FUNDAMENTALS OF ALGAE AND BRYOPHYTES

BOOKS ARCADE

Dr. Vinoth. S
Dr. S. K. Khatik

Fundamentals of Algae and Bryophytes

Fundamentals of Algae and Bryophytes

Dr. Vinoth. S
Dr. S. K. Khatik

BOOKS ARCADE
KRISHNA NAGAR, DELHI

Fundamentals of Algae and Bryophytes

Dr. Vinoth. S
Dr. S. K. Khatik

© RESERVED

This book contains information obtained from highly regarded resources. Copyright for individual articles remains with the authors as indicated. A wide variety of references are listed. Reasonable efforts have been made to publish reliable data and information, but the author and the publisher cannot assume responsibility for the validity of all materials or for the consequences of their use.

No part of this book may be reprinted, reproduced, transmitted, or utilized in any form by any electronic, mechanical, or other means, now known or hereinafter invented, including photocopying, microfilming and recording, or any information storage or retrieval system, without permission from the publishers.

For permission to photocopy or use material electronically from this work please access booksarcade.co.in

BOOKS ARCADE

Regd. Office:
F-10/24, East Krishna Nagar, Near Vijay Chowk, Delhi-110051
Ph. No: +91-11-79669196, +91-9899073222
E-mail: info@booksarcade.co.in, booksarcade.pub@gmail.com
Website: www.booksarcade.co.in

Year of Publication 2023

International Standard Book Number-13: 978-81-19199-56-3

CONTENTS

CHAPTER 1

ALGAE: GENERAL ACCOUNT

Dr Vinoth.S, Professor
Department of Finance, CMS Business School, JAIN Deemed to-be University, Bangalore, India
Email Id- dr.vinoth@cms.ac.in

ABSTRACT:

A broad and very varied collection of eukaryotic, photosynthetic lifeforms are referred to as algae. These creatures are not linked to one another since they do not have a common ancestor (polyphyletic). ” Examples of multicellular algae include brown algae and enormous kelp. Few types of algae contain toxins that are toxic to fish, finfish, or shellfish, therefore eating these fish is dangerous. Red tides are caused by dinoflagellates, which are toxic to aquatic life and also emit poisons into the water. Every creature that breathes air may have health problems due to the poisons that dinoflagellates discharge into the air. Many crucial responsibilities for algae are played in the atmosphere of the Planet. Around half of the oxygen on Earth is produced by algae, which also store carbon dioxide to keep it out of the atmosphere.

KEYWORDS:

Atmosphere, Cyanophyceae, Hydrodictyon, Marine Algae, Photosynthetic.

INTRODUCTION

When someone mentions algae, these are some questions that immediately spring to mind. The majority of us have encountered the slick, green structure during the rainy season on damp, shaded areas, which is really the cause of several accidents. All of the structures we're referring to here are really the living things that the next paragraphs will focus on. These creatures are often referred to as "algae" a Latin term that literally translates to "sea weeds. Yet, phycologists refer to all types of algae together as "algae" in their terminology. These are thalloid autotrophic organisms capable of producing their own food via the process of photosynthesis when chlorophyll and sunlight are present. The term "phycology" refers to the study of algae. Many phycologists from India and other countries have studied algae[1].

General Algae Characteristics

Algae are autotrophic organisms that produce chlorophyll and have thalloid plant bodies, which do not differentiate into roots, leaves, and stems. As the thallus lacks blood vessels, it lacks a mechanism for fluid transmission. The sexual organs of algae are unicellular, and if they are multicellular, all of the cells are fertile. Moreover, there is no embryo created following fertilization in sex organs since there is no sterile cell jacket around the reproductive cell. They may be found in many different habitats, although most of them are aquatic. They exhibit a clear generational shift.

Appearance and dissemination (Habitat for algae)

The majority of the algae are aquatic and may be found in both fresh and salt water. Some may grow under the soil's surface on wet, shady sides since they are terrestrial. Thus, they might be categorized into the following category based on habitat.

- Marine algae
- Land-based algae
- Unusual environment algae

The majority of algae are aquatic and may be found in both freshwater and saltwater or marine environments. The aquatic algae are either free-floating or holdfast-attached to the substrate.

Fresh water algae

These species may be found in fresh water bodies such as ponds, lakes, rivers, pools, and streams. These fresh water organisms may be found in both stagnant and still water, such as Chlamydomanas, Hydrodictyon, and slow-moving water, such as Cladophora, Oedogonium, and Chara. There are many different types of algae, from tiny single cells to enormous multicellular organisms. They lack tissue differentiation, have a simple thallus, and are chlorophyllous, making them autotrophic. They may be found in a variety of environments, including harsh terrain and fresh and saltwater seas. There is a lot of diversity since they have a variety of habitats and structures, as shown in Figure 1.

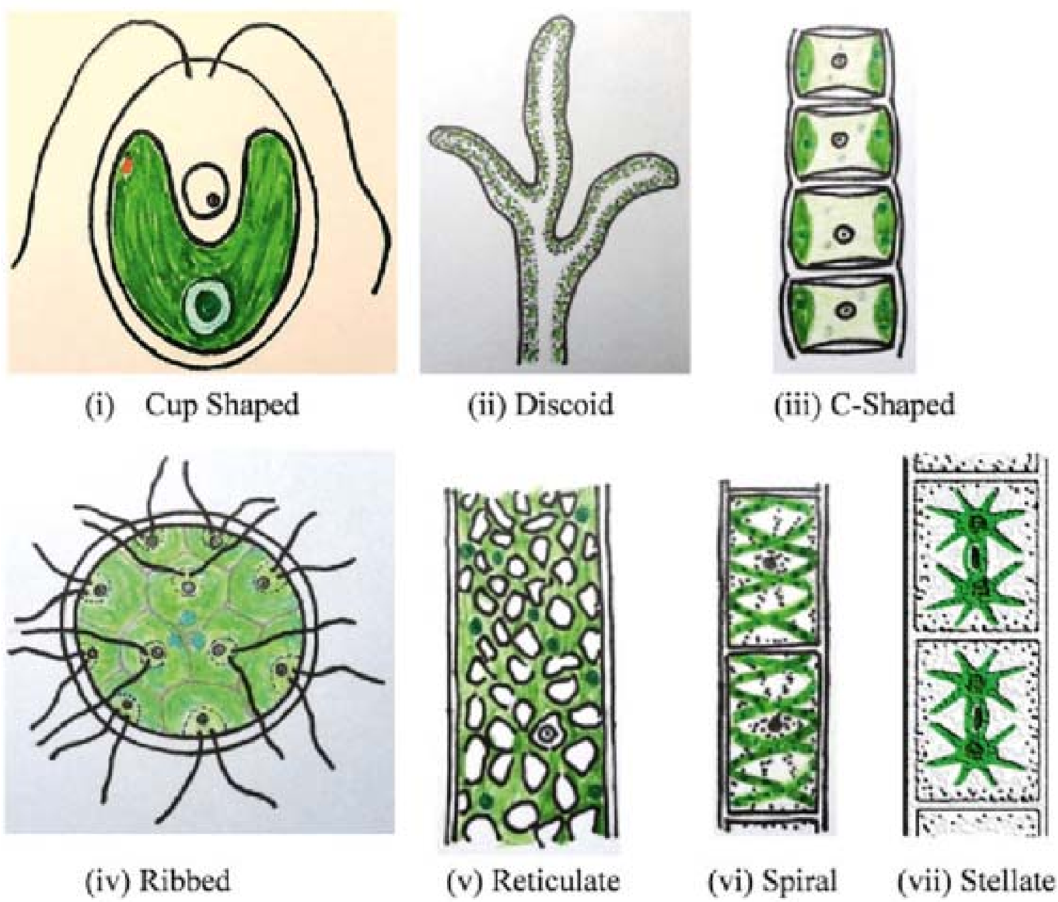

Figure 1: Algal chloroplasts come in a variety of forms, including Chlamydomonas, Vaucheria, Ulothrix, Volvox, Cladophora, Spirogyra, and Zygnema.

Marine water algae

These algae grow in salty ocean water. The majority of the Phaeophyceae and Rhodophyceae species are found in marine environments [2]. The term "sea weeds" refers to marine algae, which are often macroscopic and have huge thalli. Ectocarpus, Sargassum, Fucus, and Laminaria are a few examples of marine forms. Planktonic algae are often referred to as floating varieties of algae. These formations may be evenly dispersed in the water or they can have irregular and patchy pitches in both the horizontal and vertical axes. Chlorella, Hydrodictyon, Chlamydomonas, and Volvox are examples of freshwater planktonic algae, while Cyclotella, Hemidiscus, Fragillaria, Trichodesmium, and Ocillatoria are examples of marine planktonic algae. The water's color and smell are contributed by the prolific proliferation of planktonic algae. This occurrence is known as an algal bloom or water bloom. Algal bloom formation is largely influenced by variables including temperature, lengthier days, and nutrient availability.

Terrestrial algae

These diverse algal taxa, which are present on or below the wet soil surface, are referred to as terrestrial algae. Although certain algae have a subterranean habit, such as a few species of Nostoc, Anabaena, and Euglena, and these are known as Cryptophytes, other algal forms, such as a few species of Vaucheria, Botrydium, and Fristchilla, also exist on the surface of soil.

- *Aerophytes:* These types of algal forms, which are specialized for aerial modes of life, are found on tree trunks, damp walls, flower pots, rocks, and fence wires. They get all of the water and carbon dioxide they need from the atmosphere.
- *Cryophytes:* Cryophytic algae are those that thrive on snow-covered mountain tops. These algae give the mountains their appealing colors. The arctic and alpine areas are colored red by Haematococcus nivalis, while the snow in the mountains of Europe, especially in the Arctic, is colored yellow-green by Chlamydomanas yellowstonesis.

Thermophytes are the genus of algae that thrive in hot springs at quite high temperatures. Some algae have been shown to withstand temperatures as high as 850 C. Thermophytes include Oscillatoria brevis and Haplosiphon lignosum, which can withstand temperatures as high as 700C, beyond which plant growth is not conceivable. Most thermal algae are members of the Myxophyceae family. Lithophytes are the algae that are growing in close proximity to rocky and stone surfaces. Members of the Cyanophyceae often flourish on damp rock, wet walls, and other rocky surfaces, such as Nostoc and Rivularia.

A unique kind of algae

- Epiphytes – An epiphytic algae is an algal type that grows on other plants. These algae simply need support; they don't need food from the plants they grow on. Whereas Chaetophora on the leaves of Vallisnaria and Nelumbo, Oedogonium on Hydrilla, and Coleochaete in connection with Chara and Nitella, are regularly found growing in nature as epiphytes.
- Halophytes: Halophytes are certain algae that live in water that contains a lot of salt. Stephanoptera, Dunaliella, and Chlamydomonas chrenbergii are among them.
- Symbionts: Symbiotic algae are those that live in close connection with other organisms for the benefit of both parties. The presence of Nostoc in Anthoceros, Anabaena in the coralloid root of Cycas, and Anabaena azollae in Azolla are notable instances of such

associations. One of the greatest examples of a symbiotic relationship between algae and fungus is lichen.

- Epizoic: Epizoic algae are any of the several types of algae that develop on fish fins, turtle shells, and mollusk shells. For instance, Cladophora is found on bivalve shells and snails, whereas Protoderma and Basicladia grow on turtles' backs.
- Endozoic: Endozoic algae are those that are found within the bodies of aquatic animals. The coelom (body cavity) of the hydra and various other invertebrates contain zoochlorellae. Zooxanthella coexists closely with the coral ecosystem. 6) Parasitic algae: A small number of algae rely on other plants for nourishment; these are known as parasitic algae. Tea red rust disease is brought on by Cephaleuros, a common intercellular parasite algae that grows on the leaves of the tea plant (Thea sinesnsis)[3].

Organisation of thallus

Algal thalli varies in size from tiny unicellular structures to massive sea weeds (macro algae), like gigantic kelp, which may grow to a length of more than a hundred feet. Algae have a broad variety of diversity in their thallus arrangement. Simple motile or immobile unicells (Chlamydomonas, for example) are at one extreme, whereas colonies of cells are seen in other types of organisms (Volvox, Pediastrum). Once again, these colonies may be mobile or immobile (Hydrodictyon). A colony is referred to as a coenobium if it has a distinct form (Volvox). The multicellular filamentous habit is the most basic kind of thallus. These filaments might be straight. Ulothrix or simple branching plants, such as Cladophora or a species that is very complex, such as Ectocarpus, polysiphonia, Sargassum, or Laminaria It is interesting that multiple divisions of algae exhibit strong parallelism, and that no one kind of thallus is exclusive to any one division. Algae have two different sorts of cell structures:

Prokaryotic cell, first

Eukaryotic cell type B

Bacterial cell

Only the class Cyanophyceae contains the prokaryotic cell arrangement (Mixophyceae). The existence of a primitive or incipient nucleus, which lacks a nuclear membrane and basic proteins like histones, is a defining property of prokaryotic algae. The DNA is made up of fibrils that may spread throughout the whole cell or be concentrated in its center. The chlorophyll pigment is located in the photosynthetic lamellae or thylakoids, which may be arranged in parallel layers near the cytoplasm's perimeter or as a network that spans the whole cytoplasm of the cell. There are no mitochondria, chloroplasts, Golgi bodies, or endoplasmic reticulums (the membrane-bound organelles). Prokaryotic refers to the basic cells of blue-green algae that lack a nuclear membrane, mitochondria, plastids, and divide without mitosis. Mucopeptide, a unique strengthening substance not present in the cell walls of other algae, makes up the cell wall [4].

The eukaryotic cell

The well-organized nucleus and membrane-bound organelles including plastids, mitochondria, and Golgi bodies are characteristics of eukaryotic cells. As is well knowledge, algae are autotrophic creatures that can produce their own food via the process of photosynthesis. According to the kind of pigmentation found in each species of algae, the food created during photosynthesis is kept in different ways and is referred to as stored food or reserve food material. Starch is the reserve food of green algae, cyanophycean starch in Cyanophyceae, floridean starch in Rhodophyceae, and mannitol and laminarian starch in Phaeophyceae.

Algal pigmentation

The pigments present in algae are what give its thallus their color. Each pigment has a distinct color and set of properties. Each algal division has a unique pigment mix and distinguishing color. The algae has four distinct types of pigments in total. They include phycobilins, carotenes, xanthophylls, and chlorophyll. The algal pigments are often found in plastids. Algae include a variety of plastid types. They may be cup-shaped, formed like a parietal plate, lens-shaped, shaped like a disc or network, shaped like an axial band, or shaped like a star (stellate), an oval, a lobed disc, or a parietal ring. The pigments of the Cyanophyta are found in the lamellae, and they lack plastids [5], [6].

The five chlorophylls that are now recognized are chlorophylls a through e. All kinds of algae include chlorophyll a, which has the chemical formula C55 H72O5N4Mg and is one of these pigments. Chlorophyta, Euglenophyta, and Charophyta all contain chlorophyll a and b. Bacillariophyta, Pyrrophyta, and Phaeophyta all contain chlorophyll-c. Only red algae have chlorophyll-d, while Xanthophyta contain chlorophyll-e. Chloroplasts are plastids that contain both chlorophylls a and b, while chromatophores are plastids that lack chlorophyll b and have an excess of carotenoids over chlorophyll. Chlorophylls may dissolve in fat but not in water. They play a crucial role in photosynthetic pigmentation and absorb blue and red light.

Carotenoids (carotenes with xanthophylls)

It consists of pigments in the colors yellow, orange, red, and brown. There are about 60 distinct carotenoids in plants. They fall into two categories: yellow or brown xanthophylls or carotenols and orange-yellow carotenes. Carotenoids are protective pigments that act as light-blocking filters. Blue and green light waves are absorbed by them.

Carotenes

The chemical formula for carotenes, which are linear unsaturated hydrocarbons, is C40H56. Carotenes-a, B, e, Y, and lycopene are the five carotenes that are now recognized. Carotenes are pigments that dissolve in fat. They absorb blue and green light waves but are insoluble in aqueous solutions. Nevertheless, they are soluble in lipid solvents including ethyl alcohol, chloroform, and carbon disulphide.

Xanthophylls

These pigments have the chemical formula C40H56O2 and are either yellow or brown in color. They resemble carotenes in many ways, but in addition to carbon and hydrogen, they also include oxygen. The two xanthophylls are soluble in chloroform but insoluble in water. Zeaxanthin, Astaxanthin, Lycopene, Diatoxanthin, Oscilloxanthin, Fucoxanthin, etc. are examples of common xanthophylls. The Phaeophyta's signature pigment, fucoxanthin, gives the thalli its unique brown or olive hue[7].

It is a different class of pigments made up of globulin proteins bound to tetrapyrrolic chemicals. Seven phycobilin pigments, including both blue and red ones, have so far been enlisted. These are phycocyanin-r and -c- and pycoerythrin r, c, x, b. In red and blue green algae, there is a pigment called phytobilin that is water soluble. Among the seven phycobilins, r-phycoerythrin and r-phycocyanin are the two most prevalent; the former absorbs blue, green, and sometimes yellow rays, while the latter does so for green light.

The role of chlorophyll an in photosynthesis is crucial. The auxiliary pigments only have indirect effects. Phycocyanin and Phycoerythrin absorb [8], [9] the wavelengths of light that are not absorbed by chlorophyll. The latter two pigments capture light energy, which is subsequently passed to chlorophyll-a, which uses it for photosynthesis.

CONCLUSION

The earliest thalloid species that can produce their own sustenance via the mechanism of photosynthesis are algae. They have a wide range of thallus organization, from parenchymatous to unicellular. All groups of algae aside from Cyanophyceae and Rhodophyceae contain flagella. While they may be found practically everywhere life is possible, algae are primarily watery in nature. Algae's thalloid plant body lacks segmentation into roots, leaves, and stems. Sex organs are single-celled; if multicellular, each fertile cell is present [10]–[12].

REFRENCES

[1] E. N. Hatleback and J. M. Spring, "A refinement to the general mechanistic account," *Eur. J. Philos. Sci.*, 2019, doi: 10.1007/s13194-018-0237-1.

[2] S. Modgil and H. Prakken, "A general account of argumentation with preferences," *Artif. Intell.*, 2013, doi: 10.1016/j.artint.2012.10.008.

[3] D. L. Hull, R. E. Langman, and S. S. Glenn, "A general account of selection: Biology, immunology, and behavior," *Behav. Brain Sci.*, 2001, doi: 10.1017/s0140525x01004162.

[4] D. Blakemore, "Slurs and expletives: A case against a general account of expressive meaning," *Lang. Sci.*, 2015, doi: 10.1016/j.langsci.2014.06.018.

[5] H. Elchlepp, A. Lavric, C. D. Chambers, and F. Verbruggen, "Proactive inhibitory control: A general biasing account," *Cogn. Psychol.*, 2016, doi: 10.1016/j.cogpsych.2016.01.004.

[6] S. D. Brown, A. A. J. Marley, P. Dodds, and A. Heathcote, "Purely relative models cannot provide a general account of absolute identification," *Psychon. Bull. Rev.*, 2009, doi: 10.3758/PBR.16.3.583.

[7] F. Bonchi, D. Petrişan, D. Pous, and J. Rot, "A general account of coinduction up-to," *Acta Inform.*, 2017, doi: 10.1007/s00236-016-0271-4.

[8] E. Struys, E. Woumans, S. Nour, O. Kepinska, and M. Van Den Noort, "A domain-general monitoring account of language switching in recognition tasks: Evidence for adaptive control," *Bilingualism*, 2019, doi: 10.1017/S1366728918000342.

[9] M. Golsäter, L. O. Johansson, and M. Harder, "General practitioners' accounts of how to facilitate consultations with toddlers–an interview study," *Scand. J. Prim. Health Care*, 2017, doi: 10.1080/02813432.2017.1287518.

[10] J. B. Freeman, R. M. Stolier, and J. A. Brooks, "Dynamic interactive theory as a domain-general account of social perception," in *Advances in Experimental Social Psychology*, 2020. doi: 10.1016/bs.aesp.2019.09.005.

[11] M. Blackburn and A. Stathi, "Moral discourse in general practitioners' accounts of obesity communication," *Soc. Sci. Med.*, 2019, doi: 10.1016/j.socscimed.2019.03.032.

[12] S. R. Waxman and A. E. Booth, "On the insufficiency of evidence for a domain-general account of word learning," *Cognition*. 2001. doi: 10.1016/S0010-0277(00)00119-0.

[13] Y. Gao, X. Li, J. Guo, X. Sun, and Z. Sun, "Reproductive responses of the earthworm (Eisenia fetida) to antiparasitic albendazole exposure," *Chemosphere*, 2015, doi: 10.1016/j.chemosphere.2014.05.030.

CHAPTER 2

CELL ULTRASTRUCTURE AND REPRODUCTION

Asha.K, Assistant Professor,
School of Sciences, Jain (Deemed to be University), Bangalore, India
Email Id- k.asha@jainuniversity.ac.in

ABSTRACT:

Prokaryotic and Eukaryotic cells make up algae. Cyanobacteria (blue green algae) include prokaryotic algal cells, while other types of algae contain eukaryotic cells. The ultrastructure of prokaryotic and eukaryotic algal cell walls will be covered in this section.

KEYWORDS:

Algal Cell, Cell wall, Cyanobacteria, Eukaryotic, Prokaryotic.

INTRODUCTION

Prokaryotic Algal Cell Ultrastructure

The cytoplasm and outer cellular envelope are the two components that make up a prokaryotic algal cell. A mucilaginous sheath, often known as a slime layer, is found outside of the cell wall and is a defining trait of all cyanobacteria (blue-green algae). The sheath seems to be homogeneous due to the reticulate arrangement of the fibrils of peptic acid and mucopolysachharides inside the sheath. Its primary purpose is to hold onto absorbed water to prevent the cell from drying up [1].

Cell wall

Mucopeptide makes up the stiff cell wall. It has four levels, referred to as L1, L2, L3, and L4. Between L2 and the plasma membrane, L1 is between them and is rather translucent. Alanine, glucosamine, peptidoglycan, muramic acid, glutamic acid, and -diaminopimelic acid are components of the mucopolymers L2 and L3. Proteins and lipopolysaccharides make up the wavy L4 layer. A lipid bilayer makes up the plasma membrane, which is found underneath the cell wall. Biochemical processes take place at the plasma membrane's invaginations. Chromoplasm and centroplasm are the two types of cytoplasm.

The outside and periphery colored area is called chromoplasm. It is made up of parallel thylakoids or lamellae for photosynthetic growth. Chlorophyll A, carotenoids, and phycobilins are present in these lamellae. Cyanobacterial cells contain three different forms of phycobilins: C-phycocyanin, C-phycoerythrin, and allophycocyanin. The phycobilins are located in phycobilisomes, which are tiny granules that are situated between the photosynthetic lamellae. Chromoplasm lacks membrane-bound organelles such mitochondria, chloroplasts, golgi bodies, endoplasmic reticulum, vacuoles, etc. Nevertheless, chromoplasm contains cytoplasmic inclusions such as 70s ribosomes, -granules, -granules, structural granules, polyhedral bodies, gas vacuoles, etc. Vesicles make up gas vacuoles. The cell is buoyant thanks to these vacuoles.

Centroplasm

This is the core, colorless area of the cell that contains DNA or chromatin that is not surrounded by histone proteins. As a result, there is no structured nucleus. Little circular DNA fragments, also known as plasmids or transposons, are common and resemble microorganisms. In this area, there are also 70s ribosomes [2].

Algal cell structure in the eukaryotic kingdom

The eukaryotic cell is made up of the cells of all other types of algae, except blue-green algae. b) Plasma membrane: A protein-lipid bilayer that is found directly below the cell wall. The following list of eukaryotic algal cell components may be discussed:

- Cell wall: A cellulose-based cell wall surrounds each cell. Pectose layer may also be present outside of the cellulose cell wall in many different types of algae. In the cell walls of certain brown algae, alginic acid may be found. Certain algae, especially diatoms, have silicified cell walls. Red algae's cell walls include the substances xylan, agar, and carrageenin.
- Cytoplasm - The plasma membrane contains a lot of cytoplasm. Membrane-bound cell organelles found in the cytoplasm include the endoplasmic reticulum, chloroplasts, mitochondria, and Golgi bodies. Ribosomes are from the 1980s. With the exception of a few species whose cells have many chloroplasts, the majority of algal species have one chloroplast per cell. Almost all chloroplasts also contain one or more pyrenoids. The shapes of the chloroplasts include cup, parietal, discoid, lobed, star, spiral, and barrel or girdle.
- Nucleus: While most eukaryotic algae have a single nucleus, there are also a sizable number of multinucleate eukaryotic algae. Eukaryotic algae cells have a true nucleus with a nuclear membrane and nuclear pores, which is identical to the nucleus of higher plants. The histone proteins enclose DNA.

DISCUSSION

Flagella

The thallus of a motile algal cell carries flagella, which are produced by the basal granules or blepharoplast and emerge through a tiny canal in the cell wall. It displays a common 9+2 configuration. Nine doublet peripheral fibrils round the two center singlet fibrils. They are hyaline emergence of the cytoplasm and quite tiny [3], [4]. Via tiny holes in the cell wall, the inner cytoplasm and flagella are linked. They may exist alone, in pairs, or in an arbitrary number. A cytoplasmic sheath surrounds the axoneme, which is the flagellum's central component. End piece refers to the axoneme's bare, terminal section. The flagellum is made up of nine connected, peripheral contractile, thicker doible fibrils that are joined around two inner core simple fibrils in its cross sectionam, and the Figure 1 shows the prokaryotic cell (blue Green Algae). Two thin fibrils make up each peripheral fibril. There are just two core fibrils. Although two central fibrils pause before the granule, the nine peripheral fibrils join the basal granule. In certain algae, there are also other features including contractile vacuoles, flagella, stigma, and eye spots that are related to the mobility of the algal cells. Flagella are never generated in any stage of the life cycle in Cyanophyceae and Rhodophyceae [5].

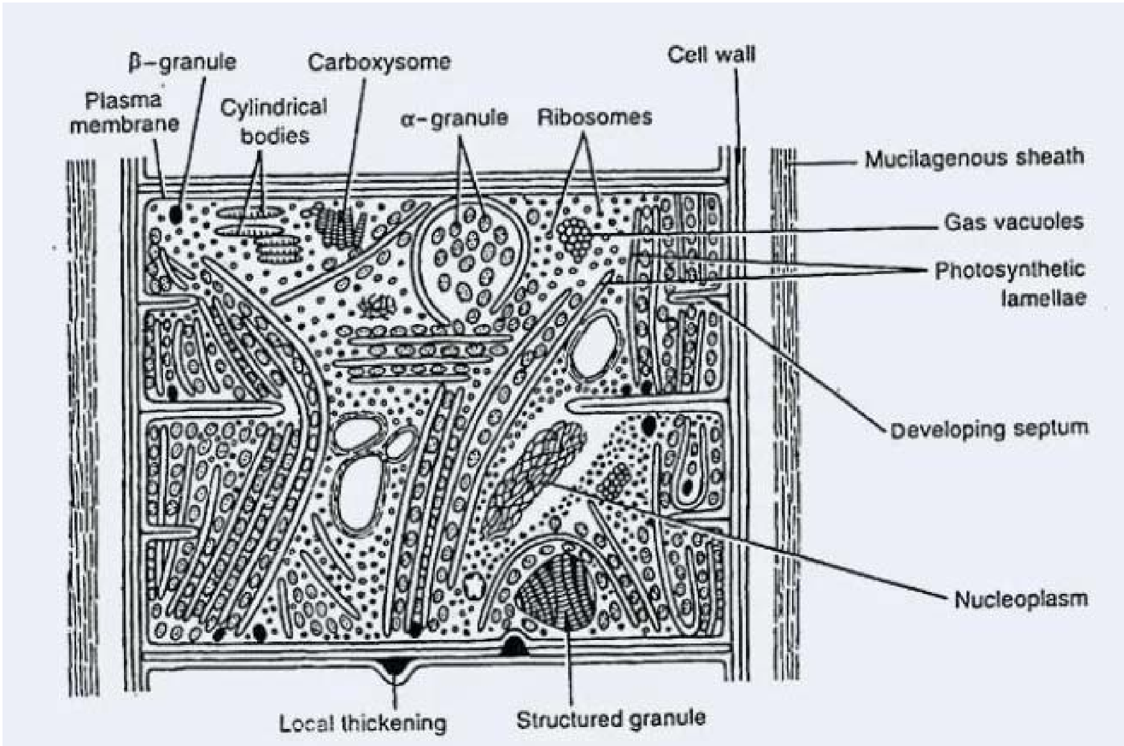

Figure 1: Illustarte the prokaryotic cell (blue Green Algae).

Algae Reproduction

In algae, sexual, asexual, and vegetative reproduction are all possible. In more advanced species of algae, both asexual and sexual reproduction are widespread. Primitive algae are recognized for their vegetative method of reproduction.

- **Vegetative Reproduction:** Algae use the following techniques for vegetative reproduction:
- Fragmentation is a frequent occurrence in filamentous forms. The filament splits into pieces during this process, and each piece produces a fresh filamentous thallus. Ulothrix, Spirogyra, Oedogonium, Zygnema, Oscillatoria, Nostoc, etc. are some typical instances.
- **Fission:** Desmids, diatoms, and other unicellular algae often engage in this process. The cell undergoes mitotic division, which results in the separation of the two pieces by the creation of a septum.
- Adventitious branches. Protonema form in certain algae, such as Chara, and when they are severed from the parent thallus, they produce new thalli. [6] The rhizoids are where these adventitious branches mostly grow. Dictyota and Fucus are two further instances.
- **Tubers:** In the lower nodes or rhizoids of Chara, tubers are round or globular entities. These tubers may produce new thalli when they separate from the parent plant.
- **Amylum stars:** Amylum stars are star-shaped bodies loaded with amylum starch that develop in Chara and separate from the parent plant to produce new individuals.
- **Budding:** Certain algae, such as Protosiphon, experience budding, which produces new individuals.

- **Hormogonia:** Cylindrospermum hormogonia, which may give birth to new thalli, develop in certain cyanobacteria like Nostoc. These heterocysts in the thallus may give rise to hormogonia of various lengths. The breakdown of filament into two or more cells results in the production of these hormogones.

Asexual Reproduction

Asexual reproduction occurs in a vast number of algae with the aid of various spore types and other structures. In essence, spores may develop into new thalluses and are used for asexual reproduction. In the case of algae, spores are an [7] internal one-celled structure. They may be created in sporangia, a specialized structure, or in the vegetative cell (Chlamydomonas). They might move about or not. Aplanospores are non-motile while zoospores are motile spores. Hormospores, also known as hormocysts, are thick-walled hormogones that form in drier environments. The following list includes many spore and structural types:

- **Akinetes:** In filamentous forms, certain vegetative cells develop into long, thick-walled structures referred to as akinetes. Akinetes are perpetual bodies that may reproduce when favorable conditions arise while also surviving in unfavorable circumstances. such as Anabaena
- **Hypnospores:** Hypnospores have thick walls, are not flagellated, and have a large supply of food. Some green algae create them when the circumstances are not ideal. As favorable environmental circumstances return, they sprout into new plants such as Protosiphon and Chlamydomonas. Snow becomes crimson in Chlamydomonas nivalis because the pigment haematochrome is present on the walls of the hypnospores.
- **Aplanospores:** The majority of aquatic algae produce these non-flagellated, thin-walled asexual spores when the development of flagella is hampered by unfavorable environmental circumstances.
- Tetraspores, which are non-motile asexual spores, are produced by a few Rhodophyceae and Phaeophyceae species. In the tetrasporangia, tetrads are where tetraspores are created. such as Polysiphonia
- **Monospores:** A monospore is a single spore produced by a sporangia. Certain Rhodophyceae members reproduce asexually through means of monospores.
- **Autospores:** They look exactly like the parent cell but are really aplanospores. Consequently, they are called autospores.
- **Auxospores:** The Bacillariophyceae member produces auxospores.
- **Carpospores:** Red algae carposporophytes create carpospores.
- **Paraspores:** Certain Rhodophyceae members produce paraspores, which develop into new individuals.
- **Nannocytes:** Members of the chroococcales undergo repetitive cell division to create a large number of tiny spores. Geitler gave these very tiny spores the name "nannocytes." Macrocystis and Gloeocapsa, as examples.
- **Vaucheria's Gongrosira stage:** At this stage, the protoplast splits into a number of cyst-like structures called hypnospores. This stage resembles the "Gongrosira" algal form. A new thallus might develop from each hypnospore or cyst.

Statospores are formed by members of the Xanthophyceae and Bacillariophyceae families. They are asexual perpetual bodies that, in the event of a favorable circumstance, may give birth to new individuals. Diatoms produce statospores with thick walls. Neutral spores are algal protoplasts that perform the role of spores directly. They are known as neutral spores. Such as Asterocystis and Ectocarpus.

Zoospores

These flagellated asexual spores are produced either directly from the vegetative cells or in the zoosporangium. The zoospores might be multiflagellate, bi, or quadric. The multiflagellate zoospores come in two variations: either they are organized in a ring around a protrusion that resembles a beak or they are flagellated throughout the full length of the body. For instance, Cladophora (quadriflagellate), Chlamydomonas (biflagellate), Ulothrix, Vaucheria, and Oedogonium (multiflagellate). The zoospores in pediastrum don't germinate or split; instead, they align themselves in a single plane and start to oppose one another to create a colony that looks like the parent cell. Other algae do not possess this trait. Heterocysts may sometimes be able to reproduce asexually, according to certain phycologists. Their precise purpose is still unclear, however. These formations may be terminal or interstitial, depending on where they are located in the thallus, and they are seen in blue green algae.

Sexual Reproduction

In advanced algae, as opposed to less advanced forms, where vegetative and asexual techniques are the primary ways of reproduction, sexual reproduction is present. Gametes from several sexual sexes combine to produce offspring sexually [8]. The characteristics of gametes and the method of sexual reproduction vary widely. Every thallus vegetative cell that has the ability to create gametes may act as a gametangium or can grow into a more specific gametangium. The gametangia might be identical (isogametangia) or different morphologically (heterogametangia).

In the gametangia, the gametes are created either by reduction division or simple mitotic division. The diploid zygote that results from the fusion of the haploid gametes gives birth to the thallus. Sexual reproduction may take one of the following forms depending on the morphological and physiological properties of gametes. Isogamous sexual reproduction is characterized by fusing gametes that are physically identical but physiologically distinct (+ and -). Chlamydomonas, Ulothrix, Zygnema, and Spirogyra are a few examples. Anisogamous sexual reproduction involves physically and physiologically distinct merging gametes. Several gametangia create the gametes. Male gametes are called microgametes, whereas female gametes are called macrogametes[9]–[11].

CONCLUSION

Oogamy is the most sophisticated form of sexual reproduction, in which a little male gamete (or microgamete) unites with a big female gamete (or egg). The antheridium is where male gametes are created, while the oogonium is where female gametes or eggs are produced. A diploid zygote is created when a male gamete fertilizes an egg within the oogonium during fertilization. Such as Chlamydomonas[12].

In certain unicellular algae, the whole thallus functions as a gamete, and during this process, oppositely strained gametes or thalli fuse to form a diploid zygote such as Chlamydomonas. In autogamy, two gametes from the same mother cell that belong to different strains fuse together. No genetic recombination occurs since both fusion gametes are produced by the same mother cell, as in the case of diatoms.

REFERENCES

[1] Y. Gao, X. Li, J. Guo, X. Sun, and Z. Sun, "Reproductive responses of the earthworm (Eisenia fetida) to antiparasitic albendazole exposure," *Chemosphere*, 2015, doi: 10.1016/j.chemosphere.2014.05.030.

[2] M. Grudniewska *et al.*, "A novel flatworm-specific gene implicated in reproduction in Macrostomum lignano," *Sci. Rep.*, 2018, doi: 10.1038/s41598-018-21107-4.

[3] V. Koutsouveli *et al.*, "Insights into the reproduction of some Antarctic dendroceratid, poecilosclerid, and haplosclerid demosponges," *PLoS One*, 2018, doi: 10.1371/journal.pone.0192267.

[4] S. Senarat *et al.*, "Ultrastructure of ovarian follicles and testis in Zebra-Snout seahorse hippocampus barbouri (Jordan & Richardson, 1908) under aquaculture conditions," *J. Adv. Vet. Res.*, 2021.

[5] A. Santos and I. Ramos, "ATG3 Is Important for the Chorion Ultrastructure During Oogenesis in the Insect Vector Rhodnius prolixus," *Front. Physiol.*, 2021, doi: 10.3389/fphys.2021.638026.

[6] V. Vasconcellos, P. Willenz, A. Ereskovsky, and E. Lanna, "Comparative ultrastructure of the spermatogenesis of three species of Poecilosclerida (Porifera, Demospongiae)," *Zoomorphology*, 2019, doi: 10.1007/s00435-018-0429-4.

[7] A. C. L. Miranda, N. Bazzoli, E. Rizzo, and Y. Sato, "Ovarian follicular atresia in two teleost species: A histological and ultrastructural study," *Tissue Cell*, 1999, doi: 10.1054/tice.1999.0045.

[8] O. Muriel, L. Michon, W. Kukulski, and S. G. Martin, "Ultrastructural plasma membrane asymmetries in tension and curvature promote yeast cell fusion," *J. Cell Biol.*, 2021, doi: 10.1083/jcb.202103142.

[9] Z. Shi, H. Zhang, Y. Liu, M. Xu, and J. Dai, "Alterations in gene expression and testosterone synthesis in the testes of male rats exposed to perfluorododecanoic acid," *Toxicol. Sci.*, 2007, doi: 10.1093/toxsci/kfm070.

[10] M. Zhang *et al.*, "Cadmium suppresses the proliferation of piglet Sertoli cells and causes their DNA damage, cell apoptosis and aberrant ultrastructure," *Reprod. Biol. Endocrinol.*, 2010, doi: 10.1186/1477-7827-8-97.

[11] P. Radhakrishnan, D. Marchini, and P. W. Taylor, "Ultrastructure of male reproductive accessory glands and ejaculatory duct in the Queensland fruit fly, Bactrocera tryoni (Diptera: Tephritidae)," *Arthropod Struct. Dev.*, 2009, doi: 10.1016/j.asd.2008.09.004.

[12] A. Amato, L. Orsini, D. D'Alelio, and M. Montresor, "Life cycle, size reduction patterns, and ultrastructure of the pennate planktonic diatom Pseudo-nitzschia delicatissima (Bacillariophyceae)," *J. Phycol.*, 2005, doi: 10.1111/j.1529-8817.2005.00080.x.

CHAPTER 3

IMPORTANT CLASSIFICATIONS

Uzma Noor Shah, Assistant Professor,
School of Sciences, Jain (Deemed to be University), Bangalore, India
Email Id- ns.uzma@jainuniversity.ac.in

ABSTRACT:

Algae have unique characteristics in terms of their colours, reserve food type, cilia/flagella type, etc. Several classes have been suggested by phycologists in light of these morphological and physiological variations. All types of algae have chlorophyll, however in certain types, other pigments predominate and conceal the chlorophyll's green color.

KEYWORDS:

Chrysophyceae, Algae, Eukaryotic, Microalgae Photosynthetic, Xanthophyceae.

INTRODUCTION

A group of mostly watery, nucleus-containing, photosynthetic organisms known as algae. Algae are not considered to be plants since they lack reproductive organs like stems, leaves, and roots. Cells present in algae are not found in any other plants or animals. Even the pigments involved in photosynthesis vary greatly from those found in plants. The size of the tiniest Algae picoplankton may vary from 0.2 to 2 micrometers, while the size of the huge kelp can reach 60 meters. A single nucleus or even numerous nuclei might be seen in an algae cell. Eukaryotic organisms called algae have three different forms of double membrane-bound organelles. It has a chloroplast, mitochondria, and nucleus [1].

Few types of algae contain toxins that are toxic to fish, finfish, and shellfish, therefore eating these fish is dangerous. Red tides are caused by dinoflagellates, which are toxic to aquatic life and also emit poisons into the water. Every creature that breathes air may have health problems due to the poisons that dinoflagellates discharge into the air. Many crucial responsibilities for algae are played in the atmosphere of the Planet. Around half of the oxygen on Earth is produced by algae, which also store carbon dioxide to keep it out of the atmosphere.

Taxonomy, Life Cycle, and Uses of Algae

The term "algae" refers to a wide variety of eukaryotic organisms, ranging from tiny, single-celled microalgae to massive kelp. Algae may often be split into two categories: photosynthetic algae and aquatic algae. Although though it resembles a plant, it lacks genuine roots, stalks, leaves, and vascular tissue in favor of rudimentary reproductive components. Algae or their spores may be found in a range of habitats, including air, soil, freshwater, and marine settings. Most types of algae are tiny, but others may grow to be very enormous, like marine seaweeds, which can reach lengths of up to 50 meters. They are separated into two categories: Microalgae and Macroalgae.

- Microalgae: This is algae's single-celled kind
- Macroalgae: This kind of algae has many cells

Heterotrophic, photosynthetic microalgae offer a remarkable potential for development as energy crops. Algae has the ability to grow or be farmed in any challenging climatic circumstances. Algae create a variety of valuable bioactive substances, including lipids, oils, carbohydrates, and other commercial byproducts. A few representatives of the red, brown, and green algae are also included in the phrase. They are "simple" because they lack the multitude of intricate organs present in terrestrial plants and are photosynthetic in nature. As a result, they are not included in the category of plants.

Chlorophyll, which is a component of algae, is what allows them to produce their own food via the photosynthesis process inside of the membrane-bound chloroplasts. Except for Cyanobacteria, which is a bacterial organism that is conventionally categorized as algae and has a prokaryotic cell structure, almost all algae are eukaryotes. Algae are very significant species. In comparison to all other live terrestrial plants, they create the most oxygen. They are also a significant source of food for several creatures, including tiny shrimp and enormous whales. They are at the bottom of the food chain as a result since so many other living things rely on them[2].

Recent studies have shown that algae may be used to produce biodiesel, which has the benefits of being an algal-based biofuel and being non-toxic, sulfur-free, and highly biodegradable. In addition, they provide higher yields than other energy crops. According to estimates, microalgae may produce up to 15,000 gallons of oil per acre each year. This oil may be used to make chemicals, fuels, and other things. They may provide biomass and fuel yields that are 10 to 100 times greater than those of similar energy crops. Also, they have the capacity to thrive in any environment that may not be ideal for the cultivation of traditional crops. Micro-algae having the ability to lower atmospheric CO2 concentrations, so resolving the rising atmospheric CO2 concentration problem that is the root cause of the world's pollution issue

Algae classification

The same principles that are used to the taxonomy of terrestrial plants are also applied to the categorization of algae. Microscopic analysis has shown variations in the characteristics of algae, which supports another approach of classifying them. Organelle structure, the flagellar apparatus, and the mechanism of cell division are a few characteristics that distinguish distinct forms of algae. Algae barely qualify for division-level or kingdom-level categorization. Xanthophyceae and Bacillariophyceae are two groups that some scientists put in the division Chromophyta, while others place each class in its own division, including Bacillariophyceae.

Algae are categorized according to the following six kinds in a common and recognized manner:

- Prokaryotic or eukaryotic nuclear organization
- Cell wall composition: cellulosic or non-cellulosic (protein, acid, polysaccharide)
- Photosynthesis and Pigmentation: Three pigments (chlorophylls, carotenoids, and lipoproteins)
- Food Reserve's Nature - The numerous kinds of reserve food in various classes include starch, oil, mannitol, leucosis, etc.
- Flagellation: The class is determined by the kind, quantity, and placement of flagella.
- Life cycle type includes complexity, total absence, and presence.

The following four categories might be distinguished based on their color.

- Phycocyanin, the predominant pigment found in cyanophyceae (blue-green algae).

- Chlorophyll a and b, the predominant pigment of Chlorophyceae (green algae).
- Phaeophyceae
- (brown algae) Xanthophyllus (fucoxanthin) is the main pigment.
- The primary pigment in Rhodophyceae (red algae) is (r-phycocrythrin) Phycobilin.

New insights into the anatomy, physiology, and reproduction of algae have emerged in recent years, allowing for the development of more natural classification systems. While phycologists debate on the exact classification of algae, in general, algae are divided into the following groups:

1. The composition and properties of pigments.
2. The chemical composition of reserve food items or assimilatory products of photosynthesis.
3. The shape, nature, number, and location of flagella.
4. Chemistry of the cell and thalli.
5. Morphological characteristics of cells and thalli.
6. The reproductive system, reproduction methods, and life history pattern.

Importnations

Classification proposed by F.E. Fritsch

The Structure and Reproduction of the Algae by F.E. Fritsch (1935, 1948) contains the first, most detailed, and definitive classification of algae. He was classified in accordance with the following criteria:

Pigments

The following three categories are assimilatory products, Thallus structure, and reproductive techniques. F.E. Fritsch divided algae into the following 11 groups[3].

- **Myxophyceae (Cyanophyceae):** Simple plants, such as Nostoc, Anabaena, Rivularia, etc., lack chromatophores and motile cells, have no distinct nucleus, reproduce by fission, and have the blue-green pigment c-phycocyanin in addition to chlorophyll as results of photosynthesis.
- **Euglenophyceae, second (Flagellates):** Unicellular plants have traits from both plants and animals. Most types are solitary and free-swimming in freshwater or saltwater, however others form connected colonies of gelatinous organisms. Plants having a distinct nucleus, one or two cilia, chloroplasts, a noticeable eye spot, and fission-only reproduction, such as Euglena, Heteronema, etc.
- **Chlorophyceae:** Variable-structured plants, such as Volvox, Ulothrix, Spirogyra, and Vaucheria that have definite nuclei, chloroplasts, and motile reproductive cells with a variable number of flagella. These plants are typically green due to chlorophyll; their products of assimilation include starch and sugar; and their sexual reproduction ranges from isogamy to anisogamy and oogamy.
- **Chloromonadineae:** Bright, excessively chlorophyll-green plants that produce fat-assimilation products, discoid chloroplasts, and individual reproduction through longitudinal division. The members of this class are yet mostly unknown.
- **Xanthophyceae (Heterokontae):** Due to an overabundance of xanthophyll, chloroplasts are yellow-green; oil substitutes starch; flagella are two and of different

lengths; sexual reproduction is uncommon but isogamous; and cell walls may have two equal or unequal portions that overlap each other, as in the case of Botrydium, Tribonema, etc.

- **Chrysophyceae:** Plants are primitive; their chloroplasts are brown or orange because of accessory pigments like phycochrysin; they may or may not have a cell wall; their food is typically stored as fat or a protein-like substance called leucosin; their cysts are silicified; their sexual reproduction is uncommon but isogamous when it does occur, as in the case of Chromulina and Chrysamoeba.
- **Bacillariophyceae (Diatoms):** Cell walls that are partially silicified and partially pectose, with symmetrical halves decorated with fine patterns; chromatophores that are yellow or golden-brown; sexual reproduction that is either isogamous or anisogamous; examples include Pinnularia, Navicula, Melosira, etc.
- **Cryptophyceae:** Each cell has two big parietal chloroplasts that are each different colors, albeit typically a brownish hue; the result of photosynthesis is starch; the cells are motile. Having two unequal flagella, primarily flagellate forms, isogamous sexual reproduction within one species, and endogenous cysts prevalent, such as those seen in Cryptomonas, Chilomonas, and other organisms.
- **Dinophyceae, (Peridineae):** The majority of the members are unicellular and motile, with a tendency toward filamentous habits: cell wall sculptured; chromatophores discoid, dark-yellow or brown in color; starch and fat are products of photosynthesis; motile cells with a longitudinal and transverse furrow, biflagellate; sexual reproduction is uncommon but isogamous when present, for example, in Heterocapsa, Ceratium, Peridinium, etc.
- **Phaeophyceae:** Fucoxanthin, a brown pigment, gives most marine organisms their brown color. Products of photosynthesis include alcohol, fat, polysaccharide, and sugar. Plants may be filamentous or highly organized into large sea weeds with internal and external differentiation. Reproductive cells may be biflagellate, with one set of flagella pointing forward and the other backward. Sexual reproduction may be iso/aniso/or oogamous. Examples include Ectocarpus, Fucu.
- **Rhodophyceae:** oogamous sexual reproduction; male cells or spermatia carried by water currents to the trichogyne of most marine species; color red or violet due to the presence of r-phycoerythrin and r-phycocyanin; food reserve is floridean starch; plants filamentous or highly organized showing complex differentiation, but not as in phaeophyceae; protoplasmic connections present between cells of all forms except proto-florideae; Fritsch has also proposed the fossil group Nematophyceae, which consists of two taxa. While internal morphology is comparable to upper Chlorophyceae and spore tetrads to Rhodophyceae, the true affinities of this class are still debatable.

2. The Xanthophyceae family (Yellow green algae)

- The majority of varieties are freshwater, while a few are marine in nature.
- Yellow xanthophyll is a prominent pigment.
- Oil as a reserve food
- Structure: Simple filamentous forms to unicellular motility. Pectic compound-rich cell wall made up of two equal halves that overlap at their borders. Two extremely different flagella are seen on motile cells absence of pyrenoids.
- Sexual reproduction is uncommon and, when it does occur, it is invariably isogamous.

- as in Vaucheria

3. The Chrysophyceae family.

- The majority of types are found in cold, fresh water; very few are marine.
- Chromatophores have an orange or brown color. The main auxiliary pigment is phycochrysin.
- Leucosin and fat are reserved foods.
- Plants range in structure from unicellular, motile species to branching filamentous forms. The front ends of the flagella are unevenly connected. There are usually one or two parietal chrmatophores present in cells.
- Reproduction: Sexual reproduction is isogamous in nature and happens seldom.

4. Class (Diatoms) Bacillariophyceae,

- Existence: In all types of freshwater, marine, terrestrial, and soil environments.
- Chromatophores have yellow or golden brown pigments. The exact nature of the auxiliary pigments is unclear.
- Reserve fare: Volatin and fat.
- All of the members are colonial or unicellular in structure. Silica and pectic materials make up a portion of the cell wall. Each of its two parts contains two or more pieces. The cell wall is lavishly decorated.
- Forms reproduce by being diploid. The unique kind of sexual reproduction involves the fusing of the protoplasts of regular people.
- as in Pinnularia

5. Cryptophyceae class

- Occurrence: In both fresh and salt water
- Chromatophores exhibit a variety of pigments. It could have a few brown hues. Parietal chromophores are typical.
- Conserve food: preferably starch or solid carbs.
- Structure: Motile cells are represented by coccoid flagella, which are found in their most advanced forms.
- Reproduction: Isogamous in the instances that have been recorded.
- as in chroomonas

7. Family: Dinophyceae

- Plants are abundant as planktons in marine water. Some could be freshwater organisms.
- Food for reserves: starch and oil
- Chromaophores are specific pigments that are dark yellow, brown, etc. in color.
- Plants are unicellular and motile to branching filaments in terms of structure.
- Reproduction: Sexual activity is isogamous in nature. It is uncommon and ambiguous.
- For instance, dinoflagellate and ceratium

7. Chloromonadineae family

- Every plant life originates in fresh water.
- Chromatophores are vivid green in color and are too chlorophyll-rich.

- Oil as a reserve food
- Structure: Plants have two almost equal flagella that are motile and flagellate.

8. Euglenine family

- Only fresh water variants are known to occur.
- Chromatophores are completely green in color. Many chromatophores are present in each cell.
- Polysaccharide and Paramylon are the reserve foods.
- Structure: Motile flagellates, which may have one or two flagella and arise from the base of an invagination resembling a canal at the front. A big, noticeable nucleus and a complicated vacuolar system.

9. Rhodophyceae, class (Red algae)

- Some types are marine, while others are freshwater.
- Chromatophores are red, blue, and include carotenes, chlorophyll a, d, and pigments such as red r-phycoerythrin and blue r-phycocyanin.
- Food for reserves: floridian starch
- Basic filamentous forms that develop significant structural complexity. Unknown motile structures exist.
- Sexual reproduction is an evolved form of oogamy. The female organ has a long receptive neck, whereas the male organ generates non-motile gametes. Special spores, known as carpospores, are formed after sexual reproduction. Example: Polysiphonia, Batrachospermum

11. Class: Myxophyceae (Cyanophyceae or Blue green algae)

- Found in fresh and salt water as well as damp areas.
- Chlorophyll, carotenes, xanthophylls, as well as c-phycocyanin and c-phycoerythrin, are pigments. The ratio of the last two pigments shows color variation, which is often blue-green.
- Store food: Glucose and Sugar
- Structure: Simple types range from cells to filamentous forms, and some filamentous forms have extremely primitive nuclei, no appropriate chromatophores, and photosynthetic pigments that are dispersed throughout the periphery. No phases of motility.
- Reproduction: Sexual reproduction is not possible.

Smith (1933, 1951, 1955) suggested a [4], [5] categorization system for algae based on the physiological characteristics of vegetative cells and the morphology of motile reproductive cells. He separated algae into seven categories, adding related subcategories to each category. The classes that exhibit a strong connection have been grouped together. For instance, despite variations in color, it is sufficient to group together Xanthophyceae, Chrysophyceae, and Bacillariophyceae in the division Chrysophyta due to similarities in the structure and content of the cell wall, flagellation, and type of food reserves. Cyanophyta, or blue-green algae, are the only prokaryotic algae in Group 1. By virtue of being the sole prokaryotic algae, it constitutes a natural group. The protoplasm of prokaryotic algae contains photosynthetic thylakoids, 70S ribosomes, and DNA fibrils but is not separated from them by a distinct membrane. This protoplasm is encased by an outer plasma membrane. The primary photosynthetic pigment is chlorophyll a, and oxygen is produced during photosynthesis.

These algae fit into a natural category of algae because their plastids are encased in two membranes. The following describes the evolutionary process that gave rise to the chloroplast. The incorporation of a cyanobacterium into a feeding vesicle by a protozoan. The endosymbiotic relationship between the protozoan and the cyanobacterium was established as a consequence. The endosymbiotic cyanobacterium transformed throughout time into a chloroplast encased in two membranes from the chloroplast envelope[6].

The Euglenophyta and Dinophyta, which make up Group 3, are natural groups since they are the only class of algae that have a single membrane containing the chloroplast endoplasmic reticulum.

A phagocytotic euglenoid or dinoflagellate that took up a chloroplast from a eukaryotic alga as a food vesicle produced chloroplast endoplasmic reticulum as a consequence. A phagocytotic protozoan first incorporated a chloroplast into a feeding vesicle. A consequence of this endosymbiosis was the development of a single membrane of chloroplast endoplasmic reticulum encircling the chloroplast from the feeding vesicle. The inner membrane of the chloroplast ER surrounds the chloroplast envelope in group 4-algae with two membranes of the chloroplast endoplasmic reticulum (chloroplast ER). Ribosomes are located on the outside of the other chloroplast ER membrane, which is contiguous with the nuclear envelope's outer membrane[7], [8].

CONCLUSION

F.E. Fritsch divided all of the algae into eleven groups based on factors such pigment kinds, reserve food resource types, reproductive methods, etc. These include the following families: Chlorophyceae, Xanthophyceae, Chrysophyceae, Bacillariophyceae, Cryptophyceae, Dinophyceae, Chloromonodineae, Euglinineae, Phaeophyceae, Rhodophyceae, and Myxophyceae (Cyanophyceae). He publishes the categorization in his book, "The Structure and Reproduction of Algae." Smith's suggested taxonomy of algae is based on the morphology of motile reproductive cells and the physiological characteristics of vegetative cells. He separated algae into seven categories, adding related subcategories to each category[9], [10].

REFERENCES

[1] P. O. Bonetti, "[Important classifications and scores in cardiology].," *Ther. Umsch.*, 2013.

[2] T. Pinna, D. N. Dongiovanni, S. Ciattaglia, and L. Barucca, "Safety important classification of EU DEMO components," *Fusion Eng. Des.*, 2019, doi: 10.1016/j.fusengdes.2019.01.040.

[3] M. Otani, A. Nishida, Y. Nakashima, T. Sato, and N. Yokoya, "Finding important people in a video using deep neural networks with conditional random fields," *IEICE Trans. Inf. Syst.*, 2018, doi: 10.1587/transinf.2018EDP7029.

[4] L. Yan, Y. Liu, and Y. Liu, "Interval feature transformation for time series classification using perceptually important points," *Appl. Sci.*, 2020, doi: 10.3390/APP10165428.

[5] M. R. Boland, P. Parhi, P. Gentine, and N. P. Tatonetti, "Climate Classification is an Important Factor in Assessing Quality-of-Care Across Hospitals," *Sci. Rep.*, 2017, doi: 10.1038/s41598-017-04708-3.

[6] M. Björck *et al.*, "Classification-important step to improve management of patients with an open abdomen," *World J. Surg.*, 2009, doi: 10.1007/s00268-009-9996-3.

[7] H. Huang *et al.*, "Is race important in genomic classification of hematological neoplasms?," *Hematological Oncology*. 2021. doi: 10.1002/hon.2909.

[8] M. Kayal, R. C. Ungaro, and J. F. Colombel, "The Chicago Classification of Pouchitis: An Important Step Toward a Needed Consensus," *Clinical Gastroenterology and Hepatology*. 2022. doi: 10.1016/j.cgh.2021.03.025.

[9] D. Lu and Q. Weng, "A survey of image classification methods and techniques for improving classification performance," *International Journal of Remote Sensing*. 2007. doi: 10.1080/01431160600746456.

[10] I. R. Montella, R. Schama, and D. Valle, "The classification of esterases: An important gene family involved in insecticide resistance - A review," *Memorias do Instituto Oswaldo Cruz*. 2012. doi: 10.1590/S0074-02762012000400001.

CHAPTER 4

MODERN CONCEPT TO CLASSIFY ALGAE

Padmapriya.G, Assistant Professor,
Department of Chemistry, School of Sciences, Jain (Deemed to be University), Bangalore, India
Email Id- g.padmapriya@jainuniversity.ac.in

ABSTRACT:

As you learned in the last section, algae are thalloid, chlorophyllous plants without differentiation into roots, stems, or leaves. They also lack jacket layers on their sex organs and don't generate embryos. Algae are termed according to their color, such as green algae, brown algae, red algae, etc., since they contain a variety of pigments that give their bodies color. Several classification criteria for algae, such as kinds of pigments, flagellation, reserve food material, pattern of life cycle, etc., came into knowledge with the progress of methods in the fields of biochemistry, biotechnology, physiology, electron microscopy, etc.

KEYWORDS:

Algae, Cyanophyceae, Chlorophyllous, Endoplasmic, Rhodophyceae.

INTRODUCTION

We will go through the standards for classifying algae in this course, as well as numerous classifications that have been sometimes presented by different scientists. The International Code for Nomenclature committee has proposed a few suffixes [1] for the categorization of algae. The divisions are phyta, the class is phyceae, the subclass is phycideae, the order is ales, the suborder is inales, the family is aceae, and the subfamily is oideae, as shown in Figure 1.

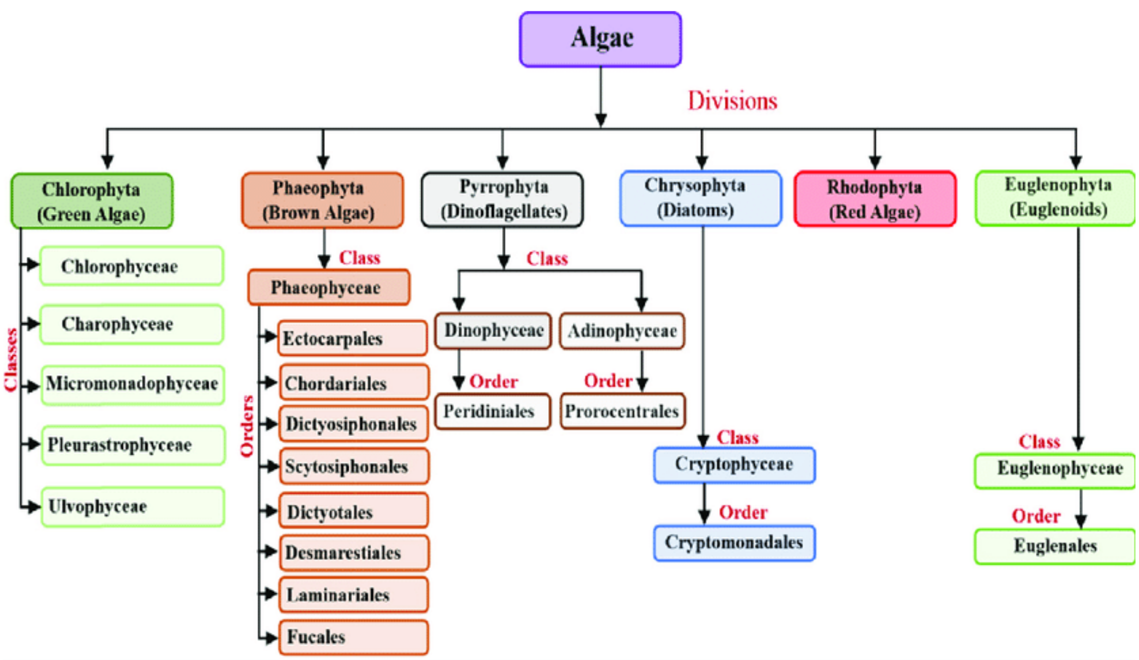

Figure 1: Illustarte the Classification of Algae.

Modern Algae Classification Theory

The following are the standards and contemporary classification for algae:

- Nuclear organization
- Cell wall elements
- Colorants
- Flagellation
- The reserve food material's chemical composition.

Life cycle and reproductive types

Nuclear structure

Algae may be classified as prokaryotic or eukaryotic based on the nuclear organization. Whereas all other algae are eukaryotic, the cyanophyceae or cyanobacteria (blue green) are prokaryotic. Nuclear membrane is lacking in cyanophyceae, and histone proteins do not surround the genetic material (chromatin threads). Moreover, organelles that are membrane-bound, such as mitochondria, plastids, Golgi bodies, endoplasmic reticulum, vacuoles, etc., are absent. In their cell structure, eukaryotic algae contain well-organized nuclei, mitochondria, Golgi bodies, chloroplasts, endoplasmic reticulum, etc.

Cell wall chemical composition

Algae's cellulose-based cell walls (polysaccharide). In general, the exterior wall is composed of pectic materials that are soluble in water,[2] Whereas the inner wall is an insoluble cellulose layer. Also, certain types of algae differ from others in that they have specific chemical components in their cell walls. For instance, the cell walls of Phaeophyceae species contain alginic and fucinic acids, while bacillariophyceae cells are saturated with silica. Rhodophyceae cells contain xylan and galactan. The mucopeptide found in cyanophyceae makes up their cell wall.

Pigments

One of the most significant characteristics used to categorize algae. Algae were once categorized according to their color as red algae, brown algae, green algae, and blue green algae. Eukaryotic algae have pigments in their plastids, while prokaryotic algae have them in their thylakoids. Algal plastids contain three different kinds of pigments. They include phycobilins, carotenoids, and chlorophyll.

Algae include five different forms of chlorophyll, called chlorophylls a, b, c, d, and e.

- There is chlorophyll an in all types of algae.
- Chlorophyceae and Euglenineae both contain chlorophyll b. Phaeophyceae and Cryptophyceae both contain chlorophyll C. Only Rhodophyceae have chlorophyll.
- Only Xanthophyceae have chlorophyll.
- Carotenoids - Carotenoids are pigments with yellow or orange hues. They provide a protective covering and are capable of absorbing harmful oxygen molecules from light. These pigments are what give algae their different colors.

DISCUSSION

Carotenoids, which may be categorised as carotene, xanthophylls, and carotenoid acids, are soluble in fat. There are six different forms of carotenes: lycopene, flavicine, and. Unsaturated hydrocarbons in a linear chain that is soluble in fat make up beta-carotene. Algae from all classes contain -carotene. Rhodophyceae and Cryptophyceae contain -carotene. Charophyceae include -carotene and lycopene. Both Cryptophyceae and [3] Bacillariophyceae contain -carotene. Flavicin is present in Cyanophyceae. Xanthophylls are oxygen-derived carotenoid compounds. Algae have roughly 20 different forms of xanthophylls. For instance, zeathanthin, flavoxanthin, diatoxanthin, myxoxanthin, myxoxanthophylls, fucaxanthin, zeaxanthin, occillaxanthin, and terraxanthin, among others. Only Cyanophyceae include Myxoxanthin and Myxoxanthophyll, Rhodophyceae contain Terraxanthin, and Euglenineae contain Antheroxanthin. Carotenoid acids are hydrocarbons made up of a chain of carbon atoms and are similar to carotene and xanthophylls.

Phycobilins, also known as biliprotiens, are soluble in water. They are joined to an amino acid in a protein. Phycocyanin, phycoerythrin, and allophycocyanin are the three different kinds of phycobilins. Whereas cyanophyceae include c-phycocyanin and c-phycoerythrin, Rhodophyceae are the only family that contain r-phycocyanin and r-phycoerythrin. Rhodophyceae contain allophycocyanin.

Type of reserve food

Starch, a byproduct of photosynthesis, is the primary reserve food in algae. The type of reserve food material may alter as a result of food being accumulated over an extended period of time. Starch continues to be the reserve food source in the chlorophyceae. It is myxophycean starch in the Cyanophyceae. The Rhodophyceae family contains floridean starch. Mannitol and laminarin are the primary reserve food components in the Pheaophyceae, while leucosine and oil are the primary reserves in the Xanthophyceae.

Flagellation

Flagella are a crucial component of the criteria used to categorize algae. Several groups of algae have varying types, numbers, and positions of flagella. Cyanophyceae and Rhodophyceae don't have any flagella at all. Flagella come in two primary varieties: tinsel or pleuronematic and whiplash or acronematic. Tinsel or pleuronematic flagellum has longitudinal rows of fine, minute flimmers or mastigonemes [4]. Pantonematic, pantoacronematic, or stichonematic tinsel flagella are possible.

- Pantonematic - In the flagellum, the mastigomes are placed in two opposing rows.
- Pantoacronematic – It has a flagellum with a terminal fibril that is pantonematic.
- Stichonematic: The flagellum's mastigaonemes are restricted to one side.

Flagella of the Chlorophyceae family may be 2, 4, or indefinitely many, located apically or subapically, and be of the acronematic form (isokontic- all flagella are of same type). Two uneven, apical flagella are present in the Xanthophyceae family (heterokontic-one whiplash and one tinsel). Two lateral, uneven flagella make up the phaeophyceae (one whiplash and one tinsel).

Life cycle and reproduction type

The complexity of the reproductive organs, the mode of reproduction, and the presence or lack of sexual reproduction are all taken into consideration when classifying algae. The life cycles of various groups have distinct features, including triphasic, haplontic, and diplontic. In

Cyanophyceae, sexual reproduction is not present at all. The Rhodophyceae and Phaeophyceae have oogamous reproduction, and their life cycles are often intricate. The life cycle of the chlorophyceae may be either simple or complicated, and reproduction in them can be isogamous, anisogamous, or oogamous.

Classification

In his Species Planatarum from 1753, Linnaeus classified algae in the same class as mosses, vascular cryptogams, and fungi. He did not further categorize algae. Algae taxonomy has changed often since then. Maybe the first to suggest a method for classifying algae was Vaucher in 1803. He identified Conferves, Ulves, and Tremelles as three distinct groupings. Around 1820, Robert Brown and Link categorised algae according to their color. Harvey developed a categorization system based on environment and pigments. Algae were split into six orders by Agardh including the Diatomaceae, Nostochineae, Confervoideae, Ulvaceae, Florideae, and Fucoideae.

i. **Chlorophyta:** Chlorophyta consists of around 5700 taxa, 90% of which are freshwater and the remainder marine. Chlorophylls a and b are the predominant pigments. Starch is a reserve food substance. Two classes make up the division: Chlorophyceae (green algae), which includes Chlamydomonas and Volvox, and Charophyceae (stoneworts), which includes Chara.

ii. **Euglenophyta:** This order has roughly 450 species that may be found in terrestrial and freshwater settings. The predominant pigments are beta-carotene and chlorophyll a and b. Paramylum and fats are reserve food items. It is broken down into only one class. a. Euglenophyceae, such as the Euglena Division

iii. **Pyrrophyta:** This group of organisms has roughly 1000 species. Members are typically unicellular forms; colonial forms are uncommon. Chlorophylls A and C, -Carotene, and Xanthophylls are the main pigments. It has been been separated into two classes: Desmophyceae (Dinophycids), which includes Desmarestia, and Dinophyceae (Dinoflagellates), which includes Dinophysis

iv. **Chrysophyta:** This group of plants has over 6000 species, of which 75% are freshwater plants and 25% are marine plants. Carotene and Xanthophylls are the predominant pigments. Leucin and oil are reserves of food. The three groups are as follows: a. Chrysophyceae (golden brown algae), such as Chromulina; b. Xanthophyceae (yellow green algae), such as Botrydium; and c. Bacillariophyceae (Diatoms), such as Pinnularia

v. **Phaeophyta (Brown Algae):** Most of them are marine species, and they are also referred to as seaweeds. Phycophyein and fucoxanthin are the predominant pigments. Laminarin and mannitol are reserve food ingredients. It is split into three classes: isogeneratae s, such as ectocarpus; heterogeneratae, such as myrionema; and cyclosporae, such as the sargassum division.

vi. **Cyanophyta (blue-green algae):** This class of organisms, which has roughly 1500 species, is mostly found in freshwater. Chlorophyll A, c-Phycocyanin, and c-Phycoerythrin are the main pigments. The starch found in cyanobacteria is a reserve food. There are no motile cells at all. It has just one class, the Myxophyceae, such as Nostoc and the Anabaena.

vii. **Rhodophyta (Red Algae):** This group, which has roughly 2500 species, is mostly marine. Chlorophylls a and d, r-phycoerythrin, and r-phycocyanin are the predominant pigments. The reserve ingredient in food is floridean starch. There are no motile cells. It is split into only one class, the a. Rhodophyceae, which includes freshwater plants like Batrachospermum, Polysiphonia, and Gracillaria.

Key Characteristics of Significant Groups of Algae

a. **Chlorophyceae:** Green algae are found in this class. Chlorophylls A and B, Xanthophylls, and Carotenoids are the primary pigments. The cells' nuclei are well arranged (eukaryotic). Starch is a reserve dietary component; oil is scarce. The plastid often contains pyrenoid. Two isokontae flagella are present in motile cells. From isogamous to oogamous sexual reproduction is possible. Most of the species are freshwater, although there are also a few marine varieties.
b. **Xanthophyceae:** The majority of members are freshwater organisms; just a small number are marine. The presence of too many xanthophylls gives the members a yellow-green color. Chlorophylls a and e, beta-carotene, and xanthophylls are the main pigments. Motile cells have two uneven flagella and are biflagellate. Plastids do not contain pyrenoids. Oil is a reserve food substance. Seldom occurs sexual reproduction, but when it does, it is isogamous.
c. **Chrysophyceae:** Most members are freshwater and marine organisms. Due to the overabundance of phycochrysin, the algae have a brown or orange color. Other pigments include chlorophyll a and beta-carotene. Leucosine and oil are reserves of food material. Similar to Xanthophyceae, sexual reproduction is uncommon and, when it does occur, isogamous. One flagellum exists in motile cells. Moreover, two or three flagella may appear sometimes.
d. **Bacillariophyceae:** The family's members are [5] referred to as diatoms. Members include both freshwater and marine organisms. Diatomin, which is yellow or golden brown in color, is the most common pigment. Chlorophylls a and c, beta-carotene, and xanthophylls are additional pigments. The silica-impregnated and ornate cell wall has different decorations. There are two parts to the wall. There are pyrenoids. Oil, volutin, and leucosine are reserves for food. The sexual process is distinct.
e. **Cryptophyceae:** This family includes both freshwater and marine species. The members come in a variety of colors (brown, red, olive green, or sometimes bluish green). Two sizable parietal chloroplasts containing pyrenoids are present in the cells. Starch is a reserve food substance. Biflagellate motile cells have different lengths and are motile. Isogamous sexual reproduction exists.
f. **Dinophyceae:** The majority of the members are motile, unicellular organisms. Biflagellate cells are motile cells. There are disc-shaped chloroplasts. There is chlorophyll a and c. Due to the presence of red phycopyrin, dark red peridinin, and yellow green chlorophyllin, the members' colors are brown or dark yellow. Starch and fat are reserves in diet. Sexual reproduction is uncommon and isogamous when it does occur.

Members of the Chloromonadineae exclusively exist in freshwater. Due to an overabundance of xanthophylls, this kind of algae has vivid green color and many discoid chromatophores on its cells. Fat is a reserve food component. Unicellular flagellates are members of the class Euglenophyceae (Euglenineae). There are two types of flagella. Members may be found in salty environments or in freshwater versions. The majority of the members are free-swimming organisms, however they sometimes form gelatinous colonies. Chlorophylls a and b, beta-carotene, and xanthophylls are the main pigments. Fats and polysaccharide paramylon are reserve food components. Fission is the typical method of reproduction.

Brown algae are the collective name for the family's members. These algae are the most intricate in terms of structure. Chlorophylls a and c, beta-carotene, and xanthophylls are examples of pigments. The extra fucoxanthin is what gives the color brown. Algae are often referred to as sea weeds. These are aquatic life forms. Laminarin and mannitol are examples of reserve food material. There are algin and fucoidin in the cellulose cell wall. Reproduction may be either vegetative or sexual. From isogamy to oogamy, sexual reproduction takes several forms. Unevenly sized motile cells are biflagellate. Uneven flagella are laterally connected.

10. RhodophyceaeMost types are marine, with a small number of freshwater variations. Red algae are the group's members. Chlorophylls a and d, beta-carotene, xanthophylls, and phycobilins, including r-phycoerythrin, r-phycocyanin, and allophycocyanin, are major pigments. Algae's red color is caused by an overabundance of r-phycoerythrin. The reserve ingredient in food is floridean starch. Thallus is complicated and well-organized. Cells contain plasmodesmata, with the exception of Protoflorideae members. Specialized and oogamous sexual reproduction exists. There are no motile cells at all.

Myxophyceae or Cyanophyceae [6] Blue green algae are the group's members. They are prokaryotic members. Simple colonial, multicellular, or unicellular entities make up Thallus. In contrast to other situations, pigments are not found in organized bodies. Chlorophyll A, beta-carotene, xanthophylls, and phycobilins (c-phycocyanin and c-phycoerythrin) are the main pigments. The excess c-phycocyanin that is present in algae is what gives them their color. The starch found in cyanobacteria is a reserve food. The mucopeptide that makes up the cell wall. The majority of the members are covered with a mucus-like coating. Many members share the traits of false branching and heterocystic special cells. As in the case of Rhodophyceae, motile cells are completely missing from the life cycle.

CONCLUSION

Whereas all other algae are eukaryotic, the cyanophyceae or cyanobacteria (blue green) are prokaryotic. In Cyanophyceae, sexual reproduction is not present. Cyanophyceae and Rhodophyceae do not have any motile cells. Mucopeptide makes up cyanobacteria's cell wall. The categorization of algae used today is based on factors such cell type, colors, flagellation, the chemical makeup of the cell wall, reserve food sources, and life cycle patterns[7]–[9].

REFERENCES

[1] D. Platvoet, J. T. A. Dick, N. Konijnendijk, and G. Van Der Velde, "Feeding on micro-algae in the invasive Ponto-Caspian amphipod Dikerogammarus villosus (Sowinsky, 1894)," *Aquat. Ecol.*, 2006, doi: 10.1007/s10452-005-9028-9.

[2] J. C. Zamora *et al.*, "Considerations and consequences of allowing DNA sequence data as types of fungal taxa," *IMA Fungus*, 2018, doi: 10.5598/imafungus.2018.09.01.10.

[3] H. Traoré *et al.*, "Clustering pesticides according to their molecular properties, fate, and effects by considering additional ecotoxicological parameters in the TyPol method," *Environ. Sci. Pollut. Res.*, 2018, doi: 10.1007/s11356-017-0758-8.

[4] J. J. Wolken, "Euglena," *Soil Sci.*, 1962, doi: 10.1097/00010694-196201000-00024.

[5] F. M. Hueber, "Rotted wood-alga-fungus: The history and life of Prototaxites Dawson 1859," in *Review of Palaeobotany and Palynology*, 2001. doi: 10.1016/S0034-6667(01)00058-6.

[6] D. E. Buetow, "Euglena," in *eLS*, 2011. doi: 10.1002/9780470015902.a0001964.pub3.

[7] K. M. Drew, "Life Histories In The Algae With Special Reference To The Chlorophyta, Phaeophyta And Rhodophyta," *Biol. Rev.*, 1955, doi: 10.1111/j.1469-185X.1955.tb01544.x.

[8] P. Raven, G. B. Johnson, K. Mason, J. B. Losos, and S. Singer, "35.3 Protist," *Biology (Basel).*, 1995.

[9] A. Verga *et al.*, "Caracterización morfológica de los algarrobos (Prosopis sp.) en las regiones fitogeográficas Chaqueña y Espinal norte de Argentina," *Quebracho*, 2009.

CHAPTER 5

RANGE OF VEGETATIVE STRUCTURE IN ALGAE

Suhas Ballal, Assistant Professor,
Department of Chemistry, School of Sciences, Jain (Deemed to be University), Bangalore, India
Email Id- b.suhas@jainuniversity.ac.in

ABSTRACT:

Algae are photosynthetic organisms that carry out photosynthesis, converting atmospheric carbon dioxide (CO2) into oxygen (O2) and producing oxygen (O2). Algae create at least 50% of the oxygen in the Earth's atmosphere during photosynthesis. Most algae live in freshwater or marine settings that are submerged in water. In addition, they may live on plants, dirt, rocks, and damp terrestrial settings. Although some marine algae are used as food, others generate poisons. Algal cellular and vegetative structures make up their structure.

KEYWORDS:

Algae, Chlorophyll, Chloroplasts, Photosynthesis, Vegetative Structure.

INTRODUCTION

Algae are thalloid autotrophic plants that possess chlorophyll, as is common knowledge. Although they may be found in many different settings, the bulk of them are aquatic. Algae belong to the thallophyta division. Often referred to as the plant's body, the thallus. A plant body known as a thallus lacks distinct roots, stems, and leaves. Algae's vegetative structure exhibits a great deal of variation and varies from simple single cells to intricate multicellular thalli. Algal thalli may be as little as a micron or as large as several meters. Repeated divisions of unicellular species have produced multicellular organisms, and Figure 1 shows the types of algae. By performing repeated transverse cell divisions without separating the daughter cells, a filamentous algal thallus was created. The daughter cells and the parental cell are still joined.

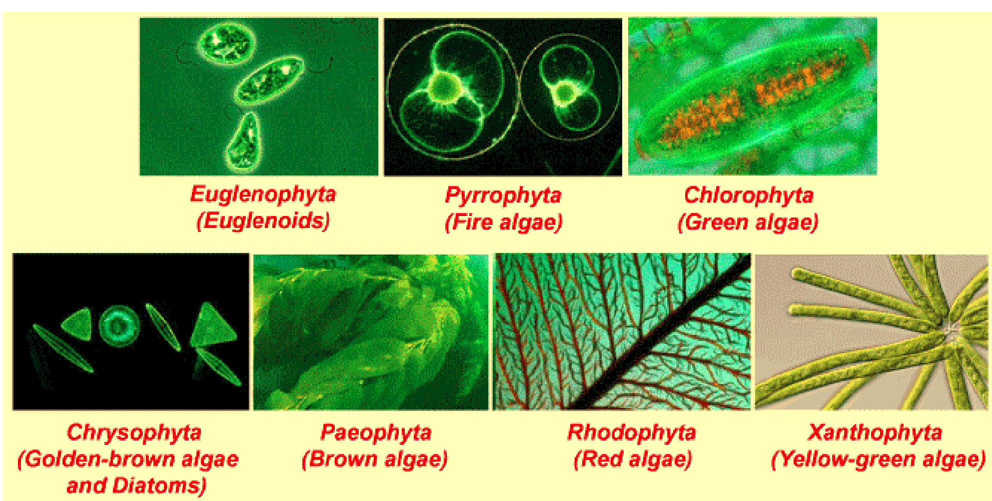

Figure 1: Illustarte the Different type of Algae.

The accumulation of cell division byproducts inside a mucilaginous mass result in a colonial kind of thallus structure. The siphonaceous kinds of thallus organization evolved by recurrent nuclear divisions, but without the creation of cross walls (septa) except from when the reproductive structure was being formed. Siphonaceous forms resemble coenocytes or multinucleate structures that resemble tubes. [1] A tissue called parenchyma is created by the repetitive division of a parent cell and is made up of thin-walled, closely related cells. Often formed by the splitting of a filament's cells into two or more planes, resulting in parenchymatous thalli. Some algal thalli have a fake parenchymatous plant body known as pseudoparenchymatous. This structure plays a supporting role in development; filament interweaving leads to tight cell attachment. As a result, the vegetative structure of algal thalli varies greatly and is as follows.

- Unicular shapes
- Colonial forms
- Siphonaceous form
- Filamentous shape;
- False parenchymal form
- Parenchymatous

Unicellular Organisms

Except for Charophyceae and Phaeophyceae, all families of algae exhibit unicellular forms very often. Without any cellular differentiation, unicellular organisms operate as a whole. Amoeboid, non-motile, or motile unicellular forms are all possible. The following sub-groups may be used to categorize unicellular kinds. -

Colonial Forms

A colony is a collection of individual cells that are gathered in a mucilaginous matrix and are often similar in structure and function. Cytoplasmic connections hold certain algal colony members together so they can't separate into separate parts or segments (e.g. Volvox). A coenobial colony, a palmelloid colony, a dendroid colony, and a rhizopodial colony are examples of colonies. Algae have the following four kinds of colonial organizations based on their morphology:

Coenobial Colony

The number of cells in a coenobium colony is fixed during the juvenile stage and does not increase throughout the colony's future development, even when the cell becomes larger. Coenobia may move or not move. Flagella are found in motile organisms like Volvox, but missing in non-motile organisms like Hydrodictyon.

Palmelloid Colony

The number of cells, their form, and size are all ambiguous in palmelloid colonies. The cells continue to be randomly arranged inside a single mucilagenous mass, yet they nonetheless carry out separate functions. Palmelloid stage may be a transient condition (as in Chlamydomonas) or a long-lasting characteristic (as in Tetraspora).

Dendroid Colony

In dendroid colonies, a mucilagenous thread holds the cells together in a branching pattern. The colony, sometimes known as a minuscule tree, has a propensity of looking like a tree. The cells in this colony might be of any size, shape, or quantity. Chrysodendron is an example.

Rhizopodial Colony

Rhizopodia connect the cells of a rhizopodial colony. Filamentous Forms as an Example. As is well known, recurrent cell transverse division results in the development of a filament. Both branched and unbranched filaments are possible[2]. Just a few kinds of algae have unbranched filaments. The filament may form a colony (like Nostoc or Oscillatoria), be linked to the substrate (like Zygnema or Oedogonium), or be free floating. Branched There are two types of filaments: false and genuine. The trichome typically breaks in the case of false branching, which happens in the scytonemataceae, as a result of the degeneration of an intercalary cell, and one or both of its ends that are near to the dead cell then emerge from the parent sheath to give the appearance of branching (e.g. Scytonema). The lateral outgrowths created by a few or many dispersed cells of the main filament undergo recurrent transverse divisions, which is how true branching develops. The two forms of real branching thalli are heterotrichous filaments and simple branched filaments.

DISCUSSION

A basal cell keeps the simple branching filaments connected to the substrate. Any cell, save the basal cell, may produce branches in such a filament. Cladophora is one example. The most highly developed filament type is heterotrichous, which may differentiate into prostrate and erect systems. The Chaetophorales, many Pheophyceae, Rhodophyceae, several Chrysophyceae, and Dinophyceae are examples of the most highly developed kind of plant body that exhibits a significant level of division of labor. This kind of algal thallus consists of two separate parts: an erect or upright system and a basal or prostrate creeping system. The prostrate system is linked to the substrate, develops apically, and produces a large number of rhizoidal and photosynthetic filaments. The rhizoid filaments of Fritschiella sometimes pierce the substrate. The erect system, which evolved from the prostrate system, consists of one or more photosynthetic filaments that are typically branching [3], [4]. Some species include Draparnaldiopsis, Ectocarpus, Sphacelaria, and Chaetopeltis.

Siphonaceous

A siphonaceous thallus lacks septation (Septa) and is multinucleate, with the exception of while the reproductive organs are developing. The basic structure takes the shape of a tiny, unbranched vesicle. It has a central vacuole and peripheral cytoplasmic nuclei and chloroplasts. Vaucheria, Botrydium, Caulerpa, Protosiphon, etc. are few examples.

False parenchymal form

The word "pseudo" refers to anything that is fake; the plant body seems to be made of paranchymatous structure. The pseudoparenchymatous thallus is a secondary development, and tight cell connection is brought about by filament interweaving. In several genera, secondary filamentous structure develops. Pseudoparenchymatous thallus can take on two different forms: I Uniaxial and (ii) Multiaxial. In Uniaxial forms, the thallus forms as a result of the branching of just one filament (like in the case of Batrachospermum), whereas Multiaxial forms involve the development of branches from more than one filament (e.g. Polysiphonia).

Pachymatous Forms

A basic permanent tissue known as parenchyma is made up of thin-walled, closely related cells that share a common parent cell [5], [6]. The filamentous habit is modified by the multi-planar cell division seen in parenchymatous thallus structure. The parenchymatus thalli might have a highly developed structure or a tubular, leaf-like, or foliose appearance. The splitting of the cells into two or three planes results in the development of flat, foliose, or tubular thalli (e.g. Ulva, Porphyra). Scytosiphon is an example of a tubular thallus, while Sargassum is an example of a complex thallus. The holdfast and main axis of the sargassum thallus, which is diploid and sporophytic, are distinct. The holdfast aids in thallus adhesion to substrate. Parenchymatous tissue also makes up the interior structure.

Thallus Organization

Chlamydomonas

Green algae called Chlamydomonas are motile and unicellular. One cell serves as a metaphor for the thallus. The cell is spherical, elliptical, or pear-shaped, biflagellate (two flagella), and is around 30 m in length and 20 m in diameter. Common thalli are pyriform or pear-shaped, with narrow anterior ends and large posterior ends. Certain Chlamydomonas species have a pointed posterior end (e.g. Chlamydomonas caudata). Each flagellum has two contractile vacuoles, sometimes three, and each cell has a noticeable chloroplast with a cup-like shape. The primary structural element of the cell wall is cellulose. In certain species, a gelatinous coating encircles the cellulose wall. A large parietal chloroplast with a cup-like shape is present in the majority of Chlamydomonas species. Several species of Chlamydomonas also have the following forms of chloroplast in addition to cup-shaped chloroplast:

In chloroplasts, there is a proteinaceous body called pyrenoid. Starch production and storage are issues that pyrenoid organisms are interested in. The thallus has a single, sizable, black nucleus that is located within the cup-shaped chloroplast's cavity. The front end of the cell contains the flagella. Flagella are of the whiplash or acronematic type and are equal in length. In most species, the flagella are longer than the thallus, but in certain species, they might be shorter or even the same length. Each flagellum emerges from a basal granule or blepharoplast and exits the cell wall via a tiny canal. Excretion or osmoregulation is the vacuole's primary purpose. The anterior portion of the cell has a pigmented area called an eye-spot or stigma. Many species have various variations in the eye spot's size and location[7]. The eye spot features a curved pigmented plate and a colorless biconvex photosensitive lens. It serves as a basic eye and is a photoreceptive organ.

Green algae called Volvox Volvox are colonial. Coenobium is the name for thallus' behavior. Each coenobium in the colonies, which are oval or spherical in form, contains 500–60,000 cells. At the edge of the gelatinous colonial envelop, the biflagellate cells are organized in a single layer. The movement is caused by the coordinated activity of individual cell flagella. The cytoplasmic threads that bind the cells together. Compared to cells at the posterior end, those at the anterior end have larger eye spots. At maturity, the cells towards the posterior end start to reproduce. Volvox colony cells are of the Chlamydomonas type. Typically pyriform with a small anterior end and a large posterior end, colony cells are spherical. There are two whiplash-shaped flagella in each cell, each of which is of identical length. The cell's plasma membrane encloses the protoplasm. Each cell has a single nucleus as well as two contractile vacuoles, a pyrenoid, a cup-shaped chloroplast, and an eye spot. The exterior face of the cell is where the eye is focused. It features a curved pigmented plate and a colorless biconvex photosensitive lens. Just a small percentage of a colony's cells are fertile. Cells that are reproductive lack flagella. Every cell in the colony may perform a variety of tasks independently.

The multicellular, filamentous fresh water alga is called oedogonium. The n-branched filaments are made up of cylindrical cells, with the exception of the basal cell, which has been transformed into a holdfast. There are no chloroplasts in the basal cell, which serves as a holdfast. The intercalary cell has an apical basal polarity, and the terminal cells of the filaments are often spherical, elongated, or acuminate. The presence of prominent transverse bands at the distal ends of certain cells is a distinguishing property of this alga. Apical cap refers to the band that forms during cell division, while cap cell refers to the cell that has apical cap.

A multicellular, highly developed, and microscopic alga is called Chara. Most Chara are 6 to 10 inches tall and are divided into rhizoids and major axes. Chara's principal axis and banches are divided into nodes and internodes. Each node has a whorl of several branches and is made up of two core cells encircled by peripheral cells. A single elongated cell and elongated narrow cells that make up the cortex make up the internode. Nodes give birth to two different kinds of branches, restricted growth branches and unlimited growth branches. The peripheral cells of the main axis nodes give birth to the branches of restricted development in whorls of 6–20, or on the branches of limitless growth. These branches are also referred to as branchlets, principal laterals, branches of first order, or leaves. The axils of the branches of restricted development are where the branches of unlimited growth emerge; hence, these branches are also known as axillary branches or long laterals. Stipulodes short, oval, pointed single cell outgrowths develop at the base of branches with restricted development. Compared to other algae, Chara has the most sophisticated and intricate reproductive organs. The sexual organs are carried on branches with restricted development (primary laterals). The female sex organ is known as nucule or oogonium, while the male sex organ is known as globule or antheridium. While globule and nucleus development usually often coincides, in certain species globules mature before nuclei. Apical cells in the dome shape of the main axis grow it.

Vaucheria

Vaucheria has a sparsely branching, coenocytic, and siphonaceous type thallus. Long, cylindrical, well-branched filaments make up the thallus. Aseptate, multinucleate (coenocytic) structure describes the filament. Via the use of branching rhizoids, the thallus is joined to the substrate. An exterior cellulosic cell wall and a central vacuole that extends continuously from one end of the thallus to the other are both present in the thallus. The thallus has a siphanaceous structure because the filaments are non-septate and the protoplasm is continuous the whole length of the thallus. Antheridium and oogonium are the names of the male and female sex organs, respectively. Only sex organs experience septa development. The development of the filament is apical; the filament expands in length by the apical growth of all the branches. The cell wall is composed of two layers, the outer layer being pectic and the inner layer being cellulosic.

Polysiphonia

A marine red alga is called Polysiphonia. Polysiphonia has a heterotrichous kind of thallus. The thallus is polysiphonous or multiaxial. The plant body is divided into an upright aerial system and a base prostrate aerial system (heterotrichous). Across the substrate, the prostrate system crawls. With the use of unicellar, elongated rhizoids, the prostrate system aids in attaching the plant to the substrate. Nevertheless, the multiaxial prostrate system is lacking in other species (such as P. elongate and P. violacea). The prostrate system gives birth to the erect aerial system. It is composed of variable-number pericentrd cells (siphons) around the central axial cells (siphons) (multiaxial). Cytoplasmic connections hold cells to one another. The thallus has two different types of branches that are laterally or dichotomously branched. The branches of restricted growth, also referred to as trichoblasts, and the branches of unlimited development, which are composed of central and pericentral siphons. An apical cell, which repeatedly divides to create a row of axial cells, is how the thallus develops. Sometimes a trichoblast's [8] axial region may develop a branch with limitless development, in which case the branch's basal cell acts as the branch initial. Amoeboid, non-motile, or motile unicellular forms are all possible.

A colony is a collection of distinct cells that are gathered in a mucilaginous matrix and are often similar in structure and function. Cytoplasmic linkages keep the individuals in an algal colony from separating into separate sections or segments. The thallus of a filamentous plant might have branches or not. Certain groups of algae include unbranched filaments. Zygnema, Oedogonium, and Spirogyra are a few examples of filaments that may be connected to the substrate, floating freely, or forming colonies (e.g. Nostoc, Oscillatoria). The distinctive characteristic of the Siphonaceous kind of thallus is a multinucleate structure that resembles a tube (coenocytes). A septation (Septa) is absent from a siphonaceous thallus unless while the reproductive organs are developing. The basic structure takes the shape of a tiny, unbranched vesicle. It has a central vacuole and peripheral cytoplasmic chloroplasts and nuclei. The pseudoparenchymatous thallus is a secondary development, and tight cell connection is brought about by filament interweaving. The filamentous habit is modified by the multi-planar cell division seen in parenchymatous thallus structure. The parenchymatus thalli might have a highly developed structure or a tubular, leaf-like, or foliose appearance.

CONCLUSION

The straightforward thalloid plants of the sub-division Algae have been covered in this section. Algae varies in size from tiny, unicellular plants (some plankton have cells as small as 1 micron in diameter) to enormous, highly developed multicellular forms. They are naturally autotrophic, which means they produce their own food. Algae are ubiquitous and may be found in a wide range of environments, including freshwater, seawater, on snow, on rocks, and on or even within the bodies of plants and animals[9], [10]. The algal thallus has several shapes. Their forms might be parenchymatous, filamentous, siphonous, colonial, and unicellular. All groups of algae, with the exception of the Charophyceae and Phaeophyceae, exhibit unicellular forms relatively often. Without cellular differentiation, unicellular forms operate as a single, fully functional entity[11], [12].

REFERENCES

[1] F. P. Mancuso, M. Milazzo, and R. Chemello, "Decreasing in patch-size of Cystoseira forests reduces the diversity of their associated molluscan assemblage in Mediterranean rocky reefs," *Estuar. Coast. Shelf Sci.*, 2021, doi: 10.1016/j.ecss.2020.107163.

[2] G. E. Aroca, M. E. Ramírez, H. Robotham, and M. Avila, "Morphological and reproductive studies on the green filamentous pest Rhizoclonium-like affecting Agarophyton chilensis commercial farms in southern Chile," *Aquat. Bot.*, 2020, doi: 10.1016/j.aquabot.2020.103291.

[3] J. Paredes-Mella and D. Varela, "Genetic population structure of the toxigenic dinoflagellate alexandrium catenella in the patagonian fjords system, southern chile," *Rev. Biol. Mar. Oceanogr.*, 2020, doi: 10.22370/rbmo.2020.55.1.2356.

[4] R. M. Bonaldo and D. R. Bellwood, "Dynamics of parrotfish grazing scars," *Mar. Biol.*, 2009, doi: 10.1007/s00227-009-1129-x.

[5] S. Wornik and M. Grube, "Joint dispersal does not imply maintenance of partnerships in lichen symbioses," *Microb. Ecol.*, 2010, doi: 10.1007/s00248-009-9584-y.

[6] M. O. Paiano, J. M. Huisman, F. P. Cabrera, H. L. Spalding, R. K. Kosaki, and A. R. Sherwood, "Haraldiophyllum hawaiiense sp. Nov. (delesseriaceae, rhodophyta): A new mesophotic genus record for the hawaiian islands," *Algae*. 2020. doi: 10.4490/ALGAE.2020.35.11.5.

[7] Y. Maltsev *et al.*, "A new species of the previously monotypic genus Iningainema (Cyanobacteria, Scytonemataceae) from the Western Ghats, India," *Eur. J. Phycol.*, 2021, doi: 10.1080/09670262.2020.1834147.

[8] S. A. Krueger-Hadfield *et al.*, "Using RAD-seq to develop sex-linked markers in a haplodiplontic alga," *J. Phycol.*, 2021, doi: 10.1111/jpy.13088.

[9] M. Dębowski, M. Zieliński, M. Rokicka, and K. Kupczyk, "The possibility of using macroalgae biomass from natural reservoirs as a substrate in the methane fermentation process," *Int. J. Green Energy*, 2015, doi: 10.1080/15435075.2014.891122.

[10] HELCOM, "Maritime activities in the Baltic Sea," *Doktorarbeit (6 Pap.*, 2018.

[11] L. K. Reynolds, L. A. Carr, and K. E. Boyer, "A non-native amphipod consumes eelgrass inflorescences in San Francisco Bay," *Mar. Ecol. Prog. Ser.*, 2012, doi: 10.3354/meps09569.

[12] L. A. Lewis, "Diversity and phylogenetic placement of Bracteacoccus Tereg (Chlorophyceae, Chlorophyta) based on 18S ribosomal RNA gene sequence data," *J. Phycol.*, 1997, doi: 10.1111/j.0022-3646.1997.00279.x.

CHAPTER 6

ALGAE IMPORTANCE ECOLOGICAL SYSTEM

Roopashree, Assistant Professor,
Department of Chemistry, School of Sciences, Jain (Deemed to be University), Bangalore, India
Email Id- r.roopashree@jainuniversity.ac.in

ABSTRACT:

An enormous and varied class of oxygenic phototrophic organisms is the algae. You learned about the structure, behavior, habitat, and reproduction of algae in earlier chapters. We shall now examine the economic, ecological, and negative repercussions of algae in this chapter. The natural answer to the current energy, food, economic, and climatic crises confronting our planet is found in products manufactured from algae. The majority of algae are eukaryotic, meaning they contain a real nucleus. They are oxygenic phototrophs, which means that sunlight serves as both their primary energy source and the result of their development, oxygen. Algae are often considered to be plant-like creatures, however they differ from plants in that they lack genuine roots, stalks, leaves, and vascular tissue in addition to having basic reproductive mechanisms.

KEYWORDS:

Algae, Carragenin, Environmental, Fertilizers, Pollution.

INTRODUCTION

Algal species have a long history of serving as a direct source of food, medicine, and other necessities for humans. Algae come in roughly 30,000 different species. The world's fastest-growing vegetation are algae. Virtually everywhere on Earth, including fresh water, salt water, rocks, snow, soil, and plants. They range from simple single-celled organisms like chlorella and diatoms to sophisticated multicellular ones like giant kelps, a big brown alga that may be up to 50 meters long. The natural answer to the current energy, food, and climate concerns is found in products derived from algae. Algae have the potential to fuel our cars, recycle CO2, and provide food for both people and animals.

Environmental significance

Due to their role as the foundation of the aquatic food chain, algae are crucial to the ecology of the planet. Marine creatures depend on algae as a major source of food. Most zooplankton are crustaceans that float close to the ocean's surface and feed on phytoplankton, which is often unicellular algae [1]. Larger zooplanktons and tiny fishes feed on the zooplanktons in turn. Little fish are eaten by larger fish. Fish-eating birds, whales, seals, extremely big fish like tuna, sharks, bluefin tuna, and humans might be at the top of the open ocean food chain. Algae are also macroscopic, some of which are enormous, and they provide fish and other aquatic creatures a place to live.

Sewage disposal of algae being an aerobic process, sewage disposal needs oxygen, which is given off by algae. In sewage oxidation ponds or tanks, algae such as Chlorella, Euglena, Chlamydomonas, Scendesmus, and Spirullina are cultivated together with the necessary bacteria (algal-bacterial-systems). They provide extra oxygen needed for aerobic breakdown.

Algae absorb nitrates and phosphates from shallow effluent tanks for their metabolism, which releases oxygen during photosynthesis. It aids the aerobic bacteria in cleaning these wastes by assisting in the breakdown of raw sewage.

Algae's Function in Pollution Control

Since it lowers carbon dioxide levels and raises oxygen levels in the atmosphere, algae's photosynthesis is crucial to the biosphere. Microalgae have the capacity to fix CO2 in the atmosphere, aiding in the mitigation of rising CO2 levels. Algae use photosynthesis to repair around 50% of the planet's total CO2 emissions. Several power facilities utilize algae bioreactors to reduce their CO2 emissions. Pumping CO2 into an algae-feeding shallow pond or tank is one option. Algae need water and carbon dioxide to thrive, and as a byproduct of this process, oxygen is produced.

Algae as a pollution indicator

By examining the makeup and development patterns of the algal flora in a water body, one may determine the degree of pollution in the surrounding environment. There are three zones in a polluted river, according to Kolkwitz and Marsson (1909), and each zone has its own distinctive alga flora.

- **Mesosaprobic Zone:** This zone contains Oscilltoria, Phormidium, Ulothrix, and other types of algae as well as minimal organic waste and little oxygen. Euglena and Oscillatoria barely grow in the polysaprobic zone, which is zone number two. While there is a lot of biological stuff that can be broken down, there is not enough oxygen.
- **Oligosaprobic zone:** Calothrix, Cladophora, Meridian, and Batrachospermum algae flourish in this region when there is little to no decomposing organic matter present and the water is oxygenated to a high level.

Diatoms are very sensitive to pH, and distinct species may be found in bodies of water with various pH levels. Since these types of algae gather and absorb numerous heavy metals from the water, their excessive proliferation in a water body signals contamination from heavy metals. Examples of these algae include Stigeoclonium, Cladophora, and others. Diatoms are the ideal algae to use as indicators of water contamination, according to Patrick. Algal blooms, also known as water blooms, are the result of an excessive development of algae that forms thick floating mats on the water's surface. Blooms only occur in planktonic algae. Algae blooms have a negative impact on aquatic environments. Red tides, which color the surrounding water a deep crimson, are caused by the luxuriant development of some marine algae [2]. Water blooms reduce the amount of oxygen in water reservoirs, which results in the suffocating death of numerous fish. On certain lakes, such as the Sambhar Lake in Rajasthan, anabenopsis blooms on occasion and perhaps permanently.

Financial importance

These are a few of algae's most advantageous qualities:

Algae as Food for Man

From ancient times, humans have consumed huge quantities of green, brown, and red algae as food. They are a good source of vitamins, minerals, proteins, and carbs. Individuals who live in coastal nations like China and Japan eat seaweed and several other types of algae. Seaweed comes in a wide variety and is both nutrient- and vitamin-rich. Seaweeds are widely eaten in many nations, including Thailand, Malaya, China, Japan, Burma, and Indonesia. Porphyra contains 25–30% protein, as well as vitamins B and C and iodine. In England, a meal called porphyra is regarded as being delicious. In Japan, porphyra plants are used to make a soup. In Japan, kombu a specialty made from the stipes of Laminaria, is consumed. In Europe, ulva is known as sea lettuce and is used as food. In Scotland, ulva lactuca was used to make soups and salads. Astronauts and cosmonauts consume chlorella, which has high levels of protein and lipids, as a replacement for sustenance in space. A few Oedogonium and Spirogyra species are used as food in South India. Laminaria is used to make iodine. In Japan, algae are frequently used to adorn sandwiches, pastries, and desserts. Rhodymenia is in high demand as a meal and is also referred to as dillis in Ireland, Dulse in Scotland, and Sol in Iceland.

Using algae as fodder

Algae are a cheap, nutrient-rich, and high-protein food source for animals. In France, Great Britain, and other countries, kelps (brown algae) are cut for sheep and chicks and used as cattle feed. Norway and France both feed cattle with rhodymenia. Algal food may be used as a supplement to the diets of pigs and dairy cows. Sargassum is used as animal feed in China. Cows fed algae had a natural breakdown of unsaturated fatty acids, increasing the amount of these healthy chemicals in their milk and meat. The use of kelp enhanced the poultry's ability to produce milk and eggs. Algae are the foundation of aquatic food chains, which provide the food resources that fish are suited to ingest. Oscillatoria is the blue-green alga most often ingested by 56 species of fish, claims Chacko (1970). Additional options are Spirulina, Anabaena, Microcystis, Lyngbya, and Merismopedia, listed in order of preference. Several varieties of algae are employed in fisheries, aquariums, etc. Algae is also a food source for snails, frog tadpoles, crabs, etc. Many fish larvae naturally consume microalgae as part of their diet. Several aquatic creatures, including certain fish, depend on diatoms as a constant source of food.

Algae as Medicine

For millennia, people have utilized algae as a preventative or curative measure for a wide range of illnesses. According to research, algae are good for human health. Certain algae produce antibiotis. Chlorella is a green alga that produces the antibiotic chlorellin, which prevents certain bacteria from growing. A variety of pathogenic microorganisms are susceptible to chlorellin's effectiveness. Due of its high iodine concentration, the diatom Nitzschia palea is used to make an antibiotic that is effective against [3] Escherichia coli. Since seaweeds contain a high amount of iodine, they are often employed in the production of several goiter medications. The pancreas, gallbladder, kidneys, uterus, thyroid, and kidneys are all benefited by seaweed consumption.

The preparation of kelpeck, which is helpful in the treatment of goiter and other glandular issues, is made from kelps. Agar-Agar, which is used in the production of tablets and ointments, is an effective and significant algal product. Antibacterial compounds produced by some Polysiphonia species are effective against both gram-positive and gram-negative bacteria. Consumers of seaweed are resistant to hay fever. Both Chara and Nitella are used to ward off mosquitoes. The chara plant is helpful in eliminating mosquito larvae. The production of lens paper in Japan makes use of spirogyra.

Algae in Nitrogen Fixation

Blue-green algae species have been shown to be capable of fixing atmospheric nitrogen in the soil. The most prevalent blue green algae that fix nitrogen are the Anabena, Nostoc, Calothrix, Scytonema, Aulosira, Stigonema, Tolypothrix, and Gleotrichia species. Over 60 kinds of blue-green algae have been shown to be capable of fixing nitrogen. The soil becomes fruitful as nitrogen levels rise. In rice fields, blue green algae are employed to fix nitrogen. Blue green rice has been grown in several nations, including Japan, China, the Philippines, Thailand, and India.

Blue-green algae in soil reclamation

Bare alkaline soils may also be restored with blue-green algae. During the rainy season, it has been seen that certain blue-green algae build a thick layer on the surface of the salt soils. The reclamation of the "usar" areas may utilise these algae. Several species of Scytonema, Nostoc, Anabaena, Aulosira, etc. grow profusely during the wet season. They gradually reduce the soil's alkalinity while increasing its nitrogen, phosphorus, and organic content, which eventually turns the area into fruitful land. Algae have a significant function as a binding agent on the soil's surface in the binding of soil particles. The seaweeds have the ability to bond soil. Seaweed concentration is marketed as liquid fertilizer and applied to fields.

Algae as Fertilizers

The majority of coastal nations throughout the globe have utilized algae as fertilizers since ancient times. Potassium chloride (KCl), phosphorous, calcium, several trace minerals, and growth factors are abundant in seaweeds. In rice fields, Oscillatoria, Spirulina, Scytonema, etc. are employed. Chara is used in the fields to remedy a calcium shortage. In Ireland, fucus is often used as manure for growing tuber crops. Scientific research has Sargassum, a brown seaweed with micronutrients plants need, has been successfully converted into a liquid fertilizer. Because of the potassium content, the huge brown and red algae are employed as organic fertilizers. Moreover, green algae improve soil fertility. Algae are employed widely in many different sectors and produce a number of chemical compounds. The four main commercially available algae-derived products are diatomite, agar, carrageenin, and alginates.

Diatomite

Diatomite is a light-colored sedimentary rock that is soft, powdery, extremely porous, and friable. It was created when the amorphous silica remnants of deceased diatoms accumulated in marine deposits. The fossilized remnants are two symmetrical shells, or frustules, that are still in place. Diatomite, sometimes referred to as diatomaceous [4] earth, has several uses. In the distant past, it was used to make dynamite. While making dynamite, Alfred Nobel employed the characteristics of diatomaceous earth as a nitroglycerin absorbent. It is utilized in filters in brewing industries, sugar refineries, etc. because of its excellent absorption capacity and fire resistance. Diatomite changes the glass and shine of paints and functions as an antiblocking agent in polymers. In pipelines and furnaces, it serves as an insulator. Diatomite has been used in several face washes, metal polishes, and toothpaste. It is utilized as an insecticide because of its abrasive and physico-sorptive characteristics. Aliginic acid, potash, soda, and iodine are all abundant in kelps. Japan uses kelps to manufacture roughly 100 tons of iodine annually. Alum, soap, glassware, etc. are all made from potash and soda from seaweeds. A form of glue known as "Funori" is produced in Japan using the red alga Gleopeltis furcata. It is used to size paper and fabric. In addition, it serves as an adhesive.

Agar-agar

Made from many kinds of red algae, agar-agar is a dried, non-nitrogenous, jelly-like material. The majority of agar is produced in Japan, which also sells it to other nations. Since it offers a suitable temperature range for culturing, agar-agar is employed as a culture medium in labs to cultivate microorganisms. It has a melting point that ranges from 90 to 1000 F. Lower temperatures cause it to solidify. While making ice cream, jellies, desserts, melted milk, sweets, pastries, sauces, soups, etc., agar is used as a thickening agent. Moreover, it is utilized to create leather, silk, and prosthetic leg molds. Film for cameras is lubricated with agar. Agar is a laxative that is used in medicine.

Alginates

Alginates, also known as alginic acid, was extracted from Laminaria and found in seaweeds. Alginates are the alginic acid salts found in Phaeophyceae cell walls. While it is hard when dry and insoluble in water, it can absorb 200–300 times its weight in water. They are often removed from the major walls and middle lamella of brown and red algae. Alginates are used to make non-flammable wrapping film, flame-resistant textiles, water-proof concrete, surgical dressings, ice creams, etc. For sizing materials for water-resistant goods, colors, etc., sodium alginate is employed.

Carragenin

Carragenin is often isolated from the cell walls of red algae, such as Gigartina and Chondrus crispus. It is a polysaccharide that has been sulphate esterified. Algae are boiled in a mixture of 100 parts water to extract carrageenin. Carragenin is combined with active charcoal after it dissolves in water and is then filtered. Carrageenin was ultimately obtained in the gel. In the pharmaceutical sector, it functions as an emulsifier. Cough remedies may also be made using carryagenin. It is used in the brewing, leather, and textile industries as well as the stabilizing and gelling of food.

Using algae as fertilizer from ancient times, blue-green algae have been used as biofertilizers. A product that includes microorganisms that restore the soil's natural nutrient cycle and increase soil organic matter is referred to as a bio-fertilizer. Blue-green algae, or Cynophyaceae, serve as bio-fertilizers. Minerals including sulfur, calcium, potassium, zinc, magnesium, copper, iodine, boron, lead, nickel, antimony, arsenic, manganese, cobalt, and molybdenum may all be accumulated by them. Because of the potassium chloride they contain, seaweed is often utilized as fertilizer. Potassium is abundant in the bigger brown algae and red algae. Moreover, they serve as organic fertilizers. As liquid fertilizers, concentrated sea weed extract is offered for sale.

Algae as a biofuel source: Algae fuel or alga biofuel could serve as a substitute for fossil fuel. A new energy source is biofuels made from algae. Algae are used as a source of organic oils in algal biofuels. Oils from the crop may be recovered and converted into biodiesel, gasoline, diesel, and even jet fuels. Biofuels made from algae are non-toxic, biodegradable, and sulfate-free. It could reduce CO2 emissions. Other avenues for [5] utilizing algae to produce gasoline, diesel, and other fuels are being investigated by scientists.

Algae's negative effects: Algae has numerous beneficial purposes, however certain varieties may also cause a variety of issues. A few of algae's negative impacts include:

- Poisonous blue-green algae have been identified, including Anabaena and Microcyctis. They suffocate fish and other aquatic creatures to death. Those who drink this tainted water have had negative consequences including weakness, weight loss, and miscarriage, among others.
- Shellfish poisoning that causes paralysis: Dinoflagellates release a toxin called saxitoxin that is harmful to many marine animals and invertebrates as well as people who consume shellfish that carry the toxin. Paralytic shellfish poisoning (PSP) and neurotoxic shellfish poisoning have both been linked to dinoflagellate consumption (NSP).
- Ship fouling: Large marine algae that are growing luxuriantly may cause boats and ships to move more slowly. Ships can't sail smoothly when sargassum is present. Algae corroded the submerged metallic ship components.
- Photosynthesis blockage: Epiphytic algae that live on plants and trees may hinder photosynthesis and harm plants. Tea rusts crimson as a result of Cephaleuros virescens, a parasite that develops on tea leaves. For Assam and Darjeeling tea, the economic loss is significant.
- Water supply contamination: Plankton algae in ponds and reservoirs grow too much, making them unsuitable for use as water sources. Many types of blue-green and green algae grow in excess, clogging water tanks, pipes, and other structures, lowering water quality and rendering it tasteless, smelly, and unsafe for drinking [6], [7].

CONCLUSION

On our planet, algae play a vital role in many ecosystems. From an economic and ecological perspective, they are crucial. [8] Algae are incredibly important economically since they provide animal's food, medication, and fodder. In addition to their biological functions as oxygen makers and the primary source of food for aquatic creatures, algae also have a wide range of economic and industrial applications. Making biofuels is a further possible use. Algae are signs of a contaminated ecology.

Apart from their numerous benefits, certain varieties of algae may also be hazardous in various ways. Poisonous algae like Anabaena, Microcyctis, and others may flourish in the water[9], [10].

REFERENCES

[1] Z. Li and R. Bock, "Replication of bacterial plasmids in the nucleus of the red alga Porphyridium purpureum," *Nat. Commun.*, 2018, doi: 10.1038/s41467-018-05651-1.

[2] Y. Gao and G. Lin, "Algal diversity and their importance in ecological processes in typical mangrove ecosystems," *Biodivers. Sci.*, 2018, doi: 10.17520/BIODS.2018080.

[3] S. D'Adamo, R. Kormelink, D. Martens, M. J. Barbosa, and R. H. Wijffels, "Prospects for viruses infecting eukaryotic microalgae in biotechnology," *Biotechnology Advances*. 2022. doi: 10.1016/j.biotechadv.2021.107790.

[4] D. M. Goodstein *et al.*, "Phytozome: A comparative platform for green plant genomics," *Nucleic Acids Res.*, 2012, doi: 10.1093/nar/gkr944.

[5] C. G. Jäger, J. Hagemann, and D. Borchardt, "Can nutrient pathways and biotic interactions control eutrophication in riverine ecosystems? Evidence from a model driven mesocosm experiment," *Water Res.*, 2017, doi: 10.1016/j.watres.2017.02.062.

[6] C. A. M. M. Cordeiro, A. R. Harborne, and C. E. L. Ferreira, "The Biophysical Controls of Macroalgal Growth on Subtropical Reefs," *Front. Mar. Sci.*, 2020, doi: 10.3389/fmars.2020.00488.

[7] F. Zhang *et al.*, "Uranium isotope evidence for extensive shallow water anoxia in the early Tonian oceans," *Earth Planet. Sci. Lett.*, 2022, doi: 10.1016/j.epsl.2022.117437.

[8] E. Tarakhovskaya, V. Lemesheva, T. Bilova, and C. Birkemeyer, "Early embryogenesis of brown alga fucus vesiculosus L. is characterized by significant changes in carbon and energy metabolism," *Molecules*, 2017, doi: 10.3390/molecules22091509.

[9] X. Mao, X. Wei, D. Yuan, Y. Jin, and X. Jin, "An ecological-network-analysis based perspective on the biological control of algal blooms in Ulansuhai Lake, China," *Ecol. Modell.*, 2018, doi: 10.1016/j.ecolmodel.2018.07.020.

[10] K. Pfeifer, İ. Ergal, M. Koller, M. Basen, B. Schuster, and S. K. M. R. Rittmann, "Archaea Biotechnology," *Biotechnology Advances*. 2021. doi: 10.1016/j. biotechadv.2020.107668.

CHAPTER 7

OCCURRENCE, STRUCTURE OF THALLUS AND MODE OF REPRODUCTION IN CYANOPHYTA AND BACILLARIOPHYTA

Swarupa.V, Assistant Professor,
Department of Chemistry, School of Sciences, Jain (Deemed to be University), Bangalore, India
Email Id- v.swarupa@jainuniversity.ac.in

ABSTRACT:

These individuals exhibit typical prokaryotic characteristics. The nuclear membrane and nucleolus are absent from the primordial form of nucleus. All of the individuals in this category lack flagella. Another term for blue-green algae is cyanobacteria. Blue green algae and bacteria have a lot of similarities. The majority of the individuals in this division live in freshwater habitats. A few species have habitats in the sea. In terrestrial settings, several species, like Nostoc and Oscillatoria, may flourish. Some of the members are developing as endophytes within the Cycas roots, Azolla leaves, and Anthoceros thalli.

KEYWORDS:

Bacillariophyta, Blue Green Algae, Cyanophyta, Reproduction, Thallus**.**

INTRODUCTION

While most algae are green because of the presence of chlorophyll, others are blue green. The group Cyanophyta contains these blue algae. The Cyanophyta (Myxophyta) division's constituents are often referred to as blue-green algae. This division has 1500 species spread over 160 genera. There are 833 species and 98 genera total in India. The main pigment in these algae is c-Phycocyanin. Figure 1, shows the Pictorial representation of (Golden Algae). They also contain c-phycoerythrin, -carotene, and chlorophyll an in addition to c-phycocyanin [1].

Figure 1: Illustarte the Pictorial representation of Bacillariophyta, (Golden Algae).

A subgroup of tiny algae called Bacillariophyta stands apart from other groups of algae thanks to a few distinctive characteristics. Beautiful golden-brown algae may be seen here. There are about 10,000 species of algae in this category, which is divided into 200 genera. They are often referred to as diatoms. These creatures are among the most exquisite microscopic things because to their sophisticated cell wall sculpture and fine mathematical expressions. They may be found as free-living, photosynthetic autotrophs or photosynthetic symbionts in practically every aquatic ecosystem. Diatoms make up a significant component of the soil flora in terrestrial settings as well. They flourish with blue-green algae on tree leaves in tropical rain forests. The group is represented in India by 569 species, which are dispersed throughout 92 genera.

Cyanophyta

- The following are some of the key characteristics of blue-green algae.
- Another name for the division is myxophyta.
- This division's constituents are often referred to as blue-green algae.
- Chlorophyll a, c-phycocyanin, and c-phyoerythrin are the main pigments in this category. They seem blue green as a result of these pigments.
- Thylakoids, a kind of lamella, have pigments buried inside them.

The thallus is extremely well organized. Chroococcus, Gloeocapsa, Oscillatoria, and Scytonema are examples of unicellular, colonial, trichome-chained, or unbranched filamentous forms (e.g. Nostoc, Anabaena).

- As with bacterial cell walls, mucopeptides make up cell walls.
- Prokaryotic cells have a prokaryotic structure. Organelles that are membrane-bound are absent, and the nucleus is of an immature, underdeveloped kind.
- All of the cellular organelles, including the chloroplast, mitochondria, and endoplasmic reticulum, are missing.
- Also lacking are flagella.
- Some individuals in this group move in a gliding or jerky manner (Oscillatoria).
- Cyanophycean starch is a food reserve.
- A unique form of cell known as a heterocyst is seen in certain members of this division.

Heterocysts are somewhat larger vegetative cells that are present in Nostocales (apart from Oscillatoriaceae) and Stigonematales members. They might be intercalary or terminal. Heterocysts are thought to be responsible for nitrogen fixation in blue-green algae. Vegetative and asexual reproduction are the only methods of reproduction.

Occurrence

There are 76 species of this freshwater blue-green alga. Often found in ponds, pools, ditches, streams, and contaminated fresh water. It may also be found in moist soils and rocks. They create blue scums at the pond's bottom or on the water's top. O. princeps may grow in subaerial environments including seawater. O. terebriformis lives in hot water springs, but O. brevis can withstand temperatures of -160C. Several species live on their own and are found in animals' gastrointestinal and respiratory systems.

Form of the thallus

It is a filamentous alga that is unbranched, long, flat, and resembles a long, flat thread. Trichomes, another name for filaments. Each trichome consists of many cells that are organized unisonically. Filaments are seldom seen alone and may either be connected or free-floating. Most species either create dense, tangled masses or spongy sheets. The threads may be placed in parallel rows or woven together. The anterior end of the trichome is somewhat different, often smooth, but sometimes constricted at the cross walls. The prokaryotic arrangement of the cells is evident, and they are wider than long in length [2]. The apical cell of certain species has a thicker membrane called the calyptra.

The trichomes' cells are all identical in structure. Cyanophycean starch, lipid, globules, and cyanophycin are the reserve food components. Oscillatroia species that are planktonic have membrane-free gas vacuoles or pseudovacuoles. It is composed of many "hexagonal" objects referred to as "gas vesicles". The development of oscillatoria occurs intercalarily. The trichome's cells may divide indefinitely. Plasmodesmata link the two neighboring cells together.

Due to the unusual [3], [4] movement shown by the trichome, this alga was given the name Oscillatoria (oscillare, to swing). It's known as "oscillatory movement." They are the apical area of the trichome's jerky, pendulum-like motions. There are two motions that are often observed: oscillatory movement and gliding or creeping movement. The mucilaginous coating allows for gliding movement without changing the organism's form. The longitudinal axis is always the direction of this movement. Trichomes travel to the left and right of the axis during oscillation. Reproduction only occurs via vegetative means. The next two vegetative reproduction methods are:

- By fragmentation
- Hormogonia
- By splintering

Due to damage, the trichomes fracture during fragmentation. This injury might be the result of an insect bite or another kind of mechanical damage. Each of these pieces has the capacity to grow into a new thallus.

Hormogonia

Hormogonia, also known as hormogones, are small trichome segments with few cells. They result from the development of separating discs. These discs have a biconcave form, are mucilaginous, and resemble pads. They are created when one or more filament cell die. The term "necridia" also refers to these mucilage-filled dead cells. These hormogonia may travel and transform into new trichomes by recurrent cell division.

Nostoc/Occurrence

Both freshwater and terrestrial ecosystems are home to Nostoc. Freshwater animals build microscopic colonies on the water's surface that may range in size from a few millimeters to a few centimeters. A shared membrane defines the exterior boundaries of each colony. Several species in this genus, such N. commune, may be found in the terrestrial environment of the Alpine area. Several species in this genus are symbiotically associated with other plants, or endophytic, as is the case with N. punctiforme, which is found in the coralloid roots of Cycas. In addition to Cycas, this has also been seen in several bryophyte [5] (Anthoceros) thallus cavities. Since they can fix atmospheric nitrogen, several Nostoc species aid in boosting the soil fertility in rice fields. This genus has numerous significant species that have been found in India, including N. calcicola, N. endophyllum, N. ellipsoporum, N. muscorum, and N. punctiforme.

Form of the thallus

The nostoc thallus is filamentous or trichome-like and uniseriate. There is a gelatinous mucilaginous coating that encircles each trichome. The gelatinous envelopes of several trichomes often collect and disintegrate to produce colonies of varied sizes and forms. Sometimes it resembles a Nostoc ball, which is a ball made of many filaments. The heterocyst, a specialized cell, is this alga's key characteristic. These heterocysts are vegetative cells that have grown a little larger. They might be intercalary or terminal. The terminal heterocysts only have one (basal) polar nodule, but the intercallary heterocysts have two. Mucopolymeric material makes up the cell wall. In this genus, only vegetative reproduction has been documented. There is no sexual reproduction whatsoever. The following techniques are used for vegetative propagation.

- By splintering
- Hormogonia .
- akinetes
- By heterocysts
- By endospores,
- By splintering

In this species, this is one of the typical means of vegetative reproduction. The colony may sometimes disintegrate into little pieces owing to mechanical, physiological, or other causes. Each fragment that results from fragmentation has the capacity to grow into a new colony.

Hormogonia

The intercalary vegetative cells' degeneration or the presence of intercalary heterocysts lead the Nostoc filaments to split into little pieces. Hormogonia are the multicellular cell formations that form as a result of cell splitting. Hormogonia often emerge from the colony's gelatinous bulk, expand quickly, and establish new colonies.

Akinetes

Akinetes grow in challenging circumstances. In unfavorable circumstances, some trichome cells change into akinetes, which are resting spores with strong walls. When circumstances are good, these akinetes form new colonies. When circumstances are favorable, the protoplasm becomes active, rupturing the thick outer wall to create a new trichome or filament.

By heterocysts

In certain Nostoc species, heterocysts also take part in vegetative reproduction (e.g. N. commune). A new trichome is formed when the heterocyst's protoplasm becomes active and germinates. The heterocyst's thick wall ruptures, giving way to the growth of new filaments or trichomes.

By endospore

In certain Nostoc species, the heterocyst's protoplasm splits repeatedly to produce endospores (e.g. N. commune, N. microscopicum). The walls of enospores are thin. They are released when the heterocyst wall disintegrates, and the spherical spores eventually develop into new trichomes.

Account General of Bacillariophyta

There are about 10,000 species of algae in this category, which is divided into 200 genera. The organisms are collectively referred to as diatoms and consist of both colonial and unicellular types. The group is represented in India by 569 species, which are dispersed throughout 92 genera. Some common diatom species found in India are [6]Pinnularia graciloides, Niedium gracile, Cymbella affinis, Eunotia pectinalis, and Cosinodiscus radiatus. Diatoms are different from other algae in that their cell walls are beautifully sculptured and symmetrically decorated. These organisms are among the most exquisite tiny items due to their distinctive property. The following are some distinctive qualities of diatoms that set them apart from other types of algae: - a. Diploic cells make up vegetative cells.

- The coexistence of chlorophylls a and c.
- The cell wall is silicified, and it is made up of two overlapping, heavily perforated portions.
- The food item that is being preserved is oil and chrysolaminarin, not starch.

Some crucial characteristics of the division Bacillariophyta include the following:

- Diatoms are found all over the world. They make up a significant portion of planktonic vegetation. They live mostly in freshwater environments.
- Several species develop epiphytically on Cladophora and Oedogonium, among other freshwater algae.
- Benthic diatoms may be endozoic (like Licmophora), epiphytic (found on rocks, sand, or mud), or both.
- Diatoms make up a significant percentage of the soil flora and may also be found in terrestrial settings. They flourish with blue-green algae on tree leaves in tropical rain forests.
- While most diatom species are unicellular, some produce filaments, slack chains, or mucilagenous colonies.
- Pinnate diatoms (Pennales) and centric diatoms are the two orders into which unicellular diatoms are subdivided (Centrales).
- The cell exhibits radial or isobilateral symmetry, such as in the case of Cyclotella or Pinnularia.
- Like certain species of Melosira, colonial diatoms are arranged into uniseriate filaments.
- The cell wall is silicified; it displays traits of secondary structures known as frustules.
- The presence of raphe distinguishes movable diatoms.
- The diatoms' cell wall (frustule) is made up of two overlapping sections. The bigger top half is known as the epitheca, while the smaller lower part is known as the hypotheca.

The cells have different shapes and are tiny. [7] They may have a variety of shapes, including triangles (like Triceratium), boats (like Gyrosigma and Cymbella), rods (like Bacillaria), ovals (like Cocconeis placenula), and spheres (e.g., Coscinodiscus excentricus). Golden brown algae, or Bacillariophyta, are a frequent name for them. They include distinctive pigments, such as carotenoids, fucoxanthin, diatomin, in addition to chlorophyll-a and chlorophyll-c, that give them a golden brown appearance.

- The food item that is being kept is oil and chrysolaminarin, not starch.
- Cell division and auxospore creation are used in reproduction.
- Antherozoids, or mobile cells, feature a single pantonematic flagellum.
- There are gliding motions in the cell.
- A unique sort of spore known as an auxospore emerges from the zygote created as a consequence of gametic union.
- The diatom's life cycle is mostly diploid and lacks a well-defined alternation of generation.

Unbranched filamentous blue-green alga called oscillatoria. In addition to wet soils and rocks, it is often found in fresh and dirty water in ponds, pools, sewers, and streams. Due to the strange rhythmic movement shown by the trichome, this alga receives the name Oscillatoria. By means of fragmentation and hormogonia, [8] reproduction occurs. Another significant member of the Cyanophyta division is Nostoc.

Nostoc has a filament-like, uniseriate thallus. The gelatinous envelopes of several trichomes often collect and disintegrate to produce colonies of varied sizes and forms. Sometimes it resembles a Nostoc ball, which is a ball made up of several filaments. The heterocyst, a specialized cell, is this alga's key distinguishing characteristic. Heterocysts are thought to be a location where blue green algae fix nitrogen. In this genus, only vegetative reproduction has been documented.

We also discovered that the diatoms, which are a unified collection of unicellular and colonial forms, are members of the Bacillariophyta (golden brown algae). They include distinctive pigments, such as carotenoids, fucoxanthin, diatomin, in addition to chlorophyll-and chlorophyll-c, that give them a golden brown appearance. Diatoms are different from other algae in that their cell walls are beautifully sculptured and symmetrically decorated. Because of their silicified cell wall, which is made up of two highly perforated overlapping portions, existence of chlorophyll-and -c, and storage food material of oil and chrysolaminarin, diatoms are completely [9], [10]distinct from other divisions of algae. Cell division and auxospore creation are the means of reproduction.

CONCLUSION

We have covered the distinctive qualities of the divisions Cyanophyta and Bacillariophyta in this unit. The division Cyanophyta's members are often referred to as blue-green algae. Chlorophyll a, c-phycocyanin, and c-phyoerythrin are the main pigments in this group. They seem blue green as a result of these pigments. Thylakoids include pigments incorporated inside them. They are filamentous or unbranched trichome-like unicellular colonial chains of cells. Mucopeptides make up the cell wall. It has a prokaryotic cell structure. All of the cell organelles, including the mitochondria, endoplasmic reticulum, and chloroplast, are missing. There are no flagella at all. Some individuals in this group move in a gliding or jerky manner. The starch found in cyanobacteria is a reserve food. There are terminal or intercalary heterocysts in certain members[11]. Members of the Nostocales and Stigonematales families, with the exception of Oscillatoriaceae, include these heterocysts. Heterocysts are thought to help blue green algae fix nitrogen. The process of reproduction is asexual and vegetative. [12] There is no sexual reproduction whatsoever.

REFERENCES

[1] A. K. Kamble and J. T. Pandkar, "Enlisting Aero-algal Flora and Algal Allergens Using Fan Dust Sampling Method from Pune, Maharashtra," *Biosci. Biotechnol. Res. Asia*, 2021, doi: 10.13005/bbra/2958.

[2] A. R. Mirzajani, O. Heidari, and H. Khodaparast Sharifi, "Some biological aspects of Gammarus lacustris Sars, 1863 in Neur Lake Ardabeel province, Iran," *Iran. J. Fish. Sci.*, 2011.

[3] W. J. Woelkerling, "The marine benthic flora of southern Australia. Rhodophyta – Part IIID. Ceramiales – Delesseriaceae, Sarcomeniaceae, Rhodomelaceae.," *Phycologia*, 2003, doi: 10.2216/i0031-8884-42-4-448.1.

[4] G. A. Kopprio *et al.*, "Vulnerability of pejerrey Odontesthes bonariensis populations to climate change in pampean lakes of Argentina," *J. Fish Biol.*, 2010, doi: 10.1111/j.1095-8649.2010.02750.x.

[5] W. Wei, H. Zhuang, Y. Zhang, and L. Wang, "Crustacean zooplankton community in relation to physicochemical factors and phytoplankton of 13 waterbodies located in the Yangtze River delta," *Ann. Limnol.*, 2019, doi: 10.1051/limn/2019016.

[6] D. Xu *et al.*, "Acclimation of phytoplankton to diverse environmental variables at the initial operation stage of a free water surface constructed wetland," *J. Clean. Prod.*, 2021, doi: 10.1016/j.jclepro.2021.128442.

[7] A. E. DeBiase, R. W. Sanders, and K. G. Porter, "Relative nutritional value of ciliate protozoa and algae as food for Daphnia," *Microb. Ecol.*, 1990, doi: 10.1007/BF02012100.

[8] J. L. Pereira and L. H. Z. Branco, "Macroalgas em nascentes e arredores de riachos na região noroeste do estado de São Paulo," *Hoehnea*, 2010, doi: 10.1590/s2236-89062010000300002.

[9] F. Drouet, H. J. Humm, and S. R. Wicks, "Introduction and Guide to the Marine Bluegreen Algae.," *Bull. Torrey Bot. Club*, 1982, doi: 10.2307/2996264.

[10] K. J. Lukas and S. Golubic, "New Endolithic Cyanophytes From The North Atlantic Ocean: I. Cyanosaccus Piriformis Gen. Et Sp. Nov.," *J. Phycol.*, 1981, doi: 10.1111/j.0022-3646.1981.00224.x.

[11] M. M. Littler and S. N. Murray, "Influence of Domestic Wastes on Energetic Pathways in Rocky Intertidal Communities," *J. Appl. Ecol.*, 1978, doi: 10.2307/2402612.

[12] K. J. Lukas and S. Golubic, "New Endolithic Cyanophytes From The North Atlantic Ocean: I. Cyanosaccus Piriformis Gen. Et Sp. NOV. 1 ," *J. Phycol.*, 1981, doi: 10.1111/j.1529-8817.1981.tb00843.x.

CHAPTER 8

OCCURRENCE, STRUCTURE OF THALLUS AND MODE OF REPRODUCTION IN CHLOROPHYTA AND XANTHOPHYTA

Malathi.H, Assistant Professor,
Department of Life Science, School of Sciences, Jain (Deemed to be University), Bangalore, India
Email Id- h.malathi@jainuniversity.ac.in

ABSTRACT:

In this chapter, we'll talk about how several significant genera in the Chlorophyta and Xanthophyta division organize their thalluses and how they reproduce. The class Chlorophyta is sometimes referred to as green algae. This huge category of algae is made up of roughly 429 genera and 6500 different species. Most Chlorophyta members are fresh water algae. Common locations for freshwater species include ponds, pools, lakes, ditches, water storage tanks, rivers, and canals. This section includes certain marine organisms that may be found in the sea. Several species in this group may be found in both freshwater and saltwater habitats.

KEYWORDS:

Algae, Chlorophyta, Reproduction, Thallus, Xanthophyta.

INTRODUCTION

Numerous members are naturally epiphytic. Epizoic algae include many Cladophora and Characium species. Certain green algae, like Trebouxia and Chlorella, collaborate symbiotically with creatures like Zoochlorella and Hydra. Certain types of green algae work in symbiosis with fungus to create lichens. In the leaves of tea, coffee, piper, and magnolia plants, cephaleuros is a parasitic alga. Tea rusts crimson because to cephaleuros. Green snow is produced by Clamydomanas yellowstonensis, whereas red snow is produced by Chlamydomonas nivalis. Thermophilic Chlamydomonas species exist [1].

Another division, Xanthophyta, has individuals that are often yellow-green in color. 75 genera and 375 species make up this category. They are mostly freshwater algae. The thallus structure displays morphological variety. The majority of this division's members are Siphoneous, filamentous, motile, and coccoid forms. The coenocytic siphoneous forms are members of the order Heterosiphonales, commonly known as Vaucheriales.

CHLOROPHYTA

Key Chlorophyta characteristics

- The separation Green algae is a frequent name for the group Chlorophyta.
- The mitochondria, Golgi bodies, plastids, endoplasmic reticulum, and ribosomes are all components of the eukaryotic cells.
- The cell wall is composed of two layers, the inner layer of which is mostly composed of cellulose, and the outer layer of which is composed of pectic materials.
- The chloroplasts are well-organized, and the principal pigments are chlorophyll a and b, with carotenes and xanthophylls serving as the other pigments.

- The chloroplast's shape may change. It might have a cup form, like Chlamydomonas, a girdle shape, like Ulothrix, a reticulate shape, like Cladophora, a stellate shape, like Zygnema, or a spiral shape, like Spiraea. Spirogyra, discoid, for instance, Chara.
- The reserve food is starch, and pyrenoids are involved in its synthesis.
- The gametes and zoospores, which are mobile reproductive structures, contain two or four flagella that are apical or subapical, equal in size, and of the acronematic (whiplash) type.
- There are three types of sexual reproduction: isogamous, anisogamous, and oogamous.

Chlamydomonas/Occurrence

Chlamydomonas is a vast genus that may be found practically everywhere. 400 different species are found. This is a straightforward, one-celled, and mobile freshwater alga. Mostly found in fresh water that is enriched in organic materials and nitrogen salts. Moreover, it may be found in slow-moving water that is stagnant in ditches, water tanks, sewage tanks, and ponds. A planktonic alga called Chlamydomonas causes the water's surface to look green. Terrestrial Chlamydomonas species may be found in rice fields, on the sides of rivers and lakes, and on damp soil surfaces. On dirt surfaces, palmella sages of the genus produce scum. Some species may be found in brackish, salty water. Chlamydomonas may also be found as cryophytes, or organisms that grow on snow. For example, C. nivalis turns snow red by producing the pigment haematochrome, while C. yellowstonenris turns snow green by producing chlorophyll. Only Tribonema, Botrydium, and Vaucheria have been found to exhibit sexual reproduction, which is less common and only occurs when isogamous or anisogamous gametes are united. Vaucheria also exhibits a very distinctive oogamy as shown in Figure 1, in which male and female reproductive structures emerge close to the tip of vegetative filaments on monoecious or dioecious thalli.

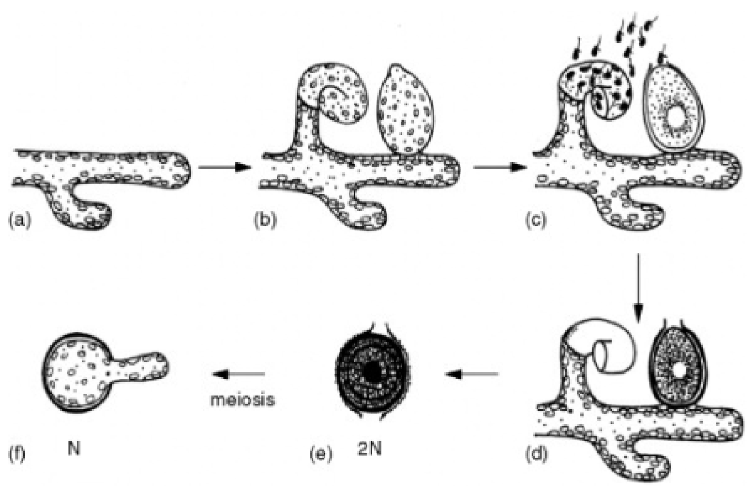

Figure 1: Illustrate the Sexual reproduction (oogamy) of monoecious Vaucheria species.

Form of the thallus

Green algae called Chlamydomonas are motile and unicellular. One cell serves as a metaphor for the thallus. The cell is round, elliptical, or pear-shaped, biflagellate (with two flagella) and is approximately 30 m in length and 20 m in diameter. The common pyriform or pear-shaped thalli have a large rear end and a small anterior end. Certain Chlamydomonas species have a pointed posterior end (e.g. Chlamydomonas caudata) [2]. Around the bases of the flagella, two contractile vacuoles rarely more are located, and each cell has a noticeable chloroplast with a cup-like form. The primary structural element of the cell wall is cellulose. In certain species, a gelatinous coating encircles the cellulose wall. Several species of Chlamydomonas additionally include the following forms of chloroplast in addition to cup-shaped chloroplast:

Protein-rich structures called pyrenoids are found in chloroplasts. In pyrenoids, starch production and storage are important processes. The thallus has a single, sizable, black nucleus that is located within the cup-shaped chloroplast's cavity. The anterior end of the cell is where the flagella are located. Flagella are of the whiplash or acronematic type and are equal in length. Nevertheless, in certain species, the flagella may be shorter or on par with the thallus. The flagella are often longer than the thallus. Each flagellum emerges from a basal granule or blepharoplast and exits the cell wall via a tiny canal. The base of the flagella has two contractile vacuoles. Excretion or osmoregulation are these vacuoles' primary tasks. a pigmented area known as an eye-spot or stigma that is situated in the cell's anterior region. Many species have various variations in the eye spot's size and location. The eye spot features a curved pigmented plate and a colorless biconvex photosensitive lens. It serves as a basic eye and is a photoreceptive organ.

The following spore types are used in asexual reproduction:

The generation of zoospores is a characteristic of Chlamydomonas. These zoospores grow under favorable circumstances. The protoplast contracts and separates from the cell wall during zoospore development. Loss of flagella in the parental cell. The neuromotor appearatus and the contractile vacuoles vanish. Two daughter protoplasts are formed when the protoplasm splits longitudinally by simple mitotic division. Four daughter chloroplasts are produced when the second longitudinal division of protoplasm occurs at a [3] straight angle to the first. Each daughter cell grows a flagellum, a cell wall, and a zoospore. By gelatinizing or rupturing the parent cell wall, the zoospores are released from the parent cell or zoosporangium. The zoospores are smaller than the parent cell but structurally similar to it. Just becoming larger, the zoospores develop into adult Chlamydomonas.

Aplanospores develop under unfavorable circumstances. When circumstances are not favorable, the parent cell loses its flagella. Daughter protoplasts are created when the protoplast splits. The protoplast does not produce flagella but rounds off and secretes a thin wall outside. These immobile objects are known as aplanospores. Aplanospores may germinate directly or by dividing to create zoospores under favorable circumstances. Such as C. nivalis.

The palmella stage also developed when there was a lack of water, an excess of salts, etc. The parent cell's protoplast splits to produce several daughter protoplasts, but they do not develop into zoospores.

To create a mucilaginous sheath surrounding the daughter protoplasts, the parent cell wall gelatinizes. Without growing flagella, the daughter protoplasts likewise surround themselves with a gelatinous wall. Palmellospores are the name given to these protoplast segments. The palmella stage, which results from the division and redivision of the protoplast, is an amorphous colony with an illimitable number of spores. The gelatinous wall disintegrates, palmella spores grow flagella, and these spores are discharged to form new thalli when favorable circumstances prevail once again. This phase is non-motile and transitory.

1. **Sexual activity**

Chlamydomonas reproduces sexually using the following techniques:

A. Isogamous
B. Anisogamous
C. Oogamous

A. Isogamy

The majority of Chlamydomonas species have an isogamous sexual behavior. Gametes that are identical in size, shape, and structure fuse during isogamous reproduction. These gametes have a similar morphology, yet they differ physiologically. The two gametes approach one another at their anterior ends before fusing together laterally. The fusion result has two pyrenoids, two eye spots, and a quadriflagellate and binucleate structure. The zygote of the quadriflagellate stays mobile for few hours to a few days. In the end, the two nuclei combine to create a zygote.

B. Anisogamy

The fusing gametes in angiogamous reproduction are of different sizes. Male gametes, also known as microgametes, are smaller than female gametes, known as macrogametes, which are bigger. The female gametangium, where only 2 to 4 gametes are produced when the protoplast splits, is where the macrogametes are created. In the male gametangium, where the protoplast splits to create 8–16 gametes, the microgametes are produced. Compared to macrogametes, microgametes are more active. The microgametes approach the macrogametes, the microgamete protoplast penetrates the macrogamete, and after fusion, a diploid zygote is produced.

C. Oogamy

In a few species of this genus, such as C. coccifera and C. ooganum, sexual reproduction is oogamous. The vegetative thallus, which is a female cell, retracts its flagella and starts acting like a macrogamete or an egg that is incapable of moving. There are several pyrenoids in the female gamete. As in the case of anisogamous reproduction, the protoplast is divided into four divisions to create the microgametes. The microgamete reaches the female gamete, fuses with it via its anterior ends, and creates a diploid zygote.

Zygote and its growth

It is a diploid spore, the zygote. The zygote endures prolonged unfavorable circumstances before germinating when favorable conditions arrive. By using reduction division, the zygote creates four daughter protoplasts. Each protoplast develops into a mature thallus by becoming a biflagellate zoospore.

Occurrence

Green colonial algae that floats freely in fresh water is called Volvox. It contains around 20 species and forms planktons on the surface of temporary and permanent ponds, water tanks, and other bodies of water. The surface of water bodies becomes green during the rainy season as a result of its rapid development. The Volvox colonies are visible as rolling green balls on the water's surface. V. globator, V. aureus, V. prolificus, V. africanus, and V. rousselettii are a few significant species in India.

A motile colonial alga with a distinct form and number of cells is the coenobium and makes up the thallus of Volvox. The colonies have 500–60,000 cells apiece and are spherical or oval in form. At the edge of the gelatinous colonial envelop, the biflagellate cells are organized in a single layer. The movement is caused by the coordinated activity of individual cell flagella. Cytoplasmic threads link each of the cells to the [4] others. The eye spots on the cells at the anterior end are larger than those on the cells at the posterior end. When the cells are mature, they participate in reproduction.

Chlamydomonas-like cells resemble those of the Volvox colony. Typically pyriform with a small anterior end and a large posterior end, colony cells are spherical. Each cell has two flagella that are of equal size and whiplash type. The cell's plasma membrane encloses the protoplasm. Each cell has a single nucleus, two contractile vacuoles, pyrenoids, an eye spot, a cup-shaped chloroplast, and other components. The exterior face of the cell is where the eye is focused. It features a curved pigmented plate and a colorless biconvex photosensitive lens. Just a small percentage of a colony's cells are fertile. Cells that are reproductive lack flagella. Each colony cell is autonomous for a variety of tasks.

The cells in the colony's back participate in reproduction in Volvox. Larger size, conspicuous nuclei, thick granular cytoplasm, more pyrenoids, and the lack of flagella help identify these reproductive cells. Replication comes in the following forms. Asexual reproduction occurs in the spring and early summer when the circumstances are ideal. The following are some crucial processes in this genus' asexual reproduction:

- During asexual reproduction, some cells in the colony's back become fertile. They are known as parthenogonidia or gonidia.
- The vegetative cells are smaller than the gonidia. Gonidia lack flagella and dots on their eyes. Pyrenoids are multiplying.
- The colony's interior is where these gonidia are pushed. The gonidium's protoplast splits and creates daughter colonies.
- The initial division of the gonidium produces two cells and is longitudinal to the plane of the coenobium.
- The second division is parallel to the first and similarly longitudinal, generating.
- By the third longitudinal division, all four cells split into eight cells, four of which are central. The plakea stage refers to the arrangement of these 8 cells, which resembles a curved plate.

The creation of a constriction opposed to phialopore marks the beginning of the colony's inversion. Once the whole structure emerges through the phialopore, the posterior end cells and constriction are forced into the sphere. The cells form cell walls, flagella, and eye spots after inversion. The formation of a gelatinous sheath surrounding each cell causes the cells to become separated. Daughter colony is the name of this young colony. The offspring colonies at first stick to the parent colonies gelatinized wall, but subsequently break away into the parent colony's gelatinous matrix.

Sexual Procreation

In this genus, sexual reproduction is of the oogamous type. The Volvox species may be monoecious (like V. globator) or dioecious (like V. aureus). The majority of monoecious species are prototandrous, meaning that antheridia develop before oogonia. A colony that reproduces sexually often does not produce asexual offspring. The phases of development for sexual reproduction in Volvox are as follows:

- The back of the colony is where reproductive cells differentiate most often. Gameteangia are the enlarged, flagellated versions of these cells.
- Female reproductive cells are known as oogonia or gynogonidia, whereas the male reproductive cells are known as antheridia or androgonidia.
- The development of the antheridium begins at the colony's posterior ends with the establishment of the androgonidial or first antheridial cell.
- The early cells expand, lose their flagella, develop thick protoplasm, and grow in size. This cell divides simply numerous times, producing a large number of daughter cells.
- Each cell matures into an antherozoid, a male reproductive cell that is fusiform, biflagellate, and naked.
- The antherozoid is an elongated, spindle-shaped, bifurcated structure with two contractile vacuoles, a nucleus, cup-shaped chloroplasts, pyrenoid, and an eye spot. It has a light green or yellow hue.
- The antherozoids are sometimes discharged in clusters or separately.
- In comparison to other colony cells, the oogonium is bigger.
- The mature oosphere or ovum has a flask-like form.
- The egg has an uninucleate structure, and the oogonium's beak serves as a receptive area
- The antherozoids reach the oogonia as a result of chemotactic reaction. Each oogonium contains some antherozoids. The oogonium only receives one antherozoid via the receptive site.
- After this, male and female nuclei fuse together in a process known as karyogamy and plasmogamy, respectively. As a consequence, a diploid zygote is produced.
- The wall of the diploid zygote is thick. It could slumber for a while. When favorable environmental circumstances arrive, the latent zygote undergoes reduction division and begins to grow. Just one of the four daughter cells survives after three of them degenerate. The remaining cell develops into a zoospore.

Oedogoniums/Occurrence

This freshwater unbranched filamentous alga is often found in lakes, tanks, and ponds since they are permanent bodies of water. Several species are terrestrial and dwell in damp soil, such as O. terrestris and O. randhawe. In India, 200 species have been identified.

Form of the thallus

The multicellular, filamentous alga is called Oedogonium. Except for the basal cell, which has been transformed into a holdfast, Oedogonium's filaments are unbranched and made up entirely of cylindrical cells. There are no chloroplasts in the basal cell, which serves as a holdfast. The filament's terminal cells are often spherical, elongated, or acuminate. The presence of prominent transverse bands at the distal ends of certain cells is a distinguishing property of this alga. Apical cap refers to the band that forms during cell division, while cap cell refers to the cell that has apical cap. How it is reproduced

- *Fragmentation:* Little Oedogonium filament pieces have the ability to grow independently and form a new thallus, much like many other types of algae. Thallus fragmentation may be caused by mechanical pressure or transverse wall breakdown.
- *Akinetes:* Akinetes are generated in adverse circumstances. When adverse circumstances arise, cells create short chains of thick-walled, reddish or brownish structures. Under favorable circumstances, each of these akinetes germinates and produces new filaments.

Asexual reproduction

Zoospores are used in the asexual reproductive process. The intercalary cap cell is where the multiflagellate zoospores are generated separately. As the zoosporangium, the newly produced cap cell typically serves. Following maturity, the zoosporangium's wall separates around the apical area, releasing the zoospore. The ovoid, spherical, or pyriform adult zoospores. They have a chloroplast and are uninucleate. After being released, these zoospores swim before landing with their anterior end facing downward on the substrate. The apical cell repeatedly splits to create a new filament.

Sexual procreation

This genus has an advanced form of oogamous sexual reproduction. Male and female gametes are used to make it happen. The female gametes (eggs) are generated in oogonia, whilst the male gametes (antherozoids) are produced in antheridia. Due to the physical and physiological differences between the gametes, the genus Oedogonium displays sexual dimorphism. The following are some crucial stages in the development of sexual [5] reproduction in this genus:

- The genus is split into two categories of species, namely Macrandrous species and Nannandrous species, based on the distribution of sex organs.
- Antheridia are formed on normal-sized filaments in macrandrous species. When antheridia and oogonia grow on the same filament, a species is said to be macrandrous monocious, nodulosum and fragile are two examples.
- Macrandrous dioecious species are those in which the antheridia and oogonia are born on distinct threads. Crassum and aquaticum are two examples.

The filaments bearing antheridia and oogonia in the nannandrous species exhibit morphological difference. The dwarf male or nannandrium filaments are substantially smaller than the female filaments. The androspores generated in the androsporangia give rise to the dwarf males[6].

The antherozoids are multiflagellate, unicellular, uninucleate entities.

- Oogonia develops similarly in macrandrous and nannandrous species.
- A single antherozoid enters the oogonium during fertilization via a hole on the oogonial wall. After fertilization, a diploid zygote is created.
- The zygote generally goes through a period of rest. The right circumstances are needed for zygotes to germinate. The reduction division of the zygote results in the formation of four daughter cells that develop into zoospores.
- Once the zygote wall ruptures, zoospores are released.
- These zoospores grow new haploid filaments after germination.

XANTHOPHYTA

Key Xanthophyta characteristics

- This division's constituents are referred to as yellow green algae.
- The plastids are yellow-green in color and contain beta-carotene, chlorophyll a, chlorophyll e, and e.
- Carotenoids often exist in significant quantities.
- Each cell has many discoid chromatophores.
- Leucosin or chrysolaminarin, oil, and fat are reserve food ingredients.
- A few species silicify their cell walls.
- The motile species have two flagella that are not equal. The anterior end is where these flagella are introduced. The whiplash flagellum is shorter than the tinsel flagellum.
- Sexual reproduction is uncommon but oogamous in Vaucheria.
- While some of the species in this division are subaerial and terrestrial, most of its members are freshwater forms.
- The Coenocytic siphoneous forms are members of the order vaucheriales. such as Vaucheria
- Botrydiaceae and Vaucheriacea are two of the families that make up the order Vaucheriales, also known as Heterosiphonales.

CONCLUSION

We have covered the broad properties and traits of Xanthophyta and Chlorophyta in this unit. The class Chlorophyta is sometimes referred to as green algae. This huge category of algae is made up of roughly 429 genera and 6500 different species. Chlorophyta consists mostly of freshwater organisms (about 90 percent species are fresh water and 10 percent marine). Several of the species in this group [7], [8] are both freshwater and marine. Several types of green algae are epiphytic or epizoic in growth. Some, like Zoochlorella and Hydra, develop in symbiotic relationships with other living things. Certain types of green algae work in symbiosis with fungus to create lichens. Alga Cephaleuros is a parasite. Thermophilic Chlamydomonas species exist. Asexual, sexual, and vegetative reproduction are all possible. Division Xanthophyta members have a yellow-green color. They are often found in freshwater. The thallus structure displays morphological variety. Most of the members of this category are filamentous, Siphoneous, and motile and coccoid forms [9], [10]. The coenocytic siphoneous form is a member of the order Heterosiphonales, commonly known as Vaucheriales. One prominent genus in this class is Vaucheria.

REFERENCES

[1] X. Shang, P. Liu, M. Moczydłowska, and B. Yang, "Algal affinity and possible life cycle of the early Cambrian acritarch Yurtusia uniformis from South China," *Palaeontology*, 2020, doi: 10.1111/pala.12491.

[2] F. Hindák and A. Hindáková, "Ettliella tetraspora (Chlorophyta, Chlorophyceae): Life cycle and taxonomy," *Fottea*, 2012, doi: 10.5507/fot.2012.006.

[3] Q. Liu, C. Wu, W. Xie, J. Zhao, and P. Jiang, "Validation of mating type-related markers in Ulva prolifera (Ulvophyceae, Chlorophyta) and their detection during various reproductive modes," *Algal Res.*, 2022, doi: 10.1016/j.algal.2021.102611.

[4] H. J. Sluiman and C. Guihal, "Phylogenetic position of Chaetosphaeridium (Chlorophyta), a basal lineage in the Charophyceae inferred from 18s rDNA sequences," *J. Phycol.*, 1999, doi: 10.1046/j.1529-8817.1999.3520395.x.

[5] A. A. Gontcharov, A. Y. Nikulin, V. Y. Nikulin, V. B. Bagmet, R. Z. Allaguvatova, and S. R. Abdullin, "New species of chloroidium (Trebouxiophyceae, chlorophyta) from east asia," *Plants*, 2021, doi: 10.3390/plants10122560.

[6] H. Nozaki, M. Ito, H. Uchida, M. M. Watanabe, and T. Kuroiwa, "Phylogenetic analysis of Eudorina species (Volvocaceae, Chlorophyta) based on rbcL gene sequences," *J. Phycol.*, 1997, doi: 10.1111/j.0022-3646.1997.00859.x.

[7] H. Nozaki and M. Itoh, "PHYLOGENETIC RELATIONSHIPS WITHIN THE COLONIAL VOLVOCALES (CHLOROPHYTA) INFERRED FROM CLADISTIC ANALYSIS BASED ON MORPHOLOGICAL DATA," *J. Phycol.*, 1994, doi: 10.1111/j.0022-3646.1994.00353.x.

[8] P. Přibyl, "Light is a crucial signal for zoosporogenesis and gametogenesis in some green microalgae," *Eur. J. Phycol.*, 2013, doi: 10.1080/09670262.2013.772243.

[9] M. Eliáš, Y. Němcová, P. Škaloud, J. Neustupa, V. Kaufnerová, and L. Šejnohová, "Hylodesmus singaporensis gen. et sp. nov., a new autosporic subaerial green alga (Scenedesmaceae, Chlorophyta) from Singapore," *Int. J. Syst. Evol. Microbiol.*, 2010, doi: 10.1099/ijs.0.012963-0.

[10] C. Fernández-García, J. Cortés, J. J. Alvarado, and J. Nivia-Ruiz, "Physical factors contributing to the benthic dominance of the alga Caulerpa sertularioides (Caulerpaceae, Chlorophyta) in the upwelling Bahía Culebra, north Pacific of Costa Rica," *Rev. Biol. Trop.*, 2012, doi: 10.15517/rbt.v60i2.19970.

CHAPTER 9

THE OCCURRENCE, STRUCTURE, AND MODE OF REPRODUCTION OF THALLUSES IN PHAEOPHYTA

Asha.K, Assistant Professor,
Department of Life Science, School of Sciences, Jain (Deemed to be University), Bangalore, India
Email Id- k.asha@jainuniversity.ac.in

ABSTRACT:

Phaeophyta members are often referred to as "brown algae." This category includes roughly 1500 species and 250 genera. The majority of the individuals in this division live in maritime habitats. Lithophytes, which mostly thrive on rocky seacoast regions of seas, are brown algae. In the coldest parts of the Arctic and Antarctic waters, they are particularly common. In the western and southern beaches of India, brown algae are often seen. Warm waters are ideal for the growth of Ectocarpales, Dictyotales, and several Sargassum species. They are most prevalent in the Atlantic Sargasso Sea in the tropics. Separated this division into three divisions, namely Isogeneratae, Heterogeneratae, and Cyclosporeae. There are a few fresh water species as well. Two isomorphic generations alternate amongst members of the isogenerate. The heterogeneratae members exhibit alternating heteromorphic generations. In the cyclosporeae, there is no alternation of free-living multicellular generations.

KEYWORDS:

Algae, Asexual Reproduction, Heterogeneratae, Reproduction, Phaeophyta, Thalluses.

INTRODUCTION

Mode of Reproduction and Asexual Reproduction

Zoospores are used in the asexual reproductive process. These zoospores grow in sporangia and are biflagellate in origin. Two different forms of sporangia are produced by sporophytic (diploid) plants: unilocular zoosporangia and plurilocular or neutral zoosporangia. Either the same plant or other plants may produce both kinds of zoosporangia. Both the unilocular and plurilocular sporangia produce haploid and diploid zoospores, respectively. At the terminals of tiny branchlets, unilocular sporangia form singly [1]. The branchlet's terminal cell enlarges in size and serves as the sporangial beginning. It then divides repeatedly, going through meiotic divisions initially and then mitotic divisions to form several hundred tiny cubical cells. Each cubical cell produces a biflagellate zoospore and is haploid. These zoospores were released by a lateral or terminal pore. Following release, these zoospores land with their anterior end on a solid substrate and develop into a haploid or gametophytic thallus.

Sexual Reproduction

The majority of Ectocarpus species are anisogamous, while sexual reproduction may also be isogamous, anisogamous, or oogamous. Ansiogamy might be morphological or physiological. The plurilocular gametangia, which resemble plurilocular sporangia, grow in the gametophytic thallus where the gametes are produced. Each locule produces one zoogamete, which is equivalent in size and morphologically similar to a zoospore. It produces two different forms of gametangia and exhibits morphological ansiogamy. Both the megagametangium and the microgametangium have bigger locules and larger gametes, respectively. Female gametes are often docile and slow, whereas male gametes are typically energetic and motile. To generate clumps, several male gametes assemble around each female gamete. A zygote or zygospore is created when one male gamete unites with a female gamete. The zygote develops into a fresh, diploid thallus right away. There is no meiosis during zygote germination. Both unilocular and plurilocular sporangia are present on the newly formed diploid thallus.

Sargassums Occurrence

Over 150 species in this genus are found across the warmer subtropical and tropical oceans of the southern hemisphere. Because of the vast and widespread prevalence of this species, the Atlantic Ocean of the African continent is known as the Sargasso Sea. [2] There are 16 species in India that belong to this genus, and they are all found in the western and southern coasts. The species S. tenerrium, S. carpophyllum, S. duplicatum, S. plagiophyllum, and S. wightii are some of the common ones in India.

Form of the thallus

The thalli have bilateral or radial architecture and are a well-developed parenchymatous structure. The holdfast and main axis of the sporophytic (diploid) thallus are distinct. The holdfast aids in thallus adhesion to substrate. In certain species, the holdfast resembles a stolon, whereas in others, it is missing in the case of free-floating species. The primary axis, also known as the stipe or stem, is upright, elongated or flat and may reach a length of 30 cm. But thallus length varies from species to species. The principal laterals on the main axis may develop indefinitely. Secondary laterals or leaves are flat, leaf-like branches that grow from the main axis and the primary laterals. These flat, straightforward structures that resemble leaves include blades, veins, and petiole-like components. Except for S. enerve, the mid-rib is present in all leaves. There are also air bladders, which increase buoyancy to aid in the flotation of plants. Several species' air sacs end in structures resembling leaves. Conceptacles are peculiar flask-shaped structures that develop from branches bearing reproductive organs as receptacles.

How it is reproduced

Vegetative and sexual reproduction both occur throughout the reproductive process. There is no asexual reproduction whatsoever. Via thallus fragmentation, sargassum grows. Older parts of the thallus experience death and decay as a result of damage, and the thallus fragments into tiny pieces. New thallus are formed from these segments.

PHAEOPHYTA

The following are some of this division's key distinguishing characteristics:

- The parenchymatous organization of the thallus varies from basic to complicated. They include heterotrichous forms (like Ectocarpus), pseudoparenchymatous forms with one axis, multiaxial forms, and parenchymatous forms with more than one axis.
- The holdfast, stipe, and blade of the thallus are distinct.
- Discoid or branching holdfasts are used to secure these algae to the rock.
- Eukaryotic cells have a sort of structure.

- There are two or more layers in the cell wall. The exterior mucilaginous layer is constructed of pectin that contains alginic and fucinic acid, whereas the inner layer is composed of cellulose.
- There is only one sizable nucleus in the cell.
- The chromatophores may range in number from one to many and are typically pariental.
- Fucoxanthin, a carotenoid pigment, is the dominant pigment responsible for the distinctive brown color. Chlorophyll A, Chlorophyll C, and Xanthophylls are the additional pigments.
- Cells have a single, stalked, or protruding pyrenoid-like body.
- As a metabolic byproduct, fucosan vesicles, which are tiny, colorless vacuoles, are found in the cytoplasm of cells.

Ectocarpus is found all throughout the planet, however it is more common in polar and temperate locations with cooler sea water. Algae are often seen in India's western coastal areas growing epiphytically on seaweed or affixed to rock. Around 13 species have been found in India. Some common Indian species are Ectocarpus indicus, E. coniferus, E. geminifructus, and E. dermonematus.

Form of the thallus

The thallus generally has two distinct rhizoidal systems: one that creeps or is prostrate, and the other that is upright and branching. One of the two systems may be diminished in certain animals. The prostrate system is more developed in epiphytic forms than the erect system. The thallus of many species is sparsely to profusely branching, and the cells are uniseriate and arranged in a row end to end. In certain species, a layer of descending rhizoidal shoots corticates the older part of the main branch. In several species, a branch's tip may terminate in an amorphous hair with a basal meristem [3]. Typically, the upright portion of the thallus is irregularly branched. Uninucleate rectangular cells make up the filaments. An outside layer of gelatin and an interior layer of cellulose make up a cell wall. Fucoiden and algin make up the outer gelatinous layer. The main algal pigments in this genus include chlorophyll-a, chlorophyll-c, carotene (fucoxanthin), and xanthophylls. In addition to chlorophyll, the chromatophores also contain significant amounts of xanthophylls. In the cell, there are many pyrenoid-like structures and fucosan vesicles or granules. Mannitol and laminarin make up the reserve food material. Apical growth occurs in the prostrate section of the thallus, whereas intercalary growth occurs in the upright half.

Sexual reproduction

Oogamous sexual reproduction is a kind. Conceptacles are peculiar flask-shaped chambers where the reproductive organs grow. The female sex organ is known as oogonium, and the male sex organ as antheridium. Separate conceptacles are where the male and female sex organs develop. The following are key phases in the development of sargassum sexual reproduction:

The starting cell, which is the first cell from which the conceptacle emerges. Transverse division creates two cells from the original cell. Basal cell and tongue cell are the names of the top and lower cells, respectively. The tongue cell expands and splits transversely to create a brief filament that quickly vanishes. The basal cell gives rise to the fertile layer of the conceptacle. The cells that make up this layer give rise to the sex organs. The fertile layer of the conceptacle is where antheridium grows. The lower stalk cell and an upper antheridial cell split out from the antheridial starting cell. Antheridium emerges from upper cell. A two-layered wall encircles the oval structure of the adult antheridium. The inner wall layer is known as endochite, while the outside wall is known as exochite. With the aid of a stalk cell, the antheridium joined to the conceptacle's base. 64 biflagellate antherozoids with a pear shape are produced by Antheridium. These antheridia separate from the stalk during development and emerge from the conceptacle via the ostiole. Every cell in the female conceptacle's fertile layer may serve as the oogonial initial. The extremely tiny lower stalk cell and the huge higher oogonial cell are created by a transverse division of the oogonial initial.

The oogonial cell progressively develops thick cytoplasm and a sphere-like shape. The oogonial cell's diploid nucleus goes through a meiotic division (reduction division), which is followed by two simple divisions, resulting in the formation of eight haploid nuclei. Just one of them is the egg nucleus, and the others have degenerated. [4] The adult oogonia are expelled from the conceptacle, but a lengthy gelatinous stalk keeps them anchored to the conceptacle wall. A significant number of antherozoids surround the oogonium and use the anterior flagellum to connect to the oogonial wall. One antherozoid alone may pass through the oogonial wall. A diploid zygote is created when the male and female nuclei combine. The zygote begins to grow right away after fertilization. First, the zygote separates transversely into a lower and an upper cell. During anticlinal and periclinal divisions, the higher cell generates a new diploid thallus while the bottom cell produces rhizoids. There is no alternation of morphological generations in the diplontic life cycle of sargassum. Heterotrichous forms, Uniaxial [5], [6] pseudoparenchymatous structure, Mutiaxial forms, and Parenchymatous forms are all parts of the Thallus organization. This algae's brown color is a result of the carotenoid pigment fucoxanthin, which is an accessory pigment. Chlorophyll a, Chlorophyll c, and Xanthophylls are additional pigments.

In cooler sea water, the division's Ectocarpus, a significant genus, may be discovered. The alga in India is mostly found along the western coast. Around 13 species have been found in India. The thallus generally has two distinct rhizoidal systems: one that creeps or prostrates and one that is upright and branching. There are both asexual and sexual methods of reproduction. The zoospores that form in sporangia are used to carry out asexual reproduction. Two different forms of sporangia are produced by sporophytic (diploid) plants: unilocular zoosporangia and plurilocular or neutral zoosporangia. Both zoosporangia species might be found on the same plant or distinct plants. While sexual reproduction may be isogamous, anisogamous, or oogamous, the majority of Ectocarpus species practice anisogamous sexual reproduction. Without going through any reduction division, the zygote germinates immediately into a new diploid thallus after fertilization (meiosis) [7], [8].

The second constituent, sargassum, is extensively spread in the southern hemisphere's warmer tropical and subtropical oceans. This genus has roughly 16 species in India, and they are found along the western and southern coasts. Sargassums have well developed thallus tissue that is of the parenchymatous kind. The major axis and holdfast of the diploid thallus are distinct. The primary axis and leaf's internal structure has developed and differentiated into meristoderm, cortex, and medulla. This alga's ability to differentiate tissues at such an advanced level makes it special. Vegetative and sexual methods are used for reproduction. In Sargassum, asexual reproduction doesn't exist at all. Fragmentation is the method [9] used in vegetative reproduction. Oogamous sexual reproduction is a kind. Conceptacles are peculiar flask-shaped chambers where the sex organs formed. Separate conceptacles are where the male and female sex organs develop. The zygote begins to grow right away after fertilization and divides by mitosis, or simple division, to produce a diploid plant. The generations do not alternate morphologically.

CONCLUSION

We have spoken about brown algae in this unit. Lithophytes, which mostly thrive on rocky seacoast regions of seas, are brown algae. In the coldest parts of the Arctic and Antarctic waters, they are particularly common. In the western and southern beaches of India, brown algae are often seen. Sargassum species thrive in warm seas. They are most prevalent in the Atlantic Sargasso Sea in the tropics. [10] The majority of the individuals in this category live in maritime environments. There are also a few known freshwater species in this group. These algae have highly developed thallus organization. Despite their appearance, they are not angiosperms because they lack sophisticated tissue structure. The parenchymatous kind of tissue that makes up the plant's body is divided into the main axis, leaves, and rhizoids [11], [12].

REFERENCES

[1] D. E. Kumalasari, H. Sulistiyowati, and D. Setyati, "Komposisi Jenis Alga Makrobentik Divisi Phaeophyta di Zona Intertidal Pantai Pancur Taman Nasional Alas Purwo," *Berk. SAINSTEK*, 2018, doi: 10.19184/bst.v6i1.7558.

[2] Z. Ma *et al.*, "Total and inorganic arsenic contents in seaweeds: Absorption, accumulation, transformation and toxicity," *Aquaculture*. 2018. doi: 10.1016/j.aquaculture.2018.07.040.

[3] N. C. Afonso, M. D. Catarino, A. M. S. Silva, and S. M. Cardoso, "Brown macroalgae as valuable food ingredients," *Antioxidants*. 2019. doi: 10.3390/antiox8090365.

[4] P. Kumari, M. Kumar, V. Gupta, C. R. K. Reddy, and B. Jha, "Tropical marine macroalgae as potential sources of nutritionally important PUFAs," *Food Chem.*, 2010, doi: 10.1016/j.foodchem.2009.11.006.

[5] M. Ito *et al.*, "Analysis of functional components and radical scavenging activity of 21 algae species collected from the Japanese coast," *Food Chem.*, 2018, doi: 10.1016/j.foodchem.2018.02.070.

[6] Y. Choi, E. Kim, S. Moon, J. D. Choi, M. S. Lee, and Y. M. Kim, "Phaeophyta extracts exhibit antiviral activity against feline calicivirus," *Fish. Aquat. Sci.*, 2014, doi: 10.5657/FAS.2014.0155.

[7] J. I. Nirmal Kumar, M. Barot, and R. N. Kumar, "Distribution and biochemical constituents of different seaweeds collected from Okha coast, Gujarat, India," *Indian J. Geo-Marine Sci.*, 2017.

[8] N. Prasanthi, C. Prasannakumar, D. Annadurai, S. Mahendran, and A. H. M. Alshehri, "Identifying seaweeds species of Chlorophyta, Phaeophyta and Rhodophyta using DNA barcodes," *bioRxiv*. 2020. doi: 10.1101/2020.08.30.274456.

[9] M. Zubia *et al.*, "Antioxidant and antitumoural activities of some Phaeophyta from Brittany coasts," *Food Chem.*, 2009, doi: 10.1016/j.foodchem.2009.03.025.

[10] M. Abdullah Al, A. Akhtar, M. F. Rahman, A. H. M. Kamal, N. U. Karim, and M. L. Hassan, "Habitat structure and diversity patterns of seaweeds in the coastal waters of Saint Martin's Island, Bay of Bengal, Bangladesh," *Reg. Stud. Mar. Sci.*, 2020, doi: 10.1016/j.rsma.2019.100959.

[11] J. I. Nirmal Kumar, R. N. Kumar, M. K. Amb, A. Bora, and Sudeshnachakraborty, "Variation of biochemical composition of eighteen marine macroalgae collected from Okha coast, Gulf of Kutch, India," *Electron. J. Environ. Agric. Food Chem.*, 2010.

[12] M. M. El-Sheekh, R. A. E. K. El-Shenody, E. A. Bases, and S. M. El Shafay, "Comparative assessment of antioxidant activity and biochemical composition of four seaweeds, rocky bay of abu qir in alexandria, egypt," *Food Sci. Technol.*, 2021, doi: 10.1590/fst.06120.

CHAPTER 10

OCCURRENCE, STRUCTURE OF THALLUS AND MODE OF REPRODUCTION IN RHODOPHYTA

Uzma Noor Shah, Assistant Professor,
Department of Life Science, School of Sciences, Jain (Deemed to be University), Bangalore, India
Email Id- ns.uzma@jainuniversity.ac.in

ABSTRACT:

The Rhodophyceae, sometimes known as red algae, is one of the largest and most diverse families of eukaryotic algae, with around 6500 species, the majority of which are multicellular and mostly marine. It is the sole class in the Rhodophyta division. A category of macroalgae known as seaweeds is made up of certain Chlorophyceae and Phaeophyceae members. The photosynthetic pigment phycoerythrin is responsible for their red color. Rhodophyceae are not completely red despite their name. Due to the presence of other pigments, these algae may also be purple, brown, or black. Chlorophyll a, Chlorophyll d, carotenes, Phycoerythrins, and Phycocyanins are the pigments that are present.

KEYWORDS:

Algae, Chlorophyll, Reproduction, Rhodophyta, Rhodophyceae.

INTRODUCTION

Around 831 genera and 5,250 species of algae make up the huge category of algae known as Rhodophyta. The members of this group are often referred to as red algae. Except for a few fresh water species, the majority of these algae live in marine habitats with uniaxial or multiaxial thalli. The freshwater species may be found in swiftly moving streams (like Batrachospermum) or in pools of still water (e.g., Compsopogon). The bigger, fleshier varieties of algae are often found in cool-temperate climates, while the smaller, filamentous varieties are found in tropical oceans. The capacity of Rhodophyta members to survive at higher ocean depths than those of other algae groups is a crucial characteristic of this group of organisms. [1] The organizational structure of thallus cells may be unicellular or multicellular. Porphyridium, a species of red algae with just one cell, is the greatest illustration. Moreover, the red algae display a high level of parasitism and epiphytism with notable selectivity. Several species live on other red algae as epiphytes. The cell wall typically consists of two layers, the inner of which is cellulosic and the outer of which is pectic.

RHODOPHYTA

The following are some of division Rhodophyta's key distinguishing characteristics:

- Red algae, in general, are lovely, velvety, and slimy.
- There are several varieties of complicated multiaxial and unicellular thallus organization.
- Members of the subclass Florideae have more complicated and advanced thallus organization, which is separated into two categories, namely uniaxial thallus and multiaxial thallus.

- A single central or axial filament, which is often corticated by several well-branched laterals, is what defines a uniaxial thallus. For instance, batrachospermum.
- The center or primary filaments of the multiaxial thallus are a mass, and each central filament sprouts lateral branches. Examples include Helminthocladia and Polysiphonia.
- The cell wall is composed of two layers, the inner layer being cellulosic and the outer layer being pectic.
- Agars and carrageenans make up the majority of the mucilaginous material in the outer pectic layer.
- Cells are typically uninucleate, however they may be multinucleate in certain species.
- Organelles including the endoplasmic reticulum, mitochondria, and dictyosomes are found in eukaryotic cells.
- The chromatophore contains photosynthetic pigments including r-phycoerythrin and r-phycocyanin, xanthophylls, chlorophyll a and d, and carotenes (biliproteins).
- The r-phycoerythrin and r-phycocyanin pigments are in charge of giving the thallus its red color.
- Porphyridium, a primitive red alga, contains phytoerythrin.
- Floridan starch is used to store the reserve food stuff.
- Neither the asexual nor the sexual phases of the life cycle include any motile stage.
- Asexual and sexual techniques are mostly used for reproduction.
- Oogamous sexual reproduction is the norm.
- Spermatangia create the non-motile male gametes known as spermatia.
- The procarp, which is made up of the trichogyne and the carpogonium, is the female reproductive organ.
- In the subclass Florideae, the development of specialized filaments known as gonimoblasts occurs after fertilization.
- This division was divided into the Bangioideae and Florideae main subclasses by Fritsch (1935).
- Rhodophyta's primordial forms are included in the subclass Bangioideae. They lack apical development and pit connection.
- The uni- or multiaxial thalli in the subclass Florideae exhibit apical development. The reproductive system is more sophisticated and intricate. During germination, the zygote produces gonimoblast filaments, the terminal cell of which transforms into a carposporangium. Polysiphonia is one example.

Polysiphonias\ Occurrence

A marine genus called Polysiphonia has 150–200 species. In the southern and western shores of India, 16 species may be found. The majority of this genus' members are lithophytic (growing on rocks). Some species, however, are epiphytic, meaning they grow on other algae, and the division of red Algae also shown in Figure 1. Tufts of the plants grow densely.

Form of the thallus

Polysiphonia has a heterotrichous kind of thallus. The thallus is polysiphonous or multiaxial. The central axial cell (or siphon) of the main axis and its branches are encircled by pericentral cells (or siphons) of varying numbers. Each cell is uninucleate and has several disc-shaped plastids. The cells are related to one another by cytoplasmic connections. The plant body is divided into an upright aerial system and a base prostrate aerial system. Across the substrate, the prostrate system crawls. With the use of single-cellular, elongated rhizoids, the prostrate system of filaments anchors the thallus to the substrate. Nevertheless, the multiaxial prostrate system is lacking in other species (such as P. elongate and P. violacea) [2]. The prostrate system gives birth to the erect aerial system. It consists of filaments with several axes and branches. The thallus has two different types of branches that are laterally or dichotomously branched. Central and pericentral siphons make up the branches with limitless development, whereas trichoblasts make up the branches with restricted expansion. An apical cell, which repeatedly divides to create a row of axial cells, is how the thallus develops. Sometimes a trichoblast's axis may develop an unbounded branch, in which case the branch's basal cell acts as the branch initial.

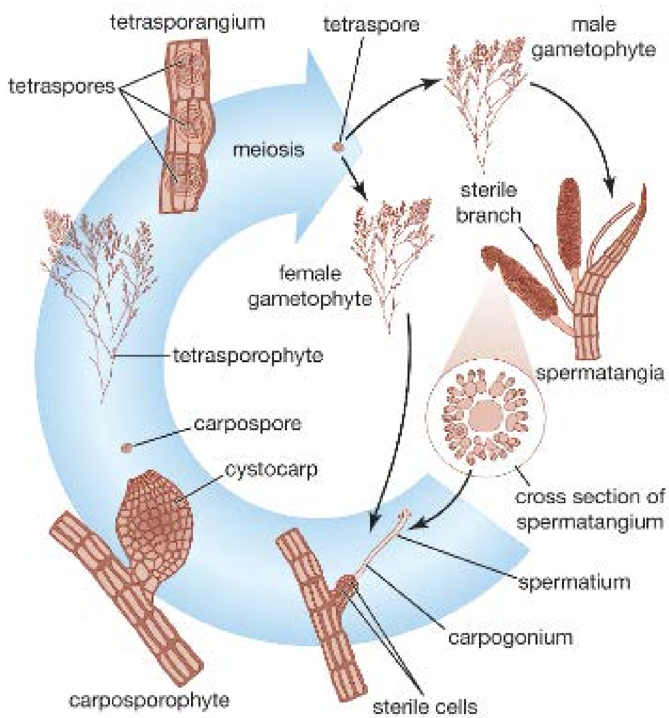

Figure 1: Illustrate the division of red Algae.

The three kinds of thalli present in polysiphonia, which is mostly heterothallic, are as follows:

- The haploid, dioecious, free-living gametophytic thalli. The sex organs for men and women grow on various thalli. The female sex organs carpogonia grow on female plants, whilst the male sex organs spermatangia are created on male plants.
- In nature, the diploid zygote undergoes mitotic division to produce the carposporophyte. It has carpospores and is reliant on the female gametophyte.
- The diploid carpospores that make up the asexual thallus, or tetrasporophyte, carry tetrasporangia. Being haploid organisms, tetraspores produce both male and female gametophytic plants.
- How it is reproduced
- Both asexual and sexual methods of reproduction are used in the Polysiphonia life cycle. Some crucial aspects of reproduction in Polysiphonia are as follows:

- Tetraspores are used for asexual reproduction, as stated in number 1. These tetraspores are haploid in nature and generated in tetrasporangia.
- Among the four tetraspores in a sporangium, two produce male gametophytes and two produce female gametophytes after release.
- Oogamous sexual reproduction is the norm. The reproductive systems of men and women grow on various thalli.
- Spermatangia or antheridia are the names of the male sex organs. At the male gametophyte's tip, fertile trichoblasts support the development of the spermatangia. Spermatangia are round or oval structures with short stalks. One male gamete or spermatangium is produced by each spermatangium.
- A small slit located at the spermatangium's tip allows the spermatium to be released.
- The carpogonium is the name of the female sex organ. On the trichoblast found on the female gametophyte, carpogonia also form. At the end of the carpogonial filament, a flask-shaped carpogonium forms. The base of the carpogonium is enlarged, and the trichogyne, a thin, lengthy portion, is present.
- During fertilization, a water stream transports the spermatia to the trichogyne of the carpogonium. The mucilage around the trichogyne helps the spermatium cling to it. Via the trichogyne, the male protoplasm penetrates the carpogonium and combines with the egg nucleus. The result of fertilization is a diploid zygote.
- During fertilization, the auxillary cell's apex is severed by the supporting cells of the carpogonia filament, and a tubular connection is made between the auxillary cell and the carpogonium.
- The diploid zygote nucleus splits into two daughter nuclei during mitosis; one of the daughter nuclei stays within the carpogonium, while the other enters the auxillary cell through the tubular link. The auxillary cell's haploid nucleus degenerates, leaving only diploid nuclei.
- The auxillary cell's diploid nucleus splits by mitosis, and gonimoblast filaments form from the auxillary cell.
- Each gonimoblast filament's apical cell matures into a carposporangium. One diploid carpospore forms in the carposporangium protoplasm.
- At the carpogonium, sterile cells proliferate to produce sterile filament, which acts as a barrier.
- The carposporophte, also known as the cystocarp, is a huge urn-shaped entity formed by the gonimoblast filaments and carposporangia.
- The ostiole of the carposporophyte is where the carpospores (diploid) are released.
- The carpospores germinates and produces a tetrasporophyte, a diploid asexual thallus.
- Tetrasporophytes are free-living diploid plants with a life cycle that resembles haploid gametophytic plants morphologically.
- Tetrasporangia grow in the core cells of the axis (central siphon).
- Tetrasporangium's diploid nucleus splits meiotically to produce four haploid nuclei. The result is the formation of four haploid tetraspores from the four uninucleate segments. These tetraspores, also known as meiospores, are grouped in a tetrahedral pattern. These tetraspores generate haploid gametophytic thalli after release; two produce male and two produce female plants.

- As a result, polysiphonia demonstrates triphasic alternation of generation. In this genus's life cycle, one haploid (gametophytic) phase alternates with two diploid phases (tetrasporophyte and carposporophyte).

Batracospermum & Occurrence

This red alga lives in freshwater. In the tropical and temperate climates, it grows in slow flowing water found in streams, lakes, and ponds [3]. Thallus often thrives in deep, shaded lakes and ponds. Algae are often found in waterways with good aeration. The thallus is reddish, violet, olive green, and blue-green in hue. Yet because of the variations in light strength, the color changes. Whereas species growing in shallow water are olive-green in color, those growing in deep water are crimson or violet.

Form of the thallus

The thallus is an extremely branching, gelatinous structure. It has a haploid thallus (gametophytic). There are two types of Thallus organization: prostrate and erect. The thallus is fixed to the substrate by the prostate system. Rhizoids attach to many species. A single, uniseriate row of big cells that have differentiated into nodes and internodes make up the principal main axis of the thallus. The nodal areas of the thallus give rise to two different kinds of lateral branches: branches with restricted development and branches with limitless expansion. Just below the septa of the axial filament, whorls include the branches with restricted growth appear. The lateral branch's basal cells develop into fine threads. The primary axis is encircled by these threads as they develop downward, hiding it and giving the area a corticated look. A glomerule is a whorl of branches with restricted growth that is seen at a node. The nodal cells of the main axis give rise to the branches of limitless expansion. Chlorophylls a and d are the primary pigments, while r-phycoerythrin and r-phycocyanin are the major pigments. The kind of cell is eukaryotic. Floridian starch serves as the emergency diet. Via pit connections, the axial filament's cells are joined together. By using hemispherical apical cells, the thallus expands [4]. A succession of cells at the posterior ends are produced by the apical cell via recurrent divisions.

How it is reproduced

Reproduction in Batrachospermum occurs both asexually and sexually

Asexual procreation

Some crucial aspects of asexual reproduction are as follows:

- Monospores produced individually in the monosporangia are used for asexual reproduction.
- Monospores are haploid, uninucleate, and immobile.
- During the "Chantransia" stage of sexual reproduction, which is created during the post-fertilization stage, monospores form in the upright section of heterotrichous filaments.
- The haploid gametophyte of Batrachospermum is produced by the monospore.

A sexual relationship

Many crucial aspects of sexual reproduction are as follows:

- This genus has highly developed oogamous type sexual reproduction. Thallus may have one or two sexes.
- The spermatangium or antheridium is the name of the male reproductive system.
- Spermatangia are spherical or globose, unicellular, uninucleate, and colorless structures.
- Spermatngia sprout at the tips of branches with restricted development.
- A single spermatium is carried by each spermatangium.
- The carpogonium is the name of the female reproductive system.
- The carpogonium is a flask-shaped structure that has developed into a narrow neck termed a trichogyne and a basal swelling egg cell.
- Special lateral branches, referred to as carpogonial branches, are where the carpogonia develops.
- With the aid of water currents, the spermatia released from the spermatangium make their way to the trichogyne of the carpogonium.
- A diploid zygote is created when the male and female nuclei combine. Trichogyne portion progressively vanishes.
- The zygote divides during meiosis, producing four haploid nuclei. These nuclei continually split into many daughter nuclei. At this point, the carpogonium's basal swelling portion is the source of many outgrowths. Gonimoblast initials are these haploid-nucleated outgrowths.
- Many tiny, unbranched or branching gonimoblast filaments are produced as a result of repeated transverse divisions of gonimobast beginnings.
- Gonimoblast strands' terminal cell serves as the carposporangium. One carpospore forms in each carposporangium. Cells below the carpogoninm produce a large number of sterile threads that cluster around the filaments of the gonimoblast.
- The term "cystocarp" or "carposporophyte" refers to the combination of gonimoblast, carpospore, and carposporangia filaments as well as sterile filaments.
- Upon release, carpospores evolve into a protonema-like structure, known as the chantransia stage or juvenile stage, which ultimately develops into a heterotrichous structure.
- This genus's life cycle is referred to as triphasic haplobiontic. The zygote (diploid phase) lasts just a few hours.

The lack of a motile stage is a crucial feature. Most reproduction is accomplished via asexual and sexual means. Asexual reproduction is accomplished using aplanospores (monospores, neutral spores, carpospores and tetraspores). The form of sexual reproduction is oogamous and quite advanced. We studied Polysiphonia and Batrachospermum (fresh water algae) in this unit (marine alga).

Freshwater Batrachospermum is a member of the Rhodophyta division. The thallus is filamentous, heavily branching, and haploid. Like Polysiphonia, the thallus organization progressed. A prostrate and an erect system are distinguished. The main axis of the thallus is composed of a row of massive, uniseriate cells that have developed into nodes and internodes. This is another distinguishing quality of this alga. There are both asexual and sexual methods of reproduction. Monospores produced individually in the monosporangia are used for asexual reproduction. The oogamous kind of sexual reproduction has progressed [5]. The life cycle comprises of two short-lived sporophytic (zygote phase) phases that alternate with two gametophytic phases (Batrachospermum and chantransia stage). This genus has a triphasic life cycle that is referred to be haplobiontic. The zygote (diploid phase) lasts just a few hours.

One prominent marine genus in this group is Polysiphonia. The thallus is likewise organized in an advanced manner. The thallus is polysiphonous or multiaxial. The plant body is divided into an upright aerial system and a base prostrate aerial system [6], [7]. across the substrate, the prostrate system crawls. The unicellular, elongated rhizoids that support the prostrate system serve as its anchors to the substrate. Both asexual and sexual methods are used to reproduce. Tetraspores are used for the asexual reproduction. The oogamous kind of sexual reproduction is sophisticated. On various male and female gametophytic thalli, the reproductive organs of men and women develop. The triphasic alternation of generation is seen in this species. Throughout the life cycle, one haploid (gametophytic) phase alternates with two diploid phases (tetrasporophyte and carposporophyte).

CONCLUSION

We have studied the Rhodophyta division in this unit [8]. There are many of algae in this category. The members of this group are often referred to as red algae. With the exception of a few species, most of them live in maritime habitats. In most cases, the cell wall is composed of two layers: an inner cellulose layer and an exterior pectic layer. The individuals that make up this division are eukaryotic in origin. The chromatophore contains biliproteins such r-phycoerythrin and r-phycocyanin, as well as chlorophylls a and d, carotenes, xanthophylls, and other photosynthetic pigments. This algae's main pigments, r-phycoerythrin and r-phycocyanin, give them their red color. Florida starch is used to store the reserve food supply[9], [10].

REFERENCES

[1] E. Cecere, A. Petrocelli, and M. Verlaque, "Vegetative reproduction by multicellular propagules in Rhodophyta: An overview," *Marine Ecology*. 2011. doi: 10.1111/j.1439-0485.2011.00448.x.

[2] L. J. Dyck and R. E. DeWreede, "Reproduction and survival in Mazzaella splendens (Gigartinales, Rhodophyta)," *Phycologia*, 2006, doi: 10.2216/04-80.1.

[3] V. Montoya, A. Meynard, L. Contreras-Porcia, and C. B. Contador, "Molecular identification, growth, and reproduction of Colaconema daviesii (Rhodophyta; Colaconematales) endophyte of the edible red seaweed Chondracanthus chamissoi," *J. Appl. Phycol.*, 2020, doi: 10.1007/s10811-020-02176-3.

[4] R. Scrosati, "Regeneration and reproduction of Mazzaella cornucopiae (Rhodophyta, Gigartinaceae) after frond harvesting," *J. Appl. Phycol.*, 1998, doi: 10.1023/A:1008029632351.

[5] J. Aguirre and F. Barattolo, "Presence of nemathecia in Parachaetetes asvapatii pia, 1936 (Rhodophyta, Gigartinales?): Reproduction in 'Solenoporaceans' revisited," *Palaeontology*, 2001, doi: 10.1111/1475-4983.00217.

[6] L. E. Mateo-Cid *et al.*, "Updated list and new records of red algae (Rhodophyta) from the coast of Michoacán, Mexico," *Rev. Mex. Biodivers.*, 2021, doi: 10.22201/IB.20078706E.2020.91.3353.

[7] S. M. P. B. Guimarães and P. A. Horta, "Morphology and reproduction of Predaea feldmannii Børgesen (Nemastomataceae, Rhodophyta), an uncommon species from Brazil," *Rev. Bras. Botânica*, 2004, doi: 10.1590/s0100-84042004000300010.

[8] E. V. Schoschina, "Seasonal and age dynamics of growth and reproduction of Phycodrys rubens (Rhodophyta) in the Barents and White Seas," *Aquat. Bot.*, 1996, doi: 10.1016/0304-3770(96)01055-8.

[9] P. García-Jiménez and R. R. Robaina, "On reproduction in red algae: Further research needed at the molecular level," *Front. Plant Sci.*, 2015, doi: 10.3389/fpls.2015.00093.

[10] M. Cao *et al.*, "A chromosome-level genome assembly of Pyropia haitanensis (Bangiales, Rhodophyta)," *Mol. Ecol. Resour.*, 2020, doi: 10.1111/1755-0998.13102.

CHAPTER 11

AN OVERVIEW ON BRYOPHYTES

Asha.K, Assistant Professor,
Department of Life Science, School of Sciences, Jain (Deemed to be University), Bangalore, India
Email Id- k.asha@jainuniversity.ac.in

ABSTRACT:

The words "Bryon," which means mosses, and "phyton," which means plants, are where the name "Bryophyta" comes from. Embryophytes like mosses, hornworts, and liverworts are categorized as bryophyta. These are tiny plants that thrive in moist, shaded environments. Vascular tissues are absent. They reproduce using spores rather than flowers and seeds. Although though bryophytes are terrestrial plants, they are known as the "amphibians of the plant world" because, during sexual reproduction, they need water to complete their life cycle.

KEYWORDS:

Alage, Bryophytes, Fertilization, Gametophyte, Thallus.

INTRODUCTION

Members of the plant kingdom called bryophyes are straightforward and primitive. These are unassuming green plants that are modest (the biggest Dawsonia may grow to a height of 40 to 70 cm). In the wet season, they often grow in tufts and pillows and provide green color to the mountains, woodlands, and moors. These are the simplest plants that can really live on land, and they can only grow in damp, shaded areas. As virtually majority of them still need water for fertilization, they are considered to be only partially adapted to land environments. The majority of them also need enough moisture for brisk development. Figure 1 illustrates the Bryophytes' reproductive mechanism. They belong to the plant kingdom and are referred to as "amphibians" since they need water to complete their life cycle [1].

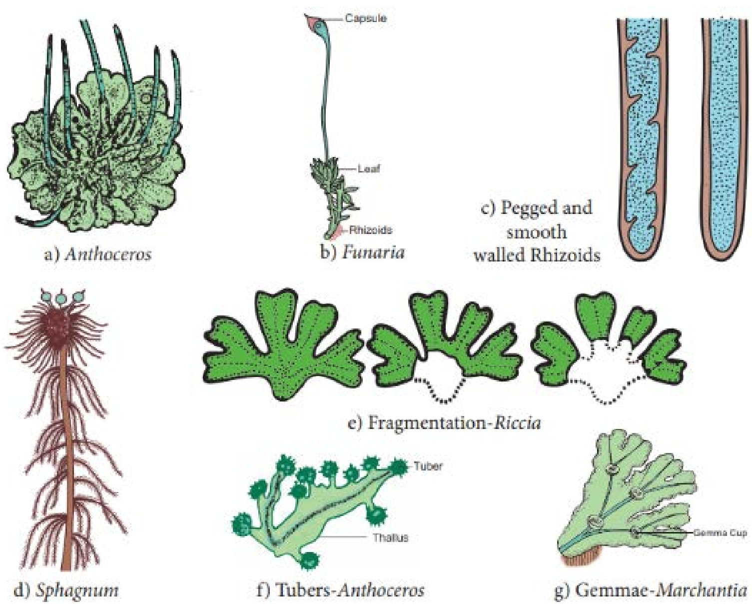

Figure 1: Illustarte the mode of reproduction in Bryophytes.

Habit

There are essentially two kinds of bryophyte plant bodies. It can only be a leafy growth or a simple thallus (thallose) (foliose). It is also possible to find partially thallose or partially foliose forms.

The gametophyte is a thallus

The stem and leaves of the thalloid forms are not differentiable. Typically, the thallus is flat, dorsi-ventral, prostrate, green, and dichotomously branched. It has a pronounced midrib, however the midrib may not be present (Anthoceros). Thallus often has scales on its ventral side and is typically anchored to the soil by rhizoids.

Leafy Forms

The gametophyte of leafy liverworts has a more or less prostrate leafy axis and three rows of leaves, two rows of larger dorsal leaves that are arranged laterally, one on each side of the stem, and a third row of smaller ventral leaves that are arranged under the stem (Porella). The leaves never have a midrib. Rhizoids do not have septa. The protonema is tiny and transient[2].

The gametophytic plant body in mosses is a leafy shoot made up of a main stem, phylloids, and rhizoids. The three vertical rows of tiny, sessile leaves are spirally arranged on the stem. The midrib of the leaves often varies in size. Funaria and Polytrichum have lateral and pinnate types of branching. Rhizoids have transverse septa and are branching. In mosses, the protonema is a well-developed, filamentous, and branching juvenile stage. Thalloid protonema is also discovered sometimes.

DISTRIBUTION

Compared to blooming plants, bryophytes often have larger ranges. There are a lot of families in the globe. There are some genera with a global distribution, including Polytrichum, Grimmia, Bryum, and Brachythecium among mosses and Plagiochila, Lophpcolea, Radula, and Frullania among liverworts. Several of the species, such Funaria hygrometrica and Tortula muralis, are recognized as global weed species due to their widespread distribution.

Herzog (1926) identified certain distributional patterns that recurred often. Hence, it is possible to observe groupings of families and genera that displayed circumboreal, Mediterranean, Pantropical, bipolar, and other types of distribution. There are two primary types of endemism in bryophytes. First, there are varieties that have just recently developed and haven't had enough time to spread widely. Second, there are those extinct old species that were formerly widespread but are now confined to only one nation. Several of them have a long evolutionary history, but due to regional restrictions they have remained endemic [3].

i. The territory of the western Himalayas: It reaches Kashmir from Nepal's western border. Little rain falls in this location. Between 6000 and 8000 feet in elevation, the most opulent vegetation may be found. Several indigenous genera and arctic species, such Sauteria alpina and S. spongiosa, are characteristics of the vegetation. There are also a few cosmopolitan or temperate characteristics that are typical to Europe. The genus Delavayella, which is only found in Almora and Darjeeling, is an intriguing plant.

ii. Eastern Himalayan Region, which encompasses a sizable portion of Assam and is made up of the easternmost mountains in Indian Territory separating India proper from Burma and China this region has a considerable amount of rainfall. Several plants, which are only found in this region of India and have a limited distribution elsewhere, have intriguing distribution patterns. Monoselenium tenerum is known from China, Japan, and Assam. Conocephalum supradecompositum is known from subtropical areas of Japan, the province of Shensi in China, and from Darjeeling. Jackielia Schiffn. has five species distributed throughout Japan, Java, Ceylon, Sumatra, Singapore, Tahiti, and Caroline Islands, with J. javanica var. carvifolia Schiffn. Being known from Darjee
iii. Hepatic development is not well adapted to the Punjab and west Rajasthan plains, a region with extremely little and variable precipitation. Just a few xeromorphic species, such those of Targionia, Plagiochasma, Riccia, and Asterella, may flourish in favorable environments. A total of 40 species are recognized, of which 26 are common to the western Himalayas, 18 to the eastern Himalayas, and 24 to South India. This region of the nation receives an average rainfall of 70 to 80 inches, but the hepatic vegetation is comparably lusher. The region serves as a gathering place for hepatics from northern and southern India. Riccia curtisii, Riella affinis, and Anthoceros crispulus are a few of the intriguing plants that are known to exist in this region.
iv. V. The west Coast area: This area is located between the Arabian Sea and the Western Ghats Mountain range. Heavy rainfall in areas like Augumbe, Kunduremukh, and Dodabetta supports luxuriant hepatic vegetation, and Augumbe in particular (rainfall of around 35 inches) is rich in epiphyllous liverworts. Cololejeunea, Diplasiolejeunea, Leptocolea, Microlejeumea, Rectolejeunea, etc., are a few of these that have a striking resemblance with their African relatives as well as the Mouflong forest in the Assam and Sikkim Himalayas. An intriguing pattern of distribution exists for Leptocolea. L. marginata and L. ocellata, known from America and Japan, also exist in South India. L. himalayensis, described from the western Himalayas, has been recorded from South Africa and likely presumably occurs in South India and the eastern Himalayas.

The Eastern Ghats, the Nilgiris, and the Deccan plateau make up this zone, which is located along the East Coast. There are around 31 species of liverworts there that are typical of Indo-Malayan nations, including those in Java, Formosa, Sumatra, the [4] Philippines, Luzon, Borneo, Siam, Caroline Islands, Nicobar, etc. The Deccan plateau, which is a meeting place for the vegetation of these two regions, has no particularly unique flora but does display species common to the Western and Eastern Ghats.

Bryophyte characteristics in general

Braun (1864) coined the word "Bryophyta," including algae, fungi, lichens, and mosses. In 1879, Schimper established the division Bryophyta. This word's definition is "plants that resemble moss" (Greek: Bryon = moss, Phyton = plant).

Bryophytes as Plant Kingdom Amphibians

The bryophytes occupy a position between the vascular cryptogams and the green Thallophyta (Algae) (Pteridophyta). Aquatic plants are those that grow in water, whereas terrestrial plants grow on land. You must have studied algae in aquatics. You will research the seed-bearing plants under terrestrial plants (spermatophytes).

There is a transitional zone between the land and the sea where plants may flourish in both ecosystems (water and land). These plants, which go by the name bryophytes, have effectively adapted to both land and water. Yet, since all of them need water for fertilization, it may be said that they are only partially suited to land conditions. [5] The majority of them need enough moisture for active vegetative development, and they cannot thrive in dry conditions. The bryophytes are referred to be the frogs of the plant world since they are totally dependent on external water to complete their life cycle.

Important Elements of the Bryophyte Life Cycle

Compared to the sporophytic generation, the gametophyte stage of the life cycle is the obvious and prominent one. The gametophyte is a tiny, highly developed, tissue-differentiated plant that exists on its own.

- Either a simple flattened thallus or a defined rootless leafy stem makes up the gametophyte plant body.
- The root, stalk, and leaves of the thalloid plant body are not distinct. It spreads out flat on the ground and is connected by rhizoids, which are branching or unbranched structures that resemble single or several cells of hair. In mosses, the plant body stands upright in leafy forms. It has a core axis with extensions that resemble leaves.
- The gametophyte stage of the bryophyte life cycle is dominant, much as it is for thallophytes. It has no connection to sexual reproduction and is autonomous.
- As fern and other higher plants have vascular tissues (xylem and phloem) present in their sporophytes and gametophytes, Tippo also referred to bryophytes as atracheata.
- A. Surface view of a tuberculate rhizoid, B&C Under a microscope, smooth-walled rhizoid and tuberculate rhizoid
- Reproduction
- Vegetative reproduction: Bryophytes are capable of vegetative reproduction. It happens in a variety of ways, including via the death and decay of the older plant parts, the development of apices, adventitious branches, fragmentation, tubers, gemmae, bulbils, primary protonema, and secondary protonema.
- Bryophytes' sexual reproduction is based on visibly different sex chromosomes.
- Oogamous sexual reproduction is a kind. The sex organs are multicellular and jacketed. The female sex organ known as the archegonium was initially discovered in bryophytes.

Fertilization

It occurs in the presence of water. The fertilized egg (zygote) remained within the archegonium's venter.

- **Zygote:** The zygote immediately goes through simple (miotitic) division after leaving the resting phase.
- **Embryo:** It proceeds through recurrent division to develop into an embryo, a multicellular entity that is not differentiated.
- **Sporogonium:** The sporophyte is created as the embryo undergoes further cell divisions and differentiation. A foot, a seta, and a capsule make up the object.

All of the sporophyte's nutritional needs are fulfilled by the parent gametophyte, on which it is permanently attached. Asexual reproduction is an issue of the sporogonium. It generates haploid meiospores that are not motile and spread by the wind. Since all meiospores have the same morphology, bryophytes are homosporous. After landing on an appropriate substrate, the unicellular haploid spores germinate and generate a juvenile filamentous or thalloid protonema, as in mosses, or a gametophytic plant immediately, as in Riccia and Marchantia. Bryophytes have a diplo-haplontic life cycle, where the haploid (Gametophytic) phase comes after the diploid (Sporophytic) phase.

Generational Transitions

The life cycle's alternating individuals are morphologically unique. Heterologous or heteromorphic refers to this kind of generational alternation. The diverse ways of living account for the differences between the two generations. [6] The sporophyte is either completely or partly reliant on the gametophyte, while the gametophyte is autonomous (Fig. 9.10).

Similarities between algae and bryophyta

1. Both bryophyta and algae have the presence of thalloid plant bodies.
2. Gametophyte is the predominant life cycle stage in both populations.
3. Plants in both categories are naturally autotrophic.
4. The chloroplasts in both groups include the pigments lutein, violaxanthin, xeoxanthin, alpha and beta carotene, and chlorophylls a and b.
5. Plastids containing pyrenoids are found in Anthocerotales and Chlorophyceae (green algae).
6. Starch is the preferred dietary component in both groups.
7. Vascular tissue is lacking in both categories, and the main component of cell walls is cellulose.
8. Flagellate and motile antherozoids with whiplash-style flagella are found in both categories.
9. A filamentous protonema that forms in the juvenile stage of mosses has structural similarities with algal filaments.

Differences between algae and bryophyta

1. Most bryophytes are terrestrial and thrive in wet, shaded settings, while most algae are aquatic.
2. Unlike algae, which have multicellular, filamentous, or pseudo-parechymatous plant bodies, bryophytes have multicellular thalloid or leaf-like plant bodies that are differentiated into rhizoids, axis, and lateral appendages.
3. Sexual reproduction is of the oogamous type in bryophytes, but it is of the isogamous, anisogamous, and oogamous types in algae.
4. The female sex organ in bryophytes is called Archegonium, whereas in algae, it is called oogonium.
5. The sex organ in algae is not covered by a sterile jacket, in contrast to bryophytes, where it is.
6. When the zygote in algae is released from the plant, it is still trapped in the archegonium in bryophytes.

7. Unlike algae, where zygote never develops into an embryo, zygote does grow into an embryo in bryophytes. Thus, Bryophytes have an embryo stage but algae do not.
8. Sporophyte in algae is independent of gametophyte, but it is reliant on it in bryophytes.
9. In bryophytes, the sporophyte is divided into the foot seta and capsule, but in algae, there is no evidence of this differentiation.
10. Whereas mitospores are often found in algae, they are missing in bryophytes.
11. Whereas the alternating of generation in algae is of the isomorphic type, it is heteromorphic in bryophytes.

There are similarities between pteridophytes and bryophytes.

1. Simple sporophytes of certain primitive pteridophytes (members of the Psilophytales) that lack leaves and roots may be likened to sporophytes of bryophytes.
2. Plants in both categories are archegoniate, and the archegonium structure is comparable.
3. A sterile jacket surrounds the antheridium in both groups.
4. Antherozoids are flagellate in both categories.
5. Water is required for fertilization in both groups.
6. The zygote develops into an embryo in both groups.
7. Psilophytales' terminal sporangia with columella resemble moss capsules.
8. The occurrence of heteromorphic alternation of generation distinguishes both groups.

Bryophyte and pteridophyte distinctions

1. The gametophyte stage of the life cycle is prevalent in bryophytes, while the sporophyte stage is prominent in pteridophyta.
2. Vascular tissue is missing in bryophytes, although it is found in pteridophyta.
3. Sporophyte in Pteridophyta is autotrophic and autonomous, but sporophyte in bryophytes is totally reliant on the gametophyte.

LITERATURE OF BRYOPHYTA

Several writers have assigned various classifications to the bryophytes. They are often classified into the Hepaticae and Musci groups. Anthocerotales were elevated to the rank of a class termed Anthocerotes by Howe (1899). Hepaticae, Anthocerotes, and Musci are the three groups into which he separated bryophytes.[7] In support of this approach, Campbell, Smith, and Takhtajan used the term Anthocerotae rather than Anthocerotes. Rothmaler (1951) proposed the following class names:

1. Hepaticopsida for liver diseases
2. Anthocerotes for Anthocerotopsida

Bryopsida for Musci

The International Code of Botanical Nomenclature has approved the new names Rothmaler proposed. Anthocerotopsida was the name proposed by Proskauer (1957) for the Anthoceropsida. Bryophyta are now divided into the following three classes:

1. Hepaticopsida
2. Anthocerotopsida
3. Bryopsida

Class Anthocerotopsida: Simple plant body, lobed thallus with or without midrib, dorsiventral, no internal tissue differentiation, archegonium develops from superficial cell, antheridium from hypobasal cell, long-lived sporophyte, presence of meristematic zone between cylindrical capsule and foot, seta absent, archesporium amphithecial in origin, dome-shaped arching over columella. Characters from the class Anthocerotopsida are found in the order Anthocerotales.

Members of the Bryopsida class, also called mosses

Gametophyte is the major life cycle stage. The body of the plant is separated into stem- and leaf-like components and is radially symmetrical. The stem has some tissue differentiation into the conducting strand and cortex. A filamentous protonemal stage and a leafy gametophyte form are the two types of the gametophyte. Monopodial branching is used. The rhizoids of moss leaves are multicellular and branching with oblique septa, and they have a midrib (costa). The stalking of sex organs. Sporophyte is a highly specialized and sterilized organism that is intricate and sophisticated. On a seta, sporogonium was raised. Around the columella, the spore sac takes the shape of a hollow cylinder. The capsule's lid opens it. Calyptra has a peristome and is well-developed.

The Thallose protonema, globular sporogonium, elevated pseudopodium on non-leafy gametophytic shoot, seta absence, columella roofed by the dome shaped spore sac, capsule opens by the separation of lid, calyptra present, and peristome absence are characteristics of the Subclass Sphagnidae of the Order Spagriales. Order Andeales, Subclass Andreaeidae Protonema with a ribbon-like form, an extended sporogonium raised on a pseudopodium, a columnella covered by the spore sac, a huge calyptra, a capsule dehiscing by longitudinal slits but with the valves remaining attached at the tip, and no peristome.

There are 12 orders in the subclass Bryidae, Protonema with filaments and Sporogonium perched on a seta Around the columella, the spore sac takes the shape of a hollow cylinder. The capsule's lid opens it. Calyptra is fully formed.

Order Buxbaumiales, Gametophyte is quite tiny and somewhat saprophytic; subclass Buxbaumidae. Sporophyte has reached complete maturity. Plants have two sexes. Male and female plants differ in size. Massive and oblique capsule. Gametophores are tall, perennial plants of the Dawsoniales family, which belongs to the subclass Polytrichidae. The leaf has a large, colorless base and a slender, green limb. The calyptra of the capsule is hood-shaped or cucculate. The beak of Operculum is distinctive. There are two air spaces around Archesporium. The peristome is made up of a ring of 32 or 64 firm, pyramidal teeth, the terminals of which are attached to the epiphragm, a thin, pale membrane, above.

BRYOPHYTES' IMPORTANCE FOR BOTH ECOLOGY AND BUSINESS

The most basic and rudimentary land plants, bryophytes were among the first to invade the terrestrial ecosystem. Between algae and pteridophyta, these plants are classified taxonomically. According to Schofield (1985), they [8] are typically represented by roughly 21000 species that are found all over the globe. The three groups of bryophyte are: Hepaticapsida (6000 species of liverworts), Anthocerotopsida (300 species of hornworts), and Bryopsida (mosses, 14000 species). Due to their ability to survive in a range of settings, they are exposed to biotic and environmental risks in varying degrees. Many secondary metabolites of various sorts are produced in their tissues as a defensive mechanism to deal with these unfavorable situations (Herout, 1990). Because of their tiny size, unnoticeable location in the ecosystem, and lack of economic value, bryophytes are of little benefit to the general population. Nonetheless, bryophytes have still served humanity well in a variety of ways.

Environmental Benefits of Bryophytes

Mosses and liverworts are often reliable indicators of the local ecology. The many kinds of forests are identified by the terrestrial bryophytes and other plants.

1. **Conditioning the soil**

Mosses are often utilized to improve soil. Mosses with coarse textures may hold more water, whereas mosses with delicate textures can hold more air. Rainfall causes mosses to assemble calcium, magnesium, and potassium. The soil may then gradually receive the discharged nutrients.

2. **Control of erosion**

Barbula, Bryum, and Weissia were discovered to be significant pioneer plants on new road banks, assisting in preventing soil erosion prior to the growth of bigger plants.

Atrichum, Pogonatum, Pohlia, Trematodon, Blasia, and Nardia have all been shown to be effective in Japan in halting river bank erosion.

3. **Fixation of Nitrogen**

In general, nitrogen is a nutrient that limits plant development. Bryophyte crusts that are rich in nitrogen-fixing bacteria Cyanobacteria may significantly increase soil nitrogen content, especially in soil from arid rangelands [9]. These Cyanobacteria sometimes coexist harmoniously with Anthoceros thalli.

4. **Bryophytes**

Are important for tracking changes in the Earth's atmosphere in pollution investigations. Hylocomium splendens was utilized in Finland as moss bags to monitor the presence of heavy metals near coal-fired power stations.

5. **UV Radiation**

The moss Bryum argenteum is used to measure the ozone layer's thickness over Antarctica (Hedenas 1991). With the ozone layer's depletion, UV radiation exposure has risen, and it also encourages this species to produce flavonoids.

6. **Indications of Radioactivity**

Bryophytes are useful for detecting radioactive buildup because they can trap minerals without harming thalli. Proposed using sphagnum to cleanse water containing radioactive elements due to its cation exchange activity.

Bryophyte Applications in the Economy

Formation of Peat

Peat's main ingredients are sphagnum and other mosses. Peat is the partly degraded plant matter that accumulates in bogs and is progressively compacted and carbonized by overlapping layers of decaying matter. As more deposits are added, this becomes harder and eventually reaches a significant thickness. Peat is a term for the deposits of compact, partly degraded, and carbonized dead plants [10].

Agent for Cleaning

Toxic waste has been cleaned up using bryophytes. To clean up manufacturing effluents comprising acid and hazardous heavy metal discharge, detergents, and dyes, sewage waste has sometimes been channeled via peat land. Sphagnum has also proved effective in removing microorganisms, perhaps as a result of the peat's antibacterial qualities [11][12].

CONCLUSION

The bryophyte plant either has a thalloid or leafy habit. Whereas leafy forms are divided into leaf, stem, and root-like structures, thalloid forms do not have leaf, stem, or root-like features. While bryophytes often have a global distribution, some of the genera and species do not, and some may even be endemic.

REFERENCES

[1] B. J. Harris, C. J. Harrison, A. M. Hetherington, and T. A. Williams, "Phylogenomic Evidence for the Monophyly of Bryophytes and the Reductive Evolution of Stomata," *Curr. Biol.*, 2020, doi: 10.1016/j.cub.2020.03.048.

[2] A. Horn *et al.*, "Natural Products from Bryophytes: From Basic Biology to Biotechnological Applications," *CRC. Crit. Rev. Plant Sci.*, 2021, doi: 10.1080/07352689.2021.1911034.

[3] J. Shaw and K. Renzaglia, "Phylogeny and diversification of bryophytes," *American Journal of Botany*. 2004. doi: 10.3732/ajb.91.10.1557.

[4] N. G. Hodgetts *et al.*, "An annotated checklist of bryophytes of Europe, Macaronesia and Cyprus," *J. Bryol.*, 2020, doi: 10.1080/03736687.2019.1694329.

[5] M. W. Chmielewski and S. M. Eppley, "Species-specific interactions in avian-bryophyte dispersal networks," *R. Soc. Open Sci.*, 2022, doi: 10.1098/rsos.211230.

[6] K. M. Davies *et al.*, "The Evolution of Flavonoid Biosynthesis: A Bryophyte Perspective," *Frontiers in Plant Science*. 2020. doi: 10.3389/fpls.2020.00007.

[7] M. W. Chmielewski and S. M. Eppley, "Forest passerines as a novel dispersal vector of viable bryophyte propagules," *Proc. R. Soc. B Biol. Sci.*, 2019, doi: 10.1098/rspb.2018.2253.

[8] M. Carriquí *et al.*, "Anatomical constraints to nonstomatal diffusion conductance and photosynthesis in lycophytes and bryophytes," *New Phytol.*, 2019, doi: 10.1111/nph.15675.

[9] M. Bourgouin, O. Valeria, and N. J. Fenton, "Predictive mapping of bryophyte diversity associated with mature forests using LiDAR-derived indices in a strongly managed landscape," *Ecol. Indic.*, 2022, doi: 10.1016/j.ecolind.2022.108585.

[10] S. Lett, M. C. Nilsson, D. A. Wardle, and E. Dorrepaal, "Bryophyte traits explain climate-warming effects on tree seedling establishment," *J. Ecol.*, 2017, doi: 10.1111/1365-2745.12688.

[11] F. de Sousa, P. G. Foster, P. C. J. Donoghue, H. Schneider, and C. J. Cox, "Nuclear protein phylogenies support the monophyly of the three bryophyte groups (Bryophyta Schimp.)," *New Phytol.*, 2019, doi: 10.1111/nph.15587.

[12] N. A. Soudzilovskaia *et al.*, "How do bryophytes govern generative recruitment of vascular plants?," *New Phytol.*, 2011, doi: 10.1111/j.1469-8137.2011.03644.x.

CHAPTER 12

MODERN SYSTEMS OF CLASSIFICATION OF BRYOPHYTES

Uzma Noor Shah, Assistant Professor,
Department of Life Science, School of Sciences, Jain (Deemed to be University), Bangalore, India
Email Id- ns.uzma@jainuniversity.ac.in

ABSTRACT:

The vascular cryptogams and the green thallophytes (algae) are separated by the bryophytes (Pteridophytes). The purpose of this course is to familiarize the pupils with the traits & division of bryophytes. Bryophytes are amphibious zone plants. They develop a texture that is practically brittle throughout the dry time. The normally dry, brittle thalli become green and become active to perform the regular activities of life as soon as the rainy season arrives.

KEYWORDS:

Alage, Bryophytes, Fertilization, Gametophyte, Thallus.

INTRODUCTION

Bryology is the study of bryophytes, which are mosses, hornworts, and liverworts together referred to as bryophytes. Even though these three kinds of species vary significantly from one another, they are sufficiently connected to merit a single word that encompasses all three. Thus, moss, liverwort, and hornwort are all examples of bryophytes. All of them are considered to be members of the Plant Kingdom. These are all spore-producing plants, not seed-producing plants, and none of them have flowers. Bryophytes are categorized hierarchically, just like any other living thing. Families are made up of [1] related genera, which are made up of related species, and so on. In moss plants, stems sprout leaves, and many varieties of moss produce solid-stalked spore capsules that emerge from the leafy section of the plant. The spore capsule will lack a stalk in other species. Hornworts don't have leaves. The majority of the plant is made up of a flat, greenish sheet that may have lobes or be slightly wrinkled. A thallose growth habit is the term used to describe this sheet-like shape. In hornworts, the capsules emerge from the thallose portion as thin, tapering "horns" or needles. A few immature capsules are rising from the thallose base of this hornwort's horns. These are mature capsules that are brown in color, as opposed to the photo's many immature but more advanced capsules that are seen in a hornwort colony. The two growth types of liverworts are thallose species and leafy species, the latter of which has leaves on stems similar to mosses. There are several techniques to make spore capsules, and Figure 1 shows the Classification of Bryophytes. The capsules of the thallose liverwort genus Riccia are embedded in the thallose sheet and are found in a few empty cavities. These are spore capsules that have opened and released the majority of their spores. The capsules are perched on stems in leafy liverworts and a few thallose liverworts [2].

Bryophytes have the following characteristics:

Habitat

- The plants often grow in wet, shaded areas. They live on land.

- But must have access to water to finish their life cycle. Bryophyta is consequently seen as the plant kingdom's equivalent of amphibians.
- The plant's body is a haploid gametophyte, which produces gametes.
- The plants are tiny and unnoticeable, measuring anything from a millimeter to at least 40 centimeters.
- The plant body may resemble a thallus, not differentiating into genuine roots, stems, and leaves (like Riccio, Marchantia, Pellia, etc.), or it may consist only of leafy branches. The leafy shoots are separated into stem-like central axes and leaf-like appendages, and they may be dorsiventral (like Porella) or upright (e.g. Funaria, Polytrichum etc.).

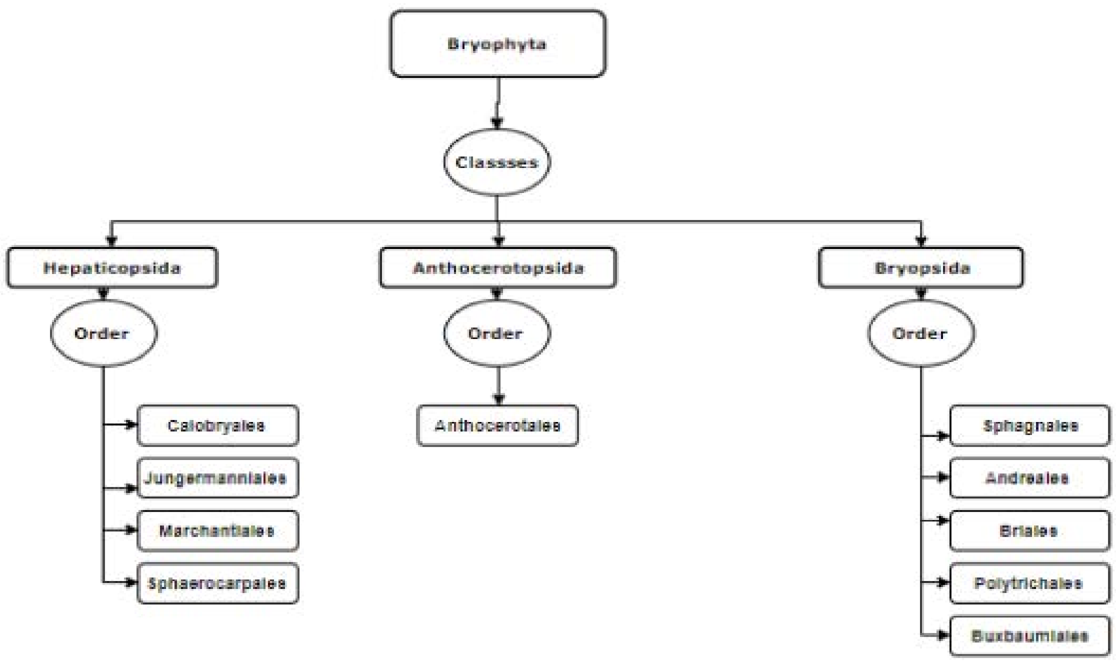

Figure 1: Illustarte the Classification of Bryophytes.

Bryophyte Characteristics and Classification

- Branching, multicelluar rhizoids that resemble roots are used to anchor the plant body to the substrate. There are no real roots at all.
- The plants have chloroplasts and are green. They grow on their own.
- Nevertheless, a few species, such Cryptothallus mirabilis (liverwort) and Buxbaumia aphylla (Mosses), are saprophytes and have a heterotrophic method of sustenance.
- There are no vascular tissues at all (xylem or phloem).
- Yet, certain mosses, like Polytrichum, have been shown to contain xylem-like hydroids that carry water and phloem-like leptoids that conduct assimilates.
- The phase of the life cycle that is most noticeable and independent of feeding is the gametophyte that carries gametes, which is involved with sexual reproduction.
- Reproduction
- Oogamous sexual reproduction is the norm. (i.e., the female gametes are huge and non-motile eggs, while the male gametes are tiny, motile antherozoids.)
- Complex multicellular jacketed sex organs create the gametes.

- Either the same person or distinct plants may produce both types of sex organs. Both are referred to as monoeicous and dioecious, respectively.
- Archegonia are the female reproductive organs whereas antheridia are the male reproductive organs.
- The antheridium has an ellipsoidal or club-shaped shape, however it may also be spherical. It may be divided into a body and a stalk. The stalk fuses with the tissue of the gametophyte. Antheridium's body contains a single layer of sterile cells along its outside. The androcytes, a collection of tiny, square or cubical cells, are surrounded by it.
- Biflagellate male gametes known as sperms are created by androcytes.
- Each antheridium produces a number of sperm. Each sperm typically has a tiny, slender, spirally curved body and two long, terminal flagella that resemble whiplashes.
- Archegonia are stalked, flask-shaped plants. The lower, bloated, sac-like section is known as the venter, while the top, thin and extended piece is known as the neck. Variable numbers of neck canal cells are enclosed by the neck, whilst a big egg and a ventral canal cell are enclosed by the venter.

Bryophyte characteristics and classification

Fertilization

For fertilization to occur, water is required. [3] The sperm is released when the mature antheridium bursts at its apex. The tip of the adult archegonium also opens at the same time as the axial row of neck canal cells, including the ventral canal cell, disorganizes. The competitive sperm makes it to the archegonia by swimming through a thin water coating, where it joins the egg. The zygote, or fertilized egg, is kept within the ventr and divides repeatedly to become an embryo. The gametes (sperms and eggs) are the last gametophytes generational formations[4].

DISCUSSION

The species of thallose liverwort known as [5], [6] Lunularia cruciata is well known. In flower pots and glasshouses, it may grow into sizable colonies. Nonetheless, there are considerably more leafy species than there are thallose species of liverworts, despite the fact that some of the thallose liverwort species are extremely noticeable. The stems and leaves of mosses and leafy liverworts may sometimes be rather short as well. The purpose of that section is to describe what a moss liverwort or hornwort looks like. There, you may learn about aspects that are visible to the unaided eye as well as some of the more minute details that a microscope makes visible. Bryophytes are categorized using a variety of characteristics. Important traits include I the thallus's external and interior structure.

- Types of rhizoids
- Scale types
- The location of the sex organs.
- Sporophyte structure and nature.
- The sporophyte's level of sterilization.

Sub-class. Andreaeobrya

This subclass contains just one family, the Andreaceceae, and one order, the Andreaeales. The Andreaea genus is significant. The distinguishing characteristics are as follows:

- The gametophores are readily fractured and fragile.
- The tissue differentiation in a plant's body is almost nonexistent.
- Typically, the leaves are broad, upright, and convoluted.
- The endothecium gives rise to the archesporium [7] and colonmella.
- IV. Subclass Eubrya (14,000 species; 650 genera):
- Three cohorts and fifteen orders have been created out of this subclass. This subclass includes the genuine mosses. The distinguishing characteristics are as follows:
- Gametophores have leaves that are more than one cell thick and have midribs on them.
- It has filaments, which is a protonema.
- The sporophyte has an extended, well-differentiated seta that forces the capsule out of the gametophore.
- The endothecium is the source of the sporogenous tissue.
- The columella and archesporium are both produced from the endothecium, but the columella does not overarch the archesporium; it extends all the way to the top of the capsule.
- Partitioned air gaps are found between the spore sac and the columella.
- The fully developed capsule has a multi-tissue complicated structure.
- An operculum at the capsule's tip opens it, and the peristome, which resembles a set of teeth, controls how the spores spread.

Order-Funariales (356 species; 26 genera): Characteristics

- The plants are tiny, terrestrial, and either annual or biannual in nature.
- The leaves are grouped in rosettes at the apex of the gametophyte and have prominent midribs.
- The operculum is not beaked, and the capsule is broad.
- The capsule's peristome is twofold and is divided into an inner and an outside portion that are referred to as endostome and exostome, respectively.
- This order consists of five families, the most significant of which is Funariaceae.
- 200 species in the family Funariaceae (9 genera):
- The leaves are one cell thick throughout, with the exception of the mid-rib area.
- The tiny mosses give the sustratum's surface a velvety texture.
- The calyptra, which has long beaks, quickly separates from the opercula of the capsules.
- The pyriform capsules are found on long, elongated setae.
- Order-Polytrichales: Identifying characteristics
- The gametophyte is tall and perennial.
- The top surface of the midrib of the leaves is covered with longitudinal lamellae, making them thin.
- The capsule has reached its end.
- In the inner zone of the amphithecium, a peristome is produced by a single annular sequence of cells.
- The peristome has 32 to 64 pyramidal teeth; their ends are still connected to a thin membrance above; the epiphragm covers the capsule's mouth.
- There is just one family in this order, the Polytrichaceae, which includes the significant genera Polytrichum and Pogonatum.
- Bryophytes' Adaptations to Land Habitat

- The earliest terrestrial plants are bryophytes. The evolution of bryophytes from algae is supported by evidence. Throughout the course of their evolution, they acquired specific adaptations to land life.
- Which are:
- The emergence of a tightly packed plant body coated with epidermis.
- The creation of organs like rhizoids that cling to surfaces and absorb water.
- Using airpores to absorb atmospheric carbon dioxide for photosynthesis.
- Jacketed sex organs, which protect reproductive cells from mechanical harm and drying.
- Zygote retention inside the archegonium.
- The production of many spores with strong walls.
- Spores being spread by the wind

Bryophytes: Plant-based amphibians

Since they need water to complete their life cycle, bryophytes are sometimes referred to as amphibians in the plant world. [8] In the animal world, the vertebrates that are amphibians by nature that is, able to live both on land and in water belong to the class Amphibia (Greek: Amphi = two or both; bios = life). Similar to terrestrial plants, most bryophytes are only partially adapted to land environments. They need enough water for their vegetative development and are unable to thrive during the dry season. Water is extremely necessary for fertilization and maturation of sex organs. They can't finish their life cycle without water. Bryophytes and Pteridophytes are considered to be amphibians of the plant world because of their intricate need on external water to complete their life cycle.

Bryophytes have apogamy and apospory

Bryophytes possess a remarkable potential for [9] regeneration. Each live cell in the thallus or a portion of the plant may regenerate the whole plant. Gametophytes emerge from a protonema formed by the sporophytic cells as they renew. Apospory refers to the regeneration of a diploid gametophyte from a sporophyte without the development of spores. On the other hand, a sporophyte may regenerate from a clump of cells formed by a gametophyte. Apogamy is the regeneration of a diploid sporophyte from a gametophyte without the development of gametes. Seldom do we find apogamy and aposory in the life cycle of bryophytes.

Scales and rizoids in bryophytes

Rhizoids

The anchoring and absorption functions of roots are carried out by the filamentous structures known as rhizoids in bryophytes, which lack roots altogether. Rhizoids may be multicellular and branching in foliose forms of Bryopsida or unicellular and unbranched in thallose forms of Hepaticopsida and Anthocerotopsida (such as Riccia, Marchantia, and Anthoceros) (e.g., Funaria, Polytrichum) [10]. Rhizoids with many cells have oblique cross walls. There are two forms of unicellular rhizoids: tuberculated and smooth-walled. Riccia and Marchantia are examples of members of the order Marchantiales, which have both forms of rhizoids, while Anthocerotales, such as Anthoceros, only have smooth walled rhizoids. Rhizoids are carried along the midrib on the ventral side of thalloid forms, but in foliose forms, they start at the base of the "stem." Rhizoids are not present in aquatic bryophytes, such as Riccia fluitans and Ricciocarpus natans.

Scales

Scales are missing in all bryophytes and are exclusively found in the Marchantiales. The scales are violet in color, multicellular, and just one cell thick. Since anthocyanin, a pigment, is present, they are violet in color. On the ventral side of the thallus, scales form. Young thallus of Riccia, for example, may have them placed in a single row. Targionia, on the other hand, may have them arranged in two rows on each side of the midrib. Marchantia, on the other hand, may have them arranged in two to four rows on either side of the midrib (e.g., Corsinia). In Marchantia, the scales come in two varieties: ligulate and appendiculate (split by a tiny constriction into two parts body and appendage). The scales in Riccia are ligulate. Scales cover the sensitive cells at the developing point and secrete slime to keep them wet. Several aquatic members of the Marchantiales lack scales, such as Riccia fluitans.

CONCLUSION

Bryophytes are a general term for mosses, hornworts, and liverworts. In addition to producing spores rather than seeds and lacking the vascular tissue present in ferns and "higher" plants, bryophytes need water to reproduce sexually. Bryophytes are divided into three groups: hornworts, liverworts, and mosses. The moss gametophyte generates gametangia by sexual reproduction. The male and female gametangia may be on different gametophytes (monoecious or homothallic) or on the same thallus (heterothallic or dioecious). A sterile jacket of cells is present in both the antheridium and the archegonium, which better guards the gametes from desiccation in the terrestrial environment. Following fertilization, the sporophyte emerges from the archegonium, receiving nourishment from the gametophyte as it develops.

Hornworts (Anthocerotophyta) feature irregularly shaped thalli, or lobed or branched bodies, whose tissue is not compartmentalized into organs [11]. On the underside of the thallus, guard cells develop. Under them, cavities occur that are often populated by cyanobacteria. The only hornwort species discovered in Iceland is the Carolina phaeoceros (Phaeoceros carolinianus). Its range is restricted to geothermal regions. Although they can form large masses in favorable habitats like moist, shaded rocks or soil, tree trunks or branches, and a few even grow directly in water, liverworts are peculiar little plants that resemble small, flat green patches attached to the ground. Liverworts are distinct in three ways. Their spore-shedding generation is not green and only survives a short time. Their spore capsules swell and the spores mature before the capsule's stalk starts to lengthen. Most have special structures known as oil bodies in their leaf cells. The two primary varieties of liverwort are: While thalloid liverworts, which are sheets of cells, lack leaves, leafy liverworts have leaves. They are referred to as complex thalloid liverworts if they are thick and have internal air spaces with pores to the outside [12]. They are referred to as simple thalloid liverworts if they are thin and lack pores or air holes. Liverworts' rhizoids are usually unicellular, and they lack specialized conducting tissues, cuticles, and stomata. In the majority of species, gametophytes develop straight from spores. The majority of haploid cells in liverworts (75%) contain nine chromosomes. Based on body shape, there are two categories of liverworts.

REFERENCES

[1] E. S. J. Harris, "Ethnobryology: Traditional uses and folk classification of bryophytes," *Bryologist*. 2008. doi: 10.1639/0007-2745(2008)111[169:ETUAFC]2.0.CO;2.

[2] A. V. Troitsky, M. S. Ignatov, V. K. Bobrova, and I. A. Milyutina, "Contribution of genosystematics to current concepts of phylogeny and classification of bryophytes," *Biochem.*, 2007, doi: 10.1134/S0006297907120115.

[3] H. J. During, "Ecological classifications of bryophytes and lichens," *Bryophyt. lichens a Chang. Environ.*, 1992.

[4] K. Peters, H. Treutler, S. Döll, A. S. D. Kindt, T. Hankemeier, and S. Neumann, "Chemical diversity and classification of secondary metabolites in nine bryophyte species," *Metabolites*, 2019, doi: 10.3390/metabo9100222.

[5] E. O. Campbell, "Problems in the origin and classification of bryophytes with particular reference to liverworts," *New Zeal. J. Bot.*, 1971, doi: 10.1080/0028825X.1971.10430230.

[6] K. Peters, G. Balcke, N. Kleinenkuhnen, H. Treutler, and S. Neumann, "Untargeted in silico compound classification — A novel metabolomics method to assess the chemodiversity in bryophytes," *Int. J. Mol. Sci.*, 2021, doi: 10.3390/ijms22063251.

[7] P. J. Hokkanen, "Bryophyte communities in herb-rich forests in Koli, eastern Finland: Comparison of forest classifications based on bryophytes and vascular plants," *Ann. Bot. Fenn.*, 2004.

[8] L. Mucina *et al.*, "Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities," *Appl. Veg. Sci.*, 2016, doi: 10.1111/avsc.12257.

[9] S. Ray and S. Bhattacharya, "Classification of Bryophytes," in *Manual for Bryophytes*, 2021. doi: 10.1201/9781003208372-2.

[10] N. Ruklani and S. Rubasinghe, "A Preliminary Survey of Bryophytes in the Central Province of Sri Lanka," *Ceylon J. Sci. (Biological Sci.*, 2013, doi: 10.4038/cjsbs.v42i1.5901.

[11] J.-P. Frahm, "Two Centuries of Systematics of Bryophytes - what will bring the Future?," *Arch. Bryol.*, 2012.

[12] 田悦，赵正武，刘艳 TIAN Yue, "Classification and ordination of bryophyte communities in alpine meadow of eastern Tibet," *Acta Ecol. Sin.*, 2022, doi: 10.5846/stxb202012183215.

CHAPTER 13

CLASSIFICATION, STRUCTURE AND REPRODUCTION IN ANTHOCEROTOPSIDA

Dr. S.K.Khatik, Assistant Professor,
School of Agricultural Sciences, Jaipur National University, Jaipur, India,
Email Id- skumar.patho@jnujaipur.ac.in

ABSTRACT:

You have researched the bryophytes' distinguishing characteristics, just like you did in the earlier sections. The gametophyte serves as the common plant body for the bryophytes group as a whole. The sporophyte is a relatively simple structure that lives entirely as a parasite on the gametophyte and lacks basic organs like leaves, stems, and roots. Absent are vascular tissues. You have already learned this much. We will learn about Anthocerotopsida in this unit. The other Bryophytes are different from this group in a number of ways. Between the Hepaticopsida and Bryopsida, two significant classes, the Anthocerotopsida occupy a middle position. Since the capsules produced by this group's members have little horn-like features that emerge from the thalli, they are often referred to as hornworts.

KEYWORDS:

Anthocerotopsida, Alage, Bryophytes, Fertilization, Gametophyte, Reproduction, Thallus.

INTRODUCTION

Anthocerotopsida's General Characters

There are 300 species in the six genera that make up the class Anthocerotopsida. The families Anthocerotaceae and Notothylaceae are included in the order Anthocerotales. The following are Anthocerotopsida's distinguishing characteristics:

- The body of the gametophytic plant is straightforward, thalloid, and dorsiventral.
- Rhizoids have straightforward, smooth walls. Ventral scales and tuberculate rhizoids are missing.
- The thallus's tissue is homogenous and not distinguished into a photosynthetic and a storage zone. Intercellular mucilage cavities, which open on the ventral side via a slit-like structure termed a slime pore, are present but air chambers and air-pores are not. Each thallus cell has a sizable chloroplast and an apparent pyrenoid inside of it.
- The thallus has imbedded sex organs. The antheridia are endogenous, which means that they arise from the hypodermal cells of the thallus on the dorsal side. In the antheridial chambers, the antheridia may form alone or in clusters.
- The archegonia are discovered on the dorsal surface of the thallus in a sunken state.
- The sporophyte has a long, cylindrical shape. Foot, meristematic area, and capsule make up this structure. It has an intercalary meristem, which allows it to keep developing all during the growing season. Since chlorophyll is present in the sporogonium wall, the sporophyte is somewhat autonomous. The columella is the core

sterile region, and sporogenous tissue and spores surround it. Amphithecium gives rise to sporogenous tissue. Pseudoelaters are elaters that do not have thickening bands.

Anthoceros

The world's temperate and tropical climates are home to over 200 different species of Anthoceros. Over 25 different species of the genus may be found in India. The majority of the plants thrive in damp, extremely gloomy environments. Certain species are growing on rotting wood, and they are found in thick patches in the cracks of damp rocks. [1] The three species, Anthoceros himalayensis, A. erectus, and A. chambensis, are widespread in mountainous areas from 5,000 to 8,000 feet high in Mussoorie, Kumaon, Chamba valley, and other locations. Munsyari and Dharchula reported by Anthoceros crispulus (Uttarakhand). South India has reportedly produced several species. The Anthoceros species may be either annual (such as A. erectus and A. punctatus) or perennial (e.g., A. fusiformis, A. himalayensis). Rhizoids are present but true roots are missing in the classification division of bryophyta.

- **Class:** Anthocerotopsida (1) Thalloid (2) Rhizoids are septa-free (3) each thallus cell typically contains a single, sizable chloroplast with a pyrenoid. Order-Anthocerotales: (1) The thallus' internal structure is uniform; (2) There are only smooth-walled rhizoids; and (3) Scales and tuberculate rhizoids are not present.
- **Family:** Anthocerotaceae (1) Erect, cylindrical capsule (2) Stomata on capsule wall (3) Archesporium forms from amphithecium (4) Elaters are multicellular and lack thickening bands. Genus Anthoceros (1) Cylindrical and upright capsule (2) Stomata on capsule wall

Form of a gametophyte

External Composition

The plant body is tiny, dorsiventral, prostrate, and dark green. The thallus has lobes that are somewhat split. The centre of the thallus is thick, although the midrib is not well defined. In contrast to the velvet-like dorsal surface of A. crispulus or the rough dorsal surface of A. fusiformis, the thallus of A. laevis is smooth. Along the middle line, unicellular, smooth-walled rhizoids are present on the ventral surface. Scales and tuberculate rhizoids are completely missing. A few bluish green dots are seen on the ventral side of the thallus, suggesting the presence of blue green algae (viz. Anabaena or Nostoc). With the aid of the lens on the bottom of the thallus, spots may be seen clearly.

Internal structure

The thallus has a straightforward internal structure. Little to no distinction is seen in the thallus tissue. The parenchymatous cells that make up the thallus are homogeneous, thin-walled, and many cells thick in the center. A separate and continuous epidermis with relatively tiny cell size exists. One oval chloroplast with a central pyrenoid resembling a green alga like Coleochaete is present in each thallus cell. The chloroplast and the nucleus are still rather close. The superficial cells' chloroplasts are longer than those of the other cells'. Apart for Selaginella, no other member of the group of embryophyta has a chloroplast containing pyrenoid. Air chambers and air holes are not present, but a hand lens may make out tiny, spherical, blue green dots on the lower ventral side of the thallus. These spots are mucilage-filled chambers that have slime pores on the ventral side that allow them to open. These holes are created when neighboring epidermis cells partially separate from one another. Endophytic Nostoc colonies are [2] usually seen in these mucilage cavities. These Nostoc colonies and thalli have no mutualistic interaction. Nostoc may exist as a space parasite in the Anthoceros thalli.

A single apical cell with two lateral, one dorsal, and one ventral cutting faces often forms the thallus as it expands. The dorsal and ventral face derivatives contribute to the thallus' thickness, while the lateral face derivatives contribute to the thallus' lateral expansion. A set of apical cells have been seen to drive the growth of A. erectus and A. himalayensis.

Reproduction

- Vegetative reproduction and sexual reproduction are both used for reproduction. Plant reproduction, first: Vegetative reproduction occurs in a variety of ways, including:
- By the gradual death and decay of the thallus: The vegetative propagation occurs via the increasing death and decay of the posterior section of the thallus, which reaches the point of dichotomy, the lobes become divided, and each lobe develops into an independent thallus. Yet, compared to Riccia and Marchantia, Anthoceros uses this technique less often.
- By tubers: Under adverse conditions, the thallus thickens in a number of locations along the edge in several species of Anthoceros (A. laevis, A. tuberosus, A. hallii, A. pearsoni, and A. himalayensis). Tubers are the name given to such peripheral thickenings. These structures are perennial tubers. They remain alive despite the drought. As the proper circumstances return, each tuber develops into a thallus.
- By gemmae: Gemmae are reported to form on the thallus edge in certain species of Anthoceros. A. glandulosus, A. formosae, and other species have reported producing gemmae. As in Marchantia, these gemmae develop into new gametophytes.
- Through persistent growing apices: In the summer, species like A. fusiformis and A. pearsoni entirely dry out, leaving growing apices with surrounding tissues. These apices are affected by the drought. These apices grow into new thalli when ideal circumstances arrive.

A sexual relationship

The Anthoceros species may be heterothallic or dioecious (A. fusiformis, A. punctatus) or homothallic or monoecious (A. fusiformis, A. punctatus) (A. himalayensis). Protandrous monoecious species develop their antheridia before archegonia. Antheridia and archegonia, the sex organs, are located imbedded on the dorsal side of the thallus.

Antheridium

Creation of the antheridium: The antheridial chambers, which are closed cavities, are where the antheridia are produced, either individually or in groups. It is an endogenous process. Towards the developing apex, a thallus dorsal superficial cell splits periclinally to produce two daughter cells. The lower daughter cell serves as an antheridial initial, while the higher one serves as the roof initial. Hence, unlike other bryophytes, where the antheridial beginning is superficial, this one is endogenous. The area between the roof initial and antheridial initial eventually fills with mucilage. The mucilage cavity eventually grows to equal the size of the antheridial chambers. The growth of an antheridium has nothing to do with the roof beginning. It repeatedly separates anticlinally and periclinally, resulting in two layers of the antheridial chamber's ceiling. The antheridial beginning might grow into a single antheridium or a collection of antheridia simultaneously. In A. pearsoni, as well as sometimes in A. himalayensis, a solitary antheridium forms. Several antheridia grow in an antheridial chamber in A. erectus, claim Mehra and Handoo (1953). Here, the antheridial initial undergoes several anticlinal cell divisions, resulting in a large number of cells, each of which produces an antheridium. The following is an antheridium's future development:

Four cells are created when the antheridial beginning is divided twice by vertical walls that connect at right angles. Another transverse division follows, creating two layers with four cells each. The bottom tier's stalk cells split along transverse walls to create the multicellular stalk of the antheridium. The body of the antheridium is composed of the cells in the top layer. The higher tier's four cells divide transversely to produce eight cells, or the octant stage. Eight outer primary jacket cells and eight inner primary androgonial cells are produced by the periclinal division of all the cells of the octant stage. Creating a single layer of jacket, outer main jacket cells divide anticlinally. A mass of androcyte mother cells is created by the repetitive division of the parent androgonial cells. Two androcytes are produced by the diagonal [3] division of each androcyte mother cell. Each androcyte changes into a biciliate antherozoid that resembles a spindle.

Structure and dehiscence of mature antheridium:

The adult antheridium has a stalk and is fashioned like a club. The stalk of the antheridium may either be made up of a mass of cells (A. laevis) or four rows of cells (A. erectus and A. punctatus). There is a single layer of jacket covering the antheridium itself. Many androcytes that transform into antherozoids are present within the jacket. The ceiling of the antheridial chamber disintegrates during antheridium maturity, exposing the antheridia to the environment. The antherozoids then travel outdoors as the antheridia absorb water and rupture at their apical ends. At the antheridium's opening, the androcytes emerge as a smokey mass. They change into the antherozoids in a short period of time. The antherozoid is biciliate and spindle-shaped. The body's anterior end is where the cilia are connected. With the aid of their flagella, the antherozoids move through the water.

Archegonium

The creation of archegonium

On the dorsal side of the thallus, archegonia begin to form in an acropetal pattern. Archegonium similarly starts to grow from a single surface cell. This cell becomes noticeable and serves as the archegonial starting point. An inner main stalk cell and an outer primary archegonial cell are created from this archegonial beginning by a transverse wall. Yet, according to Mehra and Handoo (1953), the archegonial initial performs its fundamental archegonial cell function right away. Three periclinal divisions that cross in the main archegonial cell result in three jacket initials that encircle an axial cell. The axial cell splits transversely into two almost identical cells. The higher cell splits once again into a top cover initial and a lower primary neck canal cell, with the lower one becoming the main ventral cell.

As the main neck canal cell continually divides to generate a row of 4-6 neck canal cells, the cover initial develops a rosette of four cover cells [4]. The main venter cell splits transversely once, resulting in the formation of two cells: an egg and a ventral canal cell (oosphere). The transverse wall divides the three jacket initials into two layers with three cells on each tier. Six cells are formed when the cells in the higher layer divide anticlinally. Six vertical rows of cells make up the neck wall or neck. Since that the archegonium is ingrained in the gametophyte tissue, the continued growth of the jacket is difficult to see. The neck cells of the thallus blend in with the surrounding vegetative cells. The venter wall is created by the transverse and vertical divisions of the cells in the lower tier.

The mature archegonium's structure

The cover cells extend above the surface of the thallus, while the mature archegonium is entrenched in the dorsal surface. The narrow cavity of the neck is filled by an axial row of 4-6 or more neck canal cells, and the neck is made up of six vertical rows of neck cells. There is a huge egg and a rather tiny ventral canal cell in the bottom inflated ventr.

The venter canal cell and neck canal cells gelatinize as the archegonium matures. As a result, a mature archegonium has the form of a flask, lacks ventral canal cells and neck canal cells, and has an egg (oosphere) in its ventral region. There are four cover cells at the tip of each archegonium.

Syngamy (fertilization):

The cover cells at the tip of the archegonium detach prior to fertilization. The ventral canal cell and the neck canal gelatinize to create a mucilagenous mass. The tip of the archegonium is where the mucilage gathers. Chemotactically, the antherozoids are drawn to the area. Several antherozoids enter an archegonium's mouth via the medium of water. In the end, one antherozoid enters the egg, and fertilization occurs. A zygote (oospore), a diploid that results from the union of the male and female nuclei, is produced; this marks the start of the sporophytic stage.

Sporophyte

Development of the sporophyte: Upon fertilization, the zygote grows larger, fills the venter of the archegonium entirely, and secretes a cellulose wall around it. Vertical division marks the zygote's first division. Yet sometimes it could be transverse. The initial vertical division produces two almost equal daughter cells as a consequence. Now two cells divide a four cell embryo transversely forms. The top two cells are either bigger or these four cells are all the same size. Once again dividing vertically, these cells give rise to an eight-celled embryo called an octant. Cells are organized in two levels of four cells each at the octant stage.

The sporophyte's continued development reveals variety across species [5]. The octant only has two tiers in A. erectus; the bottom tier creates the foot, while the higher tier gives rise to the capsule. In A. gemmulosus, a transverse wall divides the cells of one of the two tiers, resulting in the formation of three tiers with four cells each. The foot is formed by the bottom-most layer, while the capsule is formed by the top two levels. In the four-tiered embryo of A. crispulus, cells from both tiers of the octant divide transversely. The foot develops from the cells of the lowest two layers, whereas the capsule develops from the cells of the top two tiers.

The embryonic cells responsible for developing the foot divide often and irregularly, resulting in the formation of the bulbous foot, which is made up of cells with thin walls and vacuoles. The foot's lowermost cells generate small rhizoid-like projections that increase the absorptive surface available to the growing sporophyte for sucking nourishment from the gametophyte. An embryo's top layer or tiers of cells that would eventually form the capsule divide periclinally, dividing the inner from the outer and the central from the amphithecium. The sterile columella develops from the whole endothecium. The columella of the developing sporophyte has four vertical rows of sterile cells, but as it grows, it expands to sixteen rows. According to Bhardwaj (1958), the columella of A. gemmulosus has 36 to 49 vertical rows of cells. The amphithecium separates periclinally, resulting in an inner fertile layer of archesporium and an outside sterile layer of jacket initials.

The 4 to 6 layers capsule wall is created by periclinally dividing the jacket initials several times. The epidermis becomes a single layer from the outermost layer. The cells of the epidermis are cutinized. The epidermis has regular stomata with guard cells. The parenchymatous inner cells of the jacket typically have two chloroplasts in place of the one chloroplast found in gametophytic cells, though this number can vary. However, these chlorophyllous cells assist in the food's synthesis. The archesporium, which overarches the columella's rounded apex and may or may not extend to its base, is made up of the inner cells of the amphithecium. The archesporial layer then divides periclinally, resulting in two or more layers of archesporium or sporogenous tissue in the mature capsule.

The archesporium is only ever one layer thick in some species (such as A. erectus), but it can be two, three, or even four layers thick in A. pearsoni and A. himalayensis. All of the cells in sporogenous tissue are small, rectangular, and densely cytoplasmic in their early stages. The cells in the apical part mature before the basal cells do, according to the basipetal sequence in which they develop. At maturity, the archesporium or sporogenous tissue differentiates into two types of cells: I sporocytes (spore mother cells), which are large, spherical or oval fertile cells with dense cytoplasm and larger nuclei; and (ii) sterile cells (elater mother cells), which are smaller in size and have a nucleus that is relatively small compared to their size. The juvenile capsule has about equal numbers of the two kinds of cells, which are organized in regular alternating rows.

Yet as the capsule develops, they mix. Each spore tetrad is produced by the reduction division of the spore mother cells. The sterile cells quickly divide transversely or obliquely to form 1–4 celled simple or branching elaters, which retain their thin walls and protoplasmic contents as they develop. The pseudoelaters of Anthoceros are named so because they lack thickening bands. The pseudoelaters act like actual elaters and aid in the dehiscence of the capsule. They seem to have a nutritional role in the early stages. After the differentiation of the jacket, archesporium, and columella in the capsule, the sporophyte's apical growth stops. An intercalary meristem separates at the base of the capsule during this stage, and this meristem is in charge of the capsule's further development.

The calyptras or involucre, a protective covering, covers the immature sporophyte of Anthoceros. It mostly grows from the gametophyte tissue that surrounds the archegonium. Early on, the calyptra grows at a similar rate as the sporophyte, and the young sporophyte is entirely encircled by the involucre. The sporophyte then develops more quickly and pushes through the involucre. Involucres or calyptras appear as a collar at the base of mature sporophytes in this manner.

Adult sporophyte structure

Exterior architecture on the dorsal side of the thallus, there is an elongated structure known as the mature sporophyte. The capsules emerge as little horny structures from the thalli. They typically measure between two and three millimeters [6]. Nonetheless, some species are known as "hornworts" because of their horny look and grow from five to fifteen centimeters in height. The sporophyte's base is encircled by an involucre that resembles a collar. The newborn sporophyte is green, but as it matures, it progressively changes from the apex to the base to a dark yellow or black tint. An upright, thin capsule and a bulbous foot make up the adult sporophyte. While there isn't a clear seta, there is an intercalary meristematic zone between the foot and the capsule. The base of this meristem constantly contributes new tissues to the capsule.

The foot, or basal bulbous portion of the sporophyte, is made up of vacuolated parenchymatous cells. In some species, the foot's surface cells resemble palisades, whereas in others, some of these cells lengthen and develop into haustoria in the gametophyte's surrounding tissue. For the growing sporophyte, the foot takes nutrients and water from the gametophyte. Parenchymatous cells are arranged in 4-6 layers to make up the capsule wall. Elongated cells make up the epidermis, the skin's outermost layer. The epidermal cells are cutinized on the outside. In various locations, stomata pierce the epidermis. Like those of higher plants, these stomata feature guard cells. The chlorophyllous cells' intercellular gaps are where the stomata open. Each cell typically has two chloroplasts. As a result, the sporophyte is able to produce nourishment on its own. Yet during its whole existence, the sporophyte depends on the thallus for the delivery of water and other nutrients. There are two to four shallow grooves in the epidermis at the apical portion of the capsule.

These grooves cause the capsule to dehisce. The sporogenous tissue, which is shaped like an archesporial zone, lies between the jacket and the columella. In contrast to liverworts, Anthoceros' sporogenous tissue forms a dome-shaped overhang of the columella. In a basipetal sequence, Archesporium develops. In the base of the capsule, the archesporium is undifferentiated and single-layered, while in the top part of the capsule, the spore tetrad and pseudoelaters are organized in regular alternate blocks. Elaters are made up of 1-4 atypically shaped cells and may be simple or branching. In certain species, animals only have one cell. Anthoceros' elaters are distinguished by the lack of thickening bands. The capsule's core, almost full length sterile region is called the capsuleella. It is made up of 16 vertical rows of elongated cells with thick walls. The primary purpose of the columella is to support the elongated, delicate capsule mechanically. Moreover, it aids in spore spreading. The elongated cells of the columella may also act as a tissue that conducts water under specific circumstances.

Decomposition of the capsule the sporogonium's tip matures and changes color to yellow, black, or dark brown. More or less, the loss of water determines how quickly the capsule dehisces. In this method, the dry environment aids in the capsule's dehiscence. The capsule's tip area is where the dehiscence first appears. A little longitudinal slit first emerges; it then becomes larger and extends toward the base. Consequently, depending on the species, the capsule wall divides into two or four valves. At first, the valves are still together at the tip, but as they twist and dry, they become disjointed, revealing the spores and elaters. The mature spores at the top are released by hygroscopic movement of the pseudoelaters. The wind carries the released spores from one location to another.

The spore and how it grows: The mother cell of the gametophytic generation is the haploid spore. The spores are discovered to be organized in tetrads at early stages. They are scattered after being cut off from one another. Each spore has two wall layers and is about spherical.

Exine and Intine are the names of the inner and outer wall layers, respectively. Although the exine is fairly thick and ornate, the intine is smooth and narrow. The mature spores might be yellow, brown, dark brown, or even black, depending on the species. A solitary nucleus, a colorless plastid, a few oil droplets, and feeding material are all present in each spore. The spore either germinates right away after being liberated, or it rests for many weeks to several months before germination. The exine (exospore) ruptures along the triradiate ridge, and the intine (endospore) emerges through the slit that is created as a result in the shape of a long germ tube.

Young gametophyte development: The spore's contents move into the germ tube. In the germ tube, the spore's colorless plastid changes to green. At the apex of the germ tube, two cells are differentiated by two consecutive transverse divisions. At the head of the germ tube, each of these cells divide by two vertical walls that are at perfect angles to one another to produce an 8-celled octant. The term "sporeling" refers to this 8-celled structure. The octant's four distal cells serve as the apical meristem. A new gametophyte is created as a consequence of the action of these cells.

Form of a gametophyte

Exterior structure: The thalloid, dorsiventral, slightly lobed, slender, fragile gametophytic plant body. The thallus is often lobed and has a light green or yellowish green tint.

Internal Organization: When the thallus is cut open, there is no evidence of internal tissue differentiation. It is 6 to 8 cells thick in the center, gradually becomes thinner toward the edges, and is just 1 cell thick at the very edges. As comparison to the cells in the top and lower epidermal layers, the cells in the intermediate area are twice as large. The chloroplasts of superficial cells are often lens-shaped and bigger than those in other cells. One substantial pyrenoid may be found in each chloroplast. All Notothylas species have mucilage-filled intercellular spaces that often house the blue-green alga Nostoc. Narrow openings in these chambers provide access to the ventral surface. Nevertheless, N. javanicus's thallus is solid and devoid of any blue-green alga colonies. A single apical cell initiates the thallus' apical expansion.

Reproduction: It happens via sexual and vegetative means.

Vegetative reproduction: The techniques used for vegetative reproduction are the same as those we learned about in Anthoceros. The older or posterior portions of the thallus gradually deteriorate and die, causing the vegetative reproduction to occur. The apical lobes detach and each mature into a new individual when the decay process comes close to the tip of the thallus. The surface cells may thicken at the gametophyte edges and form a corky layer. While other parts of a thallus die during drought, these structures, known as tubers, continue to exist. Each tuber grows into a new thallus as soon as ideal circumstances arrive.

Sexual reproduction: Both homothallic (monoecious) and heterothallic species are possible (dioecious). Monoecious and protandrous species include N. indica, N. chaudhurii, and N. levieri (i.e. antheridia mature before archegonia).

Antheridia: The antheridia are created close to the growth point and develop endogenously on the dorsal side of the thallus. Notothyla's antheridium [7] development resembles that of Anthoceros. They develop in groups of two to six and are contained in the antheridial chamber.

The short multicellular stalk that connects the antheridium, which is an oval or globose structure, to the floor of the antheridial chamber. A mass of anderocytes is enclosed in a single-layered sterile jacket that covers the antheridium's body. Every androcyte changes into biflagellate and uninuleate antherozoids.

Archegonia: At the developing apex of the thallus, the surface cells give rise to archegonia. Archegonia are lodged in the thallus' dorsal surface and are sessile. Similar to Anthoceros, the adult archegonium has a neck and a venter. Six vertical rows of neck cells, which surround 3-5 neck canal cells, make up the neck. On the dorsal surface of the thallus, a rosette of four cover cells is seen near the tip of the neck. An egg and a ventral canal cell are present in the venter. Archegonium develops in a manner similar to Anthoceros.

Fertilization: For fertilization to occur, water is required. The divided cover cells allow the antherozoids to enter the archegonim via a water-based media. The egg is eventually penetrated by one of the antherozoids, and fertilization occurs. A zygote is created when the male and female nuclei combine (oospore).

Sporophyte: The zygote grows in size and fills practically the whole ventral chamber after fusing with the egg from the antherozoid. Many species have varied stages of growth and structures in their adult sporophytes. Both vertical and transverse divisions of the zygote are possible. In N. javanicus, N. levieri, and N. breutelli, it is vertical. The zygote divides transversely in the Nigella sativa and Nigella orbicularis species. If the first division occurs vertically, a transverse division occurs next, resulting in the formation of four cells. At a right angle to the initial vertical division, the zygote's third division is vertical. Hence, two levels of four cells each are used to create an eight-celled embryo. The three-tiered embryo is produced by a transverse division in the cells of the top tier. The highest layer of the three tiers, whether the initial division is vertical or transverse, creates the capsule and seta or meristematic [8] zone, while the lowest two tiers form the foot in both varieties. A core endothecium and a peripheral amphithecium are formed when the cells in the top layer divide periclinally. The sporophyte's subsequent development varies, and the species of Notothylus may be divided into the following three groups:

a. Types of colombellates: The amphithecium splits periclinally to generate an inner and outer layer in N. indica and N. orbicularis. The outer layer develops into the capsule wall, while the inner layer becomes the archesporium. The columella is derived from the whole endothecium. In these species, the sporogenous tissue solely arises from an amphithecium similar to that of Anthoceros.

b. In-between species: These species serve as a connection between species that are columellate and others that are not. For instance, the endothecium often develops into a regular columella in N. javanicus a columellate species, but sometimes it is much diminished and limited to the basal section of the capsule, and in the top part the endothecium creates fertile sporogenous cells. Whereas the endothecium develops into the archesporium in N. [9]breutellii (a non-columellate species), it often generates sterile tissue near the end of development, leading to a smaller columella.

CONCLUSION

In India, there are 25 species of Anthoceros and 5 species of Notothylas. Rhizoids are unicellular, smooth-walled, and unbranched; tuberculate rhizoids and scales are absent; the thallus is slender, dorsiventral, and has an imprecise midrib. All of the thallus' cells are photosynthetic, and each one has a sizable chloroplast with a discernible pyrenoid within it. There are both monoecious and dioecious species of Anthoceros and Notothylas. Endogenous antheridia grow within a closed antheridial chamber on the dorsal aspect of the thallus; the stalk may be thick or thin, the body jacket is one layer, and the antherozoid is biciliate. Archegonia are implanted in the thallus' dorsal surface, and their neck is made up of six rows of cells that run vertically; the venter wall is one layer thick. Anthoceros has 4-6 or [10]more neck canal cells than Notothylas, which has 3-5. In Anthoceros, the columella, archesporium, and endothecium all develop from the amphithecium, which also creates the capsule wall. In the case of Notothylas, amphithecium and endothecium form, but the sporophyte's future development differs and the species might be columellate or non-columellate.

REFERENCES

[1] H. Sasongko, Z. Salamah, and U. Nurjanah, "Inventory and Characterization of Mosses Diversity (Bryophyta) in Sewu Temple Yogyakarta," 2020. doi: 10.2991/absr.k.200807.039.

[2] S. K. Singh and H. A. Barbhuiya, "Frullania evelynae (Frullaniacae, Marchantiophyta) - a very rare species from Mizoram, India," *Taiwania*. 2011.

[3] K. M. y D. R. Montoya, "La familia Lejeuneaceae (Hepaticopsida) en Cuba," *Bryophyt. Divers. Evol.*, 1992, doi: 10.11646/bde.6.1.19.

[4] H. Kurschner, B. Papp, and H. Akhani, "New records to the bryophyte flora of Iran studies on the flora and vegetation of the Golestan National Park, NE Iran IV," *Nov. Hedwigia*, 2000, doi: 10.1127/nova/71/2000/509.

[5] S. R. Germano and K. C. Pôrto, "<p>Floristic Survey of Epixylic Bryophytes of an Area Remnant of the Atlantic Forest (Timbaúba - PE, Brazil). 1. Hepaticopsida (except Lejeuneaceae) and Bryopsida</p>," *Bryophyt. Divers. Evol.*, 1996, doi: 10.11646/bde.12.1.5.

[6] O. Yano, "Briófitas Da Ilha De Maracá, Roraima, Brasil," *Acta Amaz.*, 1992, doi: 10.1590/1809-43921992224539.

[7] S. García Martínez *et al.*, "Bryophyte diversity in the Montes de María, Colosó (Sucre, Colombia)," *Colomb. For.*, 2016, doi: 10.14483/udistrital.jour.colomb.for.2016.1.a03.

[8] L. Šarčević–Todosijević and M. Šarčević, "Taxonomic and Biogeographical Analysis of Bryophytes in the Coastal Area of the Ukrina River (Bosnia and Herzegovina)," *АГРОЗНАЊЕ*, 2018, doi: 10.7251/agren1801017t.

[9] K. C. Pôrto, M. de F. G. da Silveira, and P. S. de A. Sá, "Briófitas da caatinga 1: Estação Experimental do IPA, Caruaru - PE," *Acta Bot. Brasilica*, 1994, doi: 10.1590/s0102-33061994000100008.

[10] D. M. Vital and S. R. Visnadi, "New records and notes on Brazilian Hepaticopsida," *Bryologist*, 1994, doi: 10.2307/3243352.

CHAPTER 14

CLASSIFICATION, STRUCTURE AND REPRODUCTION IN HEPATICOPSIDA

Dr. S.K.Khatik, Assistant Professor,
School of Agricultural Sciences, Jaipur National University, Jaipur, India,
Email Id- skumar.patho@jnujaipur.ac.in

ABSTRACT:

You examined the bryophytes' distinctive characteristics in the previous unit. This category contains non-vascular cryptogams, in which the zygote undergoes mitosis and develops into an embryo. Gametophyte provides the sporophyte (embryo) with food and care. These belong to the plant kingdom's amphibian species. In India, the Himalayas are home to a large population of liverworts. They thrive in regions with plenty of rain. The quantity of rainfall is directly proportional to the number of species and individuals within each species.

KEYWORDS:

Anthocerotopsida, Alage, Bryophytes, Gametophyte, Hepaticopsida, Reproduction, Thallus.

INTRODUCTION

There are about 280 genera, 6 orders, and 9,500 species in this class. The following traits best describe the group. The gametophyte, which is independent, dorsiventral, and thalloid or foliose, is the major plant body. The plant body is prostrate, lobed, and dichotomously branching in thalloid forms. In foliose forms, the central axis has two or three rows of leaf-like structures. These flat, leaf-like shapes. Many unicellular, unbranched, smooth-walled, tuberculate rhizoids and scales are present on the ventral side of the thallus. The gametophyte's anatomy is either straightforward or made up of a variety of tissues. Many chloroplasts exist in photosynthetic cells, but pyrenoids are absent. On the thallus, the sex organs are located in the dorsal or terminal position. From a single surface cell, they grow. The sex organs of thalloid liverworts are either stalked or embedded in the thallus (such as in Riccia) [1] (e.g., Marchantia). They are usually stalked in foliose shapes. The sporophyte may be straightforward (e.g., Riccia), represented by a capsule alone, or differentiated into a foot, seta, and capsule (e.g., Marchantia). The sporogenous cells arise from the endothecium in each instance. Riccia is an example of sporogenous tissue that exclusively produces spore mother cells, or it may develop into fertile spore mother cells and sterile elater mother cells (e.g. Marchantia, Pellia).

Riccias/Classification

- Division-Bryophyta
- Lack of true roots
- Multicellular antheridia and archegonia
- Absence of vascular tissue
- The life cycle includes an embryonic stage.
- Class-Hepaticopsida

Rhizoids are unicellular, there are no pyrenoids in the chloroplasts, and the capsule lacks a columella.

Order:

(1) Marchantiales
(2) Scales are present
(3) Existence of two different rhizoids kinds

The Ricciaceae family (i) Simple air holes, the presence of sex organs in the mid-dorsal groove, a sporophyte that lacks a foot or seta, and almost all sporogenous tissue cells that divide into spores round out the list of other characteristics. Scales on the edges and vertical, unbranched assimilatory filaments are characteristics of the genus Riccia. This genus has over 130 species, which are [2] found all over the globe in both tropical and temperate climates. The thallus mainly grows on wet, shaded rocks and damp soil. An aquatic species called Riccia fluitans floats on still or gently moving water.

A total of 33 different Riccia species have been identified in India. The species has been discovered in the plains and in the highlands. In the East and West Himalayas, riccia billardieri may be found up to 900 meters in elevation. Several locations in Uttrakhand have reported sightings of the aquatic species R. fluitans. India is the only place where R. pathankotensis, R. discolor, R. melamspora, R. robusta, and R. cruciate are found.

Gametophyte

Thallus's external structure:

The gametophyte is a flat, prostrate, rosette-like, dichotomously branching, dorsi-ventral structure that grows in wet soil or other common locations. It is deep green in color. Thallus branches range in form from linear to wedge-shaped. Due to the existence of numerous dichotomies adjacent to one another in terrestrial forms, the plant often adopts a classic rosette shape. The thallus is 5-7 mm long and 1-3 mm wide on average.

Each branch of the thallus has a longitudinal groove on the dorsal side. There is a midrib on the dorsal surface of each branch of the thallus. It typically extends all the way up to the thallus's tip. The midrib terminates with an apical notch, which is a depression. This notch contains the growth point. A row of the one-celled, thick scales may be seen on the ventral surface of the thallus. At the thallus border, the multicellular, pink or violet scales are grouped in a single row. They have a pink or violet tint because anthocyanin pigments are present.

Scales converge in the apical area to shield the growth tip. The habitat determines the scales' degree of persistence and size. Thallus often has large, durable scales in dry environments and tiny, fleeting scales in wet terrestrial habitats. Scales in R. crystalline are either nonexistent or very minimal. The ventral side of the thallus also has rhizoids. The rhizoids serve as the roots' functional equivalent by aiding in anchoring and absorbing nutrients and water from the substrate. Rhizoids come in two different varieties: smooth walled rhizoids, which have stretched and smooth inner and outer walls, and tuberculate rhizoids, whose inner walls develop peg-like ingrowths. The rhizoids are unicellular and unbranched in each instance. A long, thin, flat, light green, ribbon-like, dichotomously branching thallus characterizes the aquatic species R. fluitans. It measures 1mm in width and 30–50mm in length. Rhizoids and scales are absent.

Structure of the thallus's interior

Cutting a thin transverse piece of the thallus is required to analyze the thallus of Riccia's anatomy. Anatomically, the thallus is divided between a lower or ventral storage area and an upper or dorsal photosynthetic portion. A vertical row of unbranched photosynthetic filaments makes up the photosynthetic area.

With the exception of the highest cell, every cell in the photosynthetic filament is identical. There are many of discoid chloroplasts within these cells. The terminal cells, which are considerably bigger [3] and colorless, create an upper epidermis that is loose and discontinuous with little definition. Air chambers divide the photosynthetic filaments from one another. Simple air-pores on the thallus' dorsal surface provide access to these air chambers from the outside world. The exchange of gases is aided by these pores. The epidermis only has one layer. The epidermis is continuous in aquatic species, such as R. fluitans, whereas each air chamber in terrestrial forms is opened by a tiny pore.

Storage area

Underneath the photosynthetic part of the thallus is the ventral section, which is made up of tightly packed parenchymatous cells. These cells lack color and have no intercellular gaps. Starch serves as a reserve food for them. The lower epidermis is formed by the layer of the storage area that is lowest. Multicellular scales and unicellular rhizoids are produced by a few lower epidermal cells.

Apical Development

In Riccia, the thallus's apical growth is mediated by three to five or more apical cells. They are set up in a row, horizontally. The apical notch is where these cells are located. The apical cells alternately generate descendants on the dorsal and ventral surfaces. The majority of the thallus is made up of cells that were chopped off on the dorsal side. Only the lower epidermis, rhizoids, and scales are formed by the ventral descendants of the apical cell.

Reproduction

Biological reproduction in Riccia, there are two ways to reproduce: vegetatively and sexually. These techniques are used to carry out this type of reproduction. The older portions of the thallus have died and degenerated. The thallus of Riccia is dichotomously branched. As the thallus's older regions gradually deteriorate and reach the dichotomy, the young lobes separate from one another. Each of them develops into a new thallus by apical development.

- (By the conclusion of the growth season, R. discolor, R. vescata, and R. bulbifera are said to produce tubers at the tips of their thallus lobes. Tubers endure difficult circumstances and grow into new thalli when a suitable environment approaches.
- By accidently growing branches: The adventitious branches of certain species of Riccia are generated on the ventral side of the thallus. After their separation from the parent thallus, these branches develop into new gametophytes.
- Via thick apices: By the conclusion of the growth season, the apex of the thallus extends downward into the soil and thickens in certain species, such as R. himalayensis. Its thick apex endures in the soil and grows into a new plant when suitable circumstances are restored.

A sexual relationship

The sex organs are the method through which sexual reproduction occurs. The terms antheridia and archegonia, respectively, refer to the male and female reproductive systems. Most Riccia species are homothallic or monoecious, which means they carry both the male and female sex parts on the same thallus (examples include R. crystalliana, R. cruciate, and R. glauca). Also widespread are the heterothallic or dioecious species (R. discolor, R. frostii, and R. personii). In such species, archegonia and antheridia grow on several thalli. [4] The mature sex organs are present towards the posterior end of the thallus, while the younger sex organs are located at the apex. The sex organs are located on the dorsal side of the adult gametophyte in acropetal succession. In the midrib of monoecious species, antheridia and archegonia are found in a number of alternative groups.

Antheridium Structure

Antheridium is an extended structure in its mature state. It has a body that is ovoid or pear-shaped and is supported by a short stalk. The multicellular stalk of the antheridium holds it to the base of the antheridial chamber.

Archegonium

Archigonium is an organ with the form of a flask. It is made up of a long, thin neck and a basal, bulging section known as the venter. The thallus's tissue is directly connected to the archegonium. Typically, there is no stalk to be seen. The neck portion houses the cells that make up the neck canal, which are encircled by a layer of sterile cells (neck cells) that act as a jacket of defense. Six longitudinal rows are used to assemble the jacket or neck cells. The height of a row is 6–9 cells. Four specialized big cap, cover, or lid cells with a diameter larger than the neck cells make form the tip of the neck. A sterile cell jacket that is contiguous with the neck jacket above is also present in the venter portion. The wall is venter. Also one cell thick is the venter wall. The venter encloses the venter cavity, which is home to two cells: the top smaller ventral canal cell and the lower bigger egg cell (female gamete). Every archegonium is [5] enclosed in a cavity. The distal end of the archegonial neck protrudes from the thallus' surface.

Archegonial initial, which is located near to the apex of the thallus, is the solitary dorsal superficial cell from which the archegonium develops, much like the antheridium. The archegonial initial expands and protrudes from the thallus' surface. A transverse wall splits it, dividing the lower basal cell from the top outer cell. The bottom cell doesn't contribute any more to the archegonium's growth. An archegonial mother cell is shown by the higher cell. It enlarges and separates into three peripheral initials encircling a central axial cell by three consecutive vertical walls that cross in three places. The latter performs the role of the main axial cell. Six jacket initials or envelop cells are produced by the longitudinal division of each of the three peripheral initials. The six jacket initials at this point undergo a transverse division, which separates them into two tiers, each with six cells. The bottom tier's six jacket cells serve as the venter initials, while the top tier's six serve as the neck initials. The neck of the archegonium is created by the transverse division of the neck initials. Six vertical rows of neck cells, each with six to nine cells, make up the neck. The continually divided venter initials finally come together to create the bulging venter wall. A transverse division is now experienced by the [6] main axial cell. This distinguishes an inner core cell from an upper main cover cell. By making two vertical divisions that are perpendicular to one another, the primary cover cell creates a rosette of four cover cells. The upper primary neck canal cell and the primary ventral cell are separated from the central cell by a transverse wall. The former divides transversely repeatedly, producing four to six neck canal cells. The venter cell splits transversely into a big egg cell and a tiny ventral canal cell.

Fertilization

There is water present when it happens. Normally, a thin coating of rain or dew water that has collected on the dorsal surface aids in fertilization. [7] The release of antherozoids from the antheridium, the transfer of antherozoids to the archegonium, and the dissolution of neck canal cells and ventral canal cells all need the presence of water.

Sporophyte

The pioneer structure of the sporophytic phase, the zygote is the fusion result created when sperm and eggs come together. It grows in size and builds a wall around itself. The zygote and unfertilized egg are different in the following two ways:

- The nucleus of a zygote is diploid, while the nucleus of an egg before syngamy is haploid.
- The egg is bare, and the zygote has a cellulose cell wall around it.

Cell division and cell expansion occur repeatedly in the zygote that is lying in the ventro. The venter wall cells are also stimulated by the process of fertilization. They split both periclinally and anticlinally before forming a calyptra with two layers to encircle the developing sporophyte. Afterwards, the archegonium's neck withers and vanishes.

Growth of the sporophyte

A horizontal wall forms the zygote's initial division. The second division is perpendicular to the first. Four cells make up the developing embryo at this point. It is the embryo's quarter stage. A second vertical division that is perpendicular to the first one results in an eight-celled embryo (octant stage). After multiple erratic divisions, an embryo with 20–30 cells is created after the octant stage. The embryo is now divided into two areas and there is a periclinal division in the outermost layer.

The amphithecium is composed of a single layer of sterile cells that divide exclusively anticlinally to generate the sporogonium. Amphithecium is naturally protective. As an archesporium, the endothecium divides repeatedly to produce a mass of sporogenous cells. The term "sporocytes" or "spore mother cells" refers to all of the cells in the most recent generation of sporogenous tissue. Each and every spore mother cell is viable and has the capacity to produce spore tetrads. Yet, a few spore mother cells from certain [8] Riccia species (R. crystalliana) are intended to break down and generate a nutritive fluid. The nurse cells are what they are called. Some bryologists see nurse-cells as the precursors of the elaters of the more developed Marchantiales species.

The process of spore generation from the spore mother cell is known as sporogenesis. Mother cells for spores enlarge and the diploid nucleus goes through meiosis. Two steps are involved in this division. The two daughter nuclei divide mitotically in the second step after the chromosome number is reduced to half of the somatic number in the first stage. The wall construction is only partially complete after the first phase, but by the conclusion of the second step, walls are concurrently formed around each haploid nucleus. Four spores form a tetrad as a consequence. The four spores of a tetrad initially stay bound together and protected by a single sheath. Only during maturity can the spores become separable from one another. Even after maturity, R. crustisii spores remain bound together in stable tetrads. These are haploid spores.

The adult sporophyte's structure

The simplest liverwort is the sporogonium or sporophyte of Riccia. Both the foot and the seta are absent. It is only a spherical-shaped spore sac or capsule that is implanted on the gametophyte's dorsal surface. The capsule wall, a single-layered jacket, surrounds the spore mother cells. A two-layered calyptra that is a component of the gametophyte serves as a protective coating for the capsule. The sporangium's single-layered wall disintegrates before the spore mother cells split to create spores. Subsequently, the calyptra's inner layer likewise disintegrates. The mature spores are unbound and rest in a hollow or sac that is encircled by the calyptra's outer coat. No elaters exist. Hence, there are no diploid or sporophytic structures present in the adult sporogonium of Riccia at this time. [9] Therefore, at this point, the parent gametophyte is providing a cavity or sac for the spores of Riccia, which stands for the next gametophyte generation. The young gametophyte is encased inside the old gametophyte in this oddity.

Destruction of the spore sac

Riccia's capsule never breaks open. The sporophyte lacks a mechanism for the spores to dehisce and disperse. Comparatively speaking to other Hepaticopsida species, it is primitive. The surrounding outer layer of the calyptra and thallus tissue decomposes, releasing the spores. In the soil, the spores persist. They could get distributed by the wind in this situation. They continue to live for a while. They finally begin to sprout as favorable conditions for growth emerge.

Spore

Each spore has a haploid structure and is uninucleate. The food is mostly kept as oil globules in storage. Three layers make up the mature spore. Exosporium is the outermost cutinized layer. Mesosporium, the intermediate layer, has thick walls, while endosporium is the innermost homogeneous layer. Pectose and callose make up the endosporium. The term "sporoderm" refers to the whole spore wall that protects and is irregularly thickened around the spore. At one end of the spore, there is a tri-radiate mark; the spore wall is thin here.

Spore germination and development of a juvenile gametophyte

The initial cell of the gametophytic generation is the spore. Moisture is a crucial and necessary component for the germination of spores. At the triradiate ridge, the exosporium and mesosporium burst, and the endosporium the germ tube emerges as a tubular outgrowth. The germ tube quickly enlarges and becomes the shape of a club. The majority of the protoplasm, which includes chloroplasts and oil globules, has been moved to the terminal end. At the distal end of the tube, a large, terminal cell is divided by a transverse wall. At its base, close to where it emerged from the spore, the first rhizoid can be seen. The large cell at the distal end divides twice vertically at right angles to one another, then once transversely. Resulting in the creation of two layers with four cells each. An apical cell develops from one of the four cells of the upper tier. Two cutting faces on this apical cell regularly cut off cells on the dorsal and ventral sides. These modifications create a fresh thallus. Many rhizoids form from the ventral epidermis of the thallus as the new thallus expands at the tip of the germ tube. [10] Hence, the novel gametophyte Marchantia is a genus with roughly 65 species that has a global range. 11 species that can be found in the Himalaya and all of India's hills are known to exist there. The plant thrives in areas that are chilly, damp, and shaded. The scorched soil is ideal for M. polymorpha growth. During forest fires, they often emerge as a pioneer plant in the burned soil. This species was found on damp rocks at an elevation of 2175 meters near Mukteshwar (Nainital). M. Palmata provided information from South India, Kashmir, Punjab, Assam, and Kumaun. M. nepalensis was found in the Punjab plains, Kausani, Ranikhet, Mussoorie, and Nainital. For India, M. nepalensis and M. simlana are unusual species. The plants with sex organs are most plentiful in October and February-March in the Himalayas, whereas thalli with gemma cups are present all year.

Each thallus branch has a notch at its tip where the growth point is located. A growth point allows each branch of the thallus to continue growing forever. The gemma cups are located along the mid-rib on the dorsal surface of the thallus. The gemma cups' edges may be either smooth or spiky. The vegetative bodies are contained in the gemma cups, where they aid in vegetative reproduction by producing new gametophytic plants. Two or more rows of the pinkish, multicellular, and one cell thick scales are found on the ventral surface of the thallus, on each side of the midrib. The cytoplasm of these organisms contains anthocyanin pigments, which give scales their violet hue.

In Marchantia, there are two different types of scales: I appendiculate, which are distinguished by having a narrow construction that separates the scale into two parts, the body and the appendage these scales typically make up the inner row of scales, close to the midrib, and (ii) ligulate, which are both relatively small without construction and do not have any appendages. Scale's main purpose is to safeguard the growth point. Moreover, they also hold onto some water by capillary action. On the ventral surface are the colorless, unicellular, and unbranched rhizoids. Rhizoids are arranged in three or four rows on either side of the midrib. They come in two varieties: tuberculate and smooth-walled. These rhizoids maintain the thallus' connection to the substrate. They aid in nutrition and water absorption. In their growing apices, mature thalli of Marchantia form distinctive, upright and erect sexual branches. The male and female sex organs are located in the unique branches, which are generated on various thalli and are referred to as the antheridiophore and archegoniophore, respectively.

Upper and lower epidermis are included in the epidermal area. The dorsal or top epidermis is one layer thick. The cells are grouped closely together, have thin walls, and a small number of chloroplasts. It is broken up by many air-pores in the form of barrels that open internally into air chambers. Each pore is typically surrounded by four to eight layers of cells that are superimposed on top of one another. Each layer is made up of a ring of four to five cells, making the total number of cells around each hole between 16 and 40. The pores' entrance resembles a star from the surface view because the cells of the innermost tier of the pore protrude inward. The other half of the tiers extend into the air chamber under the dorsal epidermis, while half of the tiers project above the level of the epidermis [11]. The air hole seems to be similar to the stomata of higher plants, however the cells surrounding the air pore do not control the opening in the same way as guard cells do in stomata. The lower epidermis is formed by the storage region's lowest layer. Rhizoids and scales have been reported to form from some of the cells in this lower epidermis.

ii. Photosynthetic region: The air chambers are located below the upper epidermis. The air chambers are placed in a single horizontal row and have a consistent shape. Splitting of the cell wall results in the formation of air chambers (schizogenously). One layer of a partition wall divides these compartments from one another. The partitions have a height of three or four cells. Via pore, each air chamber connects with the outside world. The assimilatory or photosynthetic filaments, which are short, simple, or branching, emerge from the bottom of each chamber.

It is a zone with multiple layers of polygonal parenchymatous cells that are compactly organized and frequently lack chloroplasts close below the photosynthetic area. There are no intercellular gaps between the cells. The middle is where it is thickest. The thickness is decreased to 3–4 layers of cells at the borders. Starch and protein grains are present in the majority of cells. A few cells contain mucilage and oil bodies. Reproduction of plants. Under ideal circumstances, the thallus may replicate vegetatively in the following ways: Through the gradual degeneration and fragmentation of older thallus components:

The aging of the vegetative cells is what causes it. That happens in a manner similar to the Riccia scenario that we have explored. At the base of the thallus, the aging cells rot and dissolve. The two apical lobes or portions of the thallus detach and grow into two distinct thalli when this cell decay achieves dichotomy. Via adventitious branches, which may grow from the thallus' ventral surface or from any other area. Kashyap described the production of accidental branches from the female gametophore's stalk and disc. As these branches get separated from the parent plant due to the degeneration of the connective tissue, they grow into new people.

Via gemmae:

In Marchantia, the gemmae, specifically crafted vegetative bodies, are the most popular mode of vegetative reproduction. Gemma cups, which are small, shallow, cup-like growths with fringed borders on the dorsal surface of the thallus towards the midrib, are where the gemmae grow. The gemma cup has a height of 3 mm and a diameter of around 2 mm. There are several gemmae in each gemma cup.

A little distance from the developing point, cups are created. Each gemma originates from a single superficial cell found on the gemma cup's floor. Any of the surface cells may be seen sticking up from the ground and serving as a gemma initial. A transverse wall separates the gemma initial into a lower and an upper cell. The bottom cell stops dividing after that. The one-celled stalk is formed by it. Transverse, longitudinal, and periclinal divisions of the top cell result in the formation of the gemma proper. The gemma is flat and one cell thick at first, but later on because of further periclinal divisions, it thickens to three or four cells near the center.

In maturity, the gemma has a discoid, biconvex, multicellular structure. It is deeply notched on the lateral borders across from one another and many cells thick in the middle section. The growth point is located in every marginal notch. Cells at the growing point are meristematic. Gemma cells are all chlorenchymatous cells since they have a lot of chloroplasts. On the gemma, there are a few isolated cells that are dubbed "oil cells" because they contain oil. Rhizoidal cells are solitary, superficially colorless, somewhat bigger cells that are present on both sides. These cells have a granular, thick cytoplasm. Rhizoids are produced when these cells germinate. Moreover, a few tiny, club-shaped mucilage hairs grow from the bottom of the gemma cup. These hairs release mucilage that absorbs water, creating an imbibitional force that aids in the dispersal of gemmae from the gemma cup.

The gemmae lack a dorsal and ventral surface distinction and are bilaterally symmetrical. When ripe gemmae fall to the ground, if the circumstances are right, they instantly begin to germinate. Rhizoids are released in abundance from the gem's surface when it comes into touch with the ground. The lower or ventral surface of the thallus ultimately develops from this surface. Each developing point produces a juvenile thallus. In this manner, two juvenile thalli grow from a single gemma in opposing orientations. At some point, the middle portion of the gemma dies, separating the two thalli, which develop in opposing directions.

Since the growing points of the lobes are fully used during their development, the thallus' vegetative growth entirely stops after the production of gametophores. As each upright sexual branch originates from a prostrate thallus lobe, they are all direct extensions of that lobe. Rhizoids and scales are present in the groove on the ventral side of the gametophore, giving it a thallus-like appearance. It has air chambers with photosynthetic filament on its dorsal side. Many environmental variables affect how the reproductive branches grow. Marchantia is a strictly heterothallic genus since the male and female reproductive branches grow on distinct thalli (dioecious). In the same receptacle, antheridia and archegonia have been seen in some M. palmata and M. polymorpha specimens. These containers are referred to as androgynophore.

Water that has accumulated on the peltate disc or in the rhizoidal grooves of the antheridiophore enters the antheridial chambers via the ostiole during antheridium dehiscence. As they come into touch with water, some of the cells at the distal end of the antheridial jacket collapse. As a result, the antheridial wall ruptures, and a massive column of androcytes emerges from the ostiole. The androcytes disperse throughout the disc's surface and separate into individual androcytes. The antherozoids emerge from the androcytes quite quickly.

Carpocephalum or archegoniophore

The female thallus' apical notch is where the archegoniophore emerges and undergoes specific modification similar to that of the antheridiophore. It is made up of a stalk with a lobed disc attached to it. The stalk's internal and exterior structures are similar to those of an antheridiophore. Compared to antheridiophore, the stalk of the archegoniophore is a little bit longer (2–5 cm). The immature archegoniophore's terminal disc, which is made up of three consecutive dichotomies of the apex, typically has eight lobes. A growth point may be seen at the tip of each dorsiventral lobe. Archegonia's position on the archegoniophore: In extremely young receptacles, the archegonia are carried on the top surface of the receptacle with their necks pointing upward. Moreover, they grow in acropetal order, with older archegonia growing toward the center and juvenile ones growing toward the disc's edge. Each lobe has one row, with 12–14 archegonia in each row.

The interior anatomy of the mature female receptacle is identical to that of the male. There is the top epidermis, which contains air pores. The air chambers are organized in a single layer directly below it. The assimilatory filaments emerge from the air chambers' floors. There aren't any pits that alternate with air chambers as the male receptacle has.

Creation of archegonium from of a single superficial dorsal cell, the archegonium develops. In each lobe of the female receptacle, it is slightly below the apical cell. The archegonial initial is the name of it. Expanding is the archegonial initial. After that, it separates into an outer main archegonial cell and an inner primary stalk cell. Similar to Riccia, Marchantia develops an archegonium from a primary archegonial cell.

Fertilization

In Marchantia, the sex organs grow into lengthy receptacles. The majority of Marchantia species are dioecious or heterothallic, with receptacles carried on several thalli. These circumstances make fertilization difficult. In Marchantia, vegetative reproduction is particularly widespread, efficient, and successful due to the unpredictability of fertilization. Water is necessary for fertilization, which may occur when male and female plants are grown together. When the plants are damp from rain or dew, it occurs. Archegonia are fertilized when they are standing erect on the dorsal of the archegoniophore's disc. The ventral and neck canal cells of the archegonium degenerate just before fertilization and produce mucilaginous material. Cover cells separate as a consequence of the pressure created by this substance's absorption of water. As a result, a clear path for antherozoids to enter the archegonium is created. Rainwater splashes on the disc of the archegoniophore, splashing the antherozoids, which freely float on the surface of the antheridial disc. Due to the presence of certain compounds that ooze from the archegonium's mouth, the free-swimming antherozoids are drawn there. In other words, these chemicals favorably chemotact with antherozoids. Some proteins, malic acid, and inorganic potassium salts are among these chemicals. One antherozoid unites with the egg, despite the fact that several may enter the archegonium. The archegonia's necks are facing upward at the moment of fertilization.

Phases after fertilization

The initial cell of the sporophytic generation is the diploid zygote (oospore). The fertilized egg starts to grow in size as soon as fertilization is finished. Creates a cellulose wall around it that eventually fills the venter's cavity. Many alterations occur right after after fertilization. The archegoniophore has become longer. In the end, it causes archegonia to invert. It is followed by the fast expansion of the core portion of the archegonial disc. The process of fertilization activates the venter wall cells, which divide periclinally and give birth to a calyptra with two to three layers. The juvenile sporophyte is encased in a calyptra that serves as protection. Fertilization also stimulates some of the cells near the base of the venter. These cells regularly divide to form a thick collar with one cell, resembling a perigynium or pseudoperianth. As a result, the sporophyte develops three layers surrounding it: the perichaetium, perigynium, and calyptra.

Sporophyte

The zygote becomes larger and fills the ventral cavity. A transverse wall division of the zygote produces an exterior epibasal cell and an inner hypobasal cell. The second division is perpendicular to the first. Four cells make up the globular embryo at this stage. The stage is a quadrant. The second division of the zygote in M. chenopoda and certain other species occurs parallel to the first division and produces a 3-celled filamentous embryo. [12] In a quadrant embryo, the hypobasal cells create the foot and the remaining portion of the seta, while the epibasal cells create the capsule. In a filamentous embryo, the hypobasal cell becomes the foot, the intermediate cell becomes the seta, and the epibasal cell becomes the capsule. The four-celled embryo subsequently divides into eight cells, or the octant stage, via a vertical wall connecting at right angles.

CONCLUSION

Hepaticopsida has two stages in its life cycle: Gametophyte and sporophyte, respectively. There are roughly 130 different species of Riccia, of which 33 have been documented from India. There are 65 species of Marchantia, 11 of which are known from India. The sporophyte is the Hepaticopsida species that is best known in Riccia. It lacks the ability to eat and is merely a sac of spores. On the other hand, the Marchantia sporophyte is a complex organism that relies entirely on the gametophyte for nutrition. The sporogenous tissue's reproductive cells are gradually and thoroughly sterilized in the sporophyte.

REFRENCES

[1] H. Kürschner and A. Erdağ, "Bryophytes of Turkey: An annotated reference list of the species with synonyms from the recent literature and an annotated list of Turkish Bryological literature," *Turk. J. Botany*, 2005.

[2] F. Y. Utami, H. Harmoko, and L. Fitriani, "Eksplorasi Lumut (Bryophyta) di Kawasan Air Terjun Bukit Gatan Provinsi Sumatera Selatan," *Al-Hayat J. Biol. Appl. Biol.*, 2020, doi: 10.21580/ah.v3i2.6143.

[3] C. Giancotti and D. M. Vital, "Flora briofítica da Reserva Biológica do Alto da Serra de Paranapiacaba, São Paulo: 1 - Lejeuneaceae (Hepaticopsida)," *Acta Bot. Brasilica*, 1989, doi: 10.1590/s0102-33061989000300016.

[4] K. Banu-Fattah and S. K. Sarker, "Bryophyte flora of greater Mymensingh district of Bangladesh- class: Hepaticopsida and Anthocerotopsida," *Bangladesh J. Plant Taxon.*, 2010, doi: 10.3329/bjpt.v17i1.5390.

[5] K. C. Pôrto and M. de F. de A. Bezerra, "Briófitas de caatinga: 2. Agrestina, Pernambuco, Brasil," *Acta Bot. Brasilica*, 1996, doi: 10.1590/s0102-33061996000100009.

[6] D. S. Sukamto, "Keanekaragaman Jenis Lumut (Bryophyta) di Daerah Aliran Sungai Bedadung Jember," *BIO-CONS J. Biol. dan Konserv.*, 2022, doi: 10.31537/biocons.v3i2.619.

[7] M. S. Rahman and H. Khatun, "Floristic account of Boldha garden, Dhaka: Class - Hepaticopsida and Bryopsida," *Dhaka Univ. J. Biol. Sci.*, 2014, doi: 10.3329/dujbs.v23i2.20094.

[8] S. G. Martínez, H. D. J. B. Banqueth, F. Y. H. Vitola, J. D. M. Gómez, and M. E. M. Puentes, "Diversidad de briófitos en los montes de maría, colosó (Sucre, Colombia)," *Colomb. For.*, 2016, doi: 10.14483/udistrital.jour.colomb.for.2016.1.a03.

[9] N. S. Ariyanti and Sulistijorini, "Contrasting arboreal and terrestrial bryophytes communities of the Mount Halimun Salak National Park, West Java," *Biotropia (Bogor).*, 2011, doi: 10.11598/btb.2011.18.2.243.

[10] T. Matsunaga *et al.*, "Occurrence of the Primary Cell Wall Polysaccharide Rhamnogalacturonan II in Pteridophytes, Lycophytes, and Bryophytes. Implications for the Evolution of Vascular Plants," *Plant Physiol.*, 2004, doi: 10.1104/pp.103.030072.

[11] S. Laaka-Lindberg, “Substrate preference and reproduction in Lophozia silvicola (Hepaticopsida) in southern Finland,” *Ann. Bot. Fenn.*, 2000.

[12] S. Pressel, R. Ligrone, J. G. Duckett, and E. C. Davis, “A novel ascomycetous endophytic association in the rhizoids of the leafy liverwort family, Schistochilaceae (Jungermanniidae, Hepaticopsida),” *Am. J. Bot.*, 2008, doi: 10.3732/ajb.2007171.

CHAPTER 15

CLASSIFICATION, STRUCTURE AND REPRODUCTION IN BRYOPSIDA

Dr. S.K.Khatik, Assistant Professor,
School of Agricultural Sciences, Jaipur National University, Jaipur, India,
Email Id- skumar.patho@jnujaipur.ac.in

ABSTRACT:

The words "Bryon," which means moss, and "python," which denotes plants, are the roots of the phrase "Bryophyta." Embryophytes like mosses, hornworts, and liverworts are categorized as bryophyta. These are the little plants that thrive in moist, shaded environments. Vascular tissues are absent. Instead of generating flowers and seeds, they reproduce by spores. Although though most bryophytes don't have intricate tissue structure, they nonetheless have a diverse variety of shapes and ecosystems. In compared to most seed-bearing plants, they are quite tiny and may be found all over the planet. Bryology is the study of bryophytes.

KEYWORDS:

Alage, Bryopsida, Bryology, bryophytes, Gametophyte, Reproduction, Thallus.

INTRODUCTION

In this unit, Funaria and Polytrichum, two mosses, will have their structure and methods of reproduction studied. The order Funariales includes the genus Funaria. It is a weedy plant that thrives on nitrogen-rich soil in burned-over forest areas. The gametophyte phase of the life cycle is one of this genus' key distinguishing characteristics. It has two stages: the protonema, a young, fleeting filamentous stage, and the leafy gametophores, or moss plant. Its rhizoids are multicellular, branching, and have oblique septa. The leafy gametophyte bears the sex organs (antheridia and archegonia) in distinct branches [1]. There are two growth tips on the sporophyte. There are three parts to the adult sporogonium: the foot, seta, and capsule.

The order Polytrichales contains the genus Polytrichum. This genus has a highly developed structure. It produces aerial branches from a noticeable subsurface rhizome. The blade and base of the sheathing leaf are the two separate sections of the big leaves. Rhizoids with many cells provide a wick-like structure that aids in water conduction. Anatomically, the stem rhizome exhibits a conducting strand that is well-developed and carries hydroids (elements that conduct water) and leptoids (elements that resemble sieve tubes). Since the apical cell is not consumed during the development of antheridia, the shoot may resume growth the following year. As the calyptra dries, it becomes brown and resembles a hairy hood covering the capsule; for this reason, the moss is also known as hair cap moss, Figure 1 shows the Life Cycle in Bryophyta.

BRYOPSIDA

- Subclasses of the class Bryopsida are included, with 660 genera and 14500 species total. The following traits define this class:
- The rhizoids, leaves, and axis of the plants are all clearly distinct plant parts.
- The leaves are placed on the axis in 3–8 rows, and they typically have a midrib (costa).
- The sex organs are located near the tip of the leafy axis and are terminal in position.

- The foot, seta, and capsule of the sporophyte are distinct.
- The outer layer of the endothecium and columella gives rise to the sporogenous mass, or archesporium.
- Stomata and many layers of chlorophyllous cells make up the capsule wall.
- The terminal entrance of the capsule is surrounded by one or two rows of peristome teeth. Some occurrences include the absence of the peristome teeth.

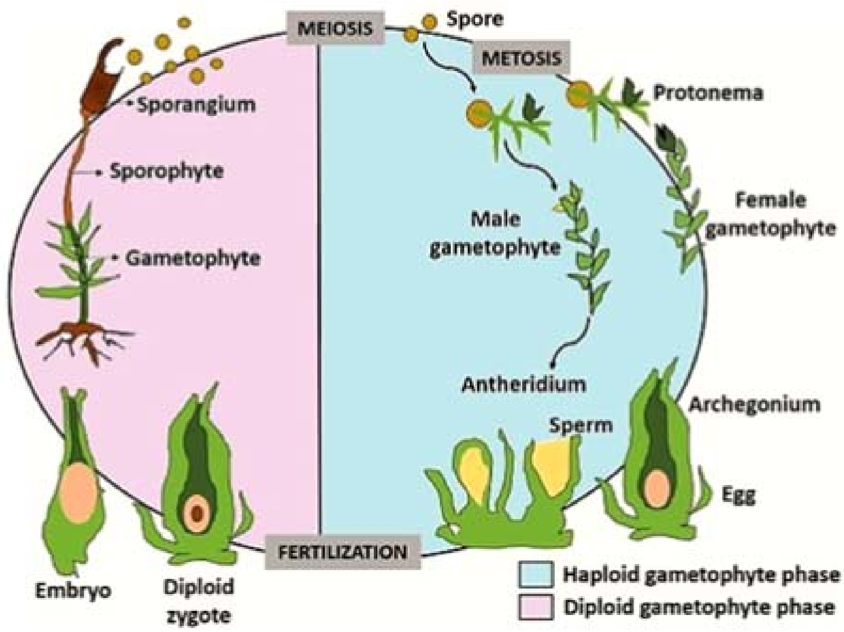

Figure 1: Illustarte the Life Cycle in Bryophyta.

Leaves

The stem's leaves are arranged in a spiral pattern. In accordance with the three cutting faces of the apical cell of the gametophores, the younger leaves at the apex are organized in three vertical rows. The higher leaves are bigger and packed towards the stem's tip, while the lower ones are smaller and dispersed. The sessile, ovate leaves have an entire border and a pointed tip. Its large base connects them to the stem [2]. There is a pronounced midrib on the leaves. A single pyramidal (tetrahedral) apical cell with three cutting faces drives the shoot's apical growth.

Anatomy Stem

A relatively straightforward internal structure is seen in the stem's transverse section. The cells have well-defined tissue differentiation into an epidermis, cortex, and central cylinder (Fig.12.2 A&B). Long, narrow, thin-walled, colorless cells lacking protoplasm make up the center cylinder. The cortical tissue encircles the center cylinder. Chloroplasts are found in the cortical cells of the juvenile portion. The mature stem has exterior cells that are reddish brown in color and have thicker walls. The inner cortex's cells have thin walls. Chlorophyll is present in the epidermis, which is one cell thick. Stomata are not present. The photosynthesis is carried out by the chlorophyll-containing epidermal cells.

A Leaf

The midrib of the leaf, which is distinct and many cells thick, is present. A single layer makes up the wing on each side of the midrib. A tiny core strand of cells with thin walls and a restricted width makes up the midrib's center, providing a straightforward sort of conducting strand. On the surface above and below, there is a sheath of green cells, and this is encircled by a sheath of thin, thick-walled cells. The polygonal (parenchymatous) cells of the sparsely populated border of the wing are packed with several big, conspicuous chloroplasts. The chloroplasts are strange because they keep dividing even after the cells have reached complete maturity.

Apical expansion

A single pyramidal (tetrahedral) apical cell that has three cutting faces, which cut off segments parallel to the three sides, is how the stem develops. A periclinal wall separates each segment into an inner and an outer cell. The inner stem tissue is created by the inner cells dividing repeatedly. Three leaves, the outside portion of the stem, and the lateral branches all develop from the outer cells. The three-sided apical cell is responsible for the leaf's growth.

First-generation reproduction: Vegetative

Funaria's gametophyte reproduces vegetatively in the following ways:

Expansion of the protonema by splitting off branches or tiny terminal groupings of cells, which may develop into new protonema, the main protonema multiplies vegetatively. In Funaria, intercalary division is used to create certain separation cells with colorless contents. These cells separate the protonema into filaments with one or more cells each. A new crop of leafy gametophores is produced as a result of these filaments developing into new protonema. In F. hygrometrica, gemmae were produced by dividing the protonemal branch terminal cells in a number of different planes. These gemmae easily regenerate into protonemata and have thin walls and many chloroplasts. In leafy plants, the gemmae form on the axis and leaves when the environment is unfavorable. On the rhizoids, resting buds known as bulbils are created. When the circumstances are favorable, they form protonema.

By Secondary Protonema: In addition to spores, additional processes may also produce protonema. Similar to main protonema, they are referred to as secondary protonema. The rhizoids of leafy gametophores exposed to light in wet circumstances create protonema, which is one of the routes for the creation of secondary protonema. (ii) The sterile cells of the capsule or seta, as well as the stem, leaves, antheridium, archegonium, paraphysis, or any other detached living portion of the gametophores, may generate protonema.

Reproductive Sexuality

Intimate Organs the expansion of the axis that carries the sex organs is constrained by the terminal clusters in which they mature. Funaria hygrometrica is an autoicous, monoecious plant (i.e., the antheridia and archegonia are borne on separate branches on the same plant). The gametophores' primary shoot, which serves as the male branch, has a cluster of antheridia at its tip. The female branch ultimately outgrows the male branch, developing subsequently as a lateral branch from the male branch's base.

The male limb: At the tip of the male shoots, which are approximately one centimeter tall, the antheridia are generated in clusters. The male shoot's bottom leaves are tiny and dispersed, while its upper leaves the perigonial leaves are gathered together to create a rosette of spreading leaves that resembles a flower (not homologous with the flower of angiosperms). Reddish color dominates the rosette's center. All phases of development may be seen in a single head because several antheridia are generated at the convex enlarged apex of the male branch inside the rosette in lengthy continuous succession without any predetermined sequence. The mature antheridium has a 0.25mm-long body and a short, hefty stalk.

The body is spherical. The body has a single-layered outer jacket made of polyhedral flattened cells that, when young, contain many chloroplasts; however, as they mature, these cells often become orange or red. One or two large, colorless opercular cells with thicker walls near the jacket's apex. A thick core mass made up of many androcytes is located inside the jacket. There are many upright multicellular hairs mixed in with the antheridia on the rounded apex of the male branch [3]. Each paraphysis is made up of one row of four to five cells. The distal cells are substantially expanded and almost spherical in shape, whilst the base cells are small. Chloroplasts are present in each and every cell of the paraphyses. Paraphyses' purpose isn't entirely understood. They most likely contribute to ensuring that the developing antheridia have enough moisture, preventing the drying of these organs either by secreting water or by keeping water between them by capillary action. The paraphyses' expanded sub-spherical terminal cells converge over the antheridia. Due to their abundance in chloroplasts, the paraphyses' cells may, to a lesser degree, aid in photosynthesis.

Dehiscence of Antheridium: As rain or dew collects in the cup-shaped space created by the perigonial leaves, mature antheridium dehisces. The inner surface of the opercular cell's outer wall becomes mucilaginous and swells if water comes into touch with the anteridium. Before the antheridium actually dehisces, the opercular cell's inner wall breaches outward, allowing its whole contents to flow into the antheridial cavity at the top of the androcyte mass. Soon after, the opercular cell's outer membrane likewise ruptures, allowing the mass of androcytes to escape through it in the shape of a stream. The androcytes split apart and form a film when this mass reaches the water's surface in the perigonial cup. When the androcyte masses fragment, the individual androcytes disperse throughout the water's surface. After a few minutes, the antherozoids are freed from the androcytes.

The woman's shot at the tip of the female branch are archegonia. Perichaetial leaves are the leaves that encircle the archegonial group. They have leaves that resemble regular foliage, and within each leaf are several archegonia and paraphyses. Since the apical cell itself is consumed during the development of the archegonium, the expansion of the female branch's axis is constrained. The archegonium has a long neck, a large, comparatively long stalk, and a somewhat expanded venter. The archegonium's jacket is double-layered at the venter, while the neck typically only has one layer made up of six ventral rows of cells that are positioned slightly obliquely. One egg, a ventral canal cell in the venter, and six or more neck canal cells in the long neck make up the middle row of cells within the jacket. As the archegonium reaches maturity, the terminal cells of the neck widely detach from one another, leaving a pathway leading to the oosphere, and the neck canal cells and ventral canal cells disintegrate to create a mucilaginous material.

Water is required for the antherozoids [4] to swim up to the archegonium during fertilization. Antherozoids may move more easily to the archegonium if raindrops splash from heads with mature antheridia to those with archegonia. The chemotactic compounds, perhaps sugars that the archegonium emits cause the antherozoids to attach themselves to the neck of the archegonium once they are close to it. Just one antherozoid bonds with the egg as it passes through the fluid-filled cavities of the neck canal cells and ventral canal cells.

A sporophyte

After fertilization, a zygote is created, which secretes a wall and becomes larger. The zygote splits into an upper epibasal cell and a lower hypobasal cell by a transverse wall. A two-sided apical cell is created in the epibasal cell by the laying down of two consecutive oblique walls. Similar to how epibasal cells originate, hypodermal cells likewise produce apical cells. In this manner, two growth points are created in the sporogonium during its early stages of development. In the end, these cells create the capsule and top section of the seta by cutting off segments alternately to the right and left.

Developed Sporogonium

Three components make up a mature sporogonium: a foot, a seta, and a capsule.

- **Foot:** The foot's development is subpar. It is a tiny, dagger-like conical structure that is incorporated into the archegonial branch's tip. It takes water and mineral nutrients for the growing sporogonium from the archegonial branch.
- **Seta:** At its higher end, the seta, a long, twisted structure, carries the capsule. The axial tissue of the seta creates an upward-extending strand of elongated cells that extends into the narrow base of the capsule. A thick-walled cortex and epidermis surround the axial cylinder. The strand conducts water as part of its job. It serves as a mechanical tissue as well.
- **Capsule:** The mature capsule is an obliquely oriented pear-shaped structure. The calyptras, a conical hood or cap, covers its top half. The capsule is separated into three distinct regions: the apophysis, the middle fertile area, theca proper, and the operculum and peristome, which are located in the top region.

The apophis

The seta continues upward to create the apophysis, or base, of the capsule. There is a conducting thread in the apophysis's center. Together with the seta's main thread, it continues. A zone of spongy, green, palisade-like tissue with intercellular space surrounds the center tissue. True stomata, which are generated by the division of epidermal cells and initially have two guard cells, are present in the epidermis. At the advanced phases, the pore is surrounded by a single annular guard cell with two nuclei. The stomata are orientated such that their long axes are parallel to the sporogonium's long axis.

The Abundant Area (The Theca Proper)

The columella, a sterile column of thin-walled parenchymatous cells, is located in the center of the fertile zone. The columella has a cone-shaped upper end that extends upward into the operculum's concave interior, and cell filaments link its tapering lower end to the apophysis's core tissue. A spore sac in the form of a barrel surrounds the columella. The spore sac looks U-shaped in L.S. of the capsule and is broken at its base by the columella. The spore sac contains a one-layer inner wall and an exterior wall made up of three to four layers of cells. Between them are the spore mother cells, each of which splits normally during meiosis to produce four spores. A large cylindrical air gap exists outside the spore sac and is connected externally to the inner surface of the capsule wall by filaments of two to four slender green cells. A well defined epidermis surrounds two to three layers of cells that make up the capsule wall in this area. The deepest layer of the wall is made up of loosely distributed cells containing chloroplasts, while the two outer layers immediately below the epidermis are made up of compact, colorless, parenchymatous cells that form a hypodermis. Below the fertile zone, the colorless hypodermal tissue of the capsule wall thins away, whilst the green inner tissue thickens and is continuous with the green apophysis tissue.

Greater Region

In terms of spore distribution, the top section of the capsule has undergone significant modification. A constriction separates this area from the theca. A diaphragm consisting of two to three layers of radiately elongated, pitted cells is located just below the constriction. The rim is in the shape of a circular ledge that is punctured by the tissue with a thin wall. The peristome and epidermis of the capsule wall are joined by the rim, which extends inward from the capsule wall epidermis. These layers are what create the thicker rim of the open capsule once the operculum breaks from the capsule.

The annulus, which sits above the rim and surrounds the operculum's widest point, is made up of five to six layers of epidermal cells that are layered on top of one another. The higher rows of cells constitute the bottom border of the loosened operculum and are narrow, thick-walled, and radiately elongated. The cells of the two lowermost levels of the annulus are enlarged and have thinner walls. These inflated cells are finally destroyed, leading to dehiscence.

Peristome is connected below the diaphragm's border. Two rows (inner and outer) of curving, thin, triangular plate-like teeth make up the peristome. There are sixteen teeth each row. The outer peristome's teeth are crimson and decorated with substantial transverse bands. These teeth have a spiraling motion to the left and converge at the tip, where they are connected to a tiny disc of persisting tissue in the middle. The teeth of the inner peristome are shorter and more delicate than those of the outer peristome, and they are colorless. At their bases, they are immediately covered by the outer peristome's teeth, but as they curve toward the capsule mouth's center, they shrink the area where the slits between the outer peristome's teeth are the widest. The operculum, which is made up of around three layers of tiny, thin-walled cells surrounded by a superficial epidermal layer and has thicker outer walls, seals the entrance of the capsule.

As the capsule reaches maturity, it starts to dry up, and the columella and other thin-walled tissues start to lose water [5]. The spores' hiding place is torn apart as they shrivel up. The annulus proper, which is made up of unusually hygroscopic and elastic cells, assists in the evacuation of the operculum. When moisture is present, the mucilaginous walls of the annulus proper cells quickly expand, causing the annulus to abruptly break free from the lip of the capsule and roll back, which causes the operculum to fall off. After that, the hygroscopic motions of the peristome teeth help to empty the spores from the capsule. The two layers that make up each tooth of the outer peristome are linked to create a two-ply structure, with one layer constituting the outside surface and the other the inner surface.

Each tooth's outer layer lengthens when it's wet and contracts when it's dry, but the inner layer is unaffected by variations in moisture content. The dome is reconstituted and the capsule opens as a consequence of the outer peristome teeth absorbing water, which causes the outer layer to lengthen more than the inner layer and bend together inwards. There are no hygroscopic motions in the inner peristome teeth. The outer peristome teeth bend outward with jerky movements as they separate from one another and the slits between the outer teeth widen in dry weather because the outer layers of the outer peristome teeth lose water and are shorter than the inner layers. The inner peristome teeth act as a sieve, only allowing the gradual discharge of the spores, a few at a time. The mature capsule's long, thin seta is wavy and twisted, and it also reveals the hygroscopic motions. The seta gets untwisted and swings about when wet. Its motions are reversible when it dries up. In this way, the spores are discharged in lower numbers over a longer time thanks to the joint efforts of the peristome and hygroscopic seta.

Little Gametophyte

The spores have a smooth surface and are about spherical in shape. The size of the spore varies from 0.012 to 0.020 mm. The spore comprises two wall layers: a smooth, colored exosporium and an inner, hyaline endosporium. A single nucleus, many oil globules, and chloroplasts make up the spore.

Protonema production and spore germination under ideal circumstances, spore starts to germinate after a few days. They continue to be functional for at least two years. The exospore swells and explodes when the spore absorbs moisture. One or two germ tubes made of the endospore that are divided by cross walls emerge from it. The main protonema is created when these cells divide to produce a branching, filamentous multicellular structure. During the division of the apical cell, the protonema expands apically. The filaments of protonema develops in two distinct ways and create two sorts of branches. The erect branches, which are the chloronemal branches, and the branches that grow prostrately on the surface of the substrate. The transverse walls that separate the thick, hyaline cell-walled chloronemal branches. The cells are chlorophyllous (many discoid tiny chloroplasts) so photosynthetic.

Rhizoidal branches have oblique cross walls, brown outer walls, and thin, brown outer walls. Leucoplasts or tiny chloroplasts are present in the cells. The major purpose of these branches is attachment, although in juvenile stage they also absorb water and minerals. When exposed to light, these branches could produce chlorophyll and change into chloronemal branches.

According to Sironval (1947), who examined the protonema's development in Funaria hygrometrica in culture, it has two distinct stages: the chloronema and caulonema. As a result, the chloronema forms right away after spore germination and varies morphologically from the caulonema, which forms after it.

The chloronema has the following characteristics: I it has sparse and irregular branching; (ii) the cross walls are at right angles to the long axis of the protonemal thread; (iii) the cell walls are colorless; (iv) there are many chloroplasts, which are circular in shape and evenly distributed; (v) the nucleus is complete and not visible under a light microscope; (vi) it is positively geotropic; (vii) it does not

Sironval claims that the caulonema, the second stage, develops from the chloronema after the caulonema endures for 20 days after the majority of its cells disintegrate. The caulonema exhibits the following characteristics: I it is abundantly and consistently branched; (ii) the cross walls are oblique to the long axis of the filaments; (iii) the cell walls are brownish; (iv) the chloroplasts are fewer, spindle-shaped, and less evenly distributed; (v) the nucleus exhibits nucleolus degeneration and is easily visible in light microscope; (vi) negatively geotropic (Bopp, 1963).

Creation of Buds

The bud develops from a parent filament cell right behind a cross wall as a lateral swelling. While sometimes developing directly on the brown filaments, the predominant location of the bud is close to the base of the chief filament of the aerial erect branch system. After removing one or two stalk cells, the lateral protrusion swells at the end and splits into three segments with oblique walls to create the terminal tetrahedral cell of the next gametophores, which has three cutting faces. It sever three pairs of lateral segments and assumes the role of the juvenile gametophores' apical cell. Before any leaves are created, rhizoids may also develop from the first few segments of the apical cell, which do not contribute to the formation of any leaves at all but rather the base of the leafy gametophores. Subsequently, the segments develop into the stem's tissue and leaves. The main protonema withers and vanishes after the development of the leafy gametophores with several leaves and rhizoids, and the numerous gametophores carried on a protonema become independent.

Funaria hygrometrica Life Cycle

Two separate vegetative individuals are present in a single life cycle.

The leafy branch is one vegetative individual, while the sporogonium is the other. The dominating phase is represented by the green, gametophytic shoot. The topic of sexual reproduction is included. The Funaria plant is now in its gametophytic or haploid (n) generation. It starts with spore creation and concludes with gametes (egg and antherozoids). The sporophyte, which stands for the sporophytic or diploid (2n) generation, is the second individual. It starts with zygote formation. The sporophytic generation is composed of the zygote, the embryo, and the sporogonium (foot, seta, and capsule).

Funaria's life cycle

A. Gametophyte.

- It is made up of (a) a protonema, a branching, green filament that resembles an alga, and (b) the moss plant, a gametophores with leaves. The protonema doesn't last long.
- The leafy gametophore has a thin, stem-like central axis with rhizoids at its base and expansions resembling leaves along the length of it. It is autonomous.
- A distinct midrib with a thickness of more than one cell runs across the so-called leaf.
- Rhizoids are multicellular, septate, and branching. The cells' septa are positioned obliquely.
- The terminal clusters of the leafy gametophores' sex organs (antheridia and archegonia) are located at the terminals of several branches.
- The adult antheridium is composed of a globose body and a short multicellular stalk.
- A single celled thick jacket wall lines the body. Androcytes, which give birth to biflagellate sperm, are found within the jacket. With a flask-like form, the mature archegonium is carried by a thin multicellular stalk. Six rows of neck cells make up the length of the neck. The venter wall is two layers thick, includes a vetral canal cell and an egg, and they encapsulate six or more neck canal cells.

- The antherozoids, after being freed from the antheridium, swim down to the open necks of the arhegonia and fertilize the egg. They are then splashed out of the perichaetial leaves by raindrops on the arcegonial cluster.

B. Sporophyte

- In nature, the zygote serves as the first sporophyte and diploid cell. The zygote splits into two developing points at either end of the embryo.
- The embryo grows apically, and by removing the segments, it transforms into a long, thin structure.
- The adult sporogonium is distinguished into a foot, a seta, and a complicated pear-shaped capsule.
- The capsule is carried high above the leafy gametophores by the lengthy seta.
- The foot serves as an anchoring and absorbing organ and is implanted in the tissues of the female branch.
- The apophysis, theca, and operculum regions of the adult capsule are distinguishable outwardly.

The apophysis is the basal, sterile region that is enlarged. Conduction and photosynthesis are connected to it. The epidermis is well formed, and the stomata are functioning and linked to the substomatal air space. The columella, which are thin-walled sterile parenchyma cells, are found in the center of the theca. Spore sacs, which do not arch over the columella, are seen on each side of the columella. There is a large air area outside the spore sac that is crossed by green filaments called trabeculae. The spore mother cells, which divide during meiosis to produce haploid spores, are found within the spore sac. [6] The theca's wall is located outside the air space. A single layer of epidermis surrounds the one to two layer thick spongy layer, which is followed by a two layer thick hypodermis. The operculum is the apical part above the theca. The theca and operculum are divided by a transverse ring of altered epidermal cells. This is known as an annulus. A double row of conical teeth that together make up the peristome is found below the operculum. There are teeth. The hygroscopic teeth are crucial for the spreading of spores.

Polytrichum Gametophyte Life Cycle

- The plant is perennial. It comprises of (a) a short, branching protonema that is green and (b) leafy gametophores.
- A subterranean rhizome gives birth to the leafy gametophore. A thin, stem-like central shaft with leaf-like expansions runs the length of the gametophore. It is autonomous.
- Rhizomes produce rhizoids, which often entangle and create wick-like structures. These rhizoids aid in retention of water and provide mechanical strength to the plant. Rhizoids are multicellular, septate, and branching. These are oblique septa.
- Vegetative reproduction depends on the rhizoid system. These rhizoid threads resemble wicks and carry buds that turn into leafy axes.
- The intermediate transitional zone and the rhizome's leaves are brown or colorless.
- With a 1/3 divergence, they are carried in three vertical rows.
- The aerial leafy shoot's rather big, thick, and inflexible leaves are arranged in a convoluted spiral on the stem. Each leaf has a wide, monochrome membranous

unistratose sheathing base that narrows into a lanceolate to linear lanceolate 'limb' above.

- The rhizome is triangular in cross section, with rounded corners that are somewhat convex. The conducting tissue has sophisticated components that conduct food (leptoids) and water (hydroids).
- The plant is dioecious, and at the apex of [7] different gametophores, archegonia and antheridia are produced in terminal clusters.
- The male shoot's terminal portion develops a noticeable open cup that nearly resembles a flower. Perigonial leaves on the gametophores create this cup; they vary from the other vegetative leaves on the gametophores in shape and color. The development of the antheridia does not inhibit the growth of the male shoot since the apical cell of the shoot is not consumed during the production of an antheridium.
- The adult antheridium has a body that is formed [8] like a club and a short stalk. A single-layered jacket covers the body's core androcyte bulk.
- At the tip of the leafy stalk, terminal clusters of archegonia are produced. The leafy shoot's apical cell produces the first archegonium by itself, causing the production of a sporogonium to mark the end of the shoot's further length growth.

CONCLUSION

Three parts make up the adult sporogonium: a foot, a lengthy seta, and a capsule. The foot is made up of thin-walled parenchymatous cells and is implanted in the tissue at the tip of an archegonial branch. The continuous, long, and thin seta supports the capsule at its apex and is continuous with the foot. The seta expands to create the [9] apophysis at the base of the capsule, which is distinguished from the sporogenous part (theca proper) by a groove [10].

REFERENCES

[1] B. Gao *et al.*, "Ancestral gene duplications in mosses characterized by integrated phylogenomic analyses," *J. Syst. Evol.*, 2022, doi: 10.1111/jse.12683.

[2] A. Samti, H. Susilo, and M. Sari, "Potensi Bryopsida Di Hutan Raya R Soerjo Sebagai Suplemen Matakuliah Keanekaragaman Tumbuhan," *J. Pendidik. - Teor. Penelitian, dan Pengemb.*, 2016.

[3] K. Banu-Fattah and S. K. Sarker, "Bryophyte flora of Greater Mymensingh District of Bangladesh - Class : Bryopsida," *Bangladesh J. Plant Taxon.*, 1970, doi: 10.3329/bjpt.v14i1.522.

[4] J. M. Glime, "Chapter 2-7 Bryophyta - Bryopsida," *Bryophyt. Ecol. Vol. 1. Physiol. Ecol.*, 2013.

[5] N. M. C. F. Castro, K. C. Pôrto, O. Yano, and A. A. J. F. Castro, "Levantamento florístico de Bryopsida de cerrado e mata ripícola do Parque Nacional de Sete Cidades, Piauí, Brasil," *Acta Bot. Brasilica*, 2002, doi: 10.1590/S0102-33062002000100008.

[6] J. M. Glime, "Bryophyta - Bryopsida. Chapt. 2-7," *Bryophyt. Ecol. Vol. 1. Physiol. Ecol.*, 2013.

[7] R. Ochyra, P. Isoviita, J. Zarnowiec, and H. Bednarek-Ochyra, "Correct author citations for class and some subclass names of the Bryophyta," *Ann. Bot. Fenn.*, 2006.

[8] B. Estébanez, C. Alfayate, and E. Ron, “Observations on spore ultrastructure in six species of Grimmia (Bryopsida),” *Grana*, 1997, doi: 10.1080/00173139709362628.

[9] I. Capesius and M. Bopp, “New classification of liverworts based on molecular and morphological data,” *Plant Syst. Evol.*, 1997, doi: 10.1007/BF00985210.

[10] L. R. Lewis *et al.*, “Resolving the northern hemisphere source region for the long-distance dispersal event that gave rise to the South American endemic dung moss Tetraplodon fuegianus,” *Am. J. Bot.*, 2017, doi: 10.3732/ajb.1700144.

CHAPTER 16

MORPHOLOGY, ANATOMY AND REPRODUCTION OF MARCHANTIALES

Dr. S.K.Khatik, Assistant Professor,
School of Agricultural Sciences, Jaipur National University, Jaipur, India,
Email Id- skumar.patho@jnujaipur.ac.in

ABSTRACT:

Over 65 species make up Marchantia, the most significant genus in the Marchantiaceae family. The botanical plant was given the name Marchantia in honor of Nicolas Merchant, who oversaw Gaston d'Orleans' botanical park in Blois, France. All species have a global range and are terrestrial in nature. The plant favors areas that are damp and shaded, such as wet open forests, stream banks, wood rocks, or shaded stub rocks. They thrive on the soil that has been burned following a forest fire. Over 11 different species of Marchantia may be found in India. These plants are often seen flourishing at elevations between 400 and 8000 feet in the Himalayan area. Several species may also be found growing in the mountainous parts of South India as well as the plains of Haryana, Punjab, and Uttar Pradesh.

KEYWORDS:

Alage, Bryophytes, Gametophyte, Morphology, Marchantiales, Reproduction, Thallus.

INTRODUCTION

Common species found in India include M. palmata, M. polymorpha, M. simlana, etc. The most extensively dispersed species is M. polymorpha. The thalli with gemma cups may be found all year long, while the thalli with sex organs are most plentiful in the Himalayas from February to March and in the South Indian highlands from October to November.

Phase of Marchantia that is gametophytic:

The plant's body is dichotomously branched, flat, prostrate, thalloid, gametophytic, and 2–10 cm long [1]. Green on the dorsal surface. It contains a noticeable midrib and many areolae, which are polygonal regions. The midrib is identified by a low ridge on the ventral surface and a shallow groove on the dorsal side. The underlying air chamber is represented by each polygonal region. These regions' borders stand in for the walls dividing each air chamber from the next one. A central pore exists in every air chamber. The midrib terminates in an apical depression that creates a developing point-containing notch.

Moreover, the vegetative and sexual reproductive components are carried by the dorsal surface. The gemma-cup-shaped vegetative reproductive structures grow along the midrib. They are roughly an eighth of an inch in diameter, crescent-shaped, and have spiky or fimbriate borders. Gametophores are unique stalked structures that support sexual reproductive systems. Gametophores that include archegonia are referred to as archegoniophores, whereas those that contain antheridia are referred to as antheridiophores. Around the midrib of the thallus' ventral surface are rhizoids and scales. Scales are multicellular, one cell thick, and violet in color. They are also grouped in 2-4 rows. Scales come in two varieties.

i. Appendiculate Simple or ligulate:

The inner row of scales near to the midrib is composed of appendiculate scales. Ligulate scales are smaller than appendiculate scales and make up the outside or marginal row.

The following are the distinguishing characteristics of the order Marchantiales:

1. On appropriate substrates, the ribbon-like, dichotomously branching, and dorsiventral thalli grow prostrate.
2. All other genera, with the exception of Dumortiera, Monoselenium, and Monoclea, have internally distinct air chambers on the dorsal side of the thallus. These chambers open to the exterior via a specific kind of air pore.
3. Parenchyma, which serves as storage tissue and may include oil and mucilage cells, makes up the ventral section of the thallus.
4. There are two different kinds of rhizoids and scales on the ventral side of the thallus (smooth-walled and tuberculate).
5. The antheridia and archegonia may both be found directly on the thallus' dorsal surface as well as on specialized branches called antheridiophores and archegoniophores, respectively.
6. The sporophytes' capsules typically have a single-layered jacket.
7. The capsule may either be straightforward, as in Riccia, or it might be divided into the foot, seta, and capsule, as in Marchantia.
8. The elaters might be there or not.

Rhizoids are single-celled, branching growths that originate from the lower epidermal cells. They come in two varieties: Rhizoids with smooth walls and tuberculate rhizoids. Whereas the inner and outer wall layers of rhizoids with smooth walls are completely extended, rhizoids with tuberculate walls resemble round spots when seen from the surface. The inner wall layer changes into a peg-like growth that extends into the lumen of the cell. Rhizoids have two key purposes: they bind the thallus to the substrate and they take up water and minerals from the soil.

The bottom storage zone and photosynthetic zone may be distinguished in a vertical cross section of the thallus. Greater photosynthetic zone: Upper epidermis is the skin's outermost layer. Its cells are square, thin-walled, tightly packed, and have few chloroplasts. There are several air pores with a barrel form present, which disrupts its continuity. Three to four cells make up each layer of the four to eight concentric rings that encircle each pore. Compound pores make up the air. Four cells from the lowest tier protrude into the pore, giving the surface view of the hole's entrance the appearance of a star. The top epidermis is partially buried under and partially above the air pore walls.

A horizontal layer of photosynthetic chambers is located just below the top epidermis. The opening of each air pore inside the air chamber aids in the exchange of gases during photosynthesis. The walls dividing these schizogenous compartments [2] from one another are just one layer thick. The partition walls range in height from two to four cells. Chloroplast are found in cells. At the base of the air chambers, several straightforward or branching photosynthetic filaments emerge.

storage space Under the air chambers, it is located. It is thicker in the middle and gradually becomes thinner as it approaches the edges. It is made up of a number of tightly packed, thin-walled, isodiametric parenchymatous lasers. There are no intercellular spaces. Starch is present in the cells of this region. Some cells are mucilaginous or have a single, massive oil body. Reticulate thickenings may be seen in the midrib cells. [3] The lower epidermis is made up of the zone's lowest layer of cells. Both kinds of scales and rhizoids are formed by a few cells that stretch from the middle layer of the lower epidermis.

DISCUSSION

Marchantia uses both vegetative and sexual reproduction techniques. Vegetative reproduction, which is highly widespread in Marchantia and occurs in the following ways:

By Gemmae

On the dorsal side of the thallus, there are gemma cups where gemmae are created. Gemma cups have smooth, spiny, or fimbriate borders and have a 3 mm diameter. In the base of the gemma cup, mature gemmae are discovered to be connected by a single celled stalk. Many mucilage hairs are mixed together with the gemmae. Each gemma is biaxially symmetrical, autotrophic, multicellular, thick in the middle, and thin at the tip. It is made up of rhizoidal, oil, and parenchymatous cells. It has two notch-shaped areas where the growth point is located[4].

With the exception of rhizoidal and oil cells, all of the gemma's cells include chloroplast. Rhizoidal cells are big and colorless. Oil cells are limited to the edges and lack chloroplasts in favor of oil bodies. As water is absorbed, mucin is released by mucin hairs. It swells up and pushes the gemmae in the gemma cup to separate from the stalk. The strain put on them by the development of the immature gemmae may also cause them to separate off the stalk. Water currents scatter the gemmae across great distances. Gemmae germinate when they touch an appropriate substrate after dropping there. The ventral surface is the area that makes touch with the dirt. Rhizoids are formed from the rhizoidal cells. In the meanwhile, thalli are formed in opposing directions by the developing places where the two lateral notches are located. Therefore, two thalli are generated from a single gemma. Male and female plants are created by gemmae that grow on the male and female thalli, respectively.

The growth of [5] Gemma From a single superficial cell, the gemma grows. It grows on the gemma cup's floor. It is termed a gemma initial and is papillate. It splits transversely to produce upper and lower stalk cells. The single celled stalk is formed from the bottom cell. Transverse division is used to further split the higher cell into two cells. Both cells divide in a manner identical to create four new cells. These cells divide both vertically and horizontally to create a structure that resembles a plate and has two marginal notches. It is known as gemma.

Fragmentation or death of the older part of the thallus:

The thallus has two distinct branches. Due to aging, the thallus's base rots and disintegrates. The lobes of the thallus divide when this process reaches the site of dichotomy. By means of apical development, the detached lobes or pieces become separate thalli.

Via accidental branches

In rare instances, the stalk and disc of the archegoniophore in species like M. palmata, the adventitious branches may form from any area of the [6] thallus or the ventral surface of the thallus. After their separation, these branches grow into new thalli. Sexual Reproduction: In Marchantia, sexual reproduction is oogamous. Every species has two sexes. Archegonia are the female reproductive organs, whereas antheridia are the male. The upright modified lateral branches of the thallus known as the antheridiophore and archegoniophore, respectively, are where antheridia and archegonia are generated.

Antheridiophore or archegoniophore internal structure:

Its transverse slice demonstrates that it may be divided into ventral and dorsal sides. Two longitudinal tows with scales and rhizoids are present on the ventral side. The stalk is covered by these grooves over its whole length. The dorsal side demonstrates the internal separation of air chambers.

Antheridiophore: It has a [7] lobed disc at the tip and a stalk that is 1 to 3 centimeters long. In M. geminate, the disc is four lobed instead of the typical eight lobeds. These dichotomies led to the formation of the lobed disc. The disc is made up of air chambers and antheridial cavities that alternate. Air chambers have an upper surface pore called an ostiole that is roughly triangular in shape. The younger ones appear at the borders and the older ones towards the center as antheridia develop in an acropetal succession. A mature antheridium has a globular form and is composed of the stalk and body. The body is attached to the base of the antheridial chamber by a short, multicellular stalk. The mass of androcyte mother cells that transform into antherozoids is encased in a single-layered sterile jacket. A tiny rod-like biflagellate structure, the antherozoid.

Creation of Antheridium: A single superficial cell located 1-2 cells beyond the developing point on the disc's dorsal surface initiates the formation of the antheridium. Antheridial beginning refers to this cell type. An upper outer cell and a lower basal cell are formed from a transverse division of the antheridial initial, which enlarges in size. The basal cell that is still immersed in the thallus tissue goes through a little amount of further development to create the embedded section of the antheridial stalk. A filament of four cells is created when the outer cell splits. The four celled filament's upper two cells are referred to as primary antheridial cells, and the bottom two cells as primary stalk cells.

To create two layers of four cells each, primary antheridial cells proliferate twice successively vertically at a straight angle to one another. In both layers of four cells, a periclinal division is established, resulting in the development of eight outside sterile jacket initials and eight inner primary androgonial cells. To create a single layer of sterile antheridial jacket, jacket initials split by multiple anticlinal divisions. The creation of a high number of tiny androgonial cells results from the repetitive transverse and vertical divisions of primary androgonial cells. Androcyte mother cells are the descendants of the final androgonial cells. Each androcyte mother cell splits diagonally during mitosis to produce two androcytes, which are triangular cells. A new cell called an antherozoid develops from each androcyte.

Carpocephalum or an archegoniophore: It has a stalk and a terminal disc and emerges from the apical notch. More so than the antheridiophore, it is somewhat longer. It might measure five to seven centimeters. The immature archegoniophore's apex splits into an eight-lobed, rosette-like disc via three sequential dichotomies. The disc's lobes each have a developing point. Each lobe's archegonia start to grow in acropetal succession, with the oldest archegonium growing closest to the disc's center and the youngest archegonium growing farthest from it. As a result, eight groups of archegonia grow on the disc's top surface. Each lobe of the disc has twelve to fourteen archegonia arranged in a single row. Archegonium formation begins in acropetal succession on the dorsal surface of the juvenile receptacle. A single superficial cell that serves as the main archegonial cell grows and splits transversely to give rise to a basal cell, also known as the primary stalk cell, and an outer cell, also known as the primary archegonial cell.

The main stalk cell divides erratically to create the archegonium's stalk. The main archegonial cell separates into three peripheral initials and one primary axial cell by means of three consecutive intercalary walls or periclinal vertical walls. Each of the three peripheral initials splits into two cells by an anticlinal vertical division. Six cells round the principal axial cell in this manner. Jacket initials are what they are called. Upper neck initials and lower vent initials are separated transversally from six jacket initials. The first layer of the neck splits repeatedly transversely to create a tube-like neck.

Mature Archegonium: An adult archegonium resembles a flask. It still has a small stalk that connects it to the archegonial disc. It consists of a base spherical section termed the venter and an upper elongated, thin neck. Eight neck canal cells and a big egg are enclosed by six vertical rows in the neck. At the very top of the neck, there are four cover cells.

In Marchantia, fertilization occurs when male and female thalli develop close proximity. For fertilization to occur, water is required. On the dorsal side of the archegoniophore's disc, the neck of the archegonium faces upward. Venter canal and neck canal cells in the adult archegonium dissolve and create a mucilaginous mass. It pushes the cover cells apart, soaks up water, swells up, and emerges through the archegonial mouth. Chemical elements make up this mucilaginous material.

Raindrops splatter the antherozoids. [8] The male disc's flattened surface has shallow splash cups that, when activated, release sperm onto the water's surface. They could land on a nearby female receptacle or swim all the way there. It is only feasible if water surrounds both the male and female receptacles. Via a chemotactic reaction, several antherozoids reach up to the egg in the archegonial neck. Splash cup mechanism is the name of this fertilization process. The egg is penetrated by one of the antherozoids, which interferes with fertilization. A diploid zygote or oospore is created when the male and female nuclei combine. The gametophytic phase is completed by fertilization.

Sporophytic Phase: Three sheaths produced from the tissue of the female receptacle shield the developing sporogonia. Perigynium, calyptra, and perichaetium are these levels. The growth of the foot and seta occur concurrently with the formation of the capsule. [9] At 48 hours following fertilization, the zygote begins to divide, producing an epibasal and a hypobasal cell. Exosporic development is seen in the globular embryo, and successive quadrant and octant phases are present. Four hypobasal cells create the foot and seta, while four epibasal cells create the capsule. The periclinal division that separates the inner endothecium from the single layer amphithecium occurs in the capsular area. Amphithecium further splits to create the capsule wall. Archesporial cells divide at the same time, [10] resulting in a significant amount of sporogenous tissue. At the beginning, these cells are similar, but with time, they differentiate into elater mother cells and spore mother cells.

CONCLUSION

Seta gradually elongates during spore maturation, and the capsule eventually penetrates the calyptra. The apical cell of the capsule dries up and ruptures when it extends beyond the perigynium and perichaetium. Along four to six lines, the capsule wall cracks apart. The hygroscopic elaters aid in spore dispersion. Elaters wriggle and stretch as a result of variations in the moisture content, which causes them to coil and uncoil. With spore germination, a fresh gametophyte is created[11], [12].

REFERENCES

[1] V. Maresca, G. Lettieri, S. Sorbo, M. Piscopo, and A. Basile, "Biological responses to cadmium stress in liverwort conocephalum conicum (Marchantiales)," *Int. J. Mol. Sci.*, 2020, doi: 10.3390/ijms21186485.

[2] W. Kwon, Y. Kim, and J. Park, "The complete chloroplast genome sequence of Dumortiera hirsuta (Sw.) Nees (Marchantiophyta, Dumortieraceae)," *Mitochondrial DNA Part B Resour.*, 2019, doi: 10.1080/23802359.2018.1546128.

[3] C. Reeb *et al.*, "A survey of Marchantiales from Madagascar," *Acta Biol. Plant. Agriensis*, 2018, doi: 10.21406/abpa.2018.6.3.

[4] J. R. Flores, A. C. Bippus, G. M. Suárez, and J. Hyvönen, "Defying death: incorporating fossils into the phylogeny of the complex thalloid liverworts (Marchantiidae, Marchantiophyta) confirms high order clades but reveals discrepancies in family-level relationships," *Cladistics*, 2021, doi: 10.1111/cla.12442.

[5] W. Kwon, J. Min, H. Xi, and J. Park, "The complete chloroplast genome of Riccia fluitans L. (Ricciaceae, Marchantiophyta)," *Mitochondrial DNA Part B Resour.*, 2019, doi: 10.1080/23802359.2019.1613193.

[6] U. Kutschera and V. Koopmann, "Growth in liverworts of the Marchantiales is promoted by epiphytic methylobacteria," *Naturwissenschaften*, 2005, doi: 10.1007/s00114-005-0640-2.

[7] K. M. Deepa, B. Mufeed, and C. N. Manju, "Wiesnerella denudata (Mitt.) Steph. (Marchantiales; Marchantiophyta) a rare species in the Western Ghats of India," *Lindbergia*, 2019, doi: 10.25227/linbg.01106.

[8] H. Bischler and S. Jovet-Ast, "The Biological Significance of Morphological Characters in Marchantiales (Hepaticae)," *Bryologist*, 1981, doi: 10.2307/3242822.

[9] Repik Febriansah, "Identifikasi Keanekaragaman Marchantiophyta Di Kawasan Air Terjun Parangkikis Pagerwojo Tulungagung," *J. Biol. dan Pembelajarannya*, 2019, doi: 10.29407/jbp.v6i2.14795.

[10] J. Russell and S. Bulman, "The liverwort Marchantia foliacea forms a specialized symbiosis with arbuscular mycorrhizal fungi in the genus Glomus," *New Phytol.*, 2005, doi: 10.1111/j.1469-8137.2004.01251.x.

[11] Y. Asakawa, M. Toyota, R. Matsuda, K. Takikawa, and T. Takemoto, "Distribution of novel cyclic bisbibenzyls in Marchantia and Riccardia species," *Phytochemistry*, 1983, doi: 10.1016/S0031-9422(00)84025-X.

[12] S. M. Perold, "Marchantiales," *Bothalia*, 1990, doi: 10.4102/abc.v20i2.922.

CHAPTER 17

JUNGERMANNIALES: MORPHOLOGY, ANATOMY AND REPRODUCTION

Ms.Varsha Shekhar, Assistant Professor,
School of Agricultural Sciences, Jaipur National University, Jaipur, India,
Email Id-varsha.shekhar@jnujaipur.ac.in

ABSTRACT:

The largest order of liverworts is the Jungermanniales, also known as "leafy liverworts," which includes species like Lophocolea, Lophozia, and Frullania. These species contrast with thalloid liverworts like Marchantia and Pellia, as well as mosses and hornworts, which together make up the bryophytes. The simplest plant species still in existence are liverworts. They are less widely known than mosses yet thrive in damp environments. Archegonia and antheridia, stalked reproductive organs, are present on the gametophyte's upper surface, while unicellular rhizoids with fine hairs protrude from the bottom surface.

KEYWORDS:

Algae, Anatomy, Jungermanniales, Morphology, Reproduction.

INTRODUCTION

The Frullaniaceae family of leafy liverworts is distinguished by creeping plants that range in size from moderate to robust, creating branching tufts and are typically epiphytic in nature. Figure 1 shows the Jungermanniales' Sexual Reproductive Structures.The stylus is multiform, the leaves are incubous, [1] with typically inflated lobes that often change into water sacs. Because of its global distribution, this family contributes to tropical environments' higher richness and variety. Several species of the big, brownish Frullaniaceae spores exhibit endosporic germination and rapid growth.

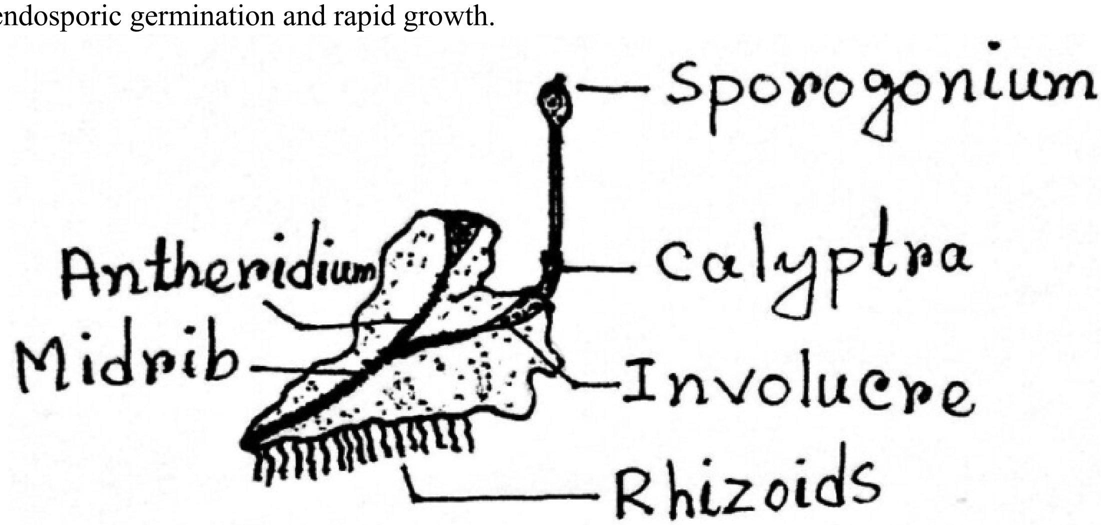

Figure 1: Illustarte the Jungermanniales' Sexual Reproductive Structures.

- The gametophyte is distinguished into a stalk and leaves; the leaves are carried along the stem in a predictable spiral sequence.
- The apical cell has three cutting faces and a pyramidal shape.
- The stem often has three rows of leaves; the first two rows are lateral and include leaves of a regular size, while the third row is made up of under leaves, which are typically smaller than lateral leaves.
- The archegonia are usually confined to the axis' and its branches' apices.
- The location of the sporophytes is invariably terminal.
- The leaf axis is where the antheridia are born, either individually or in clusters.
- The single egg cell and the ventral canal cell are both found in the archegonium, a tiny flask-shaped structure that develops from a single surface cell.
- A little neck with five in the majority of Jungermanniales neck canalcells initially blocking the canal.

In areas with high humidity, many of the 800 or so species of Frullania liverworts grow as epiphytes on the bark of trees and shrubs. This liverwort doesn't hurt trees since epiphytic plants don't remove anything from the host plants they live on. It sometimes has a highly lacy, fern-like appearance. It sometimes brings to mind the stunning fan corals seen on far-off coral reefs. Both F. dilatata and F. tamarisci are common species in Britain, although F. dilatata typically grows on trees whereas F. tamarisci grows on rocks, the ground, or less commonly on trees.

A genus of leafy liverworts called Frullania has a thallus that is pinnately branched and divided into a stem and leaves. Little olive-green plants make up the plants. The thallus often ranges in color from dark green to copper-brown to reddish. It has a particular kind of leaf. In a few species, the tiny leaves of the Frullania liverwort were strung together like beads. In particular, younger branches have rounded, sharp leaf lobe apices. The lobules are separated from the stem and joined to it in such a way that they tilt outward, are clavate-cylindric, and are compressed somewhat dorsiventrally towards the mouth in contrast to the gibbous upper half with an acute apex.

The leaves have three rows, two lateral lobes that are unevenly sized, and a ventral lobe [2]. Each leaf has two portions, the smaller of which resembles a pitcher. These tiny pitchers collect water and often include a distinctive microscopic fauna, such as rotifers, which may perhaps help the liverwort's nourishment. Leading stems have beneath leaves that are much smaller, further apart, wider than the stem, and longer than broad. Large cells make up the lobes of the leaves.

Leaf and Stem Anatomy: There is very little tissue differentiation, and even the epidermis is not clearly visible. Cortical and central medullary zones are divisions of the stem. Cortical zone cells are smaller but have a thicker wall than medullary zone cells, which are bigger and have a thinner wall. There is no conducting tissue. The cells of the single-layered leaf include oil bodies and chloroplasts. Stomata and air holes are still lacking, and the leaf lacks a midrib.

Fragmentation

When an old branch of a branching stem dies, the branches that were split off become new plants thanks to apical development.

These little or wide detachable branches aid in vegetative reproduction, according to Cladia in section: They come in two varieties: Leaf cladia: Occurring in each individual leaf cell, such as in Frullania fragilifolia. Stem cladia: Developing from a single stem cell.

Sexual Reproduction: While some species are monoecious and others are dioecious, the species in question is most likely dioecious. Special lateral branches carry the sex organs. The peculiar lateral branches are where the antheridia are born [3]. Archegonia are terminally borne on the main stalk or a branch. A mature sporophyte features a short, wide seta, and a blunt foot. The spores are enclosed in the capsule.

Sex organs are found on different branches of the same plant in monoecious species. Bracts are the leaves that are produced on fruitful stems. They are not like the vegetative leaves in terms of size and form. Perichaetial bracts are those found on the female branch while perigonial bracts are those found on the male branch.

Antheridia

It grows on unique, short branches known as androecia, or male branches. Each antheridium is a tiny, roughly spherical structure carried on a long stalk under a concave scale-like leaf on the male shoot's catkin-like growth. Each male branch has two to five pairs of perigonial bracts, which are bilobed and typically concave and close together. The size of the two lobes is practically equal. Each bract's axil typically develops two antheridia.

The antheridium has two distinct parts: a stalk and a globular body. A jacket layer surrounds the androcyte cell mass in the center of the antheridial body, and the stalk bears a double row of cells. Each androcyte mother cell undergoes a diagonal division to produce two androcytes, and each of these then undergoes a transformation into biflagellate antherozoids.

Gynoecia on short or long shoots, with 2–5 archegonia per shoot. With 0-14 keels, the perianth flattened or expanded, and the mouth shrunk into a beak. The mature archegonium has a flask-like structure with a long, thin neck and a vent. The egg cell and a ventral canal cell are enclosed by the venter. The five vertical rows of neck cells that make up the neck surround an axial row of up to eight neck canal cells.

Water is present throughout the fertilization process. The flagellated antherozoids, or male gametes, are released by the antheridia when they are mature and swim across the surface layer of wetness attracted to chemicals secreted by the egg cell (or possible associated tissues). The perianth's ability to store water may help with this. The ventral canal cell and neck canal cells in the ripe archegonium decompose into mucilage, which absorbs water and expands to open the flask-like archegonium so an antherozoid may swim down to the egg where fertilization takes place.

Sporophyte: Usually, the diploid zygote gives rise to sporophytes. After fertilization, one of the archegonia at the female shoot tip will transform into the sporophyte. It emerges from the perianth as a stalk with a spore capsule on top. When mature, the spore capsule may be more-or-less spherical but is often elongated and black in color. In certain species, a marsupium is formed when the young sporophyte starts off its growth totally wrapped in gametophyte tissue that emerges from the stem. This protective sheath of stem tissue may be a sizable structure and may be present at the tip of the shoot or hang down at an angle from the branch in certain species that lack a perianth. It may also contain leaves or bracts.

Foot, seta, and capsule development [4] of the sporophyte are complete. There are multiple rows of cells in a frullania seta. The sporophyte's foot does not enter the stem. The capsule is globose and has a two-layered wall. Elaters with 2-3-spirals that are fastened to the capsule valves and positioned vertically within the capsule. Large, multicellular, and endosporic spores.

Spread of Spores

Two to multiple cell layers of wall make up the spore capsule, and the cell walls thicken in bands. The spores are haploid because they are the result of meiosis. These bands of thickenings, which are produced in very particular patterns, put tension on the tissues when the ripe capsule dries up, causing the capsule to burst and divide into four valves (above right). The majority of leafy liverworts have a water rupture mechanism that releases the spores. Elaters, or inflated, elongated cells, are scattered throughout the spores. On the interior of the cell wall of these transparent, water-filled elaters, a double spiral band of wall-thickenings is present. In liverworts, the elaters may be free or tethered to the interior walls of the spore capsule (sporangium), but in this method, they are fixed at their base.

Each elater in certain leafy liverworts, like [5] Frullania, spans the sporangium and is securely fastened to the sporangium floor at one end and to the roof at the other. The elaters are briefly extended and each contains a single spiral of thickening, which makes them effectively a stretched spring in the wall of a water-filled tube. As the four valves of the capsule bend back, as the capsule dries and opens. The elaters are pulled free at their bottom ends in less than a second, and the spores are thrown out in an arc (much as when a stretched spring is twisted backward and then released from one end). The huge antical lobes of the bilobed leaves of Frullania fragifolia separate, leaving just the postical lobes. Porella's outer structure: Porella's [6], [7] gametophyte is foliose, dorsiventral, and flat. The bi- or tripinnately branching prostrate stem or axis. On the stem, there are three rows of leaves: two dorsal rows and one ventral row. The lateral leaves are formed by the dorsal rows, while the ventral row's leaves are known as amphigastria. There are no midribs on the leaves. Dorsal leaves have two lobes. [8] The lower posterior lobe, also known as the postical lobe or lobule, is considerably smaller and narrower with an acute apex than the upper anterior lobe, also known as the antical lobe, which is wider and often elliptical in shape. The bottom margin of each leaf is covered by the top edge of the leaf below it in the dorsal leaves, which have an incubous arrangement. While looking at the animal from the dorsal side, this layout is visible. From the ventral surface of the stem, many rhizoids with smooth walls appear in a dispersed pattern. Rhizoids' primary job is to secure the thallus to the substrate. The leaves and stem are the main parts of the plant where water and minerals are absorbed.

DISCUSSION

Internal Porella Features

Stem

The cortex and the medulla, two separate areas, are visible on the T.S. of the adult stem. The medulla is made up of thin-walled, elongated cells, whereas the cortex is a 2-3 layered zone of thick-walled parenchymatous cells.

Leaf

The arrangement of the leaves is relatively straightforward. A single layer of isodiametric parenchymatous cells with many chloroplasts makes up each leaf. Many species have oil cells in their leaves.

Porella reproduces vegetatively using any of the two techniques listed below:

- **Through Gradual Death and Decay of the Gametophyte:** The older portions of the thallus gradually deteriorate as the apical development of the thallus progresses, resulting in the separation of the younger portions at the thallus' dichotomy point. New plants are created from the split branches.
- **By Gemmae:** On the underside of the leaves of certain species (P. rotundifolia), discoid multicellular gemmae are generated. New plants are created when gemmae germinate.
- **Porella has dioecious sexual reproduction:** Comparatively speaking, male gametophytes are smaller than female gametophytes.
- **Antheridium:** At a right angle to the main axis, specialized lateral antheridial branches bear antheridia. The dorsal leaves, known as bracts, are firmly intertwined and smaller than those on the main branch. Bracteoles are the ventral leaves (amphigastria) of the antheridial branch. Each leaf's axil is home to a solitary antheridium.
- **Growth of Antheridium:** In the base of the juvenile bract, an antheridial initial separates transversely to create an outer cell and a basal cell. The buried portion of the stalk is formed by the basal cell, which does not divide any more. The outer cell serves as the mother cell of the antheridia, dividing transversely to produce the upper primary antheridial cell and the lower primary stalk cell.

After several transverse and vertical divisions, the original stalk cell develops into a two-celled thick, long stalk. The major cell of the antheridium is the primary antheridial cell. It divides vertically to produce two identical antheridial cells. Each of these cells undergoes a periclinal division, resulting in the formation of two disparate cells: the inner, bigger primary androgonial cell and the outer, smaller first jacket initial. The latter splits off once again to create a second jacket initial. After periclinal divisions, both jacket initials combine to produce the antheridium's single-layered jacket.

Antheridium Mature Structure: The adult antheridium is distinguished by its lengthy stalk and globose body [9]. The jacket has one layer in the top section and two to three layers in the bottom part thanks to periclinal divides. A mass of androcytes that eventually transform into biflagellate antherozoids is found within the jacket. The single-layered, thin distal portion of the antheridial jacket. This section of the jacket separates into several irrational lobes. The antherozoids may now discharge into the water as a result.

Sporophyte: The zygote becomes larger and surrounds itself with a wall of secreted material. Zygote splits transversely to create an epibasal cell and a hypobasal cell, much as other bryophytes. The hypobasal cell creates a suspensor rather than continuing to divide. A transverse division creates two daughter cells from the epibasal cell. These offspring cells divide repeatedly in both the transverse and vertical directions in a set order to create an uneven mass of cells. Eventually, periclinal divisions in the top region of the embryo separate the inner endothecium from the peripheral amphithecium. The capsule wall develops from the amphithecium, and the whole endothecium serves as the archesporium. The archesporium divides repeatedly in every conceivable plane to create the sporogenous tissue.

CONCLUSION

In the sporogenous tissue, spore mother cells and elater mother cells differentiate. The sterile elaters are formed when the elaters mother cells lengthen and acquire two spiral thickenings. To create haploid spores, the spore mother cells go through meiotic division. The lowest portion of the embryo gives rise to the foot and the seta. The Porella sporophyte matures and divides into three parts: the foot, seta, and capsule. Three protective coverings—the calyptra, perianth, and involucre enclose the newborn sporophyte. Seta: Composed of parenchymatous cells, it is an extended structure that joins the foot to the capsule. The capsule is a globular structure made up of a lot of spores and elaters. With the exception of four vertical rows of thin-walled cells that mark the vertical lines of dehiscence, the jacket is 3–4 cells thick and composed of parenchymatous cells with thick walls.

Detachment of the capsule: As the seta reaches maturity, it abruptly lengthens, forcing the capsule out of the calyptra and perianth. The capsule now divides into four valves along the line of dehiscence as the capsule wall dries up. Elaters' hygroscopic mobility aids in the discharge of spores.

Newborn gametophyte: The spore is the product of gametophytic production at its inception. The ornate exine on the outside and the thin-walled intine on the inside make up a spore's two concentric walls. A third layer, [10] known as the perinium, may sometimes be discovered outside the exine.

The spore begins to grow as soon as it touches a suitable substrate after falling. Apical cell differentiation occurs. After that, a multicellular thalloid structure develops. Rhizoids grow from the bottom side, whereas leaves appear on the top side. When the spores are still in the capsule, they may begin to germinate.

REFERENCES

[1] L. Veiter, V. Rajamanickam, and C. Herwig, "The filamentous fungal pellet—relationship between morphology and productivity," *Applied Microbiology and Biotechnology*. 2018. doi: 10.1007/s00253-018-8818-7.

[2] K. J. A. Zawada, M. Dornelas, and J. S. Madin, "Quantifying coral morphology," *Coral Reefs*, 2019, doi: 10.1007/s00338-019-01842-4.

[3] L. Packer, J. Gibbs, C. Sheffield, and R. Hanner, "DNA barcoding and the mediocrity of morphology," *Mol. Ecol. Resour.*, 2009, doi: 10.1111/j.1755-0998.2009.02631.x.

[4] D. Gonzalez Ortiz, C. Pochat-Bohatier, J. Cambedouzou, M. Bechelany, and P. Miele, "Current Trends in Pickering Emulsions: Particle Morphology and Applications," *Engineering*. 2020. doi: 10.1016/j.eng.2019.08.017.

[5] J. Ford, "Red blood cell morphology," *International Journal of Laboratory Hematology*. 2013. doi: 10.1111/ijlh.12082.

[6] C. Robier, "Platelet morphology," *Journal of Laboratory Medicine*. 2020. doi: 10.1515/labmed-2020-0007.

[7] A. Duckworth, N. Giofre, and R. Jones, "Coral morphology and sedimentation," *Mar. Pollut. Bull.*, 2017, doi: 10.1016/j.marpolbul.2017.08.036.

[8] K. Rastle, “The place of morphology in learning to read in English,” *Cortex*. 2019. doi: 10.1016/j.cortex.2018.02.008.

[9] C. Wang *et al.*, “Fabrication of electrospun polymer nanofibers with diverse morphologies,” *Molecules*. 2019. doi: 10.3390/molecules24050834.

[10] B. Zhou, Y. X. Zuo, and R. T. Jiang, “Astrocyte morphology: Diversity, plasticity, and role in neurological diseases,” *CNS Neuroscience and Therapeutics*. 2019. doi: 10.1111/cns.13123.

CHAPTER 18

SPHAEROCARPALES, MARCHANTIALES, JUNGERMANNIALES, METZGERIALES AND CALOBRYALES

Ms.Varsha Shekhar, Assistant Professor,
School of Agricultural Sciences, Jaipur National University, Jaipur, India,
Email Id-varsha.shekhar@jnujaipur.ac.in

ABSTRACT:

Hepatophyta are often referred to as liverworts due to the gametophyte's resemblance to the liver. Liverworts are the most basic plant species still in existence. While being less well recognized than mosses, they also thrive in moist conditions. As its gametophyte lacks xylem and phloem, liverworts are similar to mosses in that they don't have true leaves, stalks, or roots. Nonetheless, the gametophyte morphology and the simpler sporophyte make liverworts distinct from mosses. The gametophyte, or thallus, of a liverwort may take several forms, such as the ribbon-shaped or lobed structure of "thallose" liverworts or the leafy branch system of "leafy" liverworts. On substrates, both forms often flatten out and grow prostrately.

KEYWORDS:

Algae, Anatomy, Jungermanniales, Morphology, Reproduction.

INTRODUCTION

Archegonia and antheridia, stalked reproductive organs, are present on the gametophyte's upper surface, while unicellular rhizoids with fine hairs protrude from the bottom surface. The hornwort's mucous-filled chamber is absent from all liverwort thalli. The thallose liverwort Marchantia may be found growing in moist ashes after fires, amid mosses on rocks, and on stream banks. Marchantia is one of many thallose liverworts, which are distinguished by a thallus with internally differentiated tissues that exchange gases through barrel-shaped pores that open into air chambers within the thallus, despite the fact that all liverworts lack a cuticle the waxy, water-resistant layer present in mosses and hornworts [1]. Liverwort pores seem different from vascular plants' stomata. Sporophytes of liverwort lack air holes. Unlike moss rhizoids, which are always multicellular, liverwort rhizoids are single-celled. Rhizoids serve as a thallus anchor and aid in the capillary movement of water and dissolved minerals. A midrib, or thicker area that runs along the middle of each thallus lobe, is a characteristic of many thallose liverworts. While certain species have specialized tissue to help in conduction, the thallus lacks vascular tissue. Seldom do liverworts grow taller than 5 cm.

Liverworts, which resemble mosses in size and shape, reproduce both sexually using gametes and asexually using spores, fragmentation, and gemmae. Through mitotic division, the liverwort egg is created in the gametophyte's archegonium. Antheridia generate motile, antherozoid on a different thallus (male gametophyte). Raindrops carrying sperm fertilize the egg. The resulting diploid zygotes give rise to a sporophyte in the liverwort embryo. A tiny stalk holding the liverwort sporophyte firmly to the female gametophyte. The seta (stalk), foot, and capsule (sporangium) make up the sporophyte.

At the sporophyte tip, meiotic cell division occurs, resulting in the formation of haploid spores. Elaters, helical coils that twist as they dry and then abruptly break to release spores, are responsible for releasing spores after the capsule has opened. Mosses lack elaters-like cells, whereas hornworts do. Animals, water, and the wind all help spread spores. In certain genera, a filament of cells forms prior to the thallus whereas in others, a spore germinates immediately into a juvenile thallus. When this haploid gametophyte develops, the life cycle starts again. The life cycle of all mosses, liverworts, and hornworts is haploid-dominated. Liverworts develop haploid individuals that are genetically identical to the parent plant via asexual reproduction through gemmae. Certain thallose liverworts develop tiny cup-shaped organs called cupules on the thallus' top surface. Gemmae, or tiny green spheres, develop within the cupules. Raindrop-dispersed gemmae transform into new haploid liverworts when they land in appropriate wet soil.

The majority of the world's 6000 species of liverwort are [2] found in tropical areas where they grow on dirt, rocks, shady trees, and fallen logs. In addition to being epiphytes, or creatures that grow on other species but are not symbiotic, liverworts are often found around waterfalls and other areas of swiftly flowing waters. There are a variety of animals that can live in the severe climate of Antarctica by producing "antifreeze." Liverworts were thought to be helpful in treating liver conditions throughout the middle Ages. During that time, a practice known as "Doctrine of signature" included treating illnesses that affected specific organs using plants that resembled those organs. Nowadays, liverworts are not considered to have any medicinal use and are not consumed. Its usefulness comes from the role they play as pioneer plants in burned-out regions and other hostile environments.

Throughout the life cycle of bryophytes, the dependent and diploid sporophyte stage occurs. Because to a lack of chloroplasts, it is constantly linked to the gametophyte and is reliant on it for nourishment. They are rather diminutive. They lack the lateral appendages and branching that gametophytes have. They are of determinate growth since there is no mean for apical development. Yet, the sporophyte in hornworts has an unpredictable growth period because of the basal meristematic zone. The primary role of the sporophyte is to create spores and spread them to far-off locations in order to successfully complete the life cycle. They have thus evolved morphology that is ideally suited to carrying out their primary purpose. Both the bryophyte capsule and the whole bryophyte sporophyte are sometimes referred to as sporogoniums.

It is often believed that sporophytes are completely reliant on gametophytes for their nutritional needs and that they sometimes function as parasites on them, however this is not entirely accurate since chloroplasts may also be found in the cells of the capsule wall, seta, and foot. Since they have low chlorophyll levels and no stomata, the sporophytes in liverworts are more reliant on the gametophyte. However, because the foot, seta, and capsule wall cells contain chloroplasts, many liverworts, including Marchantia polymorpha, Dumortiera hirsuta, Riella Americana, Sphaerocarpos texanus, Monoselenium tenerrum, and Pellia epiphylla, have sporophytes that are capable of photosynthesis, at least in the early stages of development. The seta in certain liverworts, such Sphaerocarpus, Corsinia, and Riella, is very tiny, thin, and substantially reduced to few celled wide. Even after reaching [3] adulthood, it does not lengthen. While the seta in the majority of liverworts is small at first, as the capsule matures, it elongates quickly, pushing the capsule outside the protective coverings—the calyptra, perianth, perichaetium, or involucre and aids in spore dispersal, as in the case of members of the orders

Jungermanniales and Metzgeriales. Among bryophytes, liverworts are often recognized as the most primitive category. Marchantiales and Jungermanniales are two of them that lack water-conducting cells. Nonetheless, Calobryales and Metzgeriales have an interior strand of water-conducting cells. The water-conducting cells of Metzgeriales have thick cell walls with helicoidal pits that resemble tracheids.

DISCUSSION

Salient Features of Key Groupings with a Focus on the Given Gener

Hepaticae, Anthocerotae, and Musci are the three groups into which the bryophyta have been separated, according to Campbell, Smith, Takhtajan, and others. We'll discuss the members of the Class Hepaticae in this section.

- There is dorsiventral differentiation in the gametophytes. They might be divided into leaves and stems or be thalloid (thallose) (foliose).
- The leaves of foliose kinds are usually without a midrib and are arranged in two or three rows on the axis.
- Unless they are terminal in position, the sex organs arise from superficial cells on the dorsal side of the thallus.
- The sporophyte might be straightforward, divided into a foot and capsule, or a foot, seta, and capsule.
- The endothecium of the sporogonium gives rise to the sporogenous cells.
- Gametophytes are the only source of nutrition for the sporophyte.
- The sporogonium's wall consists of one to many layers. On the sporogonium wall, there are no stomata.
- The sporogonium's dehiscence is erratic.
- The orders Sphaerocarpales, Marchantiales, Metzgeriales, Jungermanniales, Calobryales, and Takakiales are further subdivided into the class Hepaticopsida.
- This section includes a thorough explanation of the orders Sphaerocarpales, Marchantiales, Metzgeriales, and Jungermanniales.

Sphaerocarpales' Morphology, Anatomy, and Reproduction

Among the liverworts, there is an order of plants called sphaerocarpales. There are around twenty species in this order, which is further classified into the [4] Sphaerocarpaceae and Riellaceae families. The following are some of the order's distinguishing characteristics:

- The sporophyte's structure and development of the sex organs are similar to those of the order Marchantiales, while the gametophyte's vegetative structure is similar to that of the order Metzgeriales. For this reason, the genera are classified in a different order called Sphaerocarpales.
- The presence of a globose or flask-like envelope or involucre surrounding each of the sex organs is the primary diagnostic characteristic by which the order is distinguished (i.e., antheridia and archegonia).
- The plant body is thalloid, the ventral surface is free of scales, and there are smooth-walled rhizoids.
- An involucre encloses antheridium and archegonium.

- Sporophyte with a globose capsule, seta, and tiny foot. The capsule wall is unilayered and does not have elaters.
- The dehiscence of the cleistocarpous capsule is irregular.

Sphaerocapos and Geothallus are two genera of the Sphaerocarpaceae family. The genus is absent from India and is mostly found in the USA. Its form changes according on the environmental conditions and is mostly found in damp, cooler regions. The genus Sphaerocarpos has the most straightforward kind of thallus organization.

Gametophyte

The thallus is prostrate, dorsiventral, tiny, green, and dichotomously branched, while the plant body is thalloid. There is a growing point at the apical notch. A prominent mid rib that resembles an axis is also present. The thallus has a narrow, delicate unistratose wing section and a middle multistratose cushiony midrib region.

The thallus' dorsal surface is very smooth, and unlike [5] Marchantia, it lacks air pores. Only at the apex, close to the developing point, do scales appear on the ventral surface. Mucilage hairs are also found close to the apical notch, and each one contains a big, inflated terminal cell at the tip. The rhizoids are straightforward and restricted to the thick center of the thallus. Plants with a tiny, frail, transparent, whitish-green rosette that may measure up to 8 mm in diameter.

Thallus Anatomy

The photosynthetic and storage zones of the thallus are not distinguished, making for a fairly basic anatomical structure. There have just a multistratose midrib region and unistratose leaf lobes. All cells, with the exception of rhizoidal cells, include chloroplast. Sphaerocarpos has both vegetative and sexual mechanisms of reproduction. Through dichotomous branches or adventitious branches, vegetative reproduction occurs. The lowest part of the plant may produce numerous new branches, and each branch can produce a new plant.

Sexual reproduction

The thalli are highly distinctive in that they have the sex organs in a specific involucre, while having such basic shape and anatomy. An involucre, which may be either pear- or bottle-shaped, surrounds each of the sex organs (antheridium and archegonium). Plants are unisexual, with male plants being significantly smaller than female plants and being far less common. Antheridial plants are typically 0.1–0.3 times smaller than archegonial plants in male plants. Each involucre on the dorsal surface is one layer thick and has many involucres. Antheridium contains biflagellate, spindle, or coiled antherozoids, as well as a single thickening cell. Antherozoid development resembles Marchantia.

Female Plant: Archegonial plants are 2--15 mm in diameter; their lobes are often succubous, 1-stratose, and neither divided nor lobed. A short thallus-like axis with ruffled lobe-like leaves at the edges, the leaves rounded distally, and crisped and ascending borders are concealed by the inflated female (archegonial) involucres. Archegonial involucres are prominent and occur in the late summer or early autumn. They are flask- or bottle-shaped, 1-2 mm high, and flaring open at the mouth. Archegonial involucres include capsules, however they are not visible without dissection. Quadrate to hexagonal cells are those without trigones. Ovoid sporangia with four rows of four cells each and a very short seta. Large spores,[6] spore walls that are reticulate or not, aerolate faces, and aeroles that have tubercles, lamellae, or spines.

Male and female thalli that are growing close to one another will fertilize one another. For fertilization to occur, water is required. Venter canal and neck canal cells in the adult archegonium dissolve and create a mucilaginous mass. It pushes the cover cells apart, soaks up water, swells up, and emerges through the archegonial mouth. Chemical elements make up this mucilaginous material.

Raindrops splatter the antherozoids

They may land on a nearby female receptacle or swim the whole distance by one. Via a chemotactic reaction, several antherozoids reach up to the egg in the archegonial neck. Splash cup mechanism is the name of this fertilization process. The egg is penetrated by one of the antherozoids, which interferes with fertilization. A diploid zygote or oospore is created when the male and female nuclei combine. The gametophytic phase is concluded by fertilization.

Sporophyte

A fertilized archegonium, like a flask, contains an egg that grows into a sporophyte. The development of new cells allows the fertilized egg to expand. The embryonic sporophyte elongates in the vast majority of species, and one portion develops into a foot that pierces the gametophyte and binds the embryonic sporophyte to the gametophyte. There are three components to the Sphaerocarpos sporophyte:

- **Foot:** It enters the gametophyte, binds the developing sporophyte to it, and is in charge of absorbing nutrients from the gametophyte.
- **Seta:** In contrast to what occurs in mosses, seta only elongates after the spore capsule has reached maturity. Liverwort setae are quite frail and colorless because they lengthen as a result of cell growth. Very short seta with four cell rows in height that does not elongate.
- **Capsule:** An uppermost sporophyte component that is one cell thick and formed from an amphithecium. It has chloroplasts, and spores and nurse cells made from endothecium fill the capsule's chamber. The meiotic division of the diploid endothecium cells produces the spore mother cell. Although a small percentage of diploid cells fail to serve as spore mother cells and becoming sterile, their nature changes and they are referred to as nursing cells. Chlorophyll is present in these cells, feeding the growing spores.
- **Spores:** During germination, spore tetrads generate two male and two female plants. The germ pore causes a germ tube to develop. It splits into two unequal cells at the terminal end by a transverse wall. Rhizoidal cells are formed by the lower cell, and the densely cytoplasmic higher terminal cell splits once more transversally and longitudinally. It produces a short filamentous gametophytic plant body that is two cell thick and roughly four cell high.

CONCLUSION

A category of plant species known as bryophytes [7]–[9]reproduce by spores rather than flowers or seeds. The three non-vascular land plant kinds that make up the majority of bryophytes are hornworts, mosses, and liverworts. They are often found in moist conditions. Non-vascular terrestrial plants are known as bryophytes. While they have unique features for moving through the water, they lack vascular tissue. While they may be found growing in a variety of locations, including deserts, the arctic, and high heights, bryophytes are typically found in wet situations. Bryophytes are able to thrive in settings that vascular plants cannot because they do not rely on root systems for nutrition intake (e.g., on the surface of rocks)[10], [11]. Throughout their life cycle, all bryophytes have a dominant gametophyte stage. The plant is haploid at this stage, and the development of the sex organs responsible for producing gametes has begun. In contrast to many other plant species, bryophytes stand out because they spend a lot of time in this stage.

REFERENCES

[1] J. G. Segarra-Moragues, F. Puche, and M. Sabovljević, "Rediscovery of Riella alatospora (Riellaceae, Sphaerocarpales), an aquatic, South African endemic liverwort previously known from a now largely transformed type locality," *South African J. Bot.*, 2012, doi: 10.1016/j.sajb.2011.11.006.

[2] H. J. Hewson, "Sphaerocarpales in Australia," *Bryologist*, 1981, doi: 10.2307/3242854.

[3] T. Katagiri and A. Hagborg, "Validation of ordinal and family names for a triassic fossil liverwort, naiadita (Naiaditaceae, marchantiopsida)," *Phytotaxa*, 2015, doi: 10.11646/phytotaxa.222.2.12.

[4] F. Puche and F. Boisset, "On the occurrence of Riella affinis M. Howe and Underwood (Marchantiopsida, Sphaerocarpales) in the Sahara Desert (Africa)," *Cryptogam. Bryol.*, 2009.

[5] W. A. Taylor, "Ultrastructure of lower Paleozoic dyads from southern Ohio," *Rev. Palaeobot. Palynol.*, 1996, doi: 10.1016/0034-6667(96)00109-1.

[6] J. G. Segarra-Moragues, F. Puche, M. S. Sabovljević, M. Infante, and P. Heras, "Integrative taxonomy of the model liverwort Riella helicophylla (Riellaceae, Sphaerocarpales) reveals its extreme rarity and an overlooked widespread new species, R. macrocarpa," *Taxon*, 2022, doi: 10.1002/tax.12682.

[7] H. Bischler-Causse, S. R. Gradstein, S. Jovet-Ast, D. G. Long, and N. S. Allen, "Marchantiidae," *Flora Neotrop.*, 2005.

[8] J. Proskauer, "On Sphaerocarpos stipitatus and the genus Sphaerocarpos.," *J. Linn. Soc. London, Bot.*, 1954, doi: 10.1111/j.1095-8339.1954.tb00008.x.

[9] J. G. Segarra-Moragues, F. Puche, and M. Sabovljevi, "Riella heliospora (riellaceae) a new monoicous species of Riella subgenus Trabutiella from California," *Syst. Bot.*, 2012, doi: 10.1600/036364412X635368.

[10] P. A. Hochuli and U. Groner, "Heerisporites, a new spore-genus of possible riellacean affinity," *Rev. Palaeobot. Palynol.*, 1985, doi: 10.1016/0034-6667(85)90020-X.

[11] R. C. Brown, Z. B. Carothers, and J. G. Duckett, "Comparative Spermatogenesis in the Sphaerocarpales. II. Blepharoplast Structure in Geothallus tuberosus Campb.," *Bryologist*, 1983, doi: 10.2307/3242711.

CHAPTER 19

MORPHOLOGY, ANATOMY AND REPRODUCTION OF METZGERIALES

Ms.Varsha Shekhar, Assistant Professor,
School of Agricultural Sciences, Jaipur National University, Jaipur, India,
Email Id-varsha.shekhar@jnujaipur.ac.in

ABSTRACT:

The term "simple thalloid liverworts" refers to a group of organisms that lack features like stems or leaves and are characterized by thin, generally undifferentiated tissues. Each species in the order has a tiny gametophyte stage and a tiny, spore-bearing stage that is generally short-lived. The group as a whole is extensively dispersed and may be found on every continent except Antarctica, despite the fact that these plants are nearly completely constrained to areas with high humidity or easily accessible moisture.

KEYWORDS:

Alage, Anatomy, Morphology, Metzgeriales, Reproduction.

INTRODUCTION

Most tissues in members of the Metzgeriales are just one cell layer thick, and they are generally tiny and thin enough to be transparent. The Metzgeriales are sometimes referred to as the "simple thalloid liverworts" because of their thinness and lack of tissue differentiation. The Metzgeriales' vegetative structure exhibits a great deal of variation. Simple thalloid liverworts often lack features that resemble leaves. Nevertheless, other genera, including Symphyogyna and Fossombronia, are "semileafy" and have thalluses that are quite deeply lobed, giving the impression of leafiness. It is generally considered that the leafy state originated individually and independently in each of the semileafy groups that make up the Metzgeriales since these groups are not closely linked to one another [1].

The position of their archegonia is another way that members of the Metzgeriales vary from the related Jungermanniales (female reproductive structures). Archegonia in the Metzgeriales emerge from a cell that is behind the apical cell, as opposed to the Jungermanniales, where archegonia develops straight from the apical cell at the tip of a fertile branch. As a consequence, the dorsal surface of the plant is always home to the female reproductive organs and the sporophytes that grow inside of them. These structures' growth in the Metzgeriales is referred to as anacrogynous since they do not form at the branch's apex.

The following are some of the distinctive qualities of this order:

- The gametophyte may be stem- and lateral-leave differentiated or thalloid.
- Gametophytes often lack internal tissue differentiation, although some species feature a core strand of thick-walled cells.
- Smooth-walled rhizoids are present on a gametophyte's ventral surface.
- The sex-organs are spotted all over the thallus' dorsal surface.
- The juvenile segments that the apical cell cuts off give birth to the archegonia.

- The adult sporophytes are set back from a gametophyte's developing apex.
- Every branch of the gametophyte may develop the sex organs (antheridia and archegonia), or only certain branches can create them.

The Northern Hemisphere's chilly and temperate zones are home to the tiny but widely distributed genus of liverworts known as Pellia. It belongs to the Pelliaceae family of plants and is included in the Metzgeriales order. There are just four species in the genus Pellia, which is only known to exist in India. These are P. neesiana, P. endiviaefolia, P. calycina, and P. epiphylla. It is found in the Western Himalaya, Uttarakhand, Himanchal Pradesh, and other places at elevations of 5000 to 8000 feet.

A Habit

Pellia thrives best in damp, shaded areas, particularly those near ditches and streams. They may also grow on damp soil, rocks, or, in shaded areas, in the space between rocks. Although fertile plants often thrive in open environments, sterile plant portions may be found thriving beneath regularly flowing shallow water. Strong thallus and long lobes are characteristics of plants growing in moist soil. The thallus is delicate, long and slender, [2] and has a noticeable midrib when it is grown underwater.

Plant body is slender, dorsiventral, prostrate, dichotomously branching, and has a slightly undulating edge. Thallus is flat, green, lobbed, and thin. The median midrib is noticeable, while the dorsal surface is almost smooth. Many smooth, unicellular rhizoids are produced from beneath the midrib and protrude on the ventral surface. Every lobe of the thallus bears a terminal notch that contains a developing point. Internal attributes Thallus anatomy is straightforward yet multilayered [3], [4]. There are the following strata visible in T.S. via the thallus:

- There is upper and lower epidermis. There are several smooth rhizoids in the bottom epidermis. There are many of chloroplast in cells that are close to the surface.
- Compact parenchymatous cells with chloroplasts and a few scatted fibrous cells are located in between the two epidermal layers. Typically, the midrib region is thicker than the edges (8–16 layers deep) (2-5 layers in depth).
- The thallus is made up of parenchymatous cells that are used to store food and exhibits no signs of differentiation. Like a honeycomb, the cells are connected to one another.
- A single apical cell with four cutting faces is[5], [6] responsible for apical growth.
- In the mid-rib area, unicellular rhizoids develop from the underside.
- The absence of air holes and air chambers, which are present in Marchantia.

DISCUSSION

Pellia reproduces by both sexual and vegetative processes. It reproduces vegetatively by adventitious branches and fragmentation, and in a few numbers of species, regeneration may also be seen from fragments of thallus in culture. Plants may reproduce sexually in a monoecious or dioecious manner. In the dioecious forms, the female plant's archegonia grow in a cluster slightly below the developing tip, but the male plant bears antheridia throughout the whole dorsal surface of the midrib. The antheridia follow the archegonia in monoecious species.

Antheridia

Located deep inside the thallus's dorsal surface hollow. The adult antheridium is globose, one cell thick in the jacket layer, and has a multicellular short stalk that is typically one cell in size. It is located at the base of the antheridial chamber, which has a pore opening on the dorsal side. An androcyte mother cell mass is encircled by an outer wall. These androcytes change into sperm that are biflagellate.

Archegonium

They grow in groups on the thallus' top surface. All of the archegonia in the cluster are supported by the receptacle, a transverse ridge of tissue that is slightly elevated. The involucre, a full flap-like sheath, completely encircles the archegonia of the cluster. The archegonium is a flask-shaped structure that is supported by a short, sturdy stalk. A venter carrying the egg, a ventral canal cell, four to six neck canal cells, and four cap cells are all visible in the adult archegonium.

Fertilization

Water is necessary for fertilization to occur. In the [7] archegonium, all cells save the egg disorganize, and a mucilage mass is created. It swells up, fills the neck canal, and absorbs water. Androcytes emerge through the aperture when the antheridia ruptures at its apex. Sperm are released and swim in the direction of the archegonial neck to the egg. The first sperm loses its flagella and joins with the egg cell to produce a zygote.

Sporogonium

The involucre and calyptra cover the sporophyte. A unique foot, seta, and globose capsule are present on each sporophyte. Conical foot covering a portion of the seta with collar-like protrusion. There is a little seta here. The capsule is globose in form, has a two-layered jacket with bigger outer layer cells with thicker radial walls and cells of the inner layer with enlarged inner tangential walls, as well as many spores and elaters. The capsule's jacket is made up of amphithecium, while the archesporium is made up of endothecium. Elaters, elatophores, and spore are produced by Archesporium. Each capsule has a distinctive elaterophore at the base that is made up of many elaters. The capsule wall separates into four valves and dehisces. Elaters aid in the spores' dissemination. A genus of liverwort in the Petalophyllaceae family is called Sewardiella. It includes Sewardiella tuberifera, a single species that is unique to India. Its native habitat is rocky terrain, and habitat loss is a hazard to it.

Plants that are foliose and grow in clusters on damp soil are called gametophytes. Thallus has a dorsiventral, prostrate habit, and is light green in color. The thallus is made up of two lateral rows of leaf-like structures carrying a clearly defined central axis or midrib. The plant is anchored by a large number of small, smooth-walled, violet-colored, unicellular rhizoids that grow from the ventral surface. The leaves are slender, pale or light green, and they alternate. Except for the basal part, which is two or three cells thick, the leaf is one cell thick[8].

Reproduction

Sexual and vegetative types of reproduction both occur. Vegetative reproduction: This process involves tuber creation and renewal. The plant's stem apex bends downward towards the conclusion of the growth season and develops almost vertically into the tuber that forms the soil. Most animals reproduce sexually in monoecious relationships. The sex organs grow on the dorsal surface and may be found alone or in clusters.

On the top surface of the thallus, antheridia grow in acropetal succession in groups of two to five or dispersed throughout. The majority of antheridial groups are located at the anterior end, with each group separated from its neighbor by a little scale. Round, thinly stalked, and orange in color, mature antheridia are. One cell thickens the antheridial wall. One superior cell produces one antheridium. The inner cells of antheridium are known as androgonial cells, and it is covered by a jacket layer. Androcytes are created when these cells divide diagonally. Each androcyte changes into a sperm from a biflagellate.

Archegonia

They grow lateral to the midrib, close to the developing point that is shielded by the tender leaves. Archegonium has a long neck with 5–6 neck canal cells, a large venter, and a twisted base. Each archegonial cluster receives a bell-shaped perianth after fertilization. Sex organs dehisce after ingesting moisture during fertilization, and sperms are forcedly discharged. All cells in female sex organs disorganize, with the exception of egg cells. [9]Sperm travels across water to reach egg cells. The process of fertilization gives the thallus tissue next to the fertilized archegonium's base more encouragement to develop into the perianth, a bell-shaped organ.

Sporophyte

It may be classified as a foot, seta, or capsule. The foot is haustorial and nourishes. In a few species, the seta is rather lengthy; in others, it is shorter. A capsule is a spherical shape with two cells of wall thickness. There is no elaterophore in the capsule, just elaters and spores. A perianth, a bell-shaped sheathing organ, surrounds the mature sporophyte. After fertilization has occurred, the perianth grows.

CONCLUSION

The seta elongates as the spore grows within the capsule, rupturing the calyptra and raising the capsule above the perianth as a result. Exposed capsule either [10]dehisces erratically or dries out and breaks into four valves. The hygroscopic action of the elaters releases the spores from the capsule and disperses them. After some time in the latent period, spores begin to germinate when it begins to rain. They develop a green filamentous protonema at germination, and this is how the gametophyte is formed.

REFERENCES

[1] M. Preußing, M. Nebel, F. Oberwinkler, and M. Weiß, “Diverging diversity patterns in the Tulasnella (Basidiomycota, Tulasnellales) mycobionts of Aneura pinguis (Marchantiophyta, Metzgeriales) from Europe and Ecuador,” *Mycorrhiza*, 2010, doi: 10.1007/s00572-009-0275-9.

[2] M. Preubßing *et al.*, “New insights in the evolution of the liverwort family aneuraceae (Metzgeriales, Marchantiophyta), with emphasis on the genus Lobatiriccardia,” *Taxon*, 2010, doi: 10.1002/tax.595009.

[3] A. Basile, S. Sorbo, M. Lentini, B. Conte, and S. Esposito, “Water pollution causes ultrastructural and functional damages in Pellia neesiana (Gottsche) Limpr.,” *J. Trace Elem. Med. Biol.*, 2017, doi: 10.1016/j.jtemb.2016.11.014.

[4] S. M. Perold, "Studies in the liverwort genus Fossombronia (Metzgeriales) from southern Africa. 3. An amendment to F. spinifolia," *Bothalia*, 1997, doi: 10.4102/abc.v27i1.651.

[5] T. H. Samigullin *et al.*, "Sequences of rDNA internal transcribed spacers from the chloroplast DNA of 26 bryophytes: Properties and phylogenetic utility," *FEBS Lett.*, 1998, doi: 10.1016/S0014-5793(97)01600-1.

[6] J. Bechteler *et al.*, "The evolution and biogeographic history of epiphytic thalloid liverworts," *Mol. Phylogenet. Evol.*, 2021, doi: 10.1016/j.ympev.2021.107298.

[7] S. M. Perold, "Studies in the liverwort genus Fossombronia (Metzgeriales) from southern Africa. 10. Three new species from Northern and Western Cape," *Bothalia*, 1999, doi: 10.4102/abc.v29i1.574.

[8] A. Bączkiewicz, J. Sawicki, K. Buczkowska, K. Polok, and R. Zielinski, "Application of different DNA markers in studies on cryptic species of Aneura pinguis (Jungermanniopsida, Metzgeriales)," *Cryptogam. Bryol.*, 2008.

[9] P. Sukkharak and S. Chantanaorrapint, "The liverwort genus Metzgeria (Metzgeriaceae, Marchantiophyta) in Thailand," *Phytotaxa*, 2020, doi: 10.11646/PHYTOTAXA.441.3.2.

[10] B. Norden, A. Gardeinnet, J.-P. Priou, and P. Döbbeler, "Bryocentria hypothallina (Hypocreales) – a new species on Metzgeria furcata Björn," *Ascomycete.org*, 2015.

CHAPTER 20

MORPHOLOGY, ANATOMY AND REPRODUCTION OF CALOBRYALES

Ms.Varsha Shekhar, Assistant Professor,
School of Agricultural Sciences, Jaipur National University, Jaipur, India,
Email Id-varsha.shekhar@jnujaipur.ac.in

ABSTRACT:

Pale to brilliant green calobryum plants have aerial leafy branches and a prostrate, leafless rhizome with descending, hyaline, leafless stolons. Tetrahedral apical cells, which have core strands of hydroids, are used for growth. Three-ranked, isophyllous or anisophyllous leafy shoots with the decreased row of leaves dorsal; the presence of oil bodies; and the absence of rhizoids. Positively geotropic, branched (unbranched), and hyaline stolons.

KEYWORDS:

Alage, Anatomy, Calobryales, Calobryum, Reproduction.

INTRODUCTION

Tetrahedral apical cells, which have core strands of hydroids, are used for growth. Three-ranked, isophyllous or anisophyllous leafy shoots with the decreased row of leaves dorsal; the presence of oil bodies; and the absence of rhizoids. [1] Positively geotropic, branched (unbranched), and hyaline stolons. The primary stem begins as a prostrate plant that is occasionally growing beneath the ground or tangled in a felt of other liverworts or brown leaf litter. This stem portion is white in color and has a mucilaginous coating on the exterior that is as thick as the stem itself. Rhizoids and leaves are both absent.

The tip of the underground stem goes upright and develops into a transparent, light green, leafy stern when it is 1 to 2 cm long. The erect stem's base produces lateral branches. Yet one or more of them begin to spread out forcefully, and these, after some time of horizontal development, begin to stand up as fresh green shoots.

The following are some of the distinctive qualities of this order:

- They have three rows of leaves on tall, leafy gametophytes. The two types of leaves are anisophyllous and isophyllous.
- The leaves have a central strand of conducting tissue and are dorsiventrally flattened.
- They have an upright, leafy rhizome that is pale, underground, and sparsely branched.
- The highest leaves on erect branches containing sex organs are closely spaced and arranged in more than three rows.
- They don't have any rhizoids.
- The antheridia are stalked, ovoid, and produced near the stem's tip.
- The archegonium's neck jacket only has four vertical rows of cells.

- The sporophyte produces an extended capsule, except at the apex, where the jacket layer is just one cell thick.
- There are nine chromosomes, or n = 9.
- Characters in the Calobryaceae are identical to those in the order since there is just one family. Calobryum and Haplomitrium are two genera.
- Calobryum
- Pale to brilliant green calobryum plants have aerial leafy branches and a prostrate, leafless rhizome with descending, hyaline, leafless stolons.

DISCUSSION

A central colorless zone with a possible diameter of 16 cells may be [2] seen in the erect stem. Male shoots are thinner, with an outside zone that is 5 to 7 cells broad and a center zone that is just 4 cells across. Some of the deeper cells produce mucilage hairs made up of a terminal cell with a club-like form and a short stalk cell, whereas the surface cells are roughly isodiametric, have a very thin cuticle, and contain more plastids than deeper cells. The deeper cells progressively lengthen until they reach the center zone. The apical cell at the stem's tip has three cutting faces that are all the same size, with the exception of the time immediately after cell division. A leaf grows from each piece that the apical cell removes. These leaves are initially uniseriate, but as they grow, the basal section develops many serrations, often with a thickness of four cells.

Reproduction

Dioecious or monoecious [3] sexual state; antheridia and archegonia share a developmental pattern, at least in the early ontogenetic stages. Different antheridial and archegonial plants exist, and they may grow in independent clumps or interlaced. The antheridial plant is the more upright of the two, and its leaves often have a wider spacing between them than those of female plants. Over some time, the male branches develop and produce successive generations of leaves and antheridia. Depending on the stage of growth, the look varies. The immature antheridia are present when fresh growth starts in September (spring). They are totally overarched and encircled by the three newest leaves as they lay in a mucilage-filled hole at the apex of the upright branches.

Antheridium

At the tip of the antheridiophore, mucilage hairs are dotted among the antheridia. Both amid the older antheridia and adjacent to the apical cell, young antheridia form. The antheridium develops from a surface-protruding cell that splits transversely to form an inner cell buried in the tissue of the receptacle and an outer protruding cell. The main stalk cell and primary antheridial cell are formed by a transverse division of the outer cell. To create the antheridial stalk, the latter is divided by two crossing vertical walls and transverse walls.

The initial wall of the main antheridial cell is obliquely vertical, splitting it into two cells of different sizes. More obliquely vertical walls are created in the bigger cell 2, which converge with the wall above. A three-sided pyramid-shaped center cell that is heavily stained at this stage is encircled by three jacket cells. [4] The first produced jacket cell splits vertically, and as the new cells grow, the core cell also grows vertically, expanding to form a four-sided pyramid. The other jacket cells also divide later. After transverse divisions, the antheridium's fully formed uniseriate jacket is created. The spermatogenous cells are produced when the primary pyramidal cell splits transversely and then repeatedly divides in different planes. Either all fertile cells divide at once, or the upper half of the antheridium's fertile cells divide before the bottom half. The last division in the production of spermatogenous cells might occur in any plane and need not be diagonal as it commonly does in hepaticae.

The mature antheridium is oval in form and protrudes from the receptacle's surface on a stalk made of four rows of cells that are three to five tiers high. In the presence of water, it splits open at the top, the terminal cells bend outward, and the mass of sperm cells gently emerges.

Archegonium

The archegonium replaces a leaf rudiment and develops from a superficial cell next to the apical cell. An exterior projecting cell and an inner cell that is implanted in the tissue of the receptacle are produced when the superficial cell splits transversely. The latter splits transversely to produce an initial stalk cell and an end cell. The base of the venter and the short stalk of the archegonium that protrudes beyond the receptacle's surface are created as a result of the stalk initial's rapid division into vertical and transverse walls. [5] Meanwhile, in the terminal cell, three inclined walls are gradually placed in such a manner as to separate three jacket cells into a pyramidal center cell. Four jacket cells are created when one of the jacket cells splits vertically. The jacket cells divide once periclinally shortly before the archegonium reaches maturity in the venter area, and they also divide transversely and vertically there.

A slender stalk that protrudes slightly beyond the receptacle's surface, a biseriate venter that is just marginally wider than the base of the neck, and a spirally twisted, often curved neck are all characteristics of the mature archegonium. Vertical or obliquely vertical divisions among the topmost neck canal cells occur at a late stage of development.

Germination

Sporogonium: In September, young archegonia were beginning to develop. Up to 20 archegonia may grow on the flat or dome-shaped disc that the stem tip creates. They first rest in a mucilage-filled chamber that is surrounded and overarched by the leaves, but over time, the leaves grow and flatten. These leaves are bigger than vegetative leaves and are transversely placed in three rows on the stem. If fertilization is unsuccessful, the archegoniophores stay in situ for a number of months, the disc being encircled by the big dentate leaves and covered with ancient, bronze-colored archegonia. At the extremities of several of the archegoniophores in November, ripe sporogonia are discovered.

The three components of sporogonium are the foot, seta, and capsule. A 5 to 8 mm long pengynium, or colorless, fleshy foot, surrounds the sporogonium's base. The dark brown capsule, which is 3 to 4 mm long and 0.5 mm broad, is [6] carried at the tip of the thin, colorless seta, which stands upright to a height of 22 mm. With an archegoniophore, just one sporogonium typically develops.

Except for the area of the protruding, knob-shaped terminal cap, which is up to five cells thick at the top, the mature capsule's jacket is unseriate. The cells in this area lack wall thickenings and are colorless. The cells that make up the sides of the capsule are 3 to 12 times longer than they are wide; the cells that make up the shoulders are about isodiametric. The spores are oval in form and have a brown outer wall that is rough and has tiny, rounded protrusion. They often cling together in pairs or tetrads. The fast elongation of the seta finally causes the mature capsule to be forced out through the calyptra at the top of the perigynium. Dehiscence often occurs into 4 valves, although it may also happen into 2, 3, or 5 valves. [7] The valves do not separate at the ends. The valve edges curl back as the dehiscence progresses upward from the capsule's base, releasing the spores when the twisting elaters liberate them.

The biggest order of liverworts is the Jungermanniales, or "leafy Liverworts," which contrasts with thalloid liverworts like Marchantia and Pellia as well as with the mosses and hornworts that make up the bryophytes. Shoots may be fertile shoots that terminate in female or male reproductive organs, or they can be vegetative shoots that culminate in a cluster of spreading leaves that hide the developing tip. The female shoot seen here terminates in a perianth that resembles a vase and encloses and shields the female reproductive organs (archegonia).

Most tissues in members of the Metzgeriales are just one cell layer thick, and they are generally tiny and thin enough to be transparent. The Metzgeriales are frequently referred to as the "simple thalloid liverworts" because of their thinness and low degree of tissue differentiation. The position of their archegonia is another way that members of the Metzgeriales vary from the related Jungermanniales (female reproductive structures). [8] Archegonia in the Metzgeriales emerge from a cell that is behind the apical cell, as opposed to the Jungermanniales, where archegonia develops straight from the apical cell at the tip of a fertile branch. As a consequence, the dorsal surface of the plant is always home to the female reproductive organs and the sporophytes that grow inside of them.

CONCLUSION

According to phylogenetic analysis, liverworts are the earliest [9] phylum of bryophytes. Their main characteristics are the brief sporophyte's existence (lasting for just a few weeks at most), stomata lacking in generations, and seta hyaline and elongating once the sporangium matures (capsule). The spores are largely expelled when the sporangial wall splits into four valves, helped by hygroscopic elaters with spiral wall thickenings, which are formed from sporogenous tissue together with spores[10], [11]. The capsule lacks peristome teeth and sterile tissue of the columella. There is a very little amount of gametophytic protonema in liverworts, and it only develops one bud into a leafy or thallose gametophore[12].

REFERENCES

[1] M. R. Turetsky, "The Role of Bryophytes in Carbon and Nitrogen Cycling," *Bryologist*, 2003, doi: 10.1639/05.

[2] R. Ligrone, J. G. Duckett, and K. S. Renzaglia, "Conducting tissues and phyletic relationships of bryophytes," in *Philosophical Transactions of the Royal Society B: Biological Sciences*, 2000. doi: 10.1098/rstb.2000.0616.

[3] R. M. Schuster, "On Takakia and the phylogenetic relationships of the Takakiales," *Nov. Hedwigia*, 1997, doi: 10.1127/nova.hedwigia/64/1997/281.

[4] J. J. Engel, "Haplomitrium Monoicum, A Remarkable New Species of Calobryales (Hepaticae) from New Caledonia, Together with a Reclassification of Subg. Haplomitrium," *Ann. Missouri Bot. Gard.*, 1981, doi: 10.2307/2398895.

[5] R. M. Schuster, "Two New Antipodal Species of Haplomitrium (Calobryales)," *Bryologist*, 1971, doi: 10.2307/3241827.

[6] M. Stech and W. Frey, "CpDNA-relationship and classification of the liverworts (Hepaticophytina, Bryophyta)," *Nov. Hedwigia*, 2001, doi: 10.1127/nova.hedwigia/72/2001/45.

[7] K. R. Markham, "Flavonoids and phylogeny of the 'primitive' New Zealand hepatic, Haplomitrium gibbsiae," *Phytochemistry*, 1977, doi: 10.1016/0031-9422(77)80037-X.

[8] M. Stech and W. Frey, "Molecular circumscription and relationships of selected Gondwanan species of Haplomitrium (Calobryales, Haplomitriopsida, Hepaticophytina): Studies in austral temperate rain forest bryophytes 24," *Nov. Hedwigia*, 2004, doi: 10.1127/0029-5035/2004/0078-0057.

[9] K. R. Markham and L. J. Porter, "Flavonoids of the primitive liverwort Takakia and their taxonomic and phylogenetic significance," *Phytochemistry*, 1979, doi: 10.1016/S0031-9422(00)84270-3.

[10] A. Baczkiewicz and J. Szweykowski, "Geographic distribution of Haplomitrium hookeri (Hepaticae, calobryales) in Poland," *Polish Bot. J.*, 2001.

[11] G. K. Berrie, "Cytology and Phylogeny of Liverworts," *Evolution (N. Y).*, 1963, doi: 10.2307/2406164.

[12] V. Nath and A. K. Asthana, "Sporoderm and elateroderm diversity in some rare and interesting Indian liverworts under SEM," *J. Hattori Bot. Lab.*, 1996.

CHAPTER 21

MORPHOLOGY, ANATOMY AND REPRODUCTION OF ANTHOCEROTALES

Dr. S.K.Khatik, Assistant Professor,
School of Agricultural Sciences, Jaipur National University, Jaipur, India,
Email Id- skumar.patho@jnujaipur.ac.in

ABSTRACT:

With the aid of a proper illustration, humans shall describe the morphology of anthoceros in this chapter. A unique evolutionary lineage of thalloid liverworts known as the anthocerotae, or hornwort, lacks internal thallus differentiation and contains one big chloroplast and an accompanying pyrenoid in each of its cells. The sporophyte, a tapering structure with undetermined development, is referred to as the "horn." Some authors raise hornworts to a new division of the plant kingdom called Anthocerophyta due to the existence of a single big chloroplast with an accompanying pyrenoid per cell and the indeterminate development of the sporophyte. In this report, the representative genus Anthoceros is mentioned.

KEYWORDS:

Alage, Anatomy, Anthocerotales, Morphology, Reproduction.

INTRODUCTION

Six genera, 301 species, one family, Anthocerotaceae, and one order, Anthocerotales, make up the class Anthocerotopsida. Anthocerotaceae and Notothylaceae are two of the families that make up the order Anthocerotales, according to Proskauer (1951). The latter contains just one genus, Notothylas. Yet, the Anthocerotaceae family is the sole one, according to leading bryologists. The number of genera in this [1] family ranges between five and six. Anthoceros, Phaeoceros, Aspiromitus, Notothylas, Dendroceros, and Megaceros are the genera in question. The four genera Anthoceros, Megaceros, Dendroceros, and Notothylas are the most well-known. The other bryophytes are different from this group in a number of ways.

Anthoceros's Habitat and Distribution

There are roughly 200 species of Anthoceros. All species have a global range and are terrestrial in nature. The plants thrive in areas that are highly wet and shaded, such as slopes, rocks, or ditch banks. On decomposing wood, some species may be seen developing. Anthoceros is often not well suited to withstand arid conditions, unlike other bryophytes. Over 25 different species of Anthoceros may be found in India. A. himalayensis, A. erectus, and A. chambensis are the three Anthoceros species that are most often seen growing in the Western Himalayan area at a height of 5000–8000 feet (Kashyap, 1915). This species may also be found growing in the South Indian plains and in Mussoorie, Kulu, Manali, Kumaon, Chamba Valley, Punjab, and Madras.

Anthoceros' Gametophytic Phase

The thalloid, dorsiventral, prostrate, [2] dark green body of the gametophytic plant has a propensity for dichotomous branching. The thallus takes on the appearance of an orbicular or semi-orbicular rosette as a consequence of its branching. An anthoceros plant resembles a tiny rosette. Rhizoids with just one cell are connected to the thallus' underside. There are a few tiny mucilaginous cavities on the ventral side. The blue-green algae colonies in these cavities resemble Nostoc. On the dorsal side of the thallus, there are tiny slits that resemble stomata. The dorsal surface of the thallus may be velvety due to the presence of many lobed lamellae (A. crispulus), rough with spines and ridges, or smooth (A. laevis) (A. fusiformis). It has a shiny finish, is thick in the center, and lacks a clear mid rib.

Ventral Surface:

Many unicellular, smooth-walled rhizoids are present on the ventral surface. Their major jobs are to draw water and mineral nutrients from the soil and to attach the thallus to the substrate. Rhizoids with tubercles, scales, or mucilaginous hairs are not present. On the ventral surface, there are several tiny, opaque, spherical, thickened dark blue green dots. These are the mucilage cavities that Nostoc colonies have colonized. The mature thalli exhibit tall, elongated, and cylindrical sporogonia in the months of September and October. They appear in groups and resemble horns. A sheath-like structure surrounds each sporogonium at its base. It is known as an involucre.

Internal Structure:

A very basic structure is seen in the vertical transverse section (V. T. S.) of the thallus. There is no zonation. It is consistently made up of parenchymatous cells with thin walls. The centre of the thallus is the thickest. It progressively becomes thinner as it gets closer to the edges. Several species have varying middle region thicknesses. In A. laevis, it is 6–8 cells thick, in A. punctatus, it is 8–10 cells thick, and in A. crispulus, it is 30–40 cells thick. Upper epidermis is the skin's outermost layer. The epidermal cells are smaller, properly organized, and equipped with chloroplasts that resemble big lenses. There is just one solitary big discoid- or oval-shaped chloroplast in each thallus cell. A distinctive property of the class Anthocerotopsida is the presence of a single, big, noticeable body called a pyrenoid inside each chloroplast. A pyrenoid is made up of 25–300 bodies with disc to spindle shapes. In Anthoceros, there are no air pores or chambers. On the bottom surface of the thallus, intercellular voids are seen in a small number of species. These holes develop as a result of the breakdown of the cells (schizogenous). The cavities are known as "mucilage cavities" because they are mucilage-filled. These cavities have holes or slits on the ventral side known as slime pores that resemble stomas. There are two guard cells with thin walls in each slime hole. The guard cells have no function and have no influence on pore size.

At the development of the thallus the mucilage in the cavities dries up. Cavities filled with air are created as a consequence of it. Via slime pores, the blue-green algae Nostoc enters these air spaces and establishes a colony there. It is uncertain if the presence of Nostoc colonies in the thallus of Anthoceros promotes gametophyte development. Nonetheless, according to Rodgers and Stewart (1977), the relationship is mutually beneficial. The Nostoc receives carbohydrates from the thallus, and by fixing air nitrogen, [3] it produces more nitrate nutrients. Lower epidermis is the lowest cell layer. The smooth-walled rhizoids are formed by a few cells that stretch from the lower epidermis. Anthoceros uses both vegetative and sexual reproduction techniques.

Vegetative reproduction

Through disintegration or death of the older part of the thallus:

Due to aging or dryness, the older component of the thallus begins to rot or dissolve. The lobes of the thallus divide as it ascends to the site of dichotomy. Detachable lobes become separate plants as a result of apical development. Compared to liverworts, Anthoceros does not use this technique as often.

Via tubers:

Under adverse circumstances or protracted dryness, the thallus's marginal tissues thicken and develop into perennating tubers. Some species place them in various positions. They may grow along the thallus margins or behind the growth points (A. laevis) (A. hallii, A. pearsoni). The tubers of A. himalayensis are stalked and grow along the thallus ventral surface borders. The outer two to three layers of the tubers' corky hyaline cells surround the tissue's oil globules, starch grains, and aleurone granules. They have the ability to transmit negative circumstances. When favorable circumstances return, tubers grow new thalli.

From Gemmae:

Along the edges of the dorsal surface of the thallus, various multicellular stalked structures such as A. glandulosus, A. propaguliferus, and A. formosae grow. The term "gemmae" refers to these objects. Each gemma transforms into a separate plant when it is separated from the parent thallus.

Through persistent growing apices:

In certain species of Anthoceros (A. pearsoni, A. fusiformis), the whole thallus dries up and is killed, with the exception of the growing point, during an extended dry summer or at the conclusion of the growth season. Eventually, under adverse circumstances, it penetrates the soil deeply and thickens. It grows into a brand-new thallus. More so than multiplication, it is a mechanism of perpetuation.

Via apospory:

The gametophytic thallus in Anthoceros is made up of unspecialized cells from the various sporogonium sections, including the intercalary meristematic zone, the sub epidermal layer, and the sporogenous portion of the capsule. Apospory is the name given to this phenomena. The thalli, like those of A. laevis, are diploid yet seem normal.

Sexual reproduction is oogamous:

Archegonia are the female reproductive organs, whereas antheridia are the male. A. erectus, A. chambensis, A. hallii, A. pearsoni, and A. laevis are examples of dioecious Anthoceros species, while A. longii, A. gollani, A. fusiformis, A. punctatus, A. crispulus, and A. himalayensis are monoecious Anthoceros species. The protandrous monoecious species develop before the archegonia because antheridia do.

An adult antheridium has a stalk and a body that resembles a club or a pouch. The stalk connects the base of the antheridial chamber to the antheridium. A. punctatus and A. erectus stalks are both long and made up of four rows of cells, although other species may be much larger (A. laevis). In the same antheridial chamber, there may be a single antheridia or a cluster of two to four or more. The bulk of androcytes that transform into antherozoids is enclosed in a single layer of sterile material.

The jacket layer of certain species, including A. punctatus and A. erectus, is made up of four layers of cells. It seems like the compartments in each tier are long and rectangular in shape. The uppermost layers' cells are triangular with a thin end that points upward. Plastids are the building blocks of the jacket's cells. These plastids' colors shift from green to red to vivid orange as they mature. As a result, young antheridia are green, and as they grow, they become brilliant orange or crimson. An adult antherozoid has a linear body, is unicellular, uninucleate, and bi-flagellated. Almost equal in length to the body are the flagella.

Creation of Antheridia

An outer dorsal cell is where the antheridium first begins to form. This cell never develops into a papilla. It splits into an exterior roof initial and an inner antheridial initial by periclinal division. The antheridium grows from the inner cell in contrast to the class Hepaticopsida (for instance, Marchantia). The antheridium is hence endogenous in origin. Between the antheridial initial and roof initial, a mucilaginous-filled gap develops shortly after the division. The ceiling of the antheridial chamber is divided into two layers by periclinal divisions at first, followed by many anticlinal divisions. The antheridial initial may split vertically into two, four, or even more daughter cells, or it might grow into a single antheridium (A. pearsoni) (A. erectus). Each daughter cell performs the role of the antheridial initial. To create four cells, the antheridial start splits twice vertically at an angle to one another. [4] The immature antheridium now consists of four cells.

To create eight cells, which are stacked in two layers of four cells each, all four cells undergo transverse division. The bottom tier's cells are known as stalk cells. Transverse divisions of these cells create the multicellular stalk of the antheridium. The body of the antheridium is made up of the four cells in the top layer. These cells divide transversely to create eight new cells. To create the eight outer primary jacket cells and the eight inner primary androgonial cells, each octant cell undergoes a curved periclinal division. Several tiny, cubical primary androgonial cells are produced as a consequence of repetitive transverse and vertical divisions in primary androgonial cells. Androcyte mother cells are the most recent generation of androgonial cells. The two triangular cells known as androcytes are produced by the diagonal mitotic division of each androcyte mother cell. Each androcyte's protoplast transforms into a bi-flagellated antherozoid. In certain species, the stalk of the secondary antheridia grows later from the primary one. Because of this, in more sophisticated. The number of antheridia in each antheridial group, each at a distinct stage of development, varies within each antheridial chamber.

Degeneration of Antheridium

The antheridium dehisces with the aid of water. The ceiling of the antheridial chamber develops irregularly as the antheridia mature, revealing the antheridia in a cup-like chamber. The top layer of triangle cells in the antheridia break apart as they absorb water, releasing a mass of antherozoids. The antheridium loses turgor and[5] collapses after dehiscence. Other antheridia converge towards the roof opening in its wake, making it feasible to create a continuous flow of antherozoids. It describes how sporophytes, which are abundant in hornworts, originate.

Archegonium

On the dorsal surface of the thallus, archegonia grow. A mucilage mound may be used to pinpoint the location of an archegonium on a thallus. Two to four cover cells, an axial row of four to six neck canal cells, a venter canal cell, and an egg make up a complete archegonium. Unlike most bryophytes, the jacket layer is not distinguishable from the other vegetative cells.

One superficial cell serves as the archegonial beginning as the archegonium begins to grow on the dorsal side of the thallus. It may be identified from other cells by the protoplasm, which is dense. Archegonial initials (A. crispulus, A. gemmulosus) may transversely divide to produce upper primary archegonial cells and lower primary stalk cells, or they may act as primary archegonial cells directly (A. erectus).

The main axial cell is created when the primary archegonial cell splits into three peripheral or jacket initials and a fourth middle cell by three consecutive crossing walls. Transverse divisions cause the jacket initials to split into two [6] levels of three cells each. Six cells are formed by the anticlinal division of the cells in the higher layer. Six rows of sterile neck cells are formed by the transverse division of these cells into these cells. The lowest tier's three compartments are divided transversely and vertically to create a venter wall. It is difficult to track the growth of the cells and separate them from vegetative cells since the archegonium is entrenched in the thallus.

An outer cell and an inner (central) [7] cell are created by the transverse division of the original axial cells. The inner main neck canal cell and terminal cover initial are created by a transverse division of the outer cell. The inner cell performs the main ventr cell's direct role, and it divides only once to create the bottom big egg and the top tiny ventr canal cell. Four to six neck canal cells are formed when the primary neck canal cell undergoes a series of transverse divisions. Cover cell at the tip of the neck is formed by dividing the cover initial by one and two vertical divisions.

Fertilization

For fertilization to occur, water is required. Neck canal cells in the adult archegonium, the venter canal cell, dissolve and create a mucilaginous mass. By forcing the cover cells apart, it takes in water, swells, and exits the archegonial neck. This mucilaginous mass merges with the mucilage mound, creating an open channel leading to the egg.

Chemicals make up the bulk that is mucilaginous. [8] The chemotactic reaction causes several antherozoids trapped in the mucilage to enter the archegonial neck, reach up to the egg, and interfere with fertilization. The egg grows and fills the venter cavity before fertilization. A diploid zygote or oospore is created when the male and female nuclei fuse. The gametophytic phase is completed by fertilization.

DISCUSSION

Phase of Sporophytes

The diploid zygote or oospore continues to grow after fertilization and fills the ventral cavity of the archegonium [9]. It secretes a cellulose wall on the outside. Vertical division marks the zygote's first division. The zygote's first transverse division occurs in other bryophytes. This is the key distinction between the development of the hornwort sporophyte and that of the other bryophytes. The top two cells of the second division are often longer than the bottom two due to the second division's transverse orientation (quadrant stage). By using vertical walls, all four cells split to create eight cells (octant stage). Two levels of four cells each make up the arrangement of the eight cells.

Many species have various sporophyte development patterns. In A. erectus, the foot is generated by the bottom tier of four cells in the octant stage, whereas the higher tier of four cells forms the seta and capsule. The highest tier of four cells in the majority of species, including A. fusiformis, A. pearsonia, and A himalayensis, [10] split transversely to produce three tiers of four cells each. The foot is formed by the lowest layer, the meristematic zone, or intermediate zone, is formed by the middle tier, and the capsule is formed by the top tier.

The parenchymatous cells that make up the large, bulbous foot are formed by the four cells in the lowest tier dividing in an atypical manner. In certain species (such as A. punctatus), the foot's surface cells form a palisade layer of cells, but in others (such as A. laevis and A. himalayensis), the layer develops into projections that resemble haustoria. Two to three layers of cells are created from the transverse divisions of the highest tier of four cells, which makes up the capsule. It is followed by periclinal division, [11] which produces the endothecium, a center mass of cells, and the amphithecium, an outside layer of cells. The sterile columella forms from the whole endothecium. It is formed of four cells in the immature sporophyte, but sixteen vertical rows of cells in the adult sporophyte (4 x 4).

The amphithecium differentiates into an exterior sterile layer with jacket initials and an inner fertile layer by a periclinal division. The cells of the jacket initials divide into four to six layered capsule walls by anticlinal and periclinal divisions. The epidermis is the outermost layer of the capsule wall. Stomata are what give it its distinctive characteristics. Chloroplast are found in the cells of the inner layers of the capsule wall. The archesporium produces two different kinds of cells as it matures: spore mother cells and elater mother cells. Spore mother cells have big, dense nuclei and are spherical or oval in shape. These cells split into spore tetrads by meiotic divisions. Elater mother cells have tiny, elliptical nuclei. Four celled elaters are produced by the mitotic division of these cells.

Elaters' four cells may separate into 1-, 2-, or 3-celled units or they can stay joined together. Pseudo elaters are the broken units. The elaters are known as pseudo elaters because they lack thickening bands. The meristematic zone's activity causes the capsule's numerous tissues to continually generate, which causes the capsule to lengthen. A fleshy sheath or coating surrounds the Anthoceros' immature sporophyte. It is known as an involucre. It is created in part from gametophytic thallus tissue and in part from tissue of the archegonium. The sporophyte is entirely encircled with involucre in its early stages.

Sporogonium's Mature Structure

The adult sporophyte is made up of a bulbous foot and a capsule, which is a smooth, upright, cylindrical structure. Several species' capsules range in length from two to fifteen centimeters. The sporogonium resembles a "bristle" or "horn," which is why the species are known as "hornworts."

Internal organization

The foe, seta, and capsule are the three distinct sections of a mature sporogonium. Foot: It is multicellular, bulbous, and composed mostly of parenchymatous cells. It performs the function of a haustorium by absorbing nutrients and liquids from the nearby gametophytic cells for the growing sporophyte.

Seta or the Meristematic Zone: Meristematic zone represents Seta. This is made up of meristematic cells and is located near the capsule's base. The basal capsule of these cells is continually being replenished by new cells. The base of the capsule has a meristem, which helps it develop for a long time and produce spores. It is a special characteristic of Anthoceros and is absent from all other bryophytes.

Its internal structure may be divided into the following categories:

Columella: It is the center, virtually [12] tip-extending sterile pan. It has endothecial roots. It has four vertical rows of cells when it is a juvenile sporophyte, but 16 vertical rows of cells when it is a mature sporophyte (4 x 4). These cells are seen as a solid square in a transverse slice. It serves as a tissue that conducts water, offers mechanical support, and aids in spore distribution.

Archesporium: This organism is situated in the space between the capsule wall and the columella. From the capsule's bottom to its top, it expands. It comes from the amphithecium's inner layer. In a few Anthoceros species, such as A. crenatifrons, A. hawaiensis, and A. erectus, the archesporium may only increase in thickness by one cell as it develops. Yet, it may thicken to two layers in A. pearsoni and A. himalayensis a bit above the base. It may even grow to be two to four cells thick in A. hallii. It differentiates into sporogenous tissue in the top section of the capsule, which generates spores and pseudo-elaters. Pseudo elaters may have one or more elongated cells and can be multicellular, unicellular, branching, or unbranched.

The capsule wall It has four to six layers of cells, the epidermis being the top layer. The epidermis' cells are vertically elongated and contain a cutin deposit on their inner walls. Stomata cause the epidermis' continuity to be disrupted. The stomata are widely spaced apart from one another and are orientated vertically with the sporogonium's axis. Every stoma is made up of a pore and two guard cells.

The cells of the inner layers contain chloroplast and have intercellular gaps. As a result, the sporogonium may produce some of its own organic food, but it also needs the gametophyte to provide it with water and mineral nutrients.

Breaking apart of the capsule

The capsule splits basipetally, or from the apex to the base. The apex of the capsule becomes brownish or black as it ages. In the layer of the jacket, there are vertical lines of dehiscence. The capsule normally dehisces along two longitudinal lines, although it may also happen along a single line or, very rarely, along four lines. At maturity, the capsule wall dries up and contracts.

As a result, the two valves separate, diverge, and hygroscopically twist. Moreover, the pseudo elaters twist, dry out, and aid in loosening the spores. As a result, the valves' twisting and the movement of the pseudo elaters inside the exposed spore mass aid in the spores' shedding. The movement of spores is also aided by air currents.

Spore Structure

The spores have a prominent triradiate mark and are haploid, uninucleate, and semi-circular in shape. Two wall layers still surround each spore. Exospore is the word for the thick, decorated outer layer. Colors range from dark brown to black (like those of A. punctatus) to yellowish (e.g., A. laevis). Endospore is the name for the thin inner layer. Wall layers contain food material, oil globules, and colorless plastids spore germination and development of a juvenile gametophyte. In a few species, the spores germinate right away under the right circumstances. Before germination, some spores, however, go through a resting phase that lasts a few weeks or months. The spore expands up after absorbing water during germination. At the triradiate point, the exospore bursts, releasing an endospore in the shape of a tube. It is known as a germ tube.

The colorless plastids become green as they travel inside the germinal tube. At the apex of a germinal tube, two consecutive transverse walls are laid down, producing a filament with three cells. A vertical division occurs in the higher cell, and a subsequent vertical division occurs in the bottom cell (quadrant stage). These four cells divide once again at a straight angle to the initial cell, creating eight cells (octant stage). The four cells that make up the whole tier serve as apical cells. Every cell in the developing thallus will enlarge and become the first rhizoid. The bottom surface develops mucilage slits as the development continues, and Nostoc infects these slits.

Changing of the Generations

Anthoceros exhibits a consistent alternation of two morphologically different stages during its life cycle. These two generations are haplophase and diplophase, respectively.

Gametophytic phase or the first haplophase

This phase, which creates the sex organs in Anthoceros, is dominating. Gametes from the sex organs combine to create a diploid zygote.

The sporophytic phase's diploid phase

Sporophyte emerges from zygote. The foot, meristematic zone, and capsule are Anthoceros' representations of the sporophyte. The spores in the capsule are produced by the sporophyte. The gametophyte is produced by the spores during germination.

The life cycle of Anthoceros thus consists of two morphologically different stages (haplophase and diplophase). This type's life cycle is classified as heteromorphic and diplohaplontic because it exhibits alternation of generation and sporogenic meiosis.

CONCLUSION

This group occupies a middle position between Bryopsida and Hepaticopsida (Hepaticae) (Musci). Because of its location in between the two significant groups, the Hepaticopsida and the Bryopsida, the group is regarded as being very important from the perspective of its morphology. The following are some of the group's most distinguishing characteristics: The thalloid, dorsiventral body of the gametophytic plant. The walls of the rhizoids are straightforward and smooth. Ventral scales and tuberculate rhizoids are completely missing.

REFERENCES

[1] J. Proskauer, “Studies on Anthocerotales. IV,” *Bull. Torrey Bot. Club*, 1953, doi: 10.2307/2482235.

[2] J. Proskauer, “Studies on Anthocerotales. III,” *Bull. Torrey Bot. Club*, 1951, doi: 10.2307/2481996.

[3] W. Frey and M. Stech, "A morpho-molecular classification of the Anthocerotophyta (hornworts)," *Nov. Hedwigia*, 2005, doi: 10.1127/0029-5035/2005/0080-0541.

[4] R. LIGRONE and C. LOPES, "Ultrastructure, development and cytochemistry of storage cells in the'tubers'of Phaeoceros laevis Prosk. (Anthocerotophyta)," *New Phytol.*, 1989, doi: 10.1111/j.1469-8137.1989.tb02387.x.

[5] D. C. Cargill and G. A. M. Scott, "Taxonomic studies of the Australian anthocerotales I," *J. Hattori Bot. Lab.*, 1997.

[6] F. A. Burr, "Phylogenetic Transitions in the Chloroplasts of the Anthocerotales. I. The Number and Ultrastructure of the Mature Plastids," *Am. J. Bot.*, 1970, doi: 10.2307/2440383.

[7] Z. B. Carothers, J. W. Moser, and J. G. Duckett, "Ultrastructural Studies of Spermatogenesis in the Anthocerotales. II. The Blepharoplast and Anterior Mitochondrion in Phaeoceros laevis: Later Development," *Am. J. Bot.*, 1977, doi: 10.2307/2442167.

[8] P. N. Mehra and O. N. Handoo, "Morphology of Anthoceros erectus and A. himalayensis and the Phylogeny of the Anthocerotales," *Bot. Gaz.*, 1953, doi: 10.1086/335781.

[9] H. Kaja, "Untersuchungen über die Chromatophoren und Pyrenoide der Anthocerotales," *Protoplasma*, 1954, doi: 10.1007/BF01247957.

[10] S. C. Srivastava and A. K. Asthana, "Morpho-taxonomy of Anthoceros crispulus (Mont.) Douin from south India," *Proc. Plant Sci.*, 1987, doi: 10.1007/BF03053564.

[11] J. E. Ridgway, "Factors Initiating Antheridial Formation in Six Anthocerotales," *Bryologist*, 1967, doi: 10.2307/3240945.

[12] J. G. Duckett, Z. B. Carothers, and J. W. Moser, "Ultrastructural studies of spermatogenesis in the anthocerotales. III. Gamete morphogenesis: From spermatogenous cell through midstage spermatid," *Gamete Res.*, 1980, doi: 10.1002/mrd.1120030207.

CHAPTER 22

MORPHOLOGY, ANATOMY AND REPRODUCTION OF SPHAGNALES

Dr.R.K.Bansal, Director,
School of Agricultural Sciences, Jaipur National University, Jaipur, India,
Email Id- director_agriculture@jnujaipur.ac.in

ABSTRACT:

Because of its biological significance in the formation of peat or bog, sphagnum is also often referred to as bog moss, peat moss, or turf moss. The perennial plants thrive in damp environments like marshes and steep slopes where water collects or drips. They develop around the edges of lakes, slowly encroaching on the water as creeping bogs, until eventually they entirely enclose the lake, turning it into a bog. Sphagnum is hence referred to as bog moss.

KEYWORDS:

Alage, Anatomy, Morphology, Reproduction, Sphagnales.

INTRODUCTION

Due to its ecological importance in the formation of peat and bog, sphagnum is also known as peat moss, bog turf moss, or moss moss. Perennial in nature, these plants flourish in wet environments like marshes and steep slopes where water collects or drips. Around the edges of lakes, they grow. They slowly enter the water in creeping bogs that finally totally engulf the lake, turning it into an agro-bog. As a result, another name for sphagnum is "bog moss." The bog is thereafter overrun by angiosperms. As a result, the bog's surface changes and the water becomes very corrosive. The upper section of the Sphagnum gametophores will continue to develop in this acidic soil, but the bottom half will progressively [1] deteriorate. Dead plant components are difficult to quickly breakdown in acidic soil.

The acidic media also helps to prevent the growth of bacteria, fungus, and other harmful microbes. Moreover, it delays the decomposition of dead matter. As a result, there is an enormous accumulation of dead matter each year, which is subsequently compacted by plants above, resulting in the dense, dark-colored material known as peat, which is rich in carbon. Sphagnum, which makes up the majority of peat, is often referred to as peat moss.

Sphagnum's Habit and Behavior

There are around 336 species of sphagnum, all of which are widespread and worldwide. Twenty different Himalayan species are found in India. They grow in dense heaps or cushions in ponds, swamps, lake margins, damp heaths, and wet hill slopes and are either semiaquatic or aquatic.

- Specifications of Sphagnum
- Rhizoids are not present in mature gametophore leaves.
- Each fourth leaf's axil develops into a branch tuft.

- On the leaves, there is no midrib to be seen.

Stems and leaves have distinctive patterns and architectural designs. The cortex of older stems is delicate and may spirally thicken. The two kinds of cells that make up single-layered leaves are large hyaline cells and tiny green photosynthetic cells, Figure 1 shows Morphological traits of Sphagnu.

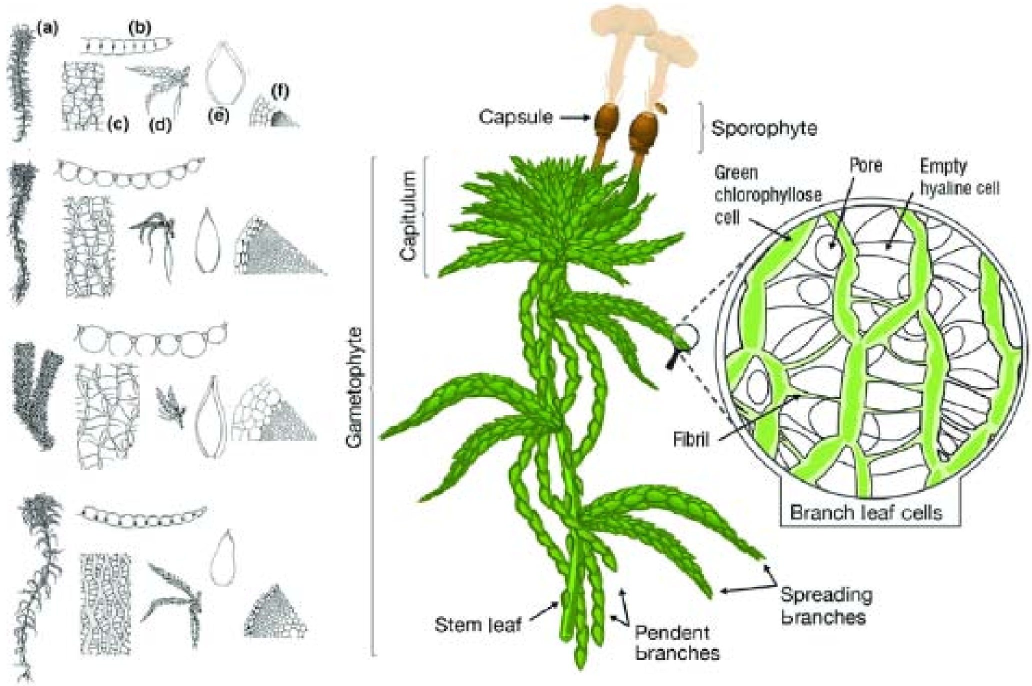

Figure 1: Illustrate Morphological traits of Sphagnum.

The existence of a hyaline retort cell

It is growing in water that is quite acidic. That happens because the cell wall contains a colloidal organic substance. Sphagnum, the only member of the Order Sphagnales, stands out among mosses as an extremely unique and isolated species.

1. The plants grow in big, light green or reddish patches on moors, and when they fill up tiny lakes or pools, they may grow as long as a few feet.
2. Peat formation has been greatly aided by their expansion.
3. The species is widespread in temperate and polar climes, but it only occurs in significant quantities in the tropics.
4. The plants develop from marginal cells, and the protonema creates a flat, lobed, thalloid structure linked to the soil by rhizoids.
5. Many branches that seem to be standing in whorls are carried by the main shoot; some of these branches bend downward and adhere to the surface of the main axis.
6. The stem and leaves have an odd structure.
7. Outside of this, there are one to five layers of huge, transparent cells with circular pores and spiral thickenings that, when they reach maturity, are dead and empty. They are used to transmit and absorb water by capillary action.

8. Since there is no midrib on the leaves and identical empty cells often appear amid the little chlorophyll-containing cells, the leaves look like a network of green.
9. The long stalked, spherical antheridia are present. They are positioned next to the leaves of distinctive club-shaped branches.
10. The apex of short branches is where the archegonial clusters reside. A broad foot and a constriction separating the mature sporogonium from the globular capsule are present.
11. The capsule lacks a peristome but contains a tiny operculum and rudimentary stomata on its wall. The dome-shaped spore-sac extends across a short, broad columella; there is no air-space between the spore-sac and the wall.
12. Many layers of cells are first produced in the embryo. The lower layers make up the foot, and the initial divisions in the top half delineate the columella, around which the archesporium, which is descended from the amphithecium, stretches.
13. When the sporogonium is almost fully developed, the calyptra bursts sporadically. Under dry conditions, the capsule explodes open, projecting the operculum and spores into the air.

Sphagnum's structural makeup:

A. Exterior Elements:

The two unique phases of the Sphagnum gametophyte phase are (a) the juvenile protonema and (b) the adult leafy or gametophore stage. The mature plants develop into thick clusters, with pale or brownish green branches. Due to the presence of the water-soluble pigments anthocyanin, all species of Sphagnum tend to absorb water and often develop with vibrant color (deep red, rose pink, etc.). They have an apical cell with three cutting faces, which allows them to develop indefinitely. Young gametophytes have multicellular, oblique-septated rhizoids. Rhizoids, however, are not produced by mature gametophytes. It has leaves and an erect, branching axis that distinguish it.

Major Branches and Axis: At an early age, the main axis is floppy and frail, but as it ages, it becomes upright and sturdy. The main axis, however, is much longer in aquatic species, but it is very short in terrestrial forms as a result of the advancing demise of the older basal section. The axis has several lateral side branches. Every fourth leaf of the main axis has an axil from which a single branch or tufts of three to eight branches emerge. Many minor branches with restricted development are packed closely together to produce a condensed head known as the coma at the tip of the main stem. [2] The condensed development of apical internodes causes the coma to form close to the apex. These small branches extend and develop into typical branches as the stem lengthens.

The branches of the submerged species (S. obesum, S. cuspidatum) are identical in shape and structure, but the branches of the terrestrial species fall into one of two categories: I pendent branches, and (ii) upwardly diverging branches.

Pendent Branches are long, thin branches that are loosely grouped. They curve downward before growing parallel to the main axis. They are also known as de-current branches or flagella form. Divergent Branches: These are short, sturdy branches that extend upward and outward. They are also known as ex-current branches. Sometimes, one divergent branch in each node grows more robustly than the others and, when it separates from the mother plant, produces a new plant.

Leaves: The leaves may be found on the branches as well as the main axis. The leaves are organized in spiral phyllotaxy on the branches, where they are densely set, overlapping, and spaced apart on the main axis. Also, the size, form, and specifics of the cell structure of the leaves on the main axis and those on the branches are different. The leaves are typically tiny, sessile, whole, thin, scale-like, with a sharp tip, and without veins.

Internal Organization:

- **Stem:** The stem internally displays three unique zones of tissue differentiation: the outer cortex, also known as the hyalodermis, the middle hadrom (a prosenchymatous area), and the inner cylinder, also known as the medulla.
- **Outer Cortex:** The cortex, also known as the hyalodermis, is the stem's outermost layer. Externally, this is enclosed by a single-layered epidermis. There are a lot of big hyaline cells in it. Based on the characteristics of the hyaline cells, the genus Sphagnum is often separated into two subgenera.
- **Middle Hadrom:** It is composed of 4-6 layers of tiny, thick-walled, prosenchymatous cells and is located close to the cortex. Hadrom is the name of the component that supports the stem mechanically.

The core part of the stem, known as the Central Cylinder or Medulla, is made up of tiny, vertically elongated, thin-walled parenchymatous cells. It serves as a storage area. The cross-section of a Sphagnum leaf reveals just one cell in thickness and is made up of a lot of elongated cells. A newborn leaf is made up of uniformly sized square or rectangular cells, but a mature leaf has two different kinds of cells: normal hyaline cells and green chlorophyllous cells, also known as assimilatory cells.

Large polygonal hyaline cells lose[3] their protoplasts to transform into colorless or hyaline cells. Its walls have pores and thicken in a spiral pattern. Rhizoids are not required in mature plants because hyaline cells, also known as capillary cells, have a remarkable ability for absorbing and retaining water.

Little triangular or biconvex living cells with several discoid chloroplasts and the capacity for photosynthetic activity are called chlorophyllous cells. This characteristic of the leaves alone may be used to identify the genus Sphagnum because the chlorophyllous and hyaline cells are arranged in an alternating sequence to produce a regular reticulate pattern.

Replenishment in Sphagnum

Both vegetative and sexual reproduction are possible in sphagnum, albeit vegetative reproduction is more frequent:

1. **Vegetative Reproduction:** It reproduces vegetatively by using creativity. One of the diverging branches may sometimes climb upward and develop to be as robust as the main stem. Innovation is the apical branch of such a tree. The innovation separates from the mother plant and eventually produces a new plant as a result of the lowest basal portion of the main axis's gradual demise. It is because of this phenomena that Sphagnum has grown so much in nature.
2. **Sexual Reproduction:** Sphagnum is capable of both monoecious and dioecious sexual reproduction, however both antheridia and archegonia are always produced on distinct branches on the same plant. Compared to vegetative branches, these branches are much smaller. The antheridial branches emerge earliest in monoecious plants.

3. **Antheridial Branch:** The antheridial branches first develop at the main shoot's apex but gradually move lower as the apical area grows. The majority of the time, these branches are shorter but heavier than vegetative branches. They resemble spindles and are heavily covered with little, often smaller than the foliage leaves, yellow, red, or dark green leaves.

Antheridium Evolution and Antheridium Structure:

Underneath the leaves, the antheridia form singly and acropetally. Each antheridium originates from a stem's superficial antheridial beginning. A little filamentous structure forms on the antheridial beginning. This filament's terminal cell [4] develops two cutting faces to become an apical cell.

The latter undergoes further differentiation to become a 12–15 cell structure, of which 2–5 distal cells divide periclinally to create the antheridium's body, while the remaining cells form the stalk. An outer jacket initial and an inner primary androgonial cell are produced by each distal cell. The antheridium is created by additional divisions of the initial androgonial cell in all conceivable planes. Initials for a jacket are fashioned into a single-layered garment.

1. **Antheridium Mature:** It features an ovoid or globose body with a long stalk made up of two to four rows of cells. A mass of androcytes created from the sperm mother cells is enclosed inside the body's jacket of one layer of cells. Each androcyte cell undergoes a transformation into a sperm or a biflagellate antherozoid with spiral coils.
2. **Antheridium degeneration:** A mature antheridium's jacket's apical cells enlarge as a result of water absorption. The wall of the inflated antheridium splits into a number of irregular lobes near the apex, which finally bends backwards as a consequence of the turgor pressure thus produced. The antherozoids are quickly released from the bulk of androcytes and are free to float in the water.
3. **Archegonial Branches:** At the apex or laterally developing archegonial branches, archegonia are produced. The archegonial branches are more or less ovoid-shaped and very short. Compared to the foliage leaves, the leaves on these branches are bigger. These branches' top leaves form the perichaetium that encloses the archegonia and shields it from harm.

Development and Organization of Archegonium:

Archegonia may form alone or in bunches at the tip of archegonial branches. The main archegonium is formed by the apical cell of this branch. From the descendants of the apical cell, two to five secondary archegonia form. One main archegonium is at the apex of a group of three archegonia, and two subsidiary archegonia arise from the base of the primary archegonium. Both the main and secondary archegonia develop in a similar manner. The archegonial initial transversely splits to produce a filament with four to six cells. The terminal cell then isolates three periclinal jacket initial cells and one main axial cell by means of three crossing vertical walls. Upper cover initial and lower central cells are created when the main axial cell splits transversely. Upper primary neck canal cell and lower primary ventral cell are created when the central cell splits transversely.

A row of 8–10 neck canal cells are formed by the main neck canal cell's repeated transverse divisions, while an egg and a ventral canal cell are created by the primary ventriloquine cell's single transverse division. [5] The top part of the archegonial jacket is made up of a group of eight or more cover cells that are created as the cover initial splits vertically. The neck, middle, and basal portions of the archegonial jacket are subsequently formed by anticlinal and periclinal divisions of the jacket initial. The archegonial jacket's topmost section is made up of cover cells.

Mature Archegonium: The mature archegonium is a structure that is somewhat substantial in size. It has a long stalk, a long, twisted neck with eight to nine neck canal cells, a large, multilayered ventrilopod, which includes an egg, and a ventral canal cell. Getting Archegonium Fertilized Only in the presence of water can the fertilization process occur. The archegonia is reached by the antherozoids, which can freely swim in water. In maturity, the antherozoids' channel is created by the ventral canal cell and the neck canal cell disorganizing. Chemotactically drawn antherozoids go toward the archegonia and enter the pathway to reach the egg. In the end, just one antherozoid joins the egg and develops into a zygote.

A SPOROPHYTE

Growth of the Sporophyte:

The initial cell of the sporophytic generation is the diploid zygote. Only one of the small number of archegonia develops into an embryo in an archegonial branch. A lower hypobasal cell and an upper epibasal cell are created when the zygote expands, coats itself in a cell wall, and divides transversely. Both cells continue to divide transversely until a 6- or 7-celled filament is formed. Uneven divisions occur in the filament's lower half, creating a parenchymatous bulbous foot. There is a haustorium in the foot.

A quadrant is created when the higher cells of the filament split twice vertically at an angle to one another. An inner endothecium and an outer amphithecium are formed by the periclinal division of the cells in the quadrant. [6] The endothecium's cells constantly split to create the columella, a central sterile portion.

The exterior 3-7 layered capsule wall and the inner 2-4 layered archesporium are distinguished by the periclinal division of the amphithecium. Over the columella, the archesporium creates a dome-shaped arch. The archesporium's cells subsequently transform into 2-4 layered sporogenous tissue.

All sporogenous cells perform the role of spore mother cells, undergoing meiotic division to produce haploid spores. A spore sac formed from the surrounding sterile tissue contains the spores. The lower bulbous foot and the top capsule are only connected by a brief neck-like discrete seta. The Mature Sporophyte's Structure The adult sporophyte has a bulbous foot, a discrete seta that resembles a neck, and a nearly spherical black to dark-brown capsule. The calyptra envelops the whole sporophyte. The vaginula is the lowest portion of the calyptra that covers the foot. The sporophyte is underneath the perichaetial leaves.

The pseudopodium is the long archegonial branch at the sporogonium's base. To help the spores disperse, it lengthens and pushes the capsule out over the perichaetial leaves. A longitudinal cut of the capsule reveals an outer jacket and a central spore-sac that overarches the inner columella's dome-shaped structure. There are numerous layers to the capsule wall (jacket). The outermost layer of the jacket is thick and has a number of simple, inoperative stomata. At the top of the jacket lies the operculum, a circular biconvex disc-shaped cover. An annulus of cells with thin walls separates the operculum from the remainder of the jacket. Deconstruction of the Capsule On a bright, sunny day, an explosive mechanism causes the capsule to detach. Heat causes the columella and capsule wall to dry out and shrivel. As a consequence, a sizable air gap develops underneath the spore-sac. The spherical capsule progressively transforms into a cylindrical one, creating an internal overpressure of 4-6 atmospheres. When this occurs, the operculum makes a loud noise as it bursts open through the annulus. The spores are launched into the air up to 20 cm. The method is referred to as the air-gun mechanism of spore dispersion.

Gametophyte:

The spore is the initial cell of the [7] gametophytic generation, much as other bryophytes. The spores are first organized in tetrahedral tetrads. The triradiate ridge on each spore is distinctive. The spore wall is composed of an inner thin intine and an exterior smooth granular or papillate exine. Spores may germinate in as little as 2-3 days or can live for 4-6 months. When a spore falls on a damp surface, it germinates and grows into a tiny thalloid primary protonema. A prostrate, green, one-celled, thick thalloid structure is produced as the protonema develops, and it is attached to the substrate by multicellular rhizoids. The main protonema's marginal cell gives birth to a single bud [8] or secondary protonema with rhizoids and leafy buds. The bud eventually matures into a fresh gametophyte with leaves.

CONCLUSION

As a consequence, the bog's topology changes and its water acquires a strong acidity. The Sphagnum gametophores' upper [9] section continues to grow indefinitely in this acidic soil, but the lower half gradually withers away. In acidic soil, the dead plant components do not quickly breakdown. As a result, a significant mound of decomposing matter collected year after year, and as plants compressed it on top, peat dense, dark-colored material rich in carbon was created. Sphagnum, which makes up the majority of peat, is often referred to as peat moss[10], [11].

REFERENCES

[1] T. L. Blockeel, “Mosses of Europe – a photographic Flora,” *J. Bryol.*, 2020, doi: 10.1080/03736687.2020.1779519.

[2] K. Flatberg, J. Whinam, and M. Lebouvier, “Three species of sphagnum endemic to île Amsterdam, terres australes et antarctiques françaises: S. cavernulosum sp. nov., s. complanatum sp. nov. and s. islei,” *J. Bryol.*, 2011, doi: 10.1179/1743282010Y. 0000000019.

[3] R. Schmid and H. Crum, “Structural Diversity of Bryophytes,” *Taxon*, 2001, doi: 10.2307/1224764.

[4] Y. Riyana, S. Gendro Sari, and G. Gunawan, “Bryophyta di Sekitar Kawasan Bandar Udara Internasional Syamsudin Noor Kalimantan Selatan,” *J. Jejaring Mat. dan Sains*, 2020, doi: 10.36873/jjms.2020.v2.i2.402.

[5] L. Z. Drábková, P. I. Dobrev, and V. Motyka, “Phytohormone profiling across the bryophytes,” *PLoS One*, 2015, doi: 10.1371/journal.pone.0125411.

[6] J. T. A. Verhoeven and E. Toth, “Decomposition of Carex and Sphagnum litter in fens: Effect of litter quality and inhibition by living tissue homogenates,” *Soil Biol. Biochem.*, 1995, doi: 10.1016/0038-0717(94)00183-2.

[7] A. Eddy, "A handbook of Malesian mosses. Volume 1. Sphagnaceae to Dicranales," *A Handb. Malesian mosses. Vol. 1. Sphagnaceae to Dicranales*, 1988.

[8] M. S. IGNATOV and E. V. MASLOVA, "Fossil mosses: What do they tell us about moss evolution?," *Bryophyt. Divers. Evol.*, 2021, doi: 10.11646/bde.43.1.7.

[9] E. Buczyńska and P. Buczyński, "Aquatic insects of man-made habitats: Environmental factors determining the distribution of caddisflies (Trichoptera), Dragonflies (Odonata), and beetles (Coleoptera) in acidic peat pools," *J. Insect Sci.*, 2019, doi: 10.1093/jisesa/iez005.

[10] R. J. Carpenter, M. K. Macphail, G. J. Jordan, and R. S. Hill, "Fossil evidence for open, proteaceae-dominated heathlands and fire in the late cretaceous of Australia," *Am. J. Bot.*, 2015, doi: 10.3732/ajb.1500343.

[11] H. Rudolph and J. Samland, "Occurrence and metabolism of sphagnum acid in the cell walls of bryophytes," *Phytochemistry*, 1985, doi: 10.1016/S0031-9422(00)84888-8.

CHAPTER 23

MORPHOLOGY, ANATOMY AND REPRODUCTION OF EUBRYALES

Dr.R.K.Bansal, Director,
School of Agricultural Sciences, Jaipur National University, Jaipur, India,
Email Id- director_agriculture@jnujaipur.ac.in

ABSTRACT:

These tiny, delicate acrocarpous mosses, which create dark brown or reddish cushions on damp siliceous rocks in hilly locations, develop capsules at the terminals of vertical branches. The capsule splits open along four vertical slits, with the four valves remaining connected at the base and apex. Other mosses' peristome teeth or operculum are absent from this moss. In contrast to Sphagnum, Andreaea lacks a seta, but like Sphagnum, the pseudopodium (ps) made of gametophyte tissue supports the sporophyte (Spf in the picture below), and the columella is encased inside the sporangium. Thalloid protonemata are produced as the spores germinate.

KEYWORDS:

Alage, Anatomy, Eubryales, Morphology, Reproduction.

INTRODUCTION

Gametophytic plants have a primary body that may be divided into two stages: the juvenile stage and the leafy stage, or gametophore. Gametophores, which grow on the protonema, are upright, leafy branches. Rhizoids, "stem," and "leaves" may be distinguished as being either branching or unbranched. "Leaves" are spirally organized in three to eight rows on the axis or stem and have a midrib, are unlobed.

- Rhizoids have oblique septa and are multicellular, filamentous, and branching.
- The axis is distinguished into a cortical-enclosed core conducting thread.
- Groups of sex organs that are borne apically on the main "stem" or a branch.
- The sporophyte may be distinguished into a foot, seta, and capsule in its early stages.
- The seta is often stiff and lengthy.
- Columella is often seen and has endothecial origins.
- Only spores allow for differentiation of the archesporiurn (spore-forming tissue).

The plant's body is gametophytic and consists of two stages: the juvenile stage, represented by the main protonema, and the adult form, symbolized by the leafy gametophore. Rhizoids, axis, or "stem," and "leaves" are the differentiating characteristics of the mature gametophyte (gametophore). Rhizoids emerge from the axis's base [1]. They feature oblique septa and are multicellular, branching, and thin.

Axis is erect, thin, branching, and between 1 and 3 cm high. Each branch arises below a leaf and is extra axillary. Sessile leaves are spirally arranged on the branches and "stem," and they are oblong-ovate in shape with an entire border and a pointed apex. One mid rib runs through each "leaf." "Leaves" are born with a phyllotaxy of 1/3, which matures to a phyllotaxy of 3/8.

Internal Organization

Epidermis

This thin, single-layered protective layer is the skin's outermost layer. It is made up of cells that contain chlorophyll and are tangentially elongated. Stomata and the cuticle are missing.

Cortex

This structure may be found between conducting tissue and the epidermis. There are parenchymatous cells in it. Chloroplasts are present in the cortex's younger portion but absent from its older portion. In maturity, just a few of the cortex's outer layers have strong walls and a reddish brown color, whilst the inner layers develop weak walls. It is composed of dead cells with long, narrow, thin walls and no protoplasm. We now refer to these cells as hydroids. In addition to providing some mechanical support, a conducting strand aids in the upward conduction of solutes and water.

Leaf

The transverse section (T. S.) of the leaf reveals two lateral wings and a well defined midrib. The "leaf" is made up of a single layer of parenchymatous polygonal cells, with the exception of the midrib area. The chloroplasts in the cells are many, big, and noticeable. A slender conducting strand of thick-walled cells in the middle of the midrib aids in conduction.

Funaria has both vegetative and sexual reproduction mechanisms.

(a) **Primary protonema fragmentation:** The spore's germination results in the development of the primary protonema. It may split into many pieces in certain situations. Each broken piece with buds has the potential to develop into a new plant.

(b) **Secondary Protonema:** A secondary protonema is a protonema that forms from any portion of the plant other than spores. Often, they develop on rhizoids, stems, leaves, or reproductive systems that have been wounded. They produce buds that have the potential to develop into new plants (Fig. 6.48B).

(c) **Bulbil:** On the rhizoidal branches, multicellular, brown, bud-like structures called bulbils form. By separating from the parent plants, the bulbils may be used for propagation under unfavorable environmental circumstances.

(d) **Gemmae:** Gemmae are multicellular green bodies made up [2] of the protonema's terminal cells (Fig. 6.48B). During the unfavorable situation, they are inactive. Yet, a gemma separates from the parent plant body when conditions are favorable again and eventually germinates into a new plant.

(e) **Apospory:** Apospory is the process by which a diploid (2n) sporophyte develops into a haploid (n) gametophyte without producing spores. In the case of Funaria, any sporophyte cell that is not specialized may evolve into a gametophytic protonema.

Afterwards, this protonema develops into the gametophyte plant body. Gametophytes are normal-looking and aposporously develop, yet they are diploid (2n). The tetraploid sporophyte then forms from the union of sterile diploid gametes (2n). The male (antheridium) and female (archegonium) reproductive organs grow on different stems of the same plant, which makes Funaria autociously monoecious. The plant's primary branch is where antheridia are produced.

The female branch grows as a side shoot that is longer and grows more actively than the male branches.

Antheridium: At the top of the primary axis, antheridia are born in groups. The antheridia are interspersed with a number of long multicellular hairs known as paraphyses (Fig. 6.53). A rosette known as the perichaetium surrounds antheridia and paraphyses with many bract-like leaves. The paraphyses contain chloroplasts and have capitated, inflated tips. In addition to their role in photosynthetic processes, paraphyses shield immature antheridia against desiccation. The para-physes help to release the antherozoids.

Construction of the Antheridium: At the end of the male branch, there is a superficial antheridial initial from which the antheridium grows. It develops papillae and extends upward. It splits into an outer cell and a basal cell through a transverse wall. The outer cell continues to divide via a series of transverse divisions, resulting in the formation of a linear filament of 2–4 cells.

The terminal cell of the filament separates into an apical cell with two cutting faces by two vertical walls that contact one another. It divides into two rows of segments in alternating order. Now, a vertically diagonal wall splits each juvenile segment of the top 3 to 4 cells into two unequal cells. The first jacket initials stand for the smaller peripheral cells. The outer second jacket initials and the inner main androgonial cell are formed by a similar division in the smaller sister cell. To create androcyte mother cells, the initial androgonial cell undergoes repeated divisions. To create two androcytes, each androcyte mother cell splits. The androcytes change into sperm or biflagellate antherozoids.

An antheridial head contains antheridia that develop at various dates. A single antheridial head may thus include antheridia at several stages of development. A single-layered antheridial jacket is created by a single anticlinal division of the jacket initials. A mature antheridium has a multicellular long stalk and a club-shaped body that are crimson or orange in color. The antheridium's cap, or hyaline operculum, is formed by the jacket's apical cell.

Dehiscence of the Antheridium: Only the presence of water causes the adult antheridium to dehisce. The opercular cell swells up after absorbing dew or rainwater. At the distal end of the antheridium, a pore ultimately forms as a result of the pressure that is exerted, which causes the inner wall to break. Due to the hygroscopic pressure that generated within the antheridial cavity, the androcytes spread out through the pore as a viscous fluid.

At the tip of the archegonial branch, archegonia are produced in clusters. Archegonium development: A cell at the female shoot's tip develops into the archegonial beginning. Transverse division creates an upper cell and a lower cell. The top cell becomes the archegonial mother cell, which splits into an apical cell with two cutting faces by two crossing oblique walls. The apical cell further splits into three peripheral cells that surround an axial cell in the center by three intersecting oblique walls [3]. The peripheral cells divide anticlinally to create a single-layered jacket, which is then double-layered by further divisions.

An outer main cover cell and an inner central cell are created when the axial cell splits along a transverse wall. An outer primary neck canal cell and an inner primary ventral cell are produced by additional transverse division of the core cell. A row of neck canal cells is formed by the primary neck canal cell via further transverse divisions. The main cover cell chops off sequentially three lateral segments, a basal segment, and three more transverse divisions of the primary ventral cell, resulting in the formation of a ventral canal cell and an egg. The fourth basal segment creates the cells that make up the neck canal, while the lateral segments create the jacket of the neck. As a result, the Funaria archegonium's single-layered long neck has two origins, one from the main cover cell and the other from the central cell.

- **Mature Archegonium:** The mature archegonium has an extended neck, a bulging venter at the base, and a lengthy stalk. Four to ten or more neck canal cells are enclosed by the twisted and tubular neck. The archegonial jacket is double-layered where the venter is, but it is just one layer thick where the neck is. An egg and a ventral canal cell are present in the venter.
- **Archegonium fertilization:** During fertilization, the archegonium's neck canal and ventral canal cells separate to create a mucilaginous material. The terminal cover cell is broken apart when this mucilaginous material swells up after absorbing water that has collected as rain or dew. Now, sugar-containing mucilaginous substances leak out the archegonial neck's aperture.

The archegonia is now being chemotactically drawn by the released antherozoids. Antherozoids enter the neck in huge numbers, but only one of them joins the egg nucleus to create the diploid zygote. The zygote separates transversely to produce an upper epibasal cell and a lower hypobasal cell during the development of the sporophyte. Each developing point at the two opposing extremities of the young embryo represents an apical cell with two cutting faces, and both the hypobasal and epibasal cells divide frequently to create this young embryo.

The calyptra, which covers the capsule till maturity, is formed as the archegonial wall enlarges. The sporophyte is subsequently transformed into a long, thin one. Later, as the amphithecium covers the endothecium, the capsule divides. The amphithecium, which contributes to the capsule's multilayered jacket, creates the columella, while the endothecium's outer layers give rise to the archesporium. The foot and upper portion of the seta are formed by the hypobasal cell, whereas the bottom portion of the seta and the capsule are created by the epibasal cell.

The Mature Sporophyte's Structure

A foot, a lengthy seta, and a pear-shaped capsule at the apex make up the adult sporophyte of Funaria.

1. **Foot:** Its conical shape is weakly formed, and it is imbedded in the tip of the archegonial branch.
2. **Seta:** Long and initially green in color, seta matures to a reddish brown hue. The T.S. of seta depicts a single-layered epidermis with a cortex consisting of relatively thick-walled cells around a core conducting strand of thin-walled cells (Fig. 6.50A). Seta aids in the transfer of water and nutrients from the gametophyte to the capsule.
3. **Third capsule:** The mature capsule has an asymmetrical pear shape. The sterile base area, the apophysis, the center fertile region, the theca, and the apical region are the three different internal divisions.
4. **Apophysis:** The neck connecting the capsule to the seta below is located at the base of the capsule. The bottom portion of the apophysis' axis reveals a core thread of thin-walled, elongated cells attached to tissue resembling the seta.

A rather thick-walled epidermis that is broken up by stomata surrounds loosely packed chlorophyllous cells. The apophysis's chlorophyllous tissue enables the sporophyte to perform photosynthesis. The sporophyte of Funaria is thus not entirely reliant on the gametophyte for nourishment.

The fertile zone of the Theca: The theca is the center region of the capsule that lies between the apophysis and the operculum. It contains four separate zones and has a slightly curved cylindrical construction. Columella, spore-sacs, the capsule wall, the air chamber, and the capsule wall.

i. **Capsule Wall:** There are numerous layers to the capsule wall. The epidermis is formed of the single-layered outermost wall, which is followed by a 2-3 layered parenchymatous hypodermis. The photosynthetic tissue of the capsule is made up of the first two to three layers of parenchymatous cells, which are chlorophyllous.
ii. **Spore Sacs:** Two elongated spore-sacs surround the columella. [4] The spore-sac comprises an exterior wall made up of three to four layers of tiny cells and an interior wall made up of one layer of smaller cells. The single-layered archesporium gives rise to the spore sacs. Six to eight sporogenous cell layers are initially formed by Archesporium. The formation of spores from spore mother cells by meiotic divisions transforms the sporogenous layer into a spore-sac.
iii. **Air Chamber:** After the spore-outer sac's wall, there is a sizable cylindrical air chamber. The air gap between the outer wall of the spore-sac and the innermost layer of the capsule wall is bridged by strings of filaments made of elongated green cells known as trabeculae.
iv. **Columella:** The center, axial region of the fertile zone, restricted at the base immediately above the apophysis, is made up of thin-walled, colorless, compact, parenchymatous cells. The distal portion of the columella has a conical form and extends into the operculum's concavity. The columella's function is to transport nutrients and water to the sporophyte as it grows.

The Apical Region: The structure of the capsule's apical area is intricate. Via a notch, this connects to the capsule properly. At this notch, there is an annular rim (or diaphragm) with 1-2 layers of radially elongated tiny cells. The top boundary of the theca proper is marked by the diaphragm. The dome-shaped lid known as the operculum, which is positioned obliquely, shuts the capsule's mouth. It is made up of two to three layers of parenchymatous cells with thin walls. The annulus, which is formed by a ring of noticeably big, prominent cells in the operculum's bottom region. Although the annulus aids in the dehiscence of the capsule, the operculum protects the peristome teeth.

The peristome teeth are connected directly below the margin of the diaphragm, right below the operculum. It consists of two rings, one within the other, of long triangular teeth. The cuticle that makes up teeth is not cellular in nature. The peristome has 16 teeth on each ring. The exostome, or exterior teeth, are bigger, thicker, browner in color, and embellished with transverse bands of thickening. The endostome, or inner peristome teeth, are tiny, fragile, and light in color. When the outer peristome teeth are superposed on the inner ring, the whole structure is known as a peristome, which is epicranoid in nature. The tapering distal extremities of the outer peristome teeth connect to a tissue disc that is positioned in the middle.

Due to the lack of water flow to the capsule during maturity, the operculum starts to dry out. As a result, the operculum's thin-walled cells and the annulus that keeps it in place contract and shrivel. In the end, the peristome teeth become revealed when the annulus splits and the loosened operculum is thrown away. The spiral twist of the peristome teeth gives them the appearance of an iris diaphragm. The hygroscopic outer peristome teeth migrate inward or outward depending on the amount of moisture in the surrounding air. The outer peristome teeth jerkily flex outward in a dry environment. Due to the outer peristome teeth moving outward, the slots between the inner peristome teeth expand, enabling spores to pass through them. The hygroscopic teeth of the outer peristome absorb water in conditions of high humidity, bend inward, and close the slits. This stops spores from escaping in rainy conditions. The calyptra that grows from the old archegonial venter wall covers the new sporophyte. It shields the capsule from drying out and sheds before decomposing.

Gametophyte, the New:

The initial cell of the gametophytic generation is the haploid spore. It is tiny, spherical, and has a diameter between 12 and 20 pm. The spore wall is divided into an exine (exosporium), which is thick and brown, and an intine (intine), which is thin and colorless (endosporium). The spore germinates when the environmental conditions are favorable. The intine emerges as a germ tube when the exine is broken. The germ tube lengthens, splits, and gives birth to a filamentous protonema [5]. The protonema freely divides into two kinds of branches: rhizoidal and chloronemal branches.

The chloronemal branches, which are either upright or very near to the substrate and create the partition walls at right angles to the lateral walls, have noticeable chloroplasts in their cells and become green. Rhizoidal branches that are brown in color and have partition walls that are oblique to the lateral wall grow below the substratum. The primary purpose of the rhizoidal filaments is to secure the protonema to the substrate. Each little bud that forms on the chloronemal stems eventually develops into an upright, leafy gametophore. Soon after the protonema dies, they become autonomous. This characteristic leads to the observation of dense plant growths. Rhizoids, protonema, and a leafy stem make up a juvenile gametophyte.

i. **General organization:** The gametophyte is the primary plant body. Rhizome and erect leafy shoot make up the two components of the mature plant. The rhizome is a part that develops horizontally underground. It has three rows of tiny, colorless or brown leaves. It also has rizoids on it. Protoplasm and oil globules abound in the cells. Rhizoids might form at the base of erect gametophores. By providing support in species whose gametophores reach to significant heights, they provide a mechanical purpose.

ii. **Leafy shoot that is upright:** Leafy shoots are substantially longer. That is the plant's most noticeable feature. It comes from the rhizome. These branches are made up of a main axis. These branches have broad, spiral-shaped leaves on them.

iii. **Leaves:** The bases of leaves are wide. The uppermost leaves are green. The bottom ones, however, are brown. A wide, colorless sheathing leaf base and a small distal limb are features of each leaf. The majority of the leaf is made up of the mid-rib. These leaves have additional photosynthetic tissue in the form of vertical plates of green cells that are arranged tightly together. Lamellae are the term for them. As extra photosynthetic tissue, green lamellae are present. There are two varieties of leaves:

Scale leaves are tiny, [6] almost colorless leaves with a brown or nearly colorless border. They surround the center axis in a spiral pattern. They are exclusively seen on the branches' uppermost part. Each foliage leaf is 6 to 10 mm in length and is divided into a proximal sheath base and a distal thin limb or blade.

Leaf anatomy: The internal structure of Polytrichum is intricate. The middle of the ribs are thick. The borders, however, are just one cell thick. The epidermis surrounds the bottom surface. The sclerenchymatous tissues are found in one or two layers above the epidermis. Parenchymatous tissues with thin walls make up the leaf's core tissue. Again, sclerenchymatous cells are present above this. A layer of large cells on the top surface gives birth to many lamellae. The majority of the leaf's photosynthetic activity occurs in this top area.

Medulla, cortex, and epidermis are the three areas seen on the stem's T.S. Once again, the medulla is divided into two zones: the central zone and the peripheral zone. The cortex is made up of cells with strong walls. Mantle refers to the cortex's deepest layer, which surrounds the conducting threads. Its cells contain grains of starch. Cortex is covered with epidermis.

Cycle of life

Biological reproduction

The following techniques are used for vegetative reproduction:

1. Protonema: Protonema is created when spores germinate. On the protonema, many buds develop. Each bud transforms into a gametophyte by way of its apical cell.
2. Another name for them is vegetative buds. On the rhizoids, they develop.
3. Fragmentation: The rhizome periodically produces upright branches. The erect branches are separated by the death or breaking of shoots. These branches act like separate plants.

A sexual relationship

Dioecious Polytrichum: Archegonia antheridia are found on various plants.

Antheridial head: At the terminals of leafy stems, axillary clusters contain the antheridia. A rosette of leaves known as perigonial leaves encircles them. These leaves vary from typical vegetative leaves in many ways. The perigonial leaves are arranged in spirals. At the axils of these leaves, clusters of antheridia are formed. As a result, there are many antheridial groups in the antheridial head. The antheridia also include paraphyses. Antheridium in adult form has a club shape. It has a body in the form of a club and a short stalk. There is a jacket covering the capsule. Androcyte mother cells are visible within the jacket. They produce sperm that is biflagellated.

Bryophytes are nonvascular plants that lack xylem and phloem. These plants may be found in a variety of environments, from barren rocks exposed to the hot sun to cold alpine slopes. They consist of mosses, liverworts, and hornworts. These plants require water from the outside, often in the form of dew or rain. They like humid, dark settings with moisture for growth. Water is needed for reproductive processes. The stems of the majority of mosses contain hydroids, which carry water. Some even possess leptoids, which are cells that carry food. Bryophytes are often shorter than xylem and are less effective than xylem or phloem. Plants lack vascular tissues, which makes them very supple and flexible.

The gametophyte, which is the sporophyte's visible form, represents the alternating of generations in nonvascular plants. The sporophyte generation develops spores at the ends of the sporophyte-producing gametophyte generations. The sporophyte is a tall, slender stalk that has a cap on top. Bryophytes are divided into three different families based on the variations in their structure and reproduction, despite the [7] fact that they all have comparable life cycles, chromosomal counts, and habituation.

Growth of Antheridium

1. The embryonic cells at the tip of the male shoot give birth to the antheridia. Antheridial beginning refers to the embryonic superficial cell that becomes the antheridium. It becomes bigger as it goes. It divides transversely to produce the top antheridial mother cell and the lower main stalk cell.
2. A few stalk cells are produced by the main stalk cell. An apical cell with two cutting sides is produced when the antheridial mother cell splits. Apical cell severed three to four fragments. Now, the operculum cell is this apical cell's role.
3. The last section is divided into two vertical sections. It develops both central main androgonial cells and peripheral jacket initials.
4. The initials of the die jacket further separate to create a single-layered garment. To create new androgonial cells, the original androgonial cells divide.
5. The androcyte mother cells are the final generation of primordial androgonial cells. Each androcyte mother cell produces two biflagellate sperm that are coil-like.
6. In the presence of water, the antheridia invariably dehisce. In the apex, a pore is created when the operculum cell is eliminated. Mucilage-encased sperm mass emerges.

Archegonial head Leafy stem apex is where flask-shaped archegonia are borne. Perichaetial leaves around the archegonium. These leaves intertwine to create a structure like a closed bud. Archegonia are seen in groups of three to six [8]. The mature archegonium resembles a flask. Its multicellular stalk is thick. The neck is twisted and long. It has cells from the neck canal. Six vertical rows of cells make up the neck. Venter gradually fuses with the neck. Lower large egg cell and upper small ventral canal cells are found in the vent.

REFERENCES

[1] K. Banu-Fattah and S. Hadiuzzaman, “Acrocarpous mosses of Bangladesh. XI Family: Bartramiaceae-2,” *Bangladesh J. Bot.*, 2006.

[2] S. Beckert, H. Muhle, D. Pruchner, and V. Knoop, “The mitochondrial nad2 gene as a novel marker locus for phylogenetic analysis of early land plants: A comparative analysis in mosses,” *Mol. Phylogenet. Evol.*, 2001, doi: 10.1006/mpev.2000.0868.

[3] J. Berthier, “Ramification du Takakia Hatt. Et inoué et morphogénèse des cormophytes,” *Bull. la Soc. Bot. Fr.*, 1971, doi: 10.1080/00378941.1971.10838964.

[4] Y. Asakawa, A. Ludwiczuk, and F. Nagashima, “Chemical Constituents of Bryophyta,” 2013. doi: 10.1007/978-3-7091-1084-3_5.

[5] K. Banu-Fattah and S. Hadiuzzaman, “Acrocarpous mosses of Bangladesh X: Family Bryaceae-genus Pohlia Hedw.,” *Bangladesh J. Bot.*, 2004.

[6] K. Banu-Fattah and S. Hadiuzzaman, “Acrocarpous mosses of Bangladesh X: Family Bryaceae-genus Bryum Hedw.,” *Bangladesh J. Bot.*, 2003.

[7] O. Yano, "Contribuição ao inventário dos Musci brasileiros: 2. Phyllodrepaniaceae," *Acta Amaz.*, 1981, doi: 10.1590/1809-43921981113505.

[8] K. Banu-Fattah and S. Hadiuzzaman, "Acrocarpous mosses of Bangladesh. XI. Family: Bartramiaceae-1," *Bangladesh J. Bot.*, 2006.

CHAPTER 24

MORPHOLOGY, ANATOMY AND REPRODUCTION OF ANDREALES

Dr.R.K.Bansal, Director,
School of Agricultural Sciences, Jaipur National University, Jaipur, India,
Email Id- director_agriculture@jnujaipur.ac.in

ABSTRACT:

The haploid spore that initiates the gametophyte stage develops into a thalloid protonema. The leafy gametophyte, which contains the male and female organs known as the antheridia and archegonia, is then produced by the protonema. Since Andreaea rupestris are autoicous, both the male and female reproductive systems are located on different branches inside the same gametophyte. Fertilization is made easier by the antheridia and archegonia's close closeness to one another. To fertilize the egg, sperm from the antheridia travels down the neck of an archegonium, which contains the egg. The egg develops into a diploid zygote, which subsequently transforms into a diploid sporangium. The sporangium is joined to a haploid pseudopodium that originated from gametophytic tissue, as you can see. Haploid spores are created during meiosis and discharged via the sporangium's dehisced gaps.

KEYWORDS:

Alage, Anatomy, Andreales, Morphology, Reproduction.

INTRODUCTION

Gametophyte Morphological Structure

The main part of the plant, the gametophyte, differentiates into a cylindrical, branching, creeping, leafless structure from which the gametophores, which are around 1 to 1.5 cm tall, emerge as aerial, upright, negatively geotropic, radially symmetrical leafly shoots. A freshly generated branch from the rhizome may sometimes grow horizontally for a short distance before turning upward and giving birth to a single, upright leafy axis. Rhizoids are entirely absent from the leafy axis and the rhizome. One or more may emerge from the base of an upright gametophore. Takakiales and calobryales have different structures for reproduction and affinities. Additional leafless branches that drop vertically into the substratum [1]. This fleshy, soft-textured, positively geotropic, leafless axis. The erect gametophore axis's leaf-like appendages have a distinctive shape. From the shoot tip, which develops as a result of the activity of a 3-sided apical cell, they are isophyllous in a spiral fashion. Three-ranked phylotaxy is used to organize the leaves.

They are tiny and scattered lower on the gametophore axis, but they get bigger and continuous further up. Initially transversely inserted on the axis, the leaves eventually become obliquely displaced as they mature. Each leaf is forked immediately at the base into two, three, or four segments, which often emerge at a distance, according to Schuster (1967). Phyllid refers to each section of a leaf. The multistratose, firm, and meaty terete segments. Each progressively narrows as it approaches its peak, which is a short, blunt, and fleshy point. Each eventually ends in a short, bluntly conical cell as it progressively thin towards the tip.

The anatomy of a leaf

The leaf is 3–5 cells thick everywhere save the tip. They progressively thin down as they approach the apex, coming to an abrupt conclusion in a brief cell. The cells have chloroplasts and are parenchymatous. The leaf segment of T. lepidozioides has only one enormous medullary cell in a cross section above and close to the centre, which is much bigger than the neighboring single-layered cortical cell. The number of medullary or axillary cell rows ranges from two to five in the bottom part of the leaf segment (usually 5 rows). A single-layered cortex of smaller cells constantly surrounds the core strand of medullary cells.

Embryonic Anatomy

The Takakia stem's transversal slice revealed that it is divided into two zones, with the outer cortical area enclosing the inner medullary region. The cortical area has walls that range from being somewhat to firmly thick and has a brownish color. It is 1-2 stratose thick. It is chlorophyllose here. The medullary area is divided into a thin-walled, relatively larger-celled medulla and a tiny central core of small-celled tissue that forms an ill-defined or feebly defined vestigeal central thread. The core strand's cells became vacant and lost their protoplasmic contents. They are lengthy, without color, and have delicate walls [2]. A research using electron microscopy demonstrates that these empty cells' walls, particularly their end wall, include many tiny holes that are descended from plasmodesmata. Among the Takakia gametophytes, Hebant (1975) noted the presence of a specific central water-conducing strand. It is a modest collection of fragile, low-growing, dark-brown rock-dwelling mosses. The leafy shoot is unremarkable, and the key characteristics are:

- The protonema is thalloid, and either a plate of cells or a cylindrical cell mass serves as the precursor of the shoot.
- Central conducting strand absent from the stem
- There is no midrib on the leaves
- The walls of cells are noticeably thick.
- Cylindrical or plate-like masses of cell often replace the early rhizoids.
- Erect, twisted perichaetial leaves
- Apical cells have a role in the development of sex organs.
- The mature capsule is present on a postfertilization leafless gametophore, and the seta are still developing.
- The spore sac covers the center columella like a dome.
- The capsule wall is porous to water

One of the two moss genera in the family Andreaceae and class Andreaeidae of mosses is Andreaea. The granite mosses, or Andreaeidae, are often seen on granite rock walls in mountainous and polar locations. The only member of the Andreaeidae family that may be found in the arctic, Antarctic, and temperate regions of the earth is Andreaea, a genus with roughly 125 species.

Gametophyte

The gametophyte resembles a typical moss in terms of appearance (Bryidae). On exposed rocks, ledges, or cliffs, the gametophyte of Andreaea is easily identified by its distinctive dark-green to red-brown or black look, which often forms pillows or tufts. Most of the species live in habitats that are either alpine or subalpine. Hardly more than 1 cm tall, the leaf-shaped gametophore is recognized by its unusual capsule. One branch of the dichotomous sympodial stem, which is prostrate on the surface of the rock, is developing more rapidly than the other. Rhizoids abound in the bottom portion of the stem, although they vary from those seen in other bryophytes. Some of them are cylindric, while others are flattened, plate-like, with the latter of which causes the stems to adhere to the rock's surface. The basal portion of the creeping stem is where several rhizoids begin to grow in tufts. They are uniseriate multicellular moss-like mosses with oblique cross walls.

An apical cell with three cutting faces and three rows of leaves form on the stem as it expands. In some species, the midribless leaves are modest, one layer of cells thick, whereas in others, the middle longitudinal axis thickens to more than one layer. The leaves are fragile, tiny, smooth, and range in color from olive to brown. On the stem, they are organized specifically in three rows and are exceedingly dense. [3] A. rupestris produces leaves with a violin shape and no costa. The leaves of A. rothii often taper into increasingly slender, costal divisions. Both species' leaves are oblong-ovate and usually concave, standing upright at the base. The gametophyte's tissue is made up of homogeneous, thicker, pappiliose cells that contain oil globules, and the leaf edges are often completely whole.

In the stem anatomy, there is no differentiation into a cortex and a central cylinder; instead, there is a homogenous mass of parenchyma cells. Yet, the superficial cells often have thicker walls and a darker color. The cells contain substantial oil droplets. Sexual Reproduction Andreaea is monoecious and homothallic. Archegonia and antheridia are terminally borne in clusters on different branches. Certain species, including A. blyttii and A. nivalis, are heterothallic. Sex organ development involves the apical cell.

Antheridia

It appears as a cluster at the terminal of the male branch. Male perigonial bracts encircle the antheridium in a number of different places. The adult antheridium is formed of one or two longitudinal rows of cells and has an ellipsoidal or nearly spherical body supported on a long stalk. A layer of sterile cells that surrounds a mass of sperm cells makes up the antheridium's body. Each perm cell's protoplast transforms into a biflagellate sperm.

The first produced antheridium in the cluster is directly influenced by the apical cell of the male branch. A transverse wall that divides an outer cell from an inner cell may be seen in the antheridial initial, which protrudes above the thallus surface. Further transverse division occurs in the outer cell, resulting in the formation of a brief filament of three cells. The major antheridial cell is the filament's terminal cell. The bottom cell has no bearing on the growth of the antheridium, whereas the middle cell makes up the major stalk cell.

To develop a two-sided apical cell, the primary antheridial cell splits along two inclined walls. Naturally, the stalk of the antheridium cannot be seen clearly in the early stages of growth since there is no pedicel. [4] The stalk's upper limits remain undefined until periclinal walls form in the segments intended to give birth to the antheridium's body, which is all that can be known about its lower segments (i.e., the first cut off by the apical cell). While the degree to which this happens varies and often affects the lower rather than the higher half of the stalk, there is frequently some subdivision of the lower segments cut off by the apical cell before they develop. The number of segments that the apical cell removes varies, although it is often eight or nine. A transverse slice through a juvenile antheridium reveals two segments divided by their enclosing wall before periclinal division takes place. Similar to other mosses, further development is reliant on apical cell divisions. The primary stalk cell divides repeatedly to create the stalk.

Archegonia

The surface cells near the tip of the female branches give birth to the archegonia, much as the antheridia do. A surface cell bulges out and takes on a papilliform appearance. While there is some variety in the initial wall that forms in it, it is often quite oblique and cuts off a two-sided apical cell, as in the antheridium. The difference lies in how slanted this initial wall is, which may be anywhere between almost vertical and virtually transverse. Before referring to a "two-sided" apical cell in the latter scenario, a second wall that meets the first one must first develop.

Before the typical growth of the archegonium from a so-called "three-sided" apical cell begins, the two-sided apical cell chops off from three to six segments in the same way as in the antheridium. The formation of a wall in the earlier cell which is more nearly vertical than the walls that proceed marks the transition from a two-sided to this "three-sided" apical cell. This now separates by a transverse wall, creating an inner cell and a terminal cell. In both liverworts and mosses, this inner cell is the first in the axial row, and the tissue below it forms the pedicel.

Lower and higher cells are created when the inner cell splits transversely. The bottom cell is the major ventral cell, while the upper cell is the primary canal beginning or mother cell of the canal row. Segments parallel to the three lateral sides are severed by the "three-sided" apical cell. Although the latter adds to the axial row of neck canal cells, the former series divides by vertical walls, resulting in six rows of cells that make up the wall of the archegonial neck. The length of the archegonium may be increased by intercalary divisions occurring in both the cells of the neck and those of the axial row. The wall thickens to two or three layers close to the egg, creating the ventr, which combines with the enormous pedicel. This latter owes its beginnings to both future divisions inside the initial segments as well as the activity of the two-sided apical cell.

The adult archegonium has the typical long neck with a spiral twist, a two-layered venter, and a large pedicel [5]. The ventral canal cell, the egg, and between ten and fourteen neck canal cells make up the axial row. The egg has always been found to be much bigger than any other axial row cell. As the archegonium is mature, the apex opens and the terminal cells diverge rather widely, perhaps becoming completely separated. At a point just before the neck opens, the canal row has all but disappeared. When the neck finally opens, there is a route to the egg because the barriers separating the cells vanish. This may include a little quantity of mucilage that was created as the canal cells dissolved, and some of it seems to be ejected when the archegonium opens [6].

A sporophyte

Via a transverse wall, the zygote separates. The foot is formed by the lower (hypobasal) cell's atypical divisions into haustorial tissue. The capsule will be created by the top (epibasal) cell. It starts off as an apical cell with two cutting faces and quickly produces an inner endothecium and an outer amphithecium [7] following periclinal divisions. The jacket is made up of 3 to 8 cells thick amphithecium. The sterile columella develops from the endothecium's inner layers, while the archesporium, formed from its outside cells, grows into a two-layered dome-shaped sporogenous tissue that arches over the columella. [8] The presence of large chloroplasts in the sterile cells demonstrates that the sporophyte is not entirely parasitic.

The adult sporophyte has an oval capsule and a swelling foot with haustorial function. The seta, a brief neck that connects the two, is this connection. The capsule's jacket consists of three to eight layers, with the exception of four vertical lines where the surface cells have strong walls. The dome-shaped spore-sac is arching over the club-shaped columella, which is in the center. The pseudopodium, a development of gametophytic tissue similar to Sphagnum, raises the whole sporophyte. The primary sporophyte is raised by the pseudopodium's tip. The swelling of the pseudopodium occurs just [9] below the tip the foot of the sporophyte being embedded within it. On the pseudopodium further down, a few of the lateral unfertilized archegonia may also be seen. Similar to other bryophytes, the calyptra, a vestige of the archegonial wall, is evident on the sporophyte.

The capsule may be identified by its dehiscence, which resembles a paper lantern. Due to cell fragility, the capsule separates into four longitudinal slits in the absence of peristome teeth. The longitudinal valves respond to humidity, allowing the spores to be taken away when the circumstances are ideal and the air is dry, and shutting when the conditions are wet. The only place where this particular dehiscence type may be found is in granite mosses. The calyptra is tiny and mitrate when it is present. Before being released from the capsule, spores often go through cell division. This specialized process, which is similar to spore discharge in liverworts, promotes survival under difficult circumstances.

The spore of the new gametophyte has two coats, as normal, and is filled with oil globules and chloroplasts. The moment the spore is released, it starts to divide within the exospore and eventually forms a globular mass of cells [10]. The exospore then bursts, causing the cell mass to start to grow one or more filaments coming from various locations. The gametophytic protonema's final appearance varies. It could resemble a branching ribbon or a thalloid leaf like Sphagnum, depending on the environment. The Andreaea protonema, in contrast to the majority of other protonema, may even fall into a dormant state if the environment becomes too harsh. On any region of the protonema, buds eventually form, and these grow into new, green gametophytic plants[11], [12].

REFERENCES

[1] S. Naramoto *et al.*, “A conserved regulatory mechanism mediates the convergent evolution of plant shoot lateral organs,” *PLoS Biol.*, 2019, doi: 10.1371/journal.pbio.3000560.

[2] X. R. Baskaran, R. Jeyachandran, and G. Melghias, “In vitro spore germination and gametophytic growth development of a critically endangered fern Pteris tripartita Sw.,” *African J. Biotechnol.*, 2014, doi: 10.5897/ajb2013.13419.

[3] H. Proust *et al.*, “RSL Class i Genes Controlled the Development of Epidermal Structures in the Common Ancestor of Land Plants,” *Curr. Biol.*, 2016, doi: 10.1016/j.cub.2015.11.042.

[4] S. Huttunen, N. Bell, and L. Hedenäs, “The Evolutionary Diversity of Mosses–Taxonomic Heterogeneity and its Ecological Drivers,” *CRC. Crit. Rev. Plant Sci.*, 2018, doi: 10.1080/07352689.2018.1482434.

[5] M. C. Gauna, E. J. Cáceres, and E. R. Parodi, "Temporal variations of vegetative features, sex ratios and reproductive phenology in a Dictyota dichotoma (Dictyotales, Phaeophyceae) population of Argentina," *Helgol. Mar. Res.*, 2013, doi: 10.1007/s10152-013-0357-0.

[6] F. Tala, M. Edding, and J. Vásquez, "Aspects of the reproductive phenology of Lessonia trabeculata (Laminariales: Phaeophyceae) from three populations in northern Chile," *New Zeal. J. Mar. Freshw. Res.*, 2004, doi: 10.1080/00288330.2004.9517235.

[7] F. M. Nogueira, P. V. F. Nogueira, A. L. L. Vanzela, and D. M. Rocha, "Ultrastructural analysis of Rhynchospora ovules: The first record of Cyperaceae megagametophyte on transmission electron microscope," *Micron*, 2021, doi: 10.1016/j.micron.2020.102962.

[8] L. Gramzow and G. Theissen, "A hitchhiker's guide to the MADS world of plants," *Genome Biology*. 2010. doi: 10.1186/gb-2010-11-6-214.

[9] V. A. Mantri *et al.*, "Limited-scale field trial confirmed differences in growth and agarose characteristics in life-cycle stages of industrially important marine red alga Gracilaria dura (Gracilariales, Rhodophyta)," *J. Appl. Phycol.*, 2021, doi: 10.1007/s10811-020-02356-1.

[10] B. X. Ravi, "In vitro polyembryony induction in a critically endangered fern, Pteris tripartita Sw," *Asian Pacific J. Reprod.*, 2016, doi: 10.1016/j.apjr.2016.06.012.

[11] C. Thornber, J. J. Stachowicz, and S. Gaines, "Tissue type matters: Selective herbivory on different life history stages of an isomorphic alga," *Ecology*, 2006, doi: 10.1890/0012-9658(2006)87[2255:TTMSHO]2.0.CO;2.

[12] K. J. Niklas, E. D. Cobb, and U. Kutschera, "Haeckel's Biogenetic Law and the Land Plant Phylotypic Stage," *BioScience*. 2016. doi: 10.1093/biosci/biw029.

CHAPTER 25

MORPHOLOGY, ANATOMY AND REPRODUCTION OF TAKAKIALES

Dr.S.K.Khatik, Assistant Professor,
School of Agricultural Sciences, Jaipur National University, Jaipur, India,
Email Id- skumar.patho@jnujaipur.ac.in

ABSTRACT:

The vast majority of mosses are members of the same phylum as Funaria, the Bryales. Each of the other two Musci divisions is represented by a single genus. The columella of the Andreaeales does not reach the top end of the capsule, which opens by a number of lateral openings. The Sphagnales also have a dome-shaped spore-sac that extends over the columella, and despite the fact that their capsule opens by an operculum, they vary significantly from other mosses in terms of how the sporogonium develops and how the sexual generation behaves.

KEYWORDS:

Alage, Anatomy, Takakiales, Morphology, Reproduction.

INTRODUCTION

The words "Bryon," which means mosses, and "phyton," which means plants, are the ancestors of the name "Bryophyta." Embryophytes like mosses, hornworts, and liverworts are categorized as bryophyta. These are tiny plants that thrive in moist, shaded environments. Vascular tissues are absent. They reproduce using spores rather than flowers and seeds. Bryology is the study of bryophytes. The three categories are explained individually [1] here, and this unit has gone into great length on the basic characteristics of the mosses. Moreover, this group is monotypic, with just one genus and family (Takakiaceae). The genus is distinguished by:

- Heterotrichous nature of plants, which are divided between upright growing aerial axis or shoots and prostrate growing rhizomatous axis.
- Mucilage papillae are heavily present on both shoots.
- The leaves are placed in three spirally organized rows.
- These cylindrical leaves (phyllids) have 2-4 finger-like lobes.
- Rhizoids don't exist.
- Antheridia are collective and terminal.
- There are also archegonia in a group that are either terminal or on the surface of the stem. They pursue you with their long necks.
- The sporophyte features an identifiable foot, an elongated seta, an ovate-elongated capsule, a multilayered capsule wall, a dome-shaped archesporium, and a central columella.
- There is no peristome, annulus, or operculum.
- The cell lumen develops a distinctive thickening in the outermost layer of the capsule wall, which makes it more or less flask-shaped.

- The capsule dehisces in a single longitudinal line (slit), which is dextrosely orientated and has unthickened cells.
- The spores have a characteristic triradiate mark and are tetrahedral in form.
- They have the fewest chromosomes, which is four.
- They are thought to be the most primordial and are sometimes referred to as living fossils. Takakia is the only genus and belongs to the Takakiaceae family.

Two species of mosses of the genus [2] Takakia are found in western North America, central Asia, and eastern Asia. The genus is classified among the mosses as a distinct family, order, and class. Its location has always been ambiguous, but the finding of sporophytes that are unmistakably of the moss-type strongly supports that classification.

Mitten identified Takakia in the Himalayas and wrote about it in 1861. It was long ignored since it was first only mentioned as a new species of liverwort (Lepidozia ceratophylla) inside an already-existing genus. Further attention was generated by Dr. Takaki's discovery of similar bizarre plants in Japan in the middle of the 20th century. The formation of the species Takakia lepidozioides in the new genus Takakia, named in honor of the person who unearthed it and identified its distinctive properties, in 1958 was prompted by the many peculiar characteristics of these plants. Later, Grolle acknowledged that the species initially reported by Mitten belonged to this new genus and called it Takakia ceratophylla.

The primordial plants were all sterile gametophyte plants, devoid of any reproductive organs. Ultimately, archegonia-containing plants were discovered that resembled the archegonia found in mosses. The Aleutian Islands were the source of the first reports of fertile plants containing antheridia and sporophytes in 1993. Both of these structures were obviously of the kind seen in early mosses. Takakia was identified as a moss genus because to this finding, although an uncommon one.

Not only is the gametophyte Takakia unique among mosses, but also among all living plants. This is reflected in the plant's Japanese name, "impossible moss" (nanjamonja-goke). The little Australian daisy Brachyscomedichromo somatica was formerly thought to have the lowest known chromosomal count (n=4) per cell of any land plant, however it is now known that certain plants have a count of n=2.

Takakia appears on the rock where it grows as a normal coating of moss or green algae from a distance. On closer examination, a turf of thin, creeping rhizomes supports tiny Takakia shoots. Hardly taller than 1 cm, the green shoots that emerge from the grass have an uneven arrangement of small, finger-like leaves (1 mm long). No other moss has leaves that are so sharply split into two or more strands as these. Their leaves and young shoots are both exceedingly fragile.

Anatomy of a Leaf The anatomy of the leaf is 3-5 cells thick, except at the tip. Gradually taper up to the tip, when they terminate in a small, angular, conical cell. Chloroplasts are seen in parenchymatous cells. A single layered cortex of smaller cells constantly surrounds the primary strand of the medullary cells [3]. The inner medullary area and the outer cortical region are the two zones that make up the stem. Chlorophyllose is present in the cortical area. It is 1-2 stratose thick and made up of cortical cells with somewhat strongly thick walls and brownish walls. A thin central core of small-celled tissue that forms an ill-defined central strand is differentiated into the medullary region, which is bordered by thick-walled cell walls. The protoplasm of the middle strand's cells has been lost, leaving them empty. They are lengthy, without color, and have delicate walls. In the cortical cells of the leaves and stems of several Takakia species, there are many tiny spherical oil bodies. Some oil bodies, such as T. lepidozioides and T. ceratophylla, are smaller than chloroplast.

DISCUSSION

Reproduction: Sexual and vegetative processes are used.

- Vegetative Reproduction: The freely eadicpis leaves and shoot of T. lepidozioides and the upper section of the shoot of T. ceratophylla both aid in vegetative reproduction. These components are carried away by the wind or the water, where they multiply and create new populations.
- Sexual Reproduction: It is either heterothallic or dioecious. There is no morphological distinction between male and female plants.

Antheridia

They are [4], [5] ellipsoidal in form, brilliant orange, and found in the axil of leaves. Stalk is poorly demarcated and consists of three to four levels, each with four cells. Antheridium dehisces via a cap or lid. The apical cell is not used or eaten during the production of the antheridium, which results in continuing growth of the male shoot. The female plant has a single archegonium, however sometimes there are two or three that are erratically dispersed. When young and stalked, archegonium is bare, big, and green. Before fertilization, the fleshy venter reaches a stratospheric stage. Unknown sporophyte.

Fertilization:

Sterile jacket haploid flagellated sperms are produced in antheridia. The transport of the motile sperm to the egg requires water. To make it easier to capture water for sperm transfer, the majority of antheridia are in terminal disk-shaped clusters. Chemotactic sperms travel through free-water up a gradient of the chemotactic agent's concentration in search of the open archegonium. As soon as the first drop of water touches the cup, the cap cell of the antheridium bursts, allowing sperm to enter the drop of water. The subsequent raindrop that enters the splash cup will release a sperm-containing fluid. To combine with the egg, they will swim through a layer of rainfall.

Mitosis of haploid gametophyte cells produces every cell in the archegonium, including the egg cell. Chemicals necessary for sperm chemotaxis are produced by the eroding neck and ventral canal cells and bond with the egg. The zygote that results from the union of the egg and sperm is diploid. Following fertilization, the sporophyte emerges from the archegonium, receiving nourishment from the gametophyte as it develops. The sporophyte features a distinctive foot, an elongated seta, an ovate-elongated capsule with a multilayered capsule wall, a dome-shaped archesporium, and a central columella. A young sporophyte requires protection, and two gametophytic coverings that form after fertilization provide that protection. Calyptra and vaginula are these coverings.

Vaginula protects the bottom portion, [6] which includes the foot and seta, while calyptra covers the top portion of the capsule and a portion of the seta. Early stages of growth result in schizocarpous erect, oval, green capsules. As a result, sporophytes are naturally autotrophic.

The centre of the capsule is thick, while the base and apex are proportionally tapered. Absent are the operculum, annulus, and peristome. The cell lumen develops a distinctive thickening in the outermost layer of the capsule wall, which causes it to resemble a flask more or less. The capsule dehisces in a single longitudinal line (slit), which is dextrosely orientated and has unthickened cells. Haploid spores are produced by meiosis within the capsule. The spores have a characteristic triradiate mark and are tetrahedral in form. The operculum, the capsule's lid, opens when spores are mature. A row or rows of hygroscopic teeth in the operculum open and release spores as a result of variations in humidity. A haploid spore's germination results in the development of the gametophyte plant. A protonema, or branching strand of photosynthetic cells, is created when a spore germinates. This filament with branches resembles a green alga. The protonema creates a filament that may result in either an asexual gametophyte for leafy moss or a hard, dry bulbil.

The green plant lineage includes mosses [7] which exhibit alternation of generations with a persistent, unbranched sporophyte generation that is reliant on the dominant leafy gametophyte generation. The sexual generation is always a green plant, but it does not emerge from the spore directly; instead, it is carried on a protonema with distinctive markings that is often filamentous. The easiest way to comprehend the overall course of the life history and the key characteristics of shape and structure is via a quick description of a specific example [8].

CONCLUSION

The Bryopsida have all the characteristics of the gametophyte (protonema, gametophore, and gametangia) and sporophyte (seta, sporangium, and peristome) reported for the Bryophyta. Here, as it offers the majority of the [9] features for the categorization at the ordinal level in the Bryopsida, the fundamental pattern of variation in the peristome needs particular consideration[10]–[12].

REFERENCES

[1] F. Zhao, C. Wang, and X. Zhan, "Morphology Control in Organic Solar Cells," *Advanced Energy Materials*. 2018. doi: 10.1002/aenm.201703147.

[2] S. K. Courtney Jones, A. J. Munn, and P. G. Byrne, "Effect of captivity on morphology: Negligible changes in external morphology mask significant changes in internal morphology," *R. Soc. Open Sci.*, 2018, doi: 10.1098/rsos.172470.

[3] K. I. Wada, K. Itoga, T. Okano, S. Yonemura, and H. Sasaki, "Hippo pathway regulation by cell morphology and stress fibers," *Development*, 2011, doi: 10.1242/dev.070987.

[4] P. M. Schirmer and K. W. Axhausen, "A multiscale classification of urban morphology," *J. Transp. Land Use*, 2016, doi: 10.5198/jtlu.2015.667.

[5] H. Zou and X. Wang, "Progress and gaps in research on urban green space morphology: A review," *Sustainability (Switzerland)*. 2021. doi: 10.3390/su13031202.

[6] C. E. Taylor, H. B. Henninger, and K. N. Bachus, "Cortical and medullary morphology of the tibia," *Anat. Rec.*, 2021, doi: 10.1002/ar.24479.

[7] L. Li, R. Sun, and R. Zheng, "Tunable morphology and functionality of multicomponent self-assembly: A review," *Mater. Des.*, 2021, doi: 10.1016/j.matdes.2020.109209.

[8] R. N. Felice, J. A. Tobias, A. L. Pigot, and A. Goswami, "Dietary niche and the evolution

of cranial morphology in birds," *Proc. R. Soc. B Biol. Sci.*, 2019, doi: 10.1098/rspb.2018.2677.

[9] N. A. Dye *et al.*, "Self-organized patterning of cell morphology via mechanosensitive feedback," *Elife*, 2021, doi: 10.7554/eLife.57964.

[10] H. E. White, A. Goswami, and A. S. Tucker, "The Intertwined Evolution and Development of Sutures and Cranial Morphology," *Frontiers in Cell and Developmental Biology*. 2021. doi: 10.3389/fcell.2021.653579.

[11] O. Speck and T. Speck, "Functional morphology of plants – a key to biomimetic applications," *New Phytol.*, 2021, doi: 10.1111/nph.17396.

[12] T. Wucherpfennig, T. Hestler, and R. Krull, "Morphology engineering - Osmolality and its effect on Aspergillus niger morphology and productivity," *Microb. Cell Fact.*, 2011, doi: 10.1186/1475-2859-10-58.