THE

RAY SOCIETY

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LONDON

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PLATE I.

NITELLA MUCRONATA VAR. GRACILLIMA.

(*much enlarged*)

Charles Whittingham & Griggs, Ltd. Lith.

THE

BRITISH CHAROPHYTA

BY

JAMES GROVES, F.L.S.

AND

GEORGE RUSSELL BULLOCK-WEBSTER

M.A., F.L.S.

RECTOR OF ST. MICHAEL ROYAL, LONDON, AND HON. CANON
OF ELY CATHEDRAL

VOLUME I

NITELLEÆ

WITH INTRODUCTION, PLATES AND TEXT-FIGURES

LONDON

PRINTED FOR THE RAY SOCIETY

1920

PRINTED BY
ADLARD AND SON AND WEST NEWMAN, LTD.
LONDON AND DORKING

TO THE MEMORY OF

HENRY GROVES

(1855-1912),

A TRUE NATURALIST,

WHO DID MUCH TO ADVANCE THE STUDY OF THE BRITISH CHAROPHYTA, AND UPON WHOSE WORK MUCH OF THE SYSTEMATIC PORTION OF THE FOLLOWING PAGES IS BASED,

THIS WORK IS DEDICATED

BY HIS BROTHER AND HIS FRIEND.

PREFACE.

THIS account of the British Charophyta will be completed in two volumes. The present volume embraces the *NITELLEÆ* (*Nitella* and *Tolypella*), the second will include the *CHAREÆ* (*Nitellopsis*, *Lamprothamnium* and *Chara*).

The systematic portion is preceded by an introductory chapter dealing with the growth and structure of the Charophyta generally, their distribution, affinities, etc. For the facts concerning their cytology and minute histology we have had to depend largely on the writings of others, having ourselves had little opportunity for such studies. Many separate papers have been published on these branches of the subject, especially by Continental botanists, and students wishing for further information thereon will find full references to such papers in the bibliography to be included in the second volume.

The plates illustrating the species included in this volume are almost all from the pencil of Miss Mary Groves, to whom we are much indebted for this important contribution to the work; twelve are now published for the first time; four have already appeared in the 'Journal of Botany'; among the latter is the beautiful illustration of *Nitella hyalina*, the work of the late Henry Groves; the two plates relating to structure, taken respectively from the works of De Bary and Pringsheim, and the text-figures, which have been gleaned from various sources, have been kindly copied for us by Miss G. M. Towsey. For permission to reproduce Strasburger's figure on page 45 we have to thank Messrs. Macmillan, and for the like courtesy in the case of the figures on page 35 we are indebted to the author, Mr. A. W. Hill, and to the proprietor of the 'New Phytologist.'

Our best thanks are due to the many friends and correspondents who have, in various ways, assisted us with the work; to Professor Otto Nordstedt, the greatest living authority on the group, and to Mr. James Britten, Dr. Daydon Jackson, Mr. Robert Paulson, and Dr. A. B. Rendle, for much valuable advice; to the other botanists too numerous to specify individually (among whom however may be mentioned Messrs. Arthur Bennett, G. C. Druce, E. S. Marshall, R. Lloyd Praeger and C. E. Salmon), for the specimens which they have communicated to us during many years, and which in particular made it possible to estimate the variation and to arrive at the distribution of the several species; to Mr. W. H. Pearsall for ecological information, and to Mr. Cecil V. B. Marquand for cytological notes; to the officers of the Department of Botany of the British Museum and of the Royal Herbarium at Kew for their extremely courteous help in consulting books and specimens.

The writers hope that the issue of these volumes may result in a larger number of British botanists being attracted to the study of this remarkable group of Cryptogams, so problematical in regard to its origin and affinities.

In the second volume it is proposed to include some account of the fossil remains of Charophyta which have been found in this country.

JAMES GROVES.

G. R. BULLOCK-WEBSTER.

February, 1920.

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BRITISH CHAROPHYTA.

INTRODUCTION.

The Charophyta are a small group of Cryptogams, and occupy a peculiarly isolated position, having no clear affinity with any other plants. The species all the world over probably do not number much more than two hundred. They are exclusively aquatic in habit, living in normal conditions entirely under water, and from this fact, added to their fragile and perishable character and their apparent lack of economic value, they have attracted little attention from any but botanists, indeed it may be safely conjectured that the majority of generally well-informed people are not even aware of their existence.

To the botanist, on the other hand, their curious and unique structure, and the uncertainty as to their position in the Vegetable Kingdom, have invested them with a peculiar interest, and as a consequence they have given rise to an extensive literature, quite out of proportion to their apparent importance. For a while teaching botanists were wont to select some species of Charophyte as one of their plant-types. The simplicity of the vegetative parts, the exceptionally large size of their cells, owing to which structure and development could be easily seen, added to the facility by which, for the same reason, the process of cyclosis could be observed, combined to render them attractive both to teacher and student. Latterly however it has been realised that so peculiar and isolated a group, without known genealogy or relationship, does not afford a fitting introduction to the study of plant-life in general.

It was in a Charophyte that cyclosis, that is the rotation of the cell-contents within the cell, was first discovered, and the ease with which this wonderful phenomenon can be watched, even under a low-power objective, in the larger cells of any of these plants, added to their great beauty, has made them favourites with the microscopist.

Rank and position of group.

The rank which should be accorded to the Charophyta, and the relative position in which the group should be placed, have always been debatable, and even at the present time much difference of opinion exists among systematists upon these points.

The early botanists, relying for the classification of plants upon a superficial resemblance in their vegetative parts, placed the few Charophytes known to them under *Equisetum* or *Hippuris*, doubtless on account of their lateral members being produced in whorls. Sébastien Vaillant was the first to separate them as a group, when in 1719 he constituted for them a new "genre" *Chara*. Linnæus, both in his natural and artificial systems, treated them as a genus of Algæ, but in Reichard's posthumous Edition VII of the 'Genera Plantarum' (1778) they were transferred to a place among the Flowering Plants, in Class *Monœcia*, sect. *Monandria*, in which position we also find them in Withering's 'Botanical Arrangement' (1776), and in the second edition of Hudson's 'Flora Anglica' (1778)

In Smith's 'Flora Britannica' (1800) they were removed to Class I, *Monandria*, sect. *Monogynia*.

Louis Richard, in Bonpland, Humboldt and Kunth's 'Nova genera et species plantarum' (1815), raised the group from generic to ordinal rank, constituting for it the order *Characeæ*.

Adanson, in 'Famille des Plantes,' II (1763), had placed the genus *Chara* in his Fam. LVI *Ara*, between *Ceratophyllon* and *Fluvialis* (*Naias*), and several other authors associated them with *Naiades*. They were placed by Lindley and others among the Bryophytes, and by a few authors among the Vascular Cryptogams, but up to recent times the greater number of systematists have regarded them as a group of Algæ.

Strasburger has recently placed them in a separate class of the Thallophyta, with the following remarks:—"The Characeæ or Charophyta form a group of highly organized green Thallophytes sharply isolated from both simpler and higher forms. Their origin must be looked for in the Chlorophyceæ, but the complicated structure of their sexual organs does not allow of any immediate connection with the oogamous Green Algæ. On the other hand in some characters they show some approach to the Brown Algæ, from which they differ in the pure green colour of the chromatophores. They cannot be regarded as leading towards the Bryophyta although their karyokinetic nuclear division exhibits a great agreement with that of the Archegoniatæ." (Fourth English ed. of 'Text-book,' 1912.)

Sachs considered them distinct from the Thallophytes, elevating the group to a position co-ordinate with his four other great divisions, Thallophyta, Muscineæ, Vascular Cryptogams, and Phanerogams, and observing: "they are so different from all other classes of plants that they must be erected into a special group by the side of the Thallophytes and Muscineæ. Among the Thallophytes they would approach most nearly to certain groups of Algæ, but differ from all the members of that group in the form of their antherozoids; and in this respect resemble the Muscineæ from which again they differ entirely in the structure of the antheridia and of the female organs of reproduction, as well as in that of their organs of vegetation." (First Engl. ed. of 'Text-book,' 1875, p. 278.)

In addition to the very distinctive character of both antheridia and oogonia, and the absence of any clear indication of affinity with other existing groups of plants, there is the fact that the form of the oogonium, which is unlike the 'fruit' of any other plant, has persisted unaltered from certainly as far back as Oolitic times. Their comparatively simple vegetative system is probably due to the fact that they grow completely submerged in still or evenly-running water, so that they are exposed to little strain, or variation in external conditions, and we do not think this should be regarded as evidence of a low rank in the scale, in view of the remarkably complicated structure of the reproductive organs, especially the antheridium. We follow Sachs in regarding the Charophyta as a separate division.

Antiquity. That the Charophytes represent a very ancient type of vegetation is demonstrated by the existence of fossil remains which undoubtedly belong to the group in the Lower Oolite, while organisms thought by some palæontologists to belong to ancestral forms, have been obtained from the

Devonian and Silurian systems. Throughout the Tertiary, and in some of the Secondary series, remains of Charophytes abound in the freshwater and estuarial deposits. In the second volume we hope to give some account of these. For the present it will suffice to say that the fossil remains of these plants which have so far been discovered do not throw any light on the relationship of the group to any of the other divisions of Cryptogams.

Geographical distribution.

The Charophyta are distributed almost throughout the world, representatives of the group having been found from 69° north in Northern Norway to about 49° south in Kerguelen Island. The Warm Temperate Zone is the most prolific as regards number of species, but they are also very numerous in the Cool Temperate Zone. In the Tropics they are less numerous and within the Arctic Circle there are very few. The Charophyte-flora of many parts of the world has been so imperfectly investigated that it is hardly safe to venture on any generalisations as to the details of distribution. Braun and Nordstedt's invaluable 'Fragmente einer Monographie der Characeen' furnishes complete information as to the known distribution of the various species up to the time of its publication in 1882. Since that date some additional localities representing important extensions of distribution have been put on record, and a large number of new species have been described, but the latter clearly represent very unequal values, and while some are evidently remarkably distinct, only a small portion can perhaps at present safely be ranked with the species in the 'Fragmente,' the claims of which to be regarded as distinct have been passed by the two greatest authorities on the group. Though many species have a wide-spread distribution only five have apparently up to the present been found in all of the six continental areas. Of these areas probably Australasia possesses by far the largest number of endemic species.

Conditions of growth.

As already stated, the Charophyta are normally entirely submerged water-plants. Very occasionally subterrestrial states of a few species are to be found growing in bog-heads and in the nearly dried-up beds of small streams. They occur almost exclusively in still or evenly-running water, being most frequently found in ponds, gravel, clay, and peat pits, and ditches, but also occurring in larger pieces of water, and occasionally in streams and rivers. Water which is liable to much disturbance, such as streams in mountainous country, or which is subject to great changes of level, is unfavourable to their growth. They are rarely present in canals or watercourses where there is continuous boat-traffic. They will flourish only in clean water, not liable to become turbid from the influx of mud, or to be contaminated by sewage or refuse from mills or factories. Many species appear to flourish most in water charged with a considerable quantity of lime, which they take up readily in the form of incrustation, not only on the exterior but beneath the cortex of the stem and branchlets. This calcareous incrustation adds greatly to the rigidity of their structure. Some species occur in brackish water, and a few actually in the Baltic Sea, but that sea is particularly low in point of salinity, being stated by A. F. W. Schimper to contain less than one per cent. of salts. Certain species are found only in water containing some marine salts, and saltmarsh ditches, lagoons, and pieces of water only separated from the sea by sand-bars, are usually good hunting-grounds. Some species are capable of existing in water at widely different degrees of temperature. Of *C. fragilis*, which is the most hardy and ubiquitous of them all, Dr. T. F. Allen remarks that it is "found in every country and clime, in ice water at the north and in the hot springs of the Yellowstone." It is also recorded from hot springs in Iceland, in water the temperature of which was such as to boil an egg in four minutes!

Though for the most part plants of the lowlands, some species occur in mountain-lakes and a few have been found at great elevations. Braun and Nordstedt record *Chara vulgaris* from 7,000 feet on the Swiss Alps, and the same species from 9,000 and 10,000 feet in Chile, and, as well as *Nitella clavata*, from 14,000 feet on the Cordilleras of Peru, *C. baltica* at about 12,800 feet in Bolivia, and *C. delicatula* on the Sierra Nevada in California at 10,000 feet.

Charophytes usually grow in rather shallow water, ranging from a few inches to a few feet deep, but sometimes, especially in the clear water of lakes, are found at much greater depths, the factor of light being a most important one. We are indebted to Messrs. W. H. & W. Harold Pearsall, M.Sc., for the following very interesting contribution to the ecology of *Nitella opaca*.

"The results appended have been confirmed by many thousands of soundings extending over the past seven years. Esthwaite Water alone, the smallest lake included, occupied four weeks' continuous work in 1914 and two in 1915.

"*Nitella opaca* occurs in mixed communities at many depths. As a *pure* community it is characteristic in Derwent Water from 13 to 20 ft. In less dense communities it occurs to depths of 24 ft. (Windermere figures are slightly less than these.) Very occasionally it includes *Potamogeton pusillus* (rare) and *P. prælongus* (in small local patches) in depths over 20 ft., but from 13–17 ft. often ousting the *Nitella*.

"In our experience *Nitella* does not fruit in these deeper communities but does so freely in more shallow water. This is probably due to the fact that the light conditions are unfavourable—the light-intensity being only ·035 to ·025 of full daylight. The temperature and CO_2 content are also known to be low at these depths.

"It should be noted that it is not the depth alone which adversely affects these plants but the *light-intensity*—ascertained by us as the result of actual experiments in these waters. The following figures show that in our English Lakes the light-intensity is *constant* at those depths where *Nitella* is dominant and in dense masses. The *waters*, of course, are very different; the bottom of Windermere is easily visible at 20 ft., but that of Esthwaite invisible at 8 ft. from the surface.

Lake.	Species.	Depth.	Light-intensity.
Esthwaite	*N. flexilis*	9′–12′	·033–·025
Derwent Water . . .	*N. opaca*	13′–20′	·035–·025
Windermere . . .	" "	12′–18′	·034–·024
Dumfries—Lotus Loch .	" "	12′–18′	·036–·025

"We are of opinion that the dominant factors which determine the position of the communities are the *character of the inorganic silt* and *the rate of sedimentation* in the lake,—not, as it is usually assumed, primarily the mineral content of the water."

Mr. George West in 'A Comparative Study of the Dominant Phanerogamic and Higher Cryptogamic Flora of Aquatic Habit in Three Lake Areas of Scotland' (1905) records the occurrence in Loch Uanagan, of *C. fragilis* or *C. delicatula* in 6 to 20 feet of water and *N. opaca* in 10 to 30 feet, while, carpeting lakes at Lismore, he found *C. desmacantha* from 2 to 20 feet, *C. delicatula* from 10 to 20 feet, and *C. rudis* from 25 to 35 feet. In the Swiss lakes Charophytes have been found at much greater depths.

The Charophytes are essentially gregarious in character, commonly occurring in dense masses with little or no intermixture of other plants. Often on the shallow margins of ponds and lakes small isolated tufts are to be found, but these are almost always merely outliers of larger colonies.

Though often growing in water with a sandy or peaty bottom, it is on thick soft mud that Charophytes perhaps flourish most freely, and, for this reason, the ditches of our Eastern Fen Country, and the Norfolk Broads, are particularly prolific in these plants. In Hickling Broad alone no less than twelve species have been found, while from the Lac de Grand-Lieu, a large piece of water in Dept. Loire Inférieure, near Nantes, Monsieur Gadeceau records the astonishing number of seventeen. Newly-made pits, such as those excavated for gravel and clay, are, at an early stage of their existence, also very favourable habitats, being often carpeted with one or other of the common species, to the exclusion of any other plants. In such situations however, after a few seasons, the Charophyte gives place to, or is ousted by, other vegetation, and by the time the large coriaceous floating-leaved plants, such as *Potamogeton natans* and the water-lilies, have obtained a hold and darkened the water, it has often entirely disappeared. Some species are curiously intermittent in their occurrence, disappearing in a locality altogether, and reappearing after some years, the oospores evidently retaining their vitality for a long period.

It is difficult to account for the introduction of these plants to newly-made pieces of water by any other explanation than that the oospores, or portions of old stems, are carried in mud on the feet of birds, although this method of seed-dispersal has been discredited by some authors.

The principal enemies of the Charophytes belong to the vegetable kingdom. Apart from their competitors for space and light among the higher water-plants, already alluded to, they are peculiarly liable to be strangled or stifled by filamentous and encrusting Algæ, which are frequently found growing among and upon them. Dr. Giesenhagen states that he has found instances of the root-bulbils of *Chara aspera* being attacked by a species of fungus, the interior of the globular cell being filled by mycelial threads. In one bulbil he detected animal organisms which he describes as "anguillula-like." Dr. Allen found that the bulbils of this species were eaten by ducks. The plants are often infested with Infusoria. We have seen one caddis-case built-up entirely of the ripe oospores of a *Chara*, and stems and branchlets are sometimes used for that purpose. It has been stated that Charophytes are eaten by molluscs, but we have met with no indication of this, though the plants are freely used by them as a medium of travel.

Many *Charas* have an extremely unpleasant smell, said to be that of sulphuretted hydrogen, and Dr.

Allen suggests that this may be protective in character, deterring animals from feeding on them.

Economic uses.

The Charophyta have been turned to comparatively little use in the economic world. Le Maout and Decaisne remark: "This family is really useless to man," but they add: "some species of *Chara* are covered with calcareous salts, and are used for polishing plate, whence their common names of 'Herbe à écurer' and 'Lustre d'eau.'" *

Large banks, formed of the remains of the decayed plants, are frequently to be found in waters where they grow freely, and deposits of so-called "Chara-marl" occur in abundance in the alluvial formations of the East Anglian and Irish fenlands, varying from a few inches to three feet or more in thickness. These deposits are often termed "shell-marl," but this name is misleading, since by far the greater part of their substance is composed of Chara-débris. Neither these deposits of the past, nor the decayed growth now accumulating, have been utilized to any considerable extent. Skertchley, in the 'Geological Survey Memoir of parts of Cambridgeshire and Suffolk,' p. 198 (1891), states that in the fens between Burwell and Lakenheath "the shell-marl is dug for manure and known as chalk-marl."

Messrs. Kennard and Woodward quote Wesenburg-Lund ('Medd. Dansk. Geol. Foren.,' No. 7, 1901), as stating that at Hingesö in Jutland the Chara-marl "is dug out of the lake by machinery and made use of for agricultural purposes." †

* 'Descriptive and Analytical Botany' (Translation), p. 921.

† "The Post-Pliocene Non-Marine Mollusca of Ireland," by A. S. Kennard and B. B. Woodward, in 'Proc. Geol. Assoc.,' xxviii, p. 155.

Professor Prósper, in 'Las Carofitas de España,' devotes an interesting chapter (pp. 197–202) to the present and potential uses of Charophyte vegetation. He begins by referring to certain parts of Switzerland, where the Charophytic deposits are collected from pools and lakes, left to dry in heaps, and then spread upon the land as manure, and he advances the opinion that the offensive odour emitted by these plants serves to some extent to free the soil from insects and rodents. He tells us that in order to study for himself the importance of the Charophytes as manure, he requested Professor Don Ramiro Suárez to make a chemical analysis of samples of *Chara hispida* from the Lake of the Isles (Daimiel) with the following results:—

Centesimal composition of the plant dried in "air."

Water	5·25
Pure ashes and silica . . .	47·00
Crude fat	1·80
Crude protein	4·37
Crude cellulose	7·64
Other carbonic hydrates . . .	33·94

In the ashes for every 1,000 parts 161 are lime and 1·57 phosphoric anhydride. He adds: "This analysis will suffice to demonstrate the importance of the Charophytes for manure and their potent calcareous incrustation, but, in order further to convince myself, I have compared the cultures of various grasses and papilionaceous plants manured with the said dried Charas, and others grown without any such manure, and have convinced myself of the enormous efficacy of the Charophytes." Dr. Prósper gives photographic illustrations of the growth of two pots of barley, the one manured with Chara-débris showing a higher and stouter growth than the other not so manured. He expresses himself as convinced that many barren areas in Spain might be rendered fertile by utilising the large accumulation of decayed Chara-débris at present allowed to go to waste. Referring to other purposes served by these plants, he says: "Another interesting use of the Charophytes not mentioned by any author is that seen at Daimiel, where in a pool of salt water for many years people have bathed, attributing the cure of their maladies to the action of the deposit of saltpetre on the banks, the 'saltpetre' being the white masses of dry Chara which surround the pool." He is, moreover, of opinion that the Charophytes are of great importance in fish-culture, having observed in a number of lakes that tench and other fish make curious nests among the Charophytes, in which they find abundant food, there being "a whole world of aquatic insects and crustaceans," and that they prefer them to other water-plants.

When all has been said, however, it would appear that the profitable uses to which Charophytes can be turned are, at the best, few or restricted.

Origin of name. Popular names.

The first mention of the name "Chara" appears, so far as we can ascertain, in Cæsar's 'De Bello Civili' III, 48, 1–2 (c. 60 B.C.), where it is applied to a plant, the identity of which is uncertain. That it was nothing like the plant to which we now apply the name, is evident from the statement that it was made with the addition of milk into a kind of bread! Pliny, 'Nat. Hist.' XIX. 41 (c. A.D. 77), in discoursing on cabbages, apparently refers Cæsar's plant to *Lapsana*, a name applied by the earlier botanists to several kinds of *Cruciferæ*, as well as to the plant now bearing the name. By others it has been variously referred to

Pastinaca sativa, *Crambe tatarica*, and one or other species of *Brassica*.

The first publication of the name "Chara" in its present sense, appears to be that in Dalechamps' magnificent folio, 'Historia Generalis Plantarum,' I, p. 1070 (1587), where, curiously enough, it is quoted as a popular name applied by the inhabitants of Lyons to a species of which they made use to scour plates and other domestic utensils.* This is apparently also the earliest reference of any kind to a member of the group. Vaillant was the first to make use of the name in a botanical sense, when in 1719 he established the genus.

The evidence of the existence of a local popular name for one of these obscure and inconspicuous plants is of great interest. Probably, with this exception, there has been no genuine common name for these plants, though in several countries pseudo-popular names have been bestowed upon them by botanists. The later eighteenth century English botanists styled them "Stoneworts," and we find them sometimes called "Water-Horsetails" and "Brittle-worts." In France, according to Adanson, 'Famille des Plantes,' II, p. 537 (1763) they were called "Girandole d'eau" and "Lustre d'eau," = water chandelier, an ingenious and apt idea, translated into German as "Armleuchter-Gewächse." In the modern French floras they are styled "Charagnes." In Pursh's 'Flora of North America' the curious name "Featherbeds" is cited for them.

* "Est et quintum genus (sc Equiseti), minimum, aquis coenosis innatans, vel sub iis occultum semper, brevissimis et asperis foliis, ac caulibus, lutosum virus olentibus. Lugdunenses vocant *chara* quasi Cheredranon, quo nomine Equisetum vocari in supposititiis nomenclaturis Dioscoridis legimus, ea quae lances escarias, et reliquam eiusmodi supellectilem abstergunt, ut et primo genere, quod vocant *Prelle,* quasi φαίδραν. Nam et sic appelari loco proximo citato traditur."

Monsieur Gadeceau tells us, in his admirable monograph 'Le Lac de Grand-Lieu' (Nantes, 1909), that the fishermen frequenting that lake know all kinds of *Characeæ* by the name of "Sart," but, unless they are very unusually observant sportsmen, it is probable that they include, under this epithet, at any rate some other kinds of water-weed.

First British record.

The following reference to two kinds of "Horse-taile" in Johnson's edition of Gerard's 'Herball,' p. 1115 (1633), represents apparently the first record of the occurrence of Charophytes in this country:

"7. In some boggie places of this kingdome is found a rare and pretty *Hippuris* or Horsetaile, which grows up with many little branches, some two or three inches high, putting forth at each joynt many little leaves, clustering close about the stalke, and set after the manner of other Horse-tailes: towards the top of the branches the joynts are very thicke; the colour of the whole plant is gray, a little inclining to green, very brittle, and as it were stony or gravelly like Coralline, and will crash under your feet, as if it were frozen: and if you chew it, you shall find it all stonie or gravelly. My friend, Mr. *Leonard Buckner*, was the first that found this plant, and brought it to me; he had it three miles beyond Oxford, a little on this side Evansham-ferry, in a bog upon a common by the Beacon hill neere Cumner-wood, in the end of August, 1632. Mr. Bowles hath since found it growing upon a bog not far from Chisselhurst in Kent. I question whether this bee not the *Hippuris lacustris quædam foliis mansu arenosis* of *Gesner*: but if *Gesners* be that which *Bauhine* in his *Prodromus*, pag. 24, sets forth by the name of *Equisetum nudum minus variegatum*, then I judge it not to be this of my description: for Bauhines differs from this in that it is without leaves, and ofttimes bigger: the stalks of his are hollow, these not so: this may be called *Hippuris Coralloides*, Horse-taile Coralline.

"8. Towards the later end of the yeare, in divers ditches, as in St. James his parke, in the ditches on the backe of Southwarke towards St. George's fields, etc., you may find covered over with water a kinde of stinking Horse-taile: it growes sometimes a yard long, with many joints and branches, and each joint set with leaves, as in the other Horse-tailes, but they are somewhat jagged or divided towards the tops. I take this to be the *Equisetum foetidum sub aqua repens*, described in the first place of *Bauhinus* his *Prodromus*: we may call it in English, stinking water Horse-taile."

STRUCTURE AND DEVELOPMENT.

The Charophyta are small to medium-sized plants, normal individuals ranging from about 10 to 60 cm. in height. When not incrusted, they are green in colour and usually flexible. The stems are slender and somewhat branched. The most prominent characteristic of the group is the whorled growth of the lateral members, styled branchlets, which with few exceptions are uniform in size and character, and upon which the organs of reproduction are borne. The male and female organs, styled respectively antheridia and oogonia, are, as already stated, unlike those of any other plants. The distinctive characteristics can be readily seen with the naked eye, or by the aid of a pocket lens, so that there need never be the slightest doubt, when even the smallest scrap of one of these plants is found, as to its belonging to the group, the variation in form being between comparatively narrow limits.

Germination.

In describing the structure and development of a Charophyte, it is convenient to start with the ripe oospore which has become detached from the plant and has buried itself in the mud preparatory to germination. The process of germination has been well described by de Bary, from whose work* the following particulars are mainly drawn, as well as the figures on

* "Zur Keimungsgeschichte der Charen," in 'Bot. Zeitung,' pp. 2–26, tt. 5, 6 (1875). Translated by Hemsley in 'Journ. Bot.' xiii, pp. 298–313, tt. 167, 168 (1875).

Plate II. The first change which takes place after fertilization is that the coarse starch-granules and oil-drops, with which the oospore is filled, begin to recede from the apical region, the part vacated becoming occupied by light-coloured fine-grained protoplasm. A transverse septum is then formed, separating the oospore into two very unequal portions (Pl. II, f. 1). The upper portion containing the protoplasm forms a small plano-convex lens-shaped cell, the so-called nodal cell (*a*) from which the young plant originates, while the larger, lower portion (*b*) remains as a store-place of reserve nutritive material. The nodal cell soon swells and protrudes, the apex of the oospore-shell splitting into five teeth to allow of this expansion (Pl. II, f. 2); the protoplasm in the cell separates into two portions, this separation being followed by the growth of a second vertical septum, cutting the nodal cell into two cells (Pl. II, f. 3). One of these cells goes to form the pro-embryo, to be described later, the other to form the primary root, using the term root in its broad sense. Although it fulfils the functions of a root in drawing food from, and anchoring the plant to, the soil, the rooting system of a Charophyte has no analogy in structure with that of a Flowering Plant, consisting as it does merely of branching processes formed of slender colourless thin-walled unicellular filaments, similar to the rhizoids met with in the Bryophytes, with more or less thickened nodes. The term "rhizoids" is used in referring specifically to these filamentous structures.

Root-system. One of the two cells into which the nodal-cell of the germinating oospore has become divided, and which has been referred to as giving rise to the primary root, usually becomes subdivided, longitudinally in relation to the axis of the oospore, into three cells, the centre cell of which grows out as the primary root, while the two lateral cells form accessory roots. Further division takes place in the three cells, numerous accessory rhizoids and sometimes accessory pro-embryos (Pl. II, f. 8 P′) being produced. The primary root elongates considerably and forms nodes (Pl. II, f. 8 *rn.*) at which rhizoids are produced. Rhizoids also originate at the first and sometimes at the second node of the pro-

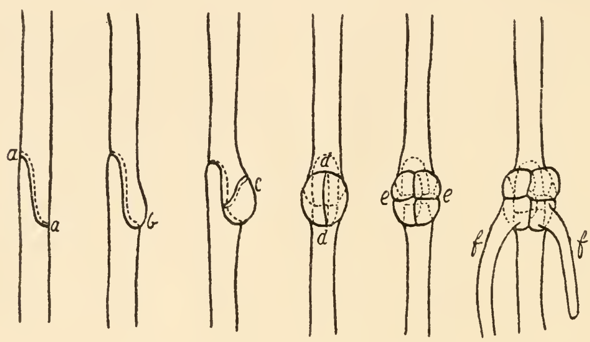


FIG. 1.—Successive development of root-node of *Chara aspera* (after Giesenhagen) (× c. 35). i. Root-filament with curved septum *a* forming "double-foot" joint. ii. Dilation of "toe" of upper "foot" *b*. iii. Toe-portion cut off by oblique septum forming separate cell *c*. iv. Subdivision of cell *c* into two cells by vertical septum *d*. v. Further subdivision into four cells by transverse septum *e*. vi. Two lower cells growing out into rhizoids *f f*.

embryo, and at the lower nodes of the sexual plant. The nodes of the rooting system differ from those of the stem-system (which will be described later) in being much simpler in construction and being primarily formed of the swollen ends of the long cylindrical cells of which the root-system consists.

The early stages in the formation of a root-node are shown in Fig. 1 above. In the first place a curved diagonal septum (*a*) is formed, giving the ends of each of the two cells a characteristic shape, which has been likened to that of the human foot, the two "feet" pointing in opposite directions and the surfaces representing their "soles" being in contact. The "toe"-end of one of the feet swells (*b*), further septa (*c*, *d*, *e*) are successively formed, and the separate cells grow out into rhizoids (*f*).

The root-nodes often become much thickened by the production of a great number of cells containing reserves of starch. These will be referred to later under the head of bulbils. The rooting system, being devoid of chlorophyll, is colourless.

Pro-embryo. The other portion of the nodal-cell of the oospore, which goes to form the pro-embryo, grows outwards as a cylindrical process, soon taking an upward direction (Pl. II, figs. 4, 5, 6, 7 P), and, in contrast to the rooting system, becomes green, chlorophyll being present at an early stage. Horizontal septa soon arise cutting off portions from below the growing point, the order in which division takes place being shown in Pl. III, figs. 7–9. The cylinder then presents a longitudinal row of cells. If we examine these cells in order we shall find that the lowest is elongated and undergoes no division. The second is very short and lenticular, and forms the pro-embryonic root-node (Pl. III, figs. 1, 2, 3, 9–12 *rn.*), vertical division taking place as shown in Fig. 2 (p. 20). From this node a number of rhizoids are produced, and sometimes one or more accessory pro-embryos. An elongated undivided internodal cell (Pl. III, figs. 1–4, 9–12 *i.*) succeeds the root-node, then a second node (*wn.*) from which the pro-embryonic whorl is produced. This is surmounted by a cylindrical process (*tp.*) of limited growth, consisting of a variable number, usually about four, of more or less elongated cells, arranged longitudinally. The pro-embryonic whorl consists of several cylindrical incurved processes of varied length but of limited growth, growing outward and upward, each process composed of a single row of a few cells. The earlier stages in the development of the pro-embryonic whorl will be seen in Pl. III, figs. 10–12.

It is as a lateral bud in the axil of this whorl that

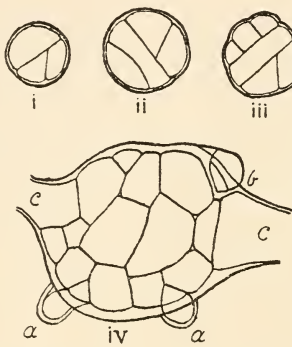


FIG. 2.—Transverse sections of root-node of pro-embryo of *Chara canescens,* showing successive stages of division (after De Bary and Kamienski) (× c. 100). i, ii, iii. Early stages. iv. Advanced stage showing outgrowths (*a b c*) of rhizoids. This section is somewhat oblique, *a a* arising below and *b* above the section plane; *c c* are older rhizoids.

the complete (sexual) chara-plant originates (Pl. III, f. 6 SP). This course of development can hardly be regarded as representing an alternation of generations. Vines refers to it as "heteroblastic, an embryonic form intervening between the oospore and the adult," and regards the pro-embryo as analogous to the protonema of a moss.

The successive divisions of the pro-embryonic whorl-node and the origin of the sexual plant are shown in

Pl. II, figs. 9–16. The discoid nodal-cell is first divided into two nearly equal portions (Pl. II, f. 9) by a vertical wall called the halving-wall (*h*). The two cells so formed undergo further division by the growth of successive walls as shown in Pl. II, figs. 10–13, the first cell being cut off on one side of the halving-wall, the second on the other, and so on, alternatively; and therefore when numbered according to their order of origin the odd numbers are on one side, the even on the other. The first two cells are from the beginning larger than the others, the succeeding ones are smaller in proportion to their higher numbers, this relation becoming more apparent as growth proceeds, and the first cell, styled by De Bary the initial cell, more especially maintaining its advance of the others. It is from the initial cell that the sexual plant arises, the other cells of the periphery developing as the rudimentary branchlets forming the pro-embryonic whorl and decreasing in size as they recede from the anterior side. The first division of the initial cell which takes place is by "an inclined tangential wall dividing it into two cells, an inner one entirely within the node, and an outer one, almost the whole of which projects beyond the node and has an arched crown. The outer one then begins to grow and form segments after the manner of the apical cell of the stem" (Pl. II, figs. 15, 16). The lowest segment is divided by a vertical radial wall into two parts which grow out into two small processes compared by De Bary to the stipulodes at the base of the whorls of branchlets of the sexual plant (Pl. II, figs. 11, 12).

Though the pro-embryo was figured by several earlier authors, its nature was not understood until Pringsheim in 1862 elucidated its structure in his admirable memoir "Ueber die Vorkeime und die nackefüssigen Zweige der Charen" in 'Jahrb. wissens. Bot.' iii, with its large series of beautiful illustrations, a few of which are reproduced on Plate III. The subject has been further investigated by the eminent Swedish botanists Nordstedt and Wahlstedt, to whose writings,* as well as to Pringsheim's and De Bary's memoirs, those wishing to pursue the matter are referred.

Pro-embryonic growths similar to those proceeding from the oospore are also frequently produced at the thickened lower stem-nodes of the sexual plants often in considerable numbers. In *Lamprothamnium papulosum* (*Lamprothamnus alopecuroides* Braun) a second rhizoid-producing node, but similar in structure to the double foot-like node of the root, is sometimes produced between the oospore and the pro-embryonic root-node, as noticed by Wahlstedt and described and figured by Miss M. McNicol, in 'Annals of Botany,' xxi, p. 66, t. 8 (1907).

Sexual Plant. An early stage in the development of the young shoot is shown in Pl. III, f. 5. The apical-cell (*a*) which is approximately hemispherical in form represents the growing point, and it is by a succession of transverse divisions and the subdivision of the parts cut off, that the whole of the plant is built up. This process is shown in Fig. 3 (p. 23). In i. the apical cell (*a*) is undivided; in ii. by the growth of a transverse septum it is divided into two cells (*a* and *b*), the former remaining at the growing point, the latter becoming again divided by a second transverse septum, as shown in iii. the upper portion (*c*) forming a

* L. J. Wahlstedt, 'Om Characeernas knoppar och öfvervintring.' (Lund 1864). C. F. O. Nordstedt, "Några iakttagelser öfver Characeernas groning," in Lund's 'Univ. Årrskrift,' ii (1865–6). Nordstedt and Wahlstedt, "Ueber die Keimung der Characeen," in 'Flora,' lviii, pp. 94–5 (1875).

stem-node, remaining quite short and undergoing division by means of longitudinal septa in the direction of the axis, the lower (*d*) forming an internode, remaining undivided but lengthening considerably. In this way the stem of a Charophyte presents a

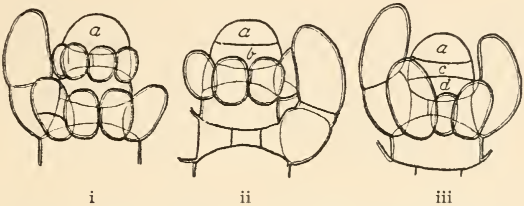


FIG. 3.—Young shoot of *Nitella* in successive stages (after Giesenhagen) (× c. 150). In i the apical cell *a* is undivided; in ii a portion *b* has been cut off from its base by a transverse section; in iii the lower cell *b* has been subdivided into a stem-node *c* and an internode *d*. The young branchlets are shown in each figure growing out from the lower nodes.

particularly well-marked series of nodes and internodes. The internodes consist each of a single elongated cylindrical cell never becoming divided but attaining in some species to the extraordinary length of 20 cm. Torsion is to a greater or less extent

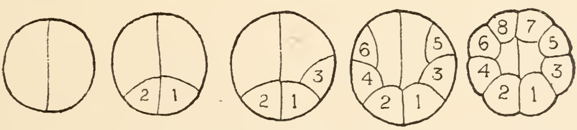


FIG. 4.—Transverse sections of young stem-node of *Chara delicatula*, showing successive division (after Kuczewski) (× c. 190). The figures denote the order in which the several cells originate.

always present, the spiral being invariably dextral and therefore in the opposite direction to that of the enveloping cells of the oogonium. The cortex, with which the internodes of many species are entirely covered, will be described when dealing with the outgrowths from the nodes, to which it properly belongs.

The stem-node consists in the first place of a single disc-shaped or biconcave cell, which is capable of division to an indefinite extent. The peripheral cells resulting from the division give rise to certain lateral outgrowths which will be dealt with in turn. The

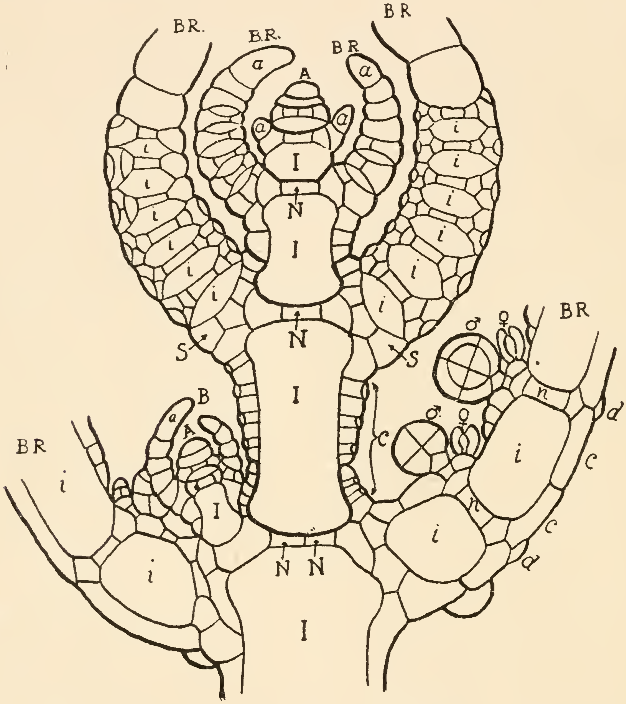


FIG. 5.—Axial section of shoot of *Chara* (after Sachs). A. Apical cell of main axis. N. Central cells of stem-node. I. Internodal cells of main axis. S. Stipulodes. C. Cortex of stem. BR. Branchlets: *a*, apical cell; *n*, central cells of node; *i*, internodal cells; *c*, cortical cells; *d*, bract-cells. ♀. Oogonia. ♂. Antheridia. B. Young branch; the parts of this are similar to those of the main axis.

earlier stages of division, which are longitudinal in the direction of the axis of the stem, are shown in Fig. 4 (p. 23), the order in which the several cells originate being very similar to that of the pro-embryonic whorl-node already referred to.

As in the case of the root-nodes the lower stem-nodes in many species become thickened, owing to the production of a very large number of small cells containing reserves of starch. These also will be referred to under the head of bulbils.

The outgrowths from the normal stem-nodes consist of (1) Branches; (2) Branchlets; (3) Stipulodes; (4) Cortex.

The origin and order of development of these outgrowths will be best understood from Fig. 5 (p. 24), taken from a species of *Chara* in which all are present.

Branches. The normal branches are similar in almost all respects to the main stem, and present a non-limited growth. In the *Chareæ* there is usually one branch produced at a node, in *Nitella* two, and in *Tolypella* several, but these numbers are subject to variation. The normal branches originate in the axils of the whorls, at the base of the oldest branchlet or branchlets, see Fig. 5 B (p. 24).

Branches of a special type are often to be met with originating from the swollen nodes of old stems, (Pl. III, f. 3 EB), and occasionally from the root-nodes of pro-embryos. These are styled by Pringsheim "branches with naked base," and by Vines "embryonic branches." In the corticate *Charæ* they are characterised by the basal segment of the stem and the lowest whorl of branchlets being wholly or partially ecorticate.

Branchlets. These organs have by many authors been styled "leaves," but this would seem to be a misuse of words, since they do not appear to present any analogy to the leaves of other plants, and their special function is to bear the reproductive organs. The branchlets are elongated processes of limited growth, and, with a few unimportant exceptions which will be referred to later, are produced in single regular whorls, those belonging to each whorl being approximately alike in size and structure. In their earlier stages they are incurved, becoming more or less spreading, but usually retaining an upward direction. The number of normal branchlets in each whorl ranges from five to twenty, but in the case of the larger numbers some are evidently accessory. In the *Nitelleæ* and in *Nitellopsis* the number is most commonly six, in the rest of the *Chareæ* seven to ten.

According to Sachs "the successive whorls of a stem alternate, and in such a manner that the oldest branchlets of the whorl, in the axils of which the branches stand, are arranged in a spiral line winding round the stem." Each branchlet originates from a lateral node, formed from one of the peripheral cells of the stem-node, and consists of a well-marked series of nodes and internodes, but is unlike the stem in having the growth limited (Fig. 5 BR., p. 24). As in the case of the stem, the internodes consist of single cells incapable of division, but increasing considerably in length. Torsion is not usual, one side commonly maintaining an inward position in relation to the axis of the stem or branch, with the exception of the ultimate rays in *Nitella*. In all the genera with the exception of *Nitella*, and usually to some extent in this also, the structure of the branchlet is monopodial, that is the axis is continuous in direction, the nodes and internodes being produced in a direct line one above another. There are, however, points of difference in the several groups, which will be best dealt with here.

In *Chara*, *Lamprothamnium*, and *Lychnothamnus*, each normal branchlet has three or more nodes, and is terminated by a more or less conical or acuminate apical cell either immediately above the highest node, or with one or more elongated cells intervening. Each node gives rise to a whorl of small 1-celled lateral members, termed bract-cells arising from the periphery of the node (Fig. 6 *h*), normally elongated, growing outward and taking an upward direction. On the outer side of the branchlet the bract-cells are usually

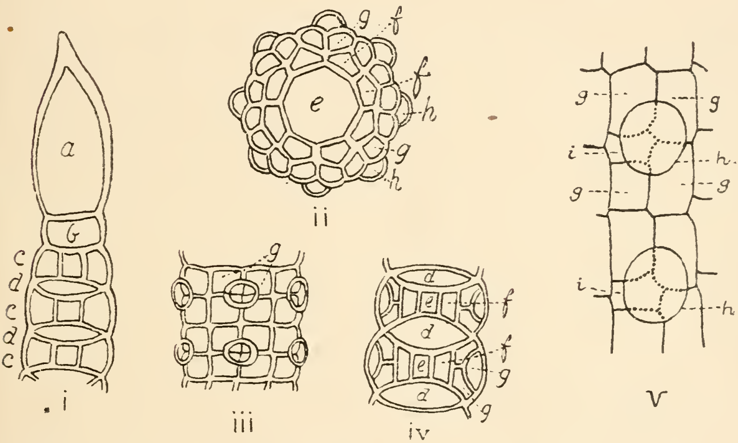


FIG. 6.—Portions of young branchlets. i–iv. *Chara fragilis* (after Sachs and Prósper). v. *Chara delicatula* (after Kuczewski) (× c. 150). i. Axial section of very young branchlet, before peripheral cells of node have become subdivided. ii. Transverse section of node of rather older example. iii and iv. Exterior view and axial section of two nodes of the same. v. Exterior view of two secondary (peripheral) nodes. *a*, terminal cell; *b*, penultimate cell; *c*, nodes, early stage; *d*, internodal cells; *e*, central cell of nodes; *f*, intermediate cell of ditto; *g*, cortical cells; *h*, bract-cells; *i*, rest-cells.

shorter than on the inner, and are often rudimentary. The bract-cells vary considerably in different species in regard to shape, length and thickness. They are usually cylindrical, and more or less acute, but sometimes blunt, at the apex. In a few species they are almost as broad as long and subglobular. In addition to the bract-cells produced direct from the periphery of the branchlet-node, a pair of similar organs spring from the node at the base of the oogonium; these are styled bracteoles. The function of the bract-cells is evidently similar to that of the bracts of flowering plants, *i. e.*, the protection of the young organs of reproduction. The branchlets of many of the *Charæ* are covered with a cortex, which will be described later.

The general construction and development of the branchlets of a corticate *Chara* are shown in Fig. 5 BR., p. 24, and the cell-divisions of one of the nodes in Fig. 6, p. 27. It will be seen that there is no halving-wall in the latter as in the case of the stem-node.

The genus *Nitellopsis* presents some variations from the type of branchlet just described. There is usually only one and never more than two nodes, and instead of a whorl of comparatively small entirely lateral bract-cells as in the genera already referred to, one or two (rarely more) long, but still 1-celled members are produced, at each node, on the inner side of the branchlets. The apical cell, instead of being short and conical, is elongated and cylindrical.

The genus *Tolypella* presents further modifications. In some species the sterile branchlets belong to an extremely simple type, resembling the terminal process of the pro-embryo, and consisting of a row of cylindrical or allantoid cells joined end to end without any intervening nodes, the apical cell in some species differing little in shape or length from those below it, while in others it is short and conical. The fertile branchlets and, in some species, the sterile also, consist of one to two cylindrical or allantoid cells, each succeeded by a node, and surmounted by a terminal member formed of a string of elongated cells, the apical cell being in some species short and conical. At each node of the branchlet several lateral members are produced, differing from the bract-cells of the *Chareæ* in that they consist of a longitudinal series of cells.

The genus *Nitella* presents a different feature. The antheridium is terminal and at each branchlet-node where one is present the axis becomes interrupted and two or more (rarely only one) lateral members arise. The branchlet in the various groups of this genus presents a great range in degree of complexity. The simplest form consists of a long internodal cell, followed by a single node which gives rise to 1–4 lateral 1-celled members, and where no antheridium is present to a 1-celled terminal segment. This terminal segment resembles the lateral members and it is only upon close examination that it is seen that the branchlet is not genuinely forked. In more complex types there are a number of nodes from which secondary axes are produced, which in their turn also give rise to lateral members, so that tertiary and even quaternary axes may occur. The terminal member may consist of a single cell, or of two to six cells. In no British species does the number exceed three. In a very few species in addition to the normal branchlets smaller accessory branchlets are produced at the same stem-nodes, above and below the normal branchlets. The only British species presenting this type is *N. hyalina.*

Stipulodes. At the base of and below the branchlets in the *Chareæ*, with the exception of *Nitellopsis*, there arises a single or double circle of organs called stipulodes, varying considerably in size, always much shorter than the branchlets, usually small, often minute (Fig. 7). They are always one-celled and vary in shape from cylindrical (v) and ellipsoid to subglobose (iii); they are often sharp-

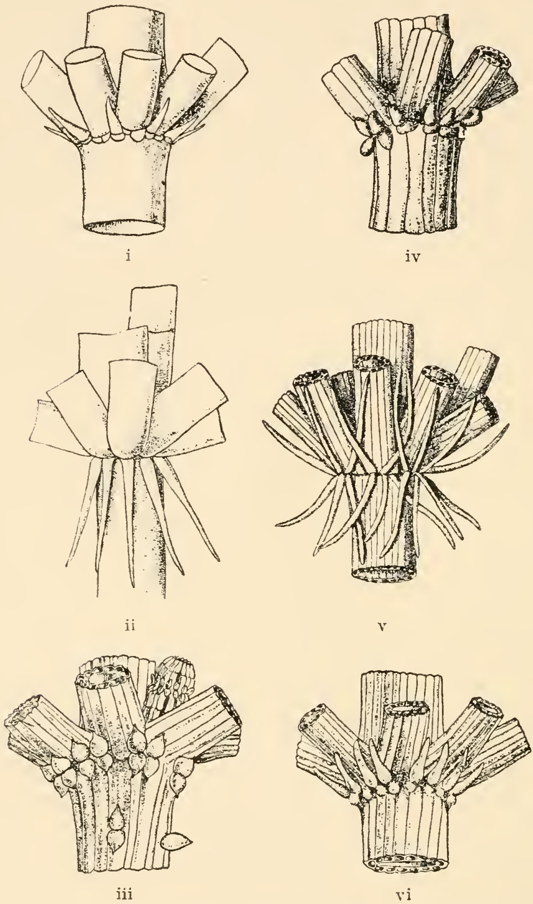


Fig. 7.—Stem-nodes showing various forms of stipulodes (after H. Groves). i, ii. Stipulodes in a single circle (haplostephanous): i, *Chara Braunii*; ii, *Lamprothamnium papulosum*. iii–vi. Stipulodes in a double circle (diplostephanous): iii, *C. tomentosa*; iv, *C. contraria*; v, *C. baltica* v. *affinis*; vi, *C. delicatula*.

pointed. In some species they are rudimentary (vi, lower circle). When a double circle of stipulodes is present (iii–vi), the upper row takes an upward, the lower a downward direction, and the number in each circle is normally double that of the branchlets. When there is only one circle, the stipulodes in some species grow upwards (i), and in others downwards (ii), and the number may be either the same or double that of the branchlets; when the same number, they may alternate with (i), or be opposite to the branchlets (ii). In luxuriant states of species producing two circles, it occasionally happens that a third circle is found growing outwards between the upper and lower circle. In a very few species the development of the stipulodes is irregular, and very rarely a ring of stipulodes is produced above the branchlets. The stipulodes originate from the node at the base of the branchlets (see Fig. 5 s., p. 24).

Stem-cortex.

In most of the *Chareæ*, all but the lowest internodes of the stem are completely covered with a sheath of cells styled the cortex. This sheath consists of a number of longitudinal rows of cells which are in almost all species contiguous. Two rows of these cortical-cells originate from certain cells belonging to the node at the base of each branchlet, one taking an upward the other a downward direction, and adhering respectively to the internodes of the stem above and below the node from which the branchlet proceeds (Fig. 5, p. 24). In this way the cortex of each internode is the joint production of the two adjacent nodes, the ascending rows of cortical cells of the lower node meeting the descending rows of the node above it about the middle of the internode; the apical cells of the two series being tapered at the end slightly overlap laterally.

Where a branch is produced, one ascending row of cortical-cells is wanting, none being developed above the particular branchlet in the axil of which the branch arises. On the basal internode of a branch there is no upward growth of cortex.

The rows of cortical-cells present a well-marked system of alternating nodes and internodes. The internodes, like those of the stem and branchlets, do

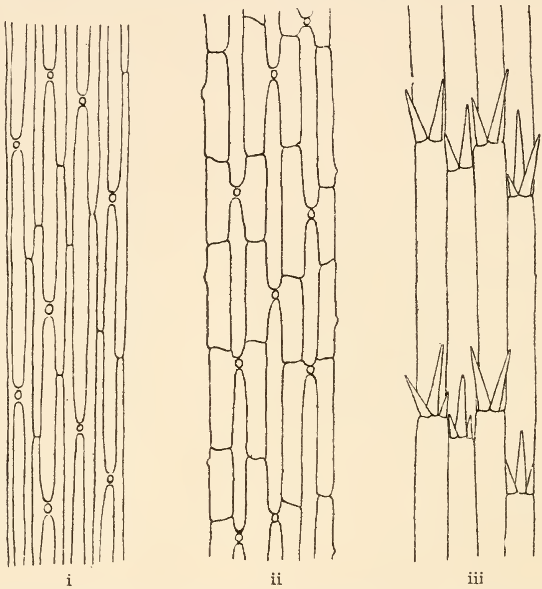


Fig. 8.—Various types of stem-cortex of *Chara*. i. Triplostichous—*C. delicatula*. ii. Diplostichous—*C. vulgaris*. iii. Haplostichous—*C. canescens*. The primary series of cortical cells can be distinguished by the presence of spine-cells. In iii there is no secondary series.

not divide, but increase considerably in length. The node-cells do not increase in length, but are capable of division in two directions, (*a*) laterally, that is, in the direction of the circumference of the stem, and (*b*) externally, that is on the side farthest from the axis of the stem.

On the two sides of each node-cell, portions are usually cut off, and become elongated; these lie alongside the internodes of the primary series and form fresh rows which are known as the secondary cortical series. When these lateral (secondary) cells are about the same length as the internodal cells of the cortex, one being formed on each side of each nodal cell, the result is the production of two complete rows of secondary cells between each pair of primary rows, and the cortex is then styled TRIPLOSTICHOUS, there being three rows of cortical-cells to each branchlet, one primary and two secondary (Figs. 8 i, 9 i, ii). In many species, however, the lateral (secondary) cells are only about one half the length of the internodal cells, and by a process of accommodation, each cell growing upwards or downwards, combine to form a single row of cells between each pair of primary rows. The cortex is then styled DIPLOSTICHOUS, there being two rows of cortical-cells to each branchlet, one primary and one secondary (Figs. 8 ii, 9 iii, iv).

When the secondary cortical-cells are truncate at the ends and therefore do not overlap, the cortex is easily seen to be either triplostichous or diplostichous, but it frequently happens that intermediate states occur, since the ends of the secondary cells often taper and overlap the adjacent cells originating from the adjoining primary row, thus producing a sub-triplostichous condition, and a transverse section of the stem will then disclose sometimes one and sometimes two secondary, between each pair of primary, cells.

In some species the cells of the secondary series are of equal diameter and prominence with the internodal cells of the primary series, so that a transverse section of the stem shows a number of tubes of equal size (Fig. 9 i). In other cases there is a varying disparity, in some species the cells of the primary (Fig. 9 ii, iii) and in others those of the secondary (Fig. 9 iv) being the larger.

In a third type of cortex, found in a very few species, no portions of the cortical node-cell are cut off at the sides, therefore no secondary cortical-cells are present. The cortex is then styled HAPLOSTICHOUS, there being only one row of cortical-cells to each

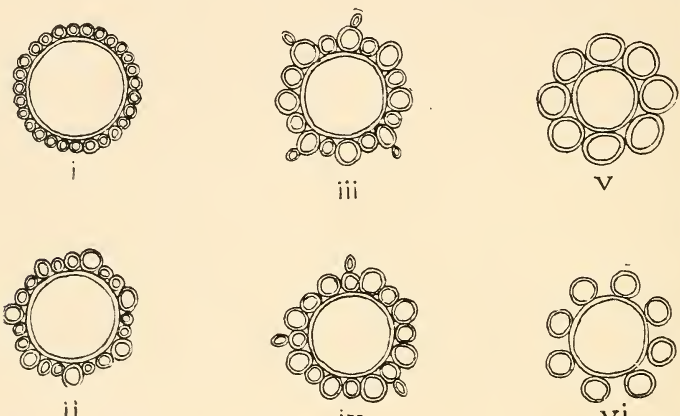


FIG. 9.—Transverse sections of stems showing various types of cortex of *Chara*. Triplostichous: i. Isostichous—*C. fragilis*; ii. Anisostichous—*C. delicatula*. Diplostichous: iii. Tylacanthous—*C. baltica*; iv. Aulacanthous—*C. rudis*. In ii and iii spine-cells are shown to indicate primary cortical rows. Haplostichous: v. Contiguous—*C. canescens*; vi. Non-contiguous—*C. imperfecta*.

branchlet (Figs. 8 iii, 9 v, vi). The cortical-rows may be contiguous (Figs. 8 iii, 9 v) or non-contiguous (Fig. 9 vi).

The second direction in which division takes place in the node-cells of the cortex is by the cutting off of a portion from the outer side of the periphery, that is the side farthest from the axis of the stem. The result of this is the production of outward free-growing cells, styled spine-cells (Fig. 10 *c*). Each node-cell may produce one, two, or a cluster of these. In some species subglobular intermediate cells, which Mr. A. W. Hill has styled head-cells, are produced between the node-cell and the spine-cells (Fig. 10 *d*).

The spine-cells are extremely diverse in size and

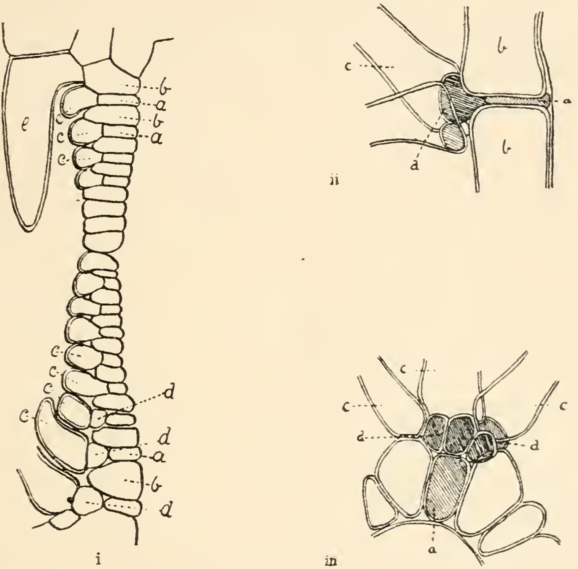


FIG. 10.—Cortex of *Chara aculeolata* (after Hill). i. Longitudinal section of an upper and a lower cortical series at an early stage, showing development of spine-cells. ii. Longitudinal section of mature cortex-node. iii. Transverse section of the same. *a*, nodal-cells; *b*, internodal-cells; *c*, spine-cells; *d*, head-cells; *e*, lower stipulode. The shading in ii and iii indicates the presence of starch.

shape, ranging from minute almost spherical or very shortly-conical processes to thin sharp spines several times as long as the diameter of the stem. They are usually deciduous and therefore absent on the older parts of the stem.

The spine-cells nearer the stem-nodes are often more developed than those towards the middle of the internode (Fig. 10), and those of the ascending row have a tendency to incline upward and those of the descending row downward.

Haberlandt suggests that the formation of the stem-cortex is similar to that of some Algæ and represents a concrescence of closely-appressed lateral branches. The cortical system can be best examined in the younger growths, and the separate development of each row of primary cells, with the lateral cells belonging to it, can frequently be observed very clearly in quite young branches in which they often grow detached from the internodal cell. The cortical rows follow the torsion of the stem, rendering it much more conspicuous than is the case with ecorticate species.

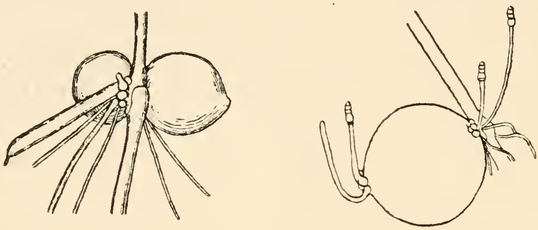
Branchlet cortex.

In most species of *Chara* the branchlets are also corticate, the cortex being somewhat similar to that of the stem, but much simpler in character. At each of the branchlet-nodes (except the highest, where there is only one) two circles of single cortical cells are produced at the base of the bract-cells, one of which grows upwards and the other downwards closely appressed to the internodes, which they completely cover, the cells being contiguous and the ascending circle from the one internode meeting the descending circle of that above it. Sometimes the cells forming the cortex are of equal length, when their points of meeting form an even ring; in other cases they are of more or less unequal length. In one of the British species (*C. canescens*) the number of cells in the ascending and descending circles equals that of the bract-cells, and the cortex is described as haplostichous; in almost all the rest of the corticate *Charæ* there are two ascending and two descending cortical-cells to each bract-cell (styled diplostichous), while in a few extra-European species there are three to each bract-cell (styled triplostichous). In all the European species except *C. tomentosa* the lowest limb of the branchlet is covered entirely by a cortex originating from the lowest free node and therefore growing downwards. In *C. tomentosa* there is an entire or partial circle of cortex-cells growing upwards from the node at the base of the branchlet. In a small number of extra-European species, the sub-section *Gymnopodes* of the *Triplostichæ*, the lowest limb of the branchlet is ecorticate.

The cortical-cells and the bract-cells arise from a series of secondary nodes, developed from the peripheral cells of the branchlet-node, which divide as shown in Fig. 6 v, a small portion of each remaining as a rest-cell, *i*.

There is usually a correspondence in the shape and extent of development of the spine-cells, stipulodes and bract-cells, all these appendages being usually long or short, acute or obtuse, bulbous-based or otherwise, in the same form and often also in the same species. There are, however, exceptions to this, as *e.g. C. vulgaris* var. *longibracteata*, in which the anterior bract-cells are very long, while the stipulodes and spine-cells are but little developed. Not infrequently an abnormal example of each of these appendages occurs in the shape of a two-lobed cell.

Bulbils. As already stated reserves of starch are accumulated in enlargements proceeding from the lower stem-nodes and root-nodes, which are styled bulbils. They are usually produced when the plant is growing in fine slimy mud, are whitish in colour, and form the basis of two forms of vegetative reproduction, embryonic and pro-embryonic branches. When first noticed, before their function was ascertained, they were assumed to be of calcareous substance. The presence of bulbils has been satisfactorily established in the case of comparatively few species, but upon further investigation these processes will probably be found to occur in many others. In collecting Charophytes the rooting portion is often neglected, moreover bulbils are apparently produced only under certain conditions of growth. Those who have the opportunity of following the growth of any



i ii

FIG. 11.—Root-bulbils (spherical type) of *Chara aspera* (after Giesenhagen). i. Root-node showing double-footed joint with three bulbils, two nearly spherical, and one cylindrical; also some rhizoids (× c. 11). ii. Root-node bearing one spherical bulbil, with young plants arising from nodes at basal and distal ends (× c. 13).

Charophyte throughout the year either in its natural condition or in cultivation will do well to examine the roots from time to time to ascertain if bulbils are being produced.

There are three distinct types of bulbil: (1) consisting mainly of a large nearly spherical cell (Fig. 11), (2) more or less amorphous, consisting of an agglomeration of numerous small cells (Figs. 12 and 13), (3) star-shaped, being modified branchlet-whorls (Fig. 15).

The first type of bulbil, those of spherical form, are found among British species, in *Chara aspera*, *C.*

desmacantha and *Lamprothamnium papulosum*. These bulbils are often 1 mm. or more in diameter and are found singly or in clusters of usually 2–4 (sometimes

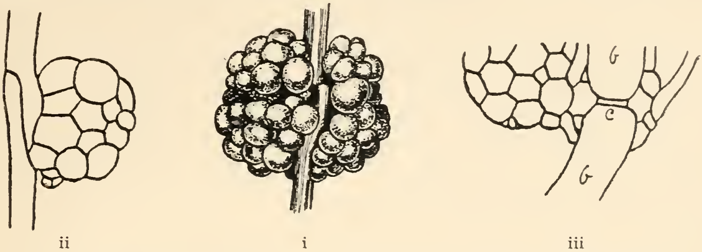


Fig. 12.—Bulbils (type 2) of *Chara fragifera* (after Giesenhagen). i. Exterior view of large root-bulbil (× 15). ii. Longitudinal section of small root-bulbil (× 24). Rhizoids showing "double-foot" node. iii. Longitudinal section of stem-bulbil (× 24): *b*, internodes of stem; *c*, stem-node.

more) proceeding from the root-nodes (Figs. 11 i, ii). Some bulbils of similar nature but fusiform also occur. Dr. Giesenhagen has carefully investigated the struc-

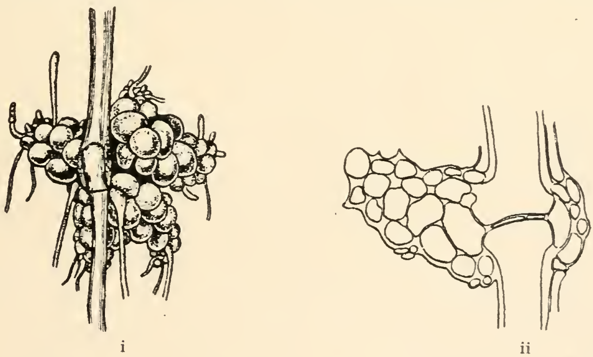


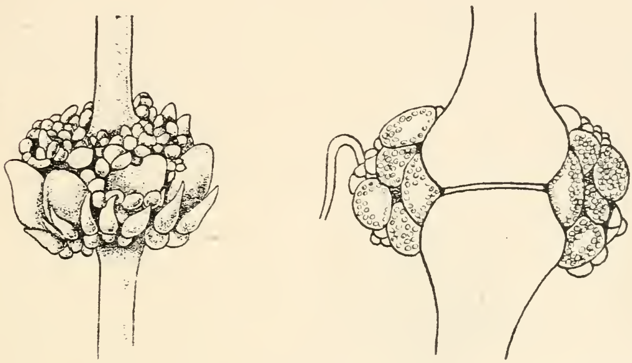
Fig. 13.—Bulbils of *Chara baltica* (after Giesenhagen). i. Multicellular root-bulbil of irregular starlike form (× c. 7). ii. Unilateral stem-bulbil (× c. 15).

ture and development of the bulbils of *C. aspera*, and gives a full account of the results with a number of excellent figures, in his valuable 'Untersuchungen über die Characeen,' pt. 1 (1902). He finds that this form of bulbil represents the internode of an outgrowth from a root-node, there being one node at the base of the bulbil consisting of a few small cells and another at the distal end, the cells of the latter being half-buried in the thick cell-wall of the bulbil, which consists of a number of layers. Either or both of these nodes may produce young plants (see Fig. 11 ii). Dr. Giesenhagen describes the starch-grains contained in the bulbils as roundish-discoid, displaying a distinct series of layers and, in the largest examples, attaining a length of ·15 mm. When the starch becomes absorbed by the growth of the young plant the bulbils lose their opacity. Miss M. McNicol in her investigation of the bulbils of *Lamprothamnus alopecuroides*, = *Lamprothamnium papulosum* ('Annals of Bot.' xxi, p. 61, 1907) found in that species that secondary bulbils were developed from the nodes at the base and apex of the primary bulbils, and that in some cases the secondary bulbils in like manner gave rise to tertiary bulbils. Bulbils of the spherical form are also produced by *Chara macropogon* Braun, an Australasian species, in great abundance.

The second type of bulbil, that consisting of an agglomeration of numerous small starch-bearing cells, has been fully described and figured in the case of *Chara fragifera*, *C. delicatula*, and *C. baltica*. These bulbils are produced most abundantly by the first-named species, and it was from this that they were originally described by its discoverer, Durieu de Maisonneuve, in 'Bull. Soc. Bot. France,' vi, p. 182 (1859), the specific name *fragifera* being given on account of the fancied resemblance of the multicellular bulbil to a strawberry (Fig. 12 i). The bulbils are produced as lateral growths on both stem- and root-nodes (Fig. 12

ii and iii). They vary greatly in shape, being irregularly lobed, the lobes rounded in outline and often very numerous, the whole bulbil sometimes measuring more than 6 mm. in its longest diameter.

The bulbils of *C. delicatula* are very similar to those of *C. fragifera*, but are smaller and less frequent. They are usually produced at the lowest stem-nodes. In *C. baltica*, besides the bulbils of the strawberry type,



i. ii.

Fig. 14.—i. Enlarged node of underground stem of *Chara delicatula*, showing rudimentary whorl of branchlets and numerous starch-bearing cells. ii. Longitudinal section of enlarged stem-node of the same. Both after Kuczewski. (× c. 24.)

i. e., those having rounded lobes, Dr. Giesenhagen finds some of a somewhat different type, with more or less acute lobes, their shape being due to several divergent outgrowths of rows of large cells surrounded by smaller ones, producing an irregularly star-shaped process (Fig. 13 i). It is difficult to draw any definite line between the multicellular stem-bulbils and the enlarged lower stem-nodes which occur in many species, and which fulfil the same function. Fig. 14 shows an enlarged stem-node, in which while stipulodes and rudimentary branchlets are produced, there are a large number of starch-bearing cells similar to those of which bulbils are composed. The thickened stem-

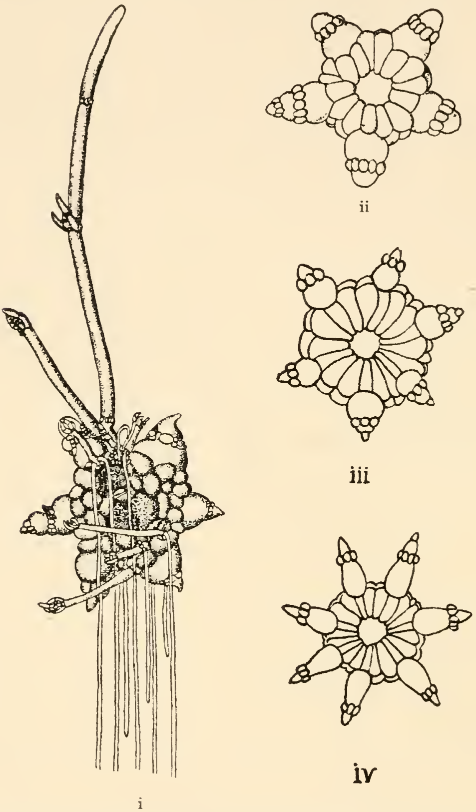


Fig. 15.—Symmetrical star-like stem-bulbils of *Nitellopsis obtusa*. i. View of upper surface showing pro-embryonic branches and rhizoids originating at the base of metamorphosed branchlets (after Giesenhagen). ii, iii, iv. Various forms of "stars" (ii after H. Groves; iii, iv after Migula). (× 7.)

nodes give rise to numerous rhizoids, and often to accessory pro-embryos and embryonic branches.

The third type of bulbil, that of a symmetrical star-like form, has been found in *Nitellopsis obtusa*, and occurs on underground branches. These are clearly metamorphosed whorls of branchlets, the cells corresponding in number and position with those of normal whorls (Fig. 15). From Dr. Giesenhagen's investigation it appears that the young plants arise from cells at the base of the rudimentary branchlets on the upper side, in the same position as normal branches in the axils of normal whorls.

In addition to the species mentioned, the occurrence of bulbils is recorded in *Nitella capillaris, opaca, translucens, gracilis* and *tenuissima* and *Chara scoparia, vulgaris, rudis, hispida, horrida, intermedia* and *aculeolata.*

Reproductive organs.

The oogonia and antheridia are produced at the free nodes of the branchlets, and occasionally also at the nodes at their base. In the several genera the origin and relative position are somewhat different. The latter can of course only be satisfactorily observed in monœcious species and at the nodes where both organs are produced, and it is to these that the following particulars apply.

In *Nitella* the antheridia are solitary and are produced on a terminal outgrowth at the apex of a branchlet-ray. The oogonia, which are solitary or 2–3 together, are produced laterally from the same outgrowth as, but below, the antheridia (Fig. 16 i, p. 44).

In *Tolypella* the antheridia are also solitary, but, as well as the oogonia which are usually clustered, are produced as lateral outgrowths and the stalk-cells are frequently elongated (Fig. 16 ii, p. 44).

In the *Chareæ* the antheridia are not infrequently two together at a branchlet-node and in all the genera are lateral.

In *Lychnothamnus* and *Nitellopsis* the arrangement is apparently similar. In *Lychnothamnus* the oogonium, which is solitary, is produced separately from the central peripheral cell on the inner side of the branchlet, that is the side facing the stem or branch, and antheridia are normally produced from peripheral cells on either side of that producing the oogonium (Fig. 16 iii A and B). In *Nitellopsis* the only known

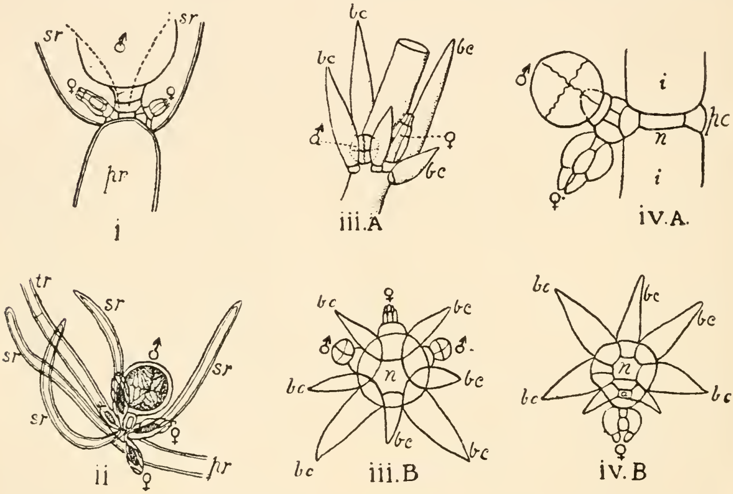


Fig. 16.—Position of reproductive organs in several genera. ♂ = antheridium, ♀ = oogonium in all figures. i. *Nitella flexilis* (after Sachs): *pr*, apex of primary ray; *sr*, bases of two secondary rays. ii. *Tolypella glomerata* (after Migula): *pr*, primary ray; *sr*, secondary lateral rays; *tr*, terminal ray. iii. *Lychnothamnus barbatus* (after Braun): A. Side view. B. Transverse section of branchlet-node (schematic)—*n*, central cell of node; *bc*, bract-cells. iv. *Lamprothamnium papulosum* (after Braun): A. Vertical section of branchlet-node. B. Transverse ditto—*n*, central cell of node; *pc*, peripheral cells of node; *bc*, bract-cells; *i*, internodal cells of branchlet; *a*, antheridium.

species is diœcious so that the relative position of the two organs cannot be ascertained, but their origin appears to be similar to that in *Lychnothamnus*.

In *Lamprothamnium* and *Chara*, which in the position of their reproductive organs are somewhat similar, the antheridia and oogonia are produced together on the inner side of the branchlets from one outgrowth arising from the central anterior peripheral cell of the branchlet-node taking the place of a bract-cell. In *Lamprothamnium* the oogonium is produced below or occasionally by the side of the antheridium (Fig. 16 iv A and B), in *Chara* the antheridium is produced below the oogonium (Fig. 17). Both oogonia and anthe-

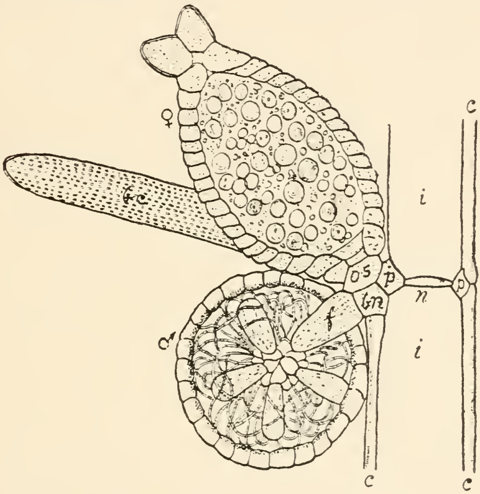


Fig. 17.—Position of reproductive organs in *Chara fragilis* (after Strasburger) (× c. 45). Vertical section of branchlet-node and reproductive organs. *n*, central cell of node; *i*, internodal cells; *bn*, basal nodal cell; *f*, flask-cell of antheridium; *p*, peripheral cells; *c*, cortical cells; *os*, stalk-cell of oogonium; *bc*, bract-cell.

ridia in these genera are almost always practically sessile, but instances occur occasionally in which the stalk-cell of one or other is elongated.

The origin of the reproductive organs will be best seen in Fig. 17. The oogonium is borne on a stalk-cell *os*, and this, as well as the flask-cell of the antheridium, arise from the cell *bn* called the basal-node-cell. The order of development and the arrangement of the cells of the outgrowth in the *Nitelleæ* is very similar. In *Nitella* there is however an extra cell beneath the antheridium between the flask-cell and the basal nodal cell.

In some species of *Nitella* the reproductive organs are surrounded by mucus which often envelopes the whole of the younger whorls.

Antheridium. This is a very highly developed organ, probably the most complex and beautiful structure of the kind throughout the vegetable kingdom. In form it is almost spherical, sometimes tapering very slightly to its base. The diameter ranges from about 150 μ in the smallest monœcious *Nitellæ* to about 1200 μ in the largest diœcious *Charæ*. The colour ranges from pale greenish-yellow to brilliant orange or dull red. The wall is composed of eight convex plates or shields roughly triangular in outline with slightly rounded sides (Fig. 19 i, ii). The four lower are really four-sided owing to the lower angle being truncate to admit of the insertion of the pedicel-cell, the fourth side being very short. The edges of the plates are rather irregularly crenate, the crenations of adjoining plates fitting in with one another. The outer surface of the plates is grooved owing to infoldings of the integument forming partial septa. These folds radiate from near the centre of the plate to the margin, corresponding with the indentations of the latter. The surface between the grooves is rounded and the whole plate has the appearance of being exquisitely sculptured in relief. The coloration of the antheridium is due to the presence of a layer of chlorophyll-granules lying close against the inner wall of each plate, the outer wall and the main substance of the plate being hyaline.

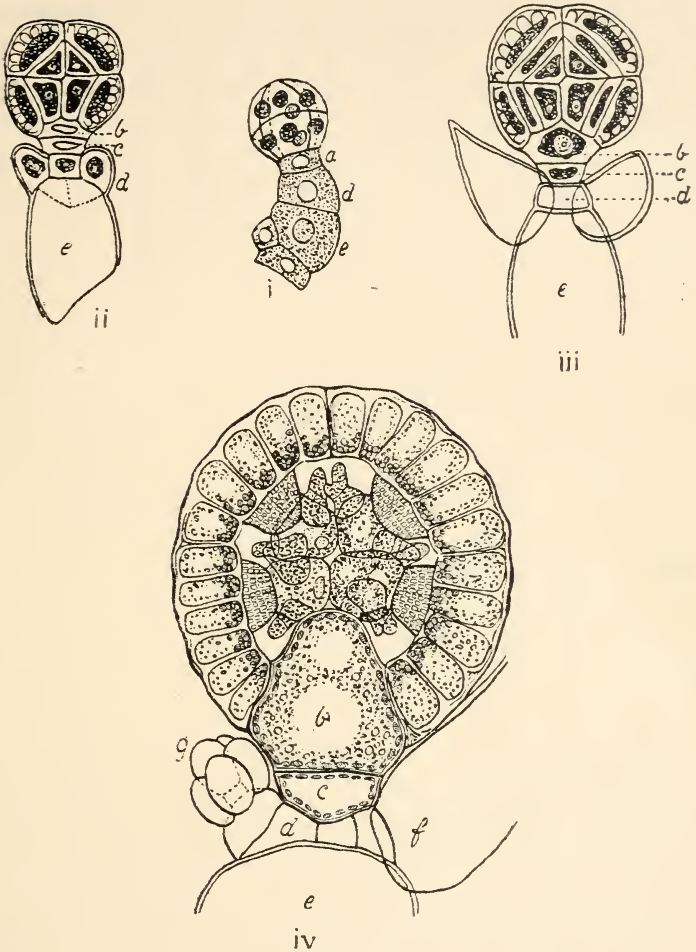


FIG. 18.—Development of antheridium of *Nitella flexilis* (after Sachs). i. Early stage showing young antheridium divided into eight equal parts by the growth of two vertical walls, at right angles to one another, and a horizontal wall. ii. Further stage showing each eighth part divided into an exterior and interior portion. iii. Later stage showing interior portion again divided, making three layers, the outermost expanding tangentially to form the plates or shields, the middle growing radially to form the manubria, and the innermost forming the head-cells which bear the filaments. iv. Section of antheridium at still later stage showing further development of parts. *a*, cell which in ii–iv divides into (*b*) flask-cell and (*c*) extra basal cell; *d*, branchlet node; *e*, branchlet internode; *f*, lateral ray; *g*, young oogonium. In i–iii the protoplasm has been contracted by glycerine.

The chlorophyll-granules become yellowish-orange to red as the antheridium matures.

The foot-stalk (Fig. 18 *b*), styled the flask-cell, is more or less flask-shaped, the narrower end projecting far into the interior of the antheridium. In the *Nitelleæ*, between the flask-cell and the node-cell, an extra cell (Fig. 18 *c*) is present.

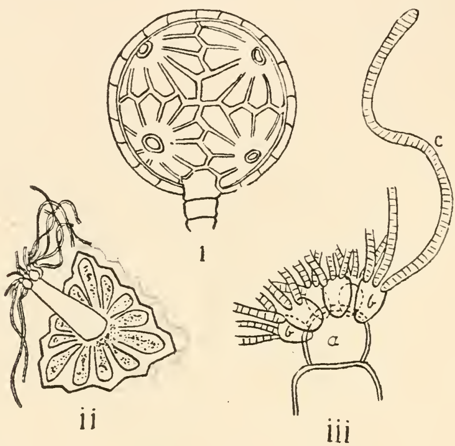


FIG. 19.—Mature antheridium (after Prósper). i. *Chara hispida*. ii, iii. *Chara tomentosa*. i. General exterior view. ii. Interior view of single plate or shield with manubrium attached. iii. Apex of manubrium with primary (*a*) and secondary (*b*) head-cells and filaments (*c*) containing antherozoids.

From the centre of each of the plates on its inner side an elongated cell, called the manubrium, projects inwards towards the centre of the antheridium (Fig. 19 ii). The manubrium as well as the flask-cell contain chlorophyll. At the distal end of each manubrium there is a nearly globular colourless cell, styled the capitulum or head-cell (Fig. 19 iii *a*). From this head-cell proceed about four to six subglobular or elongated cells, the secondary capitula (*b*), each of which gives rise to a variable number (usually two to four) of long whip-like filaments (*c*). The filaments are divided by transverse septa into about 100 to 200 disc-shaped cells, each of which contains an antherozoid. The number of antherozoids produced by a single antheridium has been computed at 20,000 to 30,000. The filaments form a dense tangled mass in the centre of the antheridium.

A careful study of the development of the anthero-

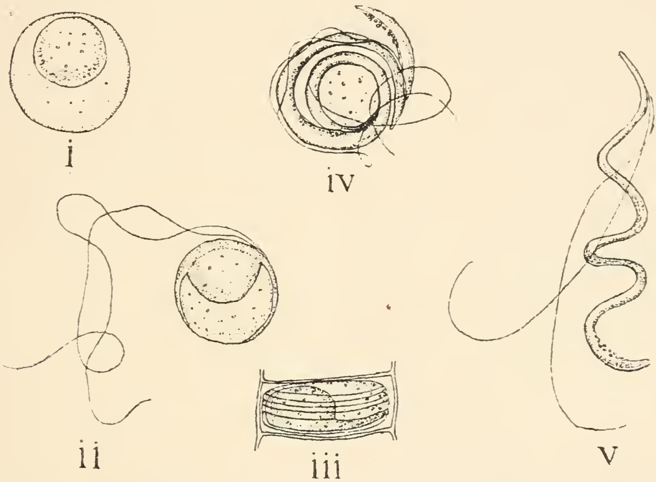


Fig. 20.—Development of antherozoids (after Guignard). i. Early stage after nucleus has moved to one side of cell. ii. Later stage showing nucleus extending in both directions along the side of the cell-wall, and two cilia developed. iii. View *in situ* with cilia curled around rest of antherozoid. iv. Advanced stage, antherozoid having assumed ultimate form and free protoplasm being almost absorbed. v. Free swimming antherozoid.

zoids has been made by M. Léon Guignard, the results of which are published, together with a series of beautiful illustrations, in the 'Revue Générale de Botanique,' I, pp. 18–27, t. 2 (1889). It appears that the nucleus of each of the disc-shaped cells in which the antherozoids are formed lies in the first place in the centre of the cell. It soon moves to one side, the remainder of the cell being filled with free protoplasm (Fig. 20 i). The protoplasm contracts slightly, leaving a space between it and the cell-wall, the nucleus on the side nearest to the cell-wall extends in both directions and two very long cilia are produced (Fig. 20 ii). The nucleus gradually narrows and elongates until it forms a very long body coiling about three times round the interior of the cell (Fig. 20 iii, iv) and the free protoplasm becomes absorbed. When fully developed the antherozoids burst from their cells and swim about freely in the water (Fig. 20 v).

Early stages in the development of the antheridium will be seen in Fig. 18. Strasburger is of opinion that the male organ should not be regarded as a single antheridium since he considers that it "contains eight groups of endogenously-formed antheridia," and "should on this account be termed an antheridiophore" ('Text-book,' 4th Engl. ed., p. 423).

Fruit. The original cell which goes to form the oogonium first divides horizontally into two cells (Fig. 21 i), the lower being the node-cell, the upper, the oosphere.

From the periphery of the node-cell portions are cut off forming smaller cells (Fig. 21 ii), which are invariably five in number, elongate upwards, and surround and envelop the oospore. These enveloping cells are contiguous and in the earlier stages of growth consist of single cylindrical cells nearly straight and erect (Fig. 21 iii). Before long however a horizontal septum appears dividing each enveloping cell into two (Fig. 21 iv). The lower of these elongates and as growth proceeds assumes a spiral direction, ascending always from right to left, and therefore in the opposite direction to the torsion of the stem (Fig. 21 v). The upper cell remains short, and in the *Nitelleæ* is again divided into two by a horizontal septum (Fig. 22, *dd*). The five or ten upper cells, as the case may be, combine to form a crown to the oogonium—the coronula.

The five elongated cells adhering along their lateral lines of contact form an envelope (Fig. 22 i–iii) which encloses the oosphere. These spiral cells are usually,

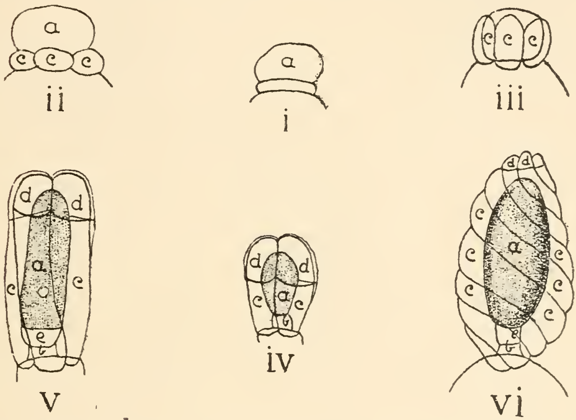


Fig. 21.—Development of oogonium of *Chara vulgaris* (after De Bary and Migula). *a*, oosphere; *b*, node-cell; *c*, enveloping cell; *d*, cells of coronula; *e*, turning cell. i. First division of cell of future oogonium. ii. Division of periphery of node-cell into five cells forming the enveloping cells of oospore. iii. Further development of the five enveloping cells. iv. Formation of horizontal septum dividing enveloping cells into two stages—the upper forming the coronula. v. Further development of enveloping cells, showing their lengthening and spiral growth and formation of turning cells. vi. Oogonium approaching maturity.

if not always, either of a greenish or orange colour. As the oosphere increases in size the enveloping cells continue to elongate and the spiral become more pronounced (Fig. 21 vi).

The oosphere with its enveloping cells, constituting the oogonium, assume a sub-globose, ellipsoidal, or ovoidal form. The lateral walls of the spiral cells subsequently break down, leaving the outer walls to form a single integument marked by spiral furrows along the lines of union.

Incased and protected by the enveloping spiral cells the oosphere consists of a nucleated mass of protoplasm enclosed by a thin and extremely delicate

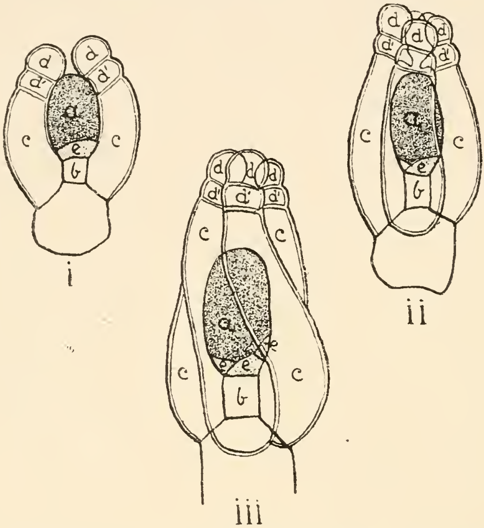


Fig. 22.—Development of oogonium of *Nitella flexilis* (after Sachs). *a*, oosphere; *b*, node-cell; *c*, enveloping cells; *d*, upper, and d^1, lower cells of coronula; *e*, turning cell. i. Early stages of the oogonium showing oosphere with turning cells at its base, and enveloping cells with upper part cut off by double septum forming two-staged coronula. ii. Further stage of development. iii. The enveloping cells assuming well-defined spiral growth, and turning cells divided by two septa.

membrane. Large numbers of starch-granules and oil-drops are developed in the protoplasm.

Turning cells. At the base of the oogonia of the *Nitellæ* are found three small cells called by Braun "turning cells" (Wendungszellen). The formation of the first of these cells occurs at an early stage of the oosphere's development and originates at its apex whence it makes its way downwards (as Goetz shows in a series of illustrations), and finally divides into three cells at the base of the oosphere.

The oogonia of the *Charæ* possess a somewhat similar cell at their base but it differs from that of the *Nitellæ* in that it originates at the base and not at the apex, appears at a later stage in the growth of the oosphere, and remains single and undivided.

Coronula. This organ presents two distinct types of structure which serve to differentiate the two principal divisions of the Charophyta. In the *Nitelleæ* it is formed of ten cells in two tiers of five one above the other (Fig. 22, *dd*), the whole being small, colourless, and inconspicuous, in some species persistent, in others deciduous. The five cells of the lower tier are very small and closely adherent, those of the upper tier are often larger and less adherent. In the *Chareæ* the coronula is formed of five cells (Fig. 21), and except in *Nitellopsis* and *Lychnothamnus*, is larger, much more conspicuous and persistent, exhibiting in different species a considerable diversity in height and the direction of the cells, which may be convergent, erect, or divergent.

Fertilization. The process of fertilization has been exhaustively investigated by De Bary in the case of *Chara vulgaris*, and described in his 'Ueber den Befruchtungsvorgang bei den Charen' (Berlin, 1871), to which admirable piece of work those wishing to pursue the matter in greater detail should refer. It will suffice for our present purpose to state the general facts.

The oogonium approaches its full development before fertilization. At the apex, and therefore at their point of contact with the base of the coronula, the spiral-cells are abruptly narrowed on their inner side, leaving a cavity (Fig. 23 i, ii). Below this the spiral-cells become tumid, leaving only a narrow channel between them, leading to a second cavity situated immediately above the oosphere (Fig. 23 ii). The upper part of the spiral-cells lengthens, forming a neck above the oosphere and under the coronula, in the process of which the outer layer of the cell-membrane splits transversely, leaving a jagged edge

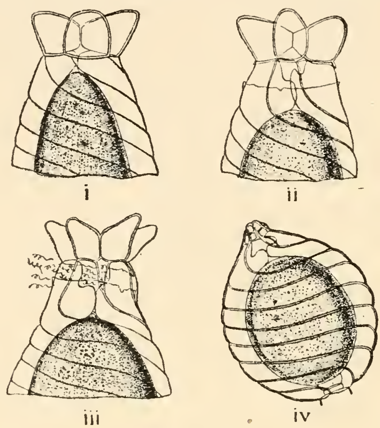
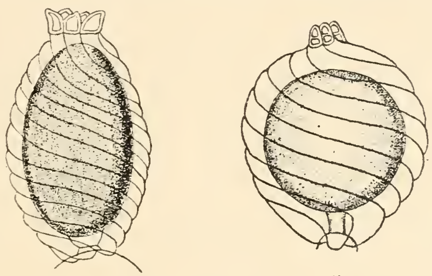


Fig. 23.—Process of fertilisation. i, ii, iii. Upper part of oogonium of *Chara vulgaris*. iv. Oogonium of *Nitella tenuissima*. i. Half-matured unfertilised oogonium showing upper and lower cavities formed by development of coronula and enveloping cells. ii. Fully matured unfertilised oogonium showing tumid growth at the head of enveloping cells, and transverse fracture of membrane caused by their extended growth. iii. Antherozoids penetrating interstices formed by contracted terminations of spiral cells, and reaching oospore through upper and lower cavities within. iv. Similar processes in development of oogonium of *Nitella* (after De Bary).

above and below (Fig. 23 iii). The apex of each of these spiral-cells becomes slightly narrowed, leaving between them a triangular space forming an aperture, admitting to the upper cavity already referred to. The aperture and cavity are filled with a colourless, soft, viscous jelly to which antherozoids from neighbouring antheridia adhere and through which they penetrate to the oosphere within. Presumably the process described by De Bary in the one species (*Chara vulgaris*) prevails in the other Charophytes in which the coronula is persistent. In species in which it is deciduous the apices of the spiral-cells dilate instead of lengthening, and when the coronula falls a direct apical approach to the oosphere is formed through which, there can be little doubt, fertilization is effected.

After fertilization the oosphere becomes an oospore



i ii

FIG. 24.—i. Fully developed oogonium of *Chara vulgaris* (× 60) (after Migula). ii. Fully developed oogonium of *Nitella tenuissima* (× 140) (after De Bary).

and other changes take place in the oogonium (Fig. 24).

Mature oogonium.

If now the matured oogonium be examined in detail it will be found to consist in the first place of an outer integument formed by the union of the outer walls of the five enveloping cells. This integument can be removed in one piece, laying bare the inner protoplasmic contents of the spiral-cells adhering to the oospore. The protoplasmic contents still maintain the form of coils and can be unwound and laid out in separate strands. The posterior walls of the enveloping cells are not distinguishable beneath, having been utilized, as it would seem, to form the membrane of the ripened oospore as explained below.

Oospore.

When the exterior integument and the contents of the spiral-cells have been removed they reveal the oospore—a minute hard nut-like body, ranging in colour from light yellow, through varying shades of red and brown, to black, varying in shape from spherical to narrow-ellipsoid, differing also largely in size, consistency, and opacity.

The oospore is found to consist of a series of delicate membranes, some coloured, some colourless, enclosing and protecting the spore-contents. These membranes are an important factor in the discrimination of the various species and therefore call for careful and detailed description. They may be classed as follows :—

1. The outer coloured membrane.
2. The inner coloured membrane.
3. The outer colourless membrane.
4. The inner colourless membrane.

Outer coloured membrane.

The fully ripe and developed oospore possesses a tough coloured outer membrane which closely envelops and seals the inner contents. The origin of this membrane is not certain, but there seems to be good ground for believing (i) that it follows as a result of the fertilization of the oosphere, and (ii) that it is formed from the posterior walls of the enveloping cells.

In support of the first assumption we have the following facts :—(a) That this membrane does not develop till the oogonium is fully matured; (b) that it forms a tough coating round the spore-contents, encasing and sealing them completely so that subsequent impregnation would be impossible; (c) that many oogonia are found fully developed yet without this coloured membrane and that these eventually become disintegrated and the cell-contents scattered, for which absence of fertilization would sufficiently account.

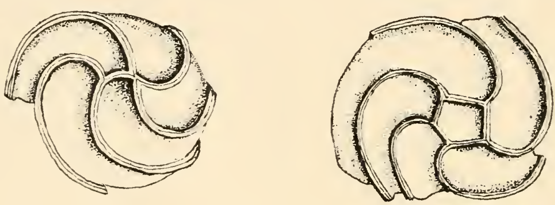
In support of the second assumption as to the origin of the coloured membrane the following considerations may be adduced:—(a) No coloured membrane is found growing upwards from the base of the oogonium, either at the time of fertilization or at any other period, the whole oospore becoming coloured simultaneously. This clearly indicates that it is a membrane already encasing the oosphere which becomes coloured and indurated. (b) The exterior and posterior walls of the tubular spiral-cells undoubtedly separate by the breaking down of the lateral walls along their line of contact, since the outer portions of these cells ultimately combine to form a single integument which as already stated can be detached as a whole. When the contents of the enveloping cells have been removed the posterior walls of the enveloping cells must necessarily lie underneath, but what is found here is the coloured membrane of the oospore without any membrane intervening.

This membrane differs largely in different species, varying in texture from thin, flimsy, or flexible, to thick, tough, or semi-rigid, and in colour from pale transparent yellow to deep red-brown or reddish black.

Dr. Nordstedt has examined the chemical nature of the membrane and detects in it, not lignin as De Bary stated, but suberin (cork) and silicic acid.

Ridges of the oospore.

The surface of the membrane exhibits a number of ridges which ascend spirally from right to left, rising from the five angles of a minute pentagonal base (Fig. 25 ii), and meeting at the apex in a series of curved lines forming an eccentric pattern (Fig. 25 i). These ridges, both in their form and in the number of convolutions visible, are more or less constant for each species and serve as an aid to determination. The ridges sometimes exhibit little more than a thin line, more often they are strongly developed, and not infrequently they extend into a prominent wing or flange. The



i ii

Fig. 25.—Terminal disposition of ridges of oospore. i. View of apex (*Nitella capillaris*). ii. View of base (*Chara baltica*).

ridges owe their origin to the overlying enveloping cells, the sutures on the posterior side of which become filled up as the membrane develops and hardens. The number visible varies according as the spiral-cells complete one, two, or three convolutions.

Basal claws and crest.

In some species of *Chara* the angles of the pentagonal base already referred to are prolonged downwards into claw-like processes which attain sometimes considerable length and often form a double stage by a transverse growth, giving the appearance of a little cage enclosing the stalk-cell. The *Nitellæ* do not produce basal claws, but conversely in some species the flanges of the ridges become broader at the apex of the oospore and form a sort of crest.

Decoration of the membrane.

The outer coloured membrane in almost all species exhibits a decorated surface. In fully developed membrane the decoration spreads on to the ridges and is also found on the flanges when the latter are produced (Plate IV, f. 2).

To Dr. Nordstedt we are indebted for pioneer work in the study and classification of these membrane decorations and his monograph on the subject (Part IV of his 'De Algis et Characeis') has proved invaluable in this branch of research. The character of the decoration of the membrane is apparently constant in the same species, and therefore often affords valuable aid to the determination of species.

Of the British Charophytes only four—*Nitella opaca*, *Nitella flexilis*, *Tolypella prolifera*, and *Tolypella nidifica*—are without a decorated membrane. For the rest the decoration falls into three classes—(*a*) tuberculate, (*b*) reticulate, (*c*) granulate. Under the first head *N. capillaris* stands alone. The tubercles of the membrane of this species are strongly marked, standing out detached and prominent (Plate IV, f. 1). Under the second head fall *N. translucens*, *N. mucronata* and *N. tenuissima* (Plate IV, f. 10; V, figs. 1, 3, 4); the distinctive characters of the reticulation of these three species are obvious and well-marked. The remaining 24 British species fall under the third class, viz. granular membranes. But the granules of the different species vary very widely in size, disposition, and character. The granulation in its earlier stages is found not infrequently arranged in linear form parallel with the ridges. As the granules develop they are crowded into disorder, penetrate deeper into the tissue, and in some species become thick and spongy in appearance (Plate V, figs. 8, 9).

The reticulate series also exhibit a progressive development. The lines which mark the reticulation begin by lying flat on the surface, but as they grow they develop little protuberances which in the case of *N. tenuissima* are very conspicuous (Plate V, figs. 3, 4).

The nature of the decorative substance calls for further investigation. The examination of the tubercles, reticulations, and granules in profile seems to suggest that in all three cases they are formed of a colourless gelatinous substance resting on a smooth pigmented base. This view is supported by the detection now and again of a piece of colourless membrane bearing the characteristic decoration and having the appearance of a fragment detached from its base.

Inner coloured membrane.

Immediately below the outer coloured membrane lies a second so closely adherent as often to require the aid of a reagent such as chromic acid to separate them (Plate IV, f. 9; Pl. V, f. 5). This membrane differs but little in colour in the different species, varying from very lightly-tinged yellow in the more translucent membranes to light yellow-brown in those which are more opaque. In texture it is very thin and flexible, frequently lying flat when separated and placed on the microscope slide. Not infrequently it exhibits traces of the ridges of the overlying membrane. The decoration of this sub-membrane is uniformly granulated, the granules being always faintly, usually very faintly, indicated. The granular character apparently exists even in species whose exterior membranes are reticulate, tuberculate or wholly smooth. Both coloured membranes are of a compound character, consisting of a series of infinitely thin layers. This is usually only apparent in cases where the membrane happens to show a ragged edge. Such ragged edge will often exhibit from two up to twelve, or fifteen, layers.

Third membrane.

Below the second coloured membrane lies a third, clear, translucent and quite colourless, having the appearance of a piece of fine glass. It has no rigidity of texture, but when removed from the inner coloured membrane spreads flat and limpid on the slide.

Fourth membrane.

On the removal of the third membrane traces of a fourth are found, representing remains of the original wall of the oosphere. This membrane apparently becomes ultimately absorbed and disappears.

Lime shell.

In many species oogonia may be observed in which the spiral lines are still conspicuous, but the whole surface presents a shell- or porcelain-like appearance, often exhibiting a metallic sheen. An examination of these fruits shows that they possess the usual thin tough surface cuticle of the spiral cells, but that a fine deposit of lime has been secreted within the spiral-cells forming a hard semi-transparent shell incasing the oospore.

Abnormal forms of fruit.

In almost every plant of every species oogonia are found in which no coloured oospore occurs, the transparent enveloping cells clasping the naked colourless oosphere which is often large and distended. If, as is conjectured, the coloured membrane follows as a consequence of fertilization, this condition may be due to non-fertilization.

Lime secretion sometimes occurs in the enveloping cells of this abnormal fruit. In this case the imperfectly developed oogonia takes the form of an opaque whitish-coloured globular body having the appearance of a small granule of chalk.

An attempt has been made to tabulate and arrange in the form of a conspectus the distinctive characteristics of the oospores and membranes of the various British species. The result will be found on pp. 69–71.

Sexual phenomena.

Nearly three-quarters of the Charophyta are monœcious and only a little more than one-quarter diœcious. Among the British species there are 23 of the former and 9 of the latter, the numbers being made up as follows:—*Nitellæ*, monœcious 8, diœcious 2; *Charæ*, monœcious 10, diœcious 6; *Tolypellæ*, all monœcious; the single *Nitellopsis* diœcious; the single *Lamprothamnium* monœcious. In reviewing the two large genera *Nitella* and *Chara* we do not find the monœcious or diœcious character correlated with greater or less complexity of structure. It is however noticeable that in the genus *Chara* it is in the triplostichous section of the *Diplostephanæ*, which may be regarded as the most highly developed type, that we meet with the largest proportion of diœcious species. In *Nitella* on the other hand the sections presenting both the simplest and also the most complex structure have the largest proportions of diœcious species, while the monœcious species greatly preponderate in the intermediate section. It is therefore difficult to advance any satisfactory theory as to the lines on which the more complex state of sexuality has been evolved.

In the case of the diœcious species the plants of the two sexes do not present any important distinctive characteristics in their vegetative parts. The antheridia of diœcious species are usually much larger than those of the most nearly allied monœcious species.

In most of the monœcious species the antheridia and oogonia are produced at the same nodes of the branchlets. In a few extra-British species they are produced on the same branchlets, but at different free nodes, while in others the oogonia are mostly produced at the basal nodes and the antheridia only at the free nodes. We have seen an instance of the two organs being developed on separate branchlets of the same whorl. These exceptions to the general rule may be regarded as deviations in the direction of diœcism.

The Charophytes are usually protandrous, sometimes in a marked degree. So much is this the case in a variety of *Nitella flexilis*, that at an early stage the plant appears entirely male, and at a late stage entirely female, and the antheridia produced in the early stage are as large as those of the diœcious species belonging to the same section.

In some instances the distinction between two species appears to consist almost entirely in their monœcious or diœcious character. For example, apart from this distinction there is a close similarity between *Chara canescens* and the American *C. hirsuta;* between the French *Nitella ornithopoda* and the Portuguese *N. Dixonii;* and most markedly perhaps between our two common British species *N. flexilis* and *N. opaca*, which are almost impossible to discriminate when not in fruit.

One species, *Chara canescens*, which is diœcious presents the curious phenomenon of parthenogenesis. The female plant, found in a few localities in the

British Isles, is widely distributed, occurring in almost all the countries of Europe, and in Asia, Africa and North America, while the male plant is extremely rare and has been found only in a very few localities; yet perfectly well-developed oospores are produced from the unimpregnated oospheres in great abundance, in fact it is one of the most freely fruiting species. The following interesting particulars are given by De Bary in 'Zur Keimungsgeschichte der Charen' as translated by Hemsley in 'Journ. Bot.' xiii, p. 299 (1875):—

"Respecting this phenomenon the examinations revealed the fact that the ovule-bud originates in precisely the same positions, and its development is exactly as in the other monœcious and diœcious species of the genus; further the neck parts into five clefts before ripening, as in other *Charas* before impregnation. These clefts are indeed small, though not smaller, for instance, than in *C. scoparia*. Moreover it was most satisfactorily demonstrated that the ripening of the oospores of isolated female plants under continual control neither showed any trace of antheridia, nor were there any antheridia-bearing plants near them. It may be asserted without exaggeration that under good culture scarcely a single oospore fails to germinate. The female plant growing wild is more fertile than any of its congeners, although the male plant, with the exception of some herbarium specimens mentioned by Braun, is unknown. Finally it was proved that the oospores mature on isolated female plants under the most perfect control would germinate. Ripe oospores were taken on November 10 from plants isolated on the 9th of the preceding July. They germinated at the beginning of April, and produced normal plants, and in many instances the first whorl of the primary stem bore oospores. The different phases of germination in these unimpregnated oospores are exactly like those in the sexually produced oospores of other species. Of the actual occurrence of parthenogenesis in this plant no shadow of doubt can exist."

Hybridity has been very rarely observed among the Charophytes, and no instances have, we believe, been recorded among the *Nitelleæ*. Among the *Chareæ* one instance has come under our personal notice, that of a plant from Hickling Broad and its adjacent Sounds. This was in the first place referred to *Chara papillosa*, but further observations have led to the conclusion that it is a hybrid between *C. hispida* and *C. contraria*. In France Professor Hy has described a hybrid between *C. connivens* and *C. fragilis*. These are the only cases which to our knowledge have been placed on record, but no doubt if careful search is made in pieces of water where allied species are growing together other cases may come to light. No attempt so far as we know has yet been made to produce artificial hybrids.

Cell-structure, cyclosis, etc.

The cells of which a Charophyte is composed are much larger than those of most other plants, the single cells forming the internodes of the stem in some cases attaining to the extraordinary length of 20 cm. There is a considerable difference in the thickness of the cell-wall in different species.

Each cell has originally a single nucleus, the nuclear division preparatory to the formation of fresh cells taking place by regular karyokinesis. The long internodal cells ultimately however possess a number of nuclei, as the result of the simple fragmentation of the original nucleus, this fragmentation being brought about either by a process of annular constriction or by the appearance of a fissure in the interior of the nucleus which extends to the exterior (see Sachs, 'Lect. Physiol. Pl.,' Transl., p. 106).

Most of the cells contain chlorophyll in the form of minute granules, "chloroplastids," disposed in rows embedded in a stationary layer of protoplasm, the "ectoplasm," lining the internal surface of the cell-walls. In the vegetative parts the chlorophyll granules remain green, in the cells of the antheridium in which they are present they assume an orange or red colour at maturity. The chlorophyll granules which are in a single layer do not completely line the cells, there being a neutral portion, appearing as a narrow spiral band, from which they are lacking. This colourless band is particularly noticeable in the long internodal cells. It has been called the neutral or indifferent line.

Cyclosis, or streaming, that is the rotation of protoplasm within the cell, which was first observed in a Charophyte, is particularly well exhibited in these plants, and may be seen in almost all fully-grown cells. The cyclotic flow is in the form of a definite stream of protoplasm within the ectoplasm, following the direction of the rows of chlorophyll granules, passing up one side of the neutral line around the end of the cell and down the other side. In the elongated lateral members, such as the internodes of the branchlets and the spiral-cells of the oogonium, the stream proceeds upwards on the outer side of the cell, *i. e.* that farthest from the axis of the stem or fruit, and downwards on the inner side. The direction of the flow in each type of cell was worked out by Alexander Braun and will be found in his wonderful little book 'Über die Richtungsverhältnisse der Saftströme in den Zellen der Characeen.'

Numerous bodies are found imbedded in the stream of moving protoplasm, consisting of nucleoli, starch-granules of various sizes, loose chlorophyll-grains and curious minute ciliated spheres. The rate of progress of the cyclotic stream depends largely on the temperature, as may be readily observed by warming a slide on which a specimen has been placed. Sachs found that the slowest continuous movement was when the temperature of the water was 1° C., the most rapid when it was 37°C. ('Lect. Physiol. Pl.,' Transl., p. 606).

Almost ever since the publication of Corti's discovery of cyclosis in 1774, its investigation has engaged the attention of botanists, experiments having been carried out with a view to ascertaining the causes and nature of the cyclotic flow and the conditions affecting it, and numerous memoirs have been published on the subject so that the literature relating thereto is considerable. The views put forward and the conclusions reached have been ably summarised by Professor Ewart in his monograph 'On the Physics and Physiology of Protoplasmic Streaming in Plants,' from which exhaustive and painstaking work the following particulars are taken.

It is shown that an increase of temperature, within certain limits, by causing a decrease in the viscosity of the moving protoplasm, accelerates its flow. In the cell of a *Nitella* the times taken to cover a space of 1 mm. at 18° C., 27° C., and 45° C. were 54, 38, and 25 seconds respectively.

Streaming appears to cease permanently when the cell is exposed to as low a temperature as −5° C., and on continued exposure to as high a temperature as 45° C.

Darkness on the one hand and intense light on the other have the effect of retarding the flow, a weak light being apparently the most favourable condition.

Cyclosis was found to continue both in species of *Chara* and of *Nitella* for some weeks in the entire absence of free oxygen in the surrounding water. The cells of Charophytes appear to be unusually resistant of the action of carbonic acid.

The results of many experiments as to the effect of acids, alkalies and alkaloids on the flow are detailed by Dr. Ewart. Dilute solutions of nitrate of potash and chloride of soda considerably retard the flow. Dilute alcohol and anæsthetics, such as ether and chloroform, tend to accelerate, while strong solutions retard the flow.

Temporary suspensions of the flow are found to occur as the result of shocks from various causes such as sudden immersion in a strong alkaline solution or mechanical disturbance.

In the larger elongated cells gravity was found appreciably to affect the rate of flow. In a cell of a *Nitella* the mean velocity of the upward stream at a temperature of 17·5° C. was measured to be 1·99 and 1·96 mm., as against that of the downward stream of 2·13 and 2·15 mm. per minute.

The rotatory movement observable in the chloroplastids carried along in the flow is apparently due to mechanical causes.

As regards the effect of magnetic and electric stimuli, Dr. Ewart in stating his conclusions as to streaming in plants generally, remarks: "The strongest magnetic force used exercised little or no direct effect on streaming, although a pronounced secondary effect is produced on prolonged exposure as the result of inductive action" (*l. c.*, p. 121). "Weak electrical currents may accelerate streaming, strong ones always retard it, sudden shocks produce temporary cessation." (p. 192.)

In the Charophytes cyclosis is stated to persist during the entire existence of the adult cell, permanent cessation always indicating fatal injury.

According to Goebel ('Physiol.' iii, pp. 165 and 174, Transl.) the shoots of *Chara* and *Nitella* show a fairly strong negatively geotropic action and the internodes show positive heliotropism in ordinary light. Haberlandt states ('Physiol. Pl. Anat.,' p. 608, Transl.) :— "the positively geotropic rhizoids of certain species of *Chara* (*C. fragilis*, *C. fœtida*, *C. aspera*) contain, near their tips, minute solid bodies of unknown chemical composition (*Glanz-Körperchen*), which have been shown by Giesenhagen to respond to the action of gravity. Each group of these bodies, together with the associated cytoplasm, seems to represent the statolith-apparatus of the rhizoid."

A CONSPECTUS

OF THE DISTINCTIVE CHARACTERISTICS OF THE OOSPORES AND MEMBRANES OF THE BRITISH CHAROPHYTES.

The membrane referred to is always the external coloured membrane. "Fossulæ" are the spaces lying between the ridges of the oospore. By "granular density per 10 μ" is meant the approximate number of granules in the fossulæ lying along a line 10 μ in length.

I. Oospore laterally compressed, ovoidal or orbicular; membrane thin or thick, flexible or semi-rigid; translucent or semi-opaque; smooth, eruptive, or decorated.

NITELLA.

(1) Membrane thick and semi-rigid—

(i) smooth or eruptive, undecorated, dark red.

(a) oospore small (375–425 μ) . *N. opaca.*

(b) oospore large (500–575 μ) . *N. flexilis.*

(ii) eruptive, granularly decorated, wine-red *N. spanioclema.*
(iii) smooth, tubercularly decorated, chestnut brown . . . . . *N. capillaris.*
(2) Membrane thin and flexible—
(i) reticularly decorated.
(a) meshes measuring c. 15–18 μ *N. translucens.*
(b) meshes measuring c. 9–10 μ *N. mucronata.*
(c) meshes measuring c. 4–5 μ *N. tenuissima.*
(ii) granularly decorated.
(a) granular density 8–10 per 10 μ *N. batrachosperma.*
(b) granular density 6-8 per 10 μ *N. hyalina.*
(c) granular density 5–7 per 10 μ *N. gracilis.*

II. Oospore terete, ovoidal, spheroidal, or ellipsoidal. Membrane translucent or semi-opaque; smooth or decorated; thin or thick; flexible or semi-rigid . . TOLYPELLA.
(1) Membrane granularly decorated—
(i) membrane thin and flexible, granules very small and faint . . . . *T. intricata.*
(ii) membrane thick, granules conspicuous *T. glomerata.*
(2) Membrane smooth—
(i) membrane yellow, thin and flexible *T. prolifera.*
(ii) membrane wine-red, thick and semi-rigid *T. nidifica.*

III. Oospore large terete, broadly obovoidal. Membrane thin, flexible, translucent, dull-yellow-brown, finely and obscurely granulate. Granular density c. 15 per 10 μ . . . . NITELLOPSIS OBTUSA.

IV. Oospore terete, long, narrowly ellipsoidal. Membrane thick and brittle, opaque, very dark red-brown, finely and obscurely granulate. Granular density c. 5 per 10 μ . . . . . LAMPROTHAMNIUM PAPULOSUM.

V. Oospore terete, fusiform or ellipsoidal. Membrane thin or thick; flexible, semi-rigid or rigid; translucent, semi-opaque or opaque; granulate . CHARA.

(1) Membrane translucent—
- (i) membrane strongly granulate.
  - (a) granular density c. 5 per 10 μ *C. hispida.*
  - (b) granular density c. 6 per 10 μ *C. contraria.*
  - (c) granular density c. 7 per 10 μ *C. vulgaris.*
  - (d) granular density c. 8 per 10 μ *C. denudata.*
- (ii) membrane very faintly granulate.
  - (a) dull brown . . . *C. aculeolata.*
  - (b) chestnut brown . . . *C. rudis.*
  - (c) clear yellow . . . *C. tomentosa.*
  - (d) red-brown . . . . *C. baltica.*

(2) Membrane semi-opaque or opaque—
- (i) membrane thick with many evident lamina.
  - (a) granules very obscure.
    - (i) dull brown and brittle *C. aspera.*
  - (b) granules less obscure.
    - (i) granular density c. 7 per 10 μ, very dark dull brown *C. connivens.*
    - (ii) granular density c. 9 per 10 μ, dark brown . *C. fragifera.*
    - (iii) granular density c. 5 per 10 μ, very dark to black . *C. fragilis.*
    - (iv) granular density c. 5 per 10 μ, very dark to black *C. delicatula.*
    - (v) granular density c. 7 per 10 μ, bright red-brown *C. desmacantha.*
- (ii) membrane less thick without evident lamina.
  - (a) granular density c. 7 per 10 μ, dull brown to black . . *C. Braunii.*
  - (b) granular density c. 6 per 10 μ, very dull brown . . . *C. canescens.*

A GLOSSARY

OF TERMS, ESPECIALLY OF THOSE USED EXCLUSIVELY, OR IN A PARTICULAR SENSE, IN RELATION TO THE CHAROPHYTA.

Obsolete terms are denoted by †.

allantoid (*ἀλλᾶς*, a sausage; *εἶδος*, resemblance), sausage-shaped. *Allantoideæ*, a section of *Tolypella* having sausage-shaped ultimate cells to the rays.

†**amphigonium** (*ἀμφὶ*, around; *γονὴ*, seed), a term applied to the **oogonium.**

anarthrodactylous (*ἀν*, not; *ἄρθρον*, a joint; *δάκτυλος*, a finger), having the ultimate rays or dactyls each composed of a single cell. *Anarthrodactylæ*, a section of *Nitella*.

anisostichous (*ἄνισος*, unequal; *στὶξ*, a row), having unequal rows, applied to the stem-cortex of Chara, when the primary and secondary rows are of unequal diameters.

antheridiophore (*ἀνθηρὸς*, flowering; *εἶδος*, resemblance; *φορὸς*, bearing), the term applied by Strasburger to the male generative process, regarding it as a composite organ, formed by the union of eight antheridia.

antheridium (*ἀνθηρὸς*, flowering; *εἶδος*, resemblance), the male generative organ.

antherozoids (*ἀνθηρὸς*, flowering; *ζῷον*, animal; *εἶδος*, resemblance), the minute motile bodies produced in the antheridium, representing the male element.

arthrodactylous (*ἄρθρον*, a joint; *δάκτυλος*, a finger), having the ultimate rays or dactyls each composed of more than one cell. *Arthrodactylæ*, a section of *Nitella*.

aulacanthous (*αὐλὸς*, a groove; *ἄκανθα*, a spine), having a stem-cortex with the secondary rows more prominent than the primary, so that the spine-cells appear to be seated in furrows. *Aulacanthæ*, a subsection of *Chara*.

bistipulate (*bis*, twice; *stipula*, a little stalk or blade), having two stipulodes at the base of each branchlet.

bract-cells (*bractea*, a thin plate of metal), vegetative single-celled processes growing outwards from the peripheral cells of the branchlet-nodes in the *Chareæ*.

bracteoles (*bracteola*, a small bract), cells similar to the bract-cells but arising below the oogonium.

branchlets, the whorled processes of limited growth, produced at the stem-nodes, and bearing the reproductive organs; by some authors styled "leaves."

bulbils (*bulbulus*, a little bulb), agglomerations of cells containing starch granules developed at the root- and stem-nodes of some Charophytes.

capitula (*lat.* little heads), the head-cells in the antheridium.

charads, a name for the group of Charophytes.

†**clonarium** (κλῶν, a young branch), a term applied to the oogonium.

†**condylium** (κόνδυλος, a knuckle), a term applied to the antheridium.

conoid (κῶνος, a cone; εἶδος, resemblance), cone-shaped. *Conoideæ*, a section of *Tolypella* having conical ultimate cells to the rays of the branchlets.

coronula (*lat.* a little crown), the small crown-like process of five or ten cells surmounting the spiral-cells of the oogonium, sometimes styled **corona** or **crown.**

cortex (*lat.* bark, rind), the cellular sheath surrounding the stem and branchlets of some *Chareæ;* **cortical-cells**, the cells of which it is composed, distinguished as primary and secondary; the **primary** representing the axis of each cortical series, and consisting of nodal and internodal cells; the **secondary** consisting of the lateral cells given off by the nodal cells, and lying alongside the primary series.

cyclosis (κύκλος, a circle), the rotation of protoplasm within the cell.

dactyl (δάκτυλος, finger), an ultimate ray of the branchlet of a *Nitella.*

diarthrodactylous (δὶς, twice; ἄρθρον, a joint; δάκτυλος, a finger), having each dactyl composed of two cells. *Diarthrodactylæ*, a section of *Nitella* [Braun].

diplostephanous (διπλόος, double; στέφανος, a crown), having a double circle of stipulodes at the base of each whorl of branchlets. *Diplostephanæ*, a section of *Chara.*

diplostichous (διπλόος, double; στὶξ, a row), having a cortex in which there are two rows of cells to each branchlet or bract-cell. *Diplostichæ*, a subsection of *Chara.*

†**epigone** (ἐπὶ, upon; γονὴ, offspring), a term applied to the oogonium.

flabellate (*flabellum*, a fan), having the secondary rays of the branchlet once or repeatedly furcate. *Flabellatæ*, a subsection of *Nitella.*

flask-cell, the stalk-cell of the antheridium.

fossulæ (*fossula*, a little ditch), the spaces between the ridges of the oospore, termed also **sulci.**

globule, a term applied to the antheridium.

glœocarpous (γλοιὸς, mucus; καρπὸς, fruit), having the reproductive organs enveloped in mucus.

gymnocarpous (γυμνὸς, naked; καρπὸς, fruit), not having the reproductive organs enveloped in mucus.

gymnophyllous (γυμνὸς, naked; φύλλον, a leaf), having branchlets destitute of cortex.

gymnopodous (γυμνὸς, naked; πoὺς, a foot), having the lowest internode of the branchlet ecorticate.

†gyrogonites (γύρος, round; γονὴ, a seed), the name applied by earlier geologists to the fossil fruits of Charophytes.

†gyroliths (γύρος, round; λίθος, a stone), another name for the fossil fruits.

haplostephanous (ἁπλὸς, single; στέφανος, a crown), having a single circle of stipulodes at the base of each whorl of branchlets. *Haplostephanæ,* a section of *Chara.*

haplostichous (ἁπλὸς, single; στὶξ, a row), having a cortex with one row of cells to each branchlet or bract-cell. *Haplostichæ,* a subsection of *Chara.*

head-cells, (1) cells attached to the distal extremity of the manubrium, and bearing the filaments which contain the antherozoids; (2) cells produced on the exterior of the node-cells of the stem-cortex in some species of *Chara,* and bearing the spine-cells.

heterophyllous (ἕτερος, different; φύλλον, a leaf), having branchlets of more than one form. *Heterophyllæ,* a subsection of *Nitella* [Braun].

holodactylous (ὅλος, whole; δάκτυλος, a finger), having ultimate rays or dactyls, each composed of a single cell. *Holodactylæ,* a section of *Nitella* [Hy].

homœophyllus (ὅμοιος, like; φύλλον, a leaf), having but one form of branchlet. *Homœophyllæ,* a subsection of *Nitella* [Braun].

isostichous ('ίσος, equal; στὶξ, a row), having equal rows, applied to the stem-cortex of *Chara,* when the primary and secondary rows are of equal diameter.

lamellæ (*lamella,* a thin plate), the layers of the membrane of the oospore.

lime-shell, a hard shell surrounding the oospore, formed by a secretion of lime within the spiral-cells of the oogonium.

manubrium (*lat.* a handle), an elongated cell proceeding from the centre of the inner side of each of the eight plates which form the outer wall of the antheridium, bearing, at its distal end, head-cells to which the filaments containing the antherozoids are attached.

monarthrodactylous (*μόνος*, single; *ἄρθρος*, a joint; *δάκτυλος*, a finger), having the ultimate rays or dactyls each composed of a single cell. *Monarthrodactylæ*, a section of *Nitella* [Braun].

mucus, mucilage, a gelatinous envelopment of the reproductive organs of certain species of *Nitella*.

nucleus (*lat.* kernel), a term applied to the oospore.

nucule (*nucula*, a small nut), a term applied to the oogonium.

oocarp (*ᾠὸν*, an egg; *καρπὸς*, a fruit), a term applied to the oospore.

oogonium (*ᾠὸν*, an egg; *γονὴ*, seed), the female sexual organ consisting, in the Charophytes, of the sac composed of five spiral-cells which enclose the egg-cell.

oosphere (*ᾠὸν*, an egg; *σφαῖρα*, a globe), the egg-cell before fertilization.

oospore (*ᾠὸν*, an egg; *σπορὰ*, a seed), the fertilised egg-cell.

papillæ (*papilla*, a nipple), nipple-like protuberances.

†physema (*φύσημα*, an inflation), a term formerly applied to the stem or branchlet.

polyarthrodactylous (*πολὺς*, many; *ἄρθρον*, a joint; *δάκτυλος*, a finger), having the ultimate rays or dactyls each composed of more than two cells. *Polyarthrodactylæ*, a section of *Nitella* [Braun].

proembryo (*πρὸ*, for; *ἔμβρυον*, a fœtus), an asexual shoot which proceeds from the nodal-cell of the oospore and from which the sexual plant arises as a lateral shoot.

protonema (*πρότος*, first; *νῆμα*, a thread), another term for the proembryo.

punctate (*punctum*, a small hole, a puncture), marked with minute depressions or holes, applied to the decoration of the membrane of the oospore.

ray, the limb of a branchlet in the *Nitelleæ*; **primary ray**, the basal portion or stalk of the branchlet; **secondary ray**, a limb arising at the first furcation; **tertiary, quaternary, quinary rays**, limbs arising respectively at the second, third and fourth furcations; **ultimate ray**, or **dactyl**, a limb arising at the uppermost furcation.

reticulate (*reticulum*, a little net), finely netted, applied to the decoration of the membrane of the oospore when net-like.

scuta (*scutum*, a shield), see under **shields**.

shields or **scuta**, the eight shield-like plates which unite to form the exterior of the antheridium.

spermatozoids (*σπέρμα*, a seed; *ζῷον*, an animal; *εἶδος*, resemblance), another term for antherozoid.

spine-cells, **spines**, cells growing outwards from the nodal-cells of the stem-cortex.

spiral-cells, the five cylindrical cells which clasp the egg-cell.

sporangium (*σπορὰ*, a seed; *ἀγγεῖον*, a vessel), a term applied to the oogonium.

sporocarp (*σπορὰ*, a seed; *καρπὸς*, a fruit), the fertilised and matured oosphere. Another term for the **oospore**.

sporophyas, **sporophydium** (*σπορὰ*, a seed; *φυὰς*, a shoot), a term applied to the oogonium.

sporostegium (*σπορὰ*, a seed; *στέγη*, a covering), a term applied to the oogonium.

stipulodes (*stipula*, little stalk or blade), certain small cells in a single or double circle arising below, and very occasionally also above, the whorl of branchlets in the *Chareæ* and growing outwards as papillæ or more or less elongated processes.

streaming, a term for **cyclosis**.

striæ (*lat.* furrows), a term applied to the spiral ridges of the oospore.

sulci (*lat.* grooves), the spaces between the ridges of the oospore; termed also **fossulæ**.

triplostichous (*τριπλόος*, triple; *στὶξ*, a row), having three rows of cortical-cells to each branchlet or bract-cell. *Triplostichæ*, a subsection of *Chara*.

tubercle, a term sometimes applied to a bulbil.

tylacanthous (*τύλος*, a ridge; *ἄκανθα*, a spine), having a stem-cortex in which the primary cells are more prominent than the secondary, so that the spine-cells appear to be seated on ridges. *Tylacanthæ*, a subsection of *Chara*.

unistipulate (*unus*, one; *stipula*, a little blade), having a single stipulode at the base of each branchlet.

TABLE OF LATIN ADJECTIVAL TERMS.

An extensive code of latin and latinized adjectives has been gradually built up descriptive of the salient characters and of the variations in size, habit, etc., of the Charophyta, by means of which the section to which a plant belongs or the form or state it presents can be concisely indicated. The following table includes the terms most generally in use, with the addition of some others complemental to them.

Adjectives in the comparative degree serve to indicate a deviation from the typical form.

The terms enclosed in brackets are practically synonymous with those preceding them.

Explanations are given only when the terms are not to be found in the glossary and their meaning is not obvious.

The names of the three main genera, *Nitella*, *Tolypella*, and *Chara*, being regarded as feminine, the adjectives are given in that gender when they refer to the whole plant, or when usually employed in continuation of the generic name or of the word "forma."

Sexual Conditions.

monœcia.

conjuncta = antheridia and oogonia at the same nodes.

sejuncta = antheridia and oogonia at different nodes.

diœcia.

per-protandra.

parthenogenetica.

Stature.

magna, major, maxima.
parva, minor, minima.
pumila.
pusilla, perpusilla.
humilis, humilior.

Habit.

laxa, laxior.
stricta, strictior.

elongata.
condensata.

robusta, robustior.
gracilis, gracilior.
tenuis, tenuior.

contracta.
expansa.

concinna.
rudis.

Colour.

perviridis.
virescens.
atro-virens.
flavo-viridis.

fuscescens.
nigricans, nigrescens.
cinerascens.
glauco-cinerascens.
pallida.

INCRUSTATION.

incrustata.
zonatim incrustata.
munda.

STEM (CAULIS).

crassus, crassior.
tenuis, tenuior.

simplicior.
ramosior.

corticatus.
subcorticatus.
ecorticatus.

WHORLS.

homœomorpha = with sterile and fertile whorls similar.
heteromorpha = with sterile and fertile whorls dissimilar.

macroclema* (macrophylla, longifolia).
microclema (microphylla, brevifolia).

pachyclema (pachyphylla, crassifolia).
leptoclema (leptophylla, tenuifolia).

orthoclema (orthophylla).
streptoclema (streptophylla).

gymnoclema (gymnophylla, nudifolia).
phlœoclema (phlœophylla).

homœoclema (homœophylla) = having all the branchlets in the same whorl uniform.
heteroclema (heterophylla) = having more than one form of branchlet in the same whorl.

VERTICILLI.

distantes (remoti).
approximati.
conglobati.
contracti.
globosi.
clausi.
moniliformes.

BRANCHLETS OF NITELLEÆ (RAMULI).

simplices.
furcati.
simpliciter furcati.
duplicato furcati.
repetito furcati (flabellati).

longifurcati.
brevifurcati.

BRANCHLETS OF CHAREÆ (RAMULI).

phlœopodes = branchlets with the lowest segment corticate.
gymnopodes = branchlets with the lowest segment ecorticate, those above corticate.

podophora = bearing sexual organs at the lowest free node.
podosteira = having the lowest free node sterile.

* As explained on page 25 we cannot regard the branchlets as leaves, hence we have substituted 'clema' for 'phylla' in this and the following terms.

macroteles, microteles, brachyteles, gymnoteles — In reference to the two or three upper segments.

corticati
ecorticati.

convergentes.
conniventes.
divergentes.
refracti.

Ultimate Rays (Dactyls) of Nitella.

anarthrodactyla.
arthrodactyla.

monarthrodactyla.
diarthrodactyla.
polyarthrodactyla.

macrodactyla.
brachydactyla.

Ultimate Cells of Branchlets.

conicæ.
allantoideæ.

obtusæ.
acutæ.

acuminatæ.
apiculatæ.
mucronatæ.

Bract-cells.

macroptila (longibracteata).
microptila (brevibracteata).

isoptila.
heteroptila.

inchoatæ.
papilliformes.
ovoideæ.
allantoideæ.
cylindricæ.
aciculatæ.

bulbosæ.

Stipulodes.

haplostephana.
diplostephana.
triplostephana.

unistipulata.
bistipulata.

macrostephana.
microstephana.

valde evoluta.

inchoata.

bulbosa.

Cortex.

haplosticha.
diplosticha.
triplosticha.

isosticha (æquistriata).
anisosticha (inæquestriata).

dissoluta = cortical rows non-contiguous.
contigua = cortical rows contiguous.

regulariter corticata.
irregulariter corticata.

Armature.

macracantha (longispina).
micracantha (brevispina).

pachyacantha.
radinacantha (leptacantha).
desmacantha.

subhispida.
hispidula.
papillata.
verrucosa.

horrida.
subinermis.

Spine-cells (Spinulæ).

solitariæ.
geminatæ.
fasciculatæ.

longæ, longiores, longissimæ.
breves, breviores, brevissimæ.

inchoatæ.
papilliformes.
ovoideæ.
allantoideæ.
cylindricæ.
aciculatæ.

truncatæ.
obtusæ.
acutæ.
acuminatæ.

bulbosæ.

patentes.
adpressæ.

OOGONIA.

macrocarpa.
microcarpa.

glœocarpa.
gymnocarpa.

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solitaria.
geminata.
aggregata.

subglobosa.
ellipsoidea.
ovoidea.

CORONULA.

longa, longior.
brevis, brevior.

connivens.
recta.
patula.

OOSPORE.

macrosperma.
microsperma.

pachysperma.
leptosperma.

oxygyra.
leiopyrena.
pachygyra.

phæopyrena (phæocarpa).
melanopyrena (melanocarpa).

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subglobosa.
ellipsoidea.
cylindrico-ellipsoidea.
ovoidea.
obovoidea.

MEMBRANE OF OOSPORE.

tenuis.
crassa.

translucens.
semi-opaca.
opaca.

flexilis.
semi-rigida.
rigida.

levis.
granulata.
reticulata.
tuberculata.

flava.
pallide-flava.
flavo-rubra.
flavo-brunnea.
rubra.
rubro-brunnea.
brunnea.
castanea.
atro-brunnea.
atra.

ANTHERIDIA.

terminalia.
lateralia.

magna, majora, maxima.
parva, minora, minima.

globosa (sphærica).
subpyriformia.

BULBILS.

unicellulares.
compositæ.

globosi.
fragariformes.
stelliformes.

SYSTEMATIC ACCOUNT OF THE BRITISH CHAROPHYTA.

The following account of the history of the identification of Charophyta in this country is reprinted from "A Review of the British Characeæ," by H. & J. Groves ('Journ. Bot.,' XVIII, pp. 97–99, 1880).

"In the second edition of Gerard's 'Herball,' edited by Johnson (1633), is the first mention we can trace of any Charas in British books. Two species are given: *Hippuris coralloides*, which is described as new, and *Equisetum fœtidum sub aqua repens* Bauh.; both of these are probably *C. vulgaris*. In Parkinson's 'Theatrum Botanicum' (1640) a figure of *C. vulgaris* is given under Gerard's second name. Ray, in 'Catalogus Plantarum Angliæ' (1670), mentions the same two species as in Gerard, but the first under Gesner's name *Equisetum s. Hippuris lacustris foliis mansu arenosis*. Plukenet, in his 'Phytographia,' vol. i (1691), figures *C. vulgaris* (tab. 29) under Gesner's name, and *C. polyacantha** (tab. 193), which he describes from a plant sent from Ireland by Sherard as *Hippuris muscosis sub aqua repens*; of the latter there is a specimen in his herbarium in the British Museum. In the second edition of Ray's 'Synopsis' (1696) four species are given, the addition being *C. minus sub aqua repens ad genicula polyspermon*, which is described from Jersey, collected by Sherard, and is probably *Nitella opaca*. Morison, in 'Plant. Hist. Universalis Oxon,' vol. iii (1699), figures a plant which he describes as *E. fragile majus subcinerea aquis immersum*: this is probably a large slightly-hispid form of *C. vulgaris*. In the third (Dillenian) edition of Ray (1724), Vaillant's generic name of *Chara* is introduced, and *C. translucens minor flexilis* (*N. opaca?*) is added.

* = *C. aculeolata* Kütz.

In Hudson's 'Flora Anglica' (1762) the four Linnean names are given:—(1) *C. tomentosa* (for large forms of *C. vulgaris*); (2) *C. vulgaris* (for *C. fragilis* and the smaller forms of *C. vulgaris*); (3) *C. hispida*; and (4) *C. flexilis* (for *N. flexilis* and *N. opaca*). In Smith's 'Flora Britannica' (1800) the same four are given, but Hudson's *C. tomentosa* is reduced to a variety of *C. hispida*. Withering, in his 'Botanical Arrangement' (1776), gives in addition to these *C. repens* as the name for Sherard's Jersey plant. In 'English Botany' *C. nidifica* (*Tolypella glomerata*) (1807), *C. translucens* (1808), and *C. gracilis* (1810) are added. S. F. Gray, in 'Natural Arrangement of Brit. Plants' (1821), describes *C. stellata* (apparently *N. tenuissima*), and adds '*C. crinita*' (*C. polyacantha*). Greville, in 'Scottish Cryptogamic Flora,' vol. vi (1828), adds *C. aspera*. In 1830, Wilson, in Hooker's 'Bot. Miscellany,' describes under the name of *C. gracilis* a diœcious plant (*N. capitata?*). In Hooker's 'Brit. Flora,' vol. ii, part 1 (1833), eight species: *translucens, flexilis, nidifica, gracilis, vulgaris, Hedwigii, aspera,* and *hispida*, are given, *C. Hedwigii* being an addition. The Rev. M. J. Berkeley, in 'E. B. Suppl.,' vol. ii (1834), figures *C. Hedwigii*, and in a note thereto gives a description of '*C. nidifica*' from Henfield (*T. prolifera*). In 1841, in the second (Johnson's) edition of 'English Botany,' the two genera, *Chara* and *Nitella*, are given. Hooker, in 'Lond. Journ. of Bot.' (1842), records *C. latifolia* (*C. tomentosa*) as British, and in 'Icones Plantarum,' vol. vi, gives a figure of it. Berkeley, in 'E. B. Suppl.,' vol. iii (1843), figures *C. pulchella* (*C. fragilis*).

"In 1850 commenced a new era in the knowledge of our Charas, when Prof. Babington, in his monograph in the 'Annals and Magazine of Nat. Hist.,' completely rearranged the species. *C. syncarpa* (Thuill.) was then first definitely separated from *C. flexilis*; *C. mucronata* and *C. crinita* Wallr. (*C. canescens*), were added; the number of the *Tolypellæ* was increased from one to four: *C. prolifera* (*T. glomerata*), *C. polysperma* (*T. intricata*), *C. Borreri* (*T. prolifera*), and *C. Smithii* (*T. glomerata*), the two latter being described as new; and *C. pulchella* and *C. Hedwigii* were united as *C. fragilis* Desv. In Johnson's 'Fern Allies' (1855) there is nothing new, but plates are given of eleven species, some of which are not good. In 1862, Babington, in Seemann's 'Journ. of Bot.,' describes *C. alopecuroides* as British. Mr. Baker, in the 'Botanical Exchange Club Report' for 1867, gives a revision of the *Tolypellæ*, reducing the certainly British species to two, giving *C. Borreri* as the var. *robustior* of *C. intricata*, and mentioning *C. nidifica* as possibly British. In the 'Journ of Bot.,' 1877, Dr. Trimen adds *C. fragifera* to the list."

The following notes will supplement the foregoing:—

In 1878 *C. connivens* was added to the British list through the identification of a specimen in Herb. Borrer collected fifty years earlier.

In 1880, in "A Review of the British Characeæ," already cited, an attempt was made to give an account of all the then-known British species, with illustrations and some particulars as to their variation and distribution. In the autumn of the same year *Nitellopsis obtusa* (*Chara stelligera* Bauer) was discovered by Mr. Arthur Bennett in one of the Norfolk Broads, and was described and figured in the 'Journal of Botany' for January, 1881.

In December, 1881, there appeared in the 'Journal of Botany' the first of a series of nine papers by H. & J. G., entitled "Notes on British Characeæ," the last being published in 1898. These included descriptions and figures of fresh species added to the British list, records for fresh counties, and odd notes. In the first instalment *C. baltica* (var. *affinis*) was described and figured from a plant first collected in 1876 by the late James Cunnack, near the Lizard. In the same paper *C. contraria* was added, with a figure from a

Cambridgeshire specimen. This species had already been included in the eighth edition of Babington's 'Manual' (1881), but the plant referred to therein proved to be a form of *C. delicatula*. In 1883 *Chara Braunii* was discovered by Mr. Charles Bailey, growing at large, though apparently not native, in a canal near Reddish, and this was described and figured in 1884.

In 1884–5 two parts of Vol. XII of the third edition of 'English Botany' were published, containing an account of the British species, written by Boswell, but edited with a number of additions by Mr. N. E. Brown. Though this contained much useful and interesting information, the account cannot be considered a satisfactory one. Several species regarded as certainly distinct by such eminent authorities on the Charophyta as Braun and Nordstedt were reduced to varieties. In two cases the plants so combined belong, in the opinion of those who have studied the group, to different sections. The old imperfect original plates were reproduced with the addition of dissections, which are not always accurate, while a number of new plates were added. Some of the latter, notably those of Tolypellæ, drawn by Mr. Brown, are excellent.

In 1885, by the discovery of *N. capillaris* (*N. capitata* Ag.) by the late Alfred Fryer in Cambridgeshire, that species was established as British, previous records being uncertain. A description and plate of this were given in 1886 in a further instalment of the "Notes," as also of a curious *Chara* collected in Norfolk by H. & J. G. and referred to *C. papillosa* (*C. intermedia* Braun). Subsequent investigations of the latter, however, led to the conclusion that the plant was a hybrid. In 1888, *N. batrachosperma* was found in the Hebrides by Mr. W. S. Duncan, and described and figured in the "Notes" in 1890 under the name of *N. Nordstedtiana* H. & J. G. This species had already been discovered in two localities in Ireland by Mr. R. W. Scully, but was thought at the time to be a small form of *N. gracilis*. In 1892 *C. denudata* was discovered by the late H. C. Levinge in West Meath, and this was figured in the "Notes" in 1895, and in the same year in the 'Irish Naturalist' an account was given of the distribution of the Charophyta in Ireland as then known. In 1898 the British list received an extremely interesting addition by the discovery by G. R. B.-W. near Helston of *N. hyalina*. This was figured the same year, in the last instalment of the "Notes," as was also *C. aspera* subsp. *desmacantha*, which latter we have thought worthy of separate specific rank. In 1901, Mr. R. Lloyd Praeger, in his 'Irish Topographical Botany,' published a much extended list of records of Irish species.

Thirty-eight years ago, prior to the appearance of the "Review," practically nothing had been done towards working out the distribution of these plants in the British Isles. In that little work the known records were brought together, with many additions, and since then the number of county and vice-county records has greatly increased, thanks to the co-operation of numerous friends and correspondents. In many cases the increase has been three- and four-fold, while species thought to be extremely local, e. g. *T. glomerata* and *C. aculeolata* have proved to be widely distributed, and *C. contraria*, which in 1880 was not known to be British, has now (Ireland included) the considerable census total of 58.

Though many blanks will probably be filled in, it may fairly be claimed that the main distribution of most of the species has been ascertained. That indefatigable botanist, Mr. Arthur Bennett, through his large circle of correspondents, has done more than anyone else to bring about this result as regards England and Scotland, while Mr. R. Lloyd Praeger has managed in a comparatively short time to work wonders in getting together records for the Irish counties.

The counties and vice-counties cited under the several species are those from which we have actually seen specimens, with a very few exceptions, and in these the authorities are stated. It has not as a rule been considered safe to depend on printed records, so many extraordinary cases of incorrect determination having occurred, even by botanists of high standing.

In the arrangement of genera and species we have in the main adopted that of Braun and Nordstedt's 'Fragmente,' but have followed Professor Hy in separating *Nitellopsis* from *Lychnothamnus*, and, among the *Charæ diplostephanæ diplostichæ*, have placed the sub-section *aulacanthæ* before the *tylacanthæ*, since among British species some of the latter appear to be more nearly allied to the section *triplostichæ* than any of the former. No linear arrangement can be entirely natural, and the separation of some closely allied species (e.g. *C. vulgaris* and *C. contraria*) is inevitable.

We have adopted the designations *Anarthrodactylæ* and *Arthrodactylæ* for the primary divisions of *Nitella* in preference to those employed by Braun, viz. *Monarthrodactylæ*, *Diarthrodactylæ*, and *Polyarthrodactylæ*, for the following reasons:—the first of Braun's names does not appear to be etymologically correct for the purpose to which it is applied, the "dactyl," i.e. the ultimate ray, not itself possessing any joint, though jointed to the limb below. The human finger could hardly be described as one-jointed, if it had but a single bone. Similarly *Diarthrodactylæ* is open to objection, since normally the 2-celled "dactyl" has but one joint or division. We combine Braun's second and third sections in view of the difficulty of drawing a satisfactory line between them. We have not adopted Professor Hy's sections *Furcinitella* and *Cornitella*, as the characters upon which they are based can be applied to European species only.

The Charophyta are extremely plastic, most species being subject to much variation of form, due probably to a great extent to external causes, which however are not always apparent. Though it is a matter of convenience to distinguish extreme forms by varietal names, they are, as a rule, connected with each other by an unbroken series of intermediates. Some authors have attempted to give names to every slight variation. In this way Dr. Migula has enumerated with elaborate diagnoses no less than 70 European varieties of *C. fœtida* (*C. vulgaris*). While admiring such patience and assiduity, it is difficult to see that any useful end is served by the attempt to make minute distinctions between plants which are evidently mere states, besides which there is no limit to such differentiation.

In this work varietal names have been used only for the most distinct forms, but we have endeavoured to give an idea of the extent of variation exhibited by the British representatives of each species.

In the synonymy for each species we have endeavoured to give references to all important European books and papers dealing exclusively with the Charophyta, to general works in which these plants have had special attention, and to all illustrations of any importance. Specific names bestowed on particular varieties or forms not found in Europe have not been included in the lists of synonyms.

The citations will, it is hoped, be found sufficiently full to allow of easy reference, in the large libraries, to the books and papers cited. The complete titles will be found in the bibliography included in the second volume.

The dimensions given of the fruits, antheridia, etc., are the result of measurements of a number of fairly normal specimens. They should be taken as an approximate guide only, since the limits of variation of size in some species are extremely wide, and the figures would lose their significance if extended so far as to include every form.

The British species of Charophyta are for the most part fairly distinct, but, except in the case of a few which are particularly compact and well marked, the various organs, especially those of the vegetative system, are liable to considerable variation, and aberrations from what is apparently the normal form of an organ in a particular species are common. In consequence of this we have been obliged to make more frequent use of the word "usually" in the diagnoses than we should wish. In the case of the more protean species, were the descriptions framed so as to include every variation to be met with in point of number, size and form of the various organs, there would be little left in the shape of characters to distinguish them.

The measurement of the internodes is taken where the stem has lengthened out and does not apply to those between the close-growing upper whorls.

The extent to which the spiral-cells of the oogonia and the ridges on the oospore are twisted, in the several species, is denoted by stating the number of convolutions and ridges visible from one side (the broader dimension in the case of *Nitellæ*), as being simpler than attempting to state in fractions the precise extent traversed by each spiral-cell.

In the matter of nomenclature, the rule of strict priority has so far as possible been followed. In doing this we have been obliged, very reluctantly, in a few cases to supersede specific names generally in use, in favour of those published earlier. The temporary inconvenience of such a course is fully recognized, but, if the 'International Rules' are to be accepted, the alterations must be made sooner or later, and it seems to us, therefore, "the sooner, the better."

That wonderfully acute and clear-sighted botanist, Alexander Braun, was the first who can be said to have acquired any real grasp of the distinctive characters of the Charophyta from a systematic point of view, and, prior to the commencement of his publications on the subject in 1834, the descriptions, based for the most part on superficial and unimportant characters, were, when unaccompanied by drawings, practically valueless for the purpose of identification. The preservation of authenticated specimens, and a certain amount of collateral evidence, have however in many cases placed the identity of the species intended beyond any reasonable doubt, and in such cases the early names should, we think, be retained.

If a name, accompanied by a description, is published by a reputable author, the onus surely rests with later writers to exhaust all possible means of ascertaining what was intended, before setting such a name aside. Braun's unquestionable authority in regard to matters of fact in relation to the Charophyta has led, quite naturally, to his nomenclature being followed implicitly by many botanists, especially among his fellow-countrymen. Unfortunately his views as regards nomenclature were by no means stable. Priority of publication was of little importance in his eyes, and he would quite readily re-name even his own species! He was, however, very careful in working out synonymy, so that his own works afford the means of correcting the nomenclature to accord with modern usage.

As in the case of many other cryptogams, the imperfect knowledge in earlier times of the minute anatomy of the Charophyta led to a very confused idea as regards the species, and it is impossible to arrive with any degree of certainty at the meaning which should be attached to most of the pre-Linnean names. They have, therefore, in only a few cases been cited in the synonymy. We hope in the second volume to include a list of all the names published prior to 1753.

The names given by Linnæus in 'Species Plantarum,' the starting point of modern nomenclature, seem to stand in a somewhat different position from those of any other author. That great work was an attempt to summarize, under binominal names, all species of plants then known, and we think that Linnæus's species should therefore be construed liberally, not narrowing them down to plants actually seen by him, still less, as some authors have attempted to do, confining them to those forms occurring in Sweden, but treating them as broad inclusive species, that is such aggregates as might be expected *at that time* to be regarded as specific units. To fasten a Linnean name to a modern micro-species of bramble, rose, or eyebright, is to verge on the ridiculous.

Four species were included by Linnæus in 'Species Plantarum,' but much difference of opinion exists as to their retention and application. We have thought it right to retain all the four specific names. The reasons for applying them as we have done are stated at length under the several species. Their original meaning we take to be roughly as follows:—No. 1, *tomentosa* intended for the plant now bearing the name; No. 2, *vulgaris* for the then-known corticate plants without, and No. 3 *hispida* for the corticate plants with, conspicuous spine-cells; No. 4, *flexilis* for the *Nitelleæ* as possessing no cortex, and therefore diaphanous.

The practice of quoting the numerous manuscript names to be found in herbaria has not been followed, our view being that if the originator of a name does not think it worth while to publish it, such a name should not be ascribed to him. In many cases manuscript names are only *obiter dicta* given provisionally without careful investigation of the plants themselves, or of the descriptions already published, and the citation of such names seems not only to add to the volume of synonymy without serving any useful purpose, but even sometimes to do an injustice to their authors. Where a manuscript name is the first one bestowed upon a plant, it is clearly allowable, perhaps even desirable, for the author who first describes the species to adopt it, but, for the reasons already given, we do not think manuscript names are entitled to any special consideration.

To supersede the earliest published name, as has been done in the case of several Charophyta, because an earlier MS. name has been unearthed from some herbarium, is not only contrary to the 'Rules,' but is obviously against the general convenience of botanists, which is after all the main object of nomenclature.

KEY TO THE GENERA.

Coronula of oogonium composed of 10 cells in two tiers. Branchlets usually furcate. Ripe oospore terete or laterally compressed . . . NITELLEÆ.

Antheridia apical in the furcations of the branchlets above the oogonia. Ripe oospore laterally compressed . . . . . . 1. NITELLA.

Antheridia lateral at the furcations of the branchlets. Ripe oospore terete . . . . . 2. TOLYPELLA.

Coronula of oogonium composed of 5 cells in one tier. Ripe oospore terete . . . . . CHAREÆ.

Stipulodes absent. Branchlets of 2–3 very long segments. Bract-cells 1–2, very long 3. NITELLOPSIS.

Stipulodes always present, sometimes rudimentary. Branchlets not furcate of 4 or more segments. Bract-cells normally 4 or more.

Oogonium normally situated below the antheridium. Stem ecorticate . . 4. LAMPROTHAMNIUM.

Oogonium and antheridium situated side by side. Stem corticate. (*Not British.*) LYCHNOTHAMNUS.

Oogonium situated above the antheridium. Stem corticate or ecorticate . . . . 5. CHARA.

KEY TO THE BRITISH SPECIES.

NITELLA.

Ultimate rays of branchlets one-celled. Coronula deciduous.

Antheridia and oogonia enveloped in mucus. Ridges of oospore very prominent. Diœcious
1. *N. capillaris.*

Antheridia and oogonia not enveloped in mucus. Ridges of oospore not prominent. Diœcious or monœcious.

Diœcious. Oospore 375–425 μ long . . 2. *N. opaca.*

Monœcious. Oospore 500–575 μ long.

Branchlets 6–8 in a whorl . . 3. *N. flexilis.*

Branchlets 1–3 developed in a whorl
4. *N. spanioclema.*

Ultimate rays 2–3-celled. Coronula persistent.

Branchlets in each whorl uniform and in one series.

Branchlets once furcate. Secondary rays usually minute and inconspicuous . . 5. *N. translucens.*

Branchlets twice to four times furcate. Ultimate rays not much shorter than the penultimate.

Penultimate cell of terminal ray rounded at the apex. Apical cell minute. Ultimate rays usually all 2-celled . 6. *N. mucronata* (type).

Penultimate cell of terminal ray tapering at the apex, which is not much broader than the base of the apical cell.

Ultimate rays, some 2-celled, some 3-celled.

Membrane reticulate
6. *N. mucronata* var. *gracillima.*

Membrane granulate . . 7. *N. gracilis.*

Ultimate rays all 2-celled.

Oogonia produced at the first furcation of the branchlet. Membrane granulate
8. *N. batrachosperma.*

Oogonia not produced at the first furcation of the branchlet. Membrane reticulate
9. *N. tenuissima.*

Branchlets in each whorl of two kinds, smaller accessory branchlets being produced above and below the primary branchlets . . 10. *N. hyalina.*

TOLYPELLA.

Ultimate cell of the rays conical. Membrane of oospore extremely thin.
- Sterile branchlets furcate . . . . 1. *T. intricata.*
- Sterile branchlets simple . . . . . 2. *T. prolifera.*

Ultimate cell of the rays allantoid. Sterile branchlets simple. Membrane of oospore thick.
- Ripe oospore small (c. 340 × 275 μ) ellipsoid, membrane dull yellow to red . . . 3. *T. glomerata.*
- Ripe oospore large (c. 450 × 400 μ) subglobose, membrane wine-red . . . . 4. *T. nidifica.*

NITELLOPSIS. One species.

LAMPROTHAMNIUM. One British species.

CHARA.

Haplostephanous, *i. e.* stipulodes in a single row.
- Stem ecorticate . . . . 1. *C. Braunii.*

Diplostephanous, *i. e.* stipulodes in a double row.
- Stem-cortex rudimentary (see also below) . 8. *C. denudata.*
- Stem-cortex haplostichous, *i. e.* having a single row of cortical-cells to each branchlet . 2. *C. canescens.*
- Stem-cortex diplostichous, *i. e.* having two rows of cortical-cells to each branchlet, a central (primary) and a lateral (secondary).
  - Aulacanthous, *i.e.* secondary cortical-cells more prominent than the primary.
    - Posterior bracts usually rudimentary. Spine-cells all solitary . . . . 3. *C. vulgaris.*
    - Posterior bract-cells developed. Spine-cells mostly two or three together.
      - Secondary cortical-cells much larger than the primary. Spine-cells mostly geminate, one above the other . . . 4. *C. rudis.*
      - Secondary cortical-cells not much larger than the primary. Spine-cells mostly 2–3 together, when geminate usually produced side-by-side . . . . 5. *C. hispida.*
  - Tylacanthous, *i. e.* primary cortical-cells more prominent than the secondary.
    - Diœcious. Spine- and bract-cells very broad. Lowest branchlet-segment with ascending cortex . . . . . 6. *C. tomentosa.*

Monœcious. Lowest branchlet-segment without ascending cortex.

Spine-cells and stipulodes short, somewhat blunt, posterior bract-cells rudimentary.

Cortex developed . . . 7. *C. contraria.*

Cortex rudimentary, or only partially developed . . . . 8. *C. denudata.*

Spine-cells and stipulodes long and acute, posterior bract-cells developed.

Primary cortical-cells scarcely the more prominent, secondary cells not overlapping.

Cortex regular, spine-cells solitary 9. *C. baltica* (type).

Cortex irregular, spine-cells 2–3 together 9. *C. baltica* var. *affinis.*

Primary cortical-cells much the more prominent, spine-cells very long, fasciculate. Cortex irregular, secondary cells often overlapping 10. *C. aculeolata.**

Stem cortex triplostichous, *i.e.* having three rows of cortical cells to each branchlet, a central (primary) and two lateral (secondary).

Diœcious.

Spine-cells developed, usually long and conspicuous. Root producing globular bulbils.

Spine-cells solitary . . . 11. *C. aspera.*

Spine-cells fasciculate . . 12. *C. desmacantha.*†

Spine-cells rudimentary.

Branchlets of male plant strongly connivent. Branchlets of 8–9 segments. Root not producing bulbils . . 13. *C. connivens.*

Branchlets of male plant not strongly connivent. Branchlets of 9–13 segments. Root producing large composite bulbils 14. *C. fragifera.*

Monœcious.

Primary and secondary cortical-cells of about equal diameter and prominence. Stipulodes and spine-cells rudimentary . . 15. *C. fragilis.*

Primary cortical-cells larger and more prominent. Stipulodes and spine-cells more or less developed . . 16. *C. delicatula.*

* *C. aculeolata* Kützing = *C. polyacantha* Braun.

† *C. desmacantha* sp. nov. = *C. aspera*, var. *desmacantha* H. & J. Groves, 'Journal of Botany,' xxxvi, p. 410, t. 391 (1898).

NITELLEÆ.

Leonhardi in Lotos, XIII, p. 69 (1863).
Charæ epigynæ Braun in Ann. Sc. Nat. ser. 2, I, p. 350 (1834).

Stem and branchlets entirely without cortex. Branches normally two or more at a stem-node. Fertile branchlets normally furcate.* Ultimate rays† one or more-celled, other rays one-celled. Coronula of oögonium of 10 cells in two tiers of 5.

Genus 1. **NITELLA** Agardh (emend. Leonhardi).

Nitella Agardh Syst. Alg. p. xxvii (1824) *pro parte.*
Leonhardi in Lotos, XIII, p. 69 (1863).
Braun in Cohn, Krypt. Fl. Schles. I, p. 395 (1876).

Nitella sect. *furcatæ* Braun in N. Denks. Schweiz. Ges. Naturw. X, p. 6 (1849).

Nitella sub. gen. *Eunitella* Braun in Hooker's Journ. Bot. I, p. 194 (1849).

Nitella sect. *ebracteatæ* Wallman Försök Syst. Charac. pp. 12 & 15 (1853); Transl. pp. 11 & 14 (1856).

Branches normally two at a stem-node. *Fertile branchlets* simply or repeatedly furcate, with more or less equal rays, or rarely simple with a single node. *Antheridia* terminal, situated in the furcations of the branchlets. *Oogonia* produced laterally at the nodes of the branchlets, in the monœcious species below the antheridia. *Oospores* ellipsoidal or spheroidal, laterally compressed.

A large genus, presenting a wide range as regards facies and complexity of vegetative structure, varying

* As a matter of convenience, we use the terms *furcate* and *furcation* in connexion with each point of division of a branchlet in the *Nitelleæ,* though strictly speaking it is applicable only to those divisions in *Nitella* where an antheridium is produced; in other cases all but one of the limbs are lateral. This point is well exemplified by Filarszky-Nandor in the diagrammatic plate (t. 3) of his *Die Characeen Ungarn* (1893).

† We use the term *ray* for each limb of the branchlet of a *Nitella* or *Tolypella,* whether central or lateral; the *primary ray* denoting the simple basal portion (stalk) of the branchlet, the *secondary rays* those limbs which arise at the first node, and so on in the case of further furcation, but the limbs arising at the uppermost furcation are also styled *ultimate rays.*

from the simplest form with few similar once-forked branchlets and 1-celled secondary rays, to complex types, (1) with numerous branchlets of differing forms, (2) with repeatedly forked branchlets often partially monopodial in growth, and (3) with the ultimate rays many-celled.

The terminal position of the antheridium is the most important distinctive character of the genus. The laterally-compressed oospore seems also to be peculiar to the genus, and affords an important distinction which does not appear to have been hitherto recognized.

The stem and branchlets are usually of a clear translucent green colour, and, owing to the absence of cortex, and the small extent to which they become incrusted with lime, are more flexible than in most of the species belonging to the other genera. The incrustation when present is almost always annular in character, the bands being approximately of the same width as the spaces between them. We have not met with any explanation of the cause of this phenomenon, which is apparently peculiar to the genus. The known species number about 100, distributed throughout the world.

Section 1. *ANARTHRODACTYLÆ* (=*Monarthrodactylæ* Braun).

Ultimate rays one-celled.

1. **Nitella capillaris** *comb. nov.*

(Plate VI.)

Chara capillaris Krocker Fl. Siles. III, p. 62 (1814).
C. capitata Nees in Denks. Baier bot. Ges. II, p. 80, t. 6 (1818).
Bruzelius Obs. gen. Charæ. p. 24 (1824).
Braun in Ann. Sc. Nat. sér. 2, I, p. 352 (1834).
C. elastica Amici in Mem. Accad. Modena, I, p. 205, t. 1–2 (1827).
C. glomerata Bischoff Krypt. Gew. t. 1, f. 6, 8 (1828) *non* Desv.
C. syncarpa Reichenbach Iconogr. Bot. *pro parte*, f. 1076–7 (1830) ?
C. syncarpa var. *capitata* Ganterer Österr. Char. p. 9 (1847).

C. gracilis Wahlenberg Fl. Suec. p. 694 (1826) *fide* Braun (*non* Smith).
Nitella capitata Agardh Syst. Alg. p. 125 (1824).
Wallman Försök syst. Charac. p. 37 (1853); Transl. p. 32 (1856).
Wahlstedt Bidrag Skand. Charac. p. 8 (1862); Mon. Sver. & Norg. Charac. p. 15 (1875) (misprinted *capita*).
Nordstedt in Bot. Notiser, 1863, p. 34.
Crépin in Bull. Soc. Bot. Belg. II, p. 130 (1863).
Rabenhorst Krypt. Fl. Sachs. I, p. 287 (1863).
Leonhardi in Verh. Nat. ver. Brünn, II, p. 166 (1864).
Braun in Monatsb. Akad. Berl. for 1867, p. 873 (1868); in Cohn, Krypt. Flor. Schles. I, p. 396 (1876).
Müller in Bull. Soc. Bot. Genève, II, p. 49 (1881).
Braun & Nordstedt Fragm. Mon. Charac. p. 31 (1882).
Sydow Europ. Charac. p. 12 (1882).
Groves in Journ. Bot. XXIV, p. 3, t. 264 (1886).
Migula Die Characeen, p. 111, f. 31-34 (1890); Syn. Charac. Europ. p. 29, f. 19–22 (1898).
Filarsky-Nandor Charac. Ungarn. p. 120, f. 17 (1893).
Holtz Characeen in Krypt. Mark-Brandenb. p. 70 (1903).
Prósper Carofit. Españ. p. 64, t. 10a (1910).
Hy in Bull. Soc. Bot. France, LX, Mém. 26, p. 7 (1913).

N. syncarpa vars. *capitata* & *glœocephala* Kützing Phyc. Germ. p. 256 (1845).

N. syncarpa vars. *capitata* & *oxygyra* Rabenhorst Deutsch. Krypt. Fl. II, p. 195 (1847).
Braun in N. Denks. Schweiz. Ges. Naturw. X, p. 7 (1849) (misprinted *oxygyna*).

N. syncarpa var. *capitata* Boswell Engl. Bot. ed. 3, XII, p. 177 (1884).

Exsiccata:—Areschoug 300; Billot 1986–7; Braun, Rabenh. & Stiz. 26–28, 104; Desmazières II, 319; Groves 30; Nielsen 2, 3, 48 (*fide* Wahlst.); Nordstedt & Wahlstedt, 3, 4.

Diœcious. *Stem* rather slender, the *internodes* sometimes, though not usually, twice as long as the branchlets. *Whorls* of 6–9 branchlets. *Branchlets* once forked, the primary and secondary rays usually of nearly equal length; secondary rays 2–4, one-celled, apex extremely variable, sometimes quite blunt, but usually abruptly or gradually narrowed into an acuminate (sharp) point. *Fertile whorls* mostly with very short branchlets forming dense heads. *Oogonia* and *antheridia* surrounded by an amorphous gelatinous envelopment. *Oogonia* 2 or 3 together or solitary, c. 550–575 μ long, c. 425–450 μ broad; *spiral cells* showing usually 7 convolutions, becoming swollen at the apex; *coronula* c. 25–35 μ high, deciduous. *Oospore* c. 375–400 μ long, 325–375 μ broad, 300 μ thick, chestnut-brown, showing about 6 very prominent sharp-flanged ridges; *outer membrane* semi-rigid and translucent, yellow-brown, decorated with minute non-contiguous rounded tubercles (Pl. IV, figs. 1, 2). *Antheridium* large, c. 600 μ in diameter.

Distribution.—Cambridgeshire, Sutton Gault, in a ditch some 50 yards long, near the Old Bedford River, where it was discovered in 1885 by the late Alfred Fryer of Chatteris.

Outside the British Isles *N. capillaris* is recorded from Norway, Sweden, Denmark, Spain, France, Belgium, Germany, Switzerland, Austria, Hungary, Italy, Serbia, and Greece; also from North Africa, Asia, and North America.

A slender elegant species, about 20–30 cm. in height, usually light-green and often with conspicuous annular incrustation.

From *N. opaca* it is distinguished by the gelatinous envelopment of the oogonia and antheridia, the more strongly and acutely flanged ridges of the oospore, and the finely tubercled membrane. It is also usually more slender, has somewhat more sharply pointed secondary rays, of which on the barren branchlets there are often 3 and sometimes 4. The fruits are also usually clustered.

Nordstedt, in his 'De Algis et Characeis,' has the following observation on *N. capitata* :—"Membrane thickly covered with little scattered warts which change to small prickles. Prickles about 1·5 μ thick, about 3–4 μ long, generally hyaline; in surface view of the membrane they are not quite rounded, but more or less angular, which probably induced de Bary to describe the membrane of this species as furrowed in a net-work" (translated).

Although the small dyke in which it was originally found, and where it continued to flourish, is connected by a small channel with the Old Bedford River, the plant seems to have spread but little. A few isolated specimens have been collected in this old river-cut, but it does not appear to have established itself in any new locality, in spite of the freedom with which it fruits. The oogonia ripen early in June.

Specimens previously collected in Kent (Stowting), Carnarvonshire (Lake Idwal), and Kerry (Killarney) were referred by Braun to this species, but we do not feel satisfied as to the identity of either of the two last-named. The Lake Idwal plant, when collected subsequently by J. E. Griffith and examined in a fresh condition, was found to be an extremely slender form of *N. opaca*. In former years sufficient care was not taken by British collectors in the selection and preparation of herbarium specimens of Charophyta, and in consequence much of the material in the public collections is unsatisfactory and inadequate for determination.

The name by which the present species is generally known is *N. capitata*, but inasmuch as there appears to be no doubt as to the identity of the plant intended by the earlier published name, *capillaris*, though the author's description is imperfect, the rules of nomenclature give no option but to adopt it. Were it allowable, it would be more satisfactory in this, as in several other cases, to be able to retain the later name, especially as, in the present instance, it was accompanied by a good illustration.

[**N. syncarpa** Chevall., a species nearly related to *N. capillaris*, is widely distributed in Europe, but has not yet been found in the British Isles. This species has also the gelatinous envelopment of the sexual organs, but the oospore is only faintly ribbed and in the female plant the branchlets are not forked but have a single secondary ray. The membrane is not decorated.]

2. **Nitella opaca** Agardh.

(PLATE VII.)

Chara flexilis SMITH Engl. Bot. 1070 (excl. synon.) (1802).

C. opaca BRUZELIUS, Obs. Char. p. 23 (1824).

Nitella opaca AGARDH Syst. Alg. p. 124 (1824).
  WALLMAN Försök syst. Charac. p. 36 (1853); Transl. p. 31 (1856).
  WAHLSTEDT Bidrag Skand. Charac. p. 6 (1862); Mon. Sver. & Norg. Charac. p. 15 (1875).
  NORDSTEDT in Bot. Notiser, 1863, p. 34.
  CRÉPIN in Bull. Soc. Bot. Belg. II, p. 129 (1863).
  LEONHARDI in Verh. Nat. ver. Brünn, II, p. 165 (1864).
  BRAUN in Monatsb. Akad. Berl. for 1867, p. 875 (1868); in Cohn, Krypt. Fl. Schles. I, p. 397 (1876).
  GROVES in Journ. Bot. XVIII, p. 166, t. 210, f. 19 (1880).
  MÜLLER in Bull. Soc. Bot. Genève, II, p. 50 (1881).
  COSSON & GERMAIN Atl. Fl. Par. ed. 2, t. 45 f.B (1882).
  BRAUN & NORDSTEDT Fragm. Mon. Charac. p. 32 (1882).
  SYDOW Europ. Charac. p. 14 (1882).
  MIGULA Die Characeen p. 121, f. 35, 36 (1890); Syn. Charac. Europ. p. 31, f. 23, 24 (1898).
  HOLTZ Characeen, in Krypt. Mark-Brandenb. p. 71 (with fig.) (1903).
  HY in Bull. Soc. Bot. France, LX, Mém. 26, p. 9 (1913).

N. pedunculata AGARDH Syst. Alg. p. xxvii (1824), *fide* Braun.
C. syncarpa AUCT. PLUR. (*non* Thuill.).
REICHENBACH Iconogr. f. 1078–1079 (1830).
BABINGTON in Ann. and Mag. Nat. Hist. ser. 2, V, p. 83 (1850).
C. capitata var. *opaca* BRAUN in Ann. Sc. Nat. sér. 2, I, p. 352 (1834).
C. syncarpa var. *pseudo-flexilis* BRAUN in Flora, XVIII, i, p. 51 (1835).
GANTERER Osterr. Char. p. 9 (1847).
C. syncarpa var. *opaca* BRAUN in Flora, XVIII, i, p. 52 (1835).
C. syncarpa var. *Smithii* COSSON, GERMAIN & WEDDELL, Introd. Fl. Par. p. 151 (1842).
N. syncarpa var. *Smithii* COSSON & GERMAIN, Fl. Par. p. 682; Atl. t. 39, f. 7–12 (1845).
N. syncarpa var. *opaca* KÜTZING Phyc. Germ. p. 256 (1845).
BOSWELL Engl. Bot. ed. 3, XII, p. 178, t. 1900 (1884).
N. syncarpa vars. *pseudoflexilis* and *opaca* RABENHORST Deutsch. Krypt. Fl. II, p. 195 (1847).
N. syncarpa vars. *opaca*, *laxa*, *glomerata*, and *pachygyra* BRAUN in N. Denks. Schweiz. Ges. Naturw. X, p. 7 (1849).
N. atrovirens WALLMAN Försök syst. Charac. p. 35 (1853); Transl. p. 30 (1856).

EXSICCATA:—Areschoug, 149; Billot, 3272; Braun Rab. & Stiz., 29, 51–53, 77, 105, 106; Groves, 28, 29, 60; Migula Syd. & Wahlst., 33, 34, 52; Mougeot & Nestl., 1278; Nielsen, 4 (*fide* Wahlst.); Nordstedt & Wahlst., 5–7; Westendorp & Wall., 1397.

Diœcious. *Stem* moderately stout; *internodes* usually 2–4 times the length of the branchlets. *Sterile whorls* of 6–7, simple or once forked, usually moderately stout branchlets. *Secondary rays* 2–3, 1-celled, about $\frac{1}{3}$–$\frac{2}{5}$ the length of the primary, usually bluntish with mucronate tips, sometimes acuminate. *Fertile whorls* usually with shorter branchlets forming more or less dense heads, but sometimes lax, the branchlets once forked, with 1-celled secondary rays. *Oogonia* solitary or geminate, c. 650–700 μ long, c. 500–565 μ broad; *spiral cells* showing about 7–9 convolutions, swelling considerably at the apex; *coronula* 25–40 μ high, deciduous. *Oospore* spheroidal, sometimes even broader than long, c. 375–425 μ long, 350–400 μ broad, 250 μ thick, dark chestnut-brown to almost black, showing about 7 low, rather thick ridges often broadening into flanges at the apex; *outer membrane* thick and semi-rigid, transparent or semi-opaque, strong red-brown or yellow-brown, smooth or scabrous with wart-like protuberances (Pl. IV, f. 3). *Antheridium* large, c. 650–775 μ in diameter.

Habitat.—In lakes, ponds, pools, ditches, and streams; common.

Distribution.—Throughout the British Isles from the Hebrides and Shetland to Devon and Cornwall, and from East Norfolk and East Kent to West Cornwall; in Ireland from Donegal to Kerry and from West Mayo to Down. Recorded from more than 75 per cent. of the counties and vice-counties, and probably occurring in almost all of the remainder.

First record: probably Ray's 'Synopsis,' ed. 3 (1724) as *Chara translucens minor flexilis*.

Outside the British Isles *N. opaca* is recorded from Norway, Sweden, Finland, Denmark, France, Belgium, Holland, Germany, Switzerland, Austria, Hungary and Italy; also from N. Africa, Asia, and N. & S. America.

An extremely variable plant, generally stoutish, of medium stature (about 15–25 cm.), usually of a darkish green, often becoming almost black, sometimes annularly, occasionally completely, incrusted.

The branchlets on the main stems are of variable length, usually $\frac{1}{3}$–$\frac{1}{2}$ the length of the internodes, but sometimes abbreviated, when the general appearance of the plant is altered. Extreme states from Scotland are quite moniliform. The branchlets are only once-forked, the primary being usually much longer than the secondary rays. In the male the branchlets, and especially the secondary rays, are rather stouter than in the female plant.

Though the branchlets of the lower whorls are often also fertile, the oogonia and antheridia are mostly produced at the apex of the stem and on rather short branches, the whorls and internodes of the fertile whorls being abbreviated, forming usually largish compact heads.

The antheridia are larger than in *N. capillaris*, the ridges on the oospore are less salient, and the membrane has no decoration. Both antheridia and oogonia are destitute of gelatinous envelopment.

The apex of the terminal ray is very variable in shape, usually bluntly mucronate, but occasionally acuminate as in

N. flexilis. Extreme forms of the apex will be seen in Pl. VI, figs. 3–7.

N. opaca is variable in habit. In its typical form it is a stout close-growing plant with rather short branchlets and dense fruiting heads. In marked contrast to this, the var. *attenuata* has long and very delicate branchlets, and the fruiting whorls, which are lax and spreading, are little distinguishable from the sterile whorls.

Small tufted forms sometimes occur on the sandy bottoms of lakes. The Llyn Idwal form, already referred to under *N. capillaris*, is very small (about 15 cm. high) and remarkably slender, and the fruiting heads are small. Occasionally the fruiting branches are very short and the heads diminutive. An extreme form of this variation was collected by G. R. B.-W. at Little Sea, Studland, Dorset.

It is by far the commonest of our Nitellas, to be found almost everywhere, occurring even in slightly brackish water. It also reaches a higher elevation than any of the others, having been collected in Perthshire at 3100–3300 feet.

This species was confused by many of the earlier writers with the allied species *N. syncarpa*, already referred to. It appears under the name *C. syncarpa*, up to the 7th ed. of Babington's 'Manual,' and specimens have in consequence been largely so labelled in British herbaria.

Var. b. **attenuata.**

GROVES in Journ. Bot. XIX, p. 356 (1881); Exsicc. 29.

Branchlets very long, often equalling in length the internodes of the stem, extremely slender; *secondary rays* about as long as the primary. *Fertile whorls* lax.

Hants, S., in a pond on Beaulieu Heath, near Hythe (first found in 1878 by *H. Groves*); Dorset, Little Sea (*G. R. B.-W.* 1903).

3. **Nitella flexilis** Agardh.

(PLATE VIII.)

Chara flexilis LINN. Sp. Plant. p. 1157 (1753), *ex parte*.
SCHKUHR Bot. Handb. III, p. 219, t. 280 (1808).
BRUZELIUS Obs. Char. pp. 15, 23 (1824).
BRAUN in Ann. Sc. Nat. sér. 2, I, p. 351 (1834); in Flora, XVIII, i, p. 50 (1835).

GANTERER Österr. Char. p. 8 (1847).
BABINGTON in Ann. & Mag. Nat. Hist. ser. 2, V, p. 83 (1850).

C. inermis pellucida SCHMIEDEL Icones, p. 53, t. 14 (1762).

C. furculata REICHENBACH in Mössler, Handb. ed. 3, III, p. 1664 (1834).

C. Brongniartiana COSSON, GERMAIN & WEDDELL Intr. Fl. Par. p. 152 (1842).

C. commutata RUPRECHT Symb. Hist. Pl. Ross. p. 77 (1845).

Nitella flexilis AGARDH Syst. Alg. p. 124 (1824).
KÜTZING Phyc. Germ. p. 256 (1845); Sp. Alg. p. 514 (1849); Tab. Phyc. VII, t. 32, f. 2 (1857).
RABENHORST Deutsch. Krypt. Fl. II, p. 195 (1847).
BRAUN in N. Denks. Schweiz. Ges. Naturw. X, p. 8 (1849); in Cohn, Krypt. Fl. Schles. I, p. 397 (1876).
WALLMAN Försök syst. Charac. p. 33 (1853); Transl. p. 28 (1856).
WAHLSTEDT Bidrag Skand. Charac. p. 4 (1862); Mon. Sver. & Norg. Charac. p. 16 (1875).
CRÉPIN in Bull. Soc. Bot. Belg. II, p. 129 (1863).
LEONHARDI in Verh. Naturf. ver. Brünn, II, p. 168 (1864).
LANGE in Flora Danica, t. 2799 (1869).
GROVES in Journ. Bot. XVIII, p. 166, t. 210, f. 18 (1880).
MÜLLER in Bull. Soc. Bot. Genève, II, p. 51 (1881).
BRAUN & NORDSTEDT Fragm. Mon. Charac. p. 34 (1882).
SYDOW Europ. Charac. p. 17 (1882).
BOSWELL Engl. Bot. ed. 3, XII, p. 174* (1884).
MIGULA Die Characeen, p. 132, f. 37, 38 (1890); Syn. Charac. Europ. p. 34, f. 25, 26 (1898).
HOLTZ Characeen, in Krypt. Mark-Brandenb. p. 72 (1903).
PRÓSPER Carofit. Espan. p. 67, f. 10B (1910).
HY in Bull. Soc. Bot. France, LX, Mém. 26, p. 10 (1913).

N. Brongniartiana COSSON & GERM. Fl. Par. p. 682, Atl. t. 40, f.C. (1845); Atl. ed. 2, t. 46, f.D (1882).

N. furculata NORDSTEDT in Bot. Notiser, 1863, p. 35.

EXSICCATA:—Areschoug, 48 (132); Billot, 1988; Braun Rabenh. & Stiz., 22, 23, 54, 55; Desmazières, II, 318; Groves, 26; Lloyd, 404; Migula Syd. & Wahlst. 28–31; Mougeot & Nestl. 591; Nielsen, 5, 6 (*fide* Wahlst.); Nordstedt & Wahlst., 8, 11, 12, 13; Rabenhorst, 139 (?), 460; Schultz, IV, 92; Westendorp & Wall., 1096 & (*fide* Sydow) 1338–1339.

Monœcious. *Stem* moderately stout; the *internodes* usually once and a half to twice the length of the branchlets. *Whorls* of 6–8 straight or slightly incurved branchlets, the fertile usually similar to the sterile, but sometimes shortened and forming heads. *Branchlets* once furcate, or sometimes simple with one node; *primary rays* usually about twice the length of the

* The plate ascribed to *N. flexilis* (t. 1899) is not cited, being so inaccurate that it is impossible to identify it with any known species. The antheridia and oogonia are represented as growing side by side, and all the sterile branchlets as consisting of single cells.

secondary; *secondary rays* 2–3 (or single), 1-celled, acuminate, or sometimes slightly mucronate. *Oogonia* usually 2–3 together, varying much in size, 625–900 μ long, 550–750 μ broad; *spiral cells* showing 8–9 convolutions, swelling considerably at the apex; *coronula* c. 40 μ high, deciduous. *Oospore* c. 500–575 μ long, 425–500 μ broad, 375 μ thick, dark reddish brown to black, showing 5–7 stout prominent ridges which broaden into flanges at the apex; *outer membrane* thick and semi-rigid, translucent or semi-opaque, strong red-brown to burnt-sienna, smooth or scabrous with wart-like protuberances (Pl. IV, f. 4). *Antheridium* usually c. 500–625 μ in diameter.

Habitat.—In ponds and lakes, rarely in running water; not uncommon.

Distribution.—*England:* Cornwall, W., Hants, S., Sussex, W. & E., Kent, W., Surrey, Essex, S. & N., Herts, Middlesex, Bucks, Suffolk, E., Norfolk, W., Cambs., Hereford, Worcester, Warwick, Staffs, Salop, Notts, Lancs, S., Yorks, N.E., S.W., N.W., Northumberland, S., Westmoreland.

Wales: Anglesey.

Scotland: Dumfries, Kirkcudbright, Ayrshire, Stirling, Perth, W., M., E., Westerness, Dumbarton.

Ireland: Kerry, S., N., Cork, W., Longford, Roscommon, Mayo, E., Leitrim, Cavan, Monaghan, Fermanagh, Donegal, W., Armagh.

Channel Islands: Jersey.

First record: doubtful, owing to confusion with *N. opaca*.

Outside the British Isles *N. flexilis* is recorded from Norway, Sweden, Denmark, Spain, France, Belgium, Holland, Germany, Switzerland, Austria, Hungary, Italy, Roumania, and Russia; also from Asia (Kamchatka and Japan) and N. & S. America.

Very variable in stature, usually rather above the medium size, but sometimes attaining a height of about 1 metre, sometimes quite small. Some of the larger and stouter forms resemble *N. translucens,* but can usually be at once distinguished by the comparatively long secondary rays, each consisting of a single cell. Dried specimens have never the peculiar sheen which characterises *N. translucens.*

The points of resemblance between *N. opaca* and *N. flexilis* are so numerous and close that the distinction between the two species can only be determined in the last resort by their sexual difference. In consequence, in their barren state precise determination is almost impossible.

Even sexually the two species tend to approximation, as is seen in var. *Fryeri,* which is markedly protandrous. Professor Hy in his "Characées de France" refers to a plant found in Lake Pavin (Puy de Dôme) which he feels compelled to assign to *N. flexilis* rather than to *N. opaca* in spite of its apparent diœcious character.

The characteristics which normally distinguish the two species may be set forth as follows: *N. opaca* is smaller and stouter, with denser heads; at the same time, stout forms of *N. flexilis* are not uncommon, var. *crassa* being very thick-stemmed, and var. *nidifica* forming dense heads; while, conversely, var. *attenuata* of *N. opaca* has an extremely slender diffuse habit. The terminal rays of *N. opaca* are usually 2–3 and end in an abrupt mucronate point; while in *N. flexilis* the terminal rays are sometimes single and tend to be acuminate. In *N. opaca* the antheridium is larger (650–775 μ) than in *N. flexilis* (500–625 μ); while conversely the oospore of *N. opaca* is on an average considerably smaller (375–425 μ) than in that of *N. flexilis* (500–575 μ). *N. flexilis* produces its fruit later than *N. opaca.*

In spite of the similarity of the two species their distribution is very different. While *N. opaca* is found in almost every county and vice-county, *N. flexilis* has been observed in forty-eight only.

The character of the membranes of *N. opaca* and *N. flexilis* is difficult to determine with precision. In some fruits the membrane is apparently quite smooth and clear, in others the upper layer of the membrane is smooth while the under layer or layers present a rorid or mottled appearance as though constituted of granules which have become swollen and distended and have assumed papillary forms. In many cases this sub-surface development does not rise to the surface, in other examples it breaks through the top layer of the membrane and then exhibits wart-like eruptions or protuberances. These appear to be smaller, more evident and more numerous in *N. flexilis* than in *N. opaca.*

The specific name *flexilis* has been retained for the present species, although, as pointed out by Dr. Nordstedt, there is little doubt the actual plant Linnæus had before him, when he published the name, was *Tolypella nidifica*, and the habitat given "in Europæ maritimis" would not apply to *N. flexilis*. The description in '*Sp. Plant.*' p. 1157 reads:—"Chara caulium articulis inermibus diaphanis superne latioribus." *It. gotl.* 215. *Fl. suec.* 995." The only synonym quoted is "Chara transfluens [*sic*] minor flexilis. *Raj. angl.* 3, p. 133," and this would not refer to *T. nidifica*. It is curious that Linnæus made no reference to Vaillant's two figures of Nitellas. We can only conclude, there being no other of his species under which they could be placed, that Linnæus did not discriminate between the Nitelleæ which had come before him, of which no doubt there would have been several, and that he included them all under the one species. Dr. Nordstedt in his "Scandinaviens Characeer" ('Bot. Notiser,' 1863, p. 35) adopted Reichenbach's name *furculata* for the present species, applying that of *N. flexilis* to *Tolypella nidifica*, the genus *Tolypella* being then generally regarded as a subgenus of *Nitella*. This course has not however been followed by other authors. Agardh, in discriminating *N. opaca*, limited the name of *flexilis* to its present application, and this view has been generally adopted.

Var. b. **crassa.**

Braun in Braun, Rabenh. & Stiz. Charac. Exs. 101 (1877); Areschoug Exs. 391; Nordstedt & Wahlstedt Exs. 14; Groves Exs. 27.

Stem and *branchlets* much stouter than in the type. *Primary rays* of sterile branchlets straight; *secondary rays* usually shorter than in the type, sometimes less than one-eighth the length of the primary, often single.

In lakes, in rather deep water. Westmoreland, Kirkcudbright, Perth, W., M., & E., Longford, Donegal, W.

Seemingly confined to the Northern lakes. In its extreme form it is strikingly different from the type, having a much stouter stem and branchlets.

Var. c. **nidifica.**

WALLMAN Charac. p. 34 (1853); NORDST. & WAHLST. Exs. 9; LLOYD, Exs. 424.

Fertile whorls with abbreviated branchlets, and forming more or less dense heads, otherwise like the type.

Perth, E., Kerry, S., Roscommon, Cavan.

More extreme than var. *subcapitata* Braun (Braun, Rabenh., & Stiz. Exs. 23), but connected with the type, and with var. *crassa*, by intermediate forms.

Var. d. **Fryeri.**

GROVES & BULLOCK-WEBSTER in Journ. Bot. LVII, p. 101 (1919).

EXSICCATA:—Nordstedt & Wahlst. 10; GROVES, 59.

Markedly protandrous. *Antheridium* much larger than in the type, c. 800 μ in diameter. *Fruiting whorls* forming more or less dense heads. *Secondary rays* often mucronate. *Oogonia* 660–745 μ long, 550–610 μ broad, 550 μ thick. *Spiral cells* showing 6–7 convolutions and distending considerably at the apex. *Oospore* 500–520 μ long, 425–450 μ broad, 375 μ thick, dark reddish-brown to black, showing 5–6 stout prominent ridges often broadly and conspicuously flanged towards the apex; *outer membrane* very thick and semi-rigid.

Cambridgeshire and adjacent Fenlands, where it has been found by the late Alfred Fryer and G. R. B.-W. in the following localities:—

Cambridgeshire: Old Bedford River at Sutton Gault; Mepal Bridge at Mepal Drain, Welches Dam; Manea; Sixteen Foot Drain at Stonea; Stretham Ferry; Drain near Ely; Wicken Lode. Norfolk, W.: Old Bedford River at Welney; Little Ouse at Brandon Creek. Huntingdonshire: Ramsey.

The plant resembles *N. opaca* rather than normal *N. flexilis* in stature and appearance, and in the density of the fruiting whorls. The whole plant is often much incrusted. On specimens gathered on 29th April, the antheridia were numerous, and many had attained their full size, while few oogonia were to be found, and these so small as to be hardly visible, so that the plant appeared entirely male. On specimens collected towards the end of June, the conditions were reversed, fully formed oogonia being numerous and antheridia few, so that the plant appeared female; at intermediate dates the plant was obviously monœcious. We have a very similar form collected at Lund, and distributed under the name of *N. flexilis* f. *incrustata.* Here the state of things is much the same as in our Fenland plant. On a specimen collected by Wahlstedt in May, 1864, the antheridia are very large and conspicuous, and the oogonia are little in evidence, while in one collected in June of the same year by Olsson, oogonia are numerous, and antheridia almost absent. In the Lund plant also the tips of the rays are strongly mucronate. In these forms there is clearly an approach to the diœcious condition. The antheridia are very conspicuous not only on account of their size but of their particularly brilliant orange-red colour. We name this variety after the late Alfred Fryer, the eminent Fenland botanist, who first found it in Cambridgeshire in 1884 and drew attention to its peculiar characteristics.

4. Nitella spanioclema.

Groves & Bullock-Webster in Journ. Bot. LVII, p. 1, t. 551 (1919); in Irish Nat. XXVIII, p. 2, t. 1 (1919).

(Plates IX & X.)

Monœcious. *Stem* slender, internodes usually equalling or not much exceeding the branchlets. *Branches* often three together, 1–2 apparently taking the place of suppressed branchlets, often arrested, and when elongating often producing rudimentary whorls. *Branchlets* few, usually 2–3 in a whorl, normally once furcate, but often with a second node; lateral rays solitary, conspicuously shorter than their axial rays, often rudimentary, very short and inconspicuous at the nodes producing antheridia. *Ultimate rays* 1-celled, apex varying from acuminate to roundish acute or bluntly mucronate. *Oogonia* and *antheridia* together or at different nodes. *Oogonia* solitary or 2–3 together, c. 800–850 μ long, 640–680 μ broad; *spiral-cells* showing 7 convolutions, swelling considerably at the apex; *coronula* c. 60 μ high, deciduous. *Oospore* c. 475–500 μ long, 425–450 μ

broad, 330 μ thick, rich red-brown, showing six thin ridges with prominent flanges towards the apex; *outer membrane* thick and semi-rigid, translucent, bright red-brown, scabrous often with small protuberances, decorated with very minute granulation somewhat reticulate in form (Pl. IV, figs. 5–9). *Antheridium* 575–675 μ in diameter.

Distribution.—*Ireland:* Donegal, W. Lough Shannagh (*G. R. B.-W.*, 1916); Lough Kindrum (*G. R. B.-W.*, 1919).

A medium-sized plant about 30–35 cm. in height, slender and extremely delicate, dull olive green in colour. It is closely allied to *N. flexilis* being anarthrodactylous, monœcious, and normally once furcate, but differs so much from that species in its lax and delicate habit, the extraordinary paucity of branchlets and secondary rays and its tendency to bifurcation that it seems to demand specific rank. It would appear in some respects to resemble the diœcious subtropical *N. monodactyla*, Braun, judging from the particulars and figures in the 'Fragmente,' but of this we have not seen satisfactory specimens. It will be seen from the illustrations that *N. spanioclema* exhibits remarkable irregularities of growth which if found in one individual would be regarded as due to extreme abnormality, but the plant occurs in plenty and the peculiarities are observable in every specimen, moreover they persist from year to year. The normal number of branches produced at a node in the genus Nitella (two) is frequently exceeded while that of the branchlets falls always far short of the usual number, six. An oogonium is often produced at the base of a whorl as well as in the normal position. The lateral rays are often so much reduced at a node where an antheridium is present that the latter appears to be seated on a long stalk.

The plant occurs in some abundance in Lough Shannagh and Lough Kindrum, in the Fanad Peninsula, West Donegal. It was first collected by G. R. B.-W. in August, 1916, again in August, 1917, and August, 1919. In Lough Shannagh it was growing in dense masses in some 5–6 feet of water and fruiting freely. Its extraordinarily delicate character may be gathered from the fact that it became flaccid almost immediately after removal from the water, and even when transferred to drying paper on the bank of the lake it was difficult to secure any satisfactory specimens.

The outer membrane of *N. spanioclema* exhibits the characteristics of *N. opaca* and *N. flexilis* as regards the rorid and mottled under-surface and the wart-like surface, but occasionally the protuberances are smaller and more prominent. It is however markedly distinguished from the membranes of these two species in that its surface is covered with an exceedingly minute decoration, granular in character and assuming a somewhat net-like disposition. This decoration is not easy to detect in some membranes but is very evident in others. It is observable also on the flanges which, as in the case of *N. opaca* and *N. flexilis*, are often conspicuously developed at the apex of the oospore.

Section 2. *ARTHRODACTYLÆ* (= *Diarthrodactylæ* and *Polyarthrodactylæ* Braun).

Ultimate rays two- or more-celled.

Subsection 1. *Homœoclemæ* (= *Homœophyllæ* Braun). Whorls simple, composed of a single circle of similar branchlets.

5. **Nitella translucens** Agardh.

(Plate XI.)

Chara translucens major flexilis Vaillant Mém. Acad. Roy. Sc., 1719, p. 18, t. 3, f. 8.

C. flexilis β, Smith Fl. Brit. III, p. 1384 (1804).

C. translucens Persoon Synopsis, II, p. 531 (1807).
Smith Engl. Bot. No. 1855 (1808).
Braun in Ann. Sc. Nat., sér. 2, I, p. 352 (1834); in Flora, XVIII. i, p. 50 (1835).
Babington in Ann. & Mag. Nat. Hist. ser. 2, V, p. 84 (1850).

C. flexilis Thuillier Fl. Par. ed. 2, p. 472 (1799) *pro parte.*

Nitella translucens Agardh Syst. Alg. p. 124 (1824).
Cosson & Germain Atl. Flor. Par. t. 40, f. B (1845); ed. 2, t. 46, f. C (1882).
Kützing Sp. Alg. p. 513 (1849); Tab. Phyc. VII, t. 26, f. 1 (1857).
Payer Bot. Crypt. f. 171 (1850).
Wallman Försök syst. Charac. p. 31 (1853); Transl. p. 27 (1856).
Wahlstedt Bidrag Skand. Charac. p. 2 (1862); Mon. Sver. & Norg. Charac. p. 17 (1875).
Norstedt in Bot. Notiser, 1863, p. 36; in Flora Danica, No. 2929 (1877).
Crépin in Bull. Soc. Bot. Belg. II, p. 128 (1863).
Leonhardi in Verh. Naturf. ver. Brünn, II, p. 173 (1864).
Braun in Monatsb. Akad. Berl. for 1867, p. 879 (1868).
Groves in Journ. Bot. XVIII, p. 165, t. 210, f. 17 (1880).

BRAUN & NORDSTEDT Fragm. Mon. Charac. p. 49 (1882).
SYDOW Europ. Charac. p. 19 (1882).
BOSWELL Engl. Bot. ed. 3, XII, p. 180, t. 1901 (1884).
MIGULA Die Characeen, p. 140, f. 39, 40 (1890); Syn. Charac. Europ. p. 36, f. 27, 28 (1898).
WILLE in Engler & Prantl., Nat. Pfl. Fam. I, 2, p. 173, f. 127 (1891).
GREEN Fl. Liverpool, f. 802 (1902).
PRÓSPER Carofit. Españ. p. 68, f. 11A (1910).
HY in Bull. Soc. Bot. France, LX, Mém. 26, p. 11 (1913).

EXSICCATA:—Areschoug, 247; Billot, 2993; Braun, Rabenh. & Stiz., 19; Desmazières, II, 317; Erbar. Critt. Ital., 451; Fries, XVI; Groves, 25, 58; Lloyd, 405; Migula, Sydow & Wahlstedt, 76; Nielsen, 7 (*fide* Wahlst.); Nordstedt & Wahlstedt, 81; Westendorp & Wall. 1095.

Monœcious. *Stem* stout; *internodes* usually $1\frac{1}{2}$–3 times the length of the branchlets. *Sterile whorls* of 4–7, usually stout, once-forked branchlets; *primary rays* very long; *secondary rays* minute, usually 2–4, but sometimes solitary, strongly acuminate, of unequal length, one usually double the length of the others, 2-celled, the upper cell conical acuminate. *Fertile whorls* usually small and close together, often forming large dense heads; *branchlets* about 6, slender, forked, with 3–6 rays, of which 1–2 are sometimes again forked; *ultimate rays* 2-celled, the lower cell narrowing gradually to the acute apical cell. *Oogonia* 2–4 together, c. 475–525 μ long, 400–425 μ broad; *spiral cells* showing 7–8 convolutions; apex of spirals not swelling; *coronula* 40–45 μ high, persistent. *Oospore* c. 325–350 μ long, 250–300 μ broad, 225 μ thick, light golden-brown, showing about 6 very prominent thin ridges; *outer membrane* thin, flexible, and translucent, yellow-brown, minutely reticulate (Pl. IV, f. 10). *Antheridium* c. 250–375 μ in diameter.

HABITAT.—In lakes and ponds and occasionally in running water; not very common.

DISTRIBUTION.—*England:* Cornwall, W. & E., Devon, S., Somerset, N., Dorset, Hants, S., Sussex, W., Surrey, Essex, S., Herts, Middlesex, Berks, Bucks, Suffolk, E., Norfolk, E., Staffs, Salop, Cheshire, Cumberland.

Wales: Anglesey.

Scotland: Dumfries, Kircudbright, Wigtown, and Fife (*fide* Boswell), Stirling, Perth, W., M., & E., Aberdeen, S., Easterness, Westerness, M., Sutherland, E., Caithness (*fide* Ar. Bennett), Hebrides, Shetland.

Ireland: Kerry, S. & N., Cork, W., M., & E., Galway, W., Mayo, W., Donegal, E. & W., Armagh, Down, Antrim, Londonderry.

Channel Isles: Guernsey.

First record: Flora Britannica, 1804.

Outside the British Isles *N. translucens* is recorded from Sweden, Denmark, Portugal, Spain, France, Belgium, Holland, Germany, Austria, and Italy; also from North Africa (Algiers).

The largest and one of the most distinctive of our Nitellas with a firm stout stem, often attaining a height of 70 cm. The only British species with which this can be confounded is *N. flexilis,* in its larger forms, and from this it can be readily distinguished by all or nearly all the secondary rays of the sterile branchlets being extremely minute, as well as by the important structural character of the two-celled ultimate rays. The secondary rays of the sterile branchlets are usually so inconspicuous that the latter appear simple, and were so described by some of the earlier authors. In deep water it attains a considerable height, the internodes of the stem being sometimes 20 cm. or more in length and the branchlets as much as 11 cm.

One of the shortest and stoutest forms we have seen was collected in a swiftly-running stream.

The branching is often irregular, the branches not being invariably produced in the axils of whorls. The upper branches often run out into long whip-like ends, producing distant minute whorls. When dried the stems and branches present a remarkably brilliant glazed appearance, by which it may be immediately recognized. It is sometimes annularly incrusted. The fertile whorls have usually very short branchlets and the internodes are short, so that they form dense heads, sometimes of considerable size.

A plant collected by G. R. B.-W. in Etang de Cazau (Gironde) possessed large composite root-bulbils, but we have not met with these in any other specimens.

One variety only has been described, f. *confervoides* Migula, having more slender stem and branchlets than in the type, and long secondary rays perceptible to the naked eye. The fertile branchlets are less abbreviated and in consequence form lax heads. This variety has not so far been observed in this country.

6. **Nitella mucronata** Miquel.

(Plate XII.)

Chara furcata Amici in Mem. Accad. Modena, I, p. 210, t. 5, f. 2 (1827) *non* Bruzelius.

C. flexilis Bischoff Krypt. Gew. t. 1, f. 1–4 (1828) *non* Linn.
Reichenbach Iconogr. f. 1071–1072 (1830).

C. mucronata Braun in Ann. Sc. Nat. sér. 2, I, p. 351 (1834); in Flora, XVIII, i, p. 52 (1835).
Ganterer Osterr. Char. p. 9 (1847).
Babington in Ann. & Mag. Nat. Hist. ser. 2, V, p. 84 (1850).

C. Barbieri Balsamo-Crivelli in Bibl. Ital. XCVII, p. 190 (1840).

C. brevicaulis Bertoloni Fl. Ital. X, p. 19 (1854).

Nitella mucronata Miquel in van Hall, Fl. Belg. sept. II, p. 428 (1840).
Kützing Phyc. Germ. p. 256 (1845); Sp. Alg. p. 514 (1849); Tab. Phyc. VII, t. 33, f. 1 (1857).
Cosson & Germain Atl. Flor. Par. t. 40, f.D (1845); ed. 2, t. 46, f.E (1882).
Braun in N. Denks. Schweiz. Ges. Naturw. X, p. 9 (1847); in Monatsb. Akad. Berl. for 1867, p. 882 (1868); in Cohn, Krypt. Fl. Schles., I, p. 398 (1876).
Rabenhorst Deutsch. Krypt. Fl. II, p. 195 (1847).
Wallman Försök syst. Charac. p. 25 (1853); Transl. p. 22 (1856).
Nordstedt in Bot. Notiser, 1863, p. 36.
Crépin in Bull. Soc. Bot. Belg. II, p. 128 (1863).
Leonhardi in Verh. Naturf. ver Brünn, II, p. 172 (1864).
Wahlstedt Mon. Sver. & Norg. Charac. p. 17 (1875).
Groves in Journ. Bot. XVIII, p. 165, t. 210, f. 16 (1880).
Müller in Bull. Soc. Bot. Genève, II, p. 52 (1881).
Braun & Nordstedt Fragm. Monogr. Charac. p. 50, t. 1, f. 39–42 (1882).
Sydow Europ. Charac. p. 22 (1882).
Boswell Engl. Bot. ed. 3, XII, p. 180, t. 1902 (1884).
Migula Die Characeen, p. 149, f. 42–44 (1890); Syn. Charac. Europ. p. 38, f. 30–32 (1898).
Holtz Characeen in Krypt. Mark-Brandenb. p. 74 (1903).
Prósper Carofit. Españ. p. 71, f. 11b (1910);
Hy in Bull. Soc. Bot. France, LX, Mém. 26, p. 13 (1913).

N. flabellata Kützing Phyc. Gen. p. 318 (1843); Phyc. Germ. p. 256 (1845) (= var. *tenuior*).

N. exilis Braun in N. Denks. Schweiz. Ges. Naturw. X, p. 9 (1849) (= var. *tenuior*, not *C. exilis*, Barb.).
Kützing Tab. Phyc. VII, t. 33, f. 2 (1857).

N. norvegica Wallman Försök syst. Charac. p. 24 (1853); Transl. p. 21 (1856).

N. Wahlbergiana WALLMAN Charac. p. 26 (1853); Transl. p. 23 (1856) (= subsp. *Wahlbergiana* Braun & Nordstedt).
NORDSTEDT in Bot. Notiser, 1863, p. 37.
WAHLSTEDT Mon. Sver. & Norg. Charac. p. 18 (1875).

EXSICCATA:—Areschoug 49 (133), 250, 393 (subsp. *Wahlbergiana, fide* Wahlstedt); Billot 2994; Braun Rab. & Stiz., 17, 20, 30, 56 (*Wahlbergiana*); Fries Hb. Norm. XII. 100; Groves 57; Jack Leiner & Stiz., 20, 204*a* & *b*; Migula, Sydow & Wahlst. 32; Nielsen 8 (*fide* Wahlstedt); Nordstedt & Wahlstedt 82, 83 (*Wahlbergiana*); Rabenhorst 67, 420; Reichenb. 98; Westendorp & Wall. 1093.

Monœcious. *Stem* moderately stout; *internodes* from once to twice the length of the branchlets. *Whorls* of usually 5–6 stoutish branchlets, the sterile and fertile whorls usually not dissimilar. *Branchlets* once to three times furcate, the sterile once or twice, the fertile usually twice or three times, the primary ray being about $\frac{2}{5}$ to $\frac{2}{3}$ the length of the whole branchlet. *Rays* at the first furcation usually 3 or 4, at the second 2–3, of which 1 or 2 is sometimes again furcate with 2–3 quaternary rays. *Ultimate rays* 2- rarely 3-celled, the lower cell usually rounded or somewhat acuminate at the apex, the upper very much narrower, short, conical acute, thus forming a distinct mucro. *Oogonia* and *antheridia* usually produced at each forking. *Oogonia* solitary or geminate, attaining to a length of c. 550–575 μ, c. 400 μ broad; *spiral cells* showing 7–9 convolutions not ultimately swelling at the apex, but lengthening considerably, making the oogonium obpyriform when fully grown, at the earlier stage subglobose, breadth c. 400–450 μ; *coronula* 35–45 μ high; persistent. *Oospore* c. 300–350 μ long, 250–300 μ broad, 200 μ thick, dark brown, showing 6–7 thin prominent ridges; *outer membrane* thin, flexible and translucent, light yellow-brown, reticulate (Pl. V, f. 1). *Antheridium* small, c. 275 μ in diameter.

HABITAT.—In still and running water; rare.

DISTRIBUTION.—*England:* Hants, N., Fleet Pond (*Hon. J. L. Warren*, 1873); Sussex, W., ditch at West Grinstead (*W. Borrer*, 1820); Middlesex, Isleworth (Dillenius about 1726); Berks and Oxon in two localities near Godstow (*G. C. Druce*, 1892); Norfolk, W., Little Ouse, near St. John's (*G. R. B.-W.*, 1897); Cambs, Roswell clay-pits, Ely (*G. R. B.-W.*, 1895); Beds, R. Ouse at Bedford (*H. Davis*, 1882), R. Ivel near Sandy (*J. Saunders*, 1891).

Ireland: Monaghan, Loughs Monalty and Naglack (*G. R. B.-W.*, 1901).

First printed record: Babington 1850 (from Borrer's Sussex gathering), but collected more than 100 years earlier by Dillenius, who evidently discriminated it from the other then-known Charophytes. It was not until 1897 that Dillenius's extremely interesting discovery was brought to light by Mr. G. C. Druce, who published the record in his 'Flora of Berkshire' p. 623). Mr. Druce in the 'Dillenian Herbaria' quotes the following description, drawn up by Dillenius and attached to the Isleworth specimens preserved in his herbarium: *Chara flexilis, ramis et setis trichotomis. In fossa secus viam quæ a vico Thistleworth* (Isleworth, Middlesex) *versus Hounslow ducit Augusto mense reperi hanc speciem, Hippuridi setis bifurcis C. G. valde similem, sed in eo diversam, quod setæ ipsius terna plerumque, nonnunquam etiam, inferne videlicet, quaterna divisione terminarentur. Ramuli ejus terna etiam, subinde tamen bina tantum divisione a se invicem secedunt, tenues et pellucidi flexiles aqueo humore repleti, quo evanescente collabuntur et Algæ cujusdam instar plani et compressi apparent, colore per exsiccationem obscure veridi cum antea dilutius virentes essent. Setæ ad singula genicula senæ plerumque observantur, in quarum divisuris maxime summitatem versus grana, tanquam semina, sedent parva, ex rotundo acuminata. . . . Odore donabatur multo evidente, sane minime fœtido. Unde dubium videtur an huic eadem sit Chara Florentina pullo-viridis, Comm. Ac. R. Sc., An. 1719, p. 18, n. 7. Equisetum fœtidum pullum aquis immersum D. Mich. ibid. cujus specimine ab ipso auctore transmisso, in tantum alias accedit, ut nulla fere inter utramque differentia conspiciatur. Sed nostra ut dictum* *plane non fœtet, nec ab initio, quod innuere videtur Micheli, sed per siccitatem saltem idq. levissime pulla fuscaque sit. Forte autem huic idem fuerit Equisetum non fœtens sub aquis repens Preston Raii Hist. iii. 104, Syn. iii, 133, Epist. 313.*

Outside the British Isles *N. mucronata* is recorded from Norway, Sweden, Finland, Denmark, Portugal, Spain, France, Belgium, Germany, Switzerland, Austria, Hungary, Italy, Roumania, Turkey and Russia; also from N.W. Africa, Asia and N. America.

A medium-sized plant 15–30 cm. high, of a darkish green colour, usually rather bushy in growth, somewhat resembling in appearance a slender form of *N. flexilis*, but at once distinguishable by the frequently twice-forked branchlets and the 2-celled ultimate ray, easily seen with a lens. The ultimate cell of the terminal ray in the typical forms being very narrow, often at its base not more than $\frac{1}{4}$ the breadth of the penultimate cell, and tapering to a sharp point, gives the characteristic mucronate outline from which the specific name was taken. The var. *gracillima* however presents a marked variation from the type.

The antheridium is relatively small, its diameter being less than the breadth of the oogonium. The lengthening of the spiral cells of the oogonium as it reaches maturity is very marked in this species, and the interstices between them below the coronula, for the admission of the antherozoids, can be readily seen.

The scattered localities in England in which the plant has been found are in a narrow band from N. Hants & W. Sussex to W. Norfolk. It is singularly fugitive and seems rarely to occur in the same station in two successive years.

N. mucronata is extremely variable; our figure is taken from the rather elongated form from the River Ouse at Bedford. In the British forms there is little difference between the fertile and sterile whorls, so that the growth is uniformly lax, but in the var. *heteromorpha* Kütz., which is found in many places on the Continent, the fertile whorls are small and crowded, forming more or less dense heads. The var. *tenuior* Braun (= *N. flabellata* Kütz.), is a weak slender form, with a smaller oospore. *N. Wahlbergiana* Wallm., treated as a subsp. of *N. mucronata* by Braun, is a rare Scandinavian type with short secondary rays; another extra-British plant, *N. virgata* Wallm., also considered by Braun as a subspecies or variety, is very long and slender, having the sterile branchlets often 3 times forked, and having geminate oogonia.

N. translucens and *N. mucronata*, so widely different in other respects, possess a close similarity in the decoration of their membranes. They, with *N. tenuissima* in its earlier stages, are the only British species which show a reticulated pattern. In *N. tenuissima* this pattern soon assumes a different and a distinctive form, but with *N. translucens* and *N. mucronata* it remains unchanged; the only apparent distinction between the two being in the size of the furrows, which measure, according to Nordstedt, in *N. translucens* 3–5 μ in diameter, and in *N. mucronata* 4–6 μ in diameter.

Var. b. **gracillima.**

GROVES & BULLOCK-WEBSTER, in Journ. Bot. LV, p. 324 (1917).

(PLATE I, much enlarged.)

Stem and branchlets usually slender. *Ultimate ray* often 3-celled; penultimate cell tapering gradually to the apex, so that the apex is not much broader than the base of the apical cell. *Oospore* c. 290 μ long, 275 μ broad.

Gloucestershire, W., small pond, near Wickwar (*Miss Ida M. Roper*, 1917).

7. **Nitella gracilis** Agardh.

(PLATE XIII.)

Chara gracilis SMITH Engl. Bot. 2140 (1810).
BRUZELIUS Obs. Char. p. 24 (1824).
REICHENBACH Iconogr. f. 1069 (1830).
BRAUN in Ann. Sc. Nat. sér. 2, I, p. 351 (1834); in Flora, XVIII, i, p. 53 (1835).
GANTERER Österr. Char. p. 10, t. 1, f. 2 (1847).
BABINGTON in Ann. & Mag. Nat. Hist. ser. 2, V, p. 84 (1850).

C. flexilis var. *gracilis* S. F. GRAY, Nat. Arr. Brit. Pl. II, p. 28 (1821).

C. exilis 'Barbieri' AMICI in Mem. Accad. Modena, I, p. 216, t. 3, f. 6–7 (1827).

Nitella gracilis Agardh Syst. Alg. p. 125 (1824).
Cosson & Germain Atl. Flor. Par. t. 41, f. E (1845); ed. 2, t. 47, f. F (1882).
Kützing Phyc. Germ. p. 256 (1845); Sp. Alg. p. 515 (1849); Tab. Phyc. t. 34, f. 1 (1857).
Braun in N. Denks. Schweiz. Ges. Naturw. X, p. 10 (1847); in Monatsb. Akad. Berl. for 1867, p. 885 (1868); in Cohn, Krypt. Fl. Schles. I, p. 399 (1876).
Rabenhorst Deutsch. Krypt. Fl. II, p. 194 (1847).
Wallman Försök syst. Charac. p. 19 (1853); Transl. p. 17 (1856).
Wahlstedt Bidrag Skand. Charac. p. 1 (1862); Mon. Sver. & Norg. Charac. p. 19 (1875).
Nordstedt in Bot. Notiser, 1863, p. 38; in Flora Danica, t. 2930, i (1877).
Crépin in Bull. Soc. Bot. Belg. II. p. 128 (1863).
Leonhardi in Verh. Naturf. ver. Brunn, p. 170 (1864).
Groves in Journ. Bot. XVIII, p. 164, t. 210, f. 15 (1880).
Müller in Bull. Soc. Bot. Genève II, p. 52 (1881).
Braun & Nordstedt Fragm. Mon. Charac. p. 58 (1882).
Sydow Europ. Charac. p. 25 (1882).
Boswell Engl. Bot. ed. 3, XII, p. 183, t. 1903 (1884).
Migula Die Characeen, p. 159, f. 45–47 (1890); Syn. Charac. Europ. p. 39, f. 33–35 (1898).
Giesenhagen Unters. ü. d. Charac. I, p. 63, ff. 29–36, 56 (1902).
Holtz Characeen, in Krypt. Mark-Brandenb. p. 75 (1903).
Hy in Bull. Soc. Bot. France LX, Mém. 26, p. 14 (1913).

Exsiccata:—Areschoug, 50 (*fide* Wahlstedt); Billot, 2992; Braun Rabenh. & Stiz., 24, 25, 57–59; Desmazières, 322; Fries, VII. 100 (*fide* Sydow); Groves, 56; Lloyd, 423; Mougeot & Nessl. 1197; Migula, Sydow & Wahlstedt, 51; Nielsen, 9 (*fide* Wahlstedt); Nordstedt & Wahlst., 15–17; Rabenhorst, 138, 169, 439; Reichenbach, I. 99; Schultz, IV. 91; Westendorp & Wall., 1094.

Monœcious. *Stem* very slender; *internodes* as long to twice as long as the branchlets. *Whorls* of 5–6 slender branchlets. *Branchlets* 2–3 times divided; *primary rays* about a half the total length; *secondary rays* 3–5; *tertiary rays* usually 3–4, of which 1–2 are again forked. *Ultimate rays* 2–3 celled, penultimate cell somewhat tapering upwards, usually not more, and often considerably less, than twice as thick at the apex as the base of the long narrowly-conical acute ultimate cell. Third cell when present much longer than the penultimate cell. *Furcations* often all fertile, an oogonium or antheridium or both being present. *Oogonia* solitary, at first subglobose, becoming ovoid-conical through the lengthening of the spiral cells at the apex, c. 525 μ long, 350 μ broad; *spiral cells* showing about 8–9 convolutions; *coronula* 25–30 μ high persistent. *Oospore* very broadly ellipsoidal c. 250–300 μ long, 225–250 μ broad, 175–200 μ thick, light brown, showing about 6 rather prominent ridges; *outer membrane* thin, flexible and translucent, bright yellow-brown, very finely granulate. (Pl. V, f. 2,) *Antheridium* c. 300 μ in diameter.

Habitat.—Pools, ditches and lakes; very rare.

Distribution.—*England:* Cornwall, W., ditch near Perranzabuloe, and pool, Newlyn East (*F. Rilstone*, 1912); Sussex, W., boggy pool, St. Leonard's Forest (*W. Borrer*, 4th Sept. 1809); Salop, small deep pool, locality not revealed (*W. E. Beckwith*, 1883).

Ireland: Wicklow, Lough Luggala and Lough Dan (*R. M. Barrington* and *H. & J. Groves*, 1892).

First record: 'English Botany,' 1810, when the species was originally described and figured.

Outside the British Isles *N. gracilis* is recorded from Norway, Sweden, Finland, France, Belgium, Germany, Switzerland, Austria, Hungary, Italy, and Russia; also from Africa, Asia, North and South America, and (?) New Caledonia.

Typically a slender, delicate, extremely graceful plant, of rather small stature (15–20 cm.) with lax whorls. It is distinguishable from typical *N. mucronata*, to which it is most nearly allied, by its more slender and flexuous habit with the rays usually more frequently forked, by the frequent occurrence of three-celled ultimate rays in which character it forms a link between Braun's two sections Diarthrodactylæ and Polyarthrodactylæ (the latter group not being represented in this country), and by the penultimate cell being less rounded at the apex, and not much broader than the base of the ultimate cell, so that the ultimate cell does not appear as a definite mucro.

The form collected by Mr. F. Rilstone in Cornwall, from which our figure is taken, is an extremely beautiful and graceful one; that from Co. Wicklow is much larger and stouter, growing in big dense tufts with the branchlets as much as 4–5 cm. long and equalling or exceeding the internodes.

Braun tersely summarizes the variation in the species as follows:—"Variat *crassior* (forma *bugellensis* Rabenh.) et *tenuior, simplicior* et magis *composita, laxa* et rarius densius *contracta* et *brachyphylla*."

A long interval elapsed after the first discovery of *N. gracilis* by William Borrer in 1809 and its next collection in 1883.

The locality for the second record is not known, Mr. Beckwith being unwilling to reveal it, fearing that the plant might be exterminated. Had he been aware of the true nature of the Nitellas—the practical impossibility on the one hand of ensuring their permanent growth, and on the other of effecting their extermination—he would scarcely have maintained his silence.

The third English discovery, in Cornwall, is, it will be observed, quite recent, and represents an interesting extension of its known distribution.

Specimens of a small unidentified *Nitella*, purporting to have been collected by the late D. Orr, in Glen Cullen, near Ballybetagh, Co. Dublin, were formerly referred to *N. gracilis*, but a re-examination shows that they do not belong to this species; moreover, there is a doubt as to their place of origin.

8. **Nitella tenuissima** Kützing.

(Plate XIV.)

Chara tenuissima Desvaux in Journ. de bot. II, p. 313 (1809).
Reichenbach Iconogr. Bot. t. 791–792, f. 1065–1068 (1830).
Braun in Flora, XVIII i, p. 53 (1835).
Ganterer Österr. Char. p. 10, t. 1, f. 1 (1847) *pro parte.*
Babington in Ann. & Mag. Nat. Hist. ser. 2, V, p. 85 (1850).

C. flexilis var. *stellata* Wallroth Ann. Bot. p. 178, t. vi, f. 1–2 (1815).

C. stellata S. F. Gray Nat. Arr. Brit. Pl. II, p. 28 (1821).

C. exigua Rabenhorst in Flora, XX i, p. 131, t. 2 (1837)?

Nitella hyalina Agardh Syst. Alg. p. 126 (1824) *pro parte.*
Curtis Brit. Entomology, XI, t. 484 (1834).
Varley in Trans. Soc. of Arts, L, p. 186, t. 7, f. 14–19 (1836).

N. tenuissima Kützing Phyc. Gen. p. 319 (1843); Phyc. Germ. p. 256 (1845), Sp. Alg. p. 515 (1849); Tab. Phyc. VII, t. 34, f. 2 (1857).
Cosson & Germain Atl. Fl. Par. t. 41, f.F (1845); ed. 2, t. 47 f.G (1882).
Braun in N. Denks. Schweiz. Ges. Naturw. X, p. 10 (1847); in Monatsb. Akad. Berl. for 1867, p. 887 (1868); in Cohn, Krypt. Fl. Schles. p. 399 (1876).
Rabenhorst Deutsch. Krypt. Fl. II, p. 196 (1847).
Wallman Försök syst. Charac. p. 18 (1853); Transl. p. 16 (1856).
Leonhardi in Verh. Naturf. ver. Brünn, p. 169 (1864).
Wahlstedt Mon. Sver. & Norg. Charac. p. 19 (1875).
Nordstedt in Bot. Notiser 1863, p. 38; in Flora Danica, t. 2928 (1877).

Groves in Journ. Bot. XVIII, p. 163, t. 209. f. 14 (1880).
Müller in Bull. Soc. Bot. Genève II, p. 53 (1881).
Braun & Nordstedt Fragm. Mon. Charac. p. 62 (1882).
Sydow Europ. Charac. p. 28 (1882).
Boswell Engl. Bot. ed. 3, XII, p. 184, t. 1904 (1884).
Migula Die Characeen, p. 173, f. 48–49 (1890); Syn. Charac. Europ. p. 45, f. 36, 37 (1898).
Holtz Characeen, in Krypt. Mark-Brandenb. p. 76 (1903).
Prósper Carofit. Españ. p. 72, f. 12, a—c (1910).
Hy in Bull. Soc. Bot. France, LX, Mém. 26, p. 16 (1913).

N. exigua Wallman Försök syst. Charac. p. 38 (1853); Transl. p. 33 (1856)?

Exsiccata:—Areschoug, 394; Billot, 1985; Braun Rab. & Stiz. 60, 103; Desmazières II. 323; Groves, 23, 24, 55; Günther, Grab. & Wim. 1829, Cent XV (*fide* Sydow); Jack, Lein. & Stiz., 811; Lloyd, 421, 422; Migula, Syd. & Wahlst., 3, 4, 126, 127; Nordstedt & Wahlstedt, 41; Reichenbach, 100 (in some sets).

Monœcious. *Stem* very slender, c. 250 μ thick; *internodes* 2–5 times the length of the branchlets. *Whorls* usually of 6 short somewhat spreading branchlets. *Branchlets* of the fertile whorls 3–4 times furcate; *primary rays* $\frac{1}{3}$–$\frac{2}{5}$ the entire length; *secondary rays* 6–7; *tertiary rays* 4–6, of which 1–4 are usually simple; *quaternary rays* 2–5 of which 1 is occasionally again furcate with 3–4 quinary rays. *Ultimate rays* long narrow straight, invariably 2-celled; lower cell of uniform thickness, usually truncate at the apex and but little broader than the base of the ultimate cell; *ultimate cell* long narrow acuminate. *Oogonia* and *antheridia* produced at the second and third (not at the first) furcations, often together. *Oogonia* solitary, at first spheroid or broadly ellipsoid, ultimately somewhat narrowed at both ends, when ripe c. 400 μ long (incl. coronula), 260 μ broad; *spiral cells* showing about 9 convolutions; *coronula* c. 30–40 μ high, persistent. *Oospore* roundish-ellipsoid, conspicuously flattened c. 200–250 μ long, 175–200 μ broad, 100–130 μ thick, showing 7–8 fine but well-defined low ridges; *outer membrane* thin, flexible, and translucent, golden-yellow-red, wine-red, or light red-brown, strongly reticulate, with beaded reticulation threads (Pl. V, figs. 3–5). *Antheridium* minute, c. 175 μ in diameter.

Habitat.—In pits, pools, and water-courses in peaty districts, and in one lake; rare.

Distribution.—*England:* Norfolk, W., turf-pool, Lopham Great Fen (*G. R. B.-W.*, 1897); Cambridgeshire, peat-pits, Bottisham, Burwell, and Wicken Fens, and in Wicken Lode; fen near Clayhithe (*W. A. Leighton*, 1831).

Wales: Anglesey, Cors Bodeilio and Cors Ddraenog (*J. E. Griffith*, 1882); peat-pools, Llanffinnan, East of Llangefni (*C. Bailey*, 1884).

Ireland: Westmeath, peat-pits, Scraw Bog, near Loughanstown (*H. C. Levinge* and *H. & J. G.*, 1892); Lough Owel (*G. R. B.-W.*, 1904); Galway, N.E. Ballindooly (*H. & J. G.*, 1892).

First record (as *C. gracilis*): Henslow Catalogue, 1829.

Outside the British Isles *N. tenuissima* is recorded from Sweden, Spain, France, Germany, Switzerland, Hungary, Italy, Dalmatia, and Greece; also from N. Africa, Asia, N. America, and the West Indies.

Usually quite a small plant, often not more than 10 cm. in height. Specimens from Wicken Fen have however been collected by G. R. B.-W., 20 cm. high, and from Galway by H. & J. G. a rather drawn-out form still taller. The Anglesey plant is very small, some of the whorls being not more than 2·5 mm. across.

The very slender stem, short branchlets, and distant whorls give this species a very distinct appearance, and it cannot well be mistaken for any of the other British *Nitellæ*, with the exception of *N. batrachosperma*. From that species it differs by the absence of oogonia and antheridia at the first furcation of the branchlets and by the remarkable decoration of the membrane. The uniformly 2-celled ultimate rays of the fruiting whorls distinguish it from any form of *N. gracilis*. Sometimes in the sterile branchlets of *N. tenuissima*, owing to there being only one ray produced at the last node, it may appear to have a 3-celled ultimate ray.

The large number of rays at each furcation cause the whorls often to be almost globular, and extreme forms are remarkably moniliform (Pl. XIV, f. 2). The stems are but little branched. It is often densely incrusted with lime.

The first forking is apparently always sterile, the place of the antheridium being taken by a central ray, thus prolonging the main axis.

The outer membrane of *N. tenuissima* exhibits a very marked and distinctive decoration seen in no other British species. In the early stages of its development this decoration is simply reticulate, but as the growth advances the threads of the reticulations give early indication of uneven lines as though developing minute knots at close intervals. These knots soon become conspicuous and decorate the reticulation-lines with delicate little beads. The patterns of the reticulations are infinite in form and arrangement and are never found repeated. The inner coloured membrane, which adheres very closely to the outer and is not easily disengaged, is very light yellow in colour, thin, and transparent. Its decoration bears no resemblance to that of the outer membrane, being obscurely granulate.

The very restricted distribution of this species is remarkable. It is most plentiful in the fenlands of Cambridgeshire, its headquarters apparently being in Wicken Lode, a large fen drain running through Wicken Fen and emptying itself into Bottisham Lode, which in its turn falls into the Cam at Upware. In this lode the little plant abounds, covering the whole bed of the dyke in many places with its thick mosslike growth, though often scarcely discernible on account of the muddy deposit which envelops it. It is found also in the peat holes and ditches of the adjacent fen, but never appears to have established itself in the same abundance in Bottisham Lode. Indeed below the spot where the Wicken waters pass into it there appears to be little or no trace of the plant.

The occurrence of *N. tenuissima* in the Norfolk fens seems very limited, a few isolated plants only having been discovered there; its distribution in its third station, Anglesey, is also much restricted. Though in Ireland it has up to the present only been collected in two counties, there is every reason to suppose that its distribution is more extensive.

Ripe fruit does not appear to be common in the British plants. A search through many specimens collected during a series of years in Wicken Fen in early and late summer, while yielding abundant oogonia and antheridia, revealed no ripe oospores. The fruit of the Anglesey plant seems to be equally undeveloped. On the other hand, specimens from Norfolk and West Meath contained abundant oospores.

9. **Nitella batrachosperma** Braun.

(Plate XV.)

Chara batrachosperma Reichenbach, Iconogr. Bot. t. 794 (1830); Flor. Germ. Exc. p. 148 (1830), *neque* Weiss, *nec* Thuillier.

C. glomerata Reichenbach in Mössl. Handb. p. 1663 (1834) (*non* Desv.).

C. tenuissima var. *batrachosperma* Rabenhorst Fl. Lusat. II, p. 166 (1840).

C. tenuissima vars. *batrachosperma* & *ramulosa* Ganterer Oesterr. Char. p. 10 (1847).

Nitella tenuissima var. *batrachosperma* Kutzing Phyc. Germ. p. 256 (1845).
Rabenhorst Deutsch. Krypt. Fl. II, p. 196 (1847).

N. batrachosperma Braun in N. Denks. Schweiz. Ges. Naturw. X, p. 10 (1847); in Cohn's Krypt. Fl. Schles. p. 400 (1876) *non* Agardh.
Kützing Sp. Alg. p. 515 (1849); Tab. Phyc. VII, t. 35, f. 1 (1857).
Wallman Försök syst. Charac. p. 28 (1853); Transl. p. 24 (1856).
Nordstedt in Bot. Notiser, 1863, p. 36.
Wahlstedt Mon. Sver. & Norg. Charac. p. 20 (1875).
Müller in Bull. Soc. Bot. Genève II, p. 54 (1881).
Braun & Nordstedt Fragm. Mon. Charac. p. 66, t. 5, f. 131–132 (1882).
Sydow Europ. Charac. p. 30 (1882).
Migula Die Characeen, p. 184, f. 52–54, 1890; Syn. Charac. Europ. p. 48, f. 40–42 (1898).
Holtz Characeen in Krypt. Mark-Brandenb. p. 78 (1903).
Prósper Carofit Españ. p. 75, f. 12, DE (1910).

N. gracilis var. *confervacea* Brébisson Fl. Normand. ed. 2 (1849).

N. tenuissima var. *Brebissonii* Braun in Brébisson, Fl. Normand. ed. 3, p. 383 (1859).

N. confervacea Braun Consp. Charac. Europe p. 2 (1867).
Braun & Nordstedt Fragm. Mon. Charac. p. 64 (1882).
Migula Die Characeen, p. 182, f. 50, 51 (1890); Syn. Charac. Europ. p. 47, f. 38, 39 (1898).
Hy in Bull. Soc. Bot. France, L. II, p. 94 (1905); IX, Mém. 26, p. 18 (1913).

N. Nordstedtiana Groves in Journ. Bot. XXVIII, p. 66, t. 296 a–i (1890).

Exsiccata:—Areschoug, 150; Braun, Rabenh. & Stiz., 78; Groves, 54; Lloyd, 402; Migula, Syd. & Wahlst., 5, 6; Nielsen, 10 (*fide* Wahlst.); Nordstedt & Wahlst., 42; Reichenbach, 100 (in some sets).

Monœcious. *Stem* extremely slender; *internodes* from once to four times the length of the branchlets. *Whorls* usually of 8 short somewhat spreading branchlets. *Branchlets* of the fertile whorls twice, occasionally three times, furcate; *primary rays* about $\frac{1}{3}$–$\frac{1}{2}$ the entire length; *secondary rays* 4–6, of which some are simple; *tertiary rays* 3–7, long, sometimes more than half the entire length of the branchlet, occasionally again furcate. *Ultimate rays* uniformly 2-celled, lower cell tapering slightly and rounded at the apex, which is but little broader than the base of the ultimate cell; *ultimate cell* narrow c. 55–110 μ long, 20–25 μ broad at the base, tapering to a sharp point. *Oogonia* and *antheridia* at the first and occasionally at the second furcation, sometimes enveloped in mucilage. *Oogonia* solitary c. 375–450 μ long, 300–350 μ broad; *spiral cells* showing 8–9 convolutions, often lengthening considerably at the apex; *coronula* minute, 15–25 μ high, persistent. *Oospore* c. 225–300 μ long, 200–250 μ broad, 175 μ thick, showing 6–8 broadly flanged ridges; *outer membrane* thin, flexible, and translucent, dull-yellow-brown, at first finely granulate, subsequently tending to become thick and reticulate (Pl. V, f. 6). *Antheridium* minute c. 175–200 μ in diameter.

HABITAT.—In lakes; very rare.

DISTRIBUTION.— *Scotland:* Outer Hebrides, loch near Obbe, Isle of Harris (*W. L. Duncan*, 1888).

Ireland: Kerry, S., Caragh Lake (*R. W. Scully*, 1889); Kerry, N., Lower Lake of Killarney (*R. W. Scully*, 1890); Mayo, W., Lough Keel, Achill I., (*G. R. B.-W.*, 1919); Donegal, W., Kindrum Lough (*G. R. B.-W.*, 1916).

First record: Journ. Bot. 1890.

Outside the British Isles *N. batrachosperma* is recorded from Sweden, Finland, Spain, France, Germany and Italy; also from N. America, and Australia.

Our smallest and most delicate species, the British specimens being mostly only 3–5 cm. high, with a stem not usually more than 200 μ thick. Larger forms occur on the Continent, the vars. *fallax* and *maxima* (Migula) attaining the height of 10–15 cm. Professor Hy has made a special study of this species and has given a detailed account of its variation in his paper in 'Bull. Soc. Bot. France,' LII, pp. 88–94 (1905), "Sur le *N. confervacea* Braun," with which species he identifies it. Migula figures the oospore of *N. confervacea* as lacking the prominent flanged ridges so characteristic of our plant, but in specimens collected by Brébisson, which we have examined, the ridges are flanged.

The gelatinous covering to the sexual organs, which gave rise to the specific name, is evidently not a constant character in this species, and if present in the British plant, is very slight.

N. batrachosperma bears a close resemblance to *N. tenuissima,* but produces reproductive organs at the first furcation, and possesses a granular, not a reticulated, membrane. The number of branchlets in each whorl is usually greater than in *N. tenuissima,* but they are less repeatedly furcate. It also somewhat resembles a very small and slender condensed form of *N. gracilis,* but may be distinguished at once by the uniformly 2-celled ultimate rays.

In the paper by H. & J. G. in 'Journ. Bot.' 1890, p. 66, the name of *N. batrachosperma* was set aside partly on the theory "once a synonym always a synonym," and partly on the ground of Reichenbach's confused ideas as to his *Chara batrachosperma,* on which Braun's *N. batrachosperma* is based. The theory mentioned, though there is much to be said in its favour, is not in accord with general usage, and since there appears little doubt as to the identity of the plant described by Reichenbach in the 'Fl. Germ. Excurs.' and none as to what Braun meant, it is thought best to reinstate the name rather than to use that of *N. confervacea* published later.

Of the British Nitellas it is the only species which is not as yet known to occur in England. Its distribution, as at present known, is noteworthy, the five known stations being situated in four widely separated areas. It is scarcely likely that the plant does not occur in some other of the innumerable lakes that intervene between the north and the south of Ireland, and it may well be expected to occur also in the English and Scottish lakes.

The plant is by no means an easy one to detect. In its Irish stations it grows in some 4–6 feet of water, beyond the range of vision, and not readily collected by means of a drag. Its discovery is therefore somewhat a matter of chance.

Subsection 2. *Heteroclemæ* (=*Heterophyllæ* Braun). Whorls compound, having accessory branchlets dissimilar to those of the primary circle.

10. **Nitella hyalina** Agardh.

(Plate XVI.)

Chara hyalina De Candolle Flore Française, V, p. 247 (1815) *ex parte.*
Braun in Ann. Sc. Nat. sér. 2, I, p. 351 (1834); in Flora, XVIII, i, p. 54 (1835).

C. condensata and *C. interrupta* Ruprecht Symb. Hist. Pl. Ross. pp. 78–79 (1845), *fide* Braun.

Nitella hyalina Agardh Syst. Alg. p. 126 (1824) *ex parte.*
Kützing Phyc. Germ. p. 256 (1845); Sp. Alg. p. 516 (1849); Tab. Phyc. VII, t. 35, f. 2 (1857).
Rabenhorst Deutsch. Krypt. Fl. II, p. 196 (1847).
Braun in N. Denks. Schweiz. Ges. Naturw. X, p. 10 (1849); in Monatsb. Akad. Berl. for 1867, p. 889 (1868).
Wallman Försök syst. Charac. p. 16 (1853); Transl. p. 14 (1856).
Nordstedt in Bot. Notiser, 1863, p. 39 (1863).
Leonhardi in Verh. Naturf. ver. Brünn, II, p. 174 (1864).
Wahlstedt Mon. Sver. & Norg. Charac. p. 20 (1875).
Müller in Bull. Soc. Bot. Genève, II, p. 54 (1881).
Braun & Nordstedt Fragm. Mon. Charac. p. 78 (1882).
Sydow Europ. Charac. p. 31 (1882).
Migula Die Characeen, p. 190, f. 55–57 (1890); Syn. Charac. Europ. p. 49, f. 43–45 (1898).
Groves in Journ. Bot. XXXVI, p. 411, t. 392 (1898).
Ernst in Viert. Naturf. Ges. Zurich, XLIX, p. 64, t. 8 (1904).
Prósper Carofit. Españ. p. 76, f. 13a (1910).
Hy in Bull. Soc. Bot. France, LX, Mém. 26, p. 19 (1913).

Exsiccata:—Braun, Rab. & Stiz., 21, 31, 107; Desmazières, II, 324; Erbar. Critt. Ital., ii. 552; Groves, 53; Jack, Lein. & Stiz., 205; Nordstedt & Wahlst., 18; Rabenhorst, 31 (*fide* Sydow), 419; Wartmann & Schenk, 250.

Monœcious. *Stem* slender; *internodes* 2–4 times the length of the branchlets. *Whorls* of usually 8 primary branchlets, with about double that number of shorter and simpler secondary branchlets in two series, the one above, the other below, the primary branchlets. *Primary branchlets* 2–3 times furcate; *primary rays* usually $\frac{1}{2}$–$\frac{3}{5}$ the total length of the branchlet; *secondary rays* 7–10 (of which 1–3 are usually simple); *tertiary rays* 4–7, of which 1–2 are sometimes again divided in 4–5 quaternary rays. *Ultimate rays* uniformly 2-celled, the lower cell gradually narrowing to the base of the apical cell; apical cell narrowly conical, acute, c. 90–140 μ long, 30–45 μ broad at its base. *Accessory branchlets* usually one above and one below each primary branchlet, those of the lower series once or twice furcate into 4–6 rays, those of the upper usually once furcate into about 5 rays, or simple. *Oogonia* and *antheridia* enveloped in thin mucus, occurring on the primary branchlets at the second, third, and more rarely at the first forkings, and sometimes also on the accessory branchlets. *Oogonia* solitary c. 500–625 μ long, 375–400 μ broad; *spiral cells* showing 9–10 convolutions; *coronula* c. 45 μ high, persistent. *Oospore* (unripe) brown, decidedly flattened; *outer membrane* thin, flexible, and translucent, bright or dull-yellow, brown, obscurely reticulate (Pl. V, f. 7). *Antheridium* 350–425 μ in diameter.

DISTRIBUTION.—West Cornwall, Looe Pool, near Helston (*G. R. B.-W.*, 1898).

First record: Journ. Bot. 1898.

Outside the British Isles *N. hyalina*, though rare, has a very wide distribution, having been found in Finland, Spain, France, Holland, Germany, Switzerland, Austria, and Italy; also in Southern Asia, Japan, North and South Africa, North America, and Australasia.

A medium-sized plant about 15–30 cm. high, the upper whorls forming densely-crowded heads. The larger and more diffuse form, which is that occurring in England, is extremely graceful. It is at once distinguishable from all other European species by the presence of the accessory branchlets, which, being shorter than the primary branchlets, are very noticeable.

Prof. Ernst has made a careful study of the origin and development of these accessory branchlets, the results of which are published in his memoir (l.c.) 'Die Stipularblätter von *Nitella hyalina* (DC.) Ag.'

The ripe oospore, which we have not seen from this country, is about 350 μ long and 300 μ broad, usually reddish-brown, and 200 μ thick, and shows 7–8 low, inconspicuous ridges.

N. hyalina, *N. gracilis*, and *N. batrachosperma* belong to the group having granulated decoration of the membrane. Of these *N. batrachosperma* is the finest grained, *N. hyalina* stands next in order, while *N. gracilis* has the largest grains. The granulation in all three species is exceedingly minute, the grains varying from 1–2 μ in diameter.

The only locality in the British Isles at present recorded for *N. hyalina*, Looe Pool, near Helston, is a large piece of water, the western end of which is only divided from the sea by a narrow sand-bar. Here the plant was found in great abundance at the end of August, 1898. It was still there in 1914.

[**N. ornithopoda** Braun, a monœcious species having the ultimate rays of the branchlets 3–5-celled, occurs in the South West of France; and **N. Dixonii** H. & J. Groves, which is very similar in character, but diœcious, has been found in the extreme South of Portugal. Both these species belong to Braun's section *Polyarthrodactylæ*, most of the members of which are natives of the southern hemisphere.]

Genus 2. TOLYPELLA Leonhardi.

Nitella sect. *caudatæ* BRAUN in N. Denks. Schweiz. Ges. Naturw. X, p. 11 (1849).

Nitella sub-gen. *Tolypella* BRAUN in Hooker's Journ. Bot. I, pp. 194 & 199 (1849) *ex parte*; in Monatsb. Akad. Berl. 1867, p. 797 (1868).

Nitella sect. *Pseudo-bracteatæ* WALLMAN Försök syst. Charac. p. 39 (1853) *pro parte*; Transl. p. 33 (1856).

Tolypella LEONHARDI in Lotos, XIII, p. 72 (1863); in Verh. Naturf. ver. Brünn, II, p. 158 (1864).
WAHLSTEDT Mon. Sver. & Norg. Charac. p. 21 (1875).
BRAUN in Cohn, Krypt. Schles. I, p. 400 (1876).
BRAUN & NORDSTEDT Fragm. Mon. Charac. p. 93 (1882).
MIGULA Die Characeen, p. 198 (1890); Syn. Charac. Europ. p. 53 (1898).

Branches frequently more than two at a stem-node. *Sterile branchlets* simple or forked; *fertile branchlets* forked with very unequal rays. *Antheridia* and *oogonia* frequently long stalked, produced laterally at the nodes of the branchlets, also often in considerable number at the base of the whorls. *Oogonia* clustered. *Oospore* subglobose or broadly ellipsoid, terete in section.

A compact natural genus, distinguished from *Nitella* by the lateral position of the antheridium, by the ripe oospore not being laterally flattened, and by the very unequal length of the branchlet-rays. The production of reproductive organs at the base of the whorl which is quite common in *Tolypella* is a rare occurrence in *Nitella*. In the constantly monopodial growth of the branchlets, and the terete oospore it diverges in the direction of the *Chareæ*. The membrane of the oospore has usually no outgrowth in the shape of crest or basal appendages. The fruiting whorls usually form dense heads, and the divergent often incurved rays of the branchlets cause them to assume a characteristic bird's-nest-like appearance, which suggested the specific name *nidifica*, given to the first species recognized.

The stem and branchlets are often densely incrusted, but the incrustation is not in rings as in *Nitella*. In some species a lime-shell is secreted in the spiral-cells of the oogonium.

Dr. T. F. Allen gave considerable attention to this genus, and his 'Notes on the American Species of Tolypella' in Bull. Torrey Bot. Club, X, pp. 109–117, tt. 37–42 (1883) will be found useful to students of the British plants.

The known species of *Tolypella* number about fourteen, all of which occur in the northern and only few in the southern hemisphere.

Section 1. *CONOIDEÆ* (= *Acutifolia* Allen).

Ultimate cell of rays short, more or less conical and acute. Spiral-cells of oogonium not swelling at the apex. Coronula persistent.

1. **Tolypella intricata** Leonhardi.

(Plate XVII.)

Chara intricata Roth Catal. bot. II, p. 125 (1800).
Nitella intricata Agardh Syst. Alg. p. 125 (1824).
Nordstedt in Bot. Notiser, 1863, p. 39.
Crépin in Bull. Bot. Soc. Belg. II, p. 130 (1863).
Lange in Flora Danica, t. 2744 (1867).
Braun in Monatsb. Akad. Berl. for 1867, p. 895 (1868).
Müller in Bull. Soc. Bot. Genev. II, p. 56 (1881).
Cosson & Germain Atl. Fl. Par. ed. 2, t. 47, f. I (1882).
Boswell Engl. Bot. ed. 3, XII, p. 187, t. 1907 (1884).
C. fasciculata Amici in Mem. Accad. Sc. Modena, I, p. 212, t. 4, f. 4, t. 5, f. 3 (1827).

C. polysperma BRAUN in Ann. Sc. Nat. sér. 2, I, p. 352 (1834); in Flora, XVIII, i, p. 56 (1835).
GANTERER Österr. Char. p. 12, t. 1, f. 3 (1847).
BABINGTON in Ann. and Mag. Nat. Hist. ser. 2, V, p. 88 (1850).
N. polysperma KÜTZING Phyc. Gen. p. 318 (1843); Phyc. Germ. p. 255 (1845).
WALLMAN Försök syst. Charac. p. 41 (1853); Transl. p. 34 (1856).
N. nidifica var. *polysperma* RABENHORST Deutsch. Krypt. Fl. II, p. 196 (1847).
N. fasciculata BRAUN in N. Denks. Schweiz. Ges. Naturw. X, p. 11 (1849).
KÜTZING Sp. Alg. p. 517 (1849); Tab. Phyc. VII, t. 36 (1857).
Tolypella intricata LEONHARDI in Lotos, XIII, p. 57 (1863); in Verh. Naturf. ver. Brünn, II, p. 175 (1864).
WAHLSTEDT Sver. & Norg. Charac. p. 22 (1875).
BRAUN in Cohn, Krypt. Fl. Schles. I, p. 400 (1876).
GROVES in Journ. Bot. XVIII, p. 163, t. 209, f. 13 (1880).
BRAUN & NORDSTEDT Fragm. Mon. Charac. p. 99 (1882).
SYDOW Europ. Charac. p. 38 (1882).
MIGULA Die Characeen, p. 214, f. 61–63 (1890); Syn. Charac. Europ. p. 56, f. 49–51 (1898).
HOLTZ Charac. in Krypt. Mark-Brandenb. IV, i, p. 80 & fig. (1903).
HY in Bull. Soc. bot. France, LX, Mém. 26, p. 21 (1913).

EXSICCATA:—Areschoug 248, 249; Billot 1393; Braun, Rabenh. & Stiz. 18, 33, 108; Desmazières II, 325; Fries XVI, "98"; Groves 22, 52; Migula, Syd. & Wahlst. 7, 35, 77, 78; Nielsen 14 (*fide* Wahlst.); Nordstedt & Wahlstedt 46–48.

Monœcious. *Stem* moderately stout, often much branched. *Whorls* of two kinds; the sterile and lower fertile ones distant, large and lax, with usually 6 long primary branchlets, the sterile usually once, the fertile once or twice, divided with a variable, often considerable, number of shorter, more slender, usually simple, accessory branchlets; the upper fertile whorls forming very large, rather dense heads, with shorter, usually twice-divided, branchlets. *Branchlets* producing at the first node 3–4 lateral, widely divergent simple rays, and one central ray, which is either considerably longer and simple, or is again divided; at the second node when present usually 3–4 lateral rays, and a central elongated ray. *Ultimate rays* 5–6-, rarely 7-, celled, the cells successively diminishing in length and thickness, so that the ray tapers to the apex; ultimate cell bluntly conical. *Oogonia* stalked or sessile, produced 2–4 together at each node, and frequently also at the base of the whorls, in the latter case often in considerable numbers; broadly-ellipsoid-biconical, c. 500 μ long, 400 μ broad, *spiral-cells* showing 11–12 convolutions, not swelling at the apex; *coronula* c. 30 μ high, 60 μ broad, persistent, the cells of each tier of about equal size. *Oospore* light golden yellow, c. 350 μ long, 275 μ thick, showing 9–10 very thin prominent often winged ridges; *outer membrane* very thin and flexible, light yellow, translucent, very finely granulate (Pl. V, f. 10.) *Antheridia* stalked or sessile produced at the nodes and at the base of the branchlets, c. 400 μ in diameter.

Habitat.—Usually in shallow pools and ditches; rare, and apparently often sporadic in its appearance.

Distribution.—*England:* Somerset, N., near Langport (*E. S. Marshall*); Surrey, Egham (*W. H. Beeby*); Essex, N. (*E. G. Varenne*); Herts, near Broxbourne (*T. B. Blow*); Middlesex, near Staines (*J. G.*); Oxon, Marston (*G. C. Druce*); Suffolk, W., near Bury St. Edmunds (*G. R. Leathes*); Cambs, Haslingfield (*C. C. Babington*), Sutton Gault (*A. Fryer*), Mepal (*G. R. B.-W.*); Beds, near Luton, near Bramingham, and near Totternhoe (*J. Saunders*); Hunts, St. Neots (*W. R. Linton*); Northants, Yardley Gobion (*G. C. Druce*); Gloster, W., near Newent Canal (*O. St. Brody*); Yorks, S.E., near Beverley (*C. Waterfall*), Yorks, S.W., near Goole (*T. R. Birks, Jr.*); Yorks, N., Dalton (*J. Comber*); Durham, Sedgefield (*A. M. Norman*).

Ireland: Dublin Co., Grand Canal, Glasnevin (*D. Moore*); Blanchardstown (*D. McArdle*).

First record: Babington, 1850.

There is a specimen in Herb. Buddle (British Museum), but no locality is given on the label.

Outside the British Isles *T. intricata* is recorded from Sweden, Denmark, France, Belgium, Holland, Germany, Switzerland, Hungary, Italy, and Rumania; also from North Africa (Algiers).

A rather large plant, sometimes attaining a height of 40 cm. When well-grown, young, and not incrusted, it is a beautiful and graceful plant, the lower whorls separated by long internodes and composed of long slender conspicuously divided branchlets. It is however often densely incrusted when in its later stages it presents a particularly dilapidated appearance. The large dense fruiting heads are perhaps more conspicuously nest-like than in any other species, but the "nests" are distinctly of the untidy order. The spiral-cells secrete a lime-shell. The divided sterile branchlets readily distinguish it from the other British species.

It varies considerably in the extent of its branching, sometimes producing but one branch at a node at others a cluster of branches. The number of adventitious branchlets is also subject to great variation.

2. **Tolypella prolifera** Leonhardi.

(Plate XVIII.)

Chara translucens var. *prolifera* Wallroth Fl. Crypt. Germ. II, p. 106 (1833), *fide* Braun & Nordstedt.

C. prolifera Braun in Ann. Sc. Nat. sér. 2, I, p. 352 (1834); in Flora, XVIII, i, p. 56 (1835).

C. nidifica Borrer in note to Engl. Bot. Suppl. t. 2762 (1834), *non* Smith.

Nitella prolifera Kützing Phyc. Germ. p. 255 (1845).
Rabenhorst Deutsch. Krypt. Fl. II, p. 196 (1847).
Wallman Försök syst. Charac. p. 41 (1853); Transl. p. 35 (1856).
Crépin in Bull. Soc. Bot. Belg. II, p. 130 (1863).
Braun Consp. Charac. europ. p. 3 (1867).
Müller in Bull. Soc. Bot. Genev. II, p. 55 (1881).

N. fasciculata var. *robustior* (printed *robuster*) Braun in N. Denks. Schweiz. Ges. Naturw. X, p. 12 (1849).
Kützing Sp. Alg. p. 517 (1849).

C. Borreri Babington in Ann. and Mag. Nat. Hist. ser. 2, V, p. 87 (1850).

N. Borreri Wallman Försök syst. Charac. p. 43 (1853); Transl. p. 36 (1856).

N. intricata var. *prolifera* Brébisson Fl. Normand, ed. 3, p. 384 (1859).
Boswell Engl. Bot. ed. 3, XII, p. 189, t. 1908 (1884).

Tolypella prolifera Leonhardi in Lotos, XIII, p. 57 (1863); in Verh. Naturf. ver. Brünn, II, pp. 158, 176 (1864).
Braun in Cohn, Krypt. Fl. Schles. I, p. 401 (1876).
Groves in Journ. Bot. XVIII, p. 162, t. 209, f. 12 (1880).
Braun & Nordstedt Fragm. Mon. Charac. p. 97 (1882).
Sydow Europ. Charac. p. 37 (1882).
Migula Die Characeen, p. 203, f. 59, 60 (1890); Syn. Charac. Europ. p. 53, f. 47–48 (1898).
Holtz Charac. in Krypt. Mark-Brandenb. IV, i. p. 79 (1903).
Hy in Bull. Soc. bot. France, LX, Mém. 26, p. 22 (1913).

Exsiccata:—Rabenhorst, 68; Groves, 49–51.

Monœcious. *Stem* very stout, often solitary, much branched. *Sterile whorls* of about 6–20, simple 3–5-celled, often very unequal branchlets, the cells diminishing gradually in length and thickness towards the apex, apical cell rather bluntly conical. *Fertile whorls* usually in large densely crowded heads. *Branchlets* once or twice divided, with usually 3 lateral rays and one central ray, which is either elongated or again divided with a central elongated ray. *Ultimate rays* 3–5-celled, the cells usually much diminishing in length and breadth towards the apex; ultimate cell conical, acute or acuminate, sometimes rather blunt. *Oogonia* and *antheridia* at the nodes of the branchlets and at the base of the whorl. *Oogonia* ellipsoid-biconical, c. 500–560 μ long, 400–450 μ thick; *spiral-cells* showing 11–12 convolutions; *coronula* prominent, persistent, c. 50 μ high, 65 μ broad, the cells of the upper tier much the longer. *Oospore* amber to dull brown, globose-ellipsoid, 330–400 μ long, 250–330 μ thick, showing about 9 very thin prominent often winged ridges; *outer membrane* very thin and flexible, light yellow and translucent, undecorated. *Antheridia* usually sessile, c. 300 μ in diameter.

Habitat.—Rivers, canals, and ditches, usually in rather shallow, slowly-flowing water; rare.

Distribution.—*England:* Sussex, W., Henfield (*W. Borrer*, 1827), Amberley (*T. Hilton*), South Stoke (*J. G.*); Sussex, E., near Eastbourne (*H. T. Mennell*); Berks, R. Isis, near Oxford (*G. C. Druce*); Oxon, Kidlington (*G. R. B.-W.*); Norfolk, E., near Beccles (*G. R. B.-W.*), Martham (*C. E. Salmon*); Norfolk, W., near Brandon Creek (*G. R. B.-W.*); Cambs, Ely (*G. R. B.-W.*), Benwick (*A. Fryer*), Stretham Ferry (*G. R. B.-W.*); Hunts, Ramsey St. Mary (*A. Fryer*), Stirtloe (*E. F. Linton*); Northants, Rockingham (*T. B. Blow*), Yelvertoft (*H. N. Dixon*); Lincs, S., Deeping Fen (*W. H. Beeby*); Lancs, W., canal between Lancaster and Preston, at Cabus and Brock, near Garstang, etc. (*A. Wilson* and *J. A. Wheldon*).

Ireland: Canal near Glasnevin (*D. Moore*).

First record (as *C. nidifica*): 'English Botany,' Suppl. 1834.

Outside the British Isles *T. prolifera* is recorded from France, Belgium, Holland, Germany, Switzerland, Austria, and Italy; also from North and South America.

By far the most robust species of the genus. A medium-sized or large plant, 20–35 cm. high with a very stout stem, the lowest portion of which is often much elongated. This, added to the large number of branches originating from the lowest whorl, gives the plant a peculiarly tree-like aspect. It is usually much incrusted and the spiral-cells often secrete a lime shell.

It is readily distinguished from *T. intricata*, of which it was formerly thought to be a variety, by the stout simple sterile branchlets. It also differs from that species in the taller coronula with elongated upper cells, and the smaller antheridium.

Section 2. *ALLANTOIDEÆ* (= *Obtusifolia* ALLEN).

Ultimate cell of rays not much abbreviated, allantoid, rounded or very slightly pointed at the apex. Spiral-cells of oogonium usually swelling at the apex at maturity. Coronula usually deciduous.

3. **Tolypella glomerata** Leonhardi.

(PLATE XIX.)

Chara nidifica SMITH Engl. Bot. t. 1703 (1807).
HOOKER Brit. Fl. II, p. 245 (1833).

C. glomerata DESVAUX in Loiseleur 'Notice aj. Fl. France' p. 135 (1810).
BRAUN in Flora XVIII, i, p. 55 (1835).

Nitella glomerata CHEVALLIER Fl. Gen. Env. Paris, ed. 2, II, p. 124 (1836).
COSSON & GERMAIN Atl. Fl. Par. t. 41, f. H (1845).
KÜTZING Sp. Alg. p. 517 (1849).
WALLMAN Försök syst. Charac. p. 42 (1853); Transl. p. 35 (1856).
BRAUN in Monatsb. Akad. Berl. for 1867, p. 894 (1868).
CRÉPIN in Bull. Soc. Bot. Belg. II, p. 130 (1863).

LANGE in Fl. Danica, t. 2800 (1869).
BOSWELL Engl. Bot. ed. 3, XII, p. 185, t. 1905–6 (1884).

C. glomerulifera RUPRECHT Symb. Hist. Pl. Ross, p. 75 (1845).

N. glomerulifera WALLMAN Försök syst. Charac. p. 42 (1853); Transl. p. 36 (1856).

C. Smithii and *C. prolifera* BABINGTON in Ann. & Mag. Nat. Hist. ser. 2, V, pp. 86–7 (1850).
JOHNSON Fern Allies, p. 44–45, t. 26 (1855).

N. Smithii WALLMAN Försök syst. Charac. p. 43 (1853); Transl. p. 36 (1856).

Tolypella glomerata LEONHARDI in Lotos, XIII, p. 57 (1863); in Verh. naturf. ver. Brünn, II, p. 176 (1864).
WAHLSTEDT Mon. Sver. & Norg. Charac. p. 22 (1875).
GROVES in Journ. Bot. XVIII, p. 162, t. 209, f. 11 (1880).
BRAUN & NORDSTEDT Fragm. Mon. Charac. p. 95 (1882).
SYDOW Europ. Charac. p. 35 (1882).
MIGULA Die Characeen, p. 227, f. 64 (1890); Syn. Charac. Europ. p. 58, f. 52 (1898).
HOLTZ Charac. in Krypt Mark-Brandenb. IV, i, p. 82 (1903).
PRÓSPER Carofit. Españ. p. 80, f. 13B (1910).
HY in Bull. Soc. bot. France, LX, Mém. 26, p. 20 (1913).

EXSICCATA:—Areschoug 395; Braun, Rabenh., & Stiz. 17; Desmazières II, 326; Fries XVI; Groves, 47, 48; Migula, Sydow, & Wahlst. 128; Nielsen 12 & (*fide* Wahlstedt) 13; Nordstedt & Wahlst. 43–45; Rabenhorst 459 (*fide* Sydow).

Monœcious. *Stem* slender to moderately stout; branches usually 2–6 at a node. *Sterile whorls* of 6–12 elongated simple 3–5-celled branchlets, the ultimate cell more or less elongated and cylindrical, obtuse. *Fertile whorls* usually in dense compound heads of once-forked branchlets. *Rays* 4–5, unequal, often tapering, usually strongly curved, the central ray much the longest, the lateral usually 3-celled, the central 3–4-celled; *ultimate cell* cylindrical obtuse. *Oogonia* and *antheridia* produced at the nodes of the branchlets, and oogonia sometimes in great number also at their base. *Oogonia* usually 2–6 together, often stalked, ellipsoidal, c. 425–500 μ long, 310–375 μ broad; *spiral cells* showing about 9–10 convolutions, usually swelling at the apex; *coronula* 35–50 μ high, 65–90 μ broad, usually deciduous. *Oospore* usually ellipsoidal, yellow to orange-brown or cold dull brown, c. 300–375 μ long, 250–300 μ broad, showing 7–9 thin, low ridges; *outer membrane* thick and semi-rigid, becoming spongy, semi-opaque, light yellow to dull yellowish brown with linear granulations (Pl. V, figs. 8, 9). *Antheridia* 325–375 μ in diameter.

HABITAT.—In pools and ditches in fresh and brackish water, most frequently near the coast, often in company with *Chara vulgaris* to which when growing, in spite of its entirely different structure, it bears a superficial resemblance. Widely distributed and not uncommon in England and Ireland, rare in Wales and Scotland.

DISTRIBUTION.—*England:* Devon, N. & S.; Somerset, N.; Wight; Hants, S.; Sussex, W. & E.; Kent, W. & E.; Essex, N.; Herts; Middlesex; Berks; Bucks; Suffolk, W.; Norfolk, E. & W.; Cambs; Beds; Hunts; Gloster, E.; Lincoln, N. & S.; Derby; Cheshire; Lancs, S. & W.; Yorks, S.E., N.E., S.W., & M.W.

Wales: Glamorgan; Anglesey.

Scotland: Forfar; Ebudes, S.; Caithness; Orkney.

Ireland: Kerry, N.; Limerick; Clare; Tipperary, N.; Carlow; Galway, S.E., W. & N.E.; King's Co.; Kildare; Dublin; Westmeath; Sligo; Donegal, E.; Armagh.

First record (as *C. nidifica*): 'English Botany,' 1807.

Outside the British Isles *T. glomerata* is recorded from Sweden, Denmark, Germany, Holland, Belgium, Spain, France, Italy, and Austria; also from North Africa, Western Asia, and Australasia.

A very variable species, usually of medium stature and tufted growth, and generally completely incrusted. The fruiting portion is usually in dense heads, but occasionally lax. The conspicuously curved rays give it a very distinctive appearance. The proembryonic terminal process often persists for a considerable time, overtopping the rest of the plant with its long whip-like ends. By the time the fruit is ripe, the plant has usually become very brittle and dilapidated in appearance, hence a mature condition of the plant is often lacking in herbarium specimens.

var. **erythrocarpa.**

GROVES & BULLOCK-WEBSTER in Journ. Bot. LVII, p. 225 (1919).

Oospore broadly ellipsoidal, c. 350–400 μ long, 300–350 μ broad, reddish brown to dark red; *outer membrane* yellow-red to red-brown, linearly granulate, with smooth intervals frequently occurring between the granular lines.

DISTRIBUTION.—*Wales :* Anglesea, Llyn Coron (*J. E. Griffith*, 1887).

Ireland : Leitrim, Lough Melvin (*R. Lloyd Praeger*, 1899); Donegal, W., Lough Magheradrumman (*G. R. B.-W.*, 1916).

There appear to be several variations of this species tending towards *T. nidifica.* Professor Hy in his 'Characées de France' (p. 20) has the following note: "Forma *littorea* vert sombre, à incrustation nulle ou faible, des eaux saumâtres. Pointe des feuilles à dernier article court et peu atténué. Plante noircissant encore par la dessiccation et assez flexible en herbier. Diffère du vrai *T. nidifica* des mers du Nord, par le nucléus de l'oocarpe plus petit, n'atteignant pas en moyenne 0·39 millimètres, à surface finement ponctuée et non vermiculée, presque lisse."

On the other hand Braun in the 'Fragmente' (pp. 94, 95) refers to a form of *T. nidifica* var. *intermedia* which approximates to *T. glomerata.* He writes: "Forma intermedia. Ireland. Dr. Moore in herb. Hooker. Habitus *N. nidificæ* balticæ, folia verticillorum fertilium eodem modo incurva et obtusa. Color nigrescens, Semina minora magis contorta 10-gyrata, unreif. 0·46–48 mm. lang, ohne Krönchen 0·43–44 mm. lang, Kern hell gelbgrün 0·30–35 mm. lang."

Both authors refer also to other intermediate forms, but none of these are stated to possess the red fruit of *T. nidifica* with the granulate membrane of *T. glomerata,* which are the main characteristics of our variety, *erythrocarpa.* A fuller investigation of the intermediate forms is very desirable.

[**T. hispanica** Nordst. and **T. giennensis** Prósper are closely allied to *T. glomerata.* The former, a Mediterranean species, is diœcious, the latter, from the south of Spain, is described as having the oogonia and antheridia on separate branches. In both of them the antheridia are much larger than in the British *T. glomerata,* being 700–800 μ in diameter.]

4. **Tolypella nidifica** Leonhardi.

(Plate XX.)

Chara caulium articulis inermibus diaphanis superne latioribus Linn. Fl. Suec. p. 363 (1745); Ölandska & Gothl. Resa, p. 215 (1745).

C. glabra Linn. Ölandska & Gothl. Resa, Index (1745).

C. flexilis Linn. Sp. Plant. p. 1157 (1753), *pro parte.*

Conferva nidifica Müller in Flora Danica, 761 (1778).

Chara Stenhammariana Wallman in Liljeblad, Svensk. Fl. ed. 3, p. 686 (1816).

C. flexilis var. *nidifica* Hartman Handb. Skand. Fl. p. 378 (1820).

C. nidifica Bruzelius Obs. Char. p. 17 (1824).
Ruprecht Symb. Hist. Pl. Ross. p. 76 (1845).

Nitella nidifica Agardh Syst. Alg. p. 125 (1824).
Kützing Phyc. Germ. p. 255 (1845); Sp. Alg. p. 517 (1849); Tab. Phyc. VII, t. 37, f. 1 (1857).
Braun Consp. Charac. Europ. p. 3 (1867).

C. flexilis var. *marina* Wahlenberg Flora Suec. II, p. 694 (1826).

N. Stenhammariana Wallman in Bot. Notiser, 1853, p. 1; Försök syst. Charac. p. 43 (1853); Transl. p. 37 (1856).

N. flexilis Nordstedt in Bot. Notiser, 1863, p. 39.

Tolypella nidifica Leonhardi in Verh. naturf. ver. Brünn, II, p. 176 in note (1864).
Wahlstedt Mon. Sver. & Norg. Charac. p. 21 (1875).
Braun & Nordstedt Fragm. Mon. Charac. p. 93 (1882).
Sydow Europ. Charac. p. 34 (1882).
Migula Die Characeen, p. 235, f. 65–68 (1890); Syn. Charac. Europ. p. 60, f. 53–56 (1898).
Giesenhagen Untersuch. ü. d. Charac. f. 44[a] (1902).

Exsiccata:—Areschoug 47, 200; Braun, Rabenh., & Stiz. 32, 61; Fries XV, 100 (*fide* Migula); Migula, Sydow & Wahlst. 79; Nielsen 11; Nordstedt & Wahlstedt 84, 85, 86.

Monœcious. *Stem* slender to moderately stout. *Sterile whorls* of about 6 rather stout simple branchlets. *Fertile whorls* forming rather large dense heads. *Branchlets* once or rarely twice forked, the basal cell short, with usually 2–3 short incurved 3–4-celled lateral rays and a much longer 3–5-celled terminal ray; cells of rays rounded at their extremities; *ultimate cell* often short and when elongated sometimes much narrower than the cell below. *Oogonia* clustered at the node and base of the branchlets, nearly globose, c. 500–575 μ long, 450–500 μ broad; *spiral-cells* showing about 10 convolutions, usually swelling at the apex; *coronula* large and conspicuous, c. 75–90 μ high, 100 μ broad, the upper cells tapering and converging, forming a rounded apex, usually deciduous. *Oospore* globose-ellipsoidal, c. 400–475 μ long, 350–450 μ broad, when ripe dark wine-red, showing about 9 fine ridges; *outer membrane* semi-rigid, transparent or semi-opaque, wine-red or dark red, smooth or sometimes exhibiting scattered tubercles. *Antheridium* large, attaining sometimes a diameter of c. 550 μ.

DISTRIBUTION.—*Ireland:* in a lagoon north of Wexford Harbour, Co. Wexford (*Rev. E. S. Marshall*, 1896).

Outside the British Isles *T. nidifica* occurs in Norway, Sweden, Finland, Russia, Denmark, France, and Northern Germany, growing in some localities in the Baltic Sea. A form (f. *antarctica* Braun & Nordstedt, *Nitella antarctica* Braun *olim*) has been found in Kerguelen-land.

A small to medium-sized plant but sometimes attaining a height of 20 cm.; of a dark brownish-green, usually unincrusted. Closely allied to *T. glomerata* from the more typical forms of which it differs in the larger, broader oogonium, the taller coronula which is conspicuously rounded above, the larger and broader oospore, which when ripe is of a rich wine-red colour, with a shining surface, the membrane being destitute of decoration. The antheridium also attains to a larger size. The rays of the fertile branchlets are strongly incurved and frequently stout, with cells rounded at their extremities; the rays are conspicuously constricted at the joints, and the apical cell is often quite short.

The only plant from the British Isles which can be confidently referred to this species is that collected by Mr. Marshall at Wexford, which was unfortunately in too far advanced a condition to admit of its being satisfactorily figured. The drawing of the plant the natural size had therefore to be taken from a foreign specimen. The Wexford plant belongs to a large form and is much incrusted.

A *Tolypella* was collected in Lough Neagh, near Langford Lodge, by Dr. Moore in 1840, which was referred by Braun with some doubt to *T. nidifica*. In 'Fragmente,' p. 94, as already stated (p. 138), this is placed under var. *intermedia* of that species. A specimen of this plant is in the Kew Herbarium but in the absence of mature fruit we have not been able to form an opinion as to its identity.

Other forms apparently intermediate between *T. glomerata* and *T. nidifica* are referred to under the former species.

[**T. Normaniana** Nordst., probably a subspecies of *T. nidifica,* a minute plant about 1–2 cm. high, usually with no sterile branchlets except those of the proembryo, the terminal process of which is 3–4-celled, and with much smaller oospores (c. 300–350 μ long) occurs in the north of Norway. 'Fl. Danica,' 2930, f. 2. Exsicc.:—Braun, Rabenh., & Stiz. 109; Nordstedt & Wahlstedt 19.]

EXPLANATION OF THE PLATES.

Plate 2

PLATE II.

GERMINATION AND EARLY STAGES IN THE DEVELOPMENT OF A CHAROPHYTE, AFTER DE BARY AND KAMIENSKI.

FIG.

1. Oospore in which a septum has formed, cutting off the nodal-cell (*a*). × 60.
2. Oospore showing nodal-cell (*a*) beginning to swell, splitting the apex of the shell. × 60.
3. Nodal-cell showing first subdivision. × 200.
4. Oospore from which the pro-embryo (*P.*) and primary root (*P.R.*) are beginning to emerge. × 60.
5. Further stage in the growth of these organs. × c. 53.

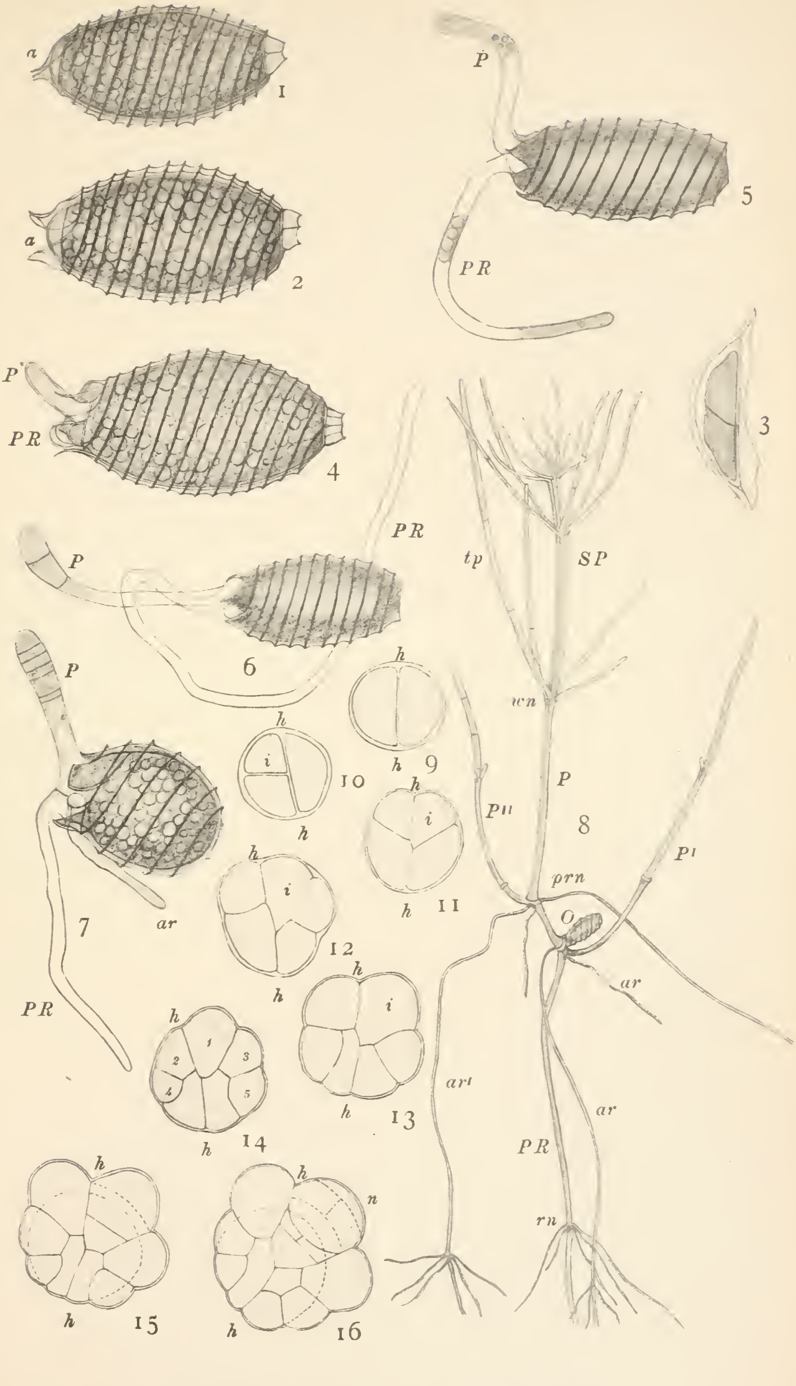
6, 7. Later stages when pro-embryo is becoming septate. In fig. 7 an accessory root (*a.r.*) is shown. × c. 53.

8. Young Chara-plant, showing pro-embryos, root system and sexual shoot. *O.*, oospore. *P.R.*, primary root. *r.n.*, node of the same. *a.r.*, accessory roots arising from division of nodal-cell. *P.*, primary pro-embryo. *P′.*, accessory pro-embryo arising from division of nodal-cell. *P″.*, accessory pro-embryo arising from root-node of primary pro-embryo. *p.r.n.*, root-node of primary pro-embryo. *a.r′.*, accessory root arising from the same. *w.n.*, node originating pro-embryonic whorl. *t.p.*, terminal process of pro-embryo. *S.P.*, sexual plant. × c. 5.

9–16. Successive stages in septation of node originating the pro-embryonic whorl, from which the sexual plant arises (see explanation in text). *h.*, halving wall. *i.*, initial cell. *n.*, a nodal-cell giving rise to sexual plant. In fig. 10 the section is reversed, the initial cell being shown on the left side of the halving wall instead of on the right as in the other figures. × 100.

Figs. 1–4, *Chara vulgaris;* 5, 6, 8, *C. canescens;* 7, *Tolypella glomerata;* 9–16, *C. aspera.*

PLATE II



EARLY STAGES OF GROWTH

(after de Bary and Kamienski)

Plate 3

PLATE III.

Pro-Embryos and Embryonic Branches of *Chara fragilis*, after Pringsheim.

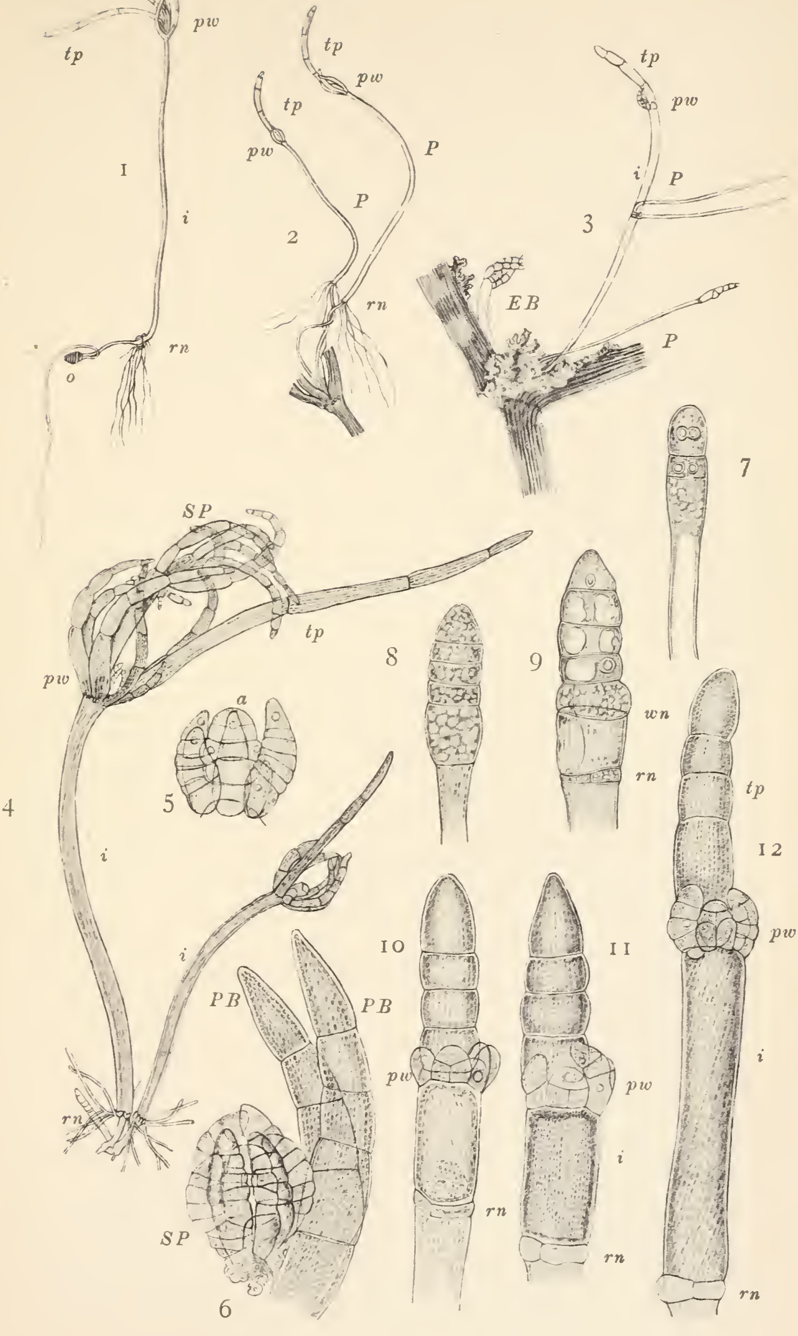
FIG.

1. Fully developed normal pro-embryo, originating from oospore (*o.*).
2. Two pro-embryos (*P.*) originating from stem-node.
3. Two pro-embryos (*P.*) and one embryonic branch (*E.B.*) originating from stem-node.
4. Two pro-embryos (from stem-node) in more advanced stage, the larger showing sexual plant (*S.P.*) in early stages.
5. Terminal bud of young sexual plant. *a*, apical-cell.
6. First whorl of sexual plant (*S.P.*) arising from axil of pro-embryonic branchlets (*P.B.*).

7–9. Earlier stages in segmentation of pro-embryonic axis.

10–12. Successive stages of the same, showing outgrowth of pro-embryonic whorl and origin of sexual plant.

In all figures *r.n.* denotes root-producing node; *i.*, principal internodal cell; *w.n.*, node originating pro-embryonic whorl; *p.w.*, pro-embryonic whorl; *t.p.*, terminal process.



EARLY STAGES OF GROWTH

(after Pringsheim)

Plate 4

PLATE IV.

Decoration of Membranes.

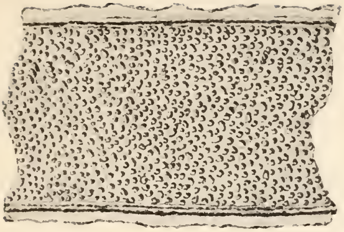
FIG.

1. *Nitella capillaris.* × c. 450.
2. *Nitella capillaris,* showing part of the flange with decoration similar to that of the membrane. × c. 220.
3. *Nitella opaca,* showing the scabrous form of membrane. × c. 240.
4. *Nitella flexilis,* showing the scabrous form of membrane. × c. 240.

5–9. *Nitella spanioclema.* 5.—Membrane in the earlier stage of development of protuberances. × c. 240. 6.—Later stage showing the granular decoration covering the surface. × c. 420. 7.—A small portion showing the disposition of the granules. × c. 800. 8.—A piece of the flange similarly decorated. × c. 600. 9.—A piece of the inner coloured membrane showing faint granulations. × c. 400.

10. *Nitella translucens.* × c. 375.

PLATE IV



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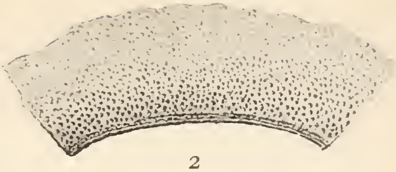

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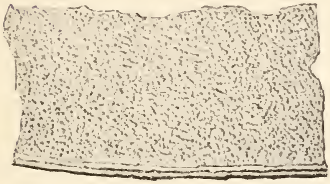

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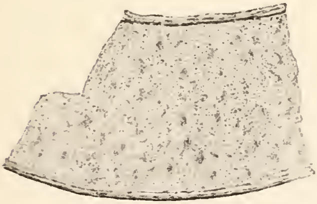

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10

DECORATION OF MEMBRANES

R. B.-W. del.

Plate 5

PLATE V.

DECORATION OF MEMBRANES.

FIG.

1. *Nitella mucronata.* × c. 450.
2. *Nitella gracilis.* × c. 450.

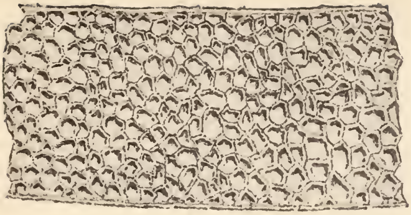
3–5. *Nitella tenuissima.* 3.—Early stage in development of decoration. 4.—Beaded reticulation of fully developed membrane. 5.—Inner coloured membrane. All × c. 600.

6. *Nitella batrachosperma.* × c. 500.
7. *Nitella hyalina.* × c. 360.

8, 9. *Tolypella glomerata.* 8.—Early stage showing linear granulation. 9.—Later stage showing spongy development. Both × c. 600.

10. *Tolypella intricata.* × c. 600.

PLATE V



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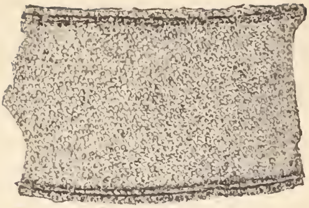

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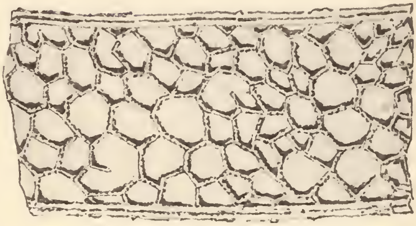

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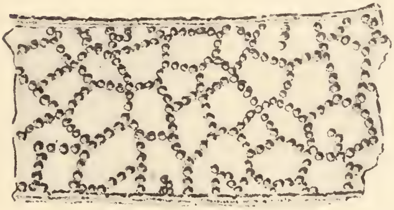

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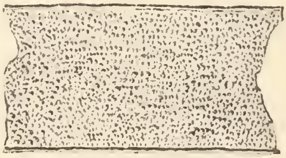

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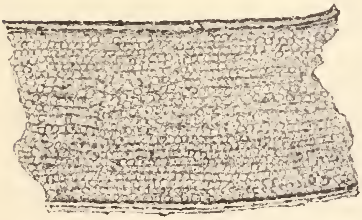

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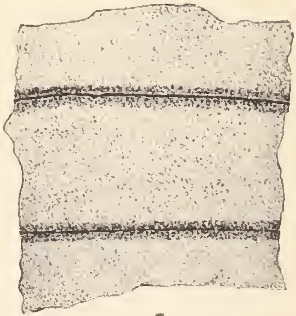

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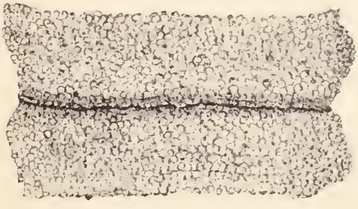

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10

DECORATION OF MEMBRANES

. R. B.-W. del.

Plate 6

PLATE VI.

Nitella capillaris comb. nov.

FIG.

1. Male plant, natural size.
2. Female plant, natural size.
   Both from Sutton, Isle of Ely.

3–5. Apices of dactyls. × c. 40.

6. Branchlet-node, with antheridium surrounded by mucus. × c. 15.
7. Branchlet-node with group of oogonia surrounded by mucus. × c. 20.
8. Oospore. × c. 45.

PLATE VI

M. Groves del.

NITELLA CAPILLARIS

Plate 7

PLATE VII.

Nitella opaca Agardh.

FIG.

1. Male plant, natural size, from Ashstead, Surrey.
2. Female plant, natural size, from Wandsworth Common, Surrey.

3–6. Apices of dactyls. × c. 40.

7. Apex of dactyl of var. *attenuata* from near Hythe, S. Hants. × c. 40.
8. Branchlet-node with antheridium. × c. 20.
9. Branchlet-node with oogonia. × c. 20.
10. Mature oogonium after shedding coronula. × c. 40.
11. Oospore. × c. 40.

M. Groves del.

NITELLA OPACA

Plate 8

PLATE VIII.

Nitella flexilis Agardh.

FIG.

1. Plant, natural size, from Wimbledon Common, Surrey.

2, 3. Apices of dactyls. × c. 40.

4. Branchlet-node with antheridium and oogonium. × c. 20.

5. Mature oogonium after shedding coronula. × c. 20.

6. Oospore. × c. 40.

M. Groves del.

NITELLA FLEXILIS

Plate 9

PLATE IX.

Nitella spanioclema Groves & Bullock-Webster.

FIG.

1, 2. Plant, natural size, from Lough Shannagh, West Donegal.

3, 4. Branches with branchlets showing short, solitary and rudimentary secondary rays, and conspicuous scars left by fallen antheridia and oogonia. × c. 10.

5. Oogonium. × c. 30.

6. Oospore. × c. 30.

7. Membrane showing wart-like protuberances and minute granular decoration. × c. 200.

8. Portion of membrane showing disposition of granules. × c. 800.

H. G. & G. R. B.-W. del.

NITELLA SPANIOCLEMA

Plate 10

PLATE X.

Nitella spanioclema Groves & Bullock-Webster.

FIG.

1–8. Fruiting portions of the plant, showing characteristic forms of branches and branchlets, and disposition of antheridia and oogonia.

Figs. 1–5. × c. 10. Figs. 6–8. × c. 20.

G. R. B.-W. & M.G. del.

NITELLA SPANIOCLEMA

Plate 11

PLATE XI.

Nitella translucens Agardh.

FIG.

1. Plant, two-thirds natural size, from Loughton, S. Essex.
2. Apex of sterile branchlet. × c. 20.
3. Portion of fruiting head. × c. 15.
4. Oogonium. × c. 20.
5. Oospore. × c. 40.

PLATE XI

M. Groves del.

NITELLA TRANSLUCENS

Plate 12

PLATE XII.

Nitella mucronata Miquel.

FIG.

1. Plant, natural size, from R. Ouse, Bedford.
2. Apex of branchlet showing 2- and 3-celled dactyls. × c. 20.

3–5. Apices of dactyls. × c. 30.

6. Fruiting branchlet. × c. 20.
7. Oogonium. × c. 40.
8. Oospore. × c. 40.

M. Groves del.

NITELLA MUCRONATA

Plate 13

PLATE XIII.

Nitella gracilis Agardh.

FIG.

1. Plant, natural size, from Perranzabuloe, Cornwall.
2. Ultimate node of branchlet, showing 2- and 3-celled dactyls. × c. 40.

3, 4. Apices of dactyls. × c. 40.

5. Fruiting branchlet. × c. 20.
6. Oogonium. × c. 40.
7. Oospore. × c. 40.

PLATE XIII

M. Groves del.

NITELLA GRACILIS

Plate 14

PLATE XIV.

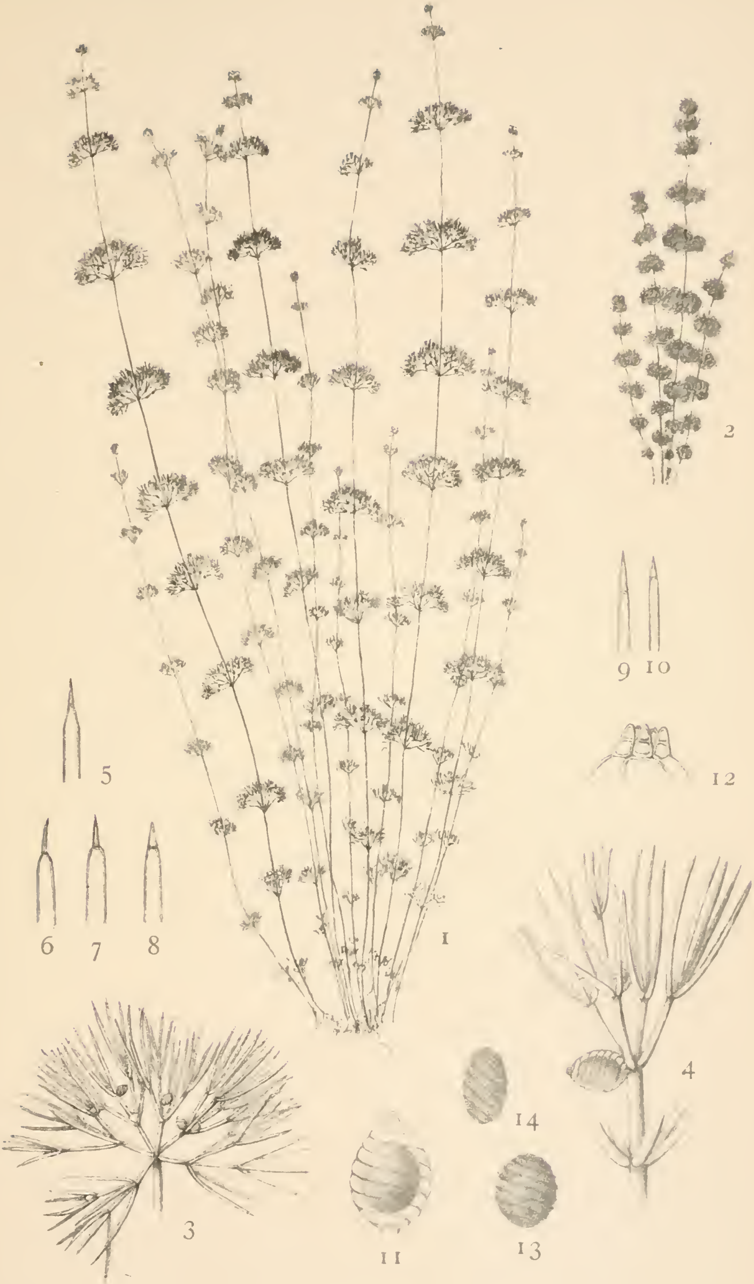
Nitella tenuissima Kützing.

FIG.

1. Plant, natural size, lax form, from near Mullingar, Westmeath.
2. Plant, natural size, compact form, from Wicken Fen, Cambridgeshire.
3. Branchlet. × c. 10.
4. Portion of branchlet showing secondary, tertiary, quaternary and quinary rays. × c. 20.

5–10. Apices of dactyls. × c. 40.

11. Oogonium. × c. 40.
12. Coronula. × c. 200 (after Migula).
13. Oospore, broad view. × c. 40.
14. The same, viewed edgewise. × c. 40.



M. Groves del.

NITELLA TENUISSIMA

Plate 15

PLATE XV.

Nitella batrachosperma Braun.

FIG.

1. Plant, natural size, from I. of Harris, Hebrides.
2. Branch. × c. 20.
3. Fruiting branchlet. × c. 30.
4. Branchlet-node with antheridium and young oogonium. × c. 60.

5, 6. Apices of dactyls. × c. 150.

7. Oogonium. × c. 60.
8. Oospore. × c. 60.
9. Membrane of oospore. × c. 375.

M. & H. Groves del.

NITELLA BATRACHOSPERMA

Plate 16

PLATE XVI.

Nitella hyalina Agardh.

FIG.

1. Plant, three-quarters natural size, from Looe Pool, Helston, W. Cornwall.
2. Portion of whorl showing primary, and upper and lower accessory branchlets. × c. 6.

3–7. Apices of dactyls. × c. 45.

8. Branchlet-node with antheridium. × c. 22.

9, 10. An upper and a lower shield of antheridium. × c. 45.

11. Oogonium. × c. 22.
12. Apex of oogonium with coronula. × c. 100.
13. Unripe oospore, broad view. × c. 22.
14. The same, viewed edgewise. × c. 22.

M. Grove, del

NITELLA HYALINA

Plate 17

PLATE XVII.

Tolypella intricata Leonhardi.

FIG.

1. Plant, half natural size, from Egham, Surrey.

2–5. Apices of dactyls. × c. 20.

6. Fruiting branchlet. × c. 20.

7. Oogonium. × c. 40.

8. Apex of oogonium with coronula. × c. 80.

9. Oospore. × c. 40.

M. Groves del.

TOLYPELLA INTRICATA

Plate 18

PLATE XVIII.

Tolypella prolifera Leonhardi.

FIG.
1. Plant, two-thirds natural size, from Ramsey St. Mary, Huntingdonshire.

2, 3. Apices of dactyls. × c. 40.

4. Fruiting branchlet. × c. 25.

5. Oogonium. × c. 40.

6. Oospore. × c. 40.

PLATE XVIII

M. Groves del.

TOLYPELLA PROLIFERA

Plate 19

PLATE XIX.

Tolypella glomerata Leonhardi.

FIG.

1. Plant, natural size, from Staines, Middlesex.
2. Part of plant, natural size, showing persistent proembryonic growth.
3. Fruiting branchlet. × c. 20.
4. Oogonium. × c. 40.
5. Mature oogonium after shedding coronula. × c. 40.
6. Oospore. × c. 40.

PLATE XIX

TOLYPELLA GLOMERATA

Plate 20

PLATE XX.

Tolypella nidifica Leonhardi.

FIG.

1. Plant, natural size.
2. Apex of branchlet. × c. 12.
3. Fruiting branchlet. × c. 12.
4. Oogonium. × c. 40.
5. Apex of oogonium with coronula. × c. 80.
6. Apex of mature oogonium after shedding coronula. × c. 50.
7. Oospore. × c. 50.

Fig. 1 from the Baltic at Valje. Figs. 2–7 from Wexford.

M Groves del

TOLYPELLA NIDIFICA

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103. The British Freshwater Rhizopoda and Heliozoa. By James Cash and G. H. Wailes, assisted by John Hopkinson. Vol. IV. Supplement to the Rhizopoda by G. H. Wailes and Bibliography by John Hopkinson. xii + 130 + 12 pp., 6 plates (lviii–lxiii). 8vo. 1919.

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104. A Monograph of the British Orthoptera. By W. J. Lucas. xii + 264 + 52 pp., 26 plates. 1920.

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The British Charophyta. By James Groves and Canon Bullock-Webster. (Vol. II will complete the work.)

The British Marine Annelids. By Prof. W. C. McIntosh.

The British Desmidiaceæ. By the late W. and G. S. West.