L. M. Underwood
April 1893

he Characeæ of America.

By DR. T. F. ALLEN.

Part I.

TRODUCTION.

MORPHOLOGY.

CLASSIFICATION.

THE

CHARACEÆ OF AMERICA

PART I.

CONTAINING THE

INTRODUCTION, MORPHOLOGY

AND

CLASSIFICATION

BY

TIMOTHY FIELD ALLEN, M.D., LL.D.

FELLOW OF THE NEW YORK ACADEMY OF SCIENCES; CORRESPONDING MEMBER OF THE
BUFFALO ACADEMY OF NATURAL SCIENCES, OF THE PORTLAND
SOCIETY OF NATURAL HISTORY, ETC.

WITH FIFTY-FIVE ILLUSTRATIONS

NEW YORK
No. 10 EAST 36TH STREET
1888

PRESS OF JOHN C. RANKIN, JR., 34 CORTLANDT ST. NEW YORK.

THE

CHARACEÆ OF AMERICA.

INTRODUCTION.

THE publication of this work has been postponed from time to time in order to accumulate material for a more complete account of the species growing in this country. The demand for information concerning these plants is, however, so pressing, that it is thought best to issue the first part of the work now, to be followed, after a year or two, by the second part, which will contain descriptions of the species now known to inhabit American waters.

The determination of the species of Characeæ should not be undertaken without a previous acquaintance with the structure and development of the plant in general; indeed, no classification, worthy to be called such, was possible, till the researches of the late Prof. A. Braun laid a sure foundation in the morphology of the Charad, and with Prof. Braun Characeæ began, as it were, a new existence in the scientific world, almost comparable to the birth of the Linnæan system. Old names of species were found to be indefinite and misleading, and, in most cases, they had to be discarded entirely and replaced by others.

Braun's "Fragmenta" have been edited by Dr. Nordstedt, who also arranged a synoptical key to all the species. This key is now translated, with the permission of Dr. Nordstedt, revised, in accordance with his recent notes (September, 1887), and made to include new species. We have repeatedly stated in this work that very little of it is original; the investigations concerning germination, development, structure, and the principles of classification have all been made by authors who have been properly credited with their work. In some places the language of these authors, especially of Prof. Braun, has been literally translated. The illustrations are mostly original, but Figures 1 to 5 and 9–17 are copied from de Bary; Figures 6 and 7 from Nordstedt, 18 to 20 and 38 and 39 from Sachs and Goebel.

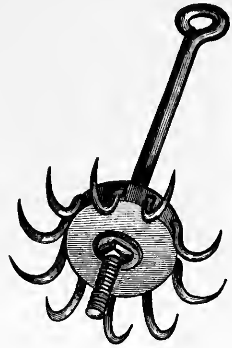
Characeæ are neglected by botanists in general, who seem to have an aversion to all aquatic plants; mainly, it is presumed, from the fact that the collection of aquatics is a specialty. One must go prepared with dredge and rake, with paper and muslin, in order to gather successfully plants of this sort. It has come about that very few bits of Characeæ have been gathered here and there by expeditions and by individuals, in America, up to recent years; but it is evident that these plants abound in our waters, and that our Chara-flora is varied and strongly characterized. Probably not one-half of the American species have as yet been brought to light, but it is confidently anticipated that a better knowledge of their structure and classification will result in a more widespread interest in them.

These plants, often delicate or brittle from an incrustation of lime, are easily destroyed by waves, so that they are rarely found on exposed shores, unless in water deep enough to be beyond the reach of the surface movements. They flourish best in sheltered bays and smaller ponds, especially if a tolerably uniform level of water be maintained. Great changes of level are destructive, alike to species that love the sun and grow in shallower water and those that hide away in the depths. It is rare, therefore, that Chara hunting is profitable in ponds or lakes which feed canals or factories; one prefers the land-locked sheets of water fed by springs, especially if there be a sandy bottom. Temperature has but little influence upon them, though the South has its distinctive species, as well as the North. One species, at least, Ch. fragilis, is universal; found in every country and clime, in ice water at the North and in the hot springs of the Yellowstone, "hot enough to cook an egg in four minutes" (see specimens in the Herbarium of Harvard College).

The best condition of the plant for examination is when it has mature fruit. The time at which this occurs is usually late summer or early fall, though a few species mature early in the spring and die off in the summer. At the South the species are often in good condition the year round, the old fruit holding on even after new shoots have started from the old nodes.

To gather Characeæ successfully a dredge must be used; for shallow water a small fine-toothed rake is preferred, but for deeper water (one rarely finds them at a depth greater than ten feet), the dredge and line is essential. The best dredge for all purposes is the one recommended by Prof. Nordstedt, made as follows:

A disk of lead about three inches in diameter and three-fourths of an inch thick, has imbedded in its circumference a row of hooks, about ten in number; through the centre of this disk is passed an iron rod, which projects about three inches below the disk and about nine inches above; to the ring in the upper end, toward which the points of the hooks are directed, a cord is attached. The dredge weighs about two and a half pounds and catches all sorts of "weeds" growing on the bottom.



Messrs. Flynn & Doyle, carriage makers, at Bantam Falls, Conn., have made these dredges for me at a cost of four dollars each.

The dissection of these plants is perfectly simple. The delicate species are placed in water till their normal form is restored (if they have been dried), and a portion is put in a "cell" on a glass slide and examined under a two-inch objective; sometimes, but rarely, a higher power is needed for determining fine points, such as the structure of the cortex.

Should the species be incrusted with lime a piece should be placed in a little strong vinegar till the lime is completely dissolved, then washed in pure water and examined.

Specimens foul with mud must be cleaned in water, with a camel's hair brush; but this is liable to detach the globules of fruit, and is only occasionally to be resorted to. Should it be desirable to preserve bits for future reference, they are best mounted in glycerine jelly, in "cells" deep enough to avoid crushing, and shallow enough to permit free examination (flattened brass curtain rings make excellent cells). When the jelly has dried at the edges turn on a ring of white zinc cement.

THE writer has prepared a few sets of Exsiccatæ for distribution to Herbaria and persons interested in the study of Characeæ. The number of sets has necessarily been limited, for very few besides himself have contributed plants, and it has been judged best not to offer them for sale. The plan has been to offer a part (containing ten species or varieties), to any one who would contribute about 100 specimens of one variety required. This plan is good in theory, but it restricts the distribution of sets; at present, however, no better way presents itself, and the offer is still open.

After a time, when a larger number of duplicates has been obtained, the sets will be more widely scattered. Even now, four numbers are exhausted and cannot be supplied to new applicants till more be collected; these Numbers are 16, 22, 24 and 27.

The species comprised in the Exsiccatæ hitherto issued are :

1. *Nitella tenuissima*, Desv., forma brevifolia.
2. " *intermedia*, Nordst., nov. sp.
3. " *megacarpa*, Allen, nov. sp.
4. *Chara intermedia*, A. Br., forma tenuior, elongata.
5. " *intermedia*, A. Br., *var. Americana*, A. Br.
6. " *contraria*, A. Br., forma brachyphylla, humilior.
7. " *sejuncta*, A. Br., forma elongata.
8. " *coronata*, A. Br., *var. Schweinitzii*, A. Br.
9. " *gymnopus*, A. Br., *var. Michauxii*, A. Br.
10. " *hydropitys*, A. Br., *var. Septentrionalis*, Nordst. in lit.
11. " *coronata*, Ziz. Forma, microcarpa, microptila, verticillata (var. gracilis, Allen).
12. " *coronata*, Ziz. Forma, meiocarpa, metioptila, partim unilateralia.
13. " *coronata*, Ziz. Forma, macrocarpa, meioptila, verticillata.
14. " *coronata*, Ziz. Forma, macrocarpa macroptila, verticillata, zonulare incrustata.
15. " *excelsa*, Allen. Bull. Torrey Bot. Club, 1882.
16. " *evoluta*, Allen. Bull. Torrey Bot. Club, 1882.
17. " *fœtida*, A. Br., Forma, brachyphylla, clausa, elongata, macroteles.
18. " *fœtida*, A. Br. Forma, incrustata, laxior.
19. " *contraria*, A. Br.
20. " *fragilis*, Desv. Forma, tenuifolia, microptila, munda, humilior.
21. " *fragilis*, Desv. Forma, microptila, incrustata, laxior.
22. " *delicatula*, Ag. non Desv. Ch. fragilis var. delicatula, A. Br.
23. " *gymnopus var. elegans*, A. Br.
24. " *gymnopus var. Humboldtii*, A. Br. Forma stolonifera.
25. " *sejuncta*, A. Br. Forma, condensata, robustior.
26. " *aspera*, (Dethard.) Willd.
27. " *aspera*, (Dethard.) Willd. *Var. Macounii*, Allen, in Bull. Torrey Bot. Club, 1882.
28. *Nitella flexilis*, Ag.

29. *Nitella flexilis*, Ag. Forma, longifolia, elongata.
30. " *flexilis Ag. var. subcapitata*, A. Br.
31. " *tenuissima*, Kütz., *forma longifolia.*
32. " *glomerulifera*, A. Br. (*N. capitata*, in Halstead).
33. " *opaca*, Ag.
34. " *minuta*, Allen, nov. sp.
35. *Tolypella comosa*, Allen.
36. " *fimbriata*, Allen.
37. " *intertexta*, Allen.
38. *Chara hydropitys, var. genuina*, A. Br.
39. " *sejuncta*, A. Br., *forma tenuifolia.*
40. " *gymnopus*, var. *armata*, A. Br. (Sandwich Islands).
40a. *Nitella tricellularis*, Nordst. (from New Zealand).

The fifth fasiculus, in preparation, will include Chara crinita, Ch. hornemanni (from Florida), Ch. gymnopitys (*alpha*), Ch. hydropitys, var. perfecta (from Mexico), Nitella morongii, Allen, and some varieties of the more common species.

Correspondence is cordially invited and the determination of species will be cheerfully undertaken, particularly as a more extended knowledge of localities will the better enable the author to give, in the second part of this work, the geographical distribution of the different species.

The second part will contain a description of all the American forms, and it is intended to facilitate their determination by an illustration of each species.

CHARACEÆ are essentially Algæ, though they cannot be included in any of the groups of that class. They possess a complicated structure, and in habit, as well as in the apparent distinction of parts, as stem and leaves, seem allied to the Cormophytes. Reproduction is peculiar and exhibits a higher development than is found in other Algoid plants. The Antheridium produces swarming spermatozoids, the Oogonium becomes enveloped even before fertilization, it does not produce zoospores, but a resting-spore, and this, in germinating, does not produce immediately the sexual plant, but an intermediate, a-sexual protonema, from which the sexual plant rises as a lateral sprout.

Other Algoid plants have enveloped oogonia (Coleochætæ and some of the Floridæ). Some Algæ even develop a pro-embryo, and some botanists have attempted to trace a genealogy from the green Algæ, through the Characeæ, to the higher Cryptogams, looking upon the Characeæ as an intermediate group which still holds on in the struggle for existence.

These plants grow wholly under water, generally in shallow, but sometimes in deep water (over six feet). Usually the seeds germinate in the spring and the mature plants bear fruit early in the fall, but some species are perennial, in deep water, throwing out young shoots in the spring from old thickened nodes or from small subterranean bulbs which have been filled with starch the previous year. Other species germinate late in the season, live over winter, and mature the following spring. Numerous observations are required to determine the habits of our American species, many of which are peculiar to this country. It is certain that in America, as in Europe, a locality may cease to furnish a species for some years, after which it will reappear, due, probably, to the persistence of the little nutlets, whose hard shell resists for a long time external influences inimical to life. Species are wonderfully constant in their locality, constant even in minute characteristics, and ponds or lakes lying but a few miles apart may contain species or varieties peculiar to each, which seem never to encroach on the other. It is quite probable that aquatic animals rarely, if ever, feed on these plants, and the seeds do not seem to be disseminated by them.

The strong, disagreeable odor (of sulphureted hydrogen), exhaled by nearly all Characeæ, seems protective to the extent of causing them to be let alone, but productive of a restricted habitat in some cases. Some species, however, are everywhere common. Chara fragilis, Desv., is constantly met with North, South, East and West, in cold water and in hot springs hot enough to cook an egg ; this species is cosmopolitan, found over the whole globe, even in Australia, which otherwise has quite a distinct Chara-flora ; Chara fœtida, A. Br., is nearly as widespread; Ch. coronata, Ziz., not so common in Europe, is here very abundant and varied; of our peculiar species, the varieties of Ch. gymnopus are most common, var. elegans, var. Michauxii, var. Humboldtii and Ch. sejuncta (very wide spread).

Forms of Nitella polyglochin are almost characteristic of America (microcarpa, megacarpa and intermediate forms). Nitella prelonga, A. Br., is a pronounced Southern species, large and fine.

It is yet too soon to speak positively of the geographical range of our Charads; so little interest has been taken in them that sufficient data are not at hand.

HISTORICAL.

THE botanical history of the Characeæ is marked by numerous changes in classification, which have varied with the notions of different botanists concerning the place of these plants in the vegetable kingdom. Vaillant first separated them from Hippuris and Equisetum (Hist. de l'Acad. Royal, d. sc. 1719), and collected nine species under the name Chara (χαρὰ.) This name had been used prior to this time by Hevel (Prodr. Astron.) for a constellation, and it is possible that the appearance in water of the whorled leaves of one of these plants may have suggested the name of a star for them.

Linnæus at first classed them with the Crypto-gamia, with Lemna, between Marsilea and Fucus, among the Algæ.

Following Linnæus, most of the older authors adopted this classification. B. Jussieu placed them between Conferva and Spongia.

Schreber (in his *Genera*) recognized the globular bodies which he noticed in the axils of the leaves as male and female organs ; the round red globules he called Antheridia; the larger oval bodies, spirally wound, with a toothed crown, were called female flowers ; the teeth were considered stigmata, and the nucule the seed. These two bodies found on the same plant, near each other, though the so-called Antheridia lacked the essential characters of Anthers, seemed to Schreber to determine the position of these organisms among flowering plants as Monandria monogynia.

Linnæus adopted this view, and in the later editions of his works we find them classified according to Schreber's notions, *Monœcia monandra;* many pupils and authors following Linnæus retained this classification (for example, *Nuttall*), which, indeed, has held, until very recent times (Bertolini Flor. Italica, Willdenord Flor. Berol.). Baumgarten placed them among the *Mondria digynia*, and Pursh, on account of the so-called five stigmata, *Polygynia.*

Louis Claude Richard, in Humb. et Boupl. nov. gen. 1815, first employed the family name, *Characeæ*, and following him Kunth, Wallroth (1815), Martius, etc., restored them to the Cryptogams; Kunth placing them between Marsiliaceæ and Piperaceæ ; Wallroth, near Conferva.

The investigations of Vaucher (Mem. de la Soc. Phys. de Geneve, 1821), and of Kaulfuss (Ueber das Keinren von Chara, 1825), led to a more definite knowledge of the character of the fruit, which has been increased by the observations of Bischoff (Crypt. Genv., 1828), Müller (Bot. Zeit., 1845), Pringsheim (Jahrb. f. Wiss Bot., 1863), Nordstedt (Act Univ. Lund., 1866), and de Bary (Bot. Zeit., 1875). References to the work of these and other observers will be made while treating of the development of the plant. To Alex. Braun, however, is due, more than to any other man, a knowledge of the complete structure of all parts of the plant, and especially correct notions of the relations of the genera and species of Characeæ, and of the proper methods of their classification.

The oospore consists of a cell surrounded by a moderately thick wall of cellulose, filled with colorless fat, grains of starch, and masses of protoplasm. External to the cellulose layer, and joined to it, is a thick shell, usually brown or black, formed by the enveloping cells and furrowed in a spiral fashion by their twisting. This envelope, consisting of five cells which arise from the base of the spore, is called the sporostegium (spore-capsule), and the whole fruit, including the spore proper, its basal cell and enveloping cells, the *Sporo-phydium.**

The furrows on the nucleus, caused by the five enveloping cells of the sporostegium, are separated by ridges, often very prominent, or, again, scarcely to be noticed; the prominence of these ridges is constant in each species, and frequently serves as a distinguishing mark; the number of ridges on the nucleus, due to the number of turns of the enveloping cells, is also constant and characteristic in different species.

These ridges are frequently continued downward between the basal cells, and then form, as in Chara fragilis, after the soft parts decay, fine sharp points, which serve clearly to distinguish the base of the nucleus, from the apex; the latter is often terminated by a single point, caused by the prominence of the last spiral. When the ridges are not prominent the base can be distinguished from the apex only

---

* NOTE.—In Braun, Sachs and Goebel, the fruiting organs are termed "Antheridium" and "*Eiknospe*," the latter referring to the spore-bud, which was held by Braun to be an axillary growth. Braun suggested the term *Sporophyas* for this growth (namely, the complete fruit, oospore, basal and enveloping cells). This term has not yet been adopted by later writers, nor, indeed, has any other term been suggested. Braun, in his latest descriptions, uses the term sporangium, which heretofore we have used, though it is not exactly appropriate. Celakowsky, in *Flora*, 1878, dissents from Braun's view of the "bud" nature of the spore-shoot, and considers the spore a metamorphosed leaf—a leaf has no significance in Characeæ, more than the simple outgrowth of a nodal cell—but, following Celakowsky's view, *Sporophydium* would still be a good term. He proposes "enveloped-oogonium," but does not suggest an appropriate technical term. We have, therefore, concluded to follow the suggestion of Braun and replace the inappropriate "Sporangium" by the most fitting *Sporophydium*, which will, we trust, be generally adopted.

by its somewhat broader or truncated appearance ; in many species the two ends can scarcely be distinguished. The nucleus of some species, for example, Chara intermedia, becomes densely incrusted (like the stem) with a deposit of lime, which seems to be imbedded in a delicate soft hyaline matrix; this deposit must be dissolved by a dilute acid before the nucleus can be studied.

GERMINATION.—The germination of the Characeæ has been examined by Vaucher*, Kaulfuss†, Bischoff‡, Pringsheim§, Nordstedt|| and A. de Bary¶. To Pringsheim belongs the credit of having discovered the true character of the first outgrowth of the spore, but Nordstedt first clearly and accurately traced, step by step, the whole process; this work, published in Swedish. not being accessible to students generally, was reviewed and enlarged by the investigations of Prof. de Bary. From these authors our account and illustrations of the process are taken.

As germination is about to commence, the granules of fat and starch in the upper part of the oospore give place to finely granular protoplasm (Fig. 1, a de-calcified nucleus of Ch. fœtida, A. Br., n).

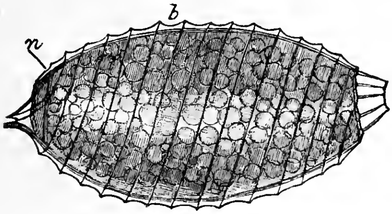


Fig. 1.

This partially clear spot fills the upper end and has the form of a plano-convex lens, with its convexity upward and its plane surface pressing against and clearly separated from the remaining contents of the cell. Along this line of demarcation a septum forms, which divides the oospore into two cells, the smaller upper one, the first nodal cell, from which all growth proceeds, and the larger lower basal cell filled with fat and starch, the reserve material for nourishing the germinating plant. The upper cell enlarges and splits the shell along the line of its angles into five parts ; it then protrudes a little into the water and undergoes fissation, by a vertical

---

* Mem. de la Soc. d. Phys. de Genevere, 1821.

† Erfahrungen ueber das Keimen der Charen, Leipzig, 1825.

‡ Die Crypt. Gewachse, Nürenberg, 1828.

§ Die Vorkeime d. Charen, 1862, and also, Ueber die Vorkeime und die Nacktfüssigen Zweige den Charen Jahrh f. Wiss. Bot. III., 1863.

|| Nagra iakttagelser öfver Charac. gronig, Lunds Univ. Arsskrift II.

¶ Zur Keimungsgeschichte der Charen, Bot. Zeit., 1875.

septum, into two cells (Fig. 3 first division of the nodal cell seen from above; Fig. 4 seen from the side, the protoplasmic mass somewhat shrunken).

These cells grow and elongate, becoming cylindrical in form, as shown in Fig. 5.

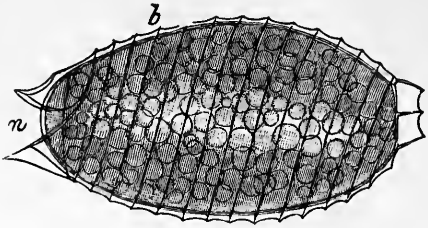


Fig. 2.

One of these cells bends down as it lengthens and becomes a root; this divides at its base, close to or partly within the nucleus, into a complex root-node, consisting of several nodal cel's, from which several rootlets arise. Fig. 6 represents a section through the primary node—"r," the rootlets; "p," the protonema; "pr. r," the primary root-node; "sm.," spore membrane. Fig. 7. Front view of node of Ch. coronata; letters as above; "sh.," shell of nucleus. These and all subsequent roots form, by acropetal division, a series of much elongated cells with swollen joints (nodes); these nodes are like two feet, united by their soles in opposite directions, and from the dorsum of the foot, directed toward the point of the root, single rootlets, or bunches of rootlets, arise by a superficial proliferation of cells. Fig. 8 represents a root-node of Nitella megacarpa, Allen, with two young rootlets (drawn from nature, T. F. A.)

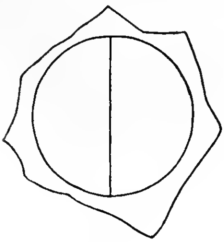


Fig. 3.

The other cell, arising by the division of the primary nodal cell, grows in an ascending direction, opposite to that of the primary root, and elongates into a tube which divides by horizontal fissation into three to seven cells; these become filled with chlorophyll and assume the appearance of a leaf of a Charad. This ceases to elongate and is now the *protonema* (pro-embryo), from which the perfect plant arises in the following manner:

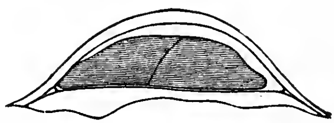


Fig. 4.

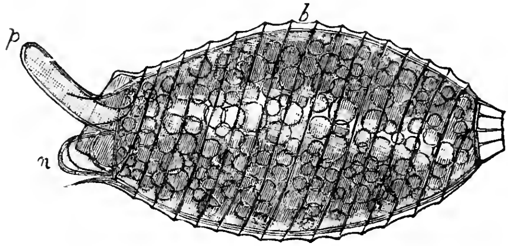


Fig. 5.

The lowest cell of the protonema undergoes division near its upper part, by a septum which interposes a cell between the first and second cells of the protonema; this intermediate cell now divides by two septa into three cells; the middle of these three speedily elongates and separates the other two. The lower of these two cells becomes a second root-node (as distinguished from the primary root-node which developed directly from the first nodal cell), the upper becomes a stem node (Fig. 17, "rn." a root-node, "s" the stem-node). The lower cell, which is to develop into a root-node, undergoes repeated fissation by vertical septa, as illustrated by Figs. 9 to 12 (Fig. 12 representing a fully developed root-node with "a," "c," "d," protruding rootlets).

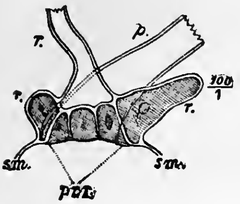


Fig. 6.

This completes the development of the roots. From the upper of the two cells a stem node develops as follows: This cell divides by a septum into two nearly equal halves (Fig. 13). In each half peripheral cells arise, first on one side, then on the other (Figs. 14 and 15), until a circle of cells is completed, inclosing two median cells. The formation of this node is similar to that of all nodal formations in the fully developed plant. The first cell now throws off another peripheral cell, which divides, by a vertical septum, into two cells, which stand for the nodal cells of the new stem ("n," Figs. 15 and 16). In Fig. 16 a side view of the node "v" is the vegetation cell, growing upward and elongating into the first stem (cell) of the perfect plant; the two nodal cells, "n," remain as small nodules on the side of the node, or develop into accessory leaflets (stipulæ).

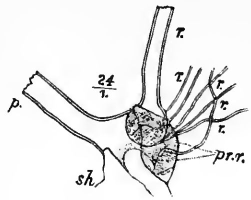


Fig. 7.

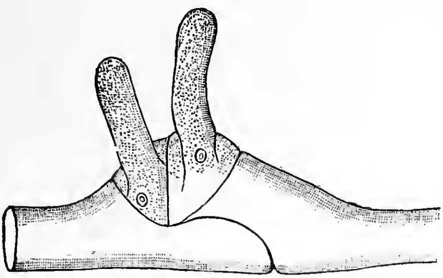


Fig. 8.

The other peripheral cells of this stem-node develop into very simple leaves of unequal length; these leaves always remain at the lowest stage; they never develop nodes nor bear fruit. The extension of the original protonema often exceeds the length of the leaves of this provisional verticil and may easily be mistaken for one of them, especially as it is crowded out of its nor-

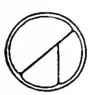


Fig. 9.

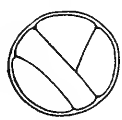


Fig. 10.

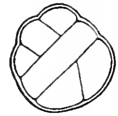


Fig. 11.

mal direction by the growth of the main stem. The unrestricted growth of the true plant has now commenced and the plant at this point has the appearance of Fig. 17 (taken from A. de Bary, representing the germination of Ch. crinita), "p," the main protonema; "p′ p′," accessory and undeveloping protonemata, which sometimes arise; "s," the stem-node, with unequally developed leaves; the real protonema seems like one of these leaves; above this node the true plant first appears and hairs are developed on its first internode; "s′," imperfectly developed nodes of the accessory protonemata.

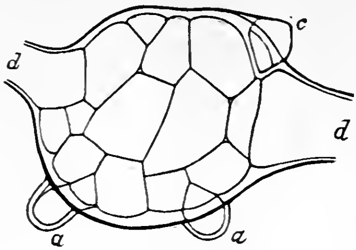


Fig. 12.

In perennial species (Ch. fragilis, Ch. gymnopus vars., etc.), shoots arise from old plants (second generation), which closely resemble the sprouts of the first generation (protonema). Old root- and stem-nodes of perennial species swell and become filled with nourishment (starch principally), and from these nodes new shoots arise, as from the seed; these shoots are called *caulescent protonemata;* they develop root- and stem-nodes and behave quite like the true proembryo. Pringsheim (l. c.) has studied these structures with special care.

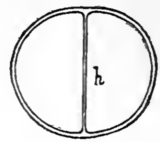


Fig. 13.

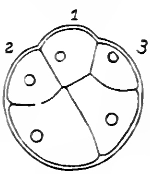


Fig. 14.

"The first shoot of the fully developed plant is frequently not the only one which rises from the verticil of the protonema; in Tolypella there are so many that the verticil of the protonema becomes the starting point of a whole bundle of shoots of varying sizes and ages. In N. syncarpa (Europe) these adventitious shoots rise not from the stem-, but from the root-node; this swells to the size even of a pea, and sends numerous roots downward and shoots (as many as fifty) upward. Some of these incline downward and form other swellings with roots and shoots (caulescent protonemata). In Chara aspera, however, the protonema-verticil remains undeveloped, producing neither leaves nor shoots, and the shoot of the second generation arises from the root-node." (A. Braun.)

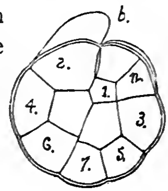


Fig. 15.

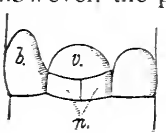


Fig. 16.

The development of the stem, with its nodes, leaves and various appendages, has been most thoroughly studied by Prof. Braun, to whose writings, especially to "Ueber die Richtungs-vorhaeltnisse der Saft-stroeme in den Zellen der Characeen, Berlin, 1862," we are greatly indebted. The apical cell (vegetative cell) of the new shoot throws off from its base a series of cells by repeated horizontal division. The apical cell itself remains plano-convex, and when its energy is exhausted, persists as a terminal cell of the same form. Each cell that is thrown off from the base of the apical cell divides immediately, by horizontal fissation, into two unequal cells, the lower shallow and bi-convex, the upper deeper and bi-concave. The lower of this pair elongates without farther division and becomes a long internodal cell, often attaining a length of several inches (internodal cells six to eight inches long are not uncommon in lake forms of Nitella megacarpa, Allen). The upper bi-concave cell of the above pair forms a stem-node as follows: Soon after its appearance it divides, by vertical fissation, into two equal halving cells (see Fig. 13). In each of these half cells a series of peripheral cells arise, by excentric division and in regular order, beginning first on one side of the septum, then on the other, and proceeding in alternation till the circle is closed. These peripheral cells are the starting points of an equal number of leaves. In Nitella the number of leaves

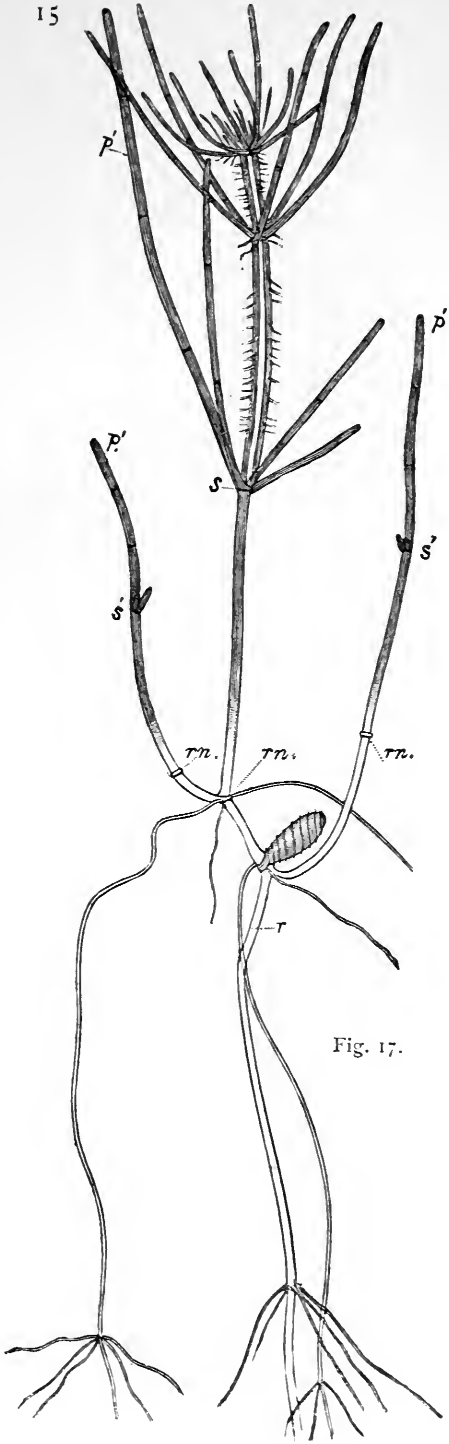


Fig. 17.

is nearly always six; in Chara there may be as many as sixteen. The peripheral cells of successive nodes are not exactly on a line, but each node deviates by half the interval between the peripheral cells, so that a regular spiral is produced; in species with a large number of leaves the divergence is small, with sixteen leaves a divergence of $\frac{1}{32}$, in Nitella there is usually a divergence of $\frac{1}{12}$. When, as in most species of Chara, the stem is corticated by longitudinal series of cells, this divergence is easily seen, especially as the stems usually twist more and more as they grow older, but in the naked species (Nitellæ and some Charæ) the torsion is noticed only by means of the clear line between the granules of Chlorophyll, the "*indifferent line,*" which marks the boundary between the up and down streams of the circulating protoplasm; this indifferent line seems to coincide with the primary septum which divides the nodal cell into halves. The direction of this divergence is to the right, upward.

LEAF.—The vegetative cell of the leaf arises from a peripheral cell of the stem-node, but, unlike the vegetative cell of the stem, it produces a limited series of nodal and internodal cells, nearly constant in number for each species, and terminates by a tip, usually pointed, divided by simple septa into two or more simple cells. The basal node is somewhat complicated in structure, since it develops, in some species, cells for stipules and cortex, and even for accessory leaflets and sporangia. A clear understanding of this basilar node of the leaf and of the organs which develop from it, is essential, since the groundwork of much of the classification of Characeæ is founded upon the variations of these organs.

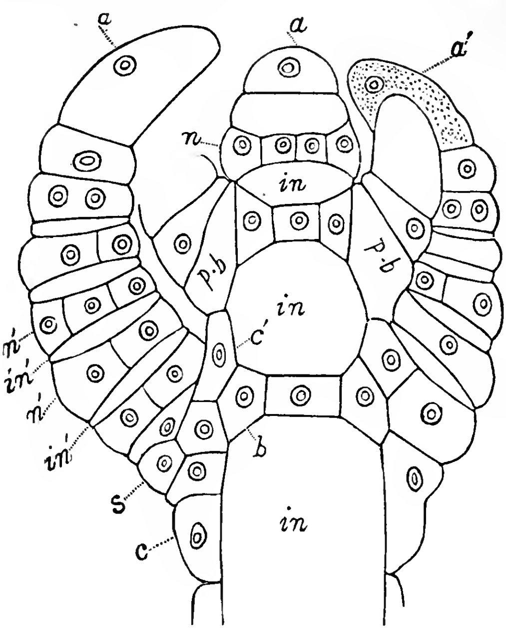


Fig. 18.

The parent cell of the basilar node (Fig. 18, p-b), swells and protrudes from the node on the side of the stem, it gives off, by division, a complex mass of cells which comprise the basilar node of the leaf. From this node are developed the cortex cells and stipules found in Chara, the adventitious leaflets (which do not develop nodes like true leaves), and even organs of fructification (especially in the genus Tolypella).

In the genus Nitella the basilar node of the leaf is much more simple than it is in Tolypella and Chara. In Nitella only a few cells surround and support the base of the leaf, and these cells rarely, if ever, give rise to any organs (except to adventitious leaflets in some species, as in our N. clavata). There may be only a circle of four cells, or even in the same species, as in N. flexilis, an indefinite number of cells may develop.

Development of the Cortex.—From the upper and lower portions of the basilar node cells arise, which extend upward and downward closely pressed against the central internodal cell of the stem. These cells grow, *pari-passu*, with the elongating stem cell, they spread laterally, and, as a rule, entirely encircle the stem and form a complete cortex. The first view of these cells is shown in Fig. 18, c and c′. A front view is shown in Fig. 19, c, which represents the side of a young growing stem; a single cell from above and one from below cover the internode vertically, and, with the adjacent cells, completely encircle the stem. As the internodal cell of the stem elongates these cells elongate and develop nodes and internodes, and,

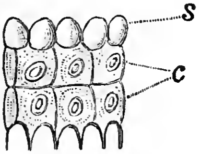


Fig. 19.

when fully developed, give off lateral cells. Since the leaves of successive verticils are not directly over each other, but diverge to the extent of half the distance between the leaves, the cortex cells which extend upward and downward from the base of each leaf (except that the oldest leaf of each verticil develops a shoot in its axil instead of a cortex cell, causing one cortex cell *less* in the encircling series which ascends from a vertical, than in the series which descends), alternate, and in the centre of the internode they interdentate, as shown in Fig. 20, which represents an elongating cortex system. Each "c" in this figure represents a single cortex "lobe," which has developed from a single cell, as shown in Fig. 19. In Fig. 20 these cortex cells (four above and three below), have begun the development of nodes and internodes; "in" the internodal cells, and "n," "cn," "n," the node; "cn" the central nodal cell. The internodal cells elongate to keep pace with the growing stem; they do not divide; the nodal cell, however, divides at first into three, a central cell and two lateral cells (Fig. 20, "n," "n" and "cn"). The central cell then divides into deep (lying next the stem) and superficial cells. The superficial central cell is the only one which develops spines, or papillæ, so that whenever a spine is seen on the stem, we may be sure that it arises from the central node of the cortex. In this way the main cortex series is always to be distinguished, since the lateral cortex cells never develop nodes or spines. This central cell may grow out into a single spine, or it may subdivide into a number of cells and develop a bundle of spines, as in *Ch. crinita.* In many species which develop but a single spine, or papilla, from the node of the cortex, great variability is observed; some varieties having numerous spines quite long, while other forms of the same species have almost smooth stems; this is particularly noticeable in Ch. fœtida, A. Br., and *Ch. intermedia;* our very common *Ch. fragilis*, with a completely developed triple cortex, rarely produces any spines, or even papillæ; while our forms of Ch. gymnopus, with an equally developed cortex, sometimes have numerous spines, as in sub-species *elegans;* sometimes have nearly smooth stems, as in sub-species *Michauxii.*

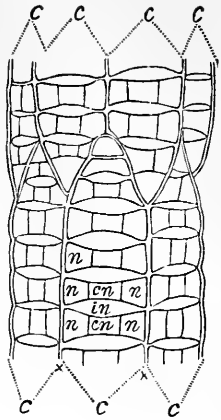


Fig. 20.

The development of the lateral cells of the cortex-node marks important groups in the classification of the species of Chara. When the lateral cells develop fully, each cell protrudes from the side of the node and extends longitudinally, forming a long cell lying by the side of the central internodal cell of the cortex and parallel to it. If each lateral cell of the node develops, the cortex "lobe" (the full development of each original cortex cell) becomes composed of the central cell, with its node (and spine) and two lateral cells, forming a triple series. Since one cortex cell arises at the base of each leaf, it follows that there will be (as in Ch. fragilis) three times as many cells surrounding the main internodal cell of the stem as there are leaves, and the stems are said to be "*triplastiche corticatæ*" (triple corticated).

Fig. 21 (drawn from nature) is taken from the centre of a young growing internode of Ch. fragilis; the development is nearly perfect, showing the growing lateral tubes from each side of each node;

showing also the manner in which the cortex-tubes interdentate (from above and from below). "1," the apical cell of each cortex system; "n," the nodes; "in," the internodal cells; "l," the lateral cells.

Fig. 22 represents the fully developed cortex of Ch. fragilis. It is, however, rare that we find a perfectly regular system in Ch. fragilis; this is more generally seen in Ch. sejuncta and the various subspecies of Ch. gymnopus. In Ch. fragilis great variability is observed, generally in the way of a redundancy of cortical cells in any

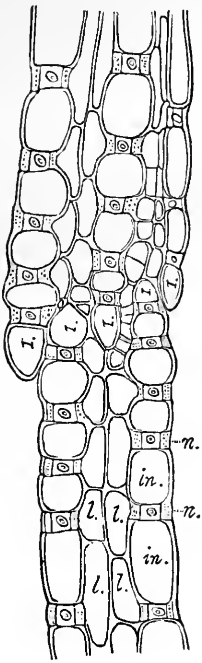


Fig. 21.

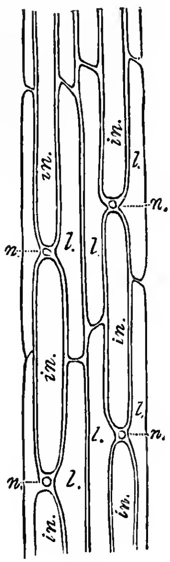


Fig. 22.

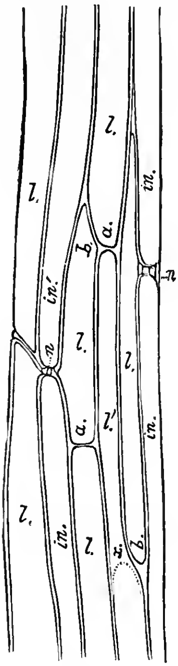


Fig. 23.

given section, due to the overlapping of the lateral tubes. Fig. 23 (drawn from nature) illustrates this peculiarity. "l′" is a lateral cell which, normally, should have stopped at "x," as shown by the dotted line, but which grew on and pushed in between the other laterals; a section just above "x" would show an extra cell.

The normal mode of union of the lateral cells is by horizontal (blunt) ends, as at "a," "a," while the oblique overlapping of these ends, as at "b," "b," is, like the characteristic cortex of our dioecious Ch. aspera. In this species the cortex is only sub- triple-corticated, the variation being toward a suppression of the lateral cells.

Fig. 24 is drawn from the cortex of a Western variety of Ch. aspera, showing at "l′" a lateral cell filling out the whole space between the two central internodal cells (primary cells) of the cortex. In a section through "l′" less than the triple number of cells would be seen.

In the development of the node of the cortex, the growth of the lateral cells may be entirely arrested, and these cells may remain in the node undeveloped, or they may grow into spines (Ch. crinita), or may variously develop, as will be shown presently.

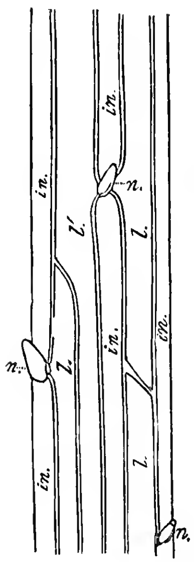


Fig. 24

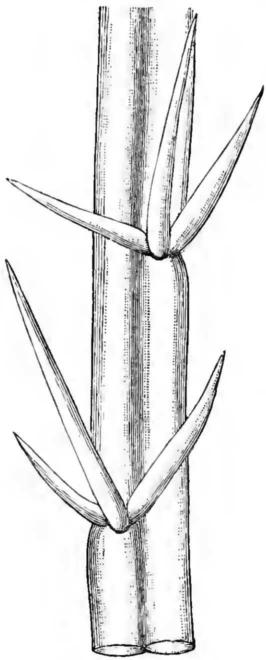


Fig. 25.

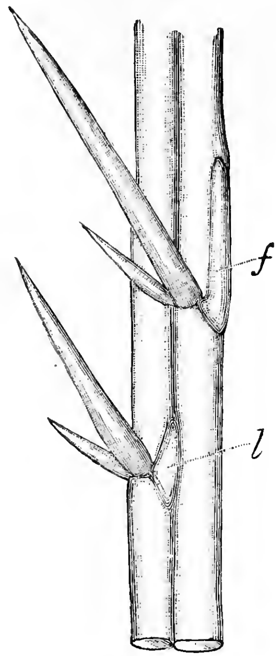


Fig. 26.

In case the nodes do not develop lateral cells lying pressed against the stem as cortex cells, then only the primary cells of the cortex system are found; we see as many cortex cells as there are leaves, and the stem is said to be "*haplistocha corticata*" (singly corticated). This is seen in our Ch. crinita, two cortex tubes of which are represented in Fig. 25. These primary cells approximate each other closely and completely encircle the stem, forming a single cortication. The nodal cells develop spines, three usually, at each node, but no lateral cortex tubes.

In Chara evoluta, Allen, a little higher development is attained. The cortex node bears *two* spines, while one of the lateral cells makes a feeble attempt at developing lateral cortex tubes.

Fig. 26, a portion of the cortex of Ch. evoluta, Allen, showing two nodes; on one side of each node a small lateral cortex cell has formed, while the node bears two spines, instead of three, as in Ch. crinita.

In case one lateral cell develops fully and extends up and down to meet the other lateral cell, then a double cortication results. This is well seen in Ch. excelsa, Allen, which, in size and general aspect, closely resembles Ch. crinita and Ch. evoluta. It is also found in our very common *Ch. fœtida* and *Ch. contraria*, species which represent two clearly defined sub-divisions of the *diplostiche* series.

In Ch. contraria (also in Ch. intermedia, Ch. excelsa, *et cetera*), the *primary* cells of the cortex system (the cells which carry the nodes), attain a larger development, while the secondary, lateral cells, remain smaller, so that in a cross section there appears an alternation of larger and smaller cells, the larger belonging to the primary (median) row of cortex tubes. On the surface we see an unevenness, the papillæ or spines are borne on the larger cells and seem to be on the top of a ridge, while the smaller lateral cells are partly hidden between these median cells. This series of Charæ is called "*tylacanthæ.*"

Should, however, the lateral cells grow to a larger size than the median, then the nodes, with their papillæ or spines, seem to lie in a valley between the higher lateral cells; this series is termed "*aulacanthæ*," and is typified by our very common Ch. fœtida, A. Br.

Stipules.—In the development of cells in the basilar node of the leaf, two or three cells at the base of each leaf arise, superficial to the parent cortex cells, and protrude as papillæ, or develop into more or less extended appendages called, by Braun, Stipules. These stipular cells remain as simple, undivided cells, though they may attain a considerable length.

In Ch. stelligera, whose stem has no cortex, there are three small stipular cells at the base of each leaf, but they do not develop farther than minute papillæ. In *Ch. coronata* a single stipule develops on one side of each leaf, so that the stipules equal the number of the leaves and seem to alternate with them (see Fig. 27).

This figure is taken from a form with minute stipules; usually the stipules in this species "are very large."

In our Ch. hydropitys and in many allied forms, two single stipules are developed at the base of each leaf, and the group is said to be *bi-stipulatæ*.

In the new and interesting species, Ch. socotrensis, Nordstedt, a third stipule frequently develops between the two normal and constant single stipules; this third stipule does not turn upward like the two normal ones, but diverges in various ways. Fig. 28 is copied from Prof. Nordstedt's drawings, and represents the third stipule, variously directed.

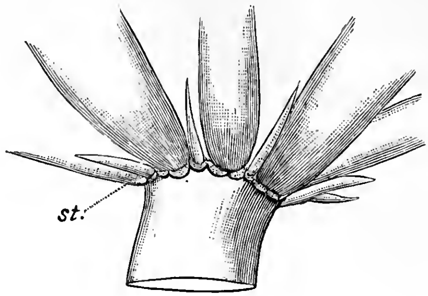


Fig. 27.

In all of these forms the stipules are single, though one, two or three times the number of the leaves. This large general series of single stipules is called *Haplostephanæ* (corona stipularis e simplice serie cellularum).

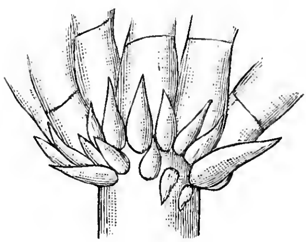


Fig. 28.

The next series comprises Charæ with double stipules. The stipular cell divides horizontally into an upper and lower cell, or apparently, in some cases, the double stipule arises from a single basal cell.

Fig. 29, drawn, by camera, from a section of Ch. crinita, shows a double basal cell "b," and the double stipule "s" directed downward, "s′" upward.

Fig. 30 shows a lateral view of a fully developed double stipular crown in our Ch. sejuncta, the upper series directed upward, equalling in length the lowest naked internodes of the leaves; the lower series directed downward, pressed against the stem. All of this series are termed *Diplostephanæ*.

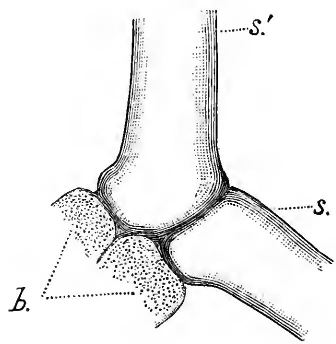


Fig. 29.

It is interesting to note that in the foreign Lychnothamnus Wallrothii a single stipule is developed exactly in front of (opposite) each leaf.

In the foreign Ch. stelligera neither stipules nor cortex are developed, but three small cells protrude slightly at the base of the leaf. In Ch. ceratophylla there are frequently three double stipules at the base of each leaf, see Fig. 31, showing the short inflated double stipules, camera drawn, x 25 diam.

In the Nitellæ there is no development of cortex or stipules, but in a few species of Nitella we find accessory leaves arising from a true verticil. These accessory leaves are more simple than the true leaves; they produce no nodes or fruit, and do not subdivide.

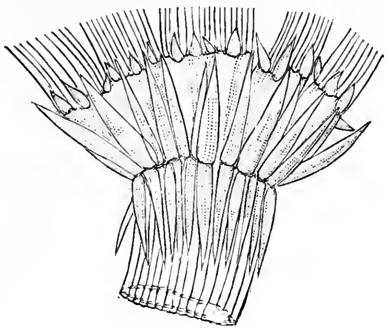


Fig. 30.

We find these accessory leaves numerous in our N. hyalina and N. clavata. In the genus Tolypella fruiting organs, both sporangia and antheridia, spring from the basilar cells of the leaf in the verticil, both external and internal, often in large numbers.

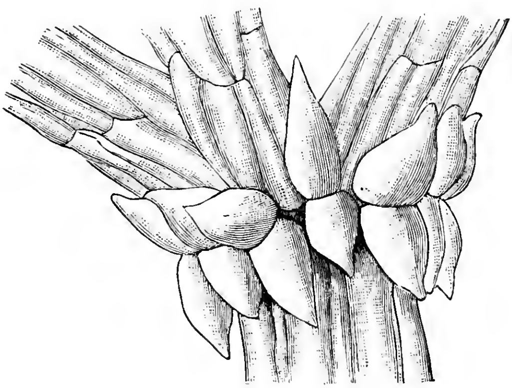


Fig. 31.

Leaves.—As the cell which is to form the leaf protrudes from its basilar node, it divides very early into a series of cells which are destined to form the nodes, internodes and tip.

The cells of the tip of the leaf attain their full size soonest and the disproportion of size in very young leaves is very great. These apical cells of the leaf may always be distinguished by the absence of any formation of nodes; consequently, they are devoid of bracts, reproductive organs and of cortical development. In Fig. 18 young growing leaves are represented with commencing differentiation of cells, "n′," nodal cells; "in," internodal cells; "a′," the apical cell, which, with the two cells immediately beneath, form the tip of the leaf. The alternation of nodes and internodes in the leaf is restricted, and the number of nodes is very constant for each species; in this respect the growth of the leaf is quite different from that of the stem. In Nitellæ the number of divisions of the leaf rarely exceeds five; in Chara it may be as many as fifteen. (Nitella flexilis, two articulations; N. mucronata, three; N. megacarpa, four or even five; in Tolypella, often six; in Chara gymnopus—Michauxii, twelve to fifteen.)

The internodal cells of the leaf, like those of the stem, increase in length, but do not subdivide.

The nodal cell divides, by excentric fissation, into a circle of marginal cells, which enclose a central cell; the formation of these marginal cells takes place, alternately, on either side of a point on the ventral (toward the axis of the plant) aspect of the leaf, until the circle of cells closes on the dorsal side.

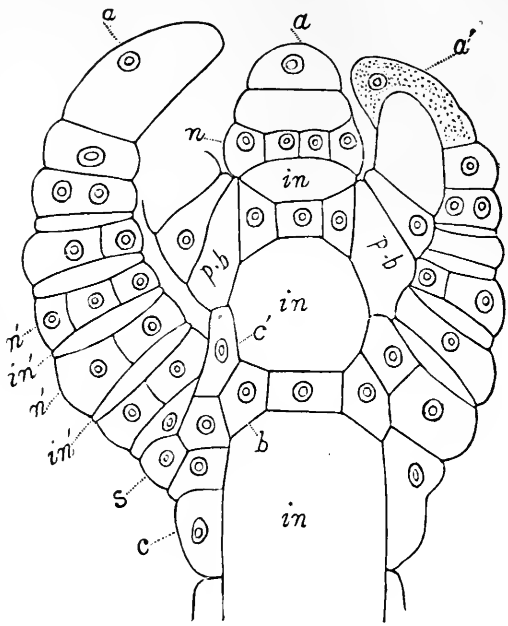


Fig. 18.

The ventral cell is, therefore, the oldest, and from it the fruiting organs are always developed. These nodal cells arise exactly in a line, and do not deviate, as do those of the stem, hence there is no torsion of the leaf, as of the stem (or, if, as rarely happens, a slight twisting is observed, it is in the opposite direction to that of the stem, and is due to the habit of growth, and not to any morphological peculiarity). From the nodes of the leaf lateral rays or bracts arise; in *Nitellæ* the lateral rays usually equal the main leaf in size and look like the leaf. This is well seen in our N. flexilis, in which the lateral ray so simulates the normal leaf, that the leaf appears simply forked.

In *Charæ* the lateral rays are shorter than the leaf and form a more or less perfectly developed circle about the leaf; here they are called bracts. These lateral rays or bracts are always simple cells in which no farther development takes place. We must now examine the basilar node of the *bract*, which is as important in the development of the cortex of the leaf and of the fruit as the basilar node of the leaf is in its development of various organs.

The (peripheral) cell of a leaf-node subdivides, by a fissation parallel to the axis of the leaf, into a superficial and deep cell; the latter again subdivides in the same way, so that there are throe cells, one on the other; the external cell grows out into a more or less elongated bract, the internal cell remains in the node undeveloped; the median cell forms the basilar node of the bract and divides into four cells in regular order—first, the upper left, second, upper right, then lower right, then lower left, closing the circle. In Ch. gymnopus and sub-species four additional cells develop between the four first cells and a circle of eight cells results. In Ch. crinita, however, only two cells develop, one above and one below.

These basilar nodal cells of the bract may not develop farther; in this case the leaf remains naked, no cortex developing on it, or they may grow in length with the elongating internodal cell of the leaf and form a cortical envelope.

In the median nodes of the leaf cortex cells extend upward and downward to meet the extended cells from adjoining nodes; in the uppermost node no extension upward takes place on the tip, only downward to meet the rising cortex cells from the node below; thus it happens that in the middle of each internode of a leaf there is a line of union of the cortex cells, and as there is no deviation of the cells of the internodes the union is opposite, and not, as in the case of the internode of the stem, alternate. On the lowest internode, only the downward cortex cells are seen, no cells rising from the node of the stem to cover the leaf, except in the rare instance of the European Ch. ceratophylla, Willd. (see Fig. 31), in which a partial system of cortex for the leaves develops in the stem-node. Fig. 32 is a leaf of Ch. crinita (x50) showing "s," two stipules at the base of a leaf; "1," the first node of the leaf covered *almost to the base* with the cortex from the first node; usually these cortex cells extend the whole length of the internode, but sometimes, as in this instance, the internode is imperfectly covered; "2," the second internode, showing the line of union of the cortex cells from the first and second nodes. In this species there is a single cortex cell from each bract and the leaf (like the stem) is "*haplostiche corticata.*"

When there are two upper and two lower nodal cells to each bract, and both sets develop into a cortex, the stem becomes "*diplostiche corticata*," when, as in Ch. sejuncta and all the allied sub-species of Ch. gymnopus, there are eight nodal cells, three upper and three lower develop into cortex cells and the two lateral cells remain undeveloped. In this case the leaf is, like the stem, "*triplostiche corticata.*"

In a number of species, especially in many American species, the lowest internode of the leaf remains naked, while the median internodes are corticated. This is the case in Ch. hydropitys and its allied species, in Ch. sejuncta and the sub-species of Ch. gymnopus (see Fig. 30).

In the first growth of a stem from the protonema, in the earliest shoots from perennial stems and in many abnormal growths, portions of the stem and leaves may be naked, in normally corticated species.

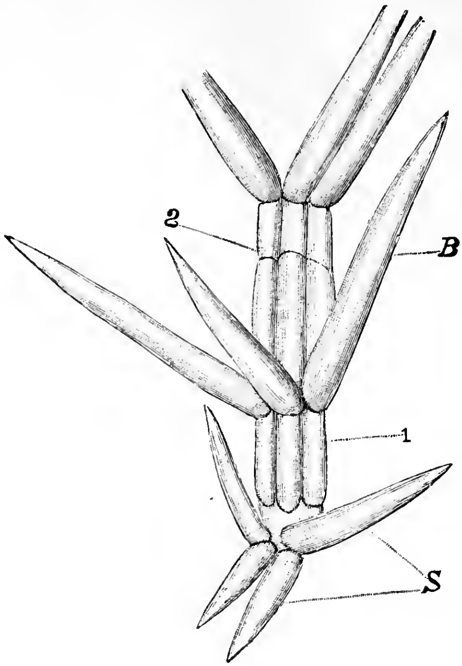


Fig. 32.

BRANCHES.—From the basilar node of a leaf (stem node) there arise not only cortex cells and stipular cells, but also new shoots, which may be called branches ; these arise always in the axil of the first leaf of the verticil (or, in some Nitellæ, two shoots arise from the first and second leaves). The leaf which develops a shoot in its axil develops no cortex system, and the neighboring cortex cells have to close in and fill the gap. So, on the leaf, when a sporangium arises (always in the axil of the first bract), no cortex system develops from that bract upward.

Many species of Characeæ are perennial in the sense that new growths arise from nodes of old stems that have retained their vitality over winter. This is especially true of Ch. fragilis in the North and Ch. gymnopus Humboldtii in the South. In some cases the nodes of old stems become swollen and filled with granules of starch.

Fig. 33 represents a subterranean node of Ch. fragilis, with the basal nodal cells filled with starch granules; not only are they deposited in these cells, but in the internodal cells of leaf and stem, as well. When a new shoot arises from an axil of this plant, this store of nutriment is drawn upon till the new plant attains size enough to enable it to appropriate its own food.

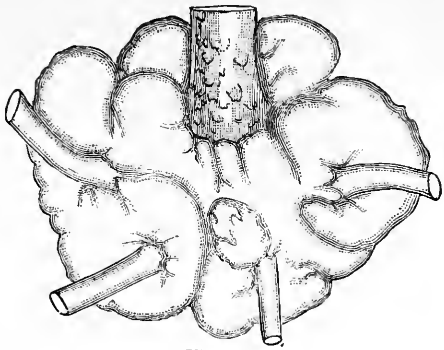


Fig. 33.

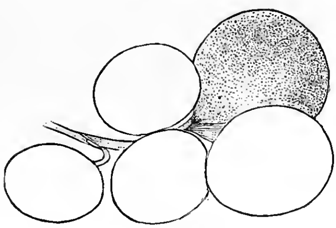


Fig. 34.

Fig. 34 represents a tuft of minute radicles enlarged at their tips and filled with starch, so that they look like a bunch of white grapes; each bulblet is nearly round and one-celled; drawn from Ch. aspera.

Pringsheim (ueber die Vorkeim und die nacktfuessigen Zweige der Charen, Jahrb. f. Botanik, 3, 294), has studied the reproduction of Ch. fragilis from old stem nodes, by means of gymnopodal shoots (naked footed), which are imperfectly developed at the base, but which subsequently become perfect stems; and, also, by means of protonemal shoots, which, at first rudimentary, give rise to perfect stems by a lateral growth, behaving, in this respect, just like the first growth of the seed, the seed protonema.

Organs of Fructification.—The Antheridia and Sporophydia are always borne on the leaves or on their basal nodes. *Antheridia*, the male organs, producing spermatozoids, *are always metamorphosed terminal segments of leaves, or of their lateral rays* (*bracts*); *Sporophydia* arise from the same node, *but lateral to the Antheridia.* In Chara the Antheridium occupies the place of a bract on the side of a leaf, and the sporophydium arises from one (the upper) of the basilar cells; if the species be diœcious the sporophydium occupies the same position in relation to the bract. In Nitella the Antheridium is terminal (on the end of the leaf), and the sporophydium arises from one of the cells of the same node, either from one of the basal cells of the Antheridium, or of the terminal ray taking the place of it. In Tolypella the Antheridia are always in the place of lateral rays, or of accessory leaves in the fundus of the verticil, never terminal on the primary ray; in this genus sporophydia, sometimes long-stalked and numerous, spring from their basal cells, or from the basal cells of the lateral rays.

Fig. 35 shows the position of the sporophydium, lateral to the Antheridium which terminates a primary ray and is surrounded by three lateral rays, which, in this species (N. intermedia, Nordstedt), again divide, and bear fruiting organs.

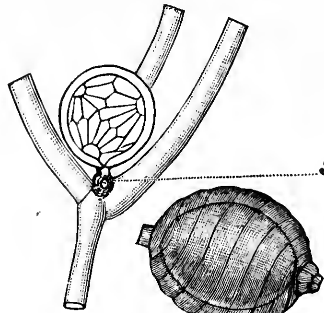


Fig. 35.

Fig. 36 shows the situation of two sporophydia in a verticil of N. megacarpa, Allen; "1" is the primary ray which bears an Antheridium on its tip. In this species the sporophydia are aggregated in the verticils and not always single, as in many other Nitellæ. (For illustrations of *Tolypella*, see plates farther on.)

Fig. 37, from Chara coronata, var. Braunii—tenera (New Mexico), shows the fruiting organs, lateral on a leaf; in this case they are double on one leaf (frequent in this species); the Antheridia are removed to show the point of attachment.

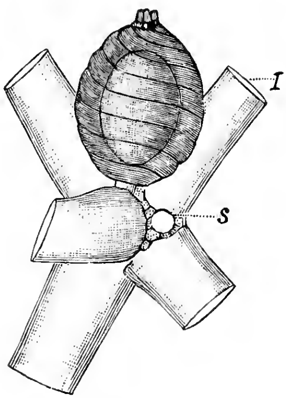


Fig. 36.

The basilar node of the lateral ray (or of the Antheridium, which may take its place), which produces sporophydia, differs in its arrangement from the basilar node of an ordinary ray or bract. The ordinary (sterile) ray has a basilar node, consisting of four peripheral cells, while the basilar node of a fertile bract has five cells, the odd cell being in the median line, upward. This fifth cell gives rise to the sporophydium, and the cells on each side of it develop *secondary rays*, or *bracteoles*; the two inferior cells may develop cortex cells (in species with corticated leaves).

In Fig. 37 two bracteoles are shown by each sporophydium.

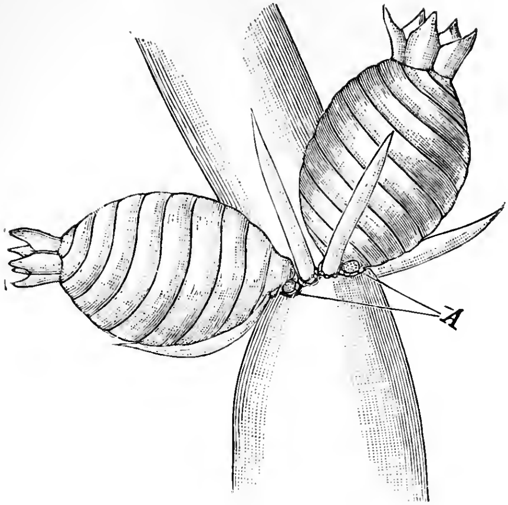


Fig. 37.

Development of the Antheridium.—The cell which is to produce the Antheridium divides horizontally (to the axis) into a disk-shaped basal cell and a terminal cell which finally becomes nearly spherical, flattened only at the base, where it rests upon the stipe cell. The stipe cell is usually quite short, but occasionally (as in Tolypella stipitata) it is considerably elongated.

The terminal cell now divides into four, then into eight cells. These eight cells occupy the whole circumference of the sphere; they now divide internally parallel to the surface in such a way that three sets, each of eight cells, form one within the other—Fig. 38, "c." These twenty-four cells are thus arranged in eight radii and form three spheres one within the other.

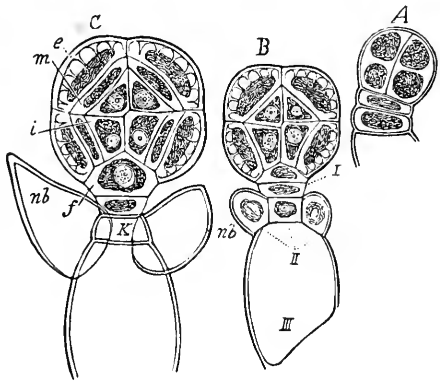


Fig. 38.

The superficial cells differ somewhat in shape; those about the free apex of the sphere come to a point and are triangular in shape, see Fig. 39, "A," while those at the base having the points downward are truncated; all are arched on the surface to make the sphere and are there called scuta. They separate when mature at the lines of union and have thus been called valves. When immature they are filled with green chlorophyll, but when approaching maturity they become as a rule brilliant red. (In Nitella megacarpa growing in deep water in Litchfield Lake, the Antheridia never become more colored than a pale gold.) The outermost layer, however, has no granules and forms a transparent zone about the sphere, see Fig. 39, "A" (N. flexilis). The sides of these scuta cells begin to exhibit folds very early; these folds look like rays extending inward. The cells of the second layer do not increase in size in the direction of the periphery, but in the direction of the radius, and become somewhat cylindrical in shape; they are attached to the centres of the superficial *scutæ* (where there is a circular space free from folds), and as the spherical body increases in size spaces are left between them. These cells are called *manubria*. Each manubrium bears on its inner extremity one

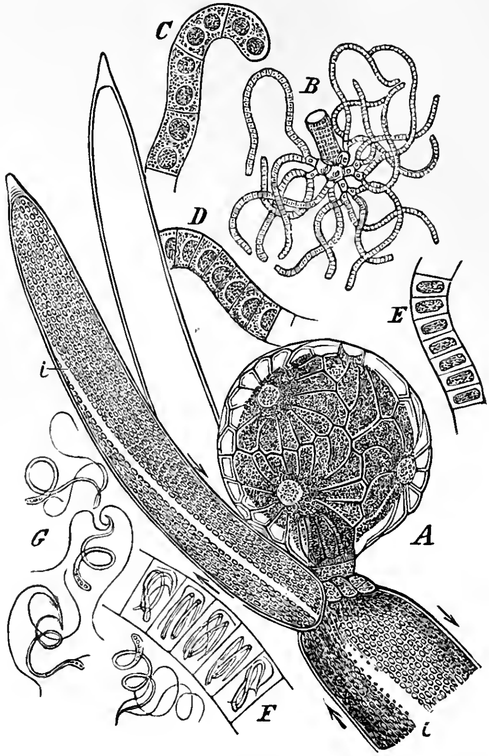


Fig. 39.

of the innermost series of cells, a roundish cell called the capitulum. These capitula are crowded together in the centre of the Antheridium, and each capitulum incloses about six small cells, from each of which grow three to five long, oscillatoria-like cells, which are divided by one or two hundred septa. Each cell of these threads contains a spermatozoid. (Fig. 39, "B," a manubrium, bearing on its inner extremity the capitula cells with their threads. C, D, E, F, represent these threads, magnified; G, the spermatozoids.)

The growth of these threads fills all the interspaces of the Antheridium with a gelatinous mass. The spermatozoid is formed directly from the nucleus of the cell in which it originates; the ciliæ, of which there are two at the anterior extremity, are (according to Schmitz) formed by the protoplasm. Even before the cells rupture the spermatozoids begin to rotate in them.

THE DEVELOPMENT OF THE SPORE.—The spore, like the Antheridium is formed on the leaf, but always on a short lateral ray, which is designated the sporophyas (spore bud). This appellation may be sanctioned if the ray bearing the spore be considered a specialised portion of the leaf, reminding one of the ovary of the Phanerogams. The spore arises in this spore bud, not within a parent cell nor in a compound receptacle, *but as a naked cell*, which becomes enclosed and tightly enveloped by rays developed from the supporting cell.

The cell which is about to develop a sporophydium divides at first into two cells and the lower of these divides again. The uppermost cell becomes the spore, the lowest the node of the spore, from which develop the cells which are to envelop the spore. The middle cell is the stipe cell of the spore and remains hidden in the mature capsule. The number of rays which develop from the node of the spore is nearly always *five;* at first these rays consist of a single cell, but as they lengthen the cells divide by a nearly horizontal wall into two cells, and in the Nitellæ the upper cell again subdivides. The lowest cell of these rays elongates, while the upper cells remain short and form a tip. As these cells elongate they twist about the spore and form an envelope, surmounted by the cells at their tips.

Fig. 40 is a young spore, with its lateral, enveloping ray cells, two-celled at the tip (drawn from N. oligospira).

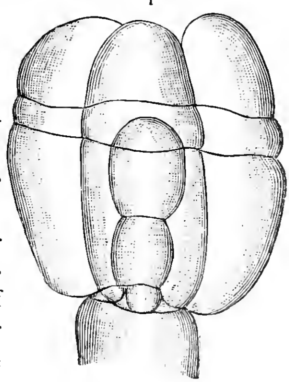


Fig. 40.

Fig. 41 shows a spore more developed and more enveloped by the twisting cells from the node at the base (from the same plant as Fig. 40).

The envelope of cells is called the sporostegium (spore capsule). It always twists to the left, upward. The cells at the tip of this capsule do not twist, but close together like a rosette and form a *coronula*. In the Charæ the coronula consists of five cells (one at the tip of each enveloping cell). The cells of this coronula are united below, while their tips frequently diverge, as in Ch. coronata (see Fig. 37), or they may, as in Ch. fragilis, closely converge. In the Nitellæ the coronula is ten-celled; the lower five cells are closely adherent, the five upper cells are less adherent, but of larger size.

In some Nitellæ the whole coronula is evanescent and drops off before the maturity of the spore. While the capsule is developing and enclosing the spore, the latter has been growing and developing, in its interior, divisions which are not understood (Braun). In the Nitellæ the division takes place very early, before the enveloping cells have scarcely attained the length of the terminal cell. At the top a flat disk is set off by a septum extending obliquely backward; then a second, also flat segment, follows, situated beneath the posterior wall of the first and reaching down to the base; lastly, a third resting on the second, is set off from the basal surface. During this process the terminal cell grows on the anterior side so that a distortion of the tip is produced, the cell formation progressing downward and backward, and the anterior wall protruding toward the tip; on this account the cells just described have been called the "turning cells." In Chara a corresponding division occurs later, when the enveloping cells of the sporostegium have united over the central cell and is confined to a separation of a flat basal cell, like an internal spore pedicle, which is distinctly seen even till the spore becomes ripe, while the "turning cells" of the Nitellæ, which do not increase in size, become difficult to recognize on account of the premature development of the spore. After the separation of these structures, which seem to be devoid of significance in the farther development, the remaining part of the terminal cell changes to the ovule, which, when fertilized, ripens into the spore.

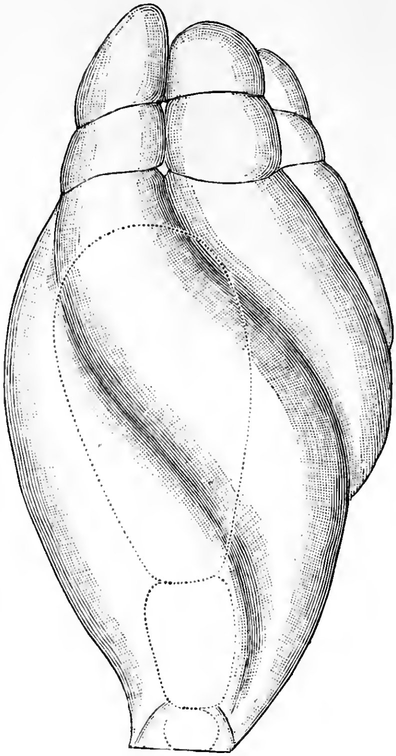


Fig. 41.

The sporophydium reaches its full size, nearly, before fertilization. The ovule fills completely the cavity of the capsule; it is at first filled by a homogeneous plasma, in which large amounts of starch granules and fat drops develop, while a finely granular plasma collects at the apex. The ovular membrane becomes extremely delicate at the vertex, and at the time of fertilization softens to a jelly, or even disappears entirely.

The cells of the coronula form a tightly closed cap over the capsule; externally the ends of the enveloping cells are firmly united over the ovule, but internally they are rounded off so that they rest loosely against each other and leave an apical, inter-cellular space between them, which is dilated upward under the coronula and downward over the ovule (infundibuliform). As soon as the ovule is ready for fertilization a sudden change occurs in the upper part of the capsule; the enveloping cells elongate just beneath the coronula by an intercalar growth of the cell membrane. The *cuticula* (the external cell membrane) does not elongate, but tears transversely, and by the separation of the margins of the tear affords accommodation to the length of the newly formed neck; this is variable in the same species, but generally less marked in Chara than in some species of Nitella. The different parts of the neck diminish upward and in a radial direction; they do not possess the same thickness that the enveloping tubes below have, so that narrow spaces, dilating upward, form between them, and a larger free inner space develops under the coronula. This process goes on at a time when the neighboring Antheridia rupture (even in *Ch. crinita*, which is fertilized parthenogenetically [without the aid of spermatozoids], the formation of a neck with inter-spaces takes place). The liberated spermatozoids penetrate the fissures in the neck and reach the interior space, beneath the coronula, whence they force their way downward and reach the germinating spot of the ovule.

In some species of Nitella and Tolypella the upper ends of the capsule cells swell, and the coronula is raised up so that the spermatozoids enter from above.

The spore now becomes full to the top of granules of starch and fat, and its cell wall becomes firm and yellowish (or colorless). The cells of the capsule, which have hitherto been thin and transparent (unless encrusted by lime), become differentiated by an unequal development of the outer and inner portions. The walls of the investing cells lying against the spore, as well as the upper wall of the cell of the spore pedicle, become thickened, indurated and colored; a hard shell is thus formed, tightly enclosing the spore and pressing firmly against it. This shell is opaque and like the stony kernel of a fruit; it is colored differently in different species, light brown, dark or reddish brown, or black; it is called the *Nucleus*.

Nucleus.—The character of the Nucleus affords important distinguishing marks for the determination of species: its color; the markings on its surface; the number of spirals (generally constant in each species); the prominence of the ridges or its smoothness; the markings on the shell wall, all are to be considered.

The spirals, due to the twisting of the enveloping tubes, may be marked by prominent ridges, or the union between the enveloping cells may be a mere line and the Nucleus may be quite smooth; if the enveloping cells complete one circuit, then five striæ are visible; if two or three turns, then ten or fifteen striæ.

At the lower end of the Nucleus, where the enveloping tubes join the pedicle, spines often project, five in number, formed by the extension of the woody formation between the enveloping tubes; at the upper end a single prominent spine is sometimes formed in a similar manner.

The contents of the enveloping tubes consist of a series of granules, at first green, but becoming colored, in some species, yellow or scarlet (Ch. crinita), or red (Ch. coronata). In the coronula of Chara the cells continue green, but in the Nitellæ the cells of the coronula remain colorless.

In most species of Chara a *calcareous shell* forms between the hard inner shell and the soft outer part of the capsule. This calcareous layer is developed in a gelatinous network lying next the woody shell and seems to be formed by the protoplasm of the enveloping cells; in this mesh lime is deposited.

This shell may persist long after the woody part has disappeared, and is found in fossil nuclei, always with an opening at one end, for the cell of the pedicle deposits no lime. No lime is deposited in the coronula and this is never found in a fossil state.

Characeæ growing in water which contains much lime frequently obtain an external coating of lime, but this is not a constant character of any species and is not a true calcareous layer.

A peculiar, abnormal development of the spore and its capsule, is not infrequently seen, which consists of the complete absence of all woody formation next the spore. In consequence of this the spore swells up and becomes filled with a large amount of starch, and looks like a round white globule filled with chalk. These abnormal *sporophydia* have been seen in a large number of species, especially of Chara, and must not be taken into serious consideration in the determination of the species.

In 1856 Braun presented to the Berlin Academy a communication concerning *Parthenogenesis* in plants, especially in Ch. crinita. Male specimens of this diœcious Chara are extremely rare, only two or three having ever been found, while the female plant is quite common.

The sporophydia develop in the same way as in other species; the same changes occur in the "neck" before the ovule is ready for fertilization; and even in isolated, cultivated plants, the spore develops in the unfertilized state just the same as it would if fertilized, and the ripe fruit germinates and reproduces its kind in the same manner. As this plant has been found already in saltish water on Long Island and in Massachusetts, opportunities for the study of this wonderful process are not wanting to American botanists.

The general structure of a Charad is extremely favorable to the study of all its organs; it is especially easy to examine the Nitellæ and a few species of Chara which have no cortex envelope and which are not incrusted with lime.

Of all the species, our very common Chara coronata is probably the best to study.

Nitella flexilis bears the confinement of an aquarium well and is a good form to study, but Ch. coronata is larger and its walls are even more transparent than those of N. flexilis.

Cyclosis.—Of all the interesting features of these plants, that of *Cyclosis* is perhaps the most attractive.

Corti, in 1773, was the first to record this phenomenon, which was confirmed by Fontana in 1776. In 1807 Treviranus re-discovered the circulation in "Ch. flexilis," and in 1818 Amici presented an important "memora" to the Italian Society of Science at Modena, on the circulation in "Ch. vulgaris." These observations were repeatedly confirmed and noted by various observers, but the most important treatise on the subject was by Agardh, on the Anatomy and Circulation of Chara, in 1826. In this work Agardh formulated laws which seemed to him to govern this circulation. In 1837 Dutrochet communicated to the Acad. des Sciences observations on the circulation in Ch. fragilis, but the most complete work, not only on the circulation, but on the whole morphology of the order, was issued by Al. Braun in 1852. In this work Braun first unfolded the structure of these plants and laid an enduring foundation for a correct classification of the species.

The cells of Characeæ are filled with protoplasm; the nucleus of the cells which form the nodes does not divide after the structure of the plant is fully developed, but in the long internodal cells the nucleus becomes divided into a number of fragmentary neuclei. In the protoplasm various substances develop, but early in the cell life vacuoles form; these after a time come together, and result in one large vacuole, which occupies the centre of the cell, while the protoplasm lies about the sides.

This protoplasm now circulates always in the direction of the long axis of the cell, and carries with it the various granules imbedded or floating in it. In some parts this protoplasm is quite thick; in others (toward the central parts of the cell) very thin and watery.

The chlorophyll grains adhere, mostly, to the walls of the cells and form a green layer of granules, arranged in beaded lines, following the direction of the stream; only in the line between the two opposite streams is there a clear streak (the "indifferent line"), which always marks the direction of the current.

One can see in this circulating protoplasm curious granules of protoplasm which are ciliated.

The current is most rapid along the cell wall. Braun, in his treatise referred to, states that no circulation has been observed in the following parts of Charads: (1) in young fissating cells; for example, in the growing apical cell and those lying next it; (2) in cells which abort early, as in the centre of the nodes of the stem and leaves; (3) in cells filled with starch and fat, as in the bulbils of various species and in the spore cell; (4) in the cells of the threads which carry the spermatozoids; (5) in the cells of the scuta of the Antheridia. Al. Braun, in his work of over seventy-five pages, has studied in detail the circulation in every part of a Charad; it is, however, unnecessary for us to quote farther from his work, or continue the subject.

Classification.—As stated in the beginning of this treatise, the position of the Characeæ in the vegetable kingdom was long a matter of doubt, and great diversity of opinion prevailed among early botanists, and affected even Linnæus. This uncertainty was eminently true concerning the species. Scarcely any attempt to classify the species was made. Vaellant, in 1719, described nine species, but Linnæus adopted but four (these four comprising several distinct species, under one name, have been unwisely retained by later, even by recent authors). Braun says that the species described by Wallroth in 1815 are in "indescribable confusion"; that the species described by him in 1833 in the Flor. crypt. German. are a "monstrous conglomeration." Agardh excessively divided up the species; his species must be reduced from thirty-two to fifteen, and similar reductions must be made in the works of Kützing and Wallman, in the latter of which 116 species must be reduced to thirty-five. Alexander Braun first brought order out of complete chaos, and to his labors in building a system of classification upon a correct understanding of the real structure of the plant, we are wholly indebted. All former classifications are worthless, and all former names, which represent a number of different species, must be discarded.

CLASSIFICATION AND SYNOPSIS.

CHARACEÆ, Richard.

Fam. I.—Nitelleæ, v. Leonhardi.

Stem and leaves always naked. *Leaves* in whorls of five to eight (often increased by accessory smaller leaflets), developing two to three nodes bearing leaflets. *Leaflets* greatly developed; 1-several articulated, often developing a leaf bearing node, which may be several times repeated.

Sporophydia, rising directly from the nodes of the leaves, often clustered, with a short stipe (usually) and a proper basilar node. Coronula, 10-celled, small, colorless, sometimes evanescent. Spore capsule without an inner calcareous layer.

Genus I.—Nitella, Ag.

Leaves with 2-several segments, but only one leaflet-forming node. *Leaflets*, either similar to the continuation of the primary ray and not again divided, or developing leaflet-bearing nodes and overtopping the primary ray, when they are either simple or repeatedly forked with numerous tips, the latter 1-many segmented. Antheridia apical, on the primary ray and secondary divisions of the leaf, separated from the leaflet-bearing node only by a low, disk-shaped stipe cell, hence appearing in the fork. *Sporophydia*, lateral on the nodes of the leaf, single or clustered; in monœcious species, just below the Antheridium.

Note to the Synopsis.—This key to the species was prepared by Dr. O. Nordstedt, and is translated, with his permission. A few alterations have been made by Dr. Nordstedt, to include his recent discoveries down to September, 1887, and by the translator to include the new American species. The synopsis of the genus Tolypella has been re-written, in order to embrace the numerous American species, which nearly equal the whole number previously known.

The measurements are given in micro-millimeters (without any sign). American species are printed in fullface; the South American species are designated by the letter "**S**" in parenthesis.

The following species have been added to the *Braun-Nordstedt Fragmenta :*

Nitella Morongii, Allen.
  " Macounii, Allen.
  " muthnatæ, Allen.
  " minuta, Allen.
  " dualis, Ndst., mss.
  " bonærensis, Spegaz.
  " Archavaletæ, Spegaz.
Tolypella hispanica, Ndst.
  " comosa, Allen.
  " finbriata, Allen.
  " stipitata, Allen.
  " intertexta, Allen.
Chara socotrensis, Ndst.
  " sub-mollusca, Ndst.
  " inconnexa, Allen.
  " evoluta, Allen.
  " excelsa, Allen.
  " sub-segregata, Ndst.
  " gymnopus-guatemalensis, Ndst.

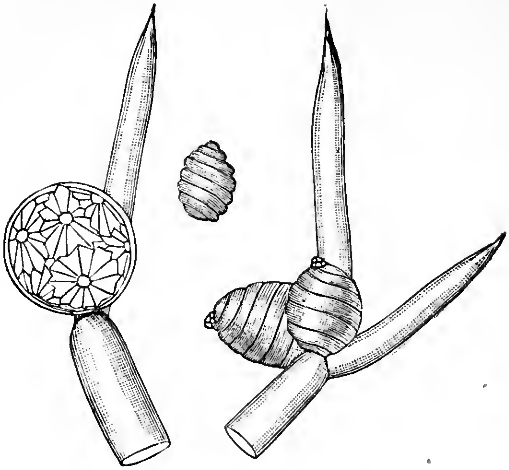


Fig. 42.

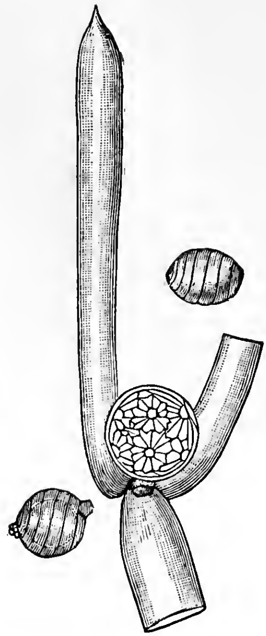


Fig. 43.

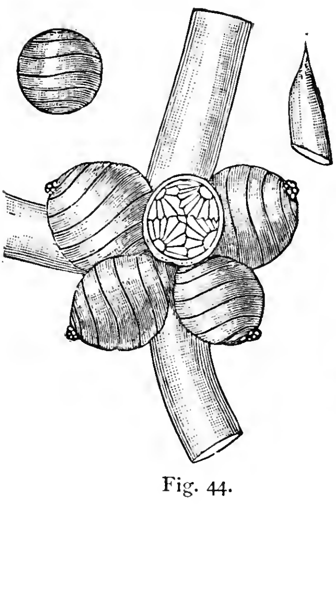


Fig. 44.

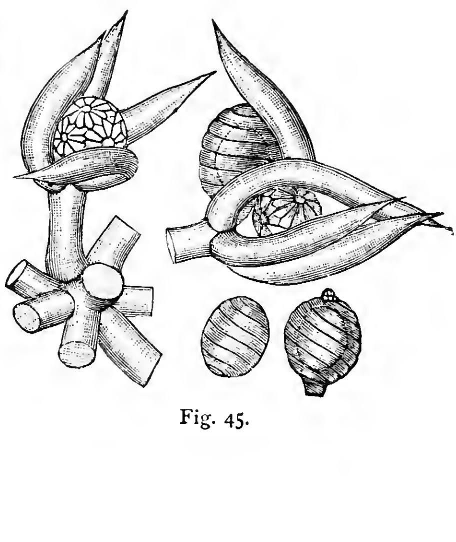


Fig. 45.

SYNOPSIS OF NITELLA.

A Monarthrodactylæ, ultimate segments of the leaves one-celled.

a. Simply branched.

a. Homœophyllæ. Leaves similar.

* Diœcious.

† Extremely simple, leaves with only a single ray, very rarely branched. 1. **monodactyla** A. Br. (**S**).

† † Branched.

╳ Nucleus with 10-11 striæ. 2. *polygyra* A. Br.

╳ ╳ Nucleus with 5-7 striæ.

§ Fertile verticils contracted into a minute head, with an elongated minute recurved peduncle, enveloped in mucus, with very short 1-celled segments. 3. **cernua** A. Br. (**S**).

§ § Fertile verticils not so contracted.

+ Glœocarpa (fruit enveloped in mucus).

1) Fertile leaves of the female plant simple; of the male plant, branched. Leiopyrena (nucleus smooth). 4. *syncarpa* (Thuill.) Kütz.

2) Fertile leaves of both sexes branched. Oxygyra (nucleus with sharp angles). 5. **capitata** (N. ab E.) Ag.

+ + Gymnocarpa (fruit naked, not enveloped in mucus), fertile leaves branched (Fig. 42). 6. **opaca** Ag.

* * Monœcious.

† Fertile verticils not enveloped in mucus.

╳ Apices of leaves acute, rarely obtuse (Fig. 43). 7. **flexilis** Ag.

╳ ╳ Apices of leaves gradually long acuminate. 8. **acuminata** A. Br.

§ Sterile leaves not much longer than the fertile verticils.

+ Small, habit like N. flexilis or N. mucronata.

1) Leaves loose.

a) Sporophydia aggregated. 8*a* (Fig. 44). **subglomerata** A. Br.

b) Sporophydia solitary, larger. 8*b*. *Indica* A. Br.

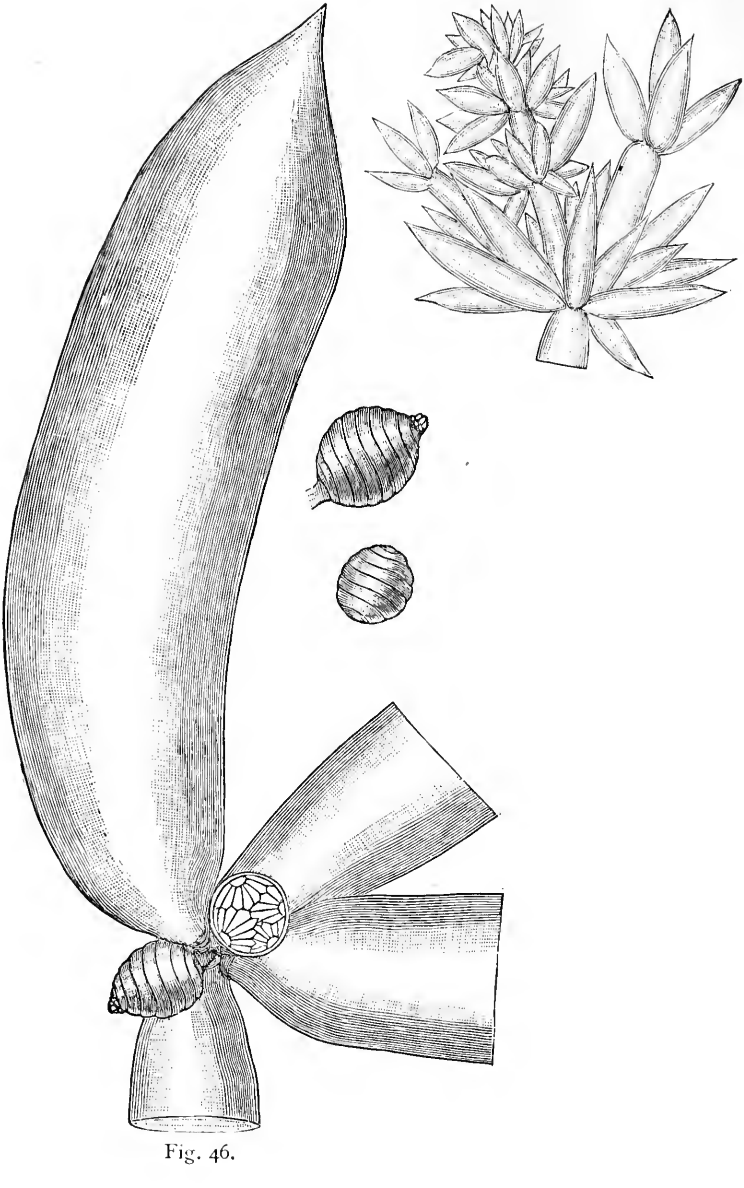


Fig. 46.

2) Leaves shorter, condensed above into a minute head, sporophydia solitary, 8c. *mauritiana* A. Br.

++ Larger, habit of N. translucens, segments of leaves very short, sporophydia aggregated

1) Larger. 8*d*. *Bellangeri.* A. Br.

2) Smaller, with shorter leaves. 8e. **Lindheimeri** A. Br.

§§ Sterile leaves long, overtopping the fertile, which are collected into terminal and axillary heads.

+ Segments of the sterile leaves very short, sporophydia solitary. 9. sub-species, **Gollmeriana** A. Br. (**S**).

++ Segments of the sterile leaves long (Fig. 45 sterile leaves not shown). 10. subsp. **glomerulifera** A. Br.

†† Fertile verticils enveloped in mucus, large. 11. **prælonga** A. Br.

b. Heterophyllæ. Leaves dissimilar (in a verticil are leaves of two sorts, some bearing nodes and others simple, adventitious; see page 23). 12 (Fig. 46). **clavata** A. Br.

b. Repeatedly branched.

* Diœcious, segments of leaves short (polyglochin). 13. *tricuspis* A. Br.

** Monœcious, segments of leaves large.

+ Nucleus 270 long. 14. *Stuarti* A. Br.

++ Nucleus 215 long. 15. **Macounii** Allen.

B. Diarthrodactylæ. Ultimate segments of the leaves 2- (rarely 3-) celled; ultimate cell mucroniform.

a. Homœophyllæ. Leaves similar.

* Diœcious.

† Fertile verticils enveloped in mucus.

× Sterile leaves branched with very short tips. 16. *glæostachys* A. Br.

×× Sterile leaves not branched with very short tips.

Ultimate, mucroniform cell of the last segments of the leaf elongated. 17. *subtilissima* A. Br.

Ultimate cell short, the colored membrane of the nucleus covered with small dentate scales. 21. *Gunnii* A. Br.

†† Fertile verticils not enveloped in mucus.

⊙ Habit sub-moniliform; nucleus 430–470 long. 18. *remota* A. Br.

⊙⊙ Habit not sub-moniliform.

1) Fertile leaves in part, 4-divided, nucleus 270–330 long. 19. *dispersa* A. Br.

2) Leaves 2-3 divided.

a) Heteromorpha, sporophyd. unknown. 20. *Robertsonii* A. Br.

b) Homo-morpha; nucleus 240–270 long. 21. *Gunnii* A. Br.

3) Leaves twice divided, nucleus 180–200 long. 22. *Sonderi* A. Br.

* * Monœcious.

† Leaves simply branched, or twice-thrice-divided, the ultimate divisions not much abbreviated. Macrodactylæ. (N. mucronata, A. Br., in its broadest sense; [the type of the group, T. F. A.] compare also † †).

× Leaves branched or twice-divided (sub-flabellatæ); compare × ×.

§ Heads not enveloped in mucus.

+ Fertile verticils contracted in axillary heads; nucleus, 290–340 long. 23. **axillaris** A. Br.

+ + Fertile heads contracted, numerous, terminal and axillary; nucleus, 250–260 long. 24. **Morongii** Allen.

+ + + Fertile heads small, terminal, or axillary; nucleus, 400–450 long.

1) Robust, verticils extremely dissimilar.

a) Ultimate segments 2-celled. 25. *translucens* (Pers.) Ag.

b) Leaves at length simply branched; segments often 3-celled. 26. *tricellularis* Nordst.

2) More slender, sterile leaves becoming shorter, gradually passing into the loose fertile heads (transition to N. mucronata). 27. *brachyteles* A. Br.

§ § Heads enveloped in mucus.

+ Robust, nucleus 250 long. 28. *leptoclada* A. Br.

+ + Very fine, leaves always simply branched; nucleus, 300–320. 29. *microphylla* A. Br.

XX Leaves repeatedly branched (flabellatæ); compare X above and † † below.

§ Gymnocarpæ (fruit not enveloped in mucus).

1) Fruit in all the divisions of the leaves (the last sometimes excepted).

+ Sporophydia solitary or aggregated; nucleus 270–380 long.

a) Segments of the second division of the leaf commonly 2-3. 30. **mucronata** A. Br.

⊙ Segments of the first division not shorter than the others.

☽ Striæ on the nucleus prominent.

♃ Robust; nucleus 320–380. 30a. *robustior* A. Br.

♃ ♃ Slender; nucleus, 280–330.

! Sporophydia usually single. 30b. **tenuior** A. Br. (Fig. 47.)

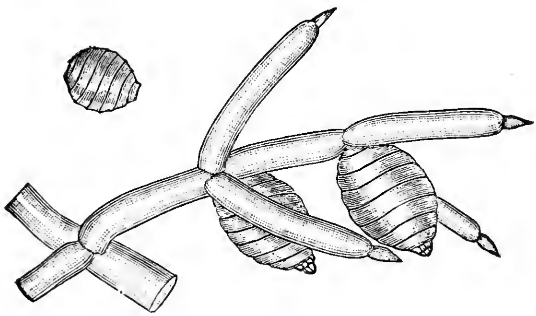


Fig. 47.

! ! Sporophydia aggregated, often 2; elongated and slender. 31. sub-species **virgata** A. Br.

☽☽ Striæ on the nucleus not prominent. 30c. sub-species **leiopyrena** A. Br.

⊙⊙ Segments of the first division of the leaves short; nucleus, 300–330 long. 32. sub-species *Wahlbergiana* A. Br.

b) Segments of the second division of the leaves commonly 4 to 6, with an acuminate slender mucro; nucleus 300–360 long. 33. *pseudo-flabellata* A. Br.

++ Sporophydia solitary; nucleus 220–280 (-300) long.

! Nucleus prominently 5-striate. 34. **capitellata** A. Br.

!! Nucleus 6-striate; striæ scarcely prominent. 35. **gracilis** (Smith) Ag.

2) Fruit in all divisions of the leaves except the first, which is usually sterile. 36. **tenuissima** (Desv.) Kütz.

3) Fruit only in the first division of the leaves.

⨀ Sporophydia single. 37. *confervacea* (Breb). A. Br.

⨀⨀ Sporophydia 2-3. 38. **pygmæa** A. Br.

4) Fruit only in the last division of the leaves; nucleus, 265–285 long. 39. *Muthnatæ* Allen.

§ § Glœocarpæ. Fruit enveloped in mucus.

1) Minute; diameter of stem, 170–250; nucleus, 230–300 long; striæ, 6-7; Antheridium, 120-140 in diameter. 40. **batrachospermum** (Reich). A. Br.

2) Minute; diam. of stem, 130; nucleus, 350 long; striæ, 6; Antherid., 200 in diam. 41. **minuta** Allen.

3) Larger; diam. of stem, 300–450; nucleus, 300–360 long; striæ, 7-8; Antherid., 160–240 in diam.

☽ Leaves twice divided; shorter above. 42. *leptosoma* Nordst.

☽☽ Leaves thrice-divided; longer. 43. **intermedia** Nordst.

4) Diam. of stem, 400–750; nucleus, 280–360 long.

! Leaves 2-3 divided.

♃ Fertile leaves contracted into a minute pedunculated head; striæ on nucleus, 6-7; diam. of Antheridium, 170. 44. **Asagrayana** Scheff. (ined.)

♃♃ Leaves gradually contracted into a head; ultimate segments, 4-5; striæ on nucleus, 6-7; diam. Antherid., 200–230. 45. (pseudoflabellata), f. *mucosa*; (compare 33).

!! Leaves only twice-divided; ultimate segments, large. 46. *conformis* Nordst.

† † Upper leaves, in part often four times divided, the ultimate divisions (almost always sterile) forming a 2-4-cuspi-

date crown. Brachy-dactylæ (N. polyglochin, A. Br., in its broadest sense [as a type of the group, T. F. A.]) (Fig. 48, tip of N. microcarpa, A. Br.); consult also species under †.

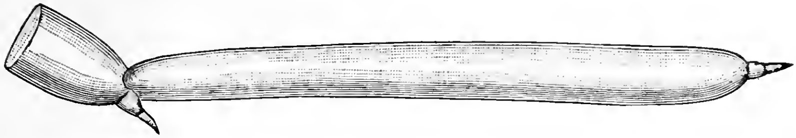


Fig. 48.

× Coronula of the sporophyd. short.

§ Sporophydia solitary.

a) Terminal segments of leaves not always short. 47. **oligospira** A. Br.

1) Nucleus, 260–330 long; f. **genuina.**

2) Nucleus, 330–350; leaves twice divided; f. *Javanica.*

3) Nucleus, 390–400; f. *Indica.*

b) Terminal segments short. 48. *Abyssinica* A. Br.

c) Terminal segments extremely short; nucleus, 200–220 long. 49. *microglochin* A. Br.

§ § Sporophydia aggregated.

1) Length of nuclei, 180. 50. **microcarpa** A. Br.

2) Length of nuclei, 240–280. 51. (sub-sp. or var.) **Glaziovii** Zell.

3) Length of nuclei, 370–450. 52. (sub-sp. or var.) **megacarpa** Allen.

× × Coronula of sporophydia elongated (N. polyglochin, broadly).

§ Sporophydia aggregated (leaves commonly thrice divided). 53. *polyglochin* A. Br.

1) Length of nucleus, 300; diam. of stem, about 1000; dimorphous. 53a. *Roxburgii* A. Br.

2) Length of nucleus not known; diam. of stem, 500; homomorphous. 53b. *Zollingeri* A. Br.

3) Length of nucleus, 190–220; diam. of stem, 500; dimorphous. 53c. *nicobarica* A. Br.

§ § Sporophydia solitary; leaves 4-divided.

⊙ Inferior cells of the terminal segments sub-quadratic; coronula unknown. 45. *Mauritiana* A. Br.

⊙⊙ Inferior cells of terminal segments longer than broad; nucleus, 240 long. 55. *guineensis* Kütz; A. Br.

b) Heterophyllæ. Leaves dissimilar.

* Diœcious.

† The small, adventitious leaves fewer (1-20;) larger leaves, 1-3 times divided.

× Smaller leaves, 1-6 (-12); ultimate segments of leaves commonly 3-5. Stem, 250–720 in diam. 56. *conglobota* A. Br.

×× Smaller leaves about 14; ultimate segments of leaves commonly 5-7; stem, about 1000 in diam. (species doubtful). 57. *heterophylla* A. Br.

†† The small, adventitious leaves about 40; most of them 4 times divided. 58. *congesta* A. Br.

** Monœcious. 59. *hyalina* (DC.) Kütz.

C Polyarthrodactylæ. Ultimate segments of the leaves (rarely 2-) 3-6-celled, often not mucroniform.

* Diœcious.

† Sporophydia also aggregated in the base of the verticil. 60. *plumosa* A. Br.

†† Sporophydia not in the fundus of the verticil.

× Fertile verticils not contracted into heads. 61. *diffusa* A. Br.

×× Fertile verticils contracted into heads, more or less dense or interrupted; sterile leaves of lower verticils simple.

⊙ Fertile and sterile leaves 3-4-divided.

☽ Terminal cell of the last segment nearly as thick as the penultimate cell.

\# Ultimate segments 2-4-celled. 62. *myriotricha* A. Br.

\#\# Ultimate segments 2-celled. 63. *dualis* Ndst. (mss.)

☽☽ Terminal cell mucroniform. 64. *huillensis* A. Br.

⊙⊙ Sterile leaves often simple; fertile, 1-2-divided.

1) Nucleus, 300–380 long. 65. *cristata* A. Br.

2) Nucleus, 200–270 long.

\+ Fertile verticils loosely condensed; terminal segments of the leaves acute, gradually attenuate. 66. *tasmanica* (F. Müll.) A. Br.

\+\+ Fertile verticils densely contracted, terminal segments obtuse. 67. *gelatinosa* A. Br.

a) Heads sessile.

§ Proliferous. 67a. *cladostachya* A. Br.

§§ Not proliferous.

♃ Fertile verticils mostly simply divided. 67b.

♃ ♃ Fertile vert. 2-divided.

☽ Heads large. 67c. *cryptostachya* A. Br.

☽☽ Heads small. 67d. *microcephala* A. Br.

b) Heads peduncled. 67e. *podostachya* A. Br.

3) Nucleus, 160–180 long. 68. *polycephala* A. Br.

** Monœcious.

† Fertile verticils not contracted into elongated, gelatinous spikes.

1) Fertile verticils commonly contracted into loose, hairy heads, the two last cells of the leaves commonly forming a two-celled mucro. 69. *Hookeri* A. Br.

1a) Terminal mucro one-celled. 70. **Bonaërensis** (**S**). Spegaz.

2) Fertile verticils in small, sub-sessile heads, long overtopped by the leaves of the sterile verticils. 71. *trichotoma* A. Br.

a) Leaves 2-divided, terminal segments 3-4-celled; Sub-sp. 72. *Zeyheri* A. Br.

b) Fertile leaves more simple, rarely 2-divided, terminal segments 4-5-celled; sub-sp. 73. **Lechleri** A. Br. (**S**).

3) Fertile verticils commonly sub-moniliform, terminal segments of leaves more or less incurved.

⊙ Leaves 2- (1-3-) divided; terminal segments 4- (3-5-) celled. 74. *ornithopoda* A. Br.

⊙⊙ Leaves partly 3- (4-) divided; terminal segments, 3- (4-) celled. 75. *havaiensis* Nordst.

†† Fertile verticils contracted into elongated, gelatinous spikes (interrupted at the base).

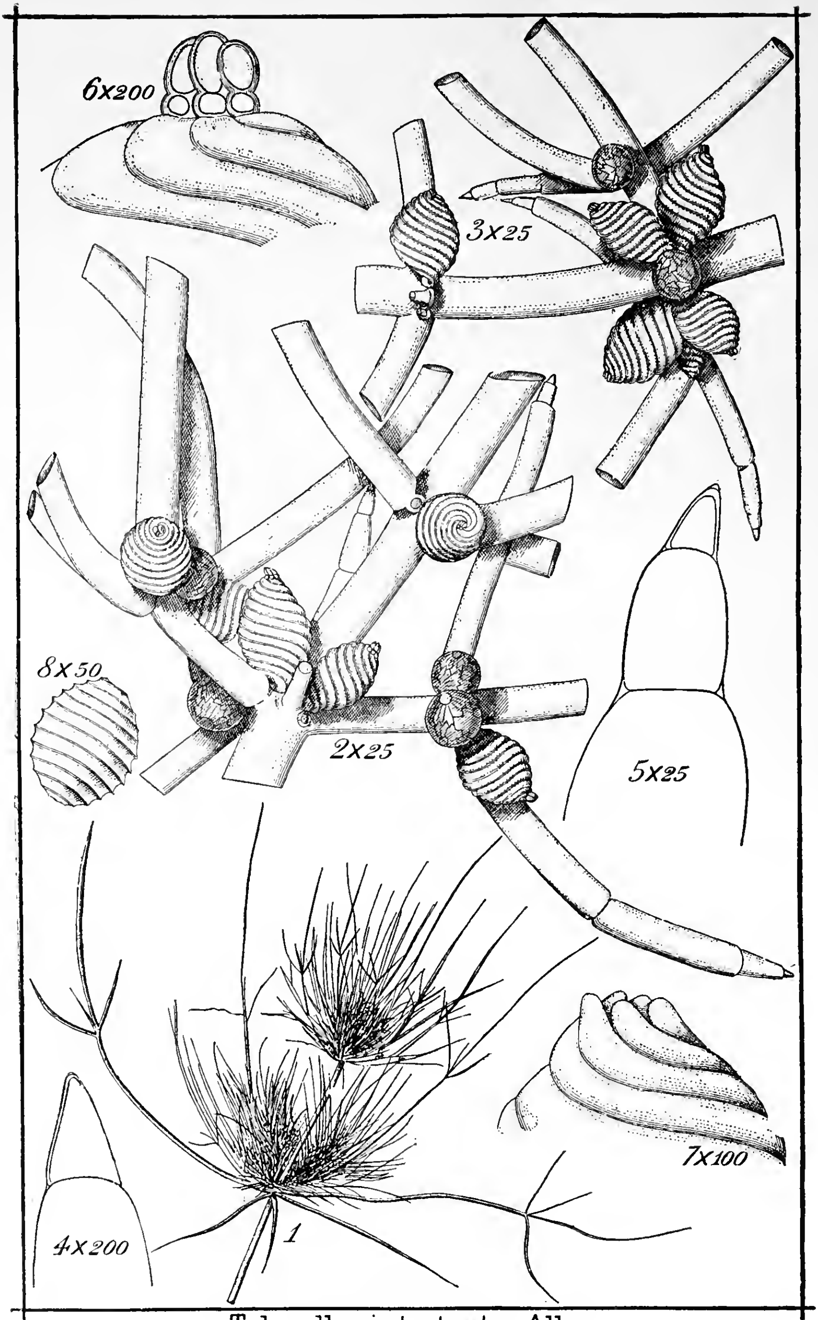
× Leaves, 3-4-divided. 76. **capillata** A. Br.

×× Fertile leaves 2-divided.

☽ Slender, terminal segments of the fertile leaves, 2-3 celled. 77. *leptostachys* A. Br.

☽☽ Stouter; terminal segments of fertile leaves bi-cellular; the colored membrane of the nucleus densely irregularly reticulated. 78. *interrupta* A. Br.

☽☽☽ Ultimate segments of the fertile leaves, 4-celled; nucleus with broad sulci; densely puncto-reticulated; the punctæ arranged in four rows. 79. *Archavaletæ* (**S**) Spegaz.



Tolypella intertexta, Allen

GENUS II.—TOLYPELLA. A. Braun.

Leaves with 1-3 nodes developing leaflets, and, usually, with many-segmented tips above the nodes.

Leaflets not equalling the primary ray in size, many-celled, sometimes also provided with leaf-bearing nodes.

ANTHERIDIA, single or numerous, LATERAL *on the nodes of the leaf and in the base of the verticil,* within the leaves, mostly with elongated stipe. *Sporophydia surrounding the Antheridia* in large numbers, on the nodes of the leaf and in the base of the verticil; also, at times, with elongated stipe. Usually the fruit-bearing leaves are contracted and form densely interwoven *nests.*

* Diœcious.

1. *T. Hispanica* Ndst. ined.

** Monœcious.

I. OBTUSIFOLIA.—*Coronula evanescent. Sterile leaves undivided.*

A. Ultimate cell of the primary ray of the leaf longer than the other cells.

2. *T.* **longicoma** A. Br.

B. Ultimate cell not longer.

† Leaflets attenuate.

3. Marine. Nucleus, 370–500 long. *T. nidifica* Leonh. (Europe).

4. Submarine. Nucleus, 300–340 long. *T. Normaniana* Ndst. (Europe).

†† Leaflets not attenuate.

5. Saline. Nucleus, 300–360 long. *T.* **glomerata** Leonh.

6. Fresh water. Nucleus, 425–475 long, maturing in fall. *T.* **comosa** Allen.

II. ACUTIFOLIA.—*Coronula persistent.* (Sub-persistent in No. 12.)

A. *Indivisa.* Sterile leaves undivided.

7. Nucleus, 350–375 long. Leiopyrena. *T.* **prolifera** Leonh.

8. Nucleus, 425–450 long. Oxygyra. *T.* **fimbriata** Allen.

B. *Divisa.* Sterile leaves divided (usually into four terminal leaflets).

† *Attenuata.* Leaflets attenuate.

§ Secondary ray undivided; sterile.

9. Nucleus, 285–355; rays, 4-7-celled. *T.* **Californica** A. Br.

10. Nucleus, 330–340; rays, 3-4-celled. *T.* **stipitata** Allen.

§ § Secondary rays divided; fertile.

11. Nucleus, 360–425 long. *T. intricata* Leonh.
12. Nucleus, 450–500 long. *T.* **intertexta** Allen.

† † *Non attenuata.*

13. Ultimate cell mucroniform; nucleus, 480–500. *T. apiculata* A. Br. (S. Am.)

FAM. II.—CHARÆ v. Leonhardi.

Stem and leaves naked or corticated. *Verticils* consist of 6-12 leaves, mostly surrounded by a simple or double crown of stipules. *Leaves* many-celled, with several leaflet-bearing nodes (rarely with only one). *Leaflets* (except from the basilar nodes) one-celled, *always much shorter than the primary ray of the leaf. Antheridia always lateral, occupying the place of the leaflets*, on the inner side of the leaf, usually only one on a node. *Sporophydia*, likewise, on inner side of leaf. CORONULA ALWAYS FIVE-CELLED, *containing chlorophyll*, persistent. Capsule of spore often developing a calcareous shell.

GENUS III.—LAMPROTHAMNUS, A. Br.

Sporophydia borne on the *inferior side* of the cell which carries the Antheridium.

European, small, *alopecuroides* A. Br.

Var. a. Pouzolsii A. Br.

Var. b. Wallrothii (Rupr.) A. Br.

Var. c. Montagnei A. Br.

GENUS IV.—LYCHNOTHAMNUS (Rupr.) v. Leonh.

Sporophydia occupying the place of a leaflet on the anterior side of the leaf, situated between Antheridia.

* Diœcious, no stipules. *stelliger* (Bauer), A. Br.

* * Monœcious, long stipules.

1) Sejuncta; sporophydia and Antheridia on different nodes of same plant. *macropogon* A. Br.

2) Conjuncta; sporo. and Anther. on same nodes. *barbatus* (Meyen), Leonh.

GENUS V.—CHARA (VAILL), v. LEONH.

Sporophydia borne on the *upper side* of the cell bearing the antheridium in monœcious species, or of the cell bearing the bract in disjoined (sejunctæ) and diœcious species.

A. HAPLOSTEPHANÆ. Crown of stipules consisting of a simple series of cells.

a. A simple cell at the base of each leaf. (UNISTIPULATÆ).

a) Ecorticatæ; stem and leaves naked.

* Diœcious.

+ Bracts minute or wanting.

⊙ Terminal segment of leaves acute or apiculate (a minute mucro). 1. *australis* A. Br.

⊙⊙ Terminal seg. of leaf short, obtuse. 2. *plebeja* (R. Br.) A. Br.

++ Bracts longer. 3. *Wallichii* A. Br.

** Monœcious.

a Antheridia and sporophydia conjoined.

× Antheridia and sporophydia, also aggregated in the fundus of the verticil. 4. *corallina* Klein.

×× Antheridia et sporophydia not in fundus of verticil.

1. Bracts on all the nodes of the leaf. 5. (Fig. 49.) **Coronata** A. Br.

2. Bracts even at the base of the leaves. 6. *socotrensis* Ndst.

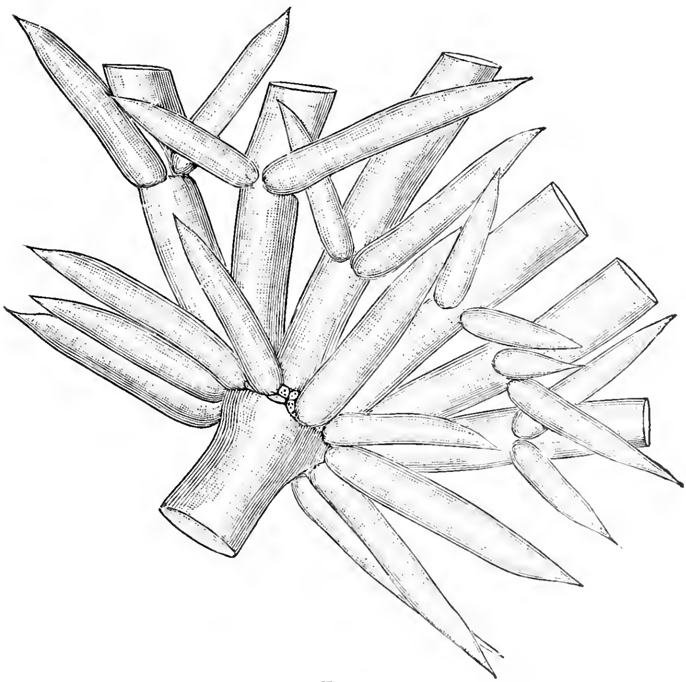


Fig. 49.

b. Antheridia and sporophydia separated; **sporophydia,** but not antheridia, in the fundus of the verticil. 7. *succincta* A. Br.

b. Corticata; stem variously corticated.

♃ Haplostichæ; series of cortex cells equal to the number of leaves.

* Diœcious. 8. *sub-mollusca* Ndst. ined.

** Monœcious. 9. *myriophylla* F. Müll.; A. Br.

♃ ♃ Diplostichæ; series of cortex cells double the number of leaves.

* Diœcious.

† Both Antheridia and sporophydia in the fundus of the verticil. 10. *leptopitys* A. Br.

† † Neither Antheridia nor sporophydia in the fundus of the verticil.

× Small, slender, stipules pressed against the verticil.

⊙ Unistipulata, stem with small papillæ. 11. *mollusca* A. Br.

⊙ ⊙ Bistipulata, stem spinescent.

+ Nucleus, 420–480. 12. *dichopitys* A. Br.

+ + Nucleus, 630. 13. subsp. *Ecklonii* A. Br.

× × Larger, stipules spreading; nucleus, 800. 14. **Hornemanni** Wallm.

** Monœcious.

† Gymnophyllæ (leaves usually naked).

× Stipules large.

+ Fruit conjoined, both sorts on one node.

⊙ Nucleus black.

Unistipulata. 15. *Benthami* A. Br. (subsp. or var. of gymnopitys).

Bistipulata (commonly.) 16. **gymnopitys** A. Br.

1) Nucleus 440–550 (330–380) long, stem equally striated. 16a. ———.

2) Nucleus 440–470, primary cortex cells more prominent; large. 16b. *duriuscula* A. Br.

3) Nucleus 700–720. 16c. *acanthopitys* A. Br.

4) Nucleus 680–700; leaves of verticil, 14-15; nodes, 4-6. 16d. *trachypitys* A. Br.

⊙⊙ Nucleus, yellowish-red. 17. (Fig. 50) **flaccida** A. Br.

++ Fruit separated (antheridia and sporophydia on different nodes of same leaf); verticil with 14-16 leaves, leaves with 6-8 nodes. 18. *Griffithii* A. Br.

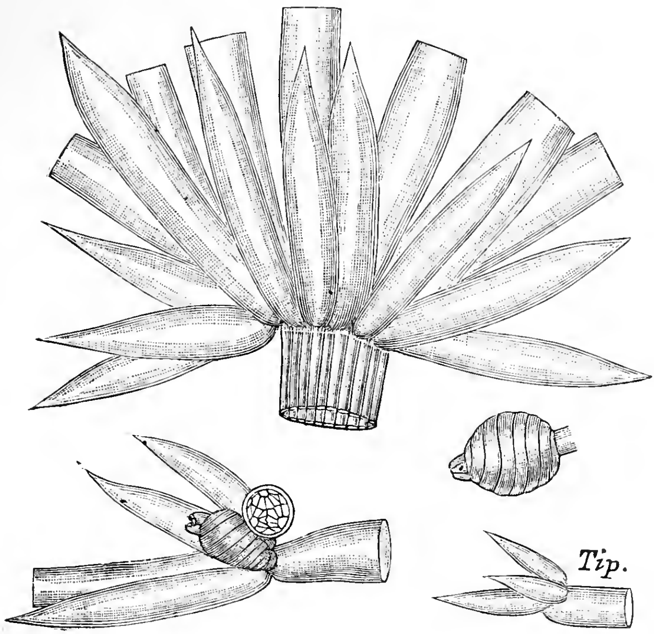


Fig. 50.

×× Stipules small.

\+ Fruit conjoined.

⊙ Nucleus yellowish-red (compare No. 17); *flaccida f. brevibracteata* A. Br.

⊙⊙ Nucleus black. 19. *psilopitys* A. Br.

1) Bracts 1½-3 times the length of the sporophydia. 19a. *Drummondii* A. Br.

2) Bracts 3-4 times as long as the sporophydia. 19b. **Weddellii** A. Br. (S.)

++ Fruit disjoined, nucleus black. 20. *Thwaitesii* A. Br.

†† Gymnopodes, usually (i. e., leaves corticated, *except the first, lowest, node*). See p. 25. (Fig. 51.) 21. **hydropitys** Reich.

+ Leaves in a verticil 9-12.

1) Nuclei 280–350 long. 21a. *Indica* A. Br.

2) Nuclei 360–400 long.

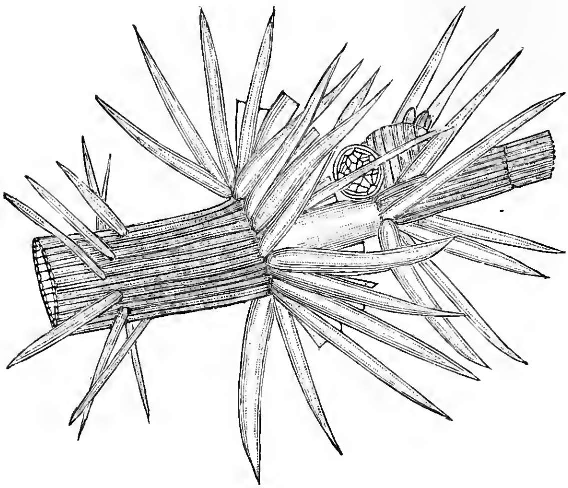


Fig. 51.

⊙ Corticated segments of leaf, 4. 21b. **perfecta** A. Br.

⊙⊙ Corticated segments 1-3. 21c. **genuina** A. Br.

3) Nuclei 450–480 long (Fig. 51). 21d. **septentrionalis** Nordst.

++ Leaves in verticil 8-9.

1) Nucleus 330–380 long. 21e. *Africana* A. Br.

2) Nucleus 580–620 long (subsp.) 21f. **brachypitys** A. Br. (S.)

♃♃♃ Triplostichæ ; series of cortex cells triple the number of leaves.

× Spinescent, posterior bracts developed. 22. *scoparia* Bauer.

×× Smooth, posterior bracts wanting. 22a. *Muelleri* A. Br.

B. Diplostephanæ; circle of stipules consisting of a double (rarely triple) series of cells (see Fig. 52.)

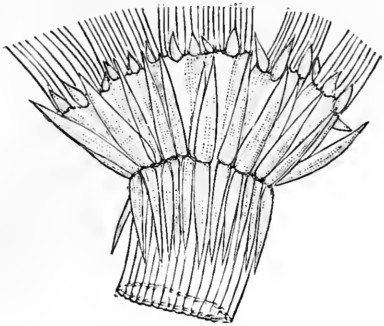


Fig. 52.

a Not corticated*.

---

* Under this section belongs a remarkable form collected by N. L. Britton, Ph. D., in New Jersey. It may be described as a *Ch. sejuncta, condensata, ecorticata, nudifolia*. It is entirely without cortex on either stem or leaf. It differs from Ch.

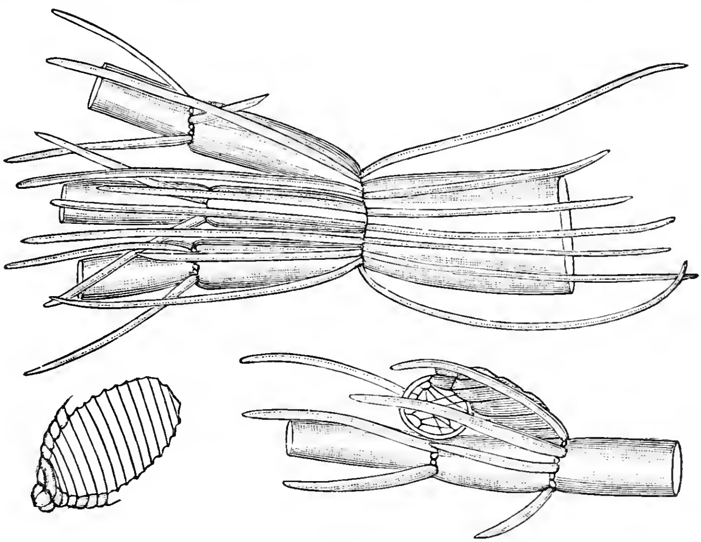


Fig. 53.

sejuncta in the stipules which are usually very long and slender, in the bracts which are much longer than the fruit and verticellate, and in the coronula of the sporophydium which is broad and low, 186 by 80 high, cells closely connivent. Nucleus 600 long, 405 broad, black, with fourteen sharp angles. Antheridium, 265 in diam., usually separate from the sporophydium on the same leaf or in different verticils. For the present, until the species can be studied in its fresh state and variations noted (all specimens of the present gathering present uniform characters), this must be known as *Britton's Chara* (Fig. 53).

b Corticated.

× Cortex of the stem consists of a series of homogeneous cells, equal in number to the leaves, **but in disunited series.** Leaves also singly corticated in disjoined series.

Diœcious. 23. **imperfecta** A. Br.

Monœcious. 24. **inconnexa** Allen.

×× Stem perfectly corticated by cells of different sorts.

§ Haplostichæ. Series of cortex cells equal in number to the leaves.

+ True haplostichæ.

⊙ Diœcious. 25. **crinita** Wallr.

⊙⊙ Monœcious. ———

++ Falsely haplostichous (a secondary series of cells more or less intermixed).

⊙ Dissolutæ; the secondary series of cortex cells distant or undeveloped; leaves naked or corticated like the stem.

Nucleus 780 long. 26. *dissoluta* A. Br.

⊙⊙ Contiguæ.

1) Leaves singly corticated.

a Nuclei smaller. 27. *altaica* A. Br.

b Nuclei larger (subsp.) 28. **evoluta** Allen

2) Leaves naked (sub-species of contraria.) 29. *nudifolia* A. Br.

§ § Diplostichæ.

* Primary cells of the cortex prominent; Tylacanthæ; see p. 21.

× Diœcious.

⊙ Large, stem with spines; corticated segments of the leaves commonly 3. 30. *ceratophylla* Wallr.

⊙⊙ Slender, stem with papillæ, all segments of the leaves naked or one corticated. 31. *Kirghisorum*, Lessing.

×× Monœcious.

☽ Sporophydia smaller.

♃ Cells of the cortex few, spines few, often scarcely developed.

a) Leaves doubly corticated.

⊙ Verticils not extremely short. 32. **contraria** A. Br.

1) Stem not equally striate. Typical form and sub-species (compare above under § + + (haplostichæ contiguæ.) 26. *dissoluta* A. Br. and 29. *nudifolia*.)

2) Stem almost equally striate. 33. **Shaffneri** A. Br.

⊙⊙ Very long; leaves very short, with few nodes. 34. subsp. *jabata* A. Br.

b) Leaves singly corticated; compare. 27. *altaica* A. Br.

♃♃ Cells of the cortex short and numerous, spines well developed. 35. *strigosa* A. Br.

☽☽ Sporophydia larger.

⊙ Cells of cortex and spines quite numerous.

1) Fascicled. 36. *polyacantha* A. Br.

2) Spines single, not fascicled. 37. **excelsa** Allen.

⊙⊙ Cells of cortex and spines fewer.

1) Incrustata. 38. **intermedia** A. Br.

2) Clean, marine, spores larger. 39. subsp. **baltica** (Hartm.) Fries.

** Secondary cells of the cortex prominent. Aulacanthæ.

╳ Sporophydia small, nucleus 460–550 (–700) long. Papillæ and spines on the stem usually few (not fasciculate).

⊙ Nuclei with (10-) 11-14 striæ.

☽ Bracts obtuse, anterior-intermediate mostly shorter than the lateral ones.

1) Bracts commonly unilateral (only on anterior aspect of leaf.) Diam. of antheridium, 360.

a) Papillæ of the stem short, scarcely noticed.

aa. Leaves more or less corticated. 40. **fœtida** A. Br.

Antherida and sporophydia united. 40. a ———

Antheridia and sporophydia often separated, sub-sp. 40. *Rabenhorstii* A. Br.

bb. Leaves naked, subsp. 40. *gymnophylla* A. Br.

Antheridia and sporophydia united. 40. a ———

Antheridia and sporophydia often separated, subsp. 40. *sub-segregata* Ndst. mss.

b) Papillæ aculeate, longer; secondary series of cortex cells extremely prominent. 40. *var. sub-hispida* A. Br.

2) Posterior bracts large, well developed; plant stouter, nucleus 520–620 long. Diam. of antherid. 420–480. 40. subsp. *crassicaulis* A. Br.

☽☽ Bracts acuminate, verticillate, the intermediate, of the four long anterior ones, longer than the lateral. 41. *Boveana* A. Br.

⊙⊙ Striæ on nuclei 9-10 (stem smooth, here and there sub-triple-corticated; habit of Ch. fragilis). 42. *capensis* A. Br.

×× Sporophydia larger, nucleus (600–) 850–950 long. Spines mostly fasciculated, acute.

1) Secondary cells of the cortex not very prominent.

⊙ Cortex cells few. 43. *hispida Lin. exp. Wallr.*

⊙⊙ Cortex cells numerous. 44. (subsp.) *horrida* Wahlst.

2) Secondary cortex cells very prominent. 45. *rudis* A. Br.

§ § § *Triplostichæ;* stem triply corticated (consult also § §).

† *Phlæopodes;* basal segment of the leaves corticated; doubly (in the last species triply).

* Diœcious.

§ Provided with radical, unicellular, globose bulblets; bracts verticellate, the anterior longer, more or less exceeding the length of the sporophydium, whose bracts are scarcely shorter, sometimes longer, than the bracteoles. Diameter of the antheridium, 500–700.

⊙ Leaves not very short. 46. **aspera** (Dethard.) Willd.

⊙⊙ Leaves very short, 2-3 mm. long. 47. (subsp. or var.) *curta* A. Br.

§ § No radical unicellular bulblets known.

× Stipules long, papillæ of the stem minute. Bracteoles long. 48. (species, doubtful) *infima.*

×× Stipules and spines mostly of equal length.

☽ No multicellular subterranean bulblets.

⊙ Leaflets verticellate (posterior, sometimes depauperate).

a) Cortex of the sporophydium transparent green.

aa) Diam. of antheridium, 800–1000.

1) Stem more or less spiny; bracts (median) and bracteoles (lateral) of the sporophydia small, shorter by almost half than the proximate lateral leaflets; bracts shorter than the bracteoles. 49. *galioides* D. C.

2) Papillæ of the stem minute. Posterior leaflets much shorter than the anterior, the lateral a little longer than the sporophydia; bracteoles shorter by almost half than the sporophydia; bracts extremely short. Fertile nodes usually two, in the female plant extremely short, longer in the male plant. 50. *Duriæi* A. Br.

bb) Diam. of antheridium, 480–700; stem smooth or the papillæ minute; posterior leaflets short or depauperate, the lateral (1-2 on either side) exceeding the antheridium, and also the sporophydium; the bracts and bracteoles much shorter than the sporophydium. 51. *Krausii* A. Br.

51a. Stem triply corticated, var. *genuina*.

51b. Stem *doubly* corticated, var. *stachyomorpha* A. Br.

b) Cortex of the sporophydium fragile, hard, dark brown; circle of stipules a swollen ring on which are papules scarcely prominent, irregularly two-ranked. Lateral leaflets as long as or a little longer than the sporophydium. *Stem diplostiche corticated.* 52. *phæochiton* A. Br.

⊙⊙ Posterior leaflets wanting, anterior very minute, much shorter than the sporophydium; bracts as long as or a little shorter than the lateral leaflets; stem smooth. 53. *connivens* Salzm., A. Br.

☽☽ Subterranean bulblets multicellular. Stem smooth. Posterior leaflets papillate or obsolete, the anterior 3-5 much shorter than the sporophydium, and the lateral mostly shorter than the bracts. Diam. antherid., 720–800. 54. *fragifera* Dur.

** Monœcious.

§ Leaves double corticated.

⊙ Spines of stem largely developed; posterior leaflets developed. Nucleus brown, 440–480. 55. *tenuispina* A. Br.

⊙⊙ Stem smooth, papillæ none or little developed.

☽ Nucleus black, 550–770 long.

1) Stem equally striate. 56. **fragilis** Desv.

2) Stem with the secondary cortex series somewhat prominent; papillæ well developed, sometimes aculei-form. 57. (subsp.) **delicatula** (Ag.) A. Br.

☽☽ Nucleus yellowish. 58. *leptosperma* A. Br.

§ § Leaves triple corticated. 59. *brachypus* A. Br.

†† *Gymnopodes;* the first segment of the leaves naked, the following triple corticated, **rarely all naked.** (Fig. 54.)

* Diœcious. 60. **Martiana** A. Br. **(S.)**

** Monœcious.

⊙ Fruit disjoined (Fig. 54.) 61. (Martiana subsp.?) **sejuncta** A. Br.

⊙⊙ Fruit conjoined. 62. **gymnopus** A. Br.

a) The lower node of the leaf usually fertile (*Podophoræ*).

aa) Leaflets equal, or the posterior at length, a little shorter. 62a. **elegans** A. Br.

bb) Posterior leaflets shorter than the others.

1) Posterior leaflets of the lowest node of the leaves ventricose, spreading or retracted like hooks, stem and leaves slender; nodes of the leaf 13-15. 62b. **trichacantha** A. Br.

2) Post. leaflets of lowest node not ventricose; nodes of the leaf 6-8; 8-10 (-12.)

§ Leaf nodes 8-10.

× Lowest segment of the leaf 2-5 times longer than its diameter.

+ Stem armed with elongated acuminate spines.

♃ Sporophydia 720–900 long. 62c. *Delilei* A. Br.

♃ ♃ Sporophydia 980–1000. 62d. *armata* A. Br.

++ Papillæ of stem very minute, abruptly conical. 62e. *angolensis* A. Br.

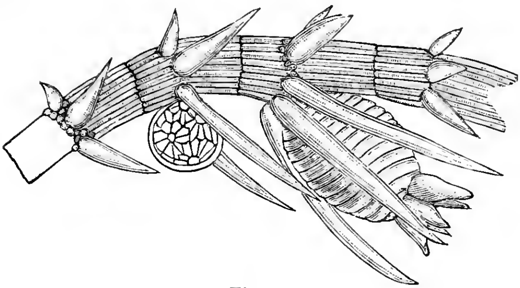


Fig. 54.

×× Lowest segment 1-3 times longer than its diameter.

+ Sporophyd. small, 520–600 (–800.) 62f. *macilenta* A. B.

++ Sporophyd. larger, 870–1200.

I. Flexible, sub-diaphnous, sub-brevi-bracteata, long naked tip of leaves. 62g. *commersonii.* A. Br.

II. More rigid and shining, sub-longi-bracteata.

x Nucleus 14 striate; posterior leaflets shorter or very short. 62h. **fertilissima (S.)** (Klein) A. Br.

x x Nucleus 11-12-striate; posterior leaflets not much shorter. 62i. *Ceylonica* A. Br.

§ § Leaf nodes 6-7 (-8.)

Gymnopodes; lowest segment only of leaf naked. 62j. *inconstans* A. Br.

A. Br. Form *Oerstediana* with short spines, small nuclei and short coronula of the sporophyd. Form *Cruegeriana* with longer spines, larger nuclei and longer coronula.

Gymnophylla; whole leaf naked! 62k. *guatemalensis* Ndst. ined.

b) Lowest node of the leaf usually sterile. *Podosteiræ.*

× Lowest corticated segment not much longer than the others.

§ Leaflets of the lowest, sterile, node of different shape, sub-ventricose.

1) Sporophydia, ovate, 1100–1240 long; anterior leaflets equal the sporophydia. 62l. **conjungens** A. Br.

2) Sporophyd. oblong 850–1050 long; leaflets shorter than sporophyd. 62m. **Berteroi** A. Br.

§ § Leaflets of the lowest, sterile, node about similar to the others.

⊙ Large, leaflets very minute. 62n. **Michauxii** A. Br.

⊙⊙ Leaflets longer.

aa) Nucleus 700–850 long.

1) Sub-longibracteata; lowest segment of the leaf twice as long as the diameter of the leaf. 62 o. *Hildebrandtiana* A. Br.

2) Longi-bracteata, the lowest segment of leaf a little longer than its diam. (sometimes the lowest node fertile.) 62p. **Humboldtii** A. Br.

bb) Nucleus 550–600 long.

1) Rigid, shining. 62q. *Ceylonica* Klein, A. Br.

2) Grayish. 62r. *curassavica* A. Br.

×× Lowest corticated segment much longer than the others. 62s. *Viellardi* A. Br.