Text

Coleochaete is the most commonly found genus of the order Coleochaetales. The "chaete" in the name of the genus refers to long, sheathed hair cells which cover the algal surface and are believed to defend the alga against potential herbivores. The genus includes forms with prostrate and erect branched filaments. Branched filaments adhere to form pseudoparenchyma, and parenchymatous thalli. In this type of thallus there may be a single, or many layer of cells. Species with a flat, tissue-like morphology are found more often in shallow waters than the filamentous species, indicating that they have a competitive advantage in this environment.

Coleochaete appears in nature as microscopic filamentous plants that produce zoospores and oogametes, and as thick-walled resting cysts that are either associated with the vegetative filaments or are free in sediments.

Systematic position and number of species

Empire Eukaryota

Kingdom Plantae

Subkingdom Viridaeplantae

Phylum Streptophyta

Class Coleochaetophyceae

Order Coleochaetales

Family Coleochaetaceae

Genus

Coleochaete

Type species *C. scutata* Brébisson

There are 31 species (and infraspecific) names in the algae database at present, of which 16 listed below have been flagged as currently accepted taxonomically.

C. areolata Entwisle & S. Skinner, *C. baileyi* K.Möbius, *C. conchata* K. Möbius, *C. divergens* Pringsheim, *C. irregularis* Pringsheim, *C. klebahnii* Schmidle, *C. leve* (Bailey) Sharma & Chapman, *C. nitellarum* Jost, *C. orbicularis* Pringsheim, *C. polytricha* (Nordst.) Klebahn, *C. pseudosoluta* Gauthier-Lièvre, *C. pulvinata* A. Braun, *C. reptans* (Düringer) A. K. Islam & M. R. Khan, *C. scutata* var. *pinguis* B. N. Prasad & D. K. Asthana, *C. scutata* f. *minor* K. Möbius, *C. soluta* (Brébisson) N. Pringsheim

The genus is represented in India by three species*, C. orbicularis, C. scutata,* and *C. nitellarum.*

Distribution and habitat

Coleochaete is widespread in freshwaters of tropical, temperate and arctic/antarctic regions. The genus is periphytic and often found attached to submerged portions of aquatic plants, such as*Hydrilla, Nymphaea, Trapa, Sagittaria,* and *Potamogeton*, or on the underside of water lilies and larger forms of algae. The species also grow endophytically inside the cell walls of Charales. *Coleochaete nitellarum,* is endophytic in *Nitella*. Majority of the species are epiphytic. They are able to survive

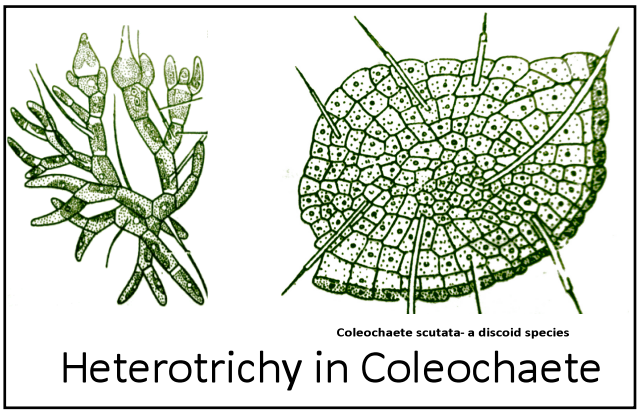
periodic dry spells while living on rocks along the edge of oligotrophic freshwater lakes and ponds.

Some species grow in moist air environments, which suggest their ability to survive in terrestrial environments, and reinforces the evolutionary link with land plants. *Coleochaete* can also grow as disk-like colonies on the sides of glass aquaria, and is sometimes found in low pH *Sphagnum* bogs.

The genus has not been found in brackish or more extreme habitats.

Structure of Thallus

The thallus of *Coleochaete* is typically heterotrichus, i.e. consists of prostrate and erect systems. Different species represent different degree of heterotrichy. The heterotrichus habit is best seen in *C.pulvinata,* which has well-developed prostrate and erect systems. In the other species, one of the two systems is either absent or reduced; e.g. in *C. nitellarum* and *C. divergens* there is a well-developed erect system, but the prostrate; system is filamentous or reduced, while the thallus of *Coleochaete scutata* is arranged so compactly that the whole system looks like a disc or cushion. The branching is dichotomous, which can be clearly seen in the species which possess free branches in the projecting system, e.g. *C. pulvinata.*



Heterotrichy in Coleochaete

The thallus of *C. scutata* is usually surrounded by a common gelatinous envelope. Almost in all thalli of the genus some of the cells posses pointed seta (chaete). The seta is a prolongation of the cell wall, and its base is usually surroundd by gelatinous material. These sheathed hairs may be as much as 100 times longer than the cell itself, and help to protect the cells from herbivores. The hairs frequently break-off at the edge of the sheath near the base, and are occasionally coiled. The seta cells differ from other cells in that they have layered cell-wall and C-shaped chloroplasts. The vegetative cell size varies from 5.5 to 38.5 um, depending upon the species. The antheridia are usually smaller than zygotes.

Cell structure

The cells of the thallus may be quadrangular, polygonal or cylindrical. They are organized into branched filaments that, together, produce a plant body less than 2 mm in diameter. This plant body is prostrate on, or embedded in, the substrate. In some species, the filaments are laterally compressed, forming a circular thallus, with no apparent gaps between cells.

Individual vegetative cells of *Coleochaete* species are usually 5-20 μm in diameter and 1-4 times as long, with a conspicuous cell wall. The cell wall consists of two layers. The outer layer consists of pectose and the inner is made up of cellulose. The cells are uninucleate. In each cell, there is a laminate parietal girdle-like chloroplast, which

wholly or partially encircles the protoplast. with 1 or 2 pyrenoids each. Mitochondria are numerous and have flattened mitochondrial cristae. Plasmodesmata are present in the cross walls between cells of the same filament. In general, the organelle structure in vegetative cells is essentially identical to that observed in land plants, except that there is one plastid rather than many. Cell division features a complex network of microtubules and membrane vesicles (the "phragmoplast"), again as found in all land plants. The zoospores and male gametes bear minute polysaccharide scales on their cell surfaces. Their flagellar apparatuses consists of two basal bodies projecting laterally from the cell in a V-shaped configuration, and one or two flagellar roots. One of these roots forms a broad "spline" of more than 20 microtubules, and is associated with a multilayered structure proximally; these features are also found in all land plants that have swimming male gametes.

Under certain conditions, especially when available nitrogen is in short supply, certain *Coleochaete* cells produce long colorless projections, with a sheathed base ("sheathed setae"). The seta-bearing cells are generally smaller and rounder than other vegetative cells, and the plastid in these cells undergoes a slow circular motion ("cyclosis"). This sheath remains attached with the thallus, even after the seta breaks off. The motile bodies are biflagellate and lack eye spots.

Growth

The branches of erect system show apical growth. The terminal cells of the erect filament divide transversally and add to its height. The growth of the prostrate discoid system takes place by means of a marginal meristem. The erect branches originate as lateral outgrowths of the prostrate system.

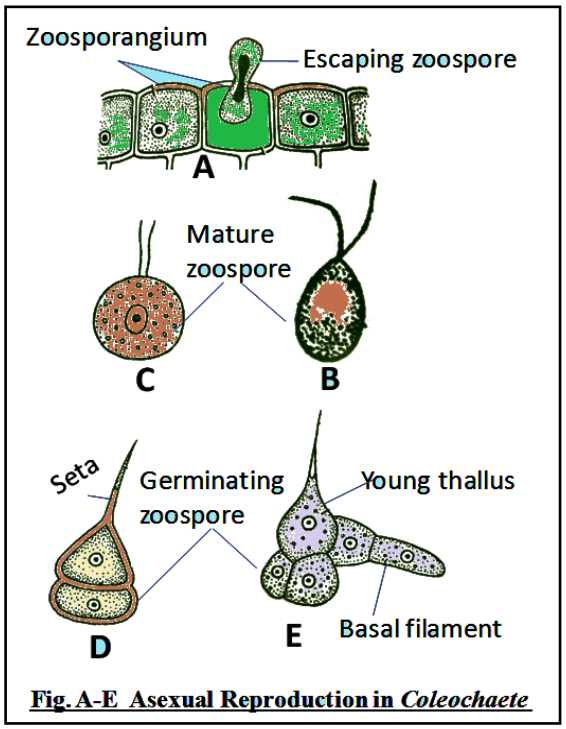


Fig. A-E Asexual Reproduction in *Coleochaete*

Reproduction

In *Coleochaete,* the reproduction is both through asexual and sexual methods.

Asexual reproduction

The asexual reproduction takes place by means of zoospores, which are produced in ordinary cells, usually in spring and summer seasons. A single zoospore may be produced in each cell. The zoospores are large, ovoid and biflagellate and uninucleate. They possess a single chloroplast but no eye spot. The zoospore is librated through a round pore formed at the apex, or through a short papilla of the parent cell. The zoospore swims for about an hour and then comes to rest. The cilia are withdrawn and the protoplast of each zoospore becomes round, and secretes a wall around it. The protoplast of this one-cell germling divides again and again, and a multicellular thalloid structure is developed. Some of the cells bear setae, and

the shape of a cushion-like disc is attained. In unfavorable conditions, aplanospores may also be produced, a single aplanospores developing in each cell; it germinates in the manner of the zoospore on the approach of favorable conditions.

Germination of zoospore

During germination the zoospore divides by a transverse or vertical wall. In *C. scutata* (which is a discoid form), the first division is transverse; the upper cell forms seta, and the lower divides repeatedly and forms the discoid thallus. In heterotrichus species, like *C. pulvinata,* the first division is vertical and both the daughter cells divide repeatedly to form the prostrate system. The erect or projecting system develops from the prostrate system.

Sexual Reproduction

The sexual reproduction is advanced oogamous. The plants may be heterothallic or homothallic, depending upon the species. The female sex organs are called oogonia or carpogonia, and the male reproductive organs are called antheridia.

Oogonia

The oogonia (carpogonia) develop on the terminal end of the lateral branches of the projecting system in *C. pulvinata.* But the cells lying just below the oogonium continue the growth of the branch and, as such, the oogonium appears lateral in position. The ogonium is

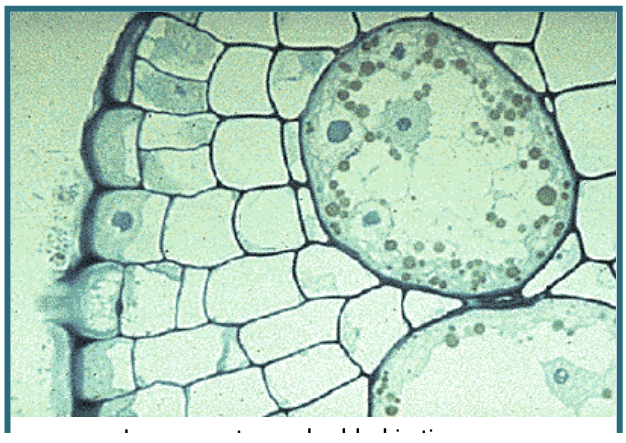
flask-shaped. The basal swollen portion of the oogonium contains an egg and chloroplast. The terminal portion is neck-like and called trichogyne, which contains colourless cytoplasm. However, in discoid species, the trichogyne and the neck are absent, and the neck is represented by a short papilla.

Antheridia

The antheridia (spermatids) develop at the terminal ends of the lateral branches, usually in groups. In discoid species, the antheridia develop midway between the periphery and the centre of the thallus. A single biflagellate antherozoid (spermatozoid) develops in each antheridium. In parenchymatous species of *Coleochaete*, the antheridium is multicellular and surrounds a region in which the sperm develop. This is in contrast to the antheridium of most other green algae, in which is a single cell divides into sperm within its original cell wall. Spermatozoids are colorless or pale green, emerging from the spermatids, which are small conical branches in filamentous species, or cells derived from asymmetrical, diagonal divisions of internal cells in parenchymatous species.

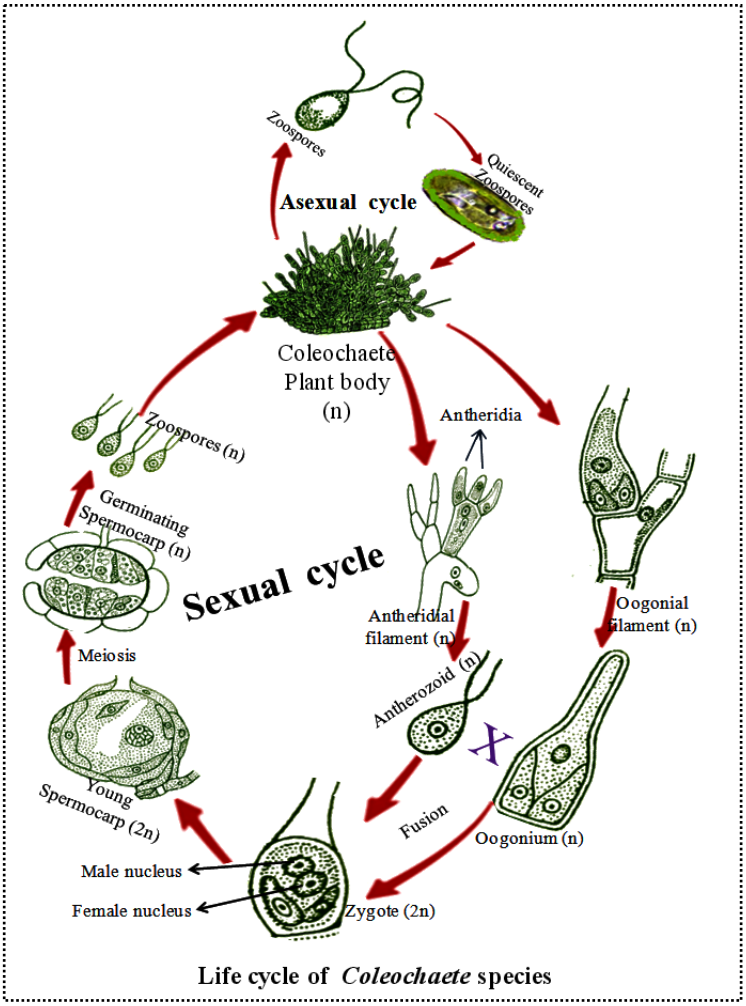
Fertilization

Spermatids develop proximally to oogonia in monoecious species. The spermatozoids swim in the



water and approach the oogonium. Just before the fertilization, the tip of the trichogyne breaks down and some colourless protoplasm is extruded from the broken tip. Although many antherozoids approach the oogonium, only one inters. The flagella are withdrawn and the protoplast of the antherozoid approaches the egg and fuses with it. When sperm and egg unite, they form a zygote, the only diploid cell in the life cycle. Coleochaetales, therefore, have a haploid life-cycle. *Coleochaete* is unique among Charophytes, in its retention of the zygotes on the parental alga. The surrounding cells divide to produce a layer of sterile tissue which envelops the zygote and may provide nourishment, as do the placental transfer cells in plants.

The zygote remains within the oogonium. It enlarges, accumulates starch and lipids and becomes corticated by growth of the adjacent thallus cells; the degree of cortication varies among species. In one species, cortical cells have localized wall ingrowths, similar to placental transfer cells of embryophytes. Cortical cell walls, and other cell walls near zygotes, are impregnated with resistant polyphenolic material; inner zygote wall with sporopollenin. Some other outgrowths develop from the base of the oogonium and a pseudoparenchymatous structure is formed. This round reddish, body is called spermocarp. The spermocarps overwinter and only then germinate.



Life cycle of *Coleochaete* species

Germination of zygote

On the return of favourable conditions, the content of the spermocarp again turn green. The nucleus of the zygote divides meiotically and followed by other mitotic divisions. In this way 8-32 protoplasts are developed.

Each protoplast metamorphoses into a scaly biflagellate zoospore (meiospores). After winter, the zoospores are liberated from the spermocarp by breaking the spermocarp wall in irregular way. The zoospores swim here and there, their flagella are withdrawn and each zoospore develops into a new thallus.

Alternation of generations

A distinct alternation of generations is not found in *Coleochaete*. The haploid thallus bears male and female gametes on erect branches, which fuse to form a diploid zygote. The zygote nucleus divides meiotically, forming 8-32 haploid meiozoospores. The meiozoospore on germination again gives rise to haploid thallus. Thus diploid phase is represented only by zygote. Such a life-cycle, where diploid phase is restricted only to zygote is called haplontic life cycle.

Phylogenetic affinities of *Coleochaete*

Plants like *Chara* and *Coleochaete* are quite complex, and, although haplontic in their life-cycle, provide an intriguing model for the types of organisms that gave rise to the bryophytes and vascular plants.

A preponderance of morphological, biochemical and molecular data provide support for the green algae, specifically the class Charophyceae, being the sister group of the land plants. Recent cladistic analysis, based upon morphological, biochemical and other characters, have

suggested that *Coleochaete orbicularis* is the most derived member of Charophyceae.

Among the green algae, *Coleochaete*, with its parenchymatous organization, and protection, nutrition, and prolonged retention of the zygote, possesses the greatest number of advanced features in the Charaophyceae; comparative biochemical and ultrastructural studies suggest that the Charophyceae show closest similarities with bryophytes and tracheophytes.

In a number of respects sperm maturation in the green alga *Coleochaete pulvinata* is similar to spermatogenesis in the Charales and lower land plants. This supports the hypothesis that *Coleochaete* and Charales are closely related to the ancestry of embryophytes, particularly hornworts and liverworts.