formation. The zoospores are pyriform, without cell wall, and biflagellated with anterior large tinsel and posterior small whiplash flagella.
- Sexual reproduction is known only in *Vaucheria*, *Tribonema* and *Botrydium*. In *Vaucheria* it is oogamous type while in rest two both the gametes are biflagellated.

Vaucheria

Division: Xanthophyta
Class: Xanthophyceae
Order: Heterosiphonales
Family: Vaucheriaceae
Genus: ***Vaucheria***



***Vaucheria*: Thallus**

Occurrence - *Vaucheria* occurs in wide habitats; found growing on ranging from damp soils to walls, in freshwater, and muds of salt marshes. Many species are amphibious which form thick, dark green felt-like structure on moist soils. Some species are marine also.

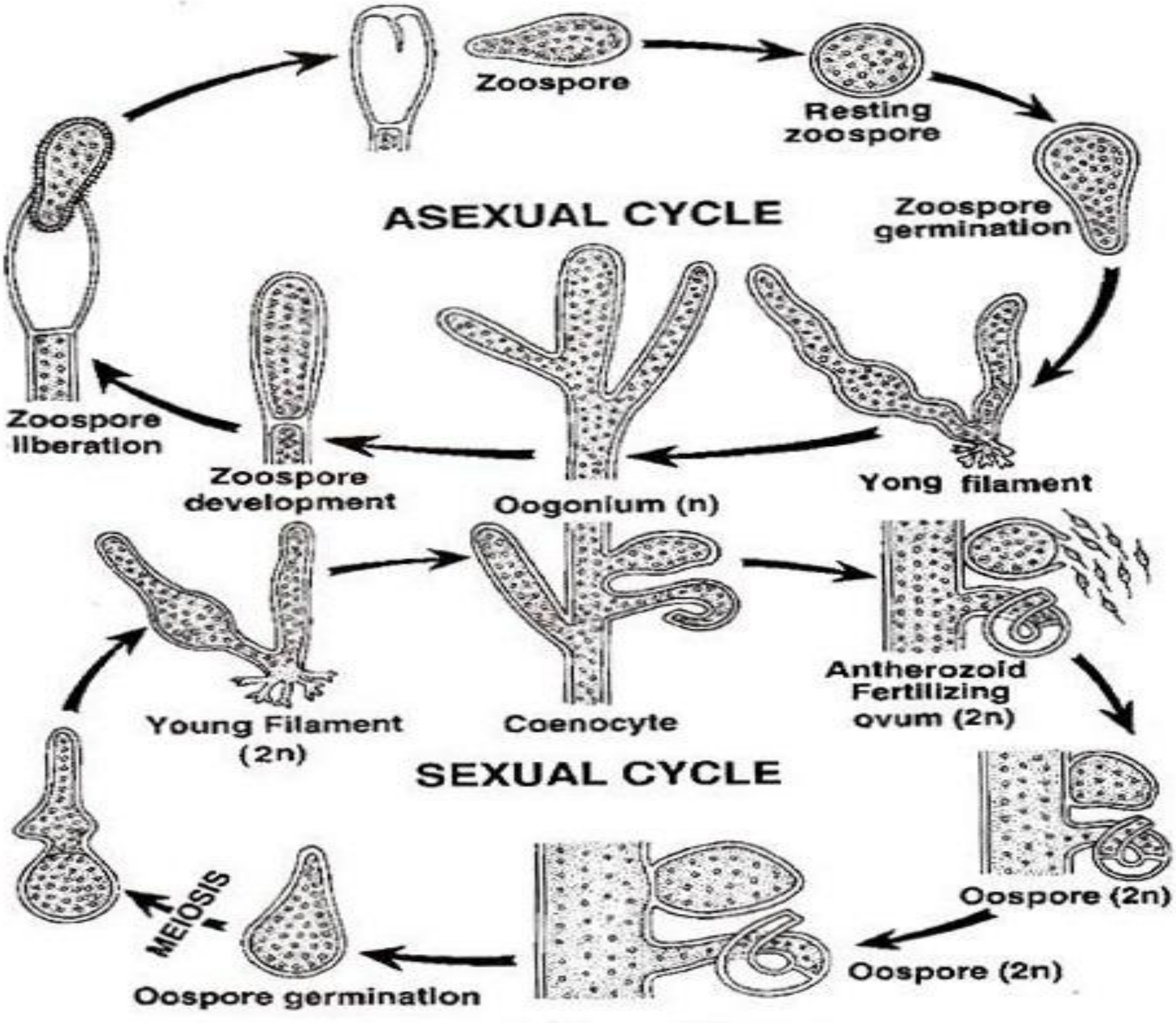
Thallus structure - The thallus of *Vaucheria* is filamentous, aseptate, siphonaceous tube-like and sparingly branched. In terrestrial species the genus is attached with the substratum with the help of rhizoidal branches. Cell wall is relatively thin, made up of cellulose. The protoplasm consists of a central vacuole which runs throughout the thallus and with surrounding cytoplasm. The peripheral region of the protoplasm consists of discoid chromatophores with pyrenoids while lying close to the vacuole are found numerous nuclei. The central region of protoplast near the vacuole shows cytoplasmic streaming movement which involves the nuclei, mitochondria and golgi. The thallus grows is restricted the at apex and takes place by simple elongation of the terminal portions of the branches. Transverse septa may develop due to injury that separated the injured portion from rest part of the thallus.

Reproduction - Vegetative reproduction in *Vaucheria* takes place occasionally by fragmentation of the filaments.

Asexual reproduction involves the formation of zoospores in club-shaped zoosporangia which are formed at the tip of the filaments. Zoospores are multinucleate and multiflagellate. There is formation of septa at the base of zoosporangium during its development and it is cut off from rest of the thallus.

- The protoplasm of the zoosporangium gets metamorphosed into the single large zoospore having numerous peripheral unequal flagella in pairs covering the entire surface of zoospore. Such type of multiflatellated zoospore of *Vaucheria* is called ‘compound zoospore’ or ‘**synzoospore**’ resulting from failure of the sporangial protoplast into the segments of biflagellate uninucleate zoospores as in case of other members of Xanthophyceae. The zoospore is liberated by gelatinization of the apical wall the zoosporangia. After swimming for some time, the zoospore settles down the substratum, the flagella are withdrawn, and a wall is secreted around. The germinating zoospore gives rise to several germ tubes which develop into new young thallus. Low light intensity, high humidity, transfer from running to still water and low nutrient availability induces the formation of zoopospores.
- In terrestrial species, asexual reproduction occurs by formation of aplanospore or hypnospores which are non-motile and thick-walled spores. Aplanospores are formed singly in club-shaped aplanosporangia and are liberated through apical pores. During hypnospore formation, entire thallus gets segmented by formation of transverse septa and the protoplasm of each unit gets converted in to the hypnospore. At this stage the thallus of *Vaucheria* looks like another alga *Gongrosira*, hence this stage is also known as ‘**Gongrosira stage’**. The hypnospores either germinate directly or divide into a number of small cysts. During germination, the protoplasm of each cyst comes out of the cyst wall through a pore, exhibit amoeboid movement for some time, and later it develops into a young thallus.

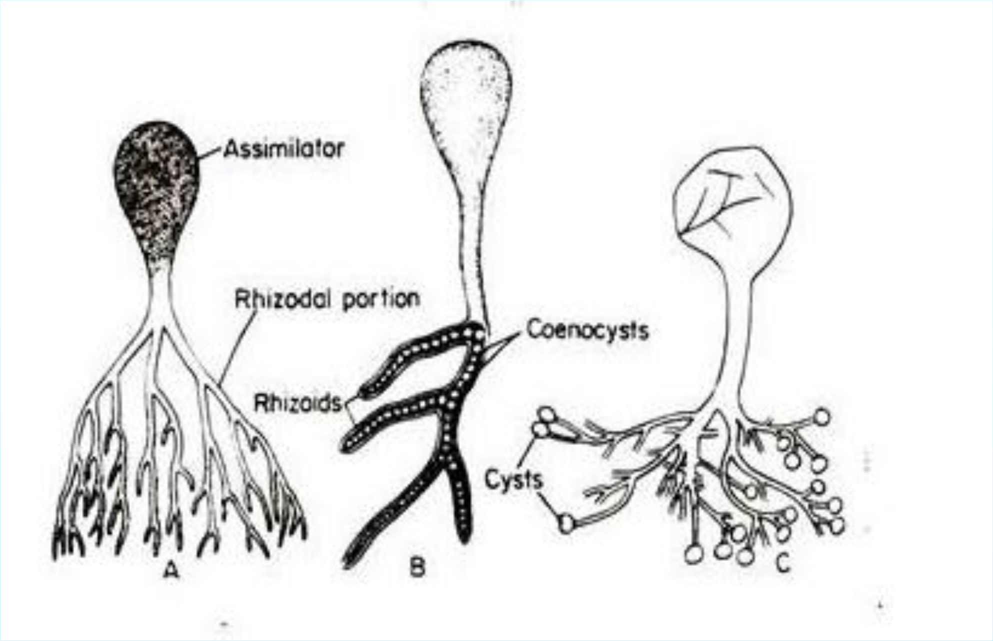
- Sexual reproduction in *Vaucheria* is oogamous type. The thallus is usually homothallic but rarely heterothallic. Antheridia and oogonia are borne adjacent to each other on the same branch or on the adjacent branches. Both the sex organs develop as a swelling on the branches. In the *Vaucheria* most of the species are protandrous. The sex organs are cut off by a septum. The oogonium has a single egg filled with the oil and chloroplasts. The mature oogonium produces a beak like structure, which gets gelatinized forming an aperture for the entry of spermatozoids. The antheridium usually develops as a curved cylindrical appendage. Its protoplasm divides into a large number of uninucleate biflagellate spermatozoids. With the gelatinization of the antheridial tip the spermatozoids are released. Each spermatozoid is cylindrical posteriorly but has a flattened proboscis in the anterior end. It has one forwardly projecting tinsel flagellum and a slightly longer backwardly directed whiplash flagellum. Fertilization takes place by fusion of a spermatozoid with egg nucleus. Zygote secretes thick wall and converts into oospore which gets coloured by accumulation of oil droplets and due to degeneration products of the chlorophyll. It remains dormant for few months. Before germination, meiosis takes place and it develops into a haploid thallus.



Vaucheria: Life Cycle

Botrydium

Division : Xanthophyta
Class: Xanthophyceae
Order: Botrydiales
Family: Botrydiaceae
Genus: ***Botrydium***



***Botrydium*: Different stages of thallus development**

Occurrence - It is a terrestrial alga found commonly growing on the muddy or damp soil near the bank of rivers, streams, ponds or pools. It grows like pinhead vesicles and usually forms a mat of thick yellowish-green coating over the soil surface.

Thallus structure - The thallus of *Botrydium* is unicellular, coenocytic, consisting of usually globose or cylindrical vesicle-like aerial portion and lower subterranean highly branched colorless rhizoidal portion. The rhizoidal portion helps in attachment of the thallus with substratum. The vesicle contains a central vacuole and peripheral protoplasm. The protoplasm consists of numerous discoid chromatophores with naked pyrenoids and nuclei. The chromatophores lie close to the cell membrane while nuclei lie close to the vacuole. Rhizoids are also multinucleate and nuclei are scattered in vacuolated and non-vacuolated cytoplasm. The cell wall is chiefly made up of cellulose and the oil and leucosin are the reserve food material.

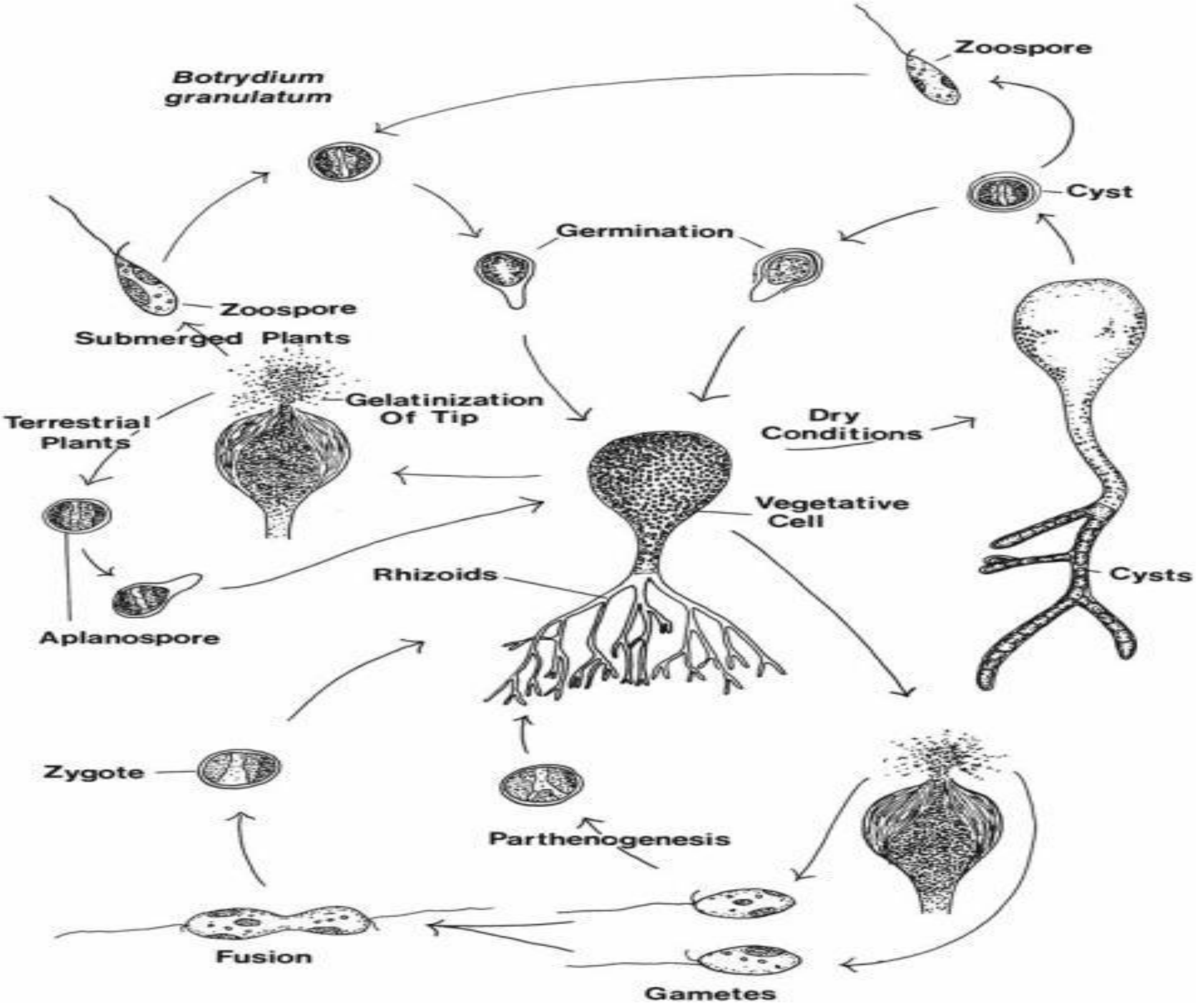
Reproduction

- Vegetative reproduction is rare if occurs it takes place by budding of the mature vesicles.
- Asexual reproduction takes place with the help of biflagellated zoospores or by formation of aplanospores or hypnospores. Zoospore formation occurs during favourable condition like high humidity and free water. The coenocytic protoplasm of the vesicle is fragmented into the uninucleate units and each unit develops into a pyriform biflagellate zoospore having unequal flagella.

Zoospores generally differentiate to produce the normal thallus. But sometimes they behave like gamete and are involved in sexual reproduction. Under certain conditions when plant fails to produce zoospores, it produces non-motile uni or multinucleate aplanospores. Both, uni and multinucleate aplanospores germinate to produce new thalli.

During adverse environmental conditions, these aplanospores get modified into the thick walled uninucleate or multinucleate hypnospores. The uninucleate hypnospores behave like aplanospores in respect of germination but multinucleate hypnospores produce uninucleate aplanospores or zoospores which eventually produce new thalli.

- During sexual reproduction, biflagellate gametes are produced, which are morphologically similar to the zoospores and are formed in the way similar to the zoospores. The gametes may be **isogamous** or **anisogamous** and after fusion, they form zygote. The zygote divides meiotically and form four haploid biflagellate zoospores. Each zoospore germinates to produce new thallus of *Botrydium*.



Life cycle of Botrydium

GENERAL CHARACTERS OF BACILLARIOPHYTA

i) They are unicellular, diploid, colonial or free living. One group of them (Pennales) live in fresh water and other group (Centrales) live in saline water of sea.

ii) They are non-flagellated. but the gametes are motile.

iii) They are ornamented in different ways.

iv) Cell wall is enriched with silica and is well tined with salve (theca).

v) Chromatophores are yellow or golden-yellow, in which feucoxanthin and Diatomin are the main pigments.

vi) Reserve food- Lipid and Volutine.

vii) Reproduction: Vegetative reproduction by cell division, Asexual reproduction by auxospore and sexual reproduction by conjugation.

PENNALES

Occurrence: These are mostly fresh water and some are marine water.

Pennales includes 4 suborders

- Raphidineae
- Araphideae
- Monoraphideae
- Biraphideae

Pennales are bilaterally symmetrical or even asymmetrical valves are present (Fig. 4.4.1.a). Araphideae shows colonial nature. Valves boat shaped. Wall markings arranged pinnately in relation to a raphe or pseudoraphe. Many forms exhibit movement. Chromatophores are large and few. Auxospores are normally formed by conjugation except in Araphideae.

1-Araphideae: Pseudoraphe is present

2- Raphidineae: rudimentary type of raphe. Raphe run from polar nodule only for short distance. Central nodule is absent.

3-Monoraphidieae: fully developed raphe but present only on one side of valve.

4-Biraphideae: two well developed raphe systems are present. Forms may be colonial or unicellular. Pennales are mostly freshwater though they are also present in marine water. Colonial forms mostly belongs to Centrales and Araphideae. The cells remains united by means of mucilage which is secreted through large pores present on the valve.

Sexual reproduction:

In pennales sexual reproduction is isogamous. The zygote grows to a special size of spore known as Auxospore. Auxospore formation in pennales takes place by three methods:

1-Gametic union

2-Autogamy

3-Parthenogenesis

1-**Auxospore formation by gametic union:** This method involves fusion of gametes either

a. there is formation of a single auxospore by two conjugating cells,

b. there is formation of two auxospores by two conjugating cells.

a. **Single auxospore formation by 2 conjugating individuals-** in this method two diatom individuals come together end to end or laterally and become enveloped in mucilage. The nucleus of both divides meiotically forming 4 haploid nuclei. Later on 3 of the 4 haploid nuclei of each conjugant degenerates. Only one nucleus survive in each protoplast which functions as the gamete. The 2 gametes fuse mid-way between the empty parent frustules after their escape from the same. With the result of fusion the zygote is formed. The zygote or fusion nuclei rest for some time. Thereafter it elongates in a plane parallel to the long axis of the parent frustules and act as an auxospore. Now this auxospore secretes a fresh frustules around it inside its perizonium. This method is isogamous type. Common in *Cocconeis*.

b. **Two Auxospore formation by 2 conjugating individuals-** the diatoms taking part in conjugation secretes a common mucilage envelope around them. The diploid nucleus of each individual divides meiotically forming 4 haploid nuclei. Later on 2 of the nuclei in each individual disintegrate. Now the protoplast with the 2 functional haploid nuclei divides into two. This division may be symmetrical or asymmetrical. In symmetrical the gametes are equal (in each conjugant) while in asymmetrical these are unequal. Fusion takes place by any of methods.

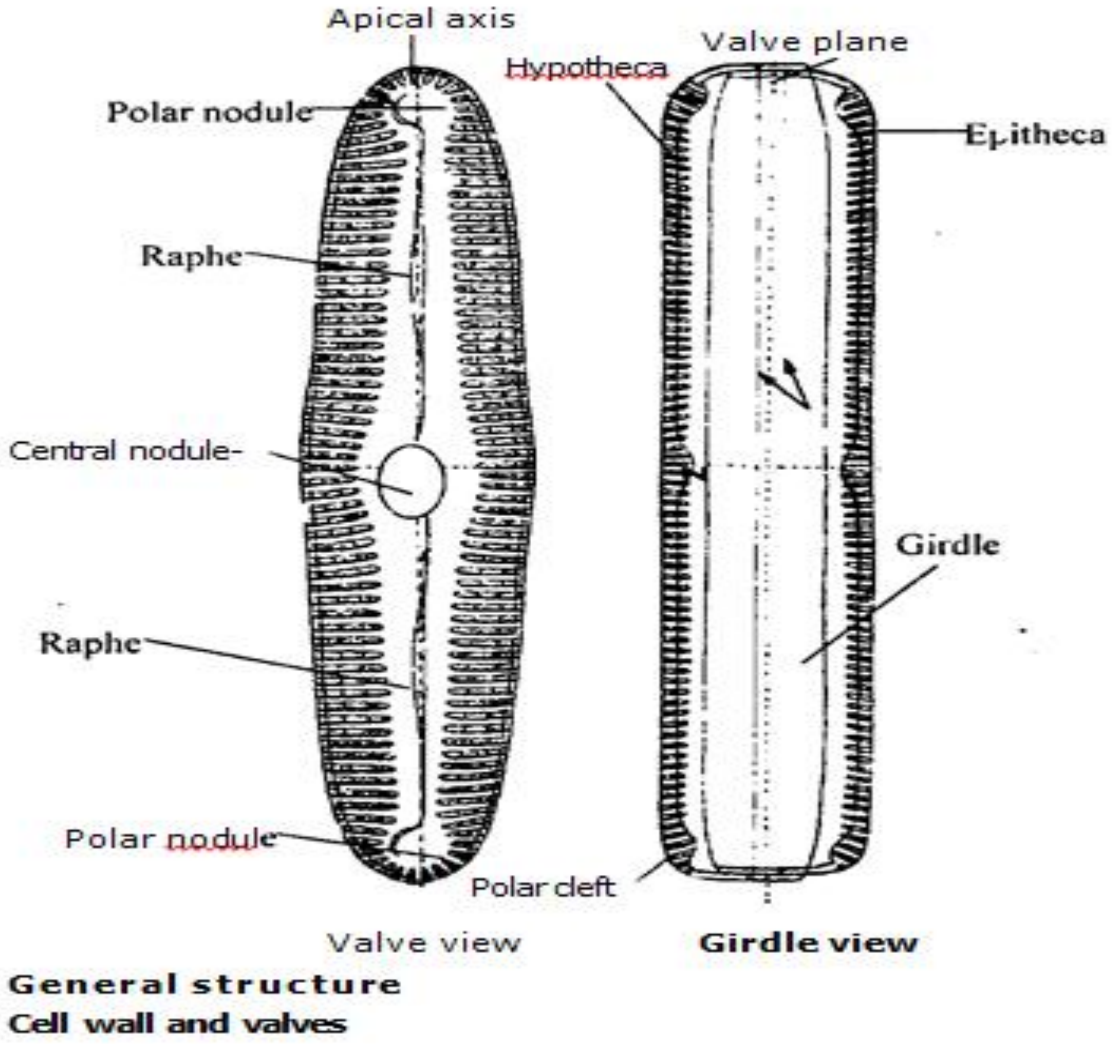
(i) Both gametes show amoeboid movement. They come out of frustules (parent) and forms 2 zygotes. E.g. *Cocconeis placentula*. It can be isogamous or anisogamous (fig. 4.4.1.d).

(ii) The gametes of one conjugant are motile while those of other are passive. The amoeboid gametes come out actively and fuse in pairs with the passive gametes. Thus one frustule remains empty and other contains 2 zygotes.

(iii) Out of 2 gametes in one conjugant one is amoeboid and other is passive. The amoeboid of each comes out and migrates to the other to fuse with immobile gamete. Thus each frustule has one zygote. Now the zygotes are released they remain dormant for sometime. Later on they elongates and function as auxospore. The auxospore remain enclosed within a silicified pectic membrane known as perizonium. Perizonium is either secreted by the auxospore itself or by the remains of the membrane of the zygote. The auxospore secretes- new frustules around it within the perizonium. It is common in *Cymbella*. This method is more common than first one (Fig. 4.4.1.e).

2- Auxospore formation by autogamy: according to Geitler (1939) the single diatom cell becomes enveloped in mucilage. The diploid nucleus undergoes meiosis. The 2 haploid daughter nuclei in the protoplast come to lie side by side in a pair and then fuse together. This phenomenon is known as autogamous pairing. The protoplast with a diploid nucleus is released out from the parent frustules which acts as an auxospore. Auxospore increases in size and secretes a fresh frustules with in the perizonium (Fig. 4.4.1.f).

3- Auxospore formation by parthenogenesis: in this there is no meiosis in the diploid nucleus. Only mitotic divisions takes place. All the nuclei formed are diploid. Out of these nuclei only one survives and rest degenerates. This single nucleus enlarges and changes into an auxospore which give rise to a single plant. Thus the process do not involved any pairing or fusion. Reported in *Cocconeis* by Geitler.



General structure of Pennales

Centrales

Occurrence: These are mostly marine water and some are fresh water. Mostly found as colonial forms.

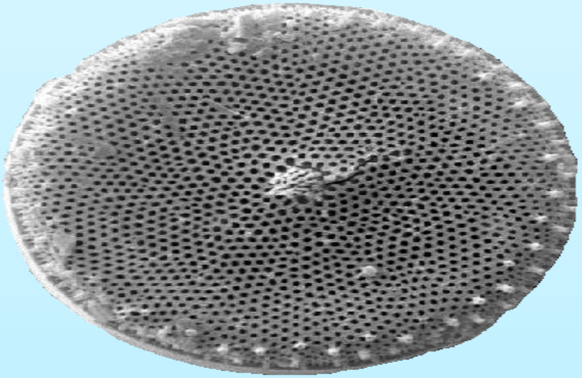
Centrales includes 4 suborders

- Discoideae
- Solenoideae
- Biddulphiodeae
- Rutilariodeae

They are well circular, polygonal or irregular. Ornamentation is radially symmetrical around a central point. Raphe or psedoraphe is absent. No movement due to absence of raphe. Chromatophores are numerous and also spores are formed without conjugation.

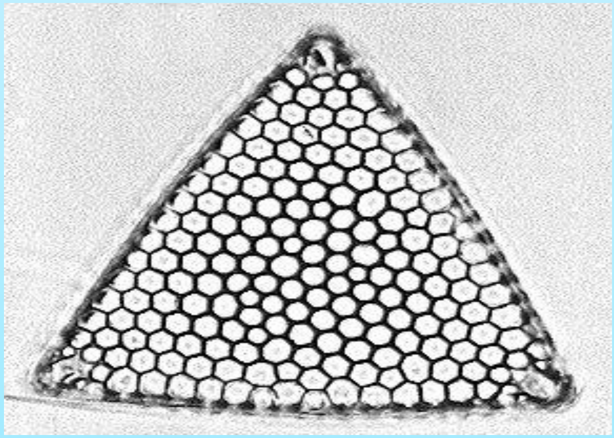
1- **Discoideae:** they have cells which have cylindrical or disc shape. Valve circular usually without special processes. e.g., *Cyclotilla, Melosira, Coscinodiscus*

- **Solenoideae:** cells elongate, cylindrical. Girdle complex with numerous intercalary mass. e.g. *Rhizosolenia*.
- **Biddulphioideae:** cells box shaped and valves mostly provided with horns. e.g. *Triceratum*, *Biddulphia*.
- **Rutilariodeae:** wall markings radially arranged or irregular. e.g. *Rutilaria*.

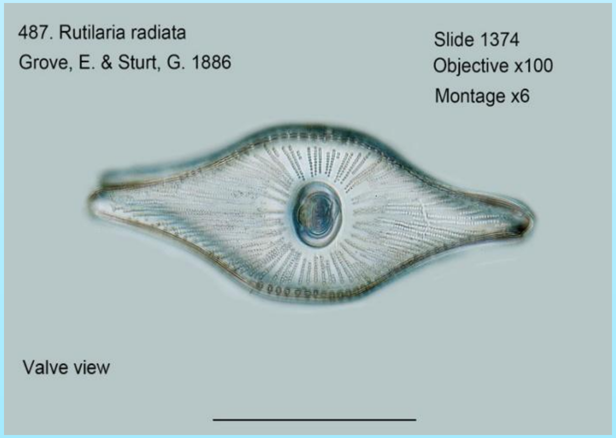


Coscinodiscus

Rhizosolenium



Triceratum



Rutilaria

Reproduction

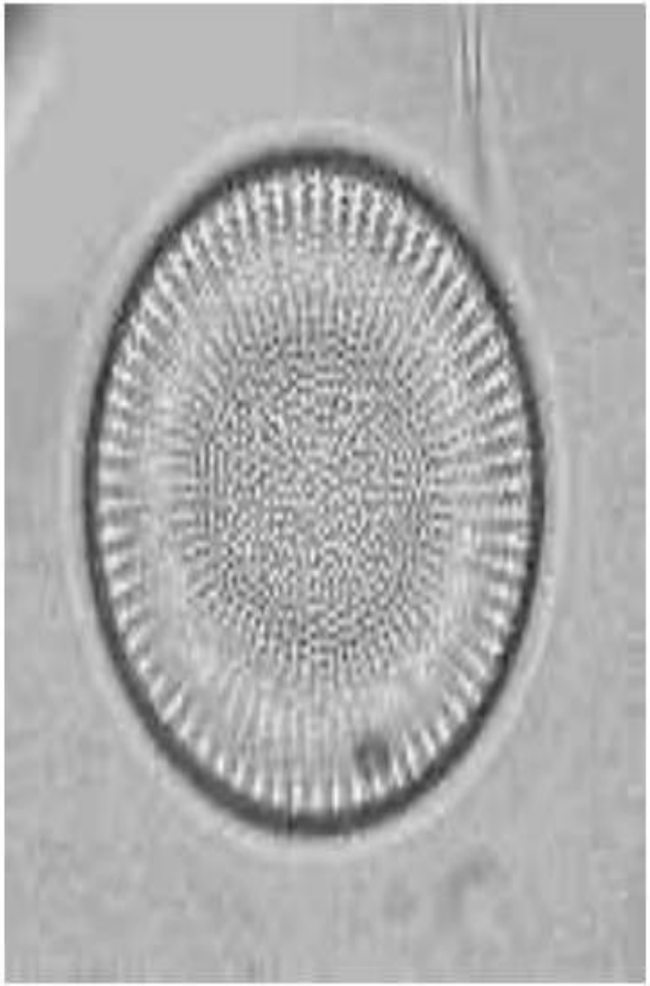
It is by two means

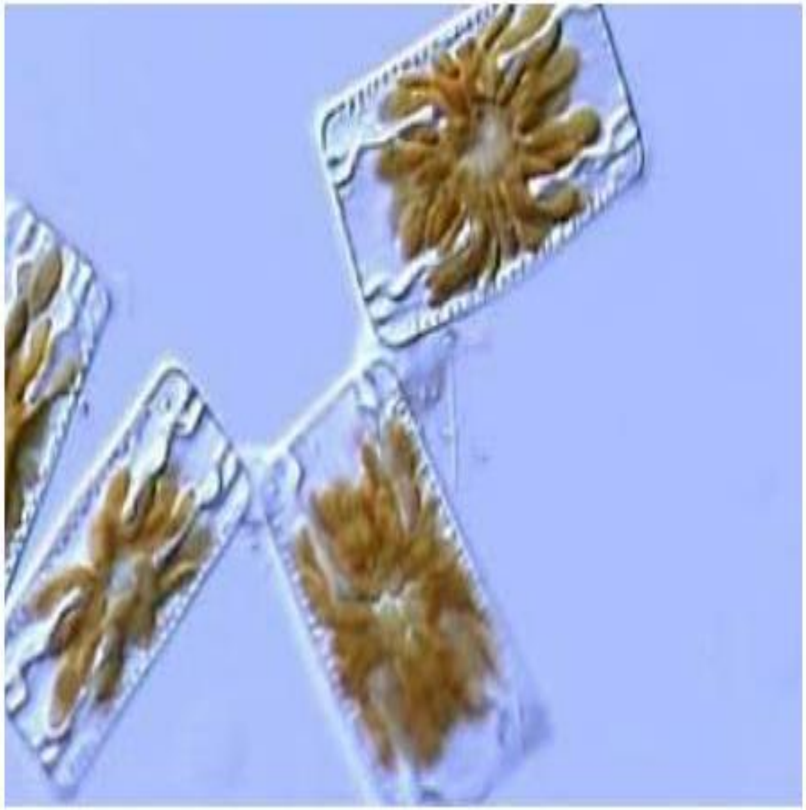
- **Vegetative:** it takes place by cell division. Most common method. The protoplast slightly increases in diameter and two halves of the cell wall slightly separate from each other. This is followed by mitotic division of the nucleus and then division of the protoplast into two in a plane parallel to the valve. So their one side is naked and on this side a new cell wall is formed. In both cases the new wall formed is always hypotheca, so the size of the cell decreases.
- **Sexual reproduction:** it is oogamous. It is influenced by several factors as light, nutrition, temperature. With the exception of *Rhabdonema* all species studied so far are homothallic or monoecious. The zygote grows to a special size of spore known as Auxospore. This type of sexual reproduction is restorative i.e. the original size of size is regained. A single Auxospore is formed within a single individual. The auxospore is formed either by Autogamy or by oogamy.

  1-**Autogamy:** at the time of autogamy the cell secrets some mucilage. Epitheca and hypotheca separate slightly and the diploid nucleus divides meiotically to form four nuclei. Two nuclei degenerate and remaining two fuse to form a diploid nucleus. The diploid zygote along with the protoplast comes out from the parent frustule and functions as Auxospore. The auxospore enlarges, secretes an overlapping wall and develops into a new diatom.

2-Oogamy: Observed in *Melosira*, *Cyclotella* and *Biddulphia*. A vegetative cell directly functions as an antheridia or spermatogonia (Fig. 4.4.2.g). Its protoplasm divides to form 4 to 128 small uninucleate protoplasmic bits. The first division is meiotic one. These are male gametes or spermatozoids. Similarly the female gametes are non-flagellated and are known as eggs. A single egg develops in a single female diatom cell or oogonium (Fig. 4.4.2.h). This cell extends slightly with an elongated nucleus. This nucleus divides meiotically forming 4 haploid nuclei. Out of these 4 haploid nuclei 3 degenerates. The male gametes are released from the male cell and swim to an oogonium. One of the spermatozoids penetrates the egg and fuses with it. The plasmogamy is followed by karyogamy. This results in formation of a diploid zygote and this function as auxospore.

Auxospore in both Centrales and Pennales increases in size and in some as much as 3 times that of the parent cell. Its diploid nuclei undergoes 2 mitotic divisions. After first mitotic division one nucleus degerates this nuclei left again divides by mitotic division resulting in the formation of 2 nuclei. Out of these 2 nuclei one degenerates and only a single nucleus is left in a new diatom cell.





Centrales: Centric Diatoms

DIFFERENCES BETWEEN

CENTRIC DIATOMS	PENNATE DIATOMS
1. Shape and size varies.	1. Boat shaped.
2. Radial symmetry.	2. Bilateral symmetry.
3. Discoid chloroplast.	3. Elongated chloroplast.
4. Raphe is absent.	4. Raphe is present.
5. Radiantly arranged striations.	5. Pinnate striations.

References

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