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On the development and systematic arrangement of the Pithophoraceæ, a new order of algæ. 1877.

ON THE DEVELOPMENT AND SYSTEMATIC ARRANGEMENT OF THE PITHOPHORACEÆ

A NEW ORDER OF ALGÆ,

BY

VEIT BRECHER WITTROCK.

WITH SIX PLATES.

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On the vast territory of the freshwater algæ, which was shrouded in almost total darkness no longer than twenty years ago, as to the knowledge of their development and systematic arrangement, the excellent researches of PRINGSHEIM, COHN and DE BARY have thrown an unexpected light. The profound morphological inquiries of these men have enriched science with the knowledge of a not inconsiderable number of orders of algæ, more nicely distinguished from each other and of much greater importance and interest, on account of the history of their development, than most other orders of plants. Nevertheless a great number of algæ still remains almost unknown as to the history of their development and their place in the system. Among these are to be counted the *Cladophoreæ*, existing as well in salt and brackish, as in fresh water, and extremely rich in varying forms. We have, however, believed we knew, that their propagation was effected, as a rule, by naked, moving, ciliated spores, — so-called zoospores. This is indisputably the case with many, or perhaps with most of the plants that have been counted among the *Cladophoreæ*. But that this is not the case with all the forms that have been referred to this genus, is proved by the researches of which I am now going to give an account.

My attention was directed to *Cladophoreæ* during a sojourn at the magnificent botanical institution at Kew in England, in the summer of 1872, by an alga which occurred in great abundance in its Tropical Aquarium, or the so-called Waterlily-house. It resembled in its general habitus a common *Cladophora*, but was distinguished by most of the specimens having, besides the common long and slender cylindric cells, others somewhat swollen, short, and very rich in chlorophyll, which were almost always single, and most frequently alternated in a regular manner with the longer, cylindric cells. A more careful examination of the rich material, containing the plant in almost every stage of development, which I gathered there, has taught me, that this *Cladophora*-like alga, far from belonging to that genus, forms the type of a distinct order of plants, distinguished by a quite original mode of development and formation of spores. The order I have named *Pithophoraceæ*, and the only genus, as yet known, belonging thereto, *Pithophora*, from πίθος = cask, and φορός = carrying, because of the peculiarly short (spore-) cells mentioned above.

From D:r P. T. CLEVE, Professor of chemistry at this University, I have received for examination a rich material of a *Cladophora*-like alga, gathered by him in the isle of S:t Thomas in the West Indies in 1868. This was also found, on a more careful examination, to belong to the genus *Pithophora*, forming a new species of this genus, very clearly distinguished by peculiar morphological characters.

From Professor E. VON MARTENS, jun:r, I received as a present, during a visit to Berlin in 1873, several very interesting algæ collected during the prussian expedition to East-Asia in 1860—62, in which v. MARTENS was one of the participators. Among these algæ occurred two, which were found, on a nearer examination, to belong to the group of *Pithophoraceæ;* one labelled *Cladophora sumatrana* v. Mart. (from Sumatra) and one *Cladophora Zelleri* v. Mart. (collected in Japan). Both these species are described — though, it is true, rather succinctly — by D:r G. v. MARTENS, sen:r, in »Die preussische Expedition nach Ost-Asien. Botanischer Theil. Die Tange.» The figures attached to the treatise intimate, that this author has already observed the characteristic short (spore-) cells in »*Cladophora sumatrana.*» In »*Cladophora Zelleri*» they have, however, escaped his attention.

During a review of the numerous figures of different species of *Cladophoreæ*, which Kützing has given in his Tabulæ Phycologicæ, I have observed two figures constructed so as to suggest the represented species to belong to the new group of *Pithophoraceæ.* These two species are *Cladophora Roettleri* (Roth) Kütz., represented in Vol. IV, plate 46, and *Cladophora Oedogonia* Mont., represented in Vol. VI, pl. 1.

By the kind mediation of Professor P. T. CLEVE, D:r A. GRUNOW in Vienna has put at my disposal, with the greatest liberality, a considerable part of his rich collection of *Cladophoreæ* from all parts of the world. This collection contained, among other things, original specimens of *Cladophora Roettleri* (Roth) Kütz.; and the examination of these specimens perfectly verified my conjecture, expressed above, that this species belonged to the genus *Pithophora.* The Grunowian collection also contained an original specimen of the *Cladophora sumatrana* v. Mart., mentioned above. Moreover, another form belonging to this genus was found in the collection; it was from Mangalore in India and was identified by Kützing as *Cladophora crispata* [1]) (the identification corrected by GRUNOW to *Cladophora Roettleri),* — and also another, belonging to this group, from La Guayra in Venezuela, called *Cladophora Roettleri var.* Besides these, which existed in fertile specimens, the Grunowian collection contained specimens of sterile [2]) *Pithophoraceæ*, partly from South America and partly from Australia.

Judging from the species as yet known, the family contains only tropical and subtropical forms (the one found in »Tropical Aquarium» in Kew probably also has its origin from the tropics), all growing either in fresh water [3]) or, as is the case with the one found by Professor CLEVE in the West-Indies, and probably also with the one collected by v. MARTENS in Japan, on moist earth.

Before passing to an account of the natural history of the *Pithophoraceæ*, I will here embrace the opportunity of offering my hearty thanks to Mssrs Professor E. VON MARTENS, Professor P. T. CLEVE and D:r A. GRUNOW for the valuable assistance they have rendered me by putting at my disposal precious material from their respective collections.

In the following exposition of the morphology and systematic arrangement of the *Pithophoraceæ*, I begin by describing the construction of their vegetative system, and then treat, in different paragraphs, the formation of their reproductive organs, their germination and increase, their whole development succintly, their place in the natural system, their specific characters, their geographical distribution, and finally I give a special account of the forms, as yet known, belonging to this group.

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[1]) This form is communicated under the same name in HOHENACKER'S Algæ marinæ siccatæ, n:o 742.

[2]) Even as sterile the *Pithophoraceæ* may generally be distinguished from *Cladophoreæ*. Regarding this, see below, pag. 4.

[3]) The australian form, found in the collection D:r GRUNOW has kindly put at my disposal, is said to occur in slightly brackish water also.

I. CONSTRUCTION OF THE VEGETATIVE SYSTEM.

The *Pithophoraceæ* belong to those simply constructed plants, whose vegetative system consists of a thallus, formed only of ramified series of cells. In a sterile condition (pl. 1, fig. 7 and 8) they resemble the common freshwater *Cladophoreæ* so much, that it seems at first impossible to distinguish them from each other in this condition. By a nearer examination, however, you succeed in finding two characters by the assistance of which it is possible to distinguish even sterile *Pithophoraceæ* from *Cladophoreæ*. One of these characters is, that in *Pithophoraceæ* the branches are, as a rule, attached to their supporting cells a small space below their top; a space in general of the same or not much less length than the diameter of the branch cells. The other character is, that the vegetative cells in *Pithophoraceæ* are, it is true, rather long, but that the length is however very variable (5—12—20 times longer than the thickness, and still more), not only in the same species, but in the same individuals. Of all the numerous species of real *Cladophoreæ* which I have had occasion to examine or of which I have seen trustworthy figures, there are only two, that have regularly their branches attached to the supporting cells in the same manner as *Pithophoraceæ*. These two are *Cladophora uncialis* Fl. Dan. [1]), (which occurs in the salt water on the coasts of the North Sea and Cattegat), and *Cladophora tomentosa* Sur., (found on moist earth in Japan). [2]) These species do not, however, make the same impression as a *Pithophora*, their vegetative cells being proportionally short (only 2—4 times as long as thick), and, moreover, they are all of about the same length.

If you observe the whole thallus of a complete specimen for instance of *Pithophora kewensis* nob. (pl. 2, fig. 1, 5, 6 and 7) you will find, that it consists of two very easily distinguished parts, situated one

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[1]) It is Professor J. E. ARESCHOUG who has indicated to me, that the branches of *Cl. uncialis* Fl. Dan. are attached in this peculiar manner.

[2]) In *Cladophora comosa* Kütz. and *Cl. Kjellmanniana* Wittr. (a new species from the glaciers of Spitzbergen) it sometimes happens, it is true, that part of the branches are attached in the same manner as in the *Pithophoraceæ*; but this mode of attachment is not the regular one. In the groups *Rhizoclonium* Kütz. and *Ægagropila* Kütz. the attaching point of the branches, especially of the lower ones, is very irregular, and with those it now and then happens, that one or two branches have the same position on their supporting cell, as that which the *Pithophoraceæ* regularly have.

on each side of the oblique cell-wall which has, in the germination of the mother spore, *sg*, first divided this spore into two cells. These two parts of the thallus have, from the beginning, developed from the two opposite ends of the spore, and have afterwards also taken their growth in two opposite directions. [1]) One of these parts is a great deal better developed than the other and almost always branched, and moreover, it is this part which, as a rule, brings forth the spores. The other part, on the figures indicated by the letters *rh*, is always much more feebly developed (most frequently it consists of only one cell) and normally it develops neither branches nor spores. The former of these parts, which resembles the stem in the higher plants by bringing forth the organs of propagation and by growing upwards, I have, on these grounds, named the cauloïd part of the thallus, or, in short, the cauloïd (from *καυλός* = stem, and *εἶδος* = form); and the latter, which shows a certain analogy to the root of the higher plants, by growing in an opposite direction to the stem and by being, as a rule, devoid of spores, the rhizoïd part of the thallus, the rhizoïd (from *ῥίζα* = root, and *εἶδος* = form). [2])

However great the differences are, you may find a peculiar resemblance between the taproot of the *Dicotyledons* and the *Archispermæ (Gymnospermæ* R. Br.) on one side, and the rhizoïd of the *Pithophoraceæ* on the other, in the fact that both are developed immediately out of the germ of the new plant (with the former the embryo, with the latter the spore), and in the circumstance, that they both form a direct continuation downwards of the primary axis of the stem system (in *Pithophoraceæ* of the cauloïd). In the same manner as in *P. kewensis* nob. such a distinction between the cauloïd and the rhizoïd part of the thallus is, as a rule, possible with all the other species of *Pithophoraceæ* that I have examined (pl. 4, fig. 1 and 15—19).

In the comparison above drawn, only the morphological characters have, as may be seen, been taken into consideration. Regarding the rhizoïd part in particular, it does not at all correspond physiologically with the root of the higher plants, because it is neither in a special

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[1]) Regarding this, see more in extenso in the paragraph treating »the Germination and Increase».

[2]) This distinction of two morphologically different parts of the thallus, i. e. one cauloïd and one rhizoïd part, may be made also in a great deal of other Thallophytæ, though these two parts are seldom so clearly separated as in *Pithophoraceæ*.

manner adapted to the absorption of food, nor serves as an affixing organ of the plant. The *Pithophoraceæ,* at least those that grow in water, are, as a rule, not attached to other objects, but float free in the water. The terrestrial species, *Pithophora Cleveana* nob., on the contrary, very often have affixing organs, which serve at the same time the physiological purpose of assimilating organs, [1]) but these belong to the cauloïd and not to the rhizoïd part of the thallus.

The general, outer shape of the thallus having now been described, a somewhat more extensive account of the nature of its two principal parts, the cauloïd and the rhizoïd, follows next. As I have mentioned above, the cauloïd is, as a rule, ramified. Full-grown individuals with a wholly unbranched cauloïd are very rare. Only in two species, *P. Cleveana* nob. and *P. æqualis* nob., I have found such specimens twice or trice (pl. 1, fig. 5). In *P. kewensis* nob., individuals with very few and small branches (pl. 2, fig. 5) are sometimes found, but I have not seen wholly unbranched specimens of this species. The system of ramification is of different strength in different species. It is feeblest in *P. sumatrana* (v. Mart.) nob., judging from the rather few and not quite perfect specimens that I have had opportunity to examine. All the branches, that exist here, proceed immediately out of the principal filament, and thus all the branches are of the 1:st degree. They are usually simple, but not rarely also opposite in pairs. *P. kewensis* nob. and *P. Cleveana* nob. generally have branches of only one degree (pl. 2, fig. 1, 6, 7, 13), but sometimes those branches ramify, and the branches they develop are then of the 2:d degree (pl. 2, fig. 3). In *P. kewensis* nob. the branches are always single; in *P. Cleveana* nob. they are not seldom opposite to each other (pl. 2, fig. 3). *P. æqualis* nob. has two types of ramification. In one the branches are only of the 1:st degree, in the other also of the second. They are always single. In *P. polymorpha* nob. specimens are found with branches of but one degree, but also with two. The branches of the 1:st degree are not seldom placed opposite to each other (pl. 2, fig. 13). *P. Zelleri* (v. Mart.) nob. always has branches of two degrees, which are partly opposite. In *P. Roettleri* (Roth) nob. the system of ramification is most powerfully developed. Here branches of three orders are regularly found, of which those that belong to the 1:st are placed three in a whorl, but those of the 2:d and 3:rd placed singly or in pairs (pl. 2, fig. 18). From this we find, that

[1]) Regarding these, which are also now and then found in the aquatic species, see pages 10 and 25.

the system of ramification in *Pithophoraceæ* is upon the whole slightly developed, when compared with what it is in most *Cladophoreæ* — in no species branches occur of a higher degree than the 3:rd — and that the species do form an unbroken series as to the ramification of the cauloïd, beginning with the species where the system of ramification possesses branches only of the 1:st degree, those being also single; continued by species where branches exist sometimes of only one degree, sometimes of two, and where the branches are partly single and partly opposite; and completed by the species where the system of ramification contains branches of three degrees, of which those belonging to the 1:st are verticillated, and those of the 2:d and 3:rd single or opposite. What has now been said on the ramification of the cauloïd has its strict and full bearing only on the fertile specimens, i. e. those that carry spores. In the sterile specimens, i. e. those that do not carry spores, the system of ramication is generally somewhate more developed; thus, that the sterile specimens, except of *P. sumatrana* (v. Mart.) nob. and *P. Roettleri* (Roth) nob. most frequently have branches of one degree more than the fertile ones, and that the branches in the sterile specimens occur oftener two and two opposite to each other than in the fertile ones. Even in *P. Roettleri* (Roth) nob. the sterile specimens show a tendency to richer ramification, having sometimes the branches of the 1:st degree not only three but even four in a whorl. Branches of a higher degree than the 3:rd I have not observed, not even in sterile specimens.

As to the place of the branches on the cells that support them, it has already been mentioned, that they are, as a rule, attached a short space below the top of their supporting cells. I may add here, that the supporting cells are regularly either common chlorophylliferous vegetative cells, or spores; only exceptionally they are subsporal cells — i. e. cells placed immediately under the spores and being sister cells of them — wanting chlorophyll. Branches, that have the position now mentioned, ought to be regarded as normal. But besides these, branches are sometimes found which deserve, by their more accidental occurrence, the epithet accessorial. These are recognized by proceeding not from the top but from another part, commonly the lower, of their supporting cells (pl. 1, fig. 4 *ac;* pl. 2, fig. 9 *ac;* pl. 4, fig. 7 *ac;* pl. 5, fig. 2 *ac);* compare what is said on ramification in the paragraph »Germination and Increase.»

That the branches on each individual supporting cell are most frequently found single, but often also two and two opposite or almost opposite to each other, and in one species — *P. Roettleri* (Roth) nob. — partly even four in a whorl, has been mentioned before.

If we try to give an account of the position the branches attached to different supporting cells have to each other, we find that it is mostly rather irregular. However, a tendency to a unilateral or bilateral arrangement, at least for short spaces, is very evident in most species (pl. 1, fig. 7, 8, 13; pl. 2, fig. 3, 4, 7).

The rhizoïd part of the thallus is, in contrast to the cauloïd, almost never ramified. Only in one specimen of *P. kewensis* nob. I have found a ramified rhizoïd (pl. 4, fig. 8). Generally this part consists of only one vegetative cell (pl. 4, fig. 1, 4, 5, 15, 16, 17); — this is, at least, the rule in both the species, *P. kewensis* nob. and *P. Cleveana* nob., of which I have had a sufficiently rich material for examination, — but now and then rhizoïds are found of an anomalous form. Thus it is not very rare in *P. kewensis* nob. to find rhizoïds consisting of several vegetative cells (pl. 4, fig. 6, 7); and in the same species as well as in *P. polymorpha* nob. also I have found rhizoïds, which have had, besides vegetative cells, as many as three spores, brought forth in the normal manner (pl. 4, fig. 9, 10, 11, 19). In contrast to this, specimens are sometimes found, in which the rhizoïd is barely rudimentary. It consists then not even of a whole cell, but only of the very lowest part of the basal cell of the plant, which part has at the germination of the mother-spore taken its increase in an opposite direction to the cauloïd (pl. 1, fig. 5, 8 *rh;* pl. 4, fig. 2, 3, 13, 14, *rh*). In *P. Cleveana* nob. I have even found specimens, in which a rhizoïd part has not at all been developed. Such a specimen I have represented pl. 4, fig. 12. (Compare the paragraph on »Germination and Increase.»)

It now remains, before I pass to treating the formation of spores, to account for the nature of the vegetative cells of the thallus. In sterile specimens, these are the only ones that occur; in fertile ones, spore-cells exist besides those. The vegetative cells agree with each other in the following particulars: 1:o They have the same principal form; they are all essentially cylindrical, even if some of them diverge from the cylindric form in some one of their parts. 2:o They have all a thin membrane of cellulose without layers. In *Cladophoreæ* particularly the cells belonging to the lower part of the thallus have often a thick membrane in distinct layers. 3:o They all have a parietal body of protoplasm, forming a not very thick layer inside the cell-wall, and enclosing a great cylindrical vacuole. — The thickness of the cells varies comparatively slightly in *Pithophoraceæ*. The narrowest cells I have seen (belonging to the branches in *P. kewensis* nob.) have had a diameter of 40 μ, and the thickest (belonging to the principal filament in *P. Roettleri* nob.) a diameter of 190 μ. The length varies more, however. Generally they are rather long, 5—20 times as long as thick, but cells that are not much more long than thick are also found, as well as those that are, on the contrary, more than 100 times as long as thick.

As to their position in the thallus, the vegetative cells may be divided into two kinds: the inclosed and the terminal. The inclosed cells are those that are placed in the series of cells, and thus are inclosed between two other cells. Terminal are those that end a series of cells, and thus touch another cell with only one end. The inclosed cells are most frequently almost purely cylindrical with abrupt ends. The small deviation from the cylindrical form, which the cells in some species show, consists in the cells having their longitudinal walls very slightly convex (pl. 1, fig. 6, 7). Of the inclosed vegetative cells two kinds are easily distinguished, viz. those of a green colour and those which are not green. The green-coloured, which are the cells that prepare the food of the plant, have received their colour from pure chlorophyll. Those parts of the parietal protoplasm which are coloured by this substance (the so-called granules of chlorophyll) have, in general, a lens-formed shape, with the line of circumference generally broken in obtuse angles (pl. 3, fig. 1). In specimens gathered in the afternoon, when the sun has influenced them for a sufficiently long time, a small granule of starch may be very clearly distiguished in each granule of chlorophyll (pl. 3, fig. 1, 3). The granules of chlorophyll are, as a rule, arranged in one layer, which is seldom uninterrupted, but usually has greater or smaller openings. Not rarely these openings are so great, that the arrangement of the granules of chlorophyll looks like a net, as pl. 3, fig. 3 shows.

In sterile specimens the cells now described are the only existing ones, but in fertile specimens colourless cells are found besides the green ones. The colourless cells, which are the subsporal branchless cells before mentioned, differ from the coloured ones by having their layer of parietal protoplasm much thinner, and by an almost total want of granules of chlorophyll. (On the cause of this, see the paragraph on »The reproductive organs.») A few such granules are, however, usually left, especially in the upper part of the cell, situated nearest to the (sister-) spore, (pl. 3, fig. 7; pl. 4, fig. 3, 9, 16 and others); but they are not sufficiently numerous to give the cell a green colour.

The terminal vegetative cells are also of two kinds: the common top cells, and the helicoïd cells. The common terminal cells resemble in their form the inclosed cells, with the exception that they have the top conical and rounded. As to their inward construction they agree with the inclosed cells. As long as the individual is increasing in growth they are rather rich in chlorophyll, but when the increase has ceased, they contain comparatively little chlorophyll. The top cells are the longest cells of the plant. In sterile specimens, where the increase has ceased, the top cell of the principal filament often has a length which is 50—100 times as great as the thickness (pl. 2, fig. 8).

Helicoïd cells I name those cells, of which the top is transformed to an affixing organ more or less like a tendril, a helicoïd (from ἕλιξ = tendril, and εἶδος = form). These cells are common only in one species, *P. Cleveana* nob., but also in the other species of *Pithophoraceæ*, with the exception of *P. sumatrana* (v. Mart.) nob. and *P. æqualis* nob., I have found them now and then. The lower part of the helicoïd cells is generally of a cylindrical form, but their upper part, the helicoïd, is of a very varying shape. In its least developed form the helicoïd cell is unbranched or almost so, and differs then as to shape from common terminal cells only by its upper part, the helicoïd, being more slenderly conical, and not straight, but curved, feebly undulating (pl. 5, fig. 1 *h'* and 2 *h*). In normally developed helicoïd cells the top of the cell is ramified in two or more small branchlets. The branchlets of the helicoïd are sometimes almost straight, with only a few small undulating curves (pl. 5, fig. 4); sometimes they are bent like a bow (pl. 5, fig. 5, 7), but most frequently they are quite claw-shaped (pl. 5, fig. 6, 11, 12; pl. 1, fig. 18 *h*). The contents in the lower part of the helicoïd cell are of the usual nature; in the upper part, or the helicoïd itself, chlorophyll-coloured protoplasm exists in a quantity so great as to fill this part of the cell almost completely (pl. 5, fig. 4, 6, 7, 10 *h*). Even if the quantity of chlorophyll-coloured protoplasm be not always so great, it is however, as a rule, greater in the helicoïd itself than in the rest of the cell (pl. 5, fig. 1 *h*, 5, 11, 12 *h*). A phenomenon which occurs regularly, at least in *P. Cleveana* nob., viz. that small foreign particles (grains of humus and other things) adhere to the surface of the helicoïd (but not to that of the other part of the helicoïd cell), indicates that the cell-membrane of the helicoïd is in some degree of a nature differing from that of the other part of the cell. However, I have neither by optical nor by chemical means been able to gain a more particular knowledge of the nature of this difference. I think it not improbable, that an extremely thin layer upon the surface of the cell-membrane has been transformed from cellulose to a jelly. — As a rule the helicoïds occur only on terminal cells, but now and then such organs are formed also on inclosed cells (pl. 5, fig. 1). — Regarding the function of the helicoïd cells, the name at once indicates that it is principally to be an attaching organ of the plant. They are particularly well adapted to this purpose by the form which their upper part, the helicoïd, has assumed. That they also have another purpose to serve, is very clearly hinted by the nature of their contents. The chlorophyll-coloured protoplasm, which exists in such uncommon abundance, especially in the helicoïd itself, no doubt officiates in the usual manner, and therefore the helicoïd cells may reasonably also be regarded as active organs of assimilation. [1]) That they have besides, like other cells of the plant, the power of absorbing liquid food for the plant, must be clear in itself.

II. ON THE REPRODUCTIVE ORGANS AND THEIR FORMATION.

The reproduction of *Pithophoraceæ* is effected in two ways, viz. 1:o by the formation of spores, and 2:o by the bringing forth of prolific cells. — Let us first describe the formation of spores. As I have had opportunity to observe it step for step only in *P. kewensis* nob., what I am going to say has its full bearing only on this species, but all signs seem to indicate, that the formation of spores in the other *Pithophoraceæ* is effected, in all essential particulars, in the same manner. Formation of spores takes place, as a rule, only in the cauloïd part of the thallus; but each cell in this part has the power of bringing forth a spore. Thus, spores may be formed by the terminal cells as well as by the inclosed, by the cells of the principal filament as well as by those of the branches. It is, however, rather rare to find specimens, in which all the cells of the cauloïd have really brought forth spores (such a specimen of *P. Cleveana* nob. is represented plate 2, fig. 12); generally the formation of spores has failed in one or more cells. Cells which have neither formed nor will ever form spores are not rare in the principal filament of the cauloïd; in the branches, on the contrary, sterile

[1]) Thus the helicoïds of *Pithophoraceæ* show a double analogy to the tendrils of certain phanerogamous plants, for instance with those of the *Passifloreæ*. Both are parts of the stem, transformed into attaching organs, and both are besides at the same time active in some degree in the assimilation.

cells are more seldom found in purely fertile specimens (pl. 2, fig. 1, 2, 3). (On the different kinds of individuals as to the power of reproduction, the fertile, the half-fertile-half-sterile, and the sterile, see below in this paragraph). At the time when the formation of spores is to take place, the formation of vegetative cells has ceased in purely fertile specimens, and the specimen has consequently attained its full size. All or most cells are then found to be so rich in chlorophyll, that the granules of chlorophyll form a continuous layer over the whole inside of the cell-wall. The formation of spores is introduced by the upper part of the mother-cell of the spore (in *P. kewensis* nob. generally $^1/_3$—$^1/_4$ of the cell) widening a little (pl. 3, fig. 4 *s*), so that it does at last assume the form of a rather slender cask; if the mother cell of the spore is a terminal cell, the upper end of the cask is pointed like a cone (pl. 3, fig. 5 *s*). It is this part of the cell that is to be developed to a spore. As yet, no change in the other part of the cell is perceptible. But when the widening of the upper part is completed, the granules of chlorophyll in the lower, cylindrical part of the cell commence to pass into the upper cask-shaped part. During this process it has seemed to me as if the parietal layer of chlorophyll were interrupted at the point where the cask-shaped widening of the cell commences — at least I have seen numerous cells during their forming spores, in which the chlorophyllaceous body of the nascent spore has already at an early period been so sharply limited at the lower end, as pl. 3, fig. 6 shows. It is possible that, at this place, only a folding inwards, without a complete interruption of the layer of chlorophyll, has taken place. Be this as it may, at all events the parietal layer in the enlarged part of the mother cell of the spore does not suffer a displacement (for instance in such a manner that the chlorophyll in the lower part of the enlarged space were removed higher up), but, remaining in its original position, it is augmented in thickness by apposition from within, till the whole swollen part of the cell is filled with chlorophyll-coloured protoplasm. The chlorophyll from the lower, cylindrical part of the cell moves into the upper cask-shaped part (pl. 3, fig. 6), at the same time completely filling the space which has been occupied by the great central vacuole of the cell. This requires, as a rule, almost the whole chlorophyllaceous mass of the cell, so that only a few granules of chlorophyll are left in the lower part (pl. 3, fig. 7). When the whole chlorophyllaceous mass has in this manner been completely removed into the upper and swollen part of the mother cell of the spore, the formation is commenced of a parting wall, which is to divide the mother cell of the spore into two daughter cells. The foundation of this parting wall is laid, in *P. kewensis* nob., not at the point where the cask-shaped widening of the cell commences, but a small space below this point (pl. 3, fig. 7 *w'*, *ba*). The parting wall first appears as a narrow ringformed ledge on the inside of the original membrane of the cell. This ringformed ledge increases successively inwards, so as to grow broader and broader (pl. 3, fig. 7 *ba*), and the hole in its centre consequently narrower and narrower; till it is at last completely filled up, and thus the parting wall quite completed. By this parting wall the mother cell is now divided into two daughter cells, an upper one rich in chlorophyll and cask-shaped, the spore, and a lower one, containing but little chlorophyll and cylindrical, the subsporal cell. The spore which has been formed in this manner, is completed by its membrane growing so much thicker, that it is at last, in *P. kewensis* nob., twice or thrice as thick as it originally was (pl. 3, fig. 9). A formation of clearly discernible layers in the membrane does not take place here. The contents of the cell do indubitably also undergo a change, for its colour, originally of a dark green or almost blackisk green, changes into brown, probably by a part (or all) of the granules of starch being transformed into a brownish oil.

By this exposition it is shown, that in the formation of spores in *P. kewensis* nob. the following four stages may be distinguished: 1:o The cask-like widening of the upper part of the mother cell of the spore: 2:o The passing of the chlorophyllaceous matter from the lower, cylindrical part of the cell to its upper, cask-like part; 3:o The appearing, just below the cask-shaped widening, of a succedaneously formed parting wall, and 4:o The ripening of the spore, situated above the parting wall, by the thickening of the membrane and the transformation in part of the contents of the cell. — The result of the whole process consequently is, that the mother cell of the spore forms, by division into two, one cell capable of germinating, the spore, in the formation of which the whole chlorophyllaceous contents of the mother cell are consumed, and one vegetative cell, the subsporal, which is not capable of further formation of cells or increase of any kind, being devoid of protoplasm, and which may consequently be regarded as being at least half dead.

If you compare the other species of *Pithophoraceæ* with *P. kewensis* nob. as to the process of the formation of spores, you will find, that the formation of spores takes place, upon the whole, much in the same manner, but withal that a couple of less essential deviations may occur.

One of these deviations consists in the fact, that the passing of the chlorophyll is begun and even completed without any previous enlargement of the upper part of the mother cell of the spore. The spore formed in this manner is not cask-shaped, but cylindrical; with its top rounded like a cone, if it is a terminal spore. Spores of this form are very often found in *P. sumatrana* (v. Mart.) nob. and in *P. polymorpha* nob. (pl. 1, fig. 2 and 13), and not seldom in *P. Zelleri* (v. Mart.) nob. and *P. Roettleri* (Roth) nob. They are more rare in *P. Cleveana* nob. (pl. 2, fig. 13); and in *P. æqualis* nob. they would seem not to occur. — The other deviation is, that not the whole chlorophyllaceous contents of the mother cell of the spore passes into the nascent spore, but a rather considerable part of it remains in the subsporal cell. The chlorophyllaceous matter, which has remained in the subsporal cell after the formation of the (first) spore, does not, however, continue in this cell, but is used to form a new spore below the first. This is done in exactly the same manner as in the formation of the first spore, only with the difference, that the enlargement of that part of the cell which is intended for a spore does not take place or is hardly perceptible. The two spores that have been brought forth in this manner by the same original mother cell, and which are placed beside each other, may be called twin spores. Such twin spores are regularly found in the principal filament (pl. 1, fig. 10, 11) and not seldom in the branches of the 1:st degree in *P. Zelleri* (v. Mart.) nob. (pl. 1, fig. 9 s' and s'' [1]). If in this species the formation of the second spore fails in the principal filament, the subsporal cell shows its creating power by forming instead a normal branch near its top (pl. 1, fig. 9 *sb*). Accidentally, twin spores occur in *P. Cleveana* nob. (pl. 2, fig. 14 and 15 s', s''), *P. polymorpha* nob. (pl. 1, fig. 16), *P. Roettleri* (Roth) nob. (pl. 1, fig. 19, 20) and now and then even in *P. kewensis* nob. (pl. 3, fig. 8 s', s''). In *P. Cleveana* nob. I have even found, twice or thrice, three spores in a row, brought forth by the same original mother cell (pl. 2, fig. 15 s^1, s^2, s^3). These may, therefore, be called triple spores. — The third deviation from the regular process of the spore formation is, that the mother cell of the spore, mistaking, as it seems, the direction of the increase, forms the

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[1]) In one case, represented pl. 2, fig. 10, I have found in this species one more deviation: the lower of the twin spores, marked s'', has, after the protoplasm has contracted, surrounded itself with a quite new membrane, instead of using that of the mother cell as far as possible.

spore in its lower end instead of the upper. Instances of this proceeding I have found in *P. kewensis* nob., but particularly in *P. Cleveana* nob. Two cases belonging to this category I have represented pl. 4, fig. 3 and pl. 3, fig. 8. In the former case, the cell marked *mc* has formed first a normal apical spore *s*, and afterwards an accessorial basal spore, *sb*. The cell just below has also formed a spore, *s*, in is top; thus this one and the basal spore of the upper cell are made to lie immediately beside each other, thus forming a pair of seeming twin spores. In the latter case, a lower cell has formed two apical spores, *s′*, *s″* (but which have received only an incomplete parting wall between them), whilst the upper cell has formed an accessorial basal spore *sb*; therefore, three spores are here made to lie beside each other, thus forming a group of seeming triple spores.

In *P. Cleveana* nob. the formation of basal spores besides or instead of apical is not at all uncommon. Especially it often happens in specimens where no rhizoïd has been developed, that the very lowest cell of the thallus, brought forth immediately by the germinated spore, forms a spore in its basal part (pl. 2, fig. 13 *sgb*, and pl. 4, fig. 12 *sgb*). A consequence of this is the remarkable circumstance, that the spore formed in this manner has quite the same place as the original mother spore of that plant, and that it even possesses, except at its upper end, exactly the same cell-membrane as the mother spore of the plant. This piece of membrane will consequently, according to the nature of the germination (see »Germination and Increase»), have belonged to three different individuals in succession, viz. 1:o the one which has formed the spore which has, by its germination, given existence to, for instance, the specimen represented pl. 2, fig. 13; 2:o the individual represented by that figure; and 3:o the specimen which the basal spore will form in future, when germinating. If it comes to pass (as it probably does sometimes), that one specimen after another, without forming a rhizoïd, forms a spore at the lower end of the plant, the same piece of cell-membrane will enter, as a living part, in a whole series of individuals. This circumstance has seemed to me the more remarkable, because it does not exist in any other pluricellular plant, as far as I know.

Only in *P. kewensis* nob. I have had opportunity to make observations on the order in which the spores are formed. Generally it is basipetal, i. e. the top cell in the principal filament or in a branch first forms a spore, then the cell just below forms one, and so on in a downward direction; pl. 2, fig. 5 and fig. 3, 4 *sf*. Deviations from this order are far from rare, especially in the principal filament. Here it does not seldom happen, especially in specimens that are but half-fertile, that the formation of spores takes place even quite acropetally (pl. 2, fig. 7). Rules as to the order of the formation of spores which have, as it has seemed to me, no exception, are 1:o That the top spore has, at least in shorter branches, been developed before all the inclosed spores of the branch, and 2:o That the spore which is developed by the supporting cell of the branch (if such a spore be developed, which is not always the case), is formed later than all the spores in the supported branch. — Although the material of the other species of *Pithophora* which I have had to examine has not in general given me opportunities to make observations on the order of the spore formation, still I have now and then succeeded in making an observation on this head. Thus, it is distinctly seen in the specimen of *P. æqualis* nob. which I have represented pl. 1, fig. 5, that here the formation of spores takes place, upon the whole, in a basipetal direction, even if the second spore from above be developed somewhat later than the third.

As has been mentioned above, the formation of spores belongs, as a rule, to the cauloïd part of the thallus. As exception spores may, however, be formed also in the rhizoïd part at least of *P. kewensis* nob. (pl. 4, fig. 9—11), *P. Cleveana* nob. (pl. 4, fig. 14, 18) and *P. polymorpha* nob. (pl. 4, fig. 19). In *P. kewensis* nob. I have even found rhizoïds with as much as three spores (pl. 4, fig. 11). The formation of spores in the rhizoïd takes place in exactly the same manner as in the cauloïd, only with the difference necessitated by the different direction of the increase, so that the spore is here formed not in the upper, but in the lower part of the mother cell.

As to the time of the spore formation it is, judging from the observations on this head that I have had access to, very different in different species. In *P. kewensis* nob. I have seen the formation of spores take place in the months of July and August. Of *P. æqualis* nob. I have fertile specimens, also collected in July. *P. Cleveana* nob. and *P. Zelleri* (v. Mart.) nob. are found with spores in October, *P. Roettleri* (Roth) nob. in January and *P. sumatrana* (v. Mart.) nob. in March. (At what time the formation of spores takes place in *P. polymorpha* nob. is quite unknown to me). However, it may be probable that the formation of spores takes place during longer periods of the year than those which have been indicated above for the different species.

In by far the greatest part of sporiferous individuals, the spores are brought forth in all parts of the cauloïd, and in almost all the cauloïd cells. For these individuals I have employed the name fertile (pl. 2, fig. 1, 2, 3, 13). But in some sporiferous individuals we find, that spores are developed only in one part of the cauloïd, while the other parts consist of cells which never develop spores. These individuals may be called half-fertile-half-sterile (pl. 2, fig. 6, 7). And the individuals in which no spores at all are ever developed, are the sterile. In the account of the construction of the vegetative system I have indicated (page 7), that another difference does also exist between the fertile and the sterile specimens, than the one consisting in the presence or absence of spores. We recollect that this difference, in short, consists in the circumstance, that the system of ramification is stronger developed in sterile than in fertile specimens. If we observe the half-fertile-half-sterile specimens somewhat nearer, we shall find that they are perfect connecting forms between the sterile and the fertile. The sporiferous part of the cauloïd of the half-fertile-half-sterile specimens has a more feebly developed system of ramification, resembling that which is found in purely fertile specimens; the part which is not sporiferous has, on the contrary, a more strongly developed, resembling that of purely sterile specimens. Fig. 6 and 7 on pl. 2 represent two half-fertile-half-sterile specimens of *P. kewensis* nob. In the specimen represented fig. 6 the upper part is fertile and the lower sterile; in the specimen represented fig. 7 the lower part is fertile and the upper sterile. In both specimens, a very considerable difference exists between the system of ramification of the fertile and of the sterile parts. While the fertile part has short and few branches (several of the cells in the principal filament are branchless), the sterile part has comparatively long and numerous branches (all the cells of the principal filament carry at least one branch, and in the specimen represented fig. 7 we find several which carry two). — In the same manner as in *P. kewensis* nob. I have found half-fertile-half-sterile specimens in other species of *Pithophoreæ*.

Although the sterile specimens do not develop spores, still they are not quite denied the possibility of reproduction. They have the power to develop another kind of reproductive cells, the so-called prolific cells. These cells are originated by common vegetative cells in the following manner: some vegetative cells, very rich in chlorophyll, absorb food in a more abundant quantity than the others, and store up this food in themselves in the shape of granules of starch (pl. 3, fig. 1 *p*).

The prolific cells are thus made to differ from the common vegetative cells by containing a greater abundance of chlorophyll, and particularly a more plentiful supply of starch. The cells which are transformed into prolific cells generally belong to the principal filament of the thallus, and are always inclosed — not terminal — cells. Besides in sterile specimens, prolific cells are also found in the sterile part of half-fertile-half-sterile individuals. In *P. Cleveana* nob. I have, even in purely fertile specimens, found cells which can hardly be anything but prolific cells; see for instance pl. 4, fig. 18 *p* and pl. 5, fig. 2 *p*. That these cells are not spores is easily seen from the fact that a passing of chlorophyll to them cannot have taken place from any quarter; but that they serve a reproductive purpose is rather clearly indicated by their rich contents. The irregularly fusiform cells represented pl. 1, fig. 15 and marked *p, p'*, which belong to a fertile specimen of *P. polymorpha* nob., may also perhaps be prolific cells. If it be so, it is the more remarkable, because the upper one, *p*, has already formed a small spore, *stc*, in its top, and the lower, *p'*, is evidently on the point of doing so. It would then come to pass, that sister cells of spores, so-called subsporal cells, which are otherwise always destined for destruction, would themselves serve as reproductive cells. The possibility of this would of course be evidenced by the subsporal cells being, in this case, so rich in chlorophyll, as a consequence of their delivering but an inconsiderable part of their contents to the comparatively small spores.

From the exposition given above we find, that the prolific cells arise immediately out of the common vegetative cells, by these cells being filled with richer store af reserved food; but without any previous enlargement or change as to the outer shape. [1]) In a species of *Cladophora*, the common *C. fracta* Dillw., growing in fresh water, we know already from the results of the observations of Kützing, exhibited in Phycol. Gener. page 263 and 264 (with beautiful illustrations on pl. 11), that such a formation of prolific cells takes place; but the prolific cells here differ from the common vegetative cells not only by the nature of their contents, but also by their shape, which is not cylindrical, but irregularly rounded or almost pear-shaped.

The following paragraph will give an account of the germination of the prolific cells as well as of that of the spores.

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[1]) Only in the subsporal cells of *P. polymorpha* nob. mentioned just above (represented pl. 1, fig. 15 *p*, *p'*), — supposing these to be really prolific cells, — an enlargement and change of shape have taken place.

III. ON THE GERMINATION AND INCREASE.

Although I have not had opportunities of immediately observing the germination of a *Pithophora* [1]), still a close study of the rich material, chiefly of *P. kewensis* nob., which I have had at my disposal, has made it possible for me to account at least for the principal moments of this act of development.

The germination of the spores takes place, as a rule, in the following manner. The spore having been made free by the dissolution of the two cells situated one on each side of the spore, and having reposed long enough [2]), it sends forth two conically-cylindrical processes, one from each of the two opposite ends of the spore. The spore cell, thus developed in a longitudinal direction, is then divided by a parting wall into two daughter cells. This parting wall is, it is true, always transversal, but sometimes obliquely transversal — as for instance in *P. sumatrana* (v. Mart.) nob. (pl. 4, fig. 1 *sg*) and regularly in *P. kewensis* nob. (pl. 2, fig. 1, 5, 7 *sg*, and pl. 4, fig. 4, 5, 6, 9 *sg*), — and sometimes transversal in a straight direction or, in other words, vertical against the longitudinal axis of the spore cell — thus as a rule in *P. Cleveana* nob. (pl. 4, fig. 16, 17 *sg*) and exceptionally in *P. kewensis* nob. (pl. 4, fig. 7, 8 *sg*). This parting wall is most frequently situated just at the midst of the germinated spore and thus divides it into two almost equal parts (pl. 4, fig. 1, 6, 9, 15); but sometimes it is placed a considerable space above or below the midst of the spore (pl. 4, fig. 4, 7, 8, 16), thus dividing it into two very unequal parts. The two daughter cells, formed by the division into two of the spore cell, now increase in two diametrically opposite directions, and give origin one to the cauloïd, and the other to the rhizoïd part of the thallus. The transversal wall which is

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[1]) My sojourn in Kew was of so short duration, that I had not time enough to succeed in any experiments of germination. After my return to Upsala I have endeavoured to make spores which have been dry germinate (this succeeds, as is known, pretty easily with some algæ), but I did not succeed.

[2]) That the spores of *Pithophoraceæ* are hypnospores may be concluded among other things from the fact that their membrane increases considerably in thickness during the ripening of the spores, a thing which does not take place in spores intended for immediate germination.

formed immediately at the germination of the spore, thus forms a sharp limit between the cauloïd and rhizoïd of the thallus. [1])

Before quitting the germination in order to pass to an account of the increase and development of the two constituent parts of the thallus, formed in the manner now described, it may seem fit to account for the deviations from the regular proceeding which may occur in the germination of the spores. I have found deviations of two kinds. The first deviation consists in the following fact: one of the two processes, which the spore sends forth in germinating, remains very small; besides, no transversal wall in the spore is developed. The process, of which the increase ceases at so early a period, is, as to its situation, analogous with the process which does, in a normal germination, give rise to the rhizoïd; and it is therefore to be regarded as a rhizoïd in a rudimentary state. This rhizoïd will thus consist not of a whole cell, but only of a process, pointing downwards, from the basal cell of the plant, otherwise belonging to the cauloïd. (Such rhizoïds I have found now and then in *P. kewensis* nob. (pl. 1, fig. 8 *rh*, and pl. 4, fig. 2, 3 *rh)* and in *P. Cleveana* nob. (pl. 4, fig. 13 *rh*), and often in *P. æqualis* nob. (pl. 1, fig. 5 *rh).* The first transversal parting wall which is formed in a germination of this kind, will be placed in the cauloïd a considerable space above the germinated spore (pl. 4, fig. 3, 13 *w*). No transversal wall being formed in the spore (as is mentioned above), it will not be possible to distinguish any sharp limit between the cauloïd and the rudimentary rhizoïd. Of *P. Cleveana* nob. I have, however, found one specimen, the one represented pl. 4, fig. 14, which has a parting wall, *w*, though imperfect, between the cauloïd and the rudimentary rhizoïd. This specimen does, moreover, show the peculiarity that a new basal spore is formed, within the membrane of the original germinated spore, by the lowest cell of the cauloïd (see regarding this in the preceding paragraph page 15). — The second deviation consists in the following process: the spore, in the germination, instead of sending forth two diametrically opposite processes, only sends forth one, which by its further development gives

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[1]) In general it is very easy even in fully developed specimens to see which is the transversal cell-wall developed at the germination of the spore, and thus to identify with certainty the limit between the rhizoïd and cauloïd; but now and then we may meet with some difficulties. Thus it would be very difficult, in the specimen of *P. Cleveana* nob. represented pl. 4, fig. 18, to decide with certainty whether the cell-wall marked *w'* or the one marked *w''* is the one first formed. For my part I think it most probable, that the one marked *w'* is the primary one; in which case all that is situated below it would belong to the rhizoïd.

rise to a cauloïd easily recognized as such by its being ramified and, in fertile specimens, by its carrying spores. A rhizoïd is, in this case, not developed, but it often happens, that the lowest cell of the cauloïd forms, in its lower end, within the membrane of the germinated spore, a new basal spore (pl. 4, fig. 12 *sgb*); see the preceding paragraph l. c. Specimens of this kind I have found only of *P. Cleveana* nob., but not so very few. The first transversal cell-wall is in this case, as in the preceding one, placed above the germinated spore in the cauloïd (pl. 4, fig. 12 *w*). It is easily understood by the account of the formation of spores contained in the preceding paragraph, that this wall must be formed before the two situated below marked *w'* and *w''*. In one specimen of *P. Cleveana* nob., the one represented pl. 4, fig. 15, I have found a transversal cell-wall in the germinated spore, seemingly without the spore's having been elongated downwards in germinating. The little cell, *rh*, situated below this parting wall must thus per analogiam be regarded as the rhizoïd of the plant. (In this specimen also a basal spore is found in the cauloïd).

The nature of certain specimens of *P. kewensis* nob. and of *P. Roettleri* (Roth) nob. gives reason to suppose, that other deviations from the normal proceeding of the germination may possibly take place. The specimen represented pl. 4, fig. 7 shows, proceeding immediately out of the germinated spore, a side branch, *ac*, pointing somewhat downwards. It is possible, that this branch may have been formed already in the germination, and in this case the spore would have sent forth no less than three processes, one upwards, one downwards and one sideways; but it might also be possible, — and this seems to me more probable, — that this branch has been formed later, when the lowest cell of the cauloïd had already attained its completion; in the same manner as we sometimes find, in *P. Cleveana* nob., that the lowest cell of the cauloïd has, after the germination, formed a spore in its lower end. The branch marked *ac* on pl. 4, fig. 10 might be analogous to the side branch mentioned above (pl. 4, fig. 7 *ac*), though it points upwards instead of downwards. [1]) The probability of the opinion, that the branches now mentioned are not formed in the germination, but later, is supported by the nature of the specimen which is represented pl. 4, fig. 9. There we see an almost full-grown specimen just in the act of developing, from its lowest cauloïd cell, a basal branch, *ac*, pointing downwards.

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[1]) Possibly this might be the case also with the branch marked *ac* belonging to the specimen of *P. Zelleri* (v. Mart.) nob. represented pl. 1, fig. 12.

Pl. 4, fig. 18 shows a specimen of *P. Roettleri* (Roth) nob. which has no normal rhizoïd, but which has sent forth, from the mother spore, *sg*, of the plant, a side branch, which is itself ramified, sending a strong branch downwards and a feebler one upwards. That this side branch has been formed already in the germination of the spore seems to me very probable. The germinated spore would thus in this case have sent forth two processes, one from one of its ends, but the other not from its opposite end, but from one of its sides, and would thus have germinated in quite a peculiar manner.

In the account of the increase of the new plant, originated in the germination of the spore, we will first take into consideration the cauloïd, and afterwards treat the rhizoïd. In its first stage the cauloïd consists, as is mentioned above, of only one cell, viz. one of those originated by the formation of the first transversal cell-wall in the germinated spore cell. This cell now increases apically, and after having attained a certain length it is divided into two daughter cells by a succedaneously formed transversal cell-wall, vertical against the longitudinal axis of the cell. The formation of this wall, as well as of all the transversal cell-walls formed in the bipartition of the vegetative cells, takes place exactly in the same manner as the formation of the transversal wall which appears, in the formation of spores, between the spore itself and the subsporal cell; see above page 13. The lower one of the two daughter cells formed in the bipartition of the first cauloïd cell, which is somewhat widened at the base, but as to the rest of the common cylindrical form, no more increases in the same direction, nor is divided, till ramification — or, in fertile specimens, possibly also formation of spores, — takes place. The upper, on the contrary, which is cylindrical with a rounded top, elongates apically in the longitudinal direction of the mother cell till it has become about twice as long as the mother cell, and then in its turn divides into two daughter cells, the lower and shorter of these being purely cylindrical with abrupt ends, but the upper and longer being of the same form as the mother cell. The lower daughter cell now formed has the same nature as the lower of those formed in the first bipartition — that is, it no more increases in a longitudinal direction, nor is divided, except when branches or spores are to be formed — but the upper elongates apically and is divided into two cells, in the same manner as its mother cell. The two cells now formed proceed in the same manner as those formed by the preceding bipartition. Thus there are formed, anew, a lower cell devoid of the power of increasing in length, and an upper one with the power of increasing apically in the longitudinal direction of the mother cell, and of bipartition. By increase and bipartition in accordance to the law now indicated, a single series of cylindrical cells is formed — the cells being longer or shorter according to the nature of the species and of the outer circumstances, — and this series of cells forms that part of the cauloïd which I call, in its description, its principal filament.

Only in very rare, exceptional cases the principal filament of the cauloïd remains unbranched — perfectly branchless, full-grown specimens I have found now and then in *P. æqualis* nob. (pl. 1, fig. 5) and *P. Cleveana* nob., and almost branchless in *P. kewensis* nob. (pl. 2, fig. 5). In common cases ramification takes place if not in all at least in most cells of the principal filament, and this very soon; generally long before the principal filament has attained its full development as to length. The oldest cells, — consequently those situated lowest, nearest to the mother spore of the specimen, — are the first which develop branches; and afterwards the formation of branches proceeds from the lower and older cells to the upper and younger ones. — i. e. acropetally, — but not quite to the top cell, this being as a rule unbranched.

The formation of the first cell in every branch takes place in the following manner. That cell of the principal filament from which the branch is to be formed, sends forth from one of its sides, a small space below the top, a small process, which is at first shaped like a truncated cone with a strongly rounded top, and which does not point straight outwards, but somewhat upwards (pl. 3, fig. 1 *b*). This process is formed by an increase as to the surface of the membrane, beginning round a central point, in consequence of which the membrane in this place by and by gets convex. Sometimes this increase of the surface takes place only in the inner layer of the membrane, which then, by its continued increase, breaks the outer layer (pl. 3, fig. 1 *b*) [1]; but sometimes the increase extends both to the inner and outer part of the membrane, and it is then not broken. [2] As pl. 3, fig. 1 *b* shows, and as is mentioned

[1]) This circumstance strongly calls to mind the proceeding at the commencement of the formation of branches in the genus *Bulbochæte* Ag. See Pringsh. Beitr. z. Morph. d. Alg. p. 22, pl. 2.

[2]) I have not been able to distinguish, previously, two layers in a cell of a *Pithophora* ready for ramification, neither by optical nor by chemical means. Their existence, at least in some cases, is proved only by the circumstance mentioned above.

above, the lateral and cone-shaped process does not appear immediately under the top of the cell, but a space below it, which space is in general about as great as half the diameter of the mother cell. On this depends the circumstance (mentioned page 4), so peculiarly characteristic in *Pithophoraceæ*, of having the branches not at the very top of the supporting cells, but a space below it. The small process formed in the manner mentioned above is elevated more and more, and little by little elongates, till it attains the form of a cylinder with a rounded top and with its base, as it were, contracted (pl. 3, fig. 2 *b*). This process has in general a position so as to form an angle of about 45 degrees with that part of the mother cell which is situated above the process. When this process has attained a length which exceeds the diameter of the mother cell 2—6 times, a cell-wall is formed at its base, which separates the process, as an individual cell, from its mother cell. This cell-wall, which is formed exactly in the same manner as the transversal cell-walls in the principal filament, has, now and then, a position so as to be almost rectangular to the process (pl. 4, fig. 2 and 6 *w*), but generally it is placed obliquely against this axis, with an evident inclination downwards (pl. 3, fig. 7 *w;* pl. 4, fig. 3, 4, 5, 11, 18 *w*, and others). Thus we find here an exception from the law indicated by Hofmeister in Handb. d. Phys. Bot. Band I, Abth. 1. page 129, that the parting wall formed at the bipartition of cells is rectangular to the direction in which the strongest preceding increase of the cell has taken place. [1]) The daughter cell formed in the manner indicated above, and placed at the side of its mother cell, and having as a rule a diameter $^1/_5$—$^1/_4$ shorter than that of its mother cell, now increases in length. When it has grown about twice as long as the mother cell, it is divided, in the usual manner, into two daughter cells, a lower one somewhat shorter, and an upper one somewhat longer. It happens, more rarely in sterile specimens, but oftener in fertile, that the branch cell, developed from a cell of the principal filament, is not divided, in which case the branch remains of course unicellular (pl. 1, fig. 8 *b*); but if a formation of spores (in fertile specimens) in the branch cell takes place later, it is thus made bicellular (pl. 2, fig. 4 *b*). Such branch cells do not, as a rule, attain a length so considerable as that of those which are to form new cells by bipartition. If, as the case most frequently is, the branches

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[1]) »Die theilende Scheidewand steht senkrecht auf der Richtung des stärksten vorausgegangenen Wachsthums der Zelle». Hofm. l. c.

are pluricellular, they increase in the same manner as the principal filament apically by the bipartition of the top cell. As a rule the lowest (oldest) branches attain the greatest length, and especially the branch (or one of the branches, if there are more than one) which is supported by the lowest one of the branch-carrying cells, is often found very strongly developed (pl. 1, fig. 8, 18; pl. 4, fig. 7, 8, *b*). Exceptionally, particularly in half-fertile-half-sterile specimens, it takes place, on the contrary, that the upper (younger) branches are stronger developed than the lower (pl. 2, fig. 7, 13). As has already been mentioned above (page 6), these branches, proceeding immediately from the principal filament and being consequently of the first degree, are the only ones existing in *P. sumatrana* (v. Mart.) nob. and in fertile specimens of *P. kewensis* nob. and *P. Cleveana* nob. The cells in the branches of the 1:st degree are, in these cases, devoid of the power of forming new branches. But in the other species, and particularly in sterile specimens, the cells in the branches of the 1:st degree have the power, partially at least, to give origin to new branches (pl. 1, fig. 8 *c*, fig. 18). These new branches, which are of the 2:d degree (pl. 1, fig. 18 b^2), are formed exactly in the same manner as those of the first, and differ from them only by having a somewhat smaller diameter of the cells and by a feebler general development. Only in one of the known species of *Pithophora*, *P. Roettleri* (Roth) nob., the cells in the branches of the 2:d degree have the power of forming new branches (of the 3:rd degree; pl. 1, fig. 18 b^3); in all the others they remain unbranched.

In all the species of *Pithophora* the cells of the principal filament possess, at least in the sterile specimens, the power of forming each not only one branch, but two, and in *P. Roettleri* (Roth) nob. even three and as much as four. These branches then proceed from the mother cell, almost at the same height, and are thus opposite (or nearly so) to each other, or placed in a whorl (pl. 1, fig. 8, 13, 18). As a rule, one of two opposite branches is considerably stronger than the other (pl. 1, fig. 8; pl. 2, fig. 7). Neither are they developed at the same time, but the stronger one first, and the feebler one often very much later (pl. 2, fig. 7).

The cauloïd of the specimen having in this manner attained its full development as to the vegetative organs, the formation of spores is commenced in fertile specimens in the manner described above. The spores are in general formed basipetally, in contrast to the branches, as we remember from the preceding paragraph. Now and then, particularly in half-fertile-half-sterile specimens, the formation of spores is begun already before the ramification is completed (pl. 2, fig. 5, 7). It then not seldom happens, especially in *P. Cleveana* nob., that the formation of a branch being commenced in a cell, it is interrupted by the formation of a spore in the same cell. A cell of this description then seems to have, as it were, suddenly changed its plan, ceasing the formation of the branch in order to form in its place a spore. Spores formed during those circumstances are recognized by carrying on one of their sides a greater or smaller process, often resembling the beak of a bird (pl. 2, fig. 3, 14, 15 *sr;* pl. 3, fig. 8 *sr*). That the formation of branches and spores may take place at the same time is also shown by pl. 3, fig. 5. Here we find a branch process, formed so lately as not yet to be parted by a cell-wall from its mother cell, but of which the upper part, *st,* is already in the act of transforming itself into a spore. [1]) This circumstance is still more evident in such rather rare and very short branches, as are wholly transformed into spores, so called sessile spores. I have found those mostly in *P. Cleveana* nob., but also in *P. kewensis* nob. (pl. 2, fig. 2 *ss*) and *P. polymorpha* nob. (pl. 1, fig. 17 *ss).*

As we have found from the exposition given above, the increase in length of the series of cells is produced by the activity of the top cells; while the formation of branches is effectuated by the inclosed cells. Here the following remarks may be made. Bipartition of the cells inclosed in the series occurs now and then. Thus, the cells marked *p* and *b* in pl. 3, fig. 1 are daughter cells of an inclosed cell. Neither is the formation of branches from top cells without an instance. Fertile specimens of small size of *P. Cleveana* nob. are not unfrequently found with not only one, but even two branches developed from the terminal cell of the principal filament, which has then also developed a spore in its top (pl. 2, fig. 13; pl. 4, fig. 16). Of *P. polymorpha* nob. I have found one specimen, the one represented pl. 1, fig. 17, where two terminal cells, one belonging to the principal filament, the other to a branch, show a beginning ramification (both the branchlets will here consist of

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[1]) In the further process of the development a parting wall will be formed here first at *ba'*, and afterwards, when the whole chlorophyllaceous mass of the branch cell has passed into the widened part of the cell, at *ba''*. All this being done, the original mother cell will form a spore in its top. Compare pl. 2, fig. 3 *st*, and pl. 5, fig. 4 *st*.

only one sessile spore). Of *P. kewensis* nob. I have also found a specimen (see pl. 1, fig. 8) of which the top cell supports a branch. It is possible, however, that this cell is not the real terminal cell of the plant, but that it has been made terminal by the breaking off in some way of the uppermost part of the specimen.

What has been said above on the formation of branches concerns in the first place the normal branches, but also of the accessorial it may, in its principal points, be true. Only the following deviations are to be remarked regarding these. The place where they occur is, as we know, different from that of the normal branches. In most cases they are formed a small space above the base of their mother cell; and when this is the case, they increase downwards instead of upwards (pl. 1, fig. 4, 18 *ac;* pl. 2, fig. 9 *ac;* pl. 4, fig. 7, 9 *ac).* [1]) By this circumstance they get quite the same relative position to the basal part of the mother cell, as the normal branches to the apical part. Only very seldom accessorial branches are found of another nature. Pl. 5, fig. 1 shows the lower part of a specimen, which possesses two accessorial branches, *ac* and *ac'*, which proceed both, it is true, from the lower part of their mother cells, but which are, nevertheless, placed considerably farther from the base of the mother cell, than accessorial branches usually are. What is most remarkable in these branches is, however, that they have increased not in a downward direction, but upwards, like the normal branches. Fig. 2 on the same plate also shows two accessorial branches, *ac*, attached in a rather uncommon place. — The accessorial branches generally remain unbranched; I have only once found one which was ramified (pl. 5, fig. 1 *ac).* Most frequently they appear on the principal filament of the cauloïd and especially on its lowest cell. Now and then I have, however, found accessorial branches proceeding also from branch cells. Pl. 1, fig. 18 *ac* shows an accessorial branch developed from a cell, belonging to a branch of no less than the 2:d degree.

Ramification, accompanied by bipartition (by which act common branches, consisting of one or more cells, are formed), from terminal cells is, as we have seen above, upon the whole very rare in *Pithophoraceæ.*

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[1]) By comparison with the *Cladophoreæ* I have later come to the conviction, that the basal accessorial branches ought to be regarded as belonging to the root-system of the plant, being the morphological equivalents of the rhizines, emitted from the cauloïd cells of the *Cladophoreæ.* See par. 5, pag. 37.

But, on the contrary, ramification of the terminal cells without the formation of new cells is not at all uncommon. In this manner the helicoïds before mentioned, so characteristic especially in *P. Cleveana* nob., are generally formed. A terminal cell, sometimes belonging to the principal filament, but more frequently to a branch, sends forth at or near its top two or more, slender, irregularly shaped, more or less crooked processes. These are not separated from the mother cell by transversal walls, but will also in future belong as branchlets to the cell from which they have been sent forth. Simultaneously with this formation of processes or branchlets, the greatest part of the chlorophyllaceous contents of the terminal cell passes from the lower part of the cell into its upper part. In this cell, two parts may consequently be easily distinguished, viz. a lower one of the common cylindrical shape and containing but a small quantity of chlorophyll-coloured protoplasm, and an upper one of a varying shape, but regularly ramified and containing an abundant supply of chlorophyll-coloured protoplasm. This upper part is the helicoïd (pl. 5, fig. 4—7, 9, 11, 12 *h*). The helicoïds are most frequently, but not always, formed by the ramification of terminal cells. Sometimes, though very seldom, they may be formed by the ramification of inclosed cells (pl. 5, fig. 1 *h*); and sometimes they may be formed without any ramification, only by a peculiar development of the upper part of an unbranched terminal cell; thus, that the upper part of the cell grows more tapering and also richer in chlorophyll (pl. 5, fig. 1 *h'*). Compare as to the rest paragraph 1, page 10.

Having now almost completed the account of the formation of branches in the cauloïd, it may seem fit to enumerate here in one place the different kinds of cauloïd cells which do not, as a rule, form any branches. These are as follows: 1:o the top cells, 2:o the spore cells, 3:o the subsporal cells and 4:o the cells belonging to that degree of branches which is, in each species, the highest (compare on this paragraph 1, pag. 6, 7). Regarding the top cells we have, however, seen above (pag. 26), that they now and then have the power to develop branches. The spore cells, on the contrary, are always devoid of this power. [1]). But this does not prevent your finding, in almost all the

[1]) After this was written I have, however, found in *P. oedogonia* (Mont.) nob. (of which I have obtained the material missing before through the kind mediation of my friend, D:r J. ROSTAFINSKI), that even spores sometimes have the power of forming branches; see pl. 6, fig. 6, and the specific description of *P. oedogonia* (Mont.) nob.

species of *Pithophora,* spores which support branches (pl. 1, fig. 13, 16, 18 *sp;* pl. 2, fig. 2. 3, 13, 15 *sp*, and others) [1]); but this does not depend on a ramification from the spore cell, but on the fact, that the original common mother cell of the branch and of the spore has first formed a branch by cell-prolification (= *Abschnürung* in the German language) and afterwards, by the usual division into two, a spore in its upper end (i. e. in that part of the cell, which supports the branch just formed). As exceptions, branches may be formed even from the subsporal cells which are, as a rule, branchless. This is not seldom the case in *P. Zelleri* (v. Mart.) nob. The vegetative cells are richer in protoplasm in this species than in the others. The consequence of this is, in general, that each cell, at least in the principal filament, forms not only one, but as much as two spores. But sometimes the cells of the principal filament form but one spore each, and then the not inconsiderable quantity of protoplasm still remaining in the original mother cell is used to form a normal branch, instead of a spore (pl. 1, fig. 9 *bs*). In the other species of *Pithophora* I have observed a subsporal cell carrying a branch only in one case, to wit in the specimen of *P. kewensis* nob. which I have represented pl. 2, fig. 7 (the subsporal branch is marked *bs).*

As we have seen by the exposition given above, a cauloïd and a rhizoïd cell are formed simultaneously, in the germination of the spore. But, whilst the first cauloïd cell gives origin by and by, by a continued and in various ways modified division into two, to a great quantity of cells, which form together a cauloïd of a comparatively complicated structure, no further development takes place, as a rule, in the first rhizoïd cell. A natural consequence of this is, that the rhizoïd part of the thallus has a very simple structure; it is unicellular. Now and then it happens, however, particularly in *P. kewensis* nob., that the rhizoïd does not remain in this low stage of development. In this case, the first rhizoïd cell increases and divides into two in the same manner as the first cauloïd cell, with the difference only, that the increase in the rhizoïd always takes place in a different direction from that of the cauloïd. By this increase the rhizoïd grows bicellular instead of unicellular (pl. 4, fig. 11. *Obs.* A formation of spores, which has taken place later, has

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[1]) Only in *P. æqualis* nob. I have never found branches supported by spores. Even the cells of the principal filament seem here to lack the power of producing more than one of these, a branch, or a spore (pl. 1, fig. 4, 5).

here changed the bicellular rhizoïd into a quadricellular). If the rhizoïd has once commenced to increase further, it not seldom happens that it does not stop at the bicellular stage. By apical increase and by division of the terminal cell, according to the same rule as in the cauloïd, rhizoïds are sometimes formed consisting of several — as much as 12 — vegetative cells (pl. 4, fig. 6, 7). As may be understood by the mode of increase now indicated, they all form a single series of cells, analogous to the principal filament of the cauloïd. Only in extremely rare exceptional cases the rhizoïd cells have the power of ramifying. As I have mentioned above (pag. 8) I have found only one specimen — belonging to *P. kewensis* nob. — with a ramified rhizoïd; see pl. 4, fig. 8. The nature of the branches (which are all of the 1:st degree and unicellular) indicates very clearly, that they are formed in a manner quite analogous to that in which the normal branches are formed in the cauloïd. Their attaching point being the lower part of the mother cell, as well as their pointing downwards, are the natural consequences of the direction of the increase of the rhizoïd, which is opposite to that of the cauloïd. That formation of spores in rare and exceptional cases may take place in the rhizoïd too, and that it then takes place in the same manner as in the cauloïd (i. e. basipetally, if more than one spore are formed) has been mentioned before (pag. 16).

A phenomenon, which may be mentioned together with the account of the formation of the rhizoïd, is, that in such sterile specimens of *P. kewensis* nob. as have had the lower part of their cauloïd broken off by some accident, the lowest cell left is not seldom found to elongate itself in the direction of the lost rhizoïd, and to form, in this manner, a rhizoïd-like process (pl. 2, fig. 11 *rl*) which is, at last, separated by bipartition as an individual cell[1]) (pl. 2, fig. 12 *rl*).

Having completed the account of the germination of the spores and of the increase of the plant to which they have given origin, it remains to describe in a few words the germination of the prolific cells and the increase of the young plant formed by them. By the destruction of the rest of the plant the prolific cells are made free, not always so that each prolific cell is quite isolated — this occurs, however, now and then — but generally thus, that two or more prolific cells still hang together and form longer or shorter series of cells (pl. 2, fig. 2,

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[1]) In the same manner a short cell is often formed upwards, if the upper part of the cauloïd is broken off in a plant; see pl. 2, fig. 7 *ct*.

3 *p*, *p'*). The germination of the prolific cells then takes place in exactly the same manner as the formation of normal branches from common cauloïd cells. The new specimen will thus appear as a normal branch, placed just below the top of the prolific cell. The increase of the new specimen follows exactly the same laws that are valid in the increase of the cauloïd in specimens which originate in spores. In consequence of this, unbranched specimens are very seldom found (pl. 2, fig. 3, the specimen developed from the prolific cell marked *p'*). As a rule, the specimens originated in prolific cells are like the others, more or less powerfully ramified (pl. 2, fig. 2, and fig. 3, the specimen developed from the prolific cell marked *p*). Of course no rhizoïd exists in the specimens formed by prolific cells. In the germination of an isolated cell, or of one which is terminal in a series of cells, it sometimes happens, that the prolific cell, besides forming, laterally, a new specimen in the manner described above, also develops a cell in its upper end by apical increase, succeeded by bipartition. In this manner the upper one, *p'*, of the two prolific cells which are represented fig. 3 on pl. 2, has proceeded; and the vegetative cell formed in this manner has, in this case, even had the power to form in its top a spore, *st*. All the specimens originated by prolific cells which I have seen, have been fertile. Of course this does not prevent sterile specimens from being perhaps also sometimes formed by prolific cells.

Appendix. On the power of the protoplasm to heal wounds which have been inflicted upon it.

Although it does not strictly belong to the subject, I may be permitted to mention in two or three words a phenomenon which I have had the opportunity to observe in *P. kewensis* nob. Pl. 2, fig. 10 shows a piece of a sterile specimen attacked by a great multitude of small *protozoa*. They have pierced the cell membrane and entered the cells, intending to revel upon the protoplasmatic contents. In the largest of the represented cells they have entered the middle part of the cell and consumed a great part of the protoplasm there, before having encysted themselves. Part of the protoplasm has, however, been left in both ends of the cell. In spite of the damage which has been inflicted upon the protoplasmatic tube belonging to one individual cell, the remaining parts of it have not died. These parts, which form, in consequence of the destruction of the middle part of the protoplasmatic tube, short sacks open at the ends which point towards the middle part of the cell, have had the power to close these openings, and to form from the new and rounded surface of the protoplasm a protecting cell-wall. In this manner two new and complete cells have been formed by the remains of the damaged protoplasmatic body. The same proceeding has taken place in the greater of the two branch cells; with this difference only, that the parasites have here left protoplasm only in one of the ends of the cell, and that the remaining quantity of protoplasm has been smaller still than in any of the two cases mentioned above. The facts related here may serve as a proof of the great power which the protoplasm has (at least in elongated cells belonging to the lower algæ) [1]) of healing wounds which have been inflicted upon it.

IV. BRIEF RECAPITULATION OF THE WHOLE DEVELOPMENT-PROCESS.

When the spore germinates (the germination takes place in water), it is elongated in two opposite directions. A transversal parting-wall is formed in that part of the germ-cell, which has belonged to the germinated spore. By this the germ-cell is divided into two daughter cells, of which the one gives rise, by continued bipartition, to the ramified part of the thallus, which serves for propagation, the cauloïd; whilst the other, which generally has not the power of further development, forms alone the antipode of the cauloïd, the rhizoïd. The development of the cauloïd takes place in the following manner. The first cauloïd cell, formed immediately at the germination of the spore, is elongated, and divides by common bipartition into two daughter cells. In the lower one of these, no further formation of vegetative cells takes place. But the upper acts in the same manner as the mother cell, is elongated and divides. The two new daughter cells thus formed now proceed in the same manner as the daughter cells formed by the division of the first cauloïd cell; and afterwards the same proceeding is continued as long as the development in length continues. Thus, the increase is, in short, terminal. The series of cells formed in this manner, the principal filament, now ramifies in the following manner. Every cell that is to form a branch sends forth, a small space below its top, a process

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[1]) In the elongated and ramified vegetative cell of the *Vaucheriæ* I have more than once observed the same occurrence. Compare besides HANSTEIN, Leb. d. *Vauch.*, Bot. Zeit. 1873, pag. 697.

pointing somewhat upwards, which is separated, when it has attained a length which exceeds the diameter of the mother cell 2—5 times, from its mother cell by a parting-wall placed at the base of the process, and thus becomes an independent cell. This cell, the lowest one in each branch, is consequently formed by cell-prolification. In most cases, a longer or shorter series of cells is afterwards formed by this cell, exactly in the same manner as the cells of the principal filament by the first cauloïd cell. In a couple of species, the system of ramification does not gain any further development (in these, branches consequently exist only of the 1:st degree), but in the other, branches of the 2:d degree are formed according to the same law as those of the 1:st, and in two even branches of the 3:rd degree exist. Most of the cells, the top cells excepted, form branches (at least in the principal filament), this being done acropetally, thus, that the formation of branches begins in the lower and older cells, and proceeds to the upper and younger. In the manner now indicated is formed an *Alga* which is as to its cauloïd *Cladophora*-like, i. e. consisting of ramified series of cells. Its rhizoïd consists, as has been mentioned above, generally of only one cell, growing in a direction opposite to that of the cauloïd. This cell, which is analogous with the root system in the higher plants (especially with the tap-root of the *Dicotyledoneæ*) as to its morphological, but not its physiological character, does consequently not serve as an attaching organ of the thallus. The plant is most frequently not at all attached, and when it is (as happens now and then), it is with the assistance of peculiar tendril-like organs, developed from the cauloïd and called, by me, helicoïds. When the specimen has attained its full size, the formation of spores commences. It is effected in the following manner. The upper part, $^1/_3$—$^1/_5$ of the mother cell of the spore, is somewhat widened. The chlorophyll-coloured protoplasm in the lower, not widened part of the cell then passes, little by little, into the upper and widened part, till it is quite filled with chlorophyll-coloured protoplasm. A transversal cell-wall is then little by little (succedaneously) formed, just below the point where the widened part of the cell commences. In this manner are formed one lower cell containing but little protoplasm, almost devoid of chlorophyll, the so-called subsporal cell, and one upper cell, rich in chlorophyll and reproductive, the spore. Its shape is as a rule cask-like or cylindrically cask-like. [1]

[1] In some species of *Pithophora* the spores are rather often purely cylindrical. The spores of this shape are formed in the same manner as the cask-like, only with the difference that a widening of the upper part of the mother cell does not take place.

When the membrane of the spore has attained a not inconsiderable increase in thickness, the spore reposes some time before germinating, and consequently belongs to the class of spores which is called hypnospores. With regard to its origin it may be called an agamospore (from *α priv.*, without, and *γάμος*, marriage), as being formed neutrally without any fecundation. — Formation of spores may take place in all the cells of the cauloïd, in the terminal as well as in the inclosed. As a rule, it begins in the youngest, i. e. the terminal, cells; afterwards proceeding downwards, or, in other words, basipetally, in the principal filament as well as in the branches. It is these spores which give origin, by their germination, to the course of development which has now been briefly described. In this manner you will see one neutral generation, forming hypnospores, follow upon another in an uninterrupted series, without any metagenesis.

The reproduction of individuals in *Pithophoraceæ* may, however, be effected also in another way than by the formation of spores. Besides the specimens which form spores there are others, which never do so. These, which are, besides, distinguished by a richer ramification, transform part of their cells into so-called prolific cells. These cells are formed simply thus: a common vegetative cell (without suffering any change as to shape) grows richer in chlorophyll-coloured protoplasm and starch, and is thus made fit to form a new individual. This the prolific cells do, when they have been made free [1]) by the destruction of the mother specimen, by forming a new specimen laterally near their top, in the same manner as a branch — and later a system of branches — is formed by a cell in the fertile specimens. That the specimens originated by prolific cells have the power of forming spores is certain, as well as that specimens forming prolific cells may have been originated by spores. I do not know with certainty, whether specimens forming prolific cells may have been originated by prolific cells themselves. But it seems to me in no wise improbable. — As to the not unfrequent deviations from the scheme of the development given here, see the two preceding paragraphs.

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[1]) Often two or three prolific cells remain, however, attached to each other.

V. ON THE AFFINITIES OF PITHOPHORACEÆ AND THE PLACE OF THIS ORDER IN THE SYSTEM.

If we regard, at first, only the vegetative system, we easily find a group of plants which in this respect shows a very close affinity to *Pithophoraceæ*. Already the circumstance that the forms now found to belong to the new order of *Pithophoraceæ*, which have formerly been described in floristic works, have all been described as species of the genus *Cladophora*, [1]) gives an unmistakeable hint on this head. The resemblance between *Pithophoraceæ* and *Cladophoreæ* as to the vegetative system is, in fact, very great. In both, the thallus consists of cylindrical chlorophylliferous cells, connected so as to form a ramified series of cells; in both, the formation and increase of the cells, as well as of the series of cells, takes place essentially in the same manner; in both, the development of branches follows in general the same law; [2]) and in some *Cladophoreæ* organs even occur which are of the same nature as the helicoïds of *Pithophoraceæ*. [3]) The resemblance as to the cauloïd part

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[1]) Only one author, Grunow, has had a conception, that one of the forms commonly referred to the genus of *Cladophora* ought perhaps to be aggregated to a genus-type separate from *Cladophora*. This author says in »Reise S. M. Freg. Novara» pag. 39 of *Cladophora Roettleri* (Roth) Kütz. (= *Pithophora Roettleri* nob.): »Von Roth als *Ceramium* beschrieben, verdient diese Art vielleicht einmal bei genauerer Kenntniss der *Cladophora*-arten als eigene Gattung davon abgeschieden zu werden». In the same place he also pronounces his opinion on the probable origin of the spores (»Fruchtzellen») of this *Cladophora* thus:» In einigen Fällen beobachtete ich (in a brasilian form) Fäden mit spatelförmig angeschwollenen Astenden mit gehäuften Chlorophyll-Inhalt, aus denen sich durch Abschnürung die Fruchtzellen zu entwickeln scheinen.»

[2]) Compare v. Mohl, Verm. d. Pflanzenz., pages 363 and 366, pl. 13 (on *Cladophora glomerata)*.

[3]) J. M. Lorentz represents in Die Straton. v. *Ægagr.* on pl. 4, figs. 14 and 15 parts of the thallus of *Ægagropila Sauteri*, where two of the terminal cauloïd cells have assumed, by the formation of small processes at their top, almost the same forms as those common in the helicoïds of *P. Cleveana* nob. As these top cells also serve the same purposes as the organs of *Pithophoraceæ*, I do not hesitate to regard them as real helicoïds. They are, like the helicoïds of *Pithophora*, very rich in chlorophyll, but not only in their upper and ramified part, but also in the lower. In Kützing, Tab. Phyc., Band 4, pl. 66 a representation is given of *Ægagropila her-*

of the thallus is, in short, so great that it sometimes meets with no small difficulty to identify, solely by the cauloïd part, whether a sterile specimen belongs to a *Cladophora* or to a *Pithophora* (on the distinguishing characters in this case, see parag. 1, pag. 4). What gives sure distinctions, even if only the vegetative organs are taken into consideration, is, on the contrary, the nature of the rhizoïd system. In *Pithophoraceæ* this consists, as a rule, of only one cell, viz. the one developed, immediately at the germination of the hypnospore, in a direction diametrically opposite to that of the cauloïd. This rhizoïd cell (which has, as we know, nothing to do with the attaching of the thallus) we regard, from reasons mentioned page 5, as analogous, in some degree at least, with the tap-root of the *Dicotyledoneæ*. But in *Cladophoreæ* (particularly in *Cladophora fracta* (Dillw.) Kütz., which in other respects belongs to the most *Pithophora*-like species) the spore — which is here a zoospore — sends forth downwards, in germinating, one or generally several irregularly formed processes, serving as attaching organs, rhizines, which have nothing in common with the tap-root, but show a certain analogy to the adventitious roots developed in the germination of the *Monocotyledoneæ*. As no formation of parting-walls takes place between these rhizines and the germinated spore, they will consist merely of processes belonging to the lowest one of the cauloïd cells, not of independent cells. In a great many *Cladophoreæ*, however, these rhizines are not the only constituent parts of the rhizoïd system.[1] A plentiful development of pluricellular rhizines, comparable to the adventitious roots from the stem of the higher plants, takes place in the cauloïd, especially in the genera of *Ægagropila* Kütz. and *Spongomorpha* Kütz. These rhizoïd organs are recognized as such by the circumstance that they are developed, in contrast to the cauloïd branches, from the lowest part of their mother cells; that they increase downwards; that they contain but little chlorophyll; and that they serve as real attaching organs, which rather often have the end of the lowest cell transformed into a peculiar grasping organ, sometimes resembling a helicoïd (see KÜTZ. Tab. Phyc., part 4, pl. 83 *Spongomorpha lanosa* fig. *g*

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pestina which gives reason to suppose that helicoïds of the same nature occur also in this form of *Ægagropila*. Besides these unicellular attaching organs, perfectly resembling those of the *Pithophora*-helicoïds, pluricellular helicoïds with a top rolled like a spiral or bent like a claw are found in numerous *Cladophoreæ* belonging to the genus *Spongomorpha* Kütz.; see KÜTZ. l. c., pl. 75—78.

[1] I am not quite certain whether all *Cladophoreæ* have other rhizines besides those developed from the germinated spore.

and *h*, and pl. 71 *Ægagropila socialis*) [1]. Organs perfectly resembling these, *Pithophoraceæ* have not, it is true; but a comparative study has convinced me that the accessorial branches sometimes developed from the cauloïd cells of the *Pithophoraceæ*, which proceed, like the rhizines of the *Cladophoreæ*, from the lowest part of their mother cells, and take, like these, their increase downwards (see parag. 3, page 27), are to be regarded as the morphological equivalent of these organs, even if they are not analogous to them in a physiological point of view. We know that they have nothing to do with the attaching; and together with the loss of their original function they have — in the same manner as the principal rhizoïd of the thallus — also lost the shape of attaching organs (rhizine branches) and assumed instead the shape of common cauloïd branches. They would thus require to be regarded as regressively transformed rhizines, or as a kind of rhizine rudiments. What gives increased probability to this view of their character is, that in some *Cladophoreæ* connecting forms occur between real rhizines, which serve as attaching organs, and the basal accessorial branches of *Pithophoraceæ;* see Kütz. l. c., pl. 82 *Spongomorpha uncialis (baltica)* figs. *a* and *b*.

We may perceive from the comparison made above, that the only essential difference which exists between the vegetative system of *Pithophoraceæ* and *Cladophoreæ* lies in the nature of the rhizoïd organs formed immediately at the germination of the spore, a difference which is very closely connected with the different nature of the reproductive organs (resp. hypnospores and zoospores) of these plants. The great conformity in everything else speaks forcibly, I think, to the advantage of a close affinity between the two groups now mentioned, the more because the reproductive system of *Pithophoraceæ* — however unlike it may seem to that of the *Cladophoreæ* — is, nevertheless, of a nature whose origin may gain its explanation (as we will endeavour to make evident hereafter) from certain phenomena apparent in *Cladophoreæ*.

If it is, consequently, perfectly evident with which group of plants the *Pithophoraceæ* show the greatest conformity as to the vegetative system, it is very much more difficult to determine the group which

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[1]) The rhizine branches differ from the cauloïd branches also by greater length and at the same time by a much smaller diameter of their cells; see Kütz. l. c. pl. 70 *Ægagropila repens*, pl. 74 *Spongomorpha arcta*, pl. 75 *S. spinescens*, pl. 76 *S. rhizophora*, and pl. 77—80.

ought to be placed nearest to *Pithophoraceæ* in regard to the reproductive system. Looking, to begin with, for a form of plants which would show a formation of spores reminding us of that of the *Pithophoraceæ*, we find a form of this description only in one group of plants, that of the *Vaucheriaceæ;* and, within this group, only in two species, *Vaucheria geminata* (Vauch.) Walz, and *V. hamata* (Vauch.) Walz. Only in these (as far as we know) have been found immoveable spores, formed neutrally (at least part of the other species have, we know, neutrally formed moving spores, so-called zoospores). The formation of spores in both these species [1]) takes place in a manner which calls to mind, in some of its phases, that of the *Pithophoraceæ.* Here, as well as in *Pithophoraceæ*, the proceeding is introduced by a slight widening of that part of the cell in which the spore is to be formed; here, as in *Pithophoraceæ*, a quantity of the chlorophyll-coloured protoplasm passes into the widened part, and here also the part of the cell thus filled with chlorophyll is separated from the other part by a transversal cell-wall formed succedaneously. So far the resemblance goes. We will now observe the differences. These are: 1:o and essentially, that the cell rich in chlorophyll and formed in the manner now described does not grow into a spore in *Vaucheriæ*, although it does in *Pithophoraceæ*, but in *Vaucheriæ* it grows into a mother cell of a spore, formed within it through cell-rejuvenescence; 2:o and as a consequence of the preceding, that the spore in *Vaucheriæ* does not (as in *Pithophoraceæ*) make use of the membrane of the mother cell, but forms one for itself; 3:o that the spore does not (as in *Pithophoraceæ*) remain for a long time united to its mother specimen, but is made free very soon by the dissolution of the environing wall of the mother cell (in analogy with the emission of the zoospores from their mother cells in other *Vaucheriæ);* 4:o that the spore is always formed terminally in *Vaucheriæ,* in contradistinction from what is the case in *Pithophoraceæ;* and 5:o that no subsporal cells devoid of chlorophyll occur in *Vaucheriæ*, as is the case in *Pithophoraceæ*, because the vegetative system consists in *Vaucheriæ* of only one cell (but that a gigantic one), which commonly does, far from being exhausted by one act of spore formation, beget numerous spores and sometimes a more or less considerable number of oogonia and antheridia besides. [2]) If we now continue our investigations by

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[1]) Compare WITTR. Utveckl. af *Vauch.* pag. 34 and 35; and WALZ Beitr. z. Morph. d. *Vauch.* pag. 132 and 133.

[2]) See WITTR. l. c. plate 2, fig. 7.

comparing the conduct of the *Vaucheria*-spore and of the *Pithophora*-spore in germinating, we first find a resemblance in the fact of their both reposing for a time before the germination commences, [1] and farther one more in their forming the new plant immediately by the stretching of their membrane to form cylindrical processes. The differences, on the other side, are: 1:o that, whilst the *Pithophora*-spore, in germinating, regularly sends forth two diametrically opposed processes, the *Vaucheria*-spore is very irregular in this respect, sometimes sending forth two processes, sometimes three, and sometimes only one; [2] 2:o and essentially, that whereas a parting wall, dividing the *Pithophora*-spore into two cells, regularly appears, no such cell-wall is ever formed in the germinating *Vaucheria*-spore. — From the facts now mentioned we perceive, that the points of resemblance between the *Pithophora*-spore and the immoveable, neutrally formed spores of two *Vaucheriæ* are, it is true, not few, but that the differences are at the same time so numerous and of so great importance that a nearer relationship between *Pithophoraceæ* and *Vaucheriæ* can from the nature of the spores not be supposed to exist. That the vegetative system in the two groups still less gives cause to a supposition of this kind, is so evident as to need no further elucidation.

As all other groups of algæ differ still more widely as to the manner of their spore formation (as far as it is known) from *Pithophoraceæ*, than the two species of *Vaucheriæ* mentioned above, it seems quite superfluous to draw any special comparisons with regard to them. The *Pithophoraceæ* would thus seem to have an extremely isolated position as to the spore formation. But that connecting points may be found, even in this respect, between them and another group — the *Cladophoreæ* — I have already indicated, and I will now endeavour to make this still clearer.

It is well known that the essential and characteristic reproductive organs of the real *Cladophoreæ*, as well as of *Confervaceæ* in general,

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[1]) In *V. geminata* (Vauch.) Walz the duration of the repose of the neutrally formed spore varies considerably. The spores formed towards the end of the autumn repose during the whole winter (here, in Sweden, several months) before germinating. But the spores which are formed in spring repose for a very much shorter time, at most a week and most frequently only two or three days (see further WITTR. l. c. pag. 31 and 35). In *V. hamata* is, according to WALZ l. c. page 133, the time of the repose of the hypnospore always very short.

[2]) See WITTR. l. c. t. 2, figs. 2—5, 7.

consist of zoospores. But it is not these that seem to me to offer points of comparison in the explanation of the spore formation in *Pithophoraceæ;* it is, on the contrary, those propagative cells (of a somewhat accessorial character) in *Cladophoreæ*, which I have before (page 18) mentioned as »prolific cells». Knowing these cells best in our common *Cladophora fracta* (Dillw.) Kütz., and having, moreover, the opportunity of referring the reader to good representations of the prolific cells in this species, I shall as a matter of course fix my attention principally on the nature of this *Cladophora.* The prolific cells of *C. fracta* (Dillw.) Kütz. can, as has been said before (page 18), assume several different shapes. One of the most common is the shape of a pear; see KÜTZING, Tab. Phyc., part 4, plate 50, figs. *b* and *d.* This shape of the prolific cell has its cause in the widening of the upper part of the cell (which was cylindrical before), whilst the lower part retains its original shape and thickness. At the same time the upper, widened part is also filled with richer chlorophyllaceous contents than the lower. Thus we here see two acts in the formation of prolific cells, which take place likewise in the formation of the hypnospores in *Pithophoraceæ.* If a division were made of the cell thus transformed, by the formation of a transversal cell-wall just below the widened part, two cells would be obtained, of which the upper one would be perfectly analogous to the spore, and the lower to the subsporal cell, in *Pithophoraceæ.* If the formation of zoospores ceased at the same time, which would not seem impossible, because the cell-contents had been disposed of for other purposes, a *Cladophora* would have been changed into an almost perfect *Pithophora.* That this, or something like it, has taken place in the realm of nature, seems to me not improbable; [1]) and on this supposition, as well as in the first place on the evident conformity of the vegetative system, I found my opinion that the *Pithophoraceæ* are to be regarded as transformed *Cladophoreæ*, thus being one of the branches on the stem of *Confervaceæ.*

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[1]) In *Pithophora oedogonia* (Mont.) nob. I have later had the opportunity of making an observation which seems to me to give a very powerful support to the opinion pronounced above on the relationship between the spores of *Pithophoraceæ* and the prolific cells of *Cladophoreæ.* In the species of *Pithophora* now mentioned it not rarely happens, that real spores, formed in the normal manner, instead of germinating in the usual way, develop a branch laterally, quite in the same manner as prolific cells in *Cladophoreæ* do in germinating; see pl. 6, fig. 6, and the specific description of *P. oedogonia* (Mont.) nob.

In order to avoid prolixity and give, at the same time, a clear indication of my manner of viewing the closer or farther removed affinities between *Pithophoraceæ* and the other classes and orders of the polymorphous chlorophylliferous algæ, I here give a sketch of these algæ, arranged in the form of a genealogical tree. A more particular account of the motives of this attempt at arrangement it is my intention to publish on another occasion. [1])

The genealogical tree of the Chlorophyllophyceæ, see the following page.

As every one knows, Cohn and Sachs have lately in their systems of plants [2]) given expression to the opinion that in the *Algæ* and in the *Fungi* (*Thallophytæ* Cohn) only characters obtained from the nature of the reproduction and the reproductive organs are of value in the systematizing [3]) (which is to me the same as in the looking for the natural affinities or, in other words, the genetic connexion between the forms of plants). That the principles by which I have been conducted in the composition of the table given below, differ essentially from

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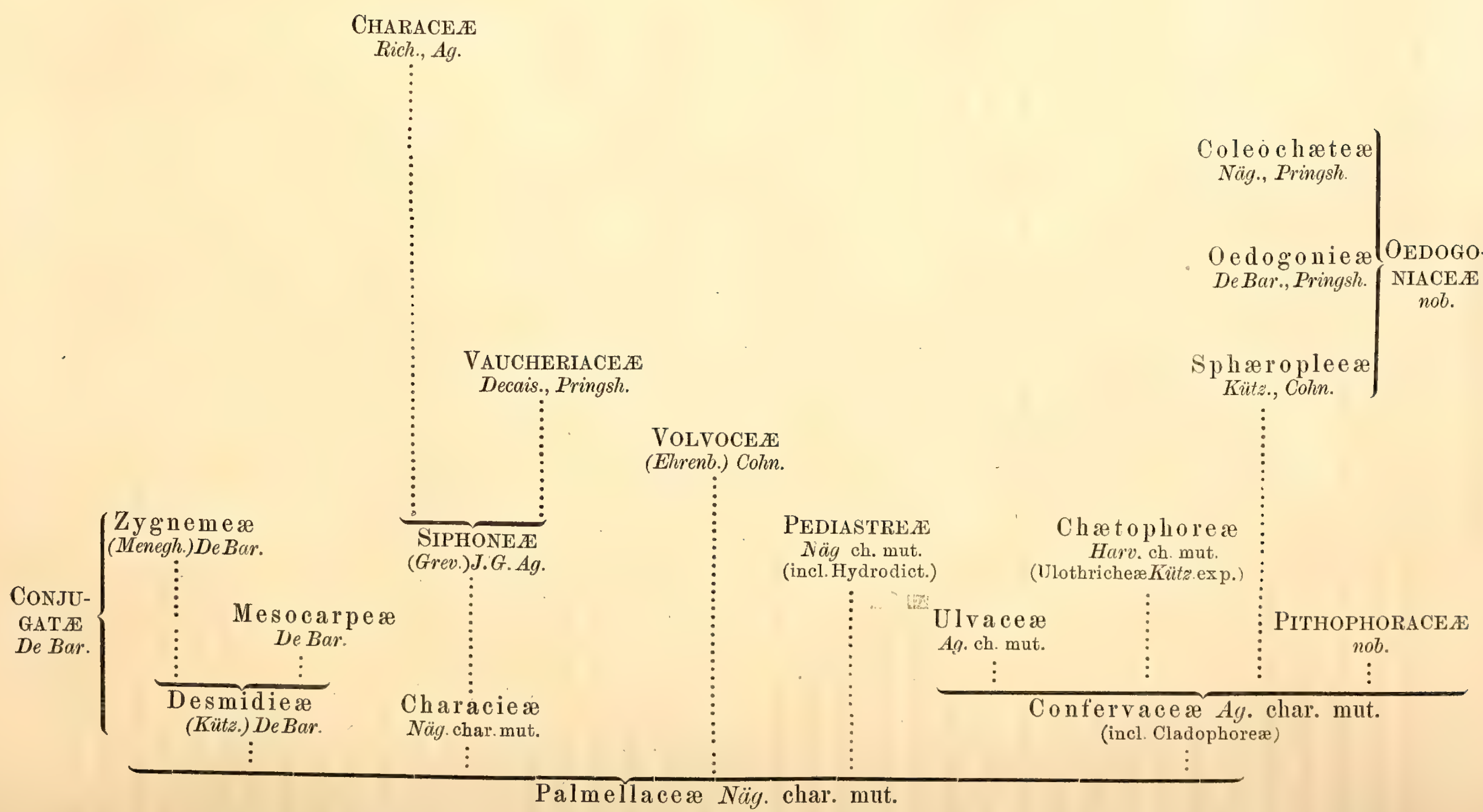
[1]) I need hardly mention that I do not regard all the groups, below indicated as classes and orders, as having as yet perfectly natural limits. The groups of for instance *Siphoneæ*, *Palmellaceæ*, *Chætophoreæ*, *Ulvaceæ* and *Confervaceæ* will, in all probability, be found on a nearer examination to embrace more than one type of order. — Whether the *Diatomaceæ* ought to have their place in the class of the *Conjugatæ*, or not, seems to me dubious. Perhaps they belong to another series of development, and are in that case only analogous, not affined, to *Conjugatæ* De Bar. — On the characters of the class of the *Oedogoniaceæ*, see Wittr. Prodr. Monog. *Oedog.* p. 1, the note.

[2]) Published: Cohn's in Hedwigia 1872, page 18 (somewhat modified in Entw. d. *Volvox* page 113), and that of Sachs in Lehrb. d. Botan. 4:te Aufl. pages 248, 249.

[3]) It is known that this is not the first time that a fusion has been attempted between the *Algæ* and *Fungi*. As early as nearly 30 years ago Nägeli says on this head in Neu. Algensyst. pages 169—170 as follows: »Wenn man die Pilze wegen ihrer von allen übrigen Pflanzen abweichenden Entstehungsweise, Lebensart und Beschaffenheit des Zellinhaltes nicht als besondere Pflanzengruppe bestehen lassen will, so gibt es gewiss kein Merkmal der Fructification, wonach sich Algen, Flechten und Pilze kennen liessen, weil alle Arten der Samenbildung der Pilze auch bei den Algen sich finden, und es bliebe keine andere Wahl, als sie alle zusammen zu werfen und dann die ganze Masse nach Bau und Fortpflanzung in Gruppen zu theilen, und dabei fortwährend Pilzgattung neben Algengattung zu stellen, *was aber gewiss zu einer ganz unnatürlichen Anordnung führen würde.*» (The italics are mine).

Chlorophyllophyceæ *(Rabenh.) nob.*



theirs, is clearly evident. [1]) As to my opinions on the systematization of the lower plants, they accord so essentially with those pronounced by Professor AL. BRAUN on this head in his lecture »Ueber die neueren Eintheilungsversuche der *Thallophyten*» [2]), that I may here content myself with referring to that work.

VI. ON THE SPECIFIC CHARACTERS.

A glance at the figures which accompany this essay may be enough to convince us that all the *Pithophoraceæ* as yet known are very nearly related to each other. They are in fact so nearly related, that they must without question form only one genus. At first it may even seem dubious whether it is possible to distinguish any well limited and »good» species; but a nearer study of the forms of *Pithophoraceæ* removes this doubt completely. By a close comparing investigation we find that the different forms, however great the resemblance may be as to their general habitus, are, however, distinguished by a not inconsiderable number of peculiar characters, taken no less from the nature of the reproductive system than from that of the vegetative. I will now try to show what those characters, which may be used for the distinguishing of species, are.

As to the vegetative system, it furnishes good characters by the differences in the ramification of the cauloïd. In two species branches exist only of one degree, in others sometimes of one and sometimes of two, and in others of three degrees. [3]) (See more in extenso on this

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[1]) If we consider what place in the system *Pithophoraceæ* would obtain if the Cohn-Sachsian principles were applied, it would be a very isolated one. As they have neither zygospores, basidiospores, ascospores, tetraspores, zoospores, oospores or carpospores, they would have no place either in Cohn's groups of *Zygosporeæ*, *Basidiosporeæ*, *Ascosporeæ*, *Tetrasporeæ*, *Zoosporeæ*, *Oosporeæ*, nor in Sachs' classes of *Zygosporeæ*, *Oosporeæ*, *Carposporeæ*. As it would no more seem fit to range them among the *Schizosporeæ* Cohn or the *Protophytæ* Sachs, nothing would remain but forming a perfectly new class for them.

[2]) Held in Gesellschaft naturforschender Freunde zu Berlin d. 19 Jan. 1875 and reported in Bot. Zeit. 1875, pages 208—211.

[3]) Among the species of which I had before a more complete knowledge there is only one, *P. Roettleri* (Roth) nob., which has branches of three degrees. In *P. oedogonia* (Mont.) nob., of which I have not received material for examination till later (during the printing of this essay), another is found. In one specimen of this species, represented pl. 6, fig. 4, I have seen a branch of no less than the 4:th degree (marked b^4), though, it is true, feebly developed.

parag. 1, pages 6 and 7). The relative position of the branches also gives specific characters thus, that the branches are in some species regularly placed singly, in others two and two opposite to each other, and in others three or four in a whorl, partly at least (see above pages 6 and 7). The existence or non-existence of so-called subsporal branches may also be used as a specific character. [1]) The same may be said of the helicoïd cells; in one species, *P. Cleveana* nob., they are found in great quantity, in the others only very sparingly. That specific characters may be had also from the nature of the rhizoïd, when a more complete knowledge of it is obtained, I think not improbable, although this part of the thallus, being in general rather rudimentary, seems to have a greater tendency to vary than the cauloïd.

The characters most essential in the distinguishing of species (and particularly of groups of species) are obtained from the reproductive system. In part of the species, viz. *P. æqualis* nob., *P. oedogonia* (Mont.) nob., *P. Cleveana* nob., *P. kewensis* nob. and *P. sumatrana* (v. Mart.) nob. (that is, the american forms, the european one, and one of the asiatic), all the spores are (in each species) of the same principal shape, though differing as to length and thickness; thus, that the inclosed spores are all either cask-shaped or cylindrical, and the terminal are all either cask-shaped or cylindrical with the top pointed like a cone. But in the other species, viz. *P. polymorpha* nob., *P. Zelleri* (v. Mart.) nob. and *P. Roettleri* (Roth) nob. (all asiatic species) we find two or more forms, at least of inclosed spores. In *P. polymorpha* nob. for instance they are of three kinds, viz. some cylindrical, some cask-shaped and some of an irregular shape; whilst the terminal spores are of two kinds, viz. some cylindrical and some cask-shaped, in both cases with the top obtusely pointed and somewhat rounded. In *P. Roettleri* (Roth) nob. the case is analogous to that in *P. polymorpha* nob. In *P. Zelleri* (v. Mart.) nob. the inclosed spores are of three kinds, but the terminal are all alike. — It is on this peculiarity as to the spores, viz. that they are in some species of the same principal form, but show in the others different forms, that I have founded the two subdivisions, *Pithophoræ isosporeæ* and *Pithophoræ heterosporeæ,* in which the genus is divided.

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[1]) Besides in *P. Zelleri* (v. Mart.) nob. subsporal branches are also found at least in most specimens of *P. oedogonia* (Mont.) nob. (see pl. 6, figs. 4 and 5).

The spores, besides giving characters for the distinction of species by their form and size (see below in this parag.), are also useful for the same purpose by their being placed singly or in pairs. Whilst the spores are placed singly in most species, formed each by its special mother cell, it frequently happens in two species, *P. Zelleri* (v. Mart.) nob. and *P. oedogonia* (Mont.) nob., that the spores are found in pairs, formed two in succession by the same original mother cell.

The size of the different parts of the thallus also gives useful specific characters, because it is constant within no very wide limits in the different forms. I have found particularly the diameter of the principal filament in the fertile specimens, and the size (length and thickness) of the inclosed, cask-shaped spores to vary comparatively little. According to the thickness of the principal filament the species range as follows: *P. kewensis* nob., the principal filament on an average 59 μ thick; *P. oedogonia* (Mont.) nob. and *P. Cleveana* nob. 70 μ; *P. polymorpha* nob. 105 μ; *P. æqualis* nob. 109 μ; *P. Zelleri* (v. Mart.) nob. 120 μ, *P. sumatrana* (v. Mart.) nob. 127 μ, *P. Roettleri* (Roth) nob. 165 μ. [1]) From this list we find that the diameter of the principal filament for instance in *P. Zelleri* (v. Mart.) nob. is on an average twice and in *P. Roettleri* (Roth) nob. thrice as great as in *P. kewensis* nob., and so on. If we arrange the species according to the diameter of the inclosed cask-shaped spores, they will have an order not a little different. The first place is, it is true, occupied by *P. kewensis* nob. now also, with 81 μ, but the others follow in this manner: *P. Cleveana* nob. 102 μ, *P. polymorpha* nob. 104 μ, *P. sumatrana* (v. Mart.) nob. 106 μ, *P. æqualis* nob. 111 μ, *P. oedogonia* (Mont.) nob. 114 μ, *P. Zelleri* (v. Mart.) nob. 144 μ, *P. Roettleri* (Roth) nob. 152 μ. From this we find, that *P. sumatrana* (v. Mart.) nob. and *P. æqualis* nob. have comparatively narrow spores, whilst *P. oedogonia* (Mont.) nob. and *P. kewensis* nob. have thick ones, and so on. Arranged according to the length of the spores now mentioned we obtain the following series: *P. polymorpha* nob. 157 μ, *P. kewensis* nob. 205 μ, *P. Cleveana* nob. 216 μ, *P. Roettleri* (Roth) nob. 226 μ, *P. oedogonia* (Mont.) nob. 230 μ, *P. Zelleri* (v. Mart.) nob. 232 μ, *P. æqualis* nob. 250 μ, and *P. sumatrana* (v. Mart.) nob. 375 μ; from which follows, that *P. polymorpha* nob. has particularly short spores, while *P. sumatrana* (v. Mart.) nob. has very long,

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[1]) The numbers given here and below in this paragraph are all average numbers, gained by comparison of a great number of measurements.

and so on. What has now been said may suffice to show that the differences in size within the group also give specific characters, though of a more subordinate kind.

VII. ON THE GEOGRAPHICAL DISTRIBUTION.

The *Pithophoraceæ*, being algæ, are principally aquatic plants. Six of the species (eight in number) which are as yet known have been found in water. One, *P. Cleveana* nob., has been found on land, viz. on humid earth in the shade of bushes. How it is with *P. Zelleri* (v. Mart.) nob. can not be decided with certainty from the information which I have regarding it. It is said of this species, that it grows in rice fields, but whether in water or on wet earth is not said.

It has already been mentioned that the aquatic *Pithophoraceæ* grow only in fresh water. Not one is known from wholly salt water, and only of one, the australian sterile form existent in the Grunowian collection, it is said that it occurs both in brackish and fresh water.

With the exception of *P. kewensis* nob. all the species of this order have been found in warmer climates. By far the greatest part are even of a tropical origin. This is the case with *P. sumatrana* (v. Mart.) nob., *P. æqualis* nob., *P. oedogonia* (Mont.) nob., *P. Cleveana* nob., *P. polymorpha* nob. and *P. Roettleri* (Roth) nob.; *P. Zelleri* (v. Mart.) nob. belongs to a subtropical climate. That *P. kewensis* nob., which has been found in England, also draws its origin from warmer countries, may be regarded as almost quite certain. This supposition is powerfully supported by the nature of its locality, which is, as has been mentioned in the introduction, the Tropical Aquarium or so-called Waterlily-house belonging to the Botanical Garden at Kew. The species here grows together with tropical *Nymphæaceæ* and other tropical aquatic plants in water which is always kept at a comparatively high degree of warmth. According to my researches it does not grow in the other aquaria at Kew, nor in the ponds and small lakes belonging to the garden. With a very great probability, as it seems to me, we may therefore conclude that spores of *P. kewensis* nob. have been brought with the rhizomes of the *Nymphæaceæ* or other aquatic plants from some tropical country, and that they have afterwards, when they have found circumstances advantageous to their development in the aquarium, germinated and brought forth specimens of the *Pithophora* capable of propagation. If we suppose *P. kewensis* nob. also to have a tropical origin, the order would embrace only tropical (and subtropical) forms. At all events it has the centre of its geographical distribution between the tropics, and in this respect stands alone among the orders of freshwater algæ as yet known.

If we inquire in which parts of the world the different species of *Pithophoraceæ* are met with, we find that four, viz. *P. sumatrana* (v. Mart.) nob., *P. polymorpha* nob., *P. Roettleri* (Roth) nob. and *P. Zelleri* (v. Mart.) nob. are found in Asia; that three, viz. *P. æqualis* nob., *P. oedogonia* (Mont.) nob. and *P. Cleveana* nob. are found in America; and one, viz. *P. kewensis* nob., in Europe. [1]) Even in Australia a *Pithophora* is found, the one mentioned before as existent in the Grunowian collection, gathered in the isles of Samoa. From Africa alone no *Pithophoraceæ* are as yet known; but that they exist there is more than probable, because everything we know of their distribution seems to indicate that they are common in the freshwater pools of the tropical countries. — As to a more particular account of the localities of the *Pithophoraceæ* as yet known, I may refer to the descriptions of the different species given hereafter.

VIII. DESCRIPTION OF THE SPECIES.

Before giving a description as complete as possible of the species of *Pithophoraceæ* known to me, I will here try to give a diagnosis of the order.

ORDER PITHOPHORACEÆ nob.

Chlorophylliferous cladophora-like freshwater algæ, consisting of cells, formed by bipartition of the terminal cell. The thallus having two distinct parts, viz. 1:o the cauloïd part, developed from the germinated spore upwards, propagative and almost always branched; the branches placed a little space below the top of their supporting cells; 2:o the (mor-

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[1]) As to the country where *P. kewensis* nob. is indigenous, it seems probable that it is the tropical part of America. Here both the species occur, which show the nearest relationship to *P. kewensis* nob., viz. *P. oedogonia* (Mont.) nob. and *P. Cleveana* nob.

phologically, not physiologically) rhizoïd part, developed from the germinated spore downwards, almost always sterile and branchless, commonly unicellular. Spores neutral, quiescent (agamo-hypnospores), generally cask-shaped, single, formed by division into two of the cauloïd cells, of the chlorophyll-filled and commonly widened upper parts of these cells; in germinating as a rule dividing into two cells, the one giving rise to the cauloïd and the other to the rhizoïd part of the thallus.

[*Pithophoraceæ* nob. Algæ (aquæ dulcis) chlorophyllaceæ, cladophoroideæ, e seriebus cellularum bipartitione cellulæ terminalis genitis exstructæ. Thallus a duabus partibus distinctis constitutus: 1:o parte cauloidea, e spora germinata sursum evoluta, propagativa, semper (fere) ramosa, ramis e cellulis suffultoriis paullo infra apicem egredientibus; 2:o parte (morphologice non physiologice) rhizoidea, e spora germinata deorsum evoluta, semper fere sterili et simplici, plerumque unicellulari. Sporæ agameæ, quiescentes (= agamo-hypnosporæ), sæpissime orculæformes, solitariæ, bipartitione cellularum partis thalli cauloideæ formatæ; (cellulæ singulæ, matres sporarum, parte superiore tumefacta et contento chlorophyllaceo farcta, sporas singulas et cellulas singulas steriles subsporales gignunt). Sporæ germinantes in binas plerumque cellulas divisæ, cellula altera in partem thalli cauloideam, altera in partem thalli rhizoïdeam denique evoluta.]

GENUS **PITHOPHORA** nob.

Character the same as that of the order.

Sectio I. PITHOPHORÆ ISOSPOREÆ:

Spores all of the same principal form in each species; the inclosed either cylindrical or cask-shaped, the terminal either cylindrical or cask-shaped with the upper end conical and the top somewhat rounded. (Species 1 to 5).

Species 1. **Pithophora sumatrana** (v. Mart.) nob.

Synon. *Cladophora sumatrana* v. Mart. Die Tange, pag. 20, pl. 2, fig. 2.

Diagnosis: Principal filament of the cauloïd part of the thallus in fertile specimens on an average 127 μ [1]) thick, with branches only of the

[1]) The numbers in the diagnoses are all average numbers, gained by comparison of a great number of measurements.

1:st degree, solitary or opposite; spores inclosed (rarely terminal), single, cylindrical or subcylindrical, on an av. 106 μ thick and 375 μ long. — Plate 1, figs. 1—3; pl. 4, fig. 1.

[P. subvalida, filo principali partis thalli cauloideæ speciminum fertilium circa 127 μ crasso, ramos unius solum ordinis, solitarios vel binos oppositos emittente; sporis inclusis (raro terminalibus), solitariis, cylindricis vel subcylindricis, c:a 106 μ crassis et 375 μ longis.]

Locality. This species is found by Professor D:r E. V. MARTENS j:r in the moats outside the fortress at Palembang in Sumatra, the 29th of March 1862. — Epiphytically on the same grows a (sterile) *Oedogonium* which has been described, l. c. pag. 20, by G. V. MARTENS s:r under the name of *Conferva (Oedogonium?) Cladophoræ*.

General Description. Fertile specimens. Cauloïd part of the thallus. The rather few fertile specimens I have seen of this species have had branches only of the 1:st degree. These have mostly occurred singly; but sometimes also two and two opposite to each other. The branches are always placed a little space below the top of the supporting cell. This space, however, is in general so short as to be smaller than the diameter of the branch. Neither accessorial branches nor helicoïds have been observed. The spores are, as a rule, inclosed. Only one terminal spore I have observed, to wit, the sessile one represented in plate 1, fig. 1 *st*. The inclosed spores are found in the principal filament as well as in the branches. Their form is generally cylindric. Sometimes they are not at all swollen and then they are almost perfectly cylindric (pl. 1, fig. 2); sometimes they are a little swollen and are then cylindrically cask-shaped (pl. 1, fig. 3). Twin spores I have not observed.

Rhizoïd-part of the thallus. I have seen only one specimen, the rhizoïd part of which has not been broken off. This one quite accords as to the nature of the basal cell with the specimen of *P. æqualis* nob. represented in pl. 1, fig. 6. Thus a rhizoïd part had never been developed in this specimen.

Sterile specimens resemble the fertile ones as to the ramification. In one of the examined specimens the basal part was preserved. This showed a rhizoïd part consisting of one cell (pl. 4, fig. 1 *rh*), parted from the cauloïd by an oblique cell-wall.

Measurements. Fertile specimens. The vegetative cells of the principal filament are on an av. 127 μ thick; the smallest observed thickness is 105 μ and the greatest 150 μ. The vegetative cells of the branches are on an av. 92 μ thick. They vary between 75 and 125 μ. The length of the cells is 5—25 times the thickness. Most frequently it is rather considerable, being 12—14 times the thickness. The inclosed spores are on an av. 106 μ thick and 375 μ long. The limits of variation are indicated by $\frac{\text{th.}\ 85}{\text{l.}\ 215},\ \frac{100}{500},\ \frac{130}{350}\ \mu$. The only terminal spore I have observed was 75 μ thick and 555 μ long.

Sterile specimens. The thickness of the principal filament is on an av. 137 μ; the smallest observed thickness is 115 μ, and the greatest 180 μ. The branches are on an av. 95 μ thick; the smallest observed thickness is 75 and the greatest 110 μ. The length of the cells is about the same as in the fertile specimens.

Affinities and Differences. This species does not seem to be very nearly related to any of the others in the same group. It is nicely distinguished from both *P. æqualis* nob. and *P. kewensis* nob. by 1:o its cylindrical or almost cylindrical and particularly long spores and 2:o by slighter ramification. From *P. æqualis* nob. especially it differs by longer vegetative cells, and from *P. kewensis* nob. by much greater dimensions.

2. Pithophora æqualis nob.

Diagnosis: Principal filament of the cauloïd part of the thallus in fertile specimens on an average 102 μ thick, either with branches of two degrees, those of the first few and long, those of the second short, or with branches of only one degree, these numerous and short; spores single, inclosed in the principal filament or in the branches of the first degree, more rarely terminal; the inclosed spores cask-shaped with somewhat rounded ends, on an av. 111 μ thick and 250 μ long; the terminal spores cask-shaped with the upper end conical and the top somewhat rounded, on an av. 98 μ thick and 288 μ long; the rhizoïd part of the thallus as a rule rudimentary. — Plate 1, figs. 4—7.

[P. validior et longior, filo principali partis thalli cauloideæ speciminum fertilium circa 102 μ crasso, ramos solitarios, aut numerosos breviores omnes primi ordinis, aut paucos longos primi ordinis ramulis brevibus secundi ordinis præditos emittente; sporis solitariis in filo principali vel in ramis primi ordinis inclusis, rarius terminalibus; sporis inclusis paullum tumidis, orculæformibus, apicibus subrotundatis, c:a 111 μ crassis et 250 μ longis; sporis terminalibus orculæformibus sursum brevi-acuminatis, apice rotundato, c:a 98 μ crassis et 288 μ longis; parte thalli rhizoidea plerumque obsoleta.]

Locality. This species is found by Mr GOLLMER in small ponds on rocks near La Guayra in Venezuela [1]. The specimens which I have examined have been communicated to me by D:r A. GRUNOW under the name of *Cladophora Roettleri* var.

General Description. Fertile specimens. Cauloïd part: As to the ramification we may in this species distinguish two types: one distinguished by few but long branches of the first degree, which generally carry short ones of the second degree (pl. 1, fig. 4), and one by numerous but short branches of the first degree, which remain unbranched. Connecting forms are found, though rare. The branches are always single, one on each supporting cell. Rather often numbers of them are unilateral. As usual in this genus they are attached somewhat below the top of the supporting cell. This distance is in general shorter than the diameter of the supporting cell. Branchless cells are more common in this species than in any other. Besides the top cells and the supporting cells of the spores, the spores

[1]) The locality was thus given on the labels: »Aus den Gebirgsbassin La Guayra und zwar aus kleineren Wasseransamlungen auf Felsen.»

themselves are also branchless (I have seen but one or two exceptions from this rule), and besides these, a great deal of the common vegetative cells are without branches. I have even seen one specimen quite devoid of branches; it is represented pl. 1, fig. 5. Short accessorial basal branches are not seldom found (pl. 1, fig. 4). I have seen no helicoïds in this species. The vegetative cells are in general somewhat swollen or, if you like it better, contracted at the joints. The spores are in *P. æqualis* nob. generally inclosed; of terminal ones I have only seen a few. In specimens of the first type of ramification the inclosed spores are placed exclusively in the branches of the 1:st degree and not in the principal filament; but in specimens of the 2:d, only in the principal filament and not in the branches. Of both types, however, I have seen one specimen with spores both in the principal filament and in the branches of the 1:st degree. The inclosed spores are a little swollen, casklike, but slender, with the ends somewhat rounded (pl. 1, fig. 4, 5). (One spore of cylindric form I have also observed.) They are always single; twin spores I have not observed. The terminal spores are also cask-shaped, but narrow, and grow tapering towards the top, which is rounded (pl. 1, fig. 5).

The rhizoïd part is in this species faintly developed. It generally consists not of a whole cell, but only of that part, pointing obliquely downwards, of the basal cell of the plant, which, in the germination, has developed in an opposite direction to the cauloïd. This part of the cell is always short; sometimes not much longer than the thickness (pl. 1, fig. 5 *rh),* but sometimes 3 or 4 times as long as thick. Not rarely I have found specimens in which the base has been formed of a cell rounded at the lower end and sometimes also a little swollen at the same end (pl. 1, fig. 6 *sg*?). If this cell has, as I suppose, developed immediately out of the germinating spore, the rhizoïd part is here missing. In one or two specimens I have found a rhizoïd consisting of one cell, of almost the same nature as in *P. kewensis* nob., and in one specimen I have found this organ formed by no less than three vegetative cells, but they were short and rather slender.

Sterile specimens resemble the fertile essentially as to the ramification. They differ somewhat, the branches generally being stronger; and moreover the branches are found sometimes single, and sometimes two and two opposite to each other.

As in *P. kewensis* nob., connecting forms are not rarely found between the sterile and fertile specimens, that is, specimens that are at the lower end fertile and have few branches, and at the upper end sterile with many branches, or vice versa.

Measurements. Fertile specimens. Cauloïd part. The cells of the principal filament are on an av. 102 μ thick. The limits of variation are 75 and 120 μ. The cells of the branches of the 1:st degree are on an av. 83 μ; they vary between 75 and 90 μ. The cells of the branches of the 2:d degree are on an av. 67 μ thick; they can vary between 65 and 70 μ. The length of the cells varies rather considerably; but they are never very long. The shortest are only twice and the longest 20 times as long as thick. Generally they are 5 or 8 times as long as thick. The diameter of the inclosed spores is on an av. 111 μ, and their length 250 μ. The limits of variation are indicated by $\frac{\text{th.}}{\text{l.}}\ \frac{100}{165},\ \frac{125}{425},\ \frac{135}{245}\ \mu$. The top spores are on an av. 98 μ thick and 288 μ long. They vary between $\frac{\text{th.}\ 90}{\text{l.}\ 300}$ and $\frac{105}{275}\ \mu$.

Sterile specimens are of the same dimensions as fertile ones.

Affinities and Differences. This species has a near relative in *P. kewensis* nob. The differences are as follows (not counting the considerable difference as to size, *P. æqualis* nob. being twice as big as *P. kewensis* nob.): the inclosed spores are in *P. æqualis* nob. proportionally less swollen and shorter than in *P. kewensis* nob.; the spore-bottoms are rounded in *P. æqualis* nob., but abrupt in *P. kewensis* nob.; the spores are branchless in *P. æqualis* nob., in *P. kewensis* nob. they often support branches; the rhizoïd is in *P. æqualis* nob. generally only rudimentary, in *P. kewensis* nob. it consists of one whole cell; not to mention several smaller differences. *P. æqualis* nob. is less nearly related to *P. sumatrana* (v. Mart.) nob. The differences are noted under *P. sumatrana* (v. Mart.) nob.

3. Pithophora kewensis nob.

Exsicc. Wittr. & Nordst. Alg. Exsicc. Fasc. I, n:o 39.

Diagnosis: Principal filament of the cauloïd part of the thallus in fertile specimens on an average 59 μ thick, with solitary branches of only one degree (rarely of two); spores single, partly inclosed, partly terminal; the inclosed spores cask-shaped, but more elongated, on an av. 81 μ thick and 205 μ long; the terminal spores cask-shaped with the upper end conical and the top somewhat rounded, on an av. 88 μ thick and 219 μ long; the rhizoïd part of the thallus as a rule unicellular. — Plate 1, fig. 8; pl. 2, figs. 1—12; pl. 3, figs. 1—9; pl. 4, figs. 2—11; pl. 5, figs. 9, 10.

[P. gracilis et elongata, filo principali partis thalli cauloideæ speciminum fertilium circa 50 μ crasso, ramos primi solius ordinis (raro secundi etiam ordinis) solitarios emittente; sporis solitariis, vel inclusis vel terminalibus; sporis inclusis elongato-orculæformibus, c:a 81 μ crassis et 205 μ longis; sporis terminalibus orculæformibus, sursum brevi-acuminatis, apice subrotundato, c:a 88 μ crassis et 219 μ longis; parte thalli rhizoidea plerumque unicellulari.].

Locality. *P. kewensis* nob. is found by me in the Tropical Aquarium or the so-called Waterlily-house at Kew in England. [1]) It was found with spores during my whole sojourn there, from the 3:rd to the 25:th of August 1872. — As is mentioned before, I think that the plant is introduced here from a tropical country, probably from South America. (See on this par. 7, pag. 46, 47.)

General Description. Fertile specimens. Cauloïd part of the thallus. This part is always branched, though sometimes but slightly. In general the cells only of the principal filament develop branches; all the branches are then of the 1:st degree. Sometimes the branches of the 1:st degree, especially the lowest ones, develop branches of the 2:d degree, though mostly but few. Regarding the different strength and nature of the branches of the 1:st degree, the following 6 types may be distinguished. In the 1:st type the branches are

[1]) I think it worth inquiry, whether plants belonging to this order may not be found also in aquaria for tropical plants on the continent.

long, most frequently longer than the principal filament, and carry plenty of spores (pl. 2, fig. 1, 2). In the 2:d the branches are considerably shorter than the principal filament and carry each but a few spores (or sometimes but one) (pl. 2, fig. 3). In the 3:d type the branches are still shorter, being generally formed of only a subsporal cell and a terminal spore (pl. 2, fig. 4). The 4:th type is characterized by a powerfully developed principal filament and an almost total want of branches; those few that are to be found are very small, almost rudimentary (pl. 2, fig. 5). The 5:th and 6:th type are represented by specimens which have only part of the principal filament and part of the branches fertile, while the rest of the specimen is sterile. Thus they are connecting forms between the purely fertile and the purely sterile specimens. In the 5:th type particularly the upper part of the specimen is fertile, with short branches, and the lower part sterile, with long branches (pl. 2, fig. 6). In the 6:th, on the contrary, the case is inverse, the lower part being fertile with short branches, the upper sterile with long ones (pl 2, fig. 7). The type oftenest met with is the 1:st, and the least common is the 4:th. The 3:rd is also rather uncommon. — In purely fertile specimens each supporting cell carries but one branch. Once, but only once, I have seen two opposite branches carrying spores sprung from one supporting cell. In specimens belonging to the 6:th type af ramification two opposite branches are not seldom found on one supporting cell in the sterile part of the specimen (in the same manner as in purely sterile specimens). One of these two opposite branches is always much more slightly developed than the other (pl. 2, fig. 7). — The branches are in this species always attached a small space below the top of their supporting cells. This space is in general of the same length as the diameter of the branch; but now and then it can be somewhat longer or shorter. — Branchless cells in the principal filament are seldom found (except in specimens belonging to the 4:th type of ramification). Accessorial branches, sprung from the lower part of the cells, are rare. Sometimes the same cell develops both one normal branch near the top, and one accessorial near the base (pl. 4, fig. 7; pl. 2, fig. 9). — Helicoïds are very rare. Among the great quantity of specimens that I have examined I have found helicoïds but in three, and but one in each. Two of these helicoïds are represented in pl. 5, fig. 9 and 10. The first ends a side branch, the second the principal filament.

The spores occur both in the principal filament and in the branches of the 1:st degree, and are brought forth both by the terminal and inclosed cells. The inclosed spores are all of the same form, cask-shaped but more slender. Sometimes they are so little swollen as to approach the cylindric form (pl. 2, fig. 3 *sc*). Now and then they are provided on one side, near the top, with a process, greater or smaller (pl. 2, fig. 3 *sr'*), which is an indication of a branch, the formation of which was commenced before the formation of the spore, but which was not continued. The terminal spores are also cask-shaped, but not abrupt in their upper end, but with a short point, somewhat rounded. Twin spores are very rare (pl. 3, fig. 8 *s' s''*). Real triple spores I have not observed. The three spores placed besides each other in pl. 3, fig. 8 are but seeming triple spores; and in the same manner the two spores placed side to side represented in pl. 4, fig. 3, are but seeming twin spores. Prolific cells are sometimes found even in fertile specimens.

Rhizoïd part. The rhizoïd, parted from the cauloïd by the oblique wall formed in the germination of the spore, consists in *P. kewensis* nob. as a rule of one cell (pl. 2, fig. 1, 5, 6, 7 *rh*, pl. 4, fig. 4, 5 *rh*). Seldom it develops so as to have several (up to 12) cells (pl. 4, fig 6, 7). In this species I have not rarely met with spores in the rhizoïd also. Pl. 4, fig. 9, 10 and 11 represent such spore-carrying rhizoïds with different number of spores. In one case I have seen a rhizoïd with fully developed branches, consisting, however, each of but one cell. This rhizoïd is represented in pl. 4, fig. 8. Very seldom it happens that the rhizoïd is but rudimentary, being formed of only a very small process from the germinated spore, which process has not been parted from the basal cell of the cauloïd by a cell-wall (pl. 1, fig. 8 *rh*, pl. 4, fig. 2, 3 *rh*).

Sterile specimens generally have a stronger ramification than the fertile ones. The branches of the 1:st degree are often formed two and two by the same mother cell and are then placed opposite, or almost so, to each other (pl. 1, fig. 8, lower part). Branches of the 2:d degree are not rare. The sterile specimens are also greater in size than the fertile; regarding this, see below in »Measurements.» Prolific cells (pl. 3, fig. 1 *p*) occur in sterile specimens much oftener than in fertile ones.

Measurements. Fertile specimens. The greatest of these, that I have seen, have had a length of 3 ½ centimeter; but generally the specimens are much shorter.

Cauloïd part of the thallus. The vegetative cells of the principal filament are on an av. 59 μ thick; the smallest observed thickness is 45 μ and the greatest 80 μ. Vegetative cells in the branches of the 1:st degree are on an av. 45 μ thick; the limits of variation 38—51 μ. The cells in the branches of the 2:d degree are in general 40 μ thick. The length of the vegetative cells varies very considerably. In general they are 12 to 20 times as long as thick, but you also find spore-carrying cells which are but little longer than the thickness; whilst cells, particularly terminal, have also been observed up to 30 or 40 times as long as thick. — The terminal spores are on an av. 88 μ thick and 219 μ long. The limits of variation are indicated by the following numbers: $\frac{th.}{l.}\,\frac{70}{205},\frac{100}{255},\frac{105}{225}\,\mu$. The inclosed spores have averaging a thickness of 81 μ and a length of 205 μ. They vary between $\frac{th.}{l.}\,\frac{55}{150}$ and $\frac{130}{300}\,\mu$. The bigger spores belong of course to the principal filament, and the smaller ones to the branches. The spore-membrane has in ripe spores a thickness of 3 to 5 μ.

Rhizoïd part. Its vegetative cell (or cells) is on an av. 42 μ thick. It varies between 35 and 55 μ. The length exceeds the thickness 4 up to 40 times. When spores occur in the rhizoïd, they are on an av. ¼ narrower than those in the cauloïd, but of about the same length.

Sterile specimens. The dimensions are here generally somewhat larger. Specimens of a length of 6—7 centimeter are not rare, and those of 4—5 c.m. seem to be the most common ones. The cells of the principal filament are on an av. 80 μ thick; they vary between 50 and 110 μ. The cells in the branches of the 1:st degree are averaging 57 μ in thickness. The limits of variation are 40 μ and 85 μ. Branches of the 2:d degree are on an av. 50 μ thick. The length of the cells is somewhat greater than in fertile specimens. The top cells in particular are often very long. I have seen top cells that have been more than 100 times as long as thick (compare pl. 2, fig. 8).

Affinities and Differences. *P. kewensis* nob. shows a near relationship to *P. Cleveana* nob. and especially to *P. oedogonia* (Mont.) nob. *P. kewensis* nob. differs from *P. Cleveana* nob. 1:o in having all the inclosed spores cask-shaped (none cylindrical), 2:o by the proportionally greater length of the inclosed, cask-shaped spores, 3:o by narrower and a great deal longer vegetative cells, 4:o by a much greater length of the whole specimen, 5:o by the want of opposite branches in the purely fertile specimens, and 6:o by the very rare occurrence of helicoïds. The differences between *P. kewensis* nob. and *P. oedogonia* (Mont.) nob. are indicated under the following species.

4. Pithophora oedogonia (Mont.) nob.

Synon. *Conferva (Cladophora) oedogonia* Mont. Crypt. Guyan. p. 301.
Cladophora Oedogonia Mont. Syll. p. 458; Kütz. Tab. Phyc. Band 6, p. 1, tab. 1, fig. 1 (the figure not good).

Diagnosis. Principal filament of the cauloïd part of the thallus in fertile specimens on an average 70 μ thick, with partly solitary, partly opposite branches of three degrees; subsporal branches rather common; spores usually single, but not rarely in pairs, partly inclosed, partly terminal; the inclosed spores cask-shaped, on an av. 114 μ thick and 230 μ long; the terminal spores cask-shaped with the upper end conical and the top somewhat rounded, on an av. 95 μ thick and 214 μ long. — Plate 6, figs. 1—6.

[P. subgracilis et elongata, filo principali partis thalli cauloïdeæ speciminum fertilium circa 70 μ crasso, ramos trium ordinum singulos vel binos oppositos ferente; ramis subsporalibus non raris; sporis plerumque singulis (non raro binis), vel inclusis vel terminalibus; sporis inclusis orculæformibus, c:a 114 μ crassis et 230 μ longis; sporis terminalibus orculæformibus, sursum brevi-acuminatis, apice subrotundato, c:a 95 μ crassis et 214 μ longis.].

Locality. This species is found by Mr Leprieur in South America at Cayenne in French Guyana. Professor Montagne gives in Crypt. Guyan. l. c. its locality thus: »in puteis hospitii nautici apud Cayenne lecta». Epiphytically on it grows a sterile *Oedogonium*.

General Description. Fertile specimens. Cauloïd part of the thallus. The ramification of the cauloïd is very powerful in this species. Branches are here regularly found of three degrees, and in the specimen which I have represented pl. 6, fig. 5 even a cell belonging to a branch of the 3:rd degree has emitted a small branch-process, marked b^4, which is consequently a rudimentary branch of the 4:th degree. The branches of the 1:st degree are sometimes single and sometimes opposite in pairs (pl. 6, figs. 2, 3, 4). The case is the same not only with the branches of the 2:d degree, but also with those of the 3:rd (pl. 6, fig. 4). — The attaching points of the branches on their supporting cells are the same as in *P. kewensis* nob. The length of that piece of the supporting cell which is situated above the attaching point of the branch is in general equal to the diameter of the branch.

The subsporal cells are in this species uncommonly productive. Very often we find that a subsporal cell has brought forth one subsporal branch, and now and then it even happens that such a cell has formed two (opposite) branches (pl. 6, fig. 5 *bs*). In one case I have observed that a subsporal cell, whose mother-cell has brought forth not only one spore but a pair of spores, has still had so much living substance left that it has been able to form a subsporal branch, however small; see pl. 6, fig. 4 bs^2. Subsporal branches exist of all degrees, of the 3:rd as well as of the 1:st and 2:d (pl. 6, fig. 4 bs^2, bs^3). As to the direction of the subsporal branches in relation to their supporting cells (the subsporal cells), a deviation here takes place from what is the case with the common, not subsporal branches. The subsporal branches form, as a rule, a greater angle (of 50 and even 90 degrees) against their supporting cells, than the common branches (the angle of these being, as in the other species of *Pithophora*, generally 45 degrees). The subsporal branches are also placed somewhat farther below the top of their supporting cells than the common branches. Neither are accessorial branches rare. They proceed from a point near the base of their mother cells (see pl. 6, fig 4 *ac*), thus being analogous to the cauloïd rhizine branches so common in *Cladophoreæ* (compare parag. 5, page 36).

In this species occurs a kind of branch formation which I have not observed in any other species of *Pithophora*. Real spores, brought forth in the normal manner and remaining attached to the mother specimen, do here sometimes form branches, instead of germinating in the common manner after having separated themselves from the mother plant. Pl. 6, fig. 6 shows the uppermost end of a specimen in which a number of spores have proceeded in this manner. We find there that the spores of this species can, as well as the common vegetative cells, form one or two branches each, and that the spore branches are formed from the side of the spores in a manner in all the principal points resembling that in which normal branches are formed from common vegetative cells. It is particularly remarkable that the spore branches proceed from the very midst of the spore, and especially that the branches have a position relative to the longitudinal axis of the spore which differs from that which common normal branches have to their supporting cells. Instead of forming an angle of only 45 degrees against the upper part of the supporting cell (here the spore), they form an angle which is much greater, sometimes even more than twice as great; see pl. 6, fig. 6. A parting-wall between the spore itself and its branch-process has not been formed in the specimen represented by this figure, but in other specimens I have observed one; see pl. 6, fig. 4 *bsp*.

The spores are developed partly in the principal filament and partly in the branches of the 1:st and 2:d degree (pl. 6, figs. 3, 4). In the branches of the 3:rd degree I have never observed spores. Both the terminal cells and the inclosed develop spores. The inclosed spores are almost purely cask-shaped; the terminal cask-shaped with the upper end conical and the top somewhat rounded. Twin spores occur not seldom, and are formed by terminal cells as well as by inclosed (pl. 6, figs. 4, 5 *s'*, *s''*).

The rhizoïd part. Only two of the examined specimens have been so perfect as to have the rhizoïd part of the thallus remaining. In the one, represented pl. 6, fig. 2, the rhizoïd consists of four vegetative cells forming a single series. In the other, represented pl. 6, fig. 3, the rhizoïd has an uncommonly powerful development. It is richly ramified, with branches even of two degrees, and is also sporiferous, having both terminal and inclosed spores. In neither specimen the limit between the cauloïd and the rhizoïd is so strongly marked as is usually the case in *Pithophoraceæ*.

Sterile specimens resemble the fertile essentially as to their ramification. The branches of the 1:st degree are, however, still more frequently placed opposite in pairs to each other (pl. 6, fig. 1). — Only in one specimen I have seen the rhizoïd part of the thallus, and in this it consisted of only one cell (pl. 6, fig. 1).

Measurements. Fertile specimens. The cauloïd. The vegetative cells of the principal filament are on an average 70 μ thick. The smallest thickness observed is 55 μ and the greatest 90 μ. The vegetative cells in the branches of the 1:st degree are on an av. 58 μ thick. They vary between 50 μ and 70 μ. The thickness of the branches of the 2:d degree is on an av. 55 μ, and of those of the 3:rd degree 53 μ. The length of the vegetative cells varies between 5 and 45 times the thickness. The top cells are the longest, as usual. — The inclosed spores are on an av. 114 μ thick and 230 μ long. The limits of variation are indicated by $\frac{\text{th. } 70}{\text{l. } 185,}\ \frac{115}{160.}\ \frac{150}{320}\ \mu$. The terminal spores are on an av. 95 μ thick and 214 μ long. They vary between $\frac{\text{th.}}{\text{l.}}\ \frac{70,}{160.}\ \frac{115}{250}\ \mu$.

The rhizoïd. The thickness of the principal filament is on an av. 60 μ, that of the branches of the 1:st and 2:d degree 50 μ. The length of the rhizoïd cells exceeds the thickness 6 to 40 times. The spores which I have found in the rhizoïd of the specimen represented pl. 6, fig. 3 are, the inclosed one 100 μ thick and 255 μ long, and the terminal one 85 μ thick and 240 μ long.

Sterile specimens. The cauloïd. The thickness of the principal filament is on an av. 86 μ. It varies between 85 μ and 90 μ. The branches of the 1:st degree are on an av. 72 μ thick, those of the 2:d 65 μ, and those of the 3:rd 60 μ. The length of the cells varies between 6 and 50 times the thickness.. The rhizoïd of the single specimen in which I have had occasion to observe this part of the thallus, was 55 μ thick.

Affinities and Differences. *P. oedogonia* (Mont.) nob. is most nearly related to *P. kewensis* nob. It differs from this species, as well as from the other species belonging to this section (*P. isosporeæ*) by a considerably stronger development of the system of ramification in the sterile specimens as well as especially in the fertile ones. But one of the other species possesses branches of the 3:rd degree, and in no one of the others opposite branches occur so often in the fertile specimens. Characteristic in this species are also the frequent occurrence of subsporal branches and of twin spores.

Obs. Having obtained material for examination of this species (by the mediation, as has been mentioned before, of D:r J. ROSTAFINSKI), when a great part of the essay was already printed, and having thus been unable to give due attention to the morphological peculiarities of this species in the general account of the morphology of the order, I may be permitted to give in this place an exposition of its most essential morphological peculiarities. They are 1:o that *P. oedogonia* (Mont.) nob. is the only one among *P. isosporeæ* that has the system of ramification of the cauloïd so strongly developed as to possess regularly branches of three degrees; 2:o that the rhizoïd part of the thallus sometimes attains so strong a development that it forms branches of two degrees; 3:o that the subsporal cells are often so rich in protoplasmatic contents, that they have the power of developing one, and now and then even two, branches; 4:o that the mother-cells of the spores have often the power of forming not only one spore, but successively even two; [1]) 5:o that the spores formed in the normal manner, remaining attached to the mother specimen, sometimes germinate in the same manner as the prolific cells, i. e. by developing a branch from one of their sides (or sometimes a branch from each of its two sides).

5. **Pithophora Cleveana** nob.

Diagnosis. Principal filament of the cauloïd part of the thallus in fertile specimens on an average 75 μ thick, with branches commonly of only one degree, but now and then of two; branches as a rule solitary (rarely opposite in pairs); helicoïd cells pretty common; spores single (rarely in pairs), partly inclosed, partly terminal; the inclosed spores cask-shaped or more rarely subcylindrical; thickness of the cask-shaped spores on an av. 102 μ, longitude 216 μ; the terminal spores cask-shaped with the upper end conical and the top somewhat rounded, on an av. 93 μ thick and 232 μ long. — Plate 2, figs. 13—15; pl. 4, figs. 12—18; pl. 5, figs. 1—8.

[P. terrestris subgracilis et subbrevis, filo principali partis thalli cauloideæ speciminum fertilium circa 75 μ crasso, ramos plerumque unius solum ordinis, interdum autem duorum, singulos vel raro binos oppositos emittente; ramis cellulis helicoideis sæpe præditis; sporis vel inclusis vel terminalibus, solitariis (raro geminatis); sporis inclusis subelongato-orculæformibus vel rarius subcylindricis, illis c:a 102 μ

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[1]) In the peculiarities indicated in the points 3 and 4, *P. oedogonia* (Mont.) nob. shows a not inconsiderable conformity with *P. Zelleri* (v. Mart.) nob. among *P. heterosporeæ*.

crassis et 216 μ altis, his c:a 70 μ crassis et 164 μ altis; sporis terminalibus (non raro sessilibus) orculæformibus, sursum brevi-acuminatis apice rotundato, c:a 93 μ crassis et 232 μ altis.]

Locality. Professor P. T. CLEVE has found this interesting species in the West-Indies, in the isle of S:t Thomas near Soldier-Bay on humid earth in the shade of bushes.[1] Oct. 1868. — Epiphytically on it grow two undescribed monoecious species of *Oedogonium*, which it is my intention to describe in another place.

General Description. Fertile specimens. Cauloïd part of the thallus. The ramification of this part is in *P. Cleveana* nob. somewhat more developed than in *P. kewensis* nob. Most specimens have, it is true, branches only of the 1:st degree; but specimens with branches of the 2:d degree are far from being rare, and in a couple of specimens I have seen branches even of the 3:rd degree, but which have almost always consisted of only one sessile spore. The branches of the 2:d degree are generally very short. Not seldom those branches consists (like those of the 3:rd degree) barely of one sessile spore; see pl. 4, fig. 13 *ss*. The principal filament is, when it ends in a spore, often very short, sometimes scarcely 2 m.m. long (pl. 2, fig. 13; pl. 4, fig. 16); the branches of the 1:st degree in such specimens are, it is true, longer, but not very much. Sometimes such little dwarf specimens are quite devoid of branches, and remind one then in a very high degree of a gigantic *Oedogonium* with ellipsoïdic oogonia. The branches are most frequently single, but not seldom those of the 1:st degree are developed two and two from one cell and are then placed opposite, or almost so, to each other (pl. 2, fig. 13; pl. 4, fig. 16; pl. 5, figs. 1 and 2). The normal branches in this species of *Pithophora* are placed, as in the others, a small space below the top of the supporting cell, which space is most frequently smaller than the diameter of the lowest branch cell, but can now and then be even longer (pl. 5, fig. 2). Cells without branches occur rather seldom, if you do not count the top cells[2], the subsporal cells, and the cells belonging to the branches of the highest degree. The lowest one of the cells in the cauloïd part of the thallus is not seldom devoid of branches (pl. 4, fig. 13 and 16); sometimes, however, this cells carries more branches than the other cells, supporting besides the one or two ordinary terminal branches, an accessorial basal branch (pl. 5, fig. 1 and 6). Accessorial branches, most frequently carrying helicoïds, are now and then found even on other cells (pl. 5, fig. 1 *ac*). The comparatively frequent occurrence of helicoïds is particularly remarkable in this species. Most specimens have one or more of these organs. These, generally consisting of the transformed top of a terminal cell, occur in numerous different shapes. Now they are unbranched (pl. 5, fig. 1 *h'*), now forked, now

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[1]) Among the *Cladophoreæ* two species, viz. *Cladophora Sagræana* Mont. (from Cuba) and *Cl. tomentosa* Sur. (from Japan), are known to occur in similar localities.

[2]) Top cells carrying branches are not, however, quite without instances. In small fertile specimens you sometimes find the top cell of the principal filament, when it is a spore, carrying branches (pl. 2, fig. 13; pl. 4, fig. 16).

branched so as to look like claws or hands in two or more branches (pl. 5, figs. 4, 5, 6, 7 *h*), with which they grasp smaller objects of an organic origin, especially particles of humus and such like things. Sometimes helicoïds, ordinarily unbranched, are developed from cells that are not terminal; these helicoïds can now have the same position as the normal (pl. 5, fig. 1 *h*) and now as the accessorial branches (pl. 5, fig. 3 *h*). — The spores are partly terminal and partly inclosed, and are found in the principal filament as well as in branches of all degrees. The terminal spores are as a rule elongated and cask-shaped with a tapering and somewhat rounded top (pl. 2, fig. 13; pl. 4, figs. 13 and 16). As exceptions top spores are found of a somewhat anomalous shape, such as pl. 2, fig. 13 *st* and pl. 5, fig. 8 show. (As I have indicated in the paragraph treating the formation of spores, this anomalous top spore has without doubt been intended, from the beginning, for a helicoïd). The inclosed spores can have two shapes. They are either swollen and cask-shaped (pl. 5, fig. 2 and pl. 2, fig. 13) or, though much more seldom, cylindrical (pl. 5, fig. 2 *sc* and pl. 2, fig. 13 *sc*). Connecting forms between both are rare. Inclosed spores of an irregular shape are found now and then. The anomalons shape most frequently has its cause in the circumstance, that the mother cell of the spore had begun, before the formation of the spore, to form a branch, but which was not completed; and from this cause the unfinished branchlet has come to belong to the spore, when it was afterwards formed, making something like a beak pointing upwards from the spore (pl. 2, fig. 14 *sr*, fig. 15 *sr*). A peculiarity in this species is, in specimens with no rhizoïd or a rudimentary one, that the thallus is rather often ended downwards in a spore, which does then take the place of a rhizoïd (pl. 2, fig. 13 *sgb*; pl. 4, figs. 12 and 14 *sgb*). The cause of this is, that the spore which has, by its germination, been the origin of the whole individual, has resumed its character of a spore when the germination was completed, by being filled from above with a protoplasm rich in chlorophyll, and by the formation of a new transversal cellwall above. (See more in extenso in the paragraph on the formation of spores.) Twin spores are not rare in this species. Most frequently they occur in the top of short branches of the 1:st and 2:d (or 3:rd) degree, but now and then they are also found in the principal filament and in other places (pl. 2, figs. 14 and 15). The lower twin spore is generally smaller, but sometimes it happens that they are of about equal size (pl. 2, fig. 14). In a couple of cases I have observed in this species triple spores (pl. 2, fig. 15 s^1, s^2, s^3), formed in the manner indicated in the paragraph treating the formation of spores. Besides the spores formed in a normal manner (i. e. after a preceding passing upwards of the chlorophylliferous protoplasm, by bipartition), there occur in this species cells of the usual form, which contain, like the spores, an abundant quantity of chlorophyll (pl. 4, fig. 18 *p*). Probably they have the same purpose as the prolific cells mentioned before in *P. kewensis* nob.

Rhizoïd part of the thallus. In the germination of the spore a transversal wall, vertical against the longitudinal axis of the spore, is formed in its midst or in its lower part. The part situated below this oblique wall constitutes its rhizoïd part. This part consists, as a rule, of one cell. Only in one case, the one represented pl. 4, fig. 18, I have found, in *P. Cleveana* nob., a rhizoïd formed by more than one cell. As the figure here quoted shows, the rhizoïd here consists of three cells, or even four, if the wall marked *w'*, and not that marked *w''*, was the one first formed in the germination. (Regarding this, see the paragraph on the germination). As to the specimens that are represented pl. 5, figs. 1 and 2, it is impossible to decide how much belongs to the rhizoïd part, when it is not known with certainty which part of the specimens has belonged to the original, germinated spore. If the supposition were true, that the irregularly shaped organs marked *sg* are transformations of this spore, only the processes *rh*, pointing downwards, would belong to the rhizoïd part. Sometimes no transversal wall is formed in the spore at the germination, and then the rhizoïd either does not exist, or is only rudimentary. The former is the case if the germinating spore has not at all been elongated downwards (pl. 2, fig. 13 *sgb*; pl. 4, fig. 12 *sgb*; pl. 5, fig. 3 *sg*); the latter if it has been somewhat elongated, but without a parting wall between the cauloïd and the rhizoïd having been formed (pl. 4, figs. 13 and 14 *rh*; pl. 5, fig. 6 *rh*). Pl. 4, fig. 14 shows a case, when the forming of a parting wall was commenced, but without being completed.

Sterile specimens differ from the fertile by stronger ramification — branches of the 2:d degree regularly existing — and by the branches being placed two and two opposite to each other as often as singly.

Measurements. This species is the smallest one in the whole genus. Its vegetative cells have, it is true, a greater diameter than those of *P. kewensis* nob., but the length of the individual cells as well as more especially of the whole plant is considerably less. The greatest specimens that I have seen have been only 25 millimeter long, and specimens of a length of only 4–5 millimeter are not rare.

Fertile specimens. Cauloïd part of the thallus. The cells of the principal filament are on an average 70 μ thick; the smallest observed thickness is 60 μ and the greatest 90 μ. The cells in the branches of the 1:st degree are on an av. 55 μ thick. The limits of variation are 50 μ and 60 μ. The branches of the 2:d and 3:rd degree are not much less thick than those of the 1:st; the diameter of the cells is on an av. 50 μ; the smallest diameter 45 μ and the greatest 55 μ. The length of the vegetative cells is less in this species than in other species. Very short cells ($1\,{}^1/_4$–2 times as long as thick) occur not seldom in the principal filament (pl. 4, fig. 13) as well as in the branches. Especially the cell just beneath a terminal spore has this form (pl. 5, fig. 4). Very long cells (such as in *P. kewensis* nob.) do not exist. Only very seldom the cells are 20 times, generally only 4—9 times as long as thick. The thickness of the terminal spores is on an av. 93 μ and their length, on an av. 232 μ. The limits of variation are indicated by ${}^{\text{th.}}_{\text{l.}}\,{}^{74}_{200,}\,{}^{110}_{270,}\,{}^{120}_{260}\ \mu$. The cask-shaped spores are on an av. 102 μ thick, and 216 μ long. The limits of variation are indicated by ${}^{\text{th.}}_{\text{l.}}\,{}^{70}_{220,}\,{}^{90}_{150,}\,{}^{120}_{290,}\,{}^{130}_{230}\ \mu$. The cylindric spores are on an av. 70 μ thick and 164 μ long. Their limits of variation are ${}^{\text{th.}}_{\text{l.}}\,{}^{50}_{120,}\,{}^{68}_{220,}\,{}^{70}_{114,}\,{}^{90}_{210}\ \mu$.

The cell of the rhizoïd has a rather variable length. Most frequently it is very short, $1\,{}^1/_4$–4 times as long as thick (pl. 4, figs. 15 and 16), but sometimes it is more developed as to length, as much as 10 times as long as thick (pl. 4, fig. 17).

Affinities and Differences. This species forms the connecting link between *Pithophoræ isosporeæ* and *P. heterosporeæ*. Besides the common cask-shaped spores, spores occur here of a cylindrical or almost cylindrical form. Inclosed spores of two kinds thus existing in *P. Cleveana* nob., it might seem most reasonable to place the species among *Pithophoræ heterosporeæ*. The cause why I have not done so is 1:o that *P. Cleveana* nob. evidently has its nearest relatives in the real *Pithophoræ isosporeæ*, and 2:o that the cylindrical spores are so rare as to deserve being regarded merely as exceptions. — The most remarkable character in *P. Cleveana* nob. is its abundant helicoïds. They are found in all specimens that are somewhat rich in branches, and they are not rare even in those poorer in branches. With *P. kewensis* nob., which is rather nearly related to *P. Cleveana* nob., it has already (page 55) been compared. From *P. ædogonia* (Mont.) nob. and *Pithophoræ heterosporeæ* it is distinguished by characters so evident as not to nead special mention.

Sectio II. PITHOPHORÆ HETEROSPOREÆ:

Spores of several, dissimilar forms in each species; the inclosed of three forms, viz. cask-shaped, cylindrical and subirregular; the terminal as a rule of two forms, viz. cask-shaped and cylindrical, both with the upper end conical and the top somewhat rounded. (Species 6 to 8).

Species 6. **Pithophora polymorpha** nob.

Exsicc. HOHENACK. Alg. mar. sicc. 10:te Liefer., n:o 472 *a;* sub nomine *Cladophora crispata* Kütz.

Diagnosis: Principal filament of the cauloïd part of the thallus in fertile specimens on an average 105 μ thick, with branches of one or two degrees; branches of the first degree solitary or more rarely opposite in pairs; branches of the second degree solitary; spores solitary (rarely in pairs), partly inclosed, partly terminal; the inclosed spores in branches of the first degree partly cylindrical, partly cask-shaped; the inclosed spores in the principal filament usually of an irregular shape; the cylindrical spores on an av. 63 μ thick and 88 μ long, the cask-shaped on an av. 104 μ thick and 157 μ long, the subirregular 121 μ thick and 133 μ long; the terminal spores commonly subconical with the top rounded, rarely cask-shaped with the upper end conical and the top somewhat rounded; the subconical spores on an av. 63 μ thick and 155 μ long, the cask-shaped on an av. 95 μ thick and 148 μ long. — Pl. 1, figs. 13—17; pl. 4, fig. 19.

[P. subvalida, filo principali partis thalli cauloideæ speciminum fertilium c:a 105 μ crasso, ramos unius vel duorum ordinum emittente; ramis ordinis primi singulis vel (rarius) binis oppositis; ramis ordinis secundi singulis; sporis solitariis (rarius geminatis), vel inclusis vel terminalibus; sporis in ramis primi ordinis inclusis vel cylindricis vel orculæformibus; sporis in filo principali inclusis plerumque forma subirregulari; sporis cylindricis c:a 63 μ crassis et 88 μ longis, orculæformibus c:a 104 μ crassis et 157 μ longis, subirregularibus 121 μ crassis et 133 μ longis; sporis terminalibus plerumque subconicis apice rotundato, raro orculæformibus sursum brevi-acuminatis apice subrotundato; sporis subconicis c:a 63 μ crassis et 155 μ longis, orculæformibus c:a 95 μ crassis et 148 μ longis.]

Locality. This species is found in fresh water on Mangalore in Canara in India, according to Hohenacker l. c.

General Description. Fertile specimens. Cauloïd part. In this many-formed species we may distinguish two types of ramification, one where only the principal filament carries branches (which are consequently all of the 1:st degree), and one where the branches of the 1:st degree are also ramified. In the first type the branches are generally short and single (pl. 1, fig. 17); in the second, the branches of the 1:st degree are rather long and partly single, partly opposite to each other in pairs, whilst the branches of the 2:d degree are short and single (pl. 1, fig. 13). Connecting forms between the two types exist, however. Most frequently the branches of this species are placed, as in the others, a space (however small) below the top of the supporting cell, but not seldom the branches proceed from the very top of their supporting cells (pl. 1, fig. 16, 17). Accessorial basal branches are not rare, especially in specimens belonging to the second type of ramification. Branchless cells in the principal filament are rare; even the top cells here show, against the rule, now and then a tendency to ramify (pl. 1, fig. 17 *ct).* Only one helicoïd I have found. It was unbranched, and belonged to a branch of the 2:d degree. — The spores, which are in this species of several different forms, are partly inclosed and partly terminal. The inclosed are of three principal forms, viz. 1:o cylindrical, 2:o cask-shaped, and 3:o of an irregular shape. As a 4:th kind might be regarded the very short, half cask-shaped lower ones of the twin spores (pl. 1, fig. 16 *s''*). The cylindrical, which are the most common, are found in branches of the 1:st and 2:d degree (pl. 1, fig. 13), the cask-shaped in branches of the 1:st degree and more seldom in the principal filament (pl. 1, fig. 16); the irregular in the principal filament (pl. 1, fig. 13). The terminal spores are of two kinds: 1:o subconical with a rounded top (pl. 1, figs. 13, 15, 17), and 2:o cask-shaped and abruptly narrowing towards the rounded top (pl. 1, fig. 14). The former is the common form; the latter is rare. As I have already indicated, twin spores are not seldom found. They are placed partly in the principal filament and partly in the branches of the 1:st degree.

Rhizoïd part. Only in one of the examined specimens this part has been preserved. It showed a very powerful development, being pluricellular and sporiferous (pl. 4, fig. 19).

Sterile specimens of this species would seem to be very rare. Among the numerous specimens I have examined, I have found only one sterile. This one had strong and opposite branches of the 1:st degree, and short and single of the 2:d.

Measurements. Fertile specimens. Cauloïd part. The vegetative cells of the principal filament are on an average 105 μ thick. Specimens of the first type of ramification have in general thicker cells; those of the second narrower. The greatest observed thickness (in the former) is 130 μ, the least (in the latter) 85 μ. The branches of the 1:st degree are on an av. 74 μ thick. They vary between 45 μ and 105 μ. The branches of the 2:d degree are on an av. 53 μ thick. They vary between 45 and 60 μ. The length of the vegetative cells is less in specimens of the first type of ramification than in those of the second. In the former they are in general 4—6 times as long as thick, but in the latter 6—8 times. The shortest vegetative cells are scarcely any longer than the thickness; but the longest as much as 20 times as long as thick. — The inclosed cylindrical spores are on an av. 63 μ thick and 88 μ long. The limits of variation are indicated by $\frac{\text{th.}}{\text{l.}}\ \frac{45}{40},\ \frac{45}{125},\ \frac{105}{110}\ \mu$. The inclosed cask-shaped spores are on an av. 104 μ thick and 157 μ long. The limits of variation are indicated by $\frac{\text{th.}}{\text{l.}}\ \frac{80}{125},\ \frac{90}{115},\ \frac{140}{210}\ \mu$. The inclosed spores of irregular shape are on an av. 121 μ thick and 133 μ long. They vary between $\frac{\text{th.}}{\text{l.}}\ \frac{75}{70}$ and $\frac{155}{200}\ \mu$. The lower of the twin spores are rather thick but very short, on an av. 117 μ thick and 103 μ long. The terminal subconical spores have on an av. the same thickness as the inclosed, viz. 63 μ, but are considerably longer, measuring on an av. 155 μ. The limits of variation are indicated by $\frac{\text{th.}}{\text{l.}}\ \frac{46}{135},\ \frac{55}{245},\ \frac{90}{165}\ \mu$. The cask-shaped terminal spores, narrowing towards their top, are on an av. 95 μ thick and 148 μ long. The limits of variation are indicated by $\frac{\text{th.}}{\text{l.}}\ \frac{75}{150},\ \frac{90}{125},\ \frac{120}{170}\ \mu$.

Rhizoïd part. In the only rhizoïd I have seen, the vegetative cell was 90 μ thick; the inclosed spore 90 μ thick and 95 μ long, and the terminal spore 90 μ thick and 175 μ long.

The single sterile specimen that I have seen had the principal filament 125 μ, the branches of the 1:st degree 75 μ and the branches of the 2:d degree 70 μ thick.

Affinities and Differences. There is no need to compare this species to any but its nearest relatives, *P. Zelleri* (v. Mart.) nob. and *P. Roettleri* (Roth) nob. It is most clearly distinguished by its very numerous inclosed cylindrical spores and by the subconical terminal ones. Besides, it differs from the two species mentioned by smaller dimensions and less powerful ramification.

7. **Pithophora Zelleri** (v. Mart.) nob.

Synon. *Cladophora Zelleri* v. Mart. Die Tange, p. 111. pl. 2. fig. 1 (the figure not good).

Diagnosis: Principal filament of the cauloïd part of the thallus in fertile specimens on an av. 120 μ thick, with branches usually of two degrees, solitary or opposite in pairs; spores partly inclosed, partly terminal; the spores of the principal filament regularly in pairs, the spores of the branches commonly solitary; the upper one in a pair of twin spores (and the solitary now and then occurring in the principal filament) cask-shaped, on an av. 144 μ thick and 232 μ long; the lower spores in a pair of twin spores subcylindrical, on an av. 113 μ thick and 179 μ long; the solitary spores of the branches of the first degree cylindrical, on an av. 85 μ thick and 135 μ long; the terminal spores cask-shaped, with the upper end conical and the top somewhat rounded, on an av. 132 μ thick and 382 μ long. — Plate 1, figs. 9—12.

[P. subvalida, filo principali partis thalli cauloideæ speciminum fertilium c:a 120 μ crasso, ramos plerumque duorum ordinum singulos vel binos oppositos emittente; sporis vel inclusis vel terminalibus; sporis in filo principali sitis plerumque geminatis; sporis in ramis sitis plerumque solitariis; sporis inclusis superioribus binarum geminatarum (solitariisque in filo principali) orculæformibus, c:a 144 μ crassis st 232 μ longis; sporis inclusis inferioribus binarum geminatarum subcylindricis, c:a 113 μ crassis et 179 μ longis; sporis inclusis solitariis ramorum cylindricis, c:a 85 μ crassis et 135 μ longis; sporis terminalibus orculæformibus sursum brevi-acuminatis apice subrotundato, c:a 132 μ crassis et 382 μ longis.]

Locality. This species is found by Professor E. v. MARTENS j:r near Yokohama in Japan, in the month of October 1860. It grows on rice-fields. — The specimens which I have examined are original specimens, presented to me by Prof. E. v. MARTENS j:r.

General Description. Fertile specimens. Cauloïd part. The branches of the 1:st degree are placed singly, or two and two opposite to each other on the principal filament. Once I have observed three branches of the first degree in a whorl. These often support branches of the 2:d degree, which are, as a rule, placed singly. These branches in their turn now and then, though seldom, support small branches of the 3:rd degree. The normal branches are attached a short space (not so long as the diameter of the branch), below the top of the supporting cells. Accessorial basal branches are rare. Subsporal branches of the 1:st degree are, on the contrary, rather common (pl. 1, fig. 9). Such branches are found only below single spores. In their formation has evidently been consumed the protoplasm, which otherwise is used in the principal filament in the formation of the lower one of the twin spores that are common there. Helicoïds I have not observed. — Spores are found in branches of the 1:st degree as well as in the principal filament; they are partly inclosed and partly terminal. The spores in the principal filament are generally formed two and two by one mother cell (pl. 1, fig. 10 and 11). In branches of the 1:st degree such twin spores are but very seldom found (pl. 1, fig. 9 *s'*, *s''*). The inclosed spores are of three kinds: 1:o the upper ones in the pairs of twin spores, and the single spores in the principal filament; 2:o the lower ones in the pairs of twin spores; 3:o the single ones in the branches of the 1:st degree. Those of the first kind are in general cask-shaped (pl. 1, fig. 11), but now and then of a somewhat irregular form (pl. 1, fig. 9 and 10); those of the second kind are cylindrical or almost so, often somewhat swollen midways (pl. 1, fig. 11 and 10 *s''*), and those of the third kind are almost quite cylindrical (pl. 1, fig. 9 *sc.*). The terminal spores, of which I have seen but very few, are cask-shaped with the top now abruptly pointed and now tapering (pl. 1, fig. 11). I think it very probable that the plant may have subconical terminal spores besides the cask-shaped.

Among the specimens I have had occasion to examine, not one has had the lower part of the thallus left; thus the nature of the rhizoïd is unknown to me.

Sterile specimens. I have seen but one such specimen. The cauloïd of the thallus had branches of three degrees. Those of the 1:st and 2:d degree were mostly found in pairs, opposite to each other, more seldom they were single; those of the 3:rd, on the contrary, were single. The lower part of this specimen I have represented pl. 1, fig. 12. From the cauloïd proceed obliquely downwards two rather long cells, of which I suppose the one, marked *rh*, to be the rhizoïd, and the other, marked *ac*, to be an accessorial (rhizine) branch on the basal cell of the cauloïd, analogous to the one represented pl. 4, fig. 7 *ac* after a sterile specimen of *P. kewensis* nob.

Measurements. Fertile specimens. The principal filament of the cauloïd is on an av. 120 μ thick. The limits of variation are 90 and 150 μ. The branches of the 1:st degree are in general 90 μ thick, varying between 70 and 115 μ. Those of the 2:d degree are also about 90 μ thick, and those of the 3:rd degree about 85 μ. The length of the vegetative cells varies between 6 and 20 times the thickness. The inclosed cask-shaped spores (i. e. the single ones in the principal filament, and the upper one in the pairs of twin spores) are on an av. 144 μ thick and 232 μ long. The limits of variation are indicated by $\frac{\text{th.}}{\text{l.}}\ \frac{110}{215},\ \frac{125}{175},\ \frac{210}{265}\ \mu$. The lower ones in the pairs of twin spores are on an av. 113 μ thick and 179 μ long. They vary between $\frac{\text{th.}}{\text{l.}}\ \frac{95}{60}$ and $\frac{175}{260}\ \mu$. The single cylindrical spores are on an av. 85 μ thick and 135 μ long. They vary between $\frac{\text{th.}}{\text{l.}}\ \frac{70}{120},\ \frac{75}{110},\ \frac{105}{175}\ \mu$.

The measures of the sterile specimen are as follows: the principal filament 115--130 μ, the branches of the 1:st degree 100—125 μ, the branches of the 2:d degree 90—100 μ, the branches of the 3:rd degree 75—80 μ, the rhizoïd (?) 95 μ.

Affinities and Differences. This species shows a near relationship to *P. polymorpha* nob. and *P. Roettleri* (Roth) nob. Its most remarkable character is, that the spores in the principal filament occur, as a rule, two and two end to end. (If an exception from this rule takes place now and then, a subsporal branch has been developed, as has been indicated above, instead of the lower one of the spores.) The ramification is feebler in this species than in *P. Roettleri* (Roth) nob., but somewhat stronger than in *P. polymorpha* nob.

8. **Pithophora Roettleri** (Roth) nob.

Synon. *Ceramium Roettleri* Roth Catal. Bot. III, p. 123.
Cladophora acrosperma Kütz. Phyc. gener. p. 265.
„ *Roettleri* Kütz. Spec. Alg. p. 409; Tab. Phyc. Band. IV, pag. 10, tab. 46.

Diagnosis: Principal filament of the cauloïd part of the thallus in fertile specimens on an average 165 μ thick, with branches of three degrees; branches of the first degree three in a whorl, branches of the second and third solitary or opposite in pairs; spores solitary (rarely in pairs), partly inclosed, partly terminal; the spores of the branches partly cask-shaped, partly cylindrical; the spores of the principal filament of an irregular shape; the cask-shaped spores on an av. 152 μ thick and 226 μ long, the cylindrical on an av. 83 μ thick and 143 μ long, the irregular 191 μ thick and 213 μ long; the terminal spores partly obovoïd with the base truncated, partly (and more rarely) subconical with the top rounded; the obovoïd spores on an av. 150 μ thick and 212 μ long, the subconical on an av. 88 μ thick and 246 μ long. — Plate 1, figs. 18—20; pl. 5, figs. 11 and 12.

[P. robusta, filo principali partis thalli cauloideæ speciminum fertilium circa 165 μ crasso, ramos trium ordinum emittente; ramis ordinis primi ternis verticillatis; ramis ordinis secundi et tertii solitariis vel binis oppositis; sporis solitariis (raro geminatis), vel inclusis, vel terminalibus; sporis ramorum vel orculæformibus vel cylindricis; sporis fili principalis forma subirregulari; sporis orculæformibus c:a 152 μ crassis et 226 μ longis, cylindricis c:a 83 μ crassis et 143 μ longis, subirregularibus c:a 191 μ crassis et 213 μ longis; sporis terminalibus vel obovoideis basi truncata, vel rarius subconicis apice rotundato; illis c:a 150 μ crassis et 212 μ longis, his 88 μ crassis et 246 μ longis.]

Locality. This species grows in India near Tranquebar in fresh water. The locality is thus given by Roth l. c.: »In aquis stagnantibus Tranquebariæ lecta a Cel. Roettlero»; and by Kützing in Phyc. gener. l. c. thus: »Aus Seesümpfen bei Tranquebar in Ostindien. Januar 1799: Klein (Herb. berol. — unter n:o 431).»

General Description. Fertile specimens. This species is distinguished at the first glance by a stronger ramification and more robust growth than the other species. The cauloïd part of the thallus has, as a rule, branches of three degrees. Those of the 1:st degree are generally placed three and three (once I have even seen four) in a whorl on the principal filament. Now and then, especially near to the lower end of the principal filament, single branches are found, which are very strongly developed. The branches of the 2:d and 3:rd degree are most frequently single, or two and two opposite to each other. Sometimes I have, however, found the branches of the 2:d degree placed three in a whorl, like those of the 1:st. The branches are attached to their supporting cells a small space below their top, as in the other *Pithophoraceæ*. This space varies as to length, but is always shorter than the diameter of the lowest branch cell, and sometimes so short as to be hardly discernible. Branchless cells are very rare in the principal filament, except the subsporal ones; they are somewhat more frequent in the branches of the 1:st and 2:d degree, though the number of branchless cells is always much less than the number of those supporting branches. Accessorial basal branches are not rare (pl. 1, fig. 18). Rather seldom the top cells develop, in or near their top, handlike helicoïds, such as pl. 5, fig. 11 and 12 shows. — The spores can be formed both by the top cells and by the other cells, both by those of the principal filament and by those of the branches. The terminal spores are of two different shapes. Either — and this most frequently — they are swollen, and have then a short, reversedly egg-like shape with an abrupt base (pl. 1, fig. 18 *st*), or they are formed without any swelling (or with an almost imperceptible one) of the mother cell, and have then the shape of a cone with a somewhat rounded point (pl. 1, fig. 18 *stc*). The inclosed spores are of three kinds; either they have the common cask-shape, or they are cylindrical, or they have an irregular form. The cask-shaped spores are most frequent in the branches of the 1:st degree, but rare in those of the 2:d (pl. 1, fig. 18). In the branches of the 3:rd degree and in the principal filament I have never found spores of this shape. Spores of a cylindrical form are more rare; they occur only in branches of the 1:st and 2:d degree, and in the rhizoïd. The spores of an irregular shape (pl. 1, fig. 18 *si*) belong to the principal filament; they are very rare in the branches of the 1:st degree (pl. 1, fig. 18 *si'*). Twin spores are sometimes found, terminal as well as inclosed in the branches. Generally the lower of the twin spores is smaller than the upper, and cylindrical, whilst the upper is swollen (pl. 1, fig. 19); but sometimes both are of about the same size, and swollen (pl. 1, fig. 20). — Among all the specimens that I have had opportunity to observe, I have found but one (represented pl. 1, fig. 18) which has been so complete as to have the oldest part remaining, brought forth immediately by the germinating spore. This specimen does not show a distinct rhizoïd, diametrically opposed to the cauloïd. The spore has, in germinating, only grown somewhat pointed downwards. But it has, on one of its sides, developed a branch, which has at a later period ramified and taken its most considerable growth in a downward direction (pl. 1, fig. 18 *rh*), showing thus an evident relationship to a normal rhizoïd part.

Sterile specimens. Of these I have seen only one, and that one was not quite entire. As to ramification and dimensions it resembled the strongest developed fertile ones. Besides three and three, the branches were also found four and four in a whorl on the principal filament.

Measurements. Fertile specimens. Cauloïd part. The vegetative cells of the principal filament are midways on an av. 165 μ thick. Most frequently they are narrower in their lower end and grow thicker upwards. The smallest diameter I have found is 135 μ, and the greatest 190 μ. The vegetative cells of the branches of the 1:st degree are on an av. 111 μ thick; the limits of variation are 90 and 140 μ. The branches of the 2:d degree vary in thickness between 90 and 100 μ, those of the 3:rd degree between 80 and 90 μ. The length of the vegetative cells is not very considerable in this species, generally 6—11 times as great as the thickness. Longer cells are rare, but shorter, on the contrary, more frequent. Particularly the top cells and the cells just below the top spores are not seldom so short as to be only twice or thrice as long as thick. The swollen top spores are on an av. 150 μ thick and 212 μ long. The limits of variation are $\frac{th.}{l.}\frac{125}{155}$ and $\frac{230}{270}$ μ. The sizes between are for instance $\frac{th.}{l.}\frac{130}{175},\frac{150}{240},\frac{150}{260}$ μ. Those top spores that are not swollen are considerably more slender, but at the same time somewhat longer; on an av. 88 μ thick and 246 μ long. They vary between $\frac{th.}{l.}\frac{75}{300},\frac{95}{165},\frac{100}{200}$ μ. The inclosed cask-shaped spores are on on an av. $\frac{th.}{l.}\frac{152}{226}$ μ. The limits of variation are indicated by the following: $\frac{th.}{l.}\frac{130}{205},\frac{150}{275},\frac{175}{275}$ μ. The inclosed cylindrical spores are on an av. $\frac{th.}{l.}\frac{83}{143}$ μ. The limits of variation lie between $\frac{th.}{l.}\frac{50}{70}$ and $\frac{110}{125}$ μ. The irregularly shaped inclosed spores are the greatest of all; they are on an av. $\begin{smallmatrix} \text{th.} & 191 \\ \text{l.} & 213 \end{smallmatrix}\ \mu$. The limits of variation are indicated by $\begin{smallmatrix} \text{th.} & 140 & 230 & 250 \\ \text{l.} & 130, & 270, & 250 \end{smallmatrix}\ \mu$.

Affinities and Differences. This species is distinguished from its nearest relations, *P. polymorpha* nob. and *P. Zelleri* (v. Mart.) nob. by considerably greater dimensions and particularly by a stronger ramification. The cells of the principal filament carry here three (or even four) branches in a whorl, and branches of the 3:rd degree occur regularly.

Having now described those species of *Pithophora* which I have seen both in a fertile and in a sterile state, it remains to say a few words on a Pithophoraceous plant which I know only as sterile. It is the australian *Pithophora* mentioned above, which has been communicated to me by D:r A. GRUNOW. According to the information kindly given by D:r A. GRUNOW it has been gathered by D:r E. GRÆFFE in two localities, both situated in Upolu, one of the isles of Samoa. One of the localities is running fresh water, the other is Mangrove-swamps with slightly brackish water on a muddy ground. As the specimens brought from the two localities show some small differences, I will describe each local form separately.

The form brought from the fresh water locality has branches of two degrees, which are sometimes placed in pairs opposite to each other, but most frequently singly. The branches regularly proceed from their supporting cells a small space below their top. The thickness of the principal filament varies between 100 and 110 μ, that of the branches of the 1:st degree between 90 and 100 μ, and that of the branches of the 2:d degree between 80 and 95 μ. The length of the common vegetative cells is generally rather considerable. The length varies between 10—30 times the thickness. In one specimen I have observed cells which very strongly call to mind real *Pithophora*-spores by their very much smaller length, their greater thickness and their greater abundance of chlorophyll. The cause of my not being able to recognize them as such with certainty is 1:o that the cells which ought to be the sister cells of the spores (the subsporal cells) are not particularly poor in chlorophyll, 2:o that the length of the supposed spores varies very much, and 3:o that they have almost all developed (not merely support) branches. If they be really spores, they must be supposed to have proceeded in the same manner as the spores which I have represented pl. 6, fig. 6, belonging to *Pithophora oedogonia* (Mont.) nob. They would then have germinated while yet remaining attached to the mother plant, in the same manner as prolific cells, by bringing forth lateral branches. The thickness of those cells varies between 100 and 150 μ, and their length between 175 and 460 μ.

The form from the Mangrove-swamps has branches of at least two degrees, which are placed singly, opposite in pairs, or now and then three in a whorl. The branches sometimes proceed from the supporting cells a small space below their top, but often at the very top.[1]) Most frequently the branch is supported by a

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[1]) This, together with other things, is the cause why I am not quite convinced of this species belonging to the genus of *Pithophora*.

lateral process belonging to the supporting cell, which circumstance is occasioned by the fact that the transversal cell-wall, which has separated the branch process first formed from its mother cell, has been formed somewhat higher up in the branch process, not at its base.[1]) The top branches are often bent like a sickle. The thickness of the cells varies between 85 and 125 μ. Their length is 7—25 times greater than the thickness.

According to D:r GRUNOW'S opinion, directly communicated to me, both the forms now mentioned belong to *Cladophora sumatrana* v. Mart. (i. e. to *Pithophora sumatrana* (v. Mart.) nob.) The one growing in brackish water D:r GRUNOW has determined as being a variety under the name of *fuscescens*. My opinion is also that these forms are nearly related to *P. sumatrana* (v. Mart.) nob. Whether they are quite identical with it can not be determined with certainty till they are known in a fertile state. The form grown in fresh water calls to mind *P. æqualis* nob. almost more than *P. sumatrana* (v. Mart.) nob.

[1]) The same circumstance sometimes takes place in *P. polymorpha* nob.; see pl. 1, figs. 15 and 17.

INDEX OF SPECIES AND SYNONYMS.

ABBREVIATIONS.

av. = average. — c. m. = centimeter. — fig. or figs. = figure or figures. — l. = length. — μ = 0,001 millimeter. — pag. = page or pages. — par. or parag. = paragraph. — pl. = plate. — th. = thickness.

LIST OF THE LITTERATURE, CITED ABOVE.

AL. BRAUN. Bot. Zeit. = AL. BRAUN. Bemerkungen über die neueren Eintheilungsversuche der Thallophyten. Reported in Botanische Zeitung herausgegeben von A. DE BARY und G. KRAUS. 33:ster Jahrg. 1875. Leipzig 1875.

COHN. Hedwigia = Conspectus familiarum cryptogamarum secundum methodum naturalem dispositarum, auct. F. COHN. In Hedwigia. Ein Notizblatt für kryptogamische Studien, redig. von L. RABENHORST. Elfter Band. Dresden 1872.

» Entw. d. *Volvox.* = Die Entwickelungsgeschichte der Gattung *Volvox* von F. COHN. In Beiträge zur Biologie der Pflanzen, herausgegeben von F. COHN. 3:tes Heft. Breslau 1875.

GRUN. Reise S. M. Freg. Novara = Reise Seiner Majestät Fregatte Novara um die Erde. Botanischer Theil. I Band. Algen. Bearbeitet von A. GRUNOW. Wien 1867.

HANST. Leb. d. *Vauch.* = Ueber die Lebenszähigkeit der *Vaucheria*-Zelle und das Reproductions-Vermögen ihres protoplasmatischen Systems von J. HANSTEIN. Reported in Botanische Zeitung, herausgegeben von A. DE BARY und G. KRAUS. 31:ster Jahrg. 1873. Leipzig 1873.

HOFMEIST. Pflanzenz. = Die Lehre von der Pflanzenzelle von W. HOFMEISTER. Leipzig 1867.

HOHENACK. Alg. mar. sicc. = Algæ marinæ siccatæ. 10:te Lieferung. Herausgegeben von R. F. HOHENACKER. Kirchheim u. T. 1862.

KÜTZ. Phyc. gener. = Phycologia generalis. Bearbeitet von F. T. KÜTZING Leipzig 1843.

» Spec. Alg. = Species Algarum. Auctore F. T. KÜTZING. Lipsiæ 1849.

» Tab. Phyc. = Tabulæ Phycologicæ. Herausgegeben von F. T. KÜTZING. Band 4 and 6. Nordhausen 1854 and 1856.

LORENZ. Strat. d. *Ægagr.* = Die Stratonomie von *Ægagropila Sauteri* von J. R. LORENZ. Aus dem X B:de der Denkschriften der Matem.-Naturw. Classe der K. Akademie der Wissenschaften. Wien 1856.

v. MART. Die Tange = Die Preussische Expedition nach Ost-Asien. Botanischer Theil. Die Tange. Bearbeitet von G. v. MARTENS. Berlin 1866.

MOHL. Verm. d. Pflanzenz. = Ueber die Vermehrung der Pflanzenzellen durch Theilung. In Vermischte Schriften botanischen Inhalts. Von H. v. MOHL. Tübingen 1844.

MONT. Crypt. Guyan. = Cryptogamia Guyanensis. Auctore C. MONTAGNE. In Annales des Sciences Naturelles. III Série. Botanique. Tome XIV. Paris 1850.

» Syll. = Sylloge generum specierumque Cryptogamarum. Auct. J. F. C. MONTAGNE. Parisiis 1856.

NÄGELI. Neu. Algensyst. = Die neuern Algensysteme und Versuch zur Begründung eines eigenen Systems der Algen und Florideen von C. NÄGELI. Neuenburg 1847.

PRINGSH. Beitr. z. Morph. d. Alg. = Beiträge zur Morphologie und Systematik der Algen. In Jahrbücher für wissenschaftliche Botanik, herausgegeben von N. PRINGSHEIM. Band. I. Berlin 1858.

ROTH. Catal. Bot. = Catalecta Botanica. Auct. A. G. ROTH. Fasciculus III. Lipsiæ 1806.

SACHS. Lehrb. d. Bot. = Lehrbuch der Botanik von J. SACHS. Vierte umgearbeitete Auflage. Leipzig 1874.

SUR. Alg. Jap. = Algæ Japonicæ Musei Botanici Lugduno-Batavi. Auct. W. F. R. SURINGAR. Harlemi 1870.

WALZ. Beitr. z. Morph. d. *Vauch.* = Beitrag zur Morphologie und Systematik der Gattung *Vaucheria D. C.* von JACOB WALZ. In Jahrbücher für wissenschaftliche Botanik herausgegeben von N. PRINGSHEIM. Band. 5. Berlin 1867.

WITTR. & NORDST. Alg. Exsicc. = Algæ aquæ dulcis exsiccatæ præcipuæ scandinavicæ, quas adjectis algis marinis chlorophyllaceis et phycochromaceis distribuerunt VEIT WITTROCK et OTTO NORDSTEDT. Fasciculus I (n:ris 1—50). Upsaliæ 1877.

WITTR. Prodr. Monog. Oedog. = Prodromus Monographiæ *Oedogoniearum.* Auct. V. B. WITTROCK. In Acta Reg. Societatis Scientiarum Upsaliensis. Ser. III. Vol. 9. Upsaliæ 1874.

» Utveckl. af *Vauch.* = Algologiska Studier. II. Om utvecklingen af *Vaucheria geminata* Walz. Af V. B. WITTROCK. Upsala 1867.

CORRECTIONS.

Page	6,	line	18	from	below,	for	simple	read	single.
»	»	»	13	»	»	»	3	»	13
»	»	»	8	»	»	»	2	»	1
»	»	»	3	»	»	»	2	»	1
»	11	»	8	»	»	»	12	»	13
»	14	»	4	»	»	»	2	»	1
»	22	»	1	»	above,	»	4	»	1
»	27	»	13	»	below,	»	*ac*	»	*ac'*
»	29	»	4	»	»	»	11	»	10
»	55	»	4	»	»	»	5	»	4

EXPLANATION OF THE PLATES.

The following letters apply to all the figures.

ac, accessorial branch.
b, b^1, b^2, b^3, b^4, normal branches of different degrees.
bs, bs^2, bs^3, subsporal branches, i. e. branches brought forth by subsporal cells.
bsp, branch developed from the side of a spore which remains attached to the mother specimen.
c, inclosed vegetative cell.
ct, terminal vegetative cell.
h, helicoïd.
p, prolific cell.
rh, rhizoïd part of the thallus.
s, inclosed cask-shaped spore.
s, the elder one of a pair of twin spores.
s', the younger one of a pair of twin spores.
s^1, the oldest one in a group of triple spores.
s^2, the middle one in a group of triple spores.
s^3, the youngest one in a group of triple spores.
sb, basal spore.
sc, inclosed cylindric spore.
sf, branch in which the act of spore-formation is taking place.
sg, the oldest part of the specimen, i. e. the part which has belonged to its mother spore.
sgb, basal spore formed by the lowest cell of the cauloïd, within the same cell-membrane as the mother spore of the specimen.
si, spore of an irregular shape.
sp, sp', spore which supports a branch.
sr, a spore furnished with a rudimentary branch process.
ss, sessile spore.
st, a terminal cask-shaped spore with a tapering top.
stc, terminal subconical spore.
w, w', w'', transversal cellwall.

PLATE I.

The figures are magnified 25 times, with the exception of fig. 8, which is magnified 20 times, and fig. 10, 50 times.

Figs 1 to 3. **Pithophora sumatrana** (v. Mart.) nob.

Fig. 1. A piece of the principal filament of the cauloïd with two short branches; the lower branch formed by only one sessile terminal spore, *st*.

Fig. 2. A piece of a branch of the 1:st degree with two inclosed cylindrical spores; in the uppermost cell a third spore is in the act of being formed.
» 3. A piece of the principal filament with an inclosed, cylindrically cask-shaped spore.

Figs 4 to 7. **P. æqualis** nob.

Fig. 4. A piece of the cauloïd, viz. a short bit of the principal filament with a very short accessorial branch, *ac*, and a long normal fertile branch of the 1:st degree, carrying a branch of the 2:d degree, b^2.
» 5. A complete and fertile specimen, quite devoid of branches, with a rudimentary rhizoïd, *rh*.
» 6. The lower part of a sterile specimen. At *sg?* the mother spore of the specimen has probably been situated; and if this be the case the specimen would be quite devoid of a rhizoïd.
» 7. The uppermost part of a big sterile specimen with the branches almost unilateral.

P. kewensis. nob.

Fig. 8. A complete, though rather small, sterile specimen with a rudimentary rhizoïd, *rh*. The top cell of the principal filament is unusually short and, against the rule, supports a branch.

Figs. 9 to 12. **P. Zelleri** (v. Mart.) nob.

Fig. 9. A piece of a fertile cauloïd. The subsporal cells have, instead of (as usual in this species) forming another spore below the one first formed, sent forth each a subsporal branch, *bs*. Another branch of the first degree incloses a pair of twin spores, *s'*, *s''*.
» 10. A piece of the principal filament of a fertile cauloïd. The lower spore, *s''*, in the upper pair of twin spores has, against the rule, formed a perfectly individual cell-wall. The upper spore in the lower pair of twin spores has germinated, like a prolific cell, while still attached to the mother specimen. Compare pl. 6, fig. 6.
» 11. The uppermost part of the principal filament of a fertile cauloïd. All its cells have formed twin spores *s'*, *s''*.
» 12. The lower part of a sterile specimen. The cell marked *rh* probably belongs to the rhizoïd, and the one marked *ac* is probably an accessorial basal (rhizine) branch.

Figs. 13 to 17. **P. polymorpha** nob.

Fig. 13. The middle part of the cauloïd of a richly ramified fertile specimen.
» 14. The top of a branch of the 1:st degree.
» 15. A piece of a cauloïd. The principal filament carries two abnormal branches, in which the cells marked *p*, *p'* are probably prolific cells.
» 16. A piece of a cauloïd with twin spores, *s'*, *s''*, in branches of the 1:st degree as well as in the principal filament.
» 17. The uppermost part of the cauloïd in a somewhat deviating, fertile specimen. Observe an inclination to ramify in the top cell of the principal filament as well as in a terminal cell of a branch.

Figs. 18 to 20. **P. Roettleri** (Roth) nob.

Fig. 18. The lower half of a fertile specimen, without any normal rhizoïd, but with a lateral branch from the mother spore of the plant. A branch carries a helicoïd, *h*.

» 19. A piece of a branch of the 1:st degree with an inclosed pair of twin spores s' s''.

» 20. The top of a branch of the 1:st degree with a terminal pair of twin spores.

PLATE II.

The figures are magnified 20 times, with the exception of figs. 10 to 12, which are magnified 50 times.

Figs. 1 to 12. **Pithophora kewensis** nob.

Fig. 1. An almost complete specimen with a rhizoïd consisting of one cell and a fertile cauloïd with long branches.

» 2. Two connected prolific cells, *p* and *p'*, which have developed a specimen each. Of the one developed from *p* only the lower part is visible. Of the one developed from *p'* the whole is visible.

» 3. Two connected prolific cells, *p* and *p'*, which have developed one specimen each laterally. The one developed from *p* is richly ramified, but the one from *p'* is unbranched. The prolific cell *p* has also developed, apically, a cell which has afterwards formed a spore, *st*, in its top.

» 4. The middle part of a fertile cauloïd with numerous but scantily developed branches.

» 5. Complete specimen with a rhizoïd of one cell, *rh*, and an almost unbranched, fertile cauloïd. The specimen very plainly shows the basipetal direction, in which the formation of spores regularly takes place.

» 6. Complete specimen with a rhizoïd of one cell, *rh*, and a cauloïd of which the lower part is sterile and the upper fertile.

» 7. Complete specimen with an unusually long rhizoïd of one cell, *rh*, and a cauloïd of which the lower part is fertile and the upper sterile. The lowest subsporal cell of the cauloïd has sent forth a subsporal branch, *bs*. The specimen has been broken off at X. From the uppermost cell left, the abnormally short topcell, *ct*, of the principal filament has afterwards been developed. (This specimen and the one represented fig. 6 belong to the so-called half-fertile-half-sterile).

» 8. Uppermost part of the principal filament in a sterile specimen. The cell-contents are not represented.

» 9. A piece of a sterile specimen, with an accessorial basal (rhizine) branch, *ac*, in the act of being formed.

» 10. A piece of a sterile specimen, of which the cells have partly been attacked by parasitical protozoa. The protoplasm in the middle of the cell of the principal filament is consumed by the parasites, but the protoplasm left in each of the two ends of the cell has individualized itself to an indepedent cell, after having limited itself towards the space occupied by the parasites by a new transversal cell-wall. The protoplasm in the uppermost part of the branch-cell has proceeded in the same manner.

Fig. 11. Piece of a sterile specimen broken off at the lower end. The lowest cell left is forming a rhizoïd-resembling cell, *rl*, in its lower end.

» 12. The same as in the preceding figure, but the rhizoïd-like cell, *rl*, is here fullgrown.

Figs. 13 to 15. **P. Cleveana** nob.

Fig. 13. A fertile specimen, rather small, but complete. No rhizoïd exists. In its place the lowest cell of the cauloïd has formed a new basal spore within the membrane of the old mother spore, *sgb*.

» 14. A piece of the cauloïd of a fertile specimen. In the principal filament several inclosed pairs of twin spores *s'*, *s''* are found.

» 15. A piece of the cauloïd in a fertile specimen. In the principal filament a group of triple spores, s^1, s^2, s^3, are found; in each of the branches a terminal pair of twin spores, *s'*, *s''*, exists.

PLATE III.

All the figures are magnified 200 times.

Pithophora kewensis nob.

Fig. 1. Two cells of the principal filament of a sterile specimen. The lower, *p*, is a prolific cell. In the upper, the formation of a branch has just begun.

» 2. A cell from a sterile specimen, which cell is in the act of forming a branch. The branch-process has just attained the size which it is to attain before the formation of the parting wall between the branch cell that is to be and the older part of the mother cell is commenced at the base of the process. The contents of the cell are not represented.

» 3. Part of a cell belonging to the rhizoïd of a sterile specimen. The granules of chlorophyll are arranged so as to form a net.

» 4. A cell, in which the formation of the spore has begun by its upper part having been somewhat enlarged. The contents of the cell, which are not represented, have not yet begun to pass towards the upper part of the cell.

» 5. An inclosed cell which is forming a branch and in its top a spore, *st*. When the terminal spore that is to be, *st*, is almost filled with chlorophyll, a parting wall will first be formed at the base, *ba'*, of the branch cell that is to be, and after this, when all the chlorophyll in the lowest part of the branch cell has passed into the spore, a new parting wall will be formed at the base, *ba''*, of the spore that is to be. All this being done, the chlorophyll left in the original mother cell is used for the formation of a spore in the upper part of the mother cell.

» 6. A spore-forming cell, where the body of chlorophyll is passing into the spore that is to be, *s*.

» 7. An inclosed cell, *cp* (of the principal filament), which has formed first a branch cell, *b*, and in its top a terminal spore, *st*, and is now in the very act of forming in its own upper end an inclosed spore, *s*.

» 8. A piece of the principal filament with a group of seeming triple spores. A lower mother cell, situated below the oblique parting-wall, *w*, has formed in its upper end first the great spore marked *s'* and after that the small spore marked *s''*, which are consequently a pair of twin spores. At the same time another mother cell, situated above the parting-wall, *w*, has formed in its lower end the spore marked *sb*, which, consequently, has not the same mother cell as the two others. The parting walls *w'* and *w''* have been arrested in their development, and remain incomplete.

» 9. An inclosed spore, ripe. Observe the thickness of the spore membrane when compared to that of the vegetative cells situated beside it.

PLATE IV.

The figures are magnified 50 times, with the exception of fig. 1, which is magnified 25 times, and figs. 7 and 8, 20 times.

Pithophora sumatrana (v. Mart.) nob.

Fig. 1. The lowest part of the thallus of a sterile specimen, with a rhizoïd consisting of one cell, *rh*.

Figs. 2 to 11. **P. kewensis** nob.

Fig. 2. The lowest part of a fertile specimen with a rudimentary, extremely small rhizoïd, *rh*.

» 3. The lower part of a fertile specimen with a rudimentary rhizoïd, *rh*. Although no parting wall exists between the rhizoïd and the cauloïd of the specimen, still an opening in the layer of chlorophyll of the basal cell indicates the limit between those two parts. The spores *sb* and *s* are only seeming twin spores, because they are formed by different mother cells, *sb* being a basal spore of an upper cell, and *s* an apical spore of a lower cell.

» 4. The lowest part of a sterile specimen with a rhizoïd, *rh*, of one cell and of normal size.

» 5. The lowest part of a sterile specimen with a very long rhizoïd of one cell.

» 6. The lowest part of a fertile specimen with a rhizoïd of six cells.

» 7. The lowest part of a fertile specimen with a rhizoïd of twelve cells and with an accessorial (rhizine) branch, *ac*, proceeding from the mother spore, *sg*, of the plant. The uppermost among the cells of the rhizoïd shows at *b* a tendency to ramify.

» 8. The lowest part of a fertile specimen with a ramified rhizoïd, *rh*.

» 9. The lowest part of a fertile specimen with a sporiferous rhizoïd of two cells, and with a rudiment of an accessorial branch, *ac*, at the lower end of the basal cell of the cauloïd.

» 10. The lowest part of a fertile specimen with a sporiferous rhizoïd, *rh*, of four cells and with an accessorial branch, *ac*, carrying spores and proceeding from the side of the mother spore, *sg*, of the plant.

» 11. The lowest part of a fertile specimen with a sporiferous rhizoïd of six cells.

Figs. 12 to 18. **P. Cleveana** nob.

Fig. 12. The lowest part of a fertile specimen without a rhizoïd, but with a basal spore, *sgb*, in the lowest cell of the cauloïd.

Fig. 13. The lower part of a fertile specimen with a rudimentary and very small rhizoïd, *rh*.

» 14. The lowest part of a fertile specimen with a rudimentary rhizoïd, *rh*, divided from the cauloïd by an incomplete parting-wall, *w*. The lowest cell of the cauloïd has formed a basal spore, *sgb*, which does also comprise the rudimentary rhizoïd.

» 15. The lowest part of a fertile specimen with a very short rhizoïd of one cell, *rh*. The lowest cell of the cauloïd has formed two spores, one apical, *s*, and one basal, *sgb*.

» 16. The lower part of a small fertile specimen with a rhizoïd of one cell and of normal size. The top cell in the principal filament of the cauloïd has formed first two branches, *b*, and then a terminal spore, *st*.

» 17. The lowest part of a fertile specimen with a rather long rhizoïd of one cell, *rh*.

» 18. The lower part of a fertile specimen with a sporiferous rhizoïd of several cells. The cauloïd incloses among other things a prolific cell, *p*.

P. polymorpha nob.

Fig. 19. The lower part of a fertile specimen with a sporiferous rhizoïd of several cells, *rh*.

PLATE V.

All the figures are magnified 50 times.

Figs. 1 to 8. **Pithophora Cleveana** nob.

Fig. 1. The lower part of a sterile specimen with an irregularly developed basal part. The mother spore of the specimen has probably comprised the round body, marked *sg*, and sent forth the three filaments of the rhizoïd, *rh*, downwards. *h* and *h'* are two unbranched helicoïds. *h* forms the top of an accessorial branch which is, against the rule, directed upwards. The case is the same with the accessorial branch marked *ac'*.

» 2. The lower part of a fertile specimen with an irregularly developed basal part. *sg* is probably the mother spore of the specimen, with two rhizoïd appendices, *rh*. *p* is a prolific cell and *h* a helicoïd. *ac* are accessorial branches placed in a not very common manner.

» 3. The lowest part of a fertile specimen without a rhizoïd. The basal cell of the cauloïd carries a helicoïd, *h*, pointing downwards.

» 4. A piece of the cauloïd of a fertile specimen. The upper branch carries a bifurcated helicoïd, *h*.

» 5. The top of a fertile branch with a trifurcated helicoïd, *h*.

» 6. The lower part of a fertile specimen with a rudimentary rhizoïd, *rh*, and with a basal spore, *sgb*, and with a handlike three-fingered helicoïd, *h*.

» 7. The top of a fertile branch with a handlike helicoïd, *h*.

» 8. The top of a fertile branch with a terminal irregularly formed spore, *hs*, which has probably originated in the transformation of a helicoïd.

Figs. 9 and 10. **P. kewensis** nob.

Fig. 9. A branch carrying a helicoïd, *h*, from a sterile specimen.
» 10. The top cell of the principal filament of a sterile specimen transformed to a helicoïd, *h*.

Figs. 11 and 12. **P. Roettleri** (Roth) nob.

Fig. 11. A branch from a fertile specimen, carrying a helicoïd, *h*, which grasps a vegetative cell belonging to another specimen of a *Pithophora*.
» 12. The top of a branch of a fertile specimen with a lateral helicoïd, *h*.

PLATE VI.

The figures are magnified 20 times, with the exception of fig. 6 which is magnified 50 times.

Pithophora oedogonia (Mont.) nob.

Fig. 1. The lowest part of a sterile specimen with a unicellular rhizoïd, *rh*, and cauloïd branches placed opposite to each other.
» 2. The lowest part of a fertile specimen with a pluricellular rhizoïd, *rh*. A parting-wall between the cauloïd and rhizoïd part has not been formed in the germination of the mother spore, *sg*.
» 3. The lower part of a fertile specimen with a very powerfully developed, sporiferous rhizoïd, *rh*, carrying branches of as much as two degrees. The upper one of the twin spores, *s'*, in the cauloïd has germinated in the same manner as the spores in fig. 6; compare the explanation of this figure.
» 4. The lower part of the cauloïd of a fertile specimen with a peculiarly rich system of ramification, even embracing a branch of the 4:th degree, b^4. Numerous subsporal branches, bs^2, bs^3, as well as also basal accessorial branches (= rhizine branches), *ac*, occur. The spore, *s*, in the principal filament has germinated in the same manner as the spores in fig. 6. Twin spores, *s'*, *s''*, occur in several places.
» 5. Part of the cauloïd in a fertile specimen. Subsporal branches, *bs*, occur, even placed opposite to each other. The subsporal cells are unusually short.
» 6. Uppermost part of the cauloïd of a fertile specimen. The spores, the inclosed, *s*, as well as the terminal one, *st*, have germinated while still attached to the mother specimen; and not in the normal manner with spores, but in the manner of prolific cells.

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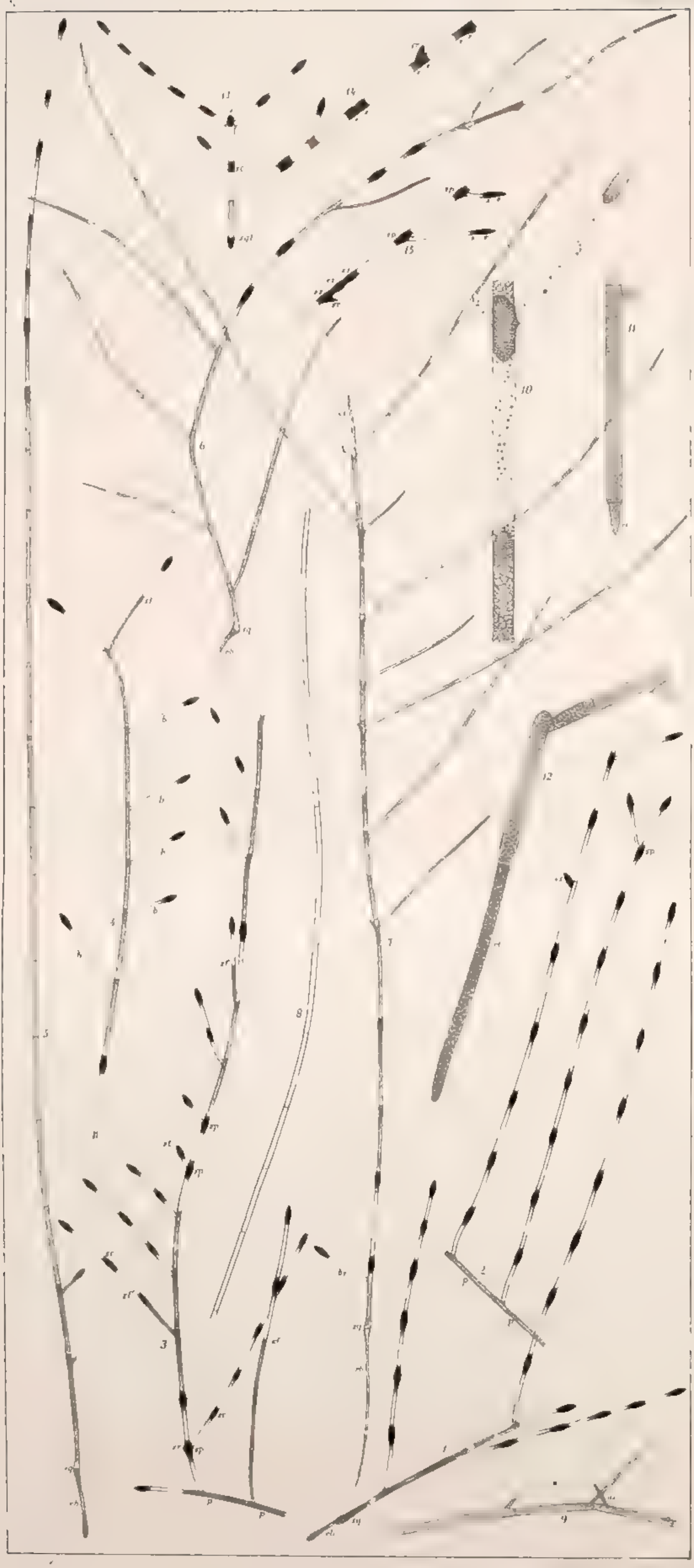
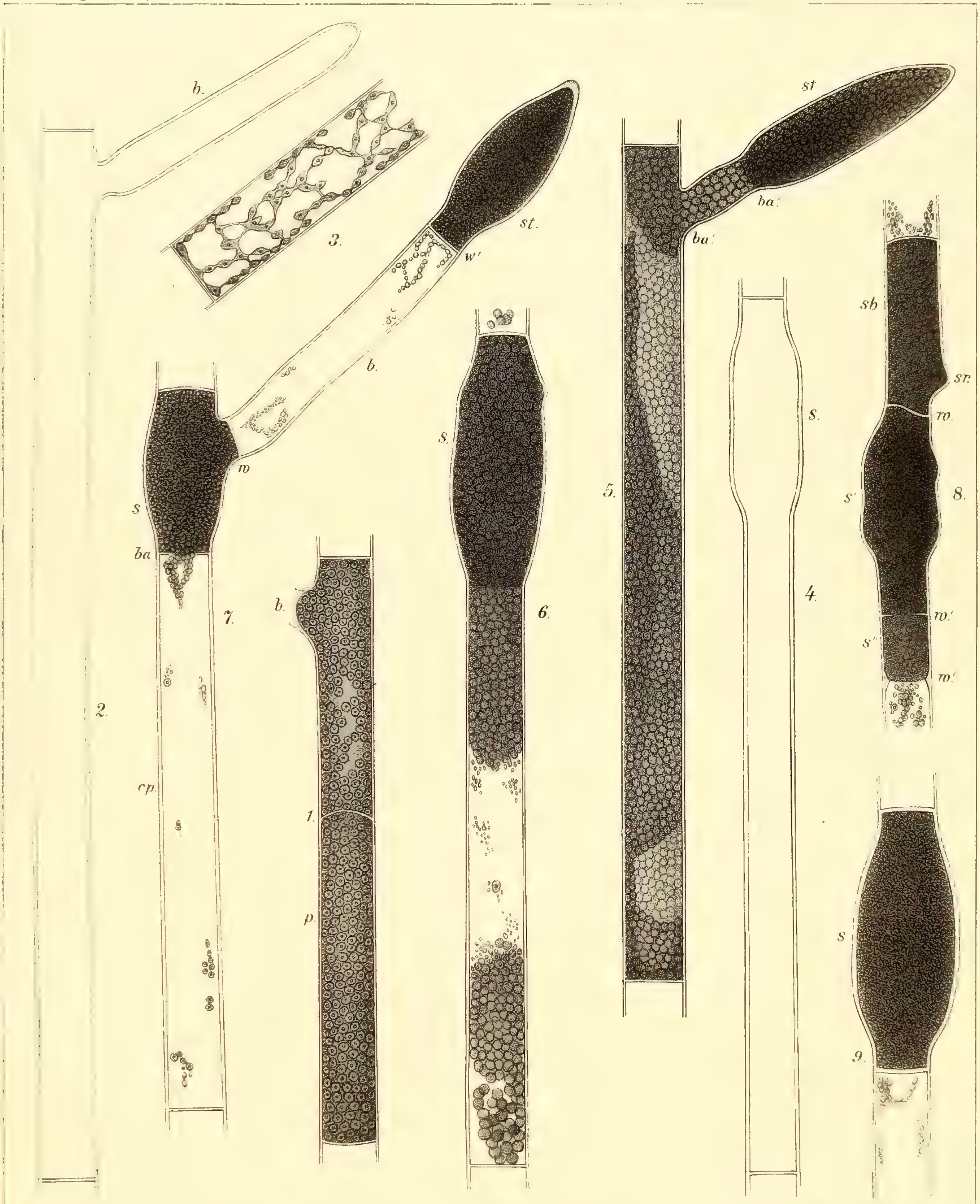


1-12 Pithophora kewensis 13-15 P Cleveana



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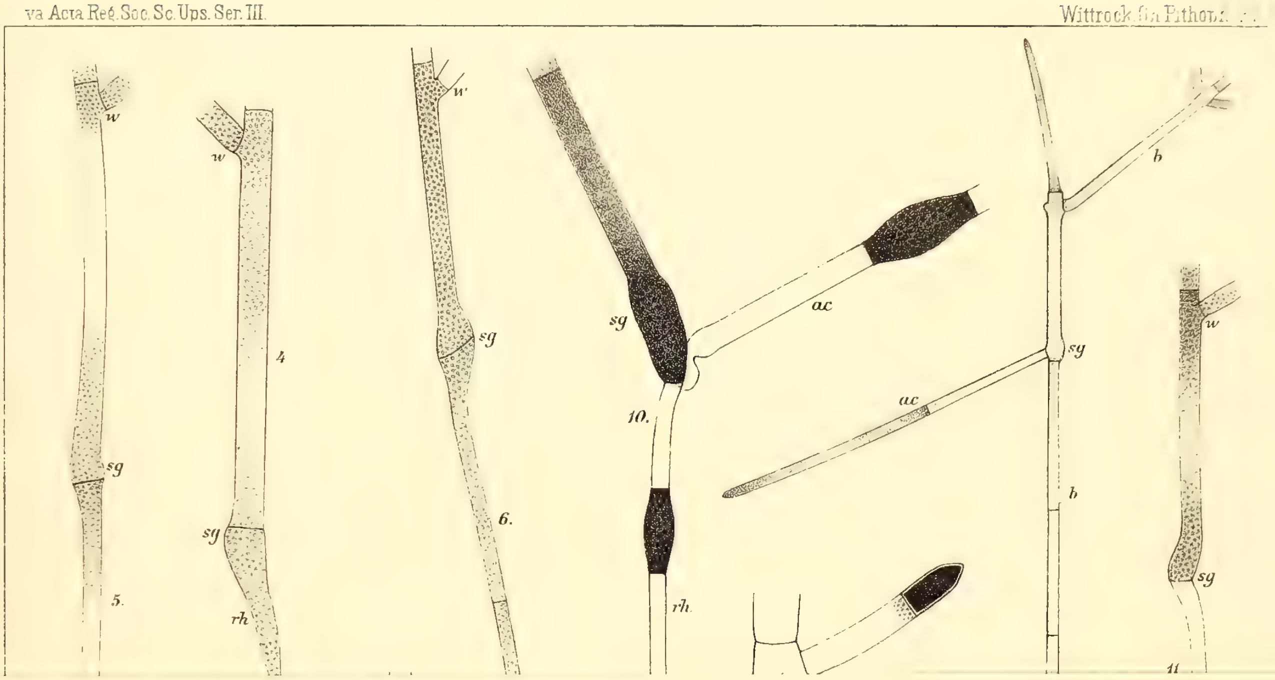
Pithophora kewensis.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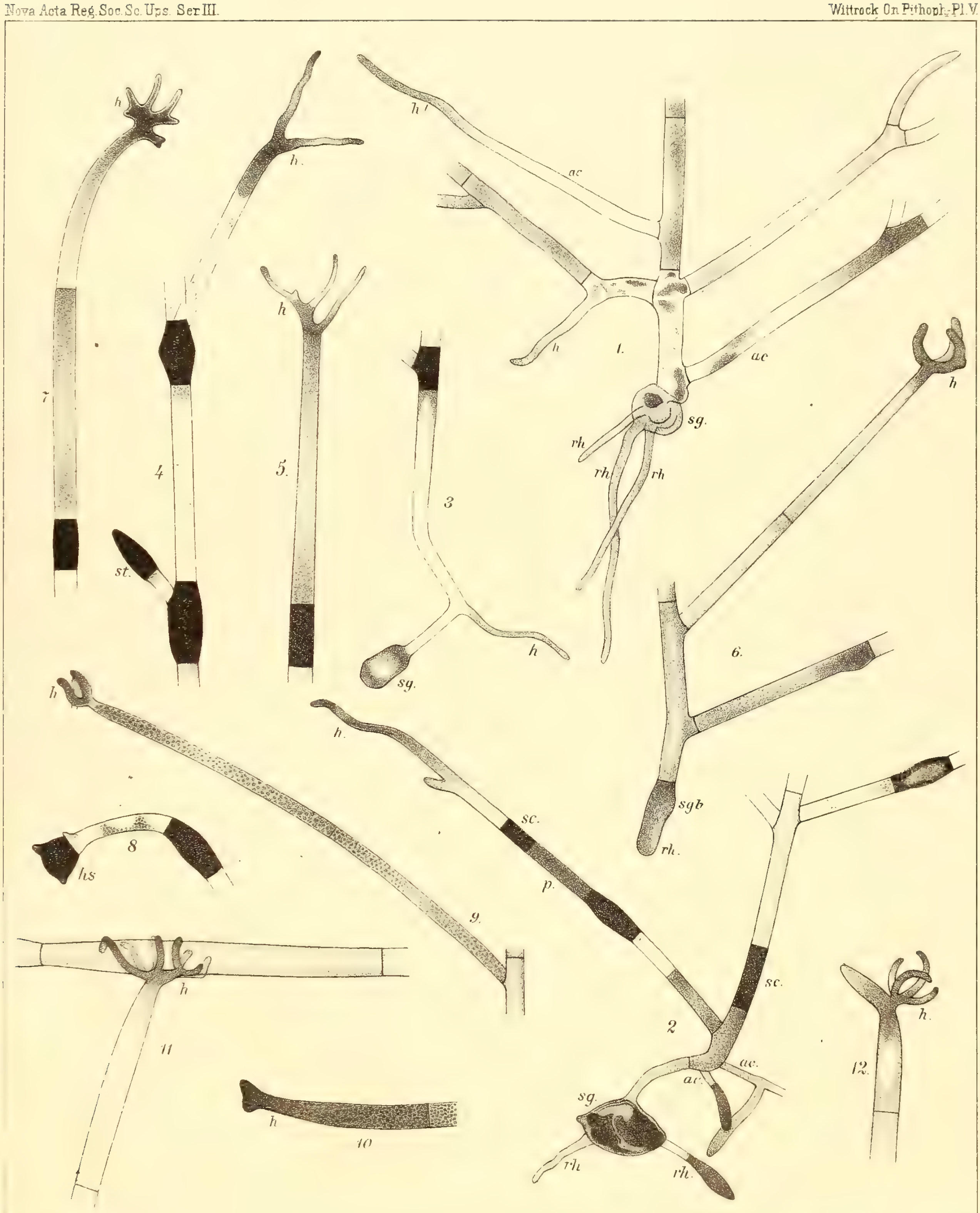
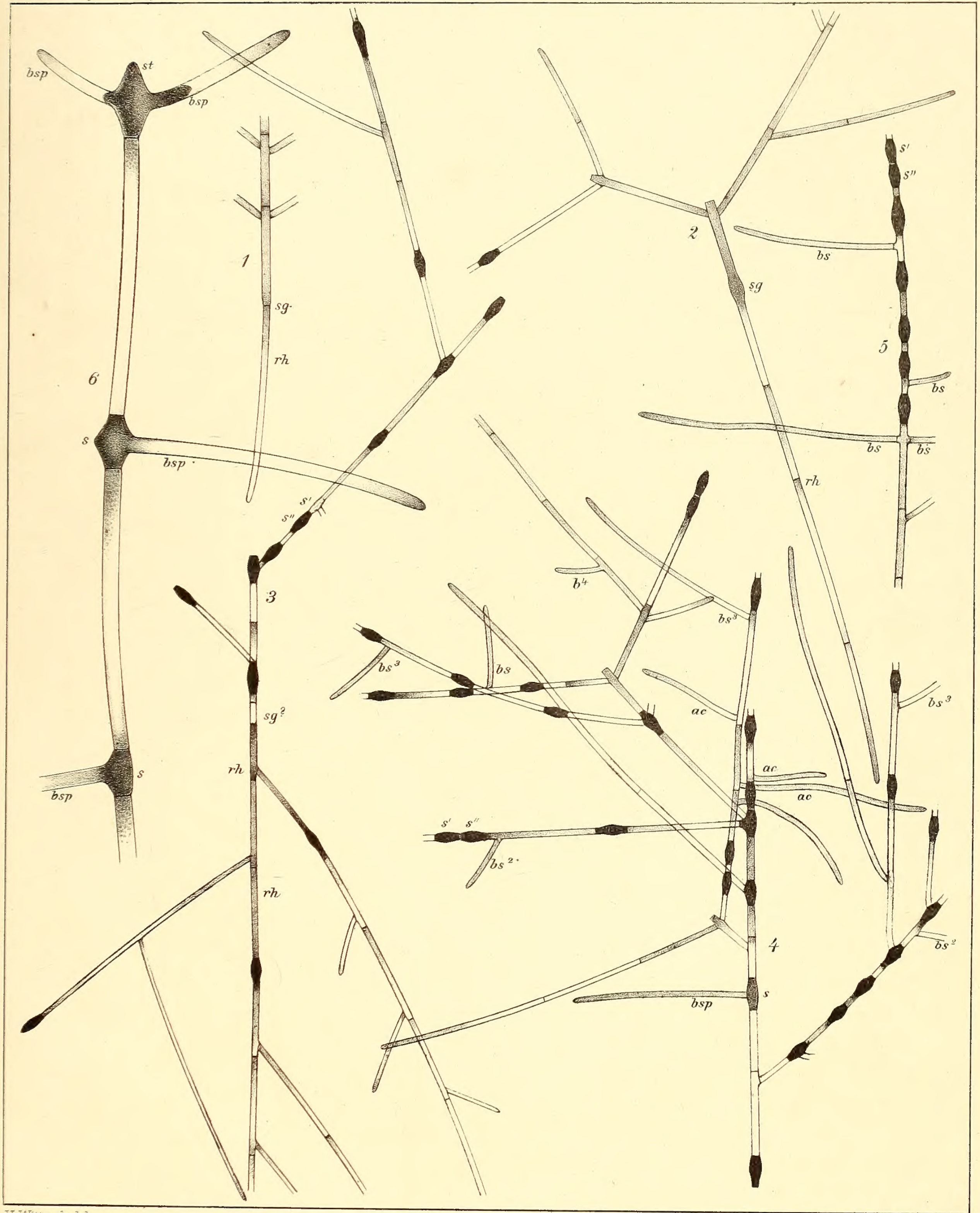
1. Pithophora sumatrana 2-11 P. kewensis. 12-18 P. Cleveana 19 P. polymorpha



1-8 Pithophora Cleveana. 9,10 P. kewensis. 11,12 P. Roettleri.



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Pithophora oedogonia.