

2nd Ser. BOTANY.]

[VOL. V. PART 1.]

THE
TRANSACTIONS
OF
THE LINNEAN SOCIETY OF LONDON.

MONOGRAPH OF THE ACETABULARIÆ.

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LONDON:

PRINTED FOR THE LINNEAN SOCIETY

BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON-HOUSE, PICCADILLY, W.,

AND BY LONGMANS, GREEN, AND CO., PATERNOSTER-ROW.

June 1895.

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I. *Monograph of the Acetabulariæ.* By HERMANN, Graf zu SOLMS-LAUBACH,
*Professor of Botany, University of Strassburg, Foreign Member of the Linnean
Society.*

(Plates I.-IV.)

Read 19th April, 1894.

THANKS to the work of Nägeli, Woronin, de Bary, and Strasburger, the structure and development of the European species of *Acetabularia* are tolerably well known, and about no other type of Dasycladeæ does there exist so rich a literature. Woronin and de Toni have sufficiently treated of the older literature occupying a standpoint which we may now consider left behind us. Leitgeb has minutely investigated the rich inuline contents of the plant; the same author has made the cell-membrane and its incrustation the subject of a critical treatise; and the other forms of Dasycladeæ have recently been repeatedly studied by Agardh, Cramer, and myself. However, a comparative examination of the genus *Acetabularia* and its nearest allies from the systematic point of view has always remained a desideratum, though serviceable preliminary treatment of it has been furnished by Kützing, Harvey, Agardh, and Cramer. Since the systematic study of *Acetabularia* provides a foundation for palæophytological work I have been the more attracted to it, and will submit the results of my examination into this side of the subject in the following pages. If I have attained anything having a claim to general interest I must attribute it first of all to the great liberality and kindness with which valuable material has been made accessible to me. I have been able to examine the *Acetabulariæ* of the British Museum, of the Kew Herbarium, of the Herbarium of Thuret, of the Berlin, Göttingen and Strassburg

Museums, and the original specimens of Beccari's collection at Florence. Single species were sent to me by Professor Perceval Wright, Professor Agardh, Dr. Schenck, and Professor Farlow, and I wish to express my indebtedness and thanks to all who have thus aided me.

Of living *Acetabulariæ* there have been described three genera: viz., *Acetabularia*, Lam., *Polyphysa*, Lam., and *Halicoryne*, Harv., with which Sonder's genus *Pleiophysa* is identical. To these are to be added the fossil forms established by Munier-Chalmas and the genera placed here, *Acicularia*, d'Archiac, *Briardina* and *Orioporella*, Mun.-Chalm. Of the two latter genera (not yet fully described) *Briardina* comes very near to *Acicularia*, as I know from a kind private communication of its author; *Orioporella*, however, does not belong here at all, as he has recently convinced himself, and therefore needs no farther mention.

According to de Bary and Woronin's description the fertile pileate shoot of *Acetabularia mediterranea* consists of the stalk, with its foot grasping the substratum; of the basal portion, immersed in this; and of the cap, which is partitioned by regular radial walls into chambers, which are in open communication with each other only in the middle, above the insertion of the stalk. This central flat area, covered with a level circular membrane terminating the apex above the insertion of the stalk, may be called the central area. It is surrounded by a continuous, circular, convex cushion, which I shall call the *corona superior*, belonging to the chambered marginal portion of the disc. The *corona superior* is farther composed of numerous firmly united radial sections or areas, the rays of the corona. Each of these radial areas bears a radial row of circular protuberances, or scars, which correspond to tufts of hairs that have fallen off or have remained incompletely developed and one-celled. The number of these scars varies. Cramer gives them as 4 to 5, though higher numbers may well occur. Where the hairs are complete they belong to the outer parts of the row in question. On the under side of the cap there are present, according to de Bary and Cramer, two concentric cushions surrounding the insertion of the stalk. The outer, more peripheral of these corresponds exactly with that found on the upper surface and may be called the *corona inferior*. It also is composed of exactly as many radial areas as there are chambers in the margin of the cap, but the hair papillæ are wholly absent. The more central cushion, adjoining the stalk, is not sharply separate from the other, but gradually becomes merged in the central area. The peripheral one consists of what may be called the vestibules of the chambers of the cap, of which there is one for each chamber, but separated by a fold of the membrane like a transverse septum, which within shows only a small opening, frequently becoming obliterated by subsequent growth in thickness. While, therefore, each disc or sporangial ray stands in open communication with the relative sections of the *corona superior* and *inferior*, it is separated from its vestibule by the membrane described with a central perforation. The *corona inferior* and vestibules were first correctly described and figured by Cramer for *A. crenulata*.

We have, then, in the middle the central area, into which open the narrow vestibules, adjoining, but separated from each other by a thick membranous process. Next there is the peripheral crown of radial chambers, firmly united to each other

laterally, and separated from the corresponding vestibule by a wall perforated in the middle. Each one of these chambers consists of the basal portion, which bears a segment of the corona superior and inferior, and runs out between both in the direction of the radius into the sporangial ray. In *Acetabularia mediterranea* there is no sharp limit between basal portion and sporangial ray*, and both pass imperceptibly into each other with an open lumen. But we shall see that this varies in allied forms, as may be seen in the description of *A. Peniculus*. Characteristic of our species is the firm union of the radial chambers already described; it extends to all parts of them and reaches the outermost margin, so that this appears as exactly circular as if cut out. The upper corona is bounded on the outer side by a simple circular line; in the lower the single chambers bulge somewhat outwards, so as to give a wavy contour, which is added to by the unusual thickening of the sections of the membrane †.

In the ripe cap-bearing shoot the whole contents of the disc are used in the formation of the egg-shaped spores, the peculiar formation of the membrane of which was represented more correctly by de Bary and Strasburger than by Woronin. At one pole of the spore the circular lid, which resembles a cone-valve inserted into the membrane from within, is situated as in *Neomeris*; its contour lines on both sides in an optical section of the spore consequently converge a little outward. De Bary states correctly that the moderately thick spore-membrane shows stratification, and consists of an outer thicker layer and an inner thinner one of different capability of swelling up. He has established that both layers are formed of cellulose, easily rendered blue and completely soluble in SO_4H_2 , but that on the surface of the spore there is found a tender cuticle-like pellicle, which stains yellow with iodine and withstands sulphuric acid, but remains over after treatment of the spore with concentrated acid in the form of a crumpled sac, when the whole internal portion has been completely destroyed. There will be a farther opportunity, in describing the genera *Chalmasia* and *Halicoryne*, of returning to the very complicated and peculiar structure of the membrane of the spores of *Acetabulariææ*, since the spore-membranes of these genera are much better adapted to investigation than those of species of *Acetabularia* on account of their greater thickness.

Woronin had already observed this cuticle-like lamella, and he states that it is the first thin membrane which the primordial spore forms on its surface. The cellulose layers are consequently differentiated immediately afterwards as the second proper cell-membrane. This point, as well as the development generally, deserves fresh investigation, which ought to be carried out under conditions of time and place unfortunately impossible for me, since they involve the summer months. Nevertheless, I will now briefly indicate the points for such revision and the question concerning it, in order that other botanists, of Italy or the south of France, who always have access to the plants, may have their attention drawn to them. According to Woronin there appear in the

* The lumen of the latter is only somewhat narrowed towards the point of contact.

† Woronin's figures, in *Ann. Sc. Nat. sér. 4*, tome xvi. pl. 9, are, so far as they are concerned with the structure of the cap, somewhat diagrammatic, but in the main correct. His pl. 9. fig. 4 shows the central opening in the membrane dividing vestibule from ray as too wide, and this division itself as a simple fold of the common membrane. Compare the figure in this memoir, Plate I. figs. 7, 8.

homogeneous chlorophyll-bearing protoplasmic layer of the sporangial ray small, completely colourless, round spots, about which the protoplasm gathers as about attraction centres. De Bary, who cites these spots, says (9, p. 719) "each spot appears to be a centre of attraction for a portion of the protoplasm, and may therefore well correspond to a nucleus." This appears to me to rest on a misunderstanding of Woronin's statement. Since, as his drawings show, these clear spots remain continuously well defined up to the complete rounding off of the spores, they cannot well be in the centre, but must rather be towards the outside of the young spores (compare Woronin's figures, pl. 6. figs. 1-5); in figs. 4 and 5 there is at the periphery of the primordial spore a shallow excavation, and Woronin says expressly "en examinant plus attentivement la structure de ces corps elliptiques on voit qu'ils ne consistent qu'en un sac primordial, qui a à sa surface une petite cavité, ou, ce qui est même probable, une ouverture." There can scarcely remain any doubt that this cavity represents the profile view of the clear spot, the filling up of which with colourless protoplasm the author had not sufficiently taken into account, although he has drawn it in fig. 4 in the form of an outline running over the excavation. Should it indeed be so, then the point ought to be farther enquired into whether the clear spot contains a nucleus, or whether these are to be found in numbers distributed throughout the protoplasm, as *a priori* appears more probable. We know from Schmitz's investigations that in the chambers of the disc of sterile plants of *Acetabularia* there are present, together with numerous small chlorophyll bodies, a large number of very small nuclei, which are much smaller than the chlorophyll grains among which they are irregularly distributed. He then continues:—"In the formation of the spores and zoospores there have been repeatedly observed, as is known, clear spots which doubtless represent nuclei. Their size, however, is far more considerable than that of the very small nuclei in the cap of the sterile plant, and their number much less. There must take place before spore-formation various processes in connection with the nuclei of these plants, perhaps conjugations like those recently described by Berthold for *Derbesia*." He takes accordingly precisely the position of de Bary in his interpretation of the clear spots.

I believe I have seen these minute nuclei in the protoplasm of the stalks of preserved material of *A. mediterranea*, and would even assume that they are to be found in the layer next the wall of the spores among the amyllum granules; but I certainly cannot express myself on this point with complete definiteness because I could not, among the many difficulties presented by this plant, succeed in obtaining an undoubted nuclear stain with any staining agent.

While I must thus leave the whole question of the nucleus and its elucidation to future observers, I should like to call attention to the possibility of explaining the whole body of facts in the following way. The peripheral clear spot of Woronin's figures recalls in a striking manner the colourless protoplasmic portion which bears the cilia of an ordinary Confervaceous zoospore. If one now assumes that there is here a true homology, then the cap would correspond to a true zoosporangium of which the zoospores no longer develop cilia and do not escape, but rather surround themselves with a membrane at the place of origin, and enter at once into a resting stage, as indeed happens elsewhere

among Algæ, *e. g.* in the formation of the *polyhedra* of *Hydrodictyon*. After a lengthened rest these spores then give rise to the sexual generation of gametes described by Strasburger*.

The formation of resting spores would then be merely shunted to another point of the life-history. We know from de Bary, moreover—and the same takes place in *Dasycladus* according to my observations—that the zygote, after coming to rest, immediately grows out in the form of a cylindrical tube. De Bary could not obtain the normal development of this in his cultures of *Acetabularia*, but he was able to establish, from specimens collected in the open, that it first forms a basal vesicle as a store for reserve-material, that it then becomes strengthened by repeated diaphysis from this part which remains after the dying of the upper part, and grows into a small plant provided with several whorls of branched hairs. After an uncertain number of diaphyses, the apex of the stalk invested with whorls of hairs arrives at the formation of a cap, which closes the development of the plant with the formation of spores. One finds clearly marked on the stalk of each fruiting specimen, below the terminal cap and at some distance apart, especially after decalcifying it, several whorls of circular scars where the tufts of branched hairs, now fallen off, were formerly situated.

As regards the development of the complicated structure of the cap there are few observations before us, and these incomplete. However, even so, they show that the marginal chambers of the cap do not arise as so many separate projections like the hairs of a whorl and subsequently unite, but that the whole margin of the cap first makes its appearance in the form of a continuous cushion below the arched apex of the shoot. With its first formation there coincides that of the chambers and the closing of them towards the vestibules, so that, as I have seen in my spirit-material, they are completely developed when the cap is still in a young state. I have represented in Plate I., figs. 4, 8, 12, such young stages of the cap in lateral view from the outside and in section. From the outside it appears like a flat, projecting, arched band, bordered above and below by a sharp circular furrow dividing the sectional views of the walls of the chambers by numerous perpendicular lines into almost rectangular areas adjoining each other. Each of these partition-walls corresponds at the stalk end of the band to a line running gradually downward—the projection of the inward fold of the membrane separating off the vestibules. The longitudinal section (Plate I. fig. 8) shows that these vestibules are completely formed, and that the folds separating them at the inner margin are frequently strengthened and irregularly thickened. From the central area the margin of the cap appears to be completely separated by the partition, a simple fold of the membrane perforated in the middle. On the other hand, all the differentiations of the wall of the cap are still absent, the outer limit of the chamber seen in section is simply convex, or shows at most a slight depression in the highly arched central portion, where the membrane also shows itself weaker. The whole cap-chamber is completely filled with dense protoplasm without vacuoles. The shallow cavity becomes more pronounced with farther growth,

* They would represent the rudimentary sexual generation of the plant and be partly male and partly female, as is expressly stated by Strasburger. With reference to such a view I am in complete agreement with Falkenberg [II, p. 270].

so that the chamber is eventually bilobed (Plate I. fig. 4). The upper of the two lobes is the corona superior, from which the young hairs at once begin to grow; the lower gives origin to the corona inferior, at the upper margin of which the sporangial ray springs from the basal portion. And since all these processes of development go on in exactly the same fashion in the neighbouring chambers they remain in close connection and form themselves into the marginal region of the disc.

Harvey has given beautiful representations of the habit of the delicate *Acetabularia* (§ *Polyphysa*) *Peniculus*. The long calcified stalk, provided with a foot at the base and bearing a cap at the apex, is furnished at intervals with small nodular swellings, each of which bears a crown of circular scars, the points of insertion of a whorl of hairs. Cramer found these still *in situ* on certain specimens, and I also have seen them. But the disc consists of a variable, relatively small number of rays, which are quite free from each other and attached at the base to a small lateral projection of the central portion. Each such ray corresponds to a chamber of the margin of the disc of *Acetabularia mediterranea*, and adjoins, as in that case, a vestibule which forms a fold-like bend of the central portion—*i. e.* the projection described. On the ray the same parts are to be distinguished, but the differentiation of basal portion and sporangial ray is here much sharper. The latter has the form of an ovate-clavate, bladder-like swollen sac, with a rounded margin, and is connected with the almost cylindrical basal portion by its much narrowed base closed by a transverse wall. On the upper surface it bears a process somewhat broadened at its blunt apex and completely free all round, its particular part of the corona superior which shows on its apical surface 2 or 3 large broad scars of hair-tufts. These Cramer [5] at first overlooked, but subsequently [6] described on the whole accurately. When three scars are present they form a triangle with the base turned outwards, and when there are only two they stand obliquely behind each other, not straight as Cramer has said. A true corona inferior is wholly wanting, unless one follows Cramer in regarding as one the slight arching-out of the basal portion beneath. The calcification of the membranes is to some extent perceptible in the stalk only and is not present in the rays of the cap, or if so only as a very slight surface incrustation covering it all equally. The spores are of regular globular form, and otherwise on the whole similar in their structure to those of *Acetabularia mediterranea* (conf. Plate II. figs. 6 & 7).

Of the genus *Polyphysa*, thus distinguished by its wholly free rays of the cap and its globular spores, for a long time only two species were known, both from Australia, viz.:—*P. aspergilloso*, Lamour., and *P. Cliftoni*, Harv. An examination of Harvey's original specimen of the latter, which I was enabled to make by the kindness of Prof. Perceval Wright, resulted in the view that at the most this form may be regarded as a variety of the other with somewhat longer, more blunt, more clavate, and less swollen sporangial rays, but in all other points in exact agreement. Besides, in examining numerous specimens of *Acetabularia Peniculus*, caps are sometimes found which show an approach to the Harveian form. The sporangial rays of the original are entirely without lime, and filled with collapsed spores (from this cause polygonal in form), to which the thin sunken sporangial membrane has become so closely pressed that it appears crumpled. The same thing is to be seen in herbarium specimens of the normal form which have been very slightly calcified.

There are described in this paper several species which, from their characters, approach *Acetabularia Peniculus*, although sufficiently distinct from it. They want, however, so far as I could observe, the transverse wall between the basal portion and the sporangial rays, and they differ farther in the form of the latter, which, for example, in my *Acetabularia exigua* (Plate II. figs. 1 & 4) are somewhat cucumber-shaped and concave above, and in the number and arrangement of the hairs on the parts of the corona superior. Moreover, many of them, i. e. g. *A. parvula*, n. sp. (Plate II. fig. 5), *A. polyphysoides*, Crouan, show a difference in the mode of calcification of the rays of the cap, which in these instances is not equal all round, but much more abundant on the side-walls adjoining each other, and is often present there only, so that the spaces between the rays are filled with lime and bind them together with the appearance of a closed disc. There would be very little, therefore, against the supposition, after this discovery in a mature state, of an actual development in the manner of *Acetabularia mediterranea*, in which the final dissolution of the rays held together only by the lime incrustation takes place by the swelling and destruction of the common middle layer of the partition-walls. If we learn from the latter species how little weight is to be attached to these characters for a generic separation of *Acetabularia* and *Polyphysa*, this appears clearer than ever if we pass such a series of species in review as I have placed in the section *Acetabuloïdes*, and contrast them with our one European species forming the section *Acetabulum*. The best known forms of this series are the nearly related *A. crenulata* and *A. caraibica*, Kütz., round which a number of other species are grouped. In *Acetabuloïdes* the corona superior and corona inferior are developed in the same way as in *Acetabulum*, but their parts are not continuous with others laterally, are, on the other hand, smaller than the basal portions of the rays, and present knobs or processes completely free all round, although often closely adjoining. It is remarkable that this character has been overlooked by all authors who have dealt with the genus.

Woronin says [31, p. 201], “ Dans le 4^{trième} tome (1856) des ‘Tabulæ phyc.’ Kützing décrit et représente une nouvelle espèce de l’*Acetabularia*: *A. caraibica*; mais cette espèce, à ce qu’il me semble, ne diffère en rien de l’*Acetabularia mediterranea*”; and Cramer, who is otherwise so accurate, says [5, p. 24]: “The caps of *A. crenulata* are provided above and below with collars, and the upper appears to differ in no respect from *A. mediterranea*.” All have observed that the connection of the sporangial rays in *Acetabuloïdes* does not reach to the outermost point, and that in consequence the margin of the disc appears toothed or notched. Agardh was the first to found on this point a division of the genus into two sections, which agree exactly with mine, although more precise knowledge of the distinctive characters was then wanting.

In regard to the firm lateral connection of the sporangial rays, the forms belonging to *Acetabuloïdes* show differences. In none of these species is this union so firm as in *A. mediterranea*; indeed, two species are described — viz. *A. Calyculus*, Quoy et Gaimard (Plate III. figs. 6, 7, 10, 13), and *A. Farlowii*, n. sp. (Plate III. fig. 1),—which in the complete separation of their rays come very near to *Polyphysa*, from which they are to be distinguished only by the presence of a well-developed corona inferior. In most of the species, certainly, the rays remain, after decalcification, more or less united laterally

by a slimy, soft substance, which opposes little resistance to a dissecting needle, and is often so soft that its consistency is destroyed by the evolution of gas in the action of the acid. In how far this substance represents the swollen middle lamella of a circular cushion of united chambers originally closed like *Acetabularia mediterranea*, or wholly or in part the cohesive product of the disorganization of the outside of the originally free walls of the ray as in *Polyphysa*, cannot be certainly determined without a knowledge of development unobtainable from dry material. Be this as it may, in any case *A. Calyculus* and *A. Farlowii*, in all other respects true *Acetabularia*, agree in this point in the mature condition with *Polyphysa*. There is otherwise such a series of intermediate cases that this character does not maintain any systematic significance. For this reason I have thought it right to sink the genus *Polyphysa*, distinguished only by the absence of a well-developed corona inferior, and to regard it as only a section of *Acetabularia*.

Acetabuloides appears to include numerous species falling under several groups within which they are to be distinguished only with difficulty. A definite elucidation of all these forms is not possible on the basis of the generally meagre specimens preserved in herbaria. Various doubtful specimens have consequently not found a place in this paper. The classification given here is less concerned with the natural relationship than with an attempt to attain a ready key to the naming of species. Otherwise *A. Farlowii*, n. sp., and *A. Suhrii*, n. sp., would probably have been brought nearer to the group of *A. crenulata* and *A. caraibica*; while *A. dentata*, n. sp., would be separated from it. *A. Calyculus*, Quoy et Gaim., would be isolated, and the three species distinguished by the size of their caps, *A. Kilneri*, J. Ag., *A. major*, Mart., and *A. Gigas*, n. sp., would form a natural group. In these three species the radial walls dividing the chambers of the cap show a common peculiarity first noticed by J. Agardh in his *A. Kilneri* (Plate I. fig. 6). The section of the radial wall shows a broad, soft, slimy middle layer, and two coarse layers bordering the lumina of the chambers. These show perpendicular stratifications irregularly distributed, but often in groups, passing out towards the slimy middle layer and not towards the lumen, and sometimes alternating with each other like notches. If one tears the chambers apart to view these stratifications from the surface, it appears that they are not equally developed over the whole surface of the wall, but most strongly at the upper and lower margin, decreasing, flattening out, and vanishing imperceptibly towards the middle. Plate I. fig. 6 *a* shows them in normal position from one side of the surface of the cap; Plate I. fig. 6 *b* in oblique surface view obtained by pressing asunder the two lamellæ.

Enough has been said to lay a foundation for the appreciation of the genus *Acetabularia* as understood here. A peculiarity is to be mentioned, however, which occurs only very rarely in other species, but appears to be characteristic of *A. crenulata* in its normal development, viz.: the shoot, after forming the first cap, grows through it and produces several others in succession. Specimens of this species are common enough with several caps of unequal development above each other (Plate I. fig. 1); very often only the uppermost remains, and thick nodular swellings, with scars, show the places on the stalk where former caps have fallen off. Between every two of such caps there is a whorl of

dichotomous sterile hairs, and if they have fallen off, the scars likewise remain on much smaller swellings of the stem. This regular alternation of cap and whorl of hairs was excellently illustrated by Harvey [12, p. 40], and later described by Cramer [5, p. 24].

The scars of the whorl of fallen hairs are easily distinguished from those of the cap. While they have the form of broad oval figures, not touching each other, with a point in the centre—the original opening now closed up—those of the disc-chambers are pressed together laterally, elongated, and marked with a narrow central perpendicular slit. In order to explain the mode of origin of this very peculiar appearance I examined such caps as were over-ripe and beginning to disintegrate. This resulted in the observation that the breaking-up was caused by the splitting of the partition-wall between the vestibule and the basal portion of the cap-chamber, but that simultaneously (through a farther thickening of the membrane of the stalk) a deeper division is attained in which the new lamellæ, produced by apposition, cut off transversely and bridge over the cavity of the vestibule. It is the lumen of the vestibule, thus cut off and much narrowed laterally by thickening, which, after the decay of the lamella originally covering the partition, appears in the form of the perpendicular slit described. Since I had only a small amount of material of *Acetabularia crenulata* suitable for determining this question, I was unable to follow out the stages in the cutting off of the vestibules; in all the caps still *in situ* which I examined there was nothing of this to be found. I have never observed this peculiarity at least in typical specimens of *A. caraibica*, in every point nearly related to *A. crenulata*; Kützing's *A. caraibica*, var. *calyculata*, of which this is the distinguishing point, is probably only the true *A. crenulata*.

The possession of several successive caps on the same shoot is otherwise a rare anomaly in the genus. Exactly this condition of *A. crenulata* was found on a specimen of *A. Calyculus*, Quoy et Gaimard, by Askenasy. On another shoot of this species the same author found two successive caps separated by several hair-whorls. They have been observed by Bornet and Woronin in a few specimens of *A. mediterranea*, and by myself in a single specimen of *A. Möbii* (Plate IV. fig. 1). But in the latter case it differed from *A. crenulata* in that the two caps were immediately one above the other without the intervening whorl of hairs. How it would be in this respect in the case of *A. mediterranea* I have been unable to decide from lack of material.

Let us now examine the genus *Acicularia*, d'Archiac, which has been hitherto known only in a fossil condition. It was established by d'Archiac on small longish bodies, pointed at one end, broad and emarginate at the other, found in the Paris Eocene, which consist of calcium carbonate and are surrounded with numerous cavities opening outwards. Both d'Archiac and Michelin referred them to the Bryozoa, and Reuss at a later date did the same, while Carpenter placed them among the Foraminifera. To the original species *A. pavantina*, d'Archiac, Reuss added another similar form from the Austrian Miocene, viz. *A. miocenica*. The circumstance that these lime-spiculæ were occasionally found together radially disposed, and that the remains of radial partition-walls were to be recognized, led Munier-Chalmas to remove them from the animal kingdom and, with rare divination, place them with the *Acetabulariæ*. This conjecture, which had little to

support it in the fossil material, has been more recently proved true in the most brilliant fashion by the discovery of a living species of this genus. Of this species I found first specimens from Martinique in the Berlin Herbarium, then several from Guadeloupe in Herb. Thuret, but later I found that it had been described as *A. Schenckii*, Möbius, from specimens gathered by Dr. Schenck, at Cabo Frio in Brazil. I was unable, however, to satisfy myself of this determination until I had received the original specimens from the discoverer. Nothing was to be made of the description of the plant, which did not mention the principal peculiarity. The cap-bearing shoots of *Acicularia Schenckii* (Plate III. fig. 14) agree in all essential points of external structure with those of *Acetabularia*, section *Acetabuloides*. Their sporangial rays are rather closely united; the coronæ superior and inferior are well developed and agree in form with those of *A. caraiibica*. While the sporangial rays of *Acetabuloides* contain numerous round free spores, in this plant each ray contains a small body that exactly corresponds in form and structure with the lime-spiculæ described for *Acicularia*. It consists of a strongly calcified substance enclosing numerous cavities lying near the surface, and consequently transparent. In each of these and completely filling it there is a spore of the same structure as those of *Acetabularia* (Plate III. figs. 9, 15). It follows that the pits of the fossil forms are spore-containing cavities from which the spores have disappeared and the external lime-covering has not been preserved, so that they appear as opening outwards. If such a spore-bearing spicula be treated with dilute acid, there remains as the substratum of calcification a slime of small consistency, which surrounds the spore-cavities and is quite homogeneous, showing no differentiation either superficially or internally, except that here and there among the spore-cavities and occupying exactly the middle there are triangular or quadrangular spaces. The spores themselves are globular, with a sharply outlined, rather thin membrane, provided with a lid in the usual way. In consequence of drying they have often collapsed in the form of a basin or dish, exposing a part of the spore-cavity, from which it may be inferred that in the mature condition they lie free within it. On treatment with sulphuric acid the membrane swells up exceedingly, and on its surface there appears a very delicate, tightly-stretched membrane, with a sharp contour, which finally bursts and sinks down folded up, proving to be a very delicate cuticle-like lamella (*cf.* Plate III. fig. 9). If we turn to the careful examination of the unaltered spicula in order to obtain a clear understanding of the origin of the slimy substratum of the calcification, we see that the lime-mass does not possess equal thickness at all places, but that each spore is surrounded as with a shell by a wall-like ring of maximum calcification. These shells appear to be stuck to each other by a slight lime-incrustation in the interstices, and the above-mentioned angular spaces, quite without lime, are to be found here and there in an unaltered state. A view of the whole gives the impression that the slimy substance has originated by a transformation of the outer layers of the spore-membrane, and that these are afterwards united into a firm mass by calcification. If the slime were the remainder of the protoplasm of the sporangial ray not used in the formation of the spores, as might very well be the case, then it would be impossible to understand why it is not evenly distributed, and why its density should decrease in so striking a way in the direction of radii from each spore. However, there is opposed to this view the circumstance that the membrane

of the enclosed spore possesses already its own cuticle-like outer lamella exactly as in *Acetabularia*, thus appearing completely closed externally. We should have to assume that this lamella gradually succumbs to the transformation into slime and is again renewed from the layers beneath, which is indeed the less impossible since the membrane in question does not represent a cuticle in the chemical sense of the word. We shall return to this point in describing the spore-structure of the genus *Halicoryne*. The tracing of the mode of development of the sporangial ray, which alone could give us more information on this point, was impossible owing to the state of the material.

The fossil form described by Andrussow as *Acetabularia miocenica*, Andr., which occurs, forming on rocks, in the Crimea, south of Sebastopol, in the ravine of Karanj, may be put with the genus *Acicularia*. But in this form there are not merely the spore-containing spiculæ, but whole caps, and their parts are preserved. From Andrussow's [2] description and figure I had thought of putting it into *Acicularia* even before I had received several fragments through the kindness of the author. The examination of this certainly scanty material has only confirmed me in my opinion. In fact it agrees with *Acetabularia* or *Acicularia* in external conformation as well as in its double corona, but whether the corona exhibits the characters of *Acetabulum* or *Acetabuloides* could not be determined from my material. The extraordinary strength of the chamber partition-walls is very striking, and it gives great consistency and hardness to the whole fossil. This is not shown in Andrussow's somewhat diagrammatic woodcut. Each sporangial ray encloses a free spicula formed like it and bearing the spore-cavities in four rows, of which two lie near the upper and two near the lower membrane, while in the middle and towards the chamber partition-walls homogeneous lime prevails. (Compare the surface view of the chambers containing the spiculæ, Plate III. fig. 13.) Round each spore-cavity there is a circular zone which stands out, when viewed in a reflected light, through its white colour against the central mass of the spicula, though a sharp contour is not visible. The calcification does not appear from Andrussow's statements to be so complete in all cases, for he says (§ 78): "But sometimes the calcification appears to have gone farther, so that almost the whole cavity of the radial chambers is filled with lime and only small round holes remain corresponding to the cells. At least certain of the specimens from the Karanj ravine indicate this, and somewhat rubbed portions of such specimens show a certain likeness to the so-called *Acicularia* from the Paris Eocene." Such, at any rate, are the specimens I have seen. Nevertheless it is not to be doubted that the spores when the plant was alive were united in calcified spiculæ, perhaps of loose porous consistency. In the fossilization of spore-bearing uncalcified *Acetabularia* chambers the spores would probably be destroyed, and would certainly not be preserved with so sharp a contour of the interior and in so characteristic and regular position. Andrussow himself assumed a calcification of the living spore-wall. He says [2, p. 79]:—"Our alga is generally more calcified than the known *Acetabulariæ*, and it is still more distinguished from them by the presence of cells in the chambers, which has not been observed in any of the living *Acetabulariæ*. This circumstance, however, appears to me to be insufficient to warrant the removal of this alga to a separate genus. We know, indeed, that the radial chambers in a ripe state are filled with spores arranged, according to Woronin, in a spiral

line. The spore-membranes of our incrustated algæ might probably be calcified [a phenomenon not seldom observed in many other *Dasycladææ*], and in this way give rise to the cell-formation mentioned." With reference to the words placed in brackets, Andrussow was not justified in their use, since, at the time he wrote them, *Acicularia*, *Chalmasia*, and *Halicoryne*, the only genera of *Dasycladææ* with calcified spore-membranes, had not been investigated with reference to this point. Since the name "*miocenica*" has been given to another *Acicularia*, I must name afresh the South Russian fossils, and they may be called *Acicularia Andrussowii*.

Chalmasia antillana is the name by which I shall refer to a plant which I discovered in Herb. Thuret, represented by a few incomplete specimens collected by Agassiz in the West Indies. In habit it agrees with *Acetabuloides*, of which the disc-chambers are easily separable after decalcification. But it shows on closer examination the characters of *Polyphysa*; the corona inferior is absent. The free parts of the corona superior have a peculiar form and terminate in obtuse processes with two or three hair-projections. The calcification is slight and apparently confined to the outside of the membrane. On the sporangial rays there are irregular lime-scales, surrounded by furrows, lying on the outside of the membrane, and somewhat easily loosened with the help of a needle. The character of the genus is to be found in the spores. These are free as in *Acetabularia* and fill the sporangial ray with their irregular mass; they are provided with a thick, very strongly calcified membrane, and appear on this account, when seen with a pocket lens, as milk-white, not transparent globules. When these spores are decalcified they show first of all that their membrane, compared with the forms already mentioned, possesses extraordinary thickness, is beautifully and abundantly stratified, and surrounded by a definite, coarse euticuloid layer. The locus of the lime-incrustation is to be found here in the layers themselves of the membrane, while those of *Acicularia*, where only the slime mass is calcified, are quite free from it. Again a lid of circular form and considerable diameter is present. It has, however, a somewhat different form and does not represent a cone-valve inserted from within, but rather it broadens towards the outside so that in optical section the two lateral bounding lines converge towards the interior, and do not diverge as in the other cases. Possibly this stands in connection with the remarkable thickness of the spore-membrane, which, if the lid were inserted as in *Acetabularia*, would necessitate a considerable increase in the volume of the spore to render its falling out possible. For the rest the spores agree down to the minutest details with those of *Halicoryne*, with which, however, *Chalmasia* could not be united owing to the wholly different structure of the shoot (comp. Plate III. figs. 2, 3, 5).

Of the genus *Halicoryne* there are two species known, viz. *H. Wrightii*, Harv., from the Loo-choo Islands and the Philippines, and *H. spicata*, Kütz., from New Caledonia. The first brief description was given by Harvey in October 1859, and then Kützing, without knowing of this publication, described the other species as *Polyphysa spicata*, Kütz., which Souder subsequently, again without knowing of the Harveyan genus, distinguished by the name of *Pleiophysa spicata* without farther statement. Since then Agardh only has made farther examination of these rare plants; Cramer had no material*.

* See note on p. 39.

Notwithstanding its aberrant external appearance, *Halicoryne* approaches in its structure near to *Acetabularia*, sect. *Polyphysa*, as Kützing justly recognized and expressed in the name he gave it. Its erect stem is clothed in regular sequence with whorls closely occurring, alternating, and with different characters; and, according to the kind of whorl, more or less strongly developed at the nodes. It terminates in a cupola or dome-shaped growing-point, surrounded by the young bud-like whorls, which are inclined towards it; or, when its growth in length has ceased, quite abruptly, with a flat surface immediately above the last fertile whorl. The whorls consist in one case of repeatedly multisept hair-tufts of the usual kind, developed as a rule in groups of eight, but very soon falling off and leaving only their round scars on the surface of the stem. These whorls correspond to the less pronounced swellings on the axis. Between these, and, as has been indicated, present only on the full-grown plant, there are 16-branched whorls of a different kind, arising from the more prominent swellings of the stem. Its branches are completely free, and consist of an almost cylindrical basal portion seated on a small vestibular fold of the stem-tube and divided from it by a basal partition-wall in the well-known fashion, and of a terminal, simple, longish ovate, pointed vesicle curved somewhat upwards and almost pod-shaped—the sporangial ray of the adult fertile plant. On the upper side of the basal portion, in the neighbourhood of the place where it turns into the sporangial ray, there is a minute papilla-like convexity which bears a terminal, short, unicellular hair-process, or two of them, one behind the other. In young branches these hairs are firm and erect, and in the mature ones collapsed; they remain, however, at least in *H. spicata*, always persistent, while in the other cases they often, certainly not always, disappear.

In *Halicoryne Wrightii* this convexity is always recognizable, even in the mature state, as a small but still definite process; in *H. spicata* its elevation is so slight that it barely appears on the mature branches, and the hair-cells rise simply from the surface of the basal portion (comp. Plate IV. figs. 9, 11). We have in it the very feebly developed parts of the corona superior (comp. Plate IV. figs. 4, 5, 10).

While in *Acetabularia* the cap-whorl reaches full development first on the older and already strengthened plants, the youngest specimens in this case that I have seen are provided with both sorts of whorls in complete and regular alternation. In such plants, however, there is no spore-formation, which occurs only on the older individuals of about a finger-length. In the young plants of *H. spicata*, so far as I can perceive, the branches of the sterile fructification-whorl are pointed upwards and lie like roof-tiles over each other, much as Kützing has figured them; in those of *H. Wrightii* (collected by the 'Challenger' Expedition at the Philippines) they sprout forth at right angles from the stem-cell and become recurved and hang down parallel with the stem. So long as the branches of the fertile whorl do not form spores and remain sterile, the basal portion stands in wide open communication with the sporangial ray; when the spores are formed a partition is developed which is characterized by strong and often very irregular thickening (Plate IV. figs. 4, 10, 11). Agardh has given a description, correct in the main points, of the structure of *Halicoryne*; he has recognized the alternation of the different whorls and has seen the coronal prominences on the basal portion of the cap in *H. Wrightii*, which he only has investigated, although the proportions are not rendered on his plate v.

exactly true to nature. The hair-scars also have escaped his notice. The very characteristic lime-incrustation of *Halicoryne* does not appear to have been taken into account by Agardh, who at all events does not describe it.

If we examine the surface of the axial tube of the young part of a plant, the whole external surface of the membrane will be seen to be covered with round scale-like groups of minute needle-shaped crystals of calcium carbonate, between which there remain small interstices almost free from lime. These scales subsequently increase greatly in size, and are easily broken out with a needle; they become united into a continuous crust, though the interstices are much less strongly calcified. If the carbonate be dissolved with acetic acid, the thick membrane is left clear as glass, and there are to be seen numerous oxalate crystals, often densely occurring, firmly attached to its inner surface. Transverse sections show that the thick, strongly refractive, clearly stratified membrane remains wholly free from lime, and that the incrustation is only in a slimy coating developed on the outermost margin; its unequal distribution may have given rise to the scaly lime-formation. On decalcifying such sections one sees the slimy substratum of the incrustation always appear in little hillocks at the places corresponding to the scales.

The whorl rays are the same in this respect, but in them the calcification is much less and inconsiderable.

The spores of *Halicoryne* (Plate IV. figs. 3, 7) are in structure similar to those of *Chalmasia*; they are, however, in the two species so far different that while in *Halicoryne Wrightii* they fill the sporangium with white globules in great numbers, in *H. spicata* they are present in much fewer numbers and are united in an irregularly formed aggregation like a small roundish oval stone, in which only after decalcification are the single elements, polygonal from mutual pressure, to be clearly recognized.

The single spore of *H. Wrightii* is almost globular, and is distinguished, as already mentioned, by the complicated structure of its extremely thick cell-membrane; to what has been said (under *Chalmasia*) with reference to the lid and its insertion there is nothing to be added. If the spores be embedded in gum and the sections so obtained be examined, the whole membrane will be seen to consist of three different layers. The greatest of these is the middle one, which is the seat of calcification. It exhibits a peculiar striation in the direction of the radii, which causes the delicate stratification, which is also present, to be scarcely apparent, if at all, though it is somewhat more distinct in *H. spicata*. The striation depends apparently on differences of density in the substance; the minute lime-granules of the incrustation, disposed in radial rows, follow it, and without doubt they are situated in the less dense layers, and they appear clearly during the first effects of dilute acetic acid or after treatment with chloriodide of zinc. After their solution the striation is still clearly apparent, but later it becomes less distinct from the swelling up. At the outer and inner margins of this layer of the membrane there is a denser seam showing the radial striation, but either free from or almost destitute of lime, which appears very sharply defined at the commencement of staining with chloriodide of zinc, because the colour-reaction begins in it later than in the remaining weaker part of the middle layer. The cellulose reaction is easily obtained, as de Bary has stated for *Acetabularia mediterranea*, and mere treatment with iodine is

sufficient to demonstrate it. The thick middle layer is bounded on the inside by a relatively thin, stratified, strongly refractive layer, turned blue with chloriodide of zinc; it directly encloses the contents. Outside the layer bearing the incrustation is the thin euticle-like membrane, either not stained with preparations of iodine or merely turned yellow; at the commencement of swelling it readily rises up in folds and is then easily observable.

If the section passes through the lid of the spore (Plate IV. fig. 8), several complications will be found at its margin. The marginal surface between lid and spore-membrane appears on both sides as a sharp line running through the membrane. This line consists of an extremely delicate, perpendicular lamella passing outwards into the euticuloid layer and inwards into the internal layer. That these connections exist and that the lamella goes transversely through the incrustated layer is shown particularly clearly at the commencement of the swelling of the section, where, for example, the euticuloid layer rises in folds and one sees the lamella in question emerge distinctly above the incrustated layer and pass into the euticuloid one. It undergoes in this apparently a stretching, not shared in by the incrustated layer in the mass. We have seen that the incrustated layer possesses a denser margin on its inner and outer sides; a similar one is also presented towards the transverse lamella forming the lid-margin, so that it is accompanied on both sides by a more strongly refractive seam of the incrustated layer connecting the similar portions of the outside and inside, in the lid as well as the rest of the spore-membrane.

When sections passing through the lid have been carefully treated with acetic acid and then stained with a little iodine, the subsequent treatment with concentrated sulphuric acid causes the membrane, coloured blue, to swell up enormously. The outer euticle-like lamella and the lamella separating spore and lid do not take part in the staining. The inner layer swells up and exhibits its stratification; soon this stratification becomes indistinct, and all begins to dissolve, with the exception of the outer euticuloid layer and the lamella between spore and lid. Finally this latter is destroyed, and there remains only its point of connection with the outer layer as a knob-like swelling forming a circle in a surface view of the section. In the end there is left over only the euticuloid layer, which undergoes no farther alteration. This layer, however, is not a true euticle, since, apart from its resistance to sulphuric acid, it shows none of the characteristic reactions of cuticle, is unaltered in chromic acid, and does not turn yellow on warming in potash. Of what nature this modification is must be left undecided.

In the examination of spores, decalcified most carefully with very dilute acetic acid, there always appear outside the euticuloid layer several very delicate parallel marginal lines which appear to indicate the presence of a clear, stratified, gelatinous envelope. If it be really present one would regard it as the equivalent of the slime mass which envelops the spores of *Acicularia* and binds them together, serving as the substratum of calcification*. Since, however, in examining sections of embedded spores, I have never been able to discern again the least trace of this, I am doubtful whether these lines may not be ascribed to an optical illusion. I should have liked to examine the condition of the spore-membrane on the opening of the lid, but I had no suitable material. It is

* The adhesion of the spores of *Halicoryne spicata* might be similarly explained.

manifest that in this process the cuticuloid lamella as well as the inner layer must be separated by a circular cut. The transverse lamella, bordering the margin of the lid, less altered than the cuticuloid layer, must then serve as a sliding surface at the removal of the lid, but whether it remains with the lid or with the spore I must leave undecided.

Disregarding the great structural differences that exist between the series of *Cymopolia*, *Bornetella*, and *Acetabularia*, the systematic connection of these groups has so impressed recent authors that they either unite them all as *Dasycladeæ*, or they divide them into two allied families of *Dasycladeæ*, which in this case also includes the *Bornetella* and separates off the *Acetabulariæ*. The more our knowledge of all these genera increases the more clearly manifest becomes their connection—their morphological homology. In spite of this, the literature contains only a few attempts at a careful comparative treatment of their organs. Only in Falkenberg, in Wille, and in Cramer do I find observations of the kind. They carry out quite correctly the comparison of the main axis—the stem, as well as the verticillate lateral members borne by it—the leaves, which are distinguished by limited duration of growth and become the bearers of the fructification. These leaves are either all alike or they are of two sorts, partly sterile and hair-like, frequently di-polychotomously branched, and partly fertile and club-shaped. Falkenberg goes farther than Wille, since he says (p. 270) of *Acetabularia*:—"The cell-branches which unite to form the cap are distinguished from the other verticillate branches not only by the absence of further branching and by their persistence on the axis, but by the fact that in them only does the formation of reproductive cells take place, while the hair-branches, like the chambers of the rudimentary cap, remain sterile." This rudimentary cap is our corona inferior. That follows from the passage which says:—"So the cap is doubtless to be regarded as equivalent to the previously formed hair-whorl of the shoot of *Acetabularia*; the transition from this hair-whorl to the mature cap-whorl is facilitated by a branch-whorl which remains rudimentary and surrounds the cap as a cushion on its under side Ordinarily the capacity for forming caps is extinguished with the development of the first fully-formed one. Above it, however, there are formed several whorls of umbellate hair-branches, which soon fall off; but the internodes of the main axis do not extend above the cap, and the membrane of the main axis, in which they were inserted, showing the scars of the fallen branches, surrounds the navel-shaped depressed apex of the shoot in the form of a circular wall." According to this view the cap is a highly complicated aggregation of hair-whorls placed together, of which one goes to the corona inferior, another to the sporangial rays, and several to the corona superior. Falkenberg has examined only *Acetabularia mediterranea*, and it in a mature state; otherwise he must have convinced himself of the untenability of his opinion. The position of the hair-scars in all *Polyphysæ*, particularly in *Acetabularia polyphysoides* and *A. Möbii*, where they form a whorl on each side of the coronal prominences (Plate IV. figs. 2, 6), shows that we have to deal in it simply with the parts of a complete peculiar body—the coronal prominences. To this is to be added the late appearance of the sporangial rays in the development of the cap of *A. mediterranea*, in which an originally undifferentiated primordium breaks up into corona superior and an under portion which,

long after the commencement of the growing out of their hairs, divides itself into sporangial ray and corona inferior. It is impossible to close one's eyes to the view that the whole chamber with all its parts represents a complete formation, if, indeed, one may not take it as the homologue of a single whorl. That this may be so I believe I am in a position to prove. It is common to all *Dasycladeæ* that the branching of their short shoots is of the di-polychotomous type, and to this rule the *Acetabulariæ*, as regards their sterile branches, form in no way an exception. As regards the morphological position of the sporangia, there are two actually different cases, if we look away from *Acetabularia* and its allies. The one occurs among the *Cymopolia*, the other among the *Bornetelleæ*. In the former case the sporangium arises from the apex of the ray which has already produced its branch-whorl, if such there be; and this teaches us that we have to do with a cymose and not with a dichotomous or polychotomous system in the branching of the short shoot. In *Dasycladus*, *Neomeris*, and *Cymopolia* it is the primary shoot which terminates in a sporangium; in *Botryophora* secondary branches take part also in this transformation, but these have no farther branching. There thus arise lateral as well as terminal sporangia, but these belong to the branch-whorl itself and are homologous with the secondary rays. It is quite otherwise in *Bornetella*. Here the sporangia occur as lateral outgrowths in indefinite numbers and position from the primary ray, which ends blind in all cases after it has given rise to the characteristic whorl of secondary rays forming the rind. The sporangia of *Bornetella* are lateral new formations, and they should not be compared with the parts of the normal branching system.

How, then, do the sporangial rays of *Acetabularia* compare with this? I do not hesitate to assert that they could be compared only with those of *Bornetella*. In *Acetabularia polyphysoides*, for example, or *A. Möbii*, the basal part, together with the coronal prominences it bears, is equivalent to the basal part of the short shoot; the crown of hairs on the terminal prominences is the whorl of the secondary branches. It is plain that the sporangial ray does not belong to this whorl—it is a protuberance of the basal portion that is only apparently pressed into a terminal position. It is distinguished from the sporangium of *Bornetella* by its aberrant form, by its occurrence singly, and by its definite position on the basiscopic side of the branch. But these relations are not so clear in all *Acetabulariæ* as they are here. In the section *Polyphysa*, which affords simpler relations of organization, and in *Halicoryne* and *Chalmasia* as well, there is present a manifest limit between sporangium and basal portion; in *Acicularia*, *Acetabuloides*, and *Acetabulum* these become somewhat obliterated. And at the same time the wreath-like position of the secondary branches on the single sections of the corona becomes less clear, until finally, in many species of *Acetabuloides* and *Acetabulum*, they come together in a radius forming a single row. The most aberrant type is *Acetabularia mediterranea*, for long the only one closely studied, in which the closed connection of the parts is found.

With this statement the course of development is in accord. The apex of the ray, the corona with its hairs, is formed much earlier than the sporangium and may be regarded at first—at least with as much justification as the other—as the terminal portion of the

whole shoot (compare the figures, Plate I. figs. 4, 8, 12, of *Acetabularia mediterranea*, as well as Plate IV. fig. 5, *Halicoryne Wrightii*). The thrusting towards the acroscopic side happens through its excessive growth in size.

A beautiful confirmation of what has just been said came into my hands after the text of this paper had been prepared. A young specimen of *A. Peniculus* was examined, in which immediately beneath the cap, normal in all respects, there was a whorl of hairs which attracted my attention from the vesicular form of its branches. Closer examination resulted in disclosing a very remarkable anomaly (Plate II. fig. 2). Among the short shoots of the whorl in question there were single ones of quite normal character, polychotomous, provided with cylindrical, hair-like, long cells of the same order as the branches. Most of them, however, were transformed into arrested fruit-discs. The stalk was formed of the primary branch of the short shoot; its secondary branches were shortened and bore at the apex in place of the tertiary outgrowths, as a rule, one terminal, short, papilla-like cell, rarely two inserted together. That these represent the branches of the third degree there could be no doubt. The sporangial ray appeared as a more or less developed knob, sometimes constricted at the base and vesicular above, on the basiscopic side of each of the secondary branches of the short shoot; it never attained complete development, and always persisted in a distinctly lateral position. We have to do here, then, with the formation of caps of a higher order, since the secondary branches of the short shoot undergo the same alteration as occurs otherwise only on the primary ones. By a farther development of the anomaly we should have a plant of which the terminal fruit-disc would be surrounded by a complete whorl of similar lateral ones. Perhaps Woronin's observation of a branching *Acetabularia mediterranea* in which each branch bore a cap may be explained in this way; or, on the other hand, it may be only a fasciation-like forking of the stalk of the apex.

Among the *Cymopolieæ* we meet with a farther difference of organization, in which the two other groups do not share, in the absence or presence of spore-formation in the sporangia. We have to thank Cramer for a criticism of the systematic significance of this character. He makes out that we are compelled, in the employment of this character for the classification of the Order, to separate the neighbouring genera *Botryophora* and *Dasycladus*, *Neomeris* and *Cymopolia*. That these two groups of genera, of which one is incrustated and the other is not, have been farther differentiated in analogous fashion is scarcely doubtful. But which of the divisions of each of these two groups is the original one, which the more strongly modified and the more advanced? I am of opinion that one may not doubt, with reference to the alternation of generations of sexual and asexual individuals so general among the *Chlorophyceæ*, that those forms in which it fails, in spite of the apparent simplification of the course of development, are still the most modified phylogenetically. So in this case *Dasycladus*, in which the sporangia, intermitting the spores, directly produce gametes, the product of the conjugation of which I saw grow directly into a normal young plant; *Cymopolia*, where possibly sexuality has been lost, and only vegetative germination of the whole sporangia retained—provided that in the case of the preceding observations (Solms) we have met with no abnormality. *Dasycladus* would stand in some such way to *Botryophora* as *Cymopolia* to *Neomeris*.

It results from the comparison of these courses of development—as also from the similar cases of *Botrydium* and *Vaucheria*—with those of most *Chlorophyceæ*, that it is, particularly in the former group, the sexual generations that become rudimentary or eventually disappear, while otherwise this is the case with the asexual. In consequence we find in our group that the vegetative functions become attached to the asexual generation, while usually they are attached to the sexual.

Possibly the consideration of this phenomenon might throw some light on the peculiar apparently analogous separation of groups among the *Archegoniata*, where the Ferns, in their course of development, would correspond with the present group and the *Bryineæ* with the remaining *Chlorophyceæ*.

So much for the mutual relations of the genera of *Cymopolieæ*. The *Bornetelleæ*, including only the genus *Bornetella*, do not enter farther into the question, and we may finally turn to the consideration of the relations which exist among the genera of *Acetabulariæ*. There are two points of view in the disposition of the forms: first, the external development of the fertile plant; and second, the distribution of the incrustated parts in these. According to the first, *Halicoryne*, with its regular alternation of numerous vegetative and fertile whorls, must be placed apart from all other genera; according to the second we should have, from the occurrence or absence of incrustation in the interior of the sporangia, at least two if not three groups. One of these contains merely the genus *Acetabularia*, the other all the remaining genera; or if not, possibly *Acicularia* should be separated from the others as a group in which not the spore-membrane as in other cases, but rather a slimy mass within it of uncertain origin is the basis of the calcification. There is naturally no certain proof whether one grouping or the other is the correct one. But I should, after considering all the circumstances, place the mode of calcification in the foreground, especially on this account,—that *Halicoryne* in this respect agrees so absolutely with *Chalmasia*. We should then retain the two or three groups mentioned, and the peculiar cap-formation must be taken as occurring in the course of development at different times in the *Acetabularideæ* and *Halicorynideæ*. That the type of *Halicoryne* stands nearer the ancestral form of the whole family of *Acetabulariæ* than the cap-forming type of the other genera seems to be supported by its similarity to the more remotely allied types of the *Dasycladeæ*, from which it is distinguished by the alternation of fertile and sterile whorls, and besides by the lateral sporangium; and this alternation we have seen occur in *Acetabularia*, where this genus in its normal course of development, and not as a monstrosity, produces several discs in succession above each other. This case, only known as yet in *A. crenulata*, would seem to correspond to a reversion to a *Halicoryne*-like type.

Clavis Generum.

- I. Sporæ incrustatione calcarea omnino destitutæ. Rami fertiles discum umbelliformem constituentes 1. ACETABULARIA.
- II. Sporæ incrustatione calcarea præditæ.
 - A. Ramorum fertiliū verticilli plures superpositi. Rami liberi vesiculiformes... 2. HALICORYNE.

B. Rami fertiles discum umbelliformem constituentes.

- α. Sporæ incrustatione calcarea in spiculam aciculiformem coadunatæ, stratis membranæ interioribus calce destitutis 4. ACICULARIA.
 β. Sporæ liberæ per totam membranam incrustatæ 3. CHALMASIA.

I. ACETABULARIA, Lam. in Bull. Soc. Phil. 1812, p. 185.

The erect axis, clothed with successive deciduous hair-whorls, terminating when ripe in a cap-like whorl, of which the rays are either free or joined together; each such ray equivalent to a cell of the hair-whorl terminating in a knob- or cushion-shaped process, closing its portion of the corona superior and bearing here branched hairs in various positions; coronal prominences forced into a lateral position by the development of the originally lateral sporangium, which finally contains the round or ovate spores with membranes free from lime, and opening after a time by means of a lid and emitting the gametes. These develop after germination into a plant which fruits once and dies down annually to the surface of the substratum, accumulating reserve-material in a basal portion which is immersed in the substratum and cut off by a partition-wall, and finally fruiting after its repeated diaphysis.

Clavis Specierum.

- A. Disci fertiles radii ad apicem usque connati, corona superiore et inferiore præditi. Coronæ processus connati, superioris pilis uniseriatis 5 et ultra præditi. (*Acetabulum.*) 1. *A. mediterranea.*
- B. Disci fertiles radii plus minus connati vel subliberi, corona superiore et inferiore præditi. Coronæ processus inter se liberi. (*Acetabuloides.*)
1. Radiorum septa lateralia verticaliter striata.
- a. Radii apiculati, processus coronæ superioris extus bilobati 2. *A. Kilneri.*
- β. Radii mutici, processus coronæ superioris integri vel leviter emarginati.
- a. Discus diametro 15–20 mm., membrana modice incrassata 3. *A. major.*
- b. Discus maximus 35 mm., membrana tenaci coriacea 4. *A. Gigas.*
2. Radiorum septa lævia, haud verticaliter striata.
- a. Radii apiculati.
- a. Coronæ superioris processus pilis ternis uniseriatis præditi. Discus parvus infundibuliformis, margine apiculis pyramidatis graciliter dentatus 5. *A. dentata.*
- b. Coronæ superioris processus pilis binis uniseriatis præditi. Discus major margine apiculis brevibus crenulatus.
- * Disci infundibuliformes sæpius plures superpositi, radiis apiculo convexo 6. *A. crenulata.*
- ** Discus planus, radiis apice emarginatis, apiculum parvum gerentibus. 7. *A. caraibica.*
- β. Radii mutici, omnino exapiculati, plus minus emarginati.
- a. Coronæ superioris processus pilis quaternis irregulariter uniradiatis præditi 8. *A. Sukrii.*
- b. Coronæ superioris processus pilis binis instructi. Radii omnino liberi.
- * Processus coronæ longe discreti, subtriangulares 9. *A. Calyculus.*
- ** Processus coronæ approximati, extus subemarginati 10. *A. Farlowii.*

- C. Disci fertilis radii liberi, interdum incrustatione plus minus coaliti. Corona inferior nulla. Coronæ superioris processus inter se liberi. (*Polyphysa*.)
1. Radii omnino liberi, incrustatione nulla vel subnulla, æquali.
 - a. Radii vesiculiformes, obtusi. Processus coronæ pilis binis oblique seriatis instructi 11. *A. Peniculus*.
 - β. Radii sursum curvati, elongati, apiculati. Processus coronæ pilis ternis triangulariter dispositis instructi 12. *A. exigua*.
 2. Radii incrustatione partiali laterali coaliti.
 - a. Processus coronæ pilis ternis instructi 13. *A. parvula*.
 - β. Processus coronæ pilis pluribus instructi.
 - * Pili circulariter dispositi 15. *A. Möbii*.
 - ** Pili elliptice dispositi 14. *A. polyphysoides*.

Section I. ACETABULUM.

Fertile disc composed of rays firmly united up to their tips, and having corona superior and inferior likewise laterally united, with ovate spores.

1. ACETABULARIA MEDITERRANEA, Lam. Hist. Polyp. corall. flex. 1816, p. 249.

Disc in fully developed state extended flat, when younger more or less concave; sporangial rays as it were cut off straight at the tips, with much thickened, completely united membranes; corona superior forming a circular continuous undulating ring surrounding the apex of the disc and corresponding without and within to the narrow individual coronal rays. Hairs or hair-scars on the apical surface of the coronal rays in a single row in greater numbers (5-7), generally in tufts; corona inferior of similar form, its rays in the apical view being notch-like at their outer margin.

Size of normal specimens: diam. of disc 10-12 mm., often much smaller; breadth of corona superior circa 0.125-0.150 mm.; longit. diam. of spores, circa 0.095 mm., transv. diam. 0.07 mm. (Plate I. figs. 4, 5, 7, 8, 12.)

This species, which is among the largest of the genus, is easily recognized by the characters of the section *Acetabulum*. Its mode of calcification has been closely studied by Leitgeb. Its degree varies very greatly; the calcification of the peripheral layers, which is excessive in sunny localities, may be completely wanting at greater depths or in shadow. The specimens then appear quite green.

Section II. ACETABULOIDES.

Sporangial rays more or less firmly united or completely or partly free; corona superior and inferior present, both consisting of free processes not united laterally with each other.

A. Side-walls of the sporangial rays notched together by distinct thick processes reaching from the upper surface to about the middle, gradually running out and springing towards the middle lamella. The largest species of the genus.

a. Sporangial rays with apiculum and with the process of the corona superior bilobed outwards.

2. ACETABULARIA KILNERI, Ag. Till Alg. Syst. viii. 1886, p. 171.

Fertile disc large, long-stalked, only terminal, extended flat or slightly infundibuliform upwards, moderately calcified. Sporangial rays (57 in number) firmly united

when fresh, but after decalcification easily separable from each other as far as the base of the corona, with the interlocking ribs irregular, but usually together in pairs and increasing in numbers towards the centre, and with flat but apiculate margin. Segments of the corona superior and inferior similar, narrow, very closely pressed together, deeply bilobed externally, often irregular from the unequal size of the processes, the membrane of which is much thickened. Hair-scars on the parts of the corona superior as a rule in fours, forming a series here and there pushed outwards. Vestibular folds much thickened in the surface view towards the apical membrane, standing out as strong, refractive, round knobs alternating with the rays.

Size: diameter of cap 10–16 mm.; breadth of corona superior 0·26 mm. (Plate I. fig. 6.)

It is found on the warmer Australian coasts—Edgecumbe Bay, coll. Kilner, Hb. Ag., Thuret, Strassburg; Port Bowen, Austr. or., coll. A. Dietrich, Hb. Thuret (nomine *A. crenulata*, var. *tricuspidata*, Grun.; a cel. Grunow missa).

Among the existing descriptions of different *Acetabulariæ*, which confine themselves for the most part to the citation of trivial things and are not therefore intelligible without an inspection of the original specimens, Agardh's representation of his *A. Kilneri* is a notable exception. He has not only rightly recognized the character of the section *Acetabuloides*, but also the form of the two coronas, and has seen the notch-processes of the side-walls of the sporangial rays, thus pointing out the actual differential characters of his species.

b. Sporangial rays without apiculum. Segments of the corona not deeply bilobed towards the outside.

3. ACETABULARIA MAJOR, Martens, in Preussisch. Exped. nach Ostasien, Bot. Theil, Die Tange, von G. v. Martens, Berlin, 1866.—*A. crenulata*, var. *major*, Sonder, Algen d. trop. Australiens, 1871.—*A. denudata*, Zanard. Phycæe Papuanæ, N. Giorn. bot. Ital. 1878, p. 38.

In habit generally resembling *A. Kilneri*; cap large, long-stalked, extended flat, only slightly calcified. Sporangial rays (70–80 in number) united in the calcified condition, but separate from each other up to the base of the corona after decalcification; notch-processes of the side-walls much less sharply defined; apices of the rays blunt, cut off straight or somewhat emarginate, wholly without apiculum; segments of the corona superior and inferior of similar shape, those of the upper quite narrow, without emargination, each with a single series of about 8 hair-scars, those of the lower with a slight bulging outwards of the margin; spores seen only in an unripe state, and, considering their extraordinary differences in size, a scarcely normal condition.

Size: diam. of cap 15–20 mm.; breadth of corona superior 0·18–0·22 mm.; size of spores 0·075 mm.

Hab. On the tropical shores of Eastern Asia. Collected at Sima-haradscha, in Siam, in February 1862 by Schottmüller (Hb. Berol.); Atapapua, Timor (Hb. Strasb.); at Warbusi, in Geelvink Bay, New Guinea, collected by Beccari, March 1872 (coll. Becc. Strasb.).

4. ACETABULARIA GIGAS, n. sp. *A. majori* simillima sed major, membranis coriaceis instructa, pilis in coronæ superioris processibus octonis vel decenis subuniseriatis.

Resembling *A. major* in all its characters, but much larger and more robust—the veritable giant form of the genus. Stalk not completely present up to 25 cm. and more in length; cap of 1.5 cm. radius; distinguished from *A. major* by the firmness and thickness of its membranes, by the much coarser and more definite notch-marks of the side-walls, in which it greatly exceeds *A. Kilneri*; rays, of which at least 76 were present, after decalcification easily separable up to the base of the corona; corona superior consisting of narrow segments entirely without emargination and bearing numerous (8–10) hair-scars, in one regular series on the inner and in two irregular series on the outer side, the outermost having only short hair-processes; segments of the corona inferior from the apical view longish ovate, quite without emargination; spores very numerous in each ray, relatively small and globular.

Size: breadth of corona superior 0.41 mm.; spores 0.077 mm.

Hab. In the seas of Eastern Asia.

The specimen preserved in the British Museum from Herb. Hance was collected floating in the sea, by Swinhoe, on the south-west coast of the island of Formosa, at Liang-kiau. As G. Murray writes to me, there are specimens of the same species named *Androsaces Luzonis*, and collected by Kamel in Luzon, in Herb. Sloane sub 163, fol. 2, and 223, fol. 36. The photographs of this plant, nat. size, kindly taken by Mr. Gepp, show a diameter of cap 25–27 mm., and come between *A. major* and *A. Gigas* in size. As to its other characters I cannot judge merely from the photograph.

It is not possible to combine this species with *A. major*, in spite of the very minute differences by which it is distinguished. Possibly, after a better examination of the localities, farther similar forms may be found. It will then be possible to settle the limits of the species, but meanwhile it appears to me at all events more expedient to maintain apart such extraordinary forms in spite of the slightness of their distinguishing characters.

c. Side-walls of the sporangial rays without distinct notch-ribs.

a. Sporangial rays with apiculate margin. Apiculum in *A. caraibica* absent altogether, or often stunted on certain rays, but seldom on all.

5. ACETABULARIA DENTATA, n. sp. Gracilis, disco infundibuliformi, tandem subexplanato.

Disci radii pyramidato-acuminati, acuti. Processus coronæ superioris pilis ternis uniradiatis instructi.

Cap-forming plant, small and delicate, with short stalk up to 2 cm. in height; disc terminal, small (about 2 mm. radius), at first basin-, later dish-shaped, a flat margin appearing sharply toothed, often ultimately turned down. Sporangial rays 30–40, somewhat strongly calcified all round, united, but after decalcification for the most part separate, with very delicate, easily ruptured membranes, elevated pyramid-fashion at the apex, with concave border and sharp pointed apiculum. Segments of the corona superior small, somewhat crowded, longish ovate, externally very little or scarcely emarginate, with three hair-prominences in one row; corona inferior similar, but with sharp bilobed margin.

Size: diam. of cap 4 mm.; breadth of upper corona 0.11 mm. (Plate I. fig. 11.)

A. Calyculus, Zanard., non Quoy et Gaim.

Hab. In tropical Eastern Asia: first collected in a young unripe state at Sorong, New Guinea, and determined by Zanardini as *A. Calyculus*, Quoy et Gaim., afterwards at Macassar in Celebes (no. 927) together with *A. parvula*, also at Maumeri in Flores (no. 1198) by Mrs. Weber van Bosse. Probably the specimens distributed as *A. caraibica* by Vieillard (no. 2047), from New Caledonia, belong to this species, but the plants are too young for determination.

The specimens from Maumeri preserved in alcohol permitted closer study of the dense and repeatedly polychotomous hairs, of which one for each coronal segment attains development. Ordinarily this is the outermost, sometimes the second of the prominences, in which latter case the outermost develops into a somewhat thick-walled knob. The New Caledonian plant shows three, in many cases four hair-scars, with the hair-tuft as a rule arising from the innermost.

A. dentata is easily to be distinguished from the two following species by its small size, the peculiar dentition of the margin of the disc, the inequality of the two coronas, and the hair-scars being in threes.

6. ACETABULARIA CRENULATA, Lam. Hist. Polyp. corall. flex. 1816, p. 249.

Plant large. Discs of the younger individuals generally 2-4, above each other, and between them in each case the scars of hair-tufts; on older plants mostly only the terminal ones persist, and beneath them the nodular thickenings of the stalk denoting the places of attachment of the others.

Discs basin-shaped, rarely flat, strongly calcified, formed of numerous narrow, united rays (32, 57, 60, 80 counted), with cupola-like arched ends with short apiculum. Corona superior and inferior alike formed of longish crowded segments, externally more or less clearly emarginate and with very much thickened membranes. Hair-prominences of the corona superior in pairs, one behind the other, on each segment.

Size: diam. of cap in good specimens 10-15 mm.; breadth of corona superior 0.22-0.26 mm.; diam. of spores 0.075 (according to Cramer 66-83 μ). (Plate I. figs. 1, 2, 3.) Exsicc. Farlow, Anderson & Eaton, Alg. exsicc. Amer. bor. no. 42.

Hab. At the southern point of Florida (Key West); in multis colls.—Guadeloupe (S. Martin, Lac de Simpson, Conquéran no. 44 Hb. Thuret); Bahama Islands, Herb. Berol.; Cobija, Bolivia, coll. Osthhaus (Hb. Göttingen), on wood, in company with *Neomeris annulata*. ("Dans les eaux tranquilles, peu profondes, souvent troublées et fortement échauffées par le soleil, sur des rochers ensablés, des bois immergés, le plus souvent même dans le sable. Se rencontre assez fréquemment en parasite sur l'*Halimeda* et le *Dasycladus*. N'a pas de saison, persiste toute l'année, entre en végétation en Décembre." —Mazé et Schramm.)

I was able to study the disposition of the hairs on a specimen from Key West. The developed hair-tufts form a wreath, while those of the outermost scars are regularly stunted. In addition to this, far fewer tufts than rays reach full development, while every fourth coronal segment bears a fully-developed hair-tuft with three lying between having no such tufts.

Compare what has been said on this point under *A. dentata*. Should these differences prove constant on farther investigation, they would yield important differential characters, but this cannot be established on the scanty material of our collections.

Typical specimens of *A. crenulata* are very easily recognized even at the first glance. All the same, there are forms which connect with the following species so well that their determination becomes difficult. The precise limits of the species must be laid down after farther study on richer material.

7. ACETABULARIA CARAIBICA, Kütz. Tab. Phyc. vi. 1859, t. 93.

Disc mostly flat, slightly calcified, often almost without lime, terminal. Rays fairly numerous, 34–40, in the larger forms 50–60, firmly united; apex depressed in the middle, somewhat sunk, with a small apiculum, sometimes not distinct. Corona superior and inferior as in *A. crenulata*, the former with two hair-scars, one behind the other, on each segment.

Size: diam. of disc 6 mm.; breadth of corona superior 0.15 mm.; spore diam. 0.1 mm. (Plate I. fig. 10.)

Hab. Guadeloupe: coll. Duchassaing (Hb. Götting. Berl.); Mazé & Schramm, no. 1347 (Pointe-à-Pitre); Herb. Thuret, Berl. Strasb. This number is a form approaching *A. crenulata*; Moulé, "sur des pierres détachées au fond du port," 276, Hb. Thuret.

As already stated in the description of *A. crenulata*, this species is very nearly related to it, but is generally to be distinguished by the terminal, flat, and slightly calcified cap, and the unusual form of the points of the rays. Especially if it bear several caps above each other (*A. caraibica*, β *calyculata*, Kütz.) it is to be regarded with caution. As a matter of fact, one often finds in herbaria, under the latter name, typical specimens of *A. crenulata*. On the other hand, it may resemble the following form very much if the apiculum disappears; indeed Agardh has united them, as appears from his diagnosis; however, they are to be distinguished by the number and position of the coronal segments.

β . Sporangial rays blunt, more or less scolloped at the margin, apiculum absent.

I. Segments of the corona superior with about four hair-insertions; rays united by the calcification of the side-walls, but completely separate after treatment with acid.

8. ACETABULARIA SUHRII, n. sp. Gracilis, disco subinfundibuliformi. Disci radii obtusi vel emarginato-præmorsi. Processus coronæ superioris pilis quaternis unibrachiatis obsessi. Syn. *A. caraibica*, Ag. ex parte.

Belongs to the smaller forms (total height $1\frac{1}{2}$ –3 cm.). Stalk stiff, strongly calcified, bearing a single, terminal, infundibuliform disc, slightly calcified, and that principally in the side-walls. Sporangial rays in moderate number (25–30), with blunt margin, as if bitten off and more or less deeply scolloped. Segments of the corona inferior of somewhat rectangular outline, externally slightly emarginate, those of the corona superior separated from each other by distinct interspaces, irregularly elongate, externally as a rule somewhat deeply scolloped, with 3–4 (mostly 4) hair-scars, of which the outermost may be thrust aside.

Size: diam. of cap 6–7 mm.; breadth of corona superior 0.09 mm. (Plate I. figs. 9, 13.)

Hab. Shores of St. Thomas (Antilles): Herb. Berol., ex herb. Mertens et Suhr. I have seen in the Vienna Museum a plant from Jamaica, Friedrichsthal, with only three oblique hair-scars.

This plant, nearly allied to *A. caraibica*, is clearly distinguished by the shape of the apices of the sporangial rays and by the greater number of scars on the coronal segments found on all the specimens I was able to examine. Though *A. crenulata* and *A. caraibica* exhibit in the decalcified state a separation of the individual rays up to the base, this is here more markedly the case. Suhr appears to have observed this, since he has actually determined one of his specimens as "*Polyphysa*."

I have seen in the British Museum a plant from Ceylon very like *A. Suhrii*, at most differing only slightly in shape and in a greater arching out of the upper corona segments. It was collected by H. Trimen on shallow sandy places on 7th February, 1890, at Nakativanturai, near Jaffna, and noted by him as equal to 153 of the Ferguson collection. Owing to the scanty material, a more definite determination of its relationship is not possible.

II. Segments of the corona superior with two hair-insertions. Rays even in the living state separate and free.

9. ACETABULARIA CALYCVLUS, Quoy et Gaimard, in Freycinet, Voy. 'Uranie' et 'Physicienne,' Zool. t. 90. figs. 6, 7.—Harv. Phyc. Austr. vol. i. pl. 21.

Of intermediate size, with a delicate terminal cap on a longish stalk; stalk with spindle-shaped swellings bearing hair-scars. Disc delicately basin-shaped in consequence of the curving upwards of all the rays, which are not very numerous (22–25). These are scarcely if at all calcified, and separate and free from each other to the lowest basal portion, bearing the coronal segments, and each springing from a small protuberance of the central area; sporangial rays closed towards the basal portion, compressed from the tip downwards, deeply emarginate, scolloped; segments of both coronæ free, remote from each other, blunt, those of the upper externally almost triangular, with two hair-insertions one behind the other, or sometimes three, when they are triangular in arrangement with the point directed inwards. Spores globular.

Size: diam. of cap about 4 mm.; breadth of corona superior 0.11 mm. (Plate III. figs. 6, 7, 8, 10.)

Hab. Australia: Baie des Chiens marins, West Austr. (*Quoy et Gaimard*); Owen's Anchorage, Fremantle, West Austr. (*Clifton fide Harvey*, Hb. Dubl.); Fremantle, Bowerbank coll. Br. Mus. (specimina in spiritu vini cons.); Deception Bay, Queensland, coll. Th. L. Bancroft (*Askenasy*).

The original specimens of this species appear to be no longer in the Paris Museum; I have not seen the Harveyan originals, but the specimens in the British Museum from the same locality, which I examined, corresponded so exactly to his description and figure that all doubt of their identity may be excluded. Harvey's plate renders the habit of the plant most strikingly. At the first sight of the spirit-specimens in the British Museum I took them to be *Polyphysa Cliftoni*, Harv., on account of the entirely free rays of the cap, and was accordingly much astonished when I recognized the corona inferior

and with it the character of *Acetabuloides*. I was then inclined to form from this species a peculiar group, *Polyphysoides*, but was soon able to convince myself that as regards the union of the rays all possible degrees were represented in the *Acetabuloides* series, so that *A. Calyculus* was merely an extreme case. The well-preserved specimens of *A. Calyculus* permitted me to ascertain the distribution of the hair-tufts on the corona superior. Each segment of the corona bears such a tuft almost regularly, and it arises from the inner insertion, while the outer produces only a blunt, unicellular, hair-like knob.

We may here consider a doubtful *Acetabularia*, very hard to elucidate owing to the dearth of material, which Harvey collected in the lagoon of Tongatabu (Friendly Islands) and distributed as no. 18 in his 'Friendly Island Algæ.' I saw it in the London collections and in Hb. Thuret. Although its rays are connected they show a certain independence, and in its habit the form approaches our plant. However, it is possible to believe that it is another member of the series of forms of *A. caraibica* so exceedingly difficult to define.

10. ACETABULARIA FARLOWII, n. sp. Minor, brevipedunculata. Disci radii soluti, flexuosi, apice obtusi, emarginati. Coronæ superioris processus pilis binis unibradiatis præditi.

A very small and apparently short-stalked plant with white calcified stalk, and completely free rays of cap curved upwards, and in ripe specimens appearing entangled with each other; sporangial rays, about 30, slightly compressed towards the blunt emarginate points; corona inferior and superior more closely adpressed than in *A. Calyculus*; both with segments somewhat broadened externally and usually faintly emarginate, those of the corona superior with two scars, one behind the other; spores large and round.

Size: diam. of cap 6-7 mm.; breadth of corona superior 0.15 mm. (Plate III. fig. 1.)

Hab. Southern point of Florida, Key West (*Farlow* in Hb. Thuret).

Unfortunately I have seen only three broken-off specimens of this peculiar species, and they wanted the lower end of the stalk, that were sent by Farlow to Thuret. From the structure of the corona it is nearer *A. caraibica* than *A. Calyculus*, with which it has, however, in common the completely free rays. It is to be hoped that this remarkable plant will be found again soon.

Section III. POLYPHYSA.

Rays of the cap completely free, inserted on small projections of the central portion, at most united by lime-incrustations; corona inferior absent, superior composed of free knobs bearing hair-tufts.

A. Rays of the disc completely free, quite uncalcified, or with a very slight lime-incrustation, evenly disposed.

11. ACETABULARIA PENICULUS.

Plant long-stalked, disc with few rays (8-12), single rays completely free, with narrow basal portion convex below and bearing the button-shaped coronal process above. Sporangial ray inserted on the basal portion with a constricted base and closed against it, vesicular, about twice as long as broad, not at all compressed, with blunt, rounded

apex, and very slight, evenly disposed calcification; hair-scars on the top of the coronal process mostly in pairs and obliquely placed, seldom in threes forming a triangle pointing inwards. Spores globular.

Size: diam. of cap 5–7 mm.; breadth of coronal process measured radially 0·11 mm. (Plate II. figs. 2, 6, 7.)

Fucus Peniculus, R. Br. in Turn. Hist. Fuc. iv. p. 77, t. 228.—*Polyphysa aspergilloso*, Lamour., Polypiers flexibles, p. 252, t. viii. f. 2; Expos. méth. p. 20, t. 69. figs. 2–6.

Hab. Australia: King George's Sound (*R. Brown*; *Harvey*, no. 565, in mult. coll.): Swan River? (*Drummond*, Hb. Kew); Port Phillip (*Harvey*, Hb. Berol. Strassb.).

Var. β . CLIFTONI. (*Polyphysa Cliftoni*, Harv. Phyc. Austr. vol. v. tab. cclv.)

Sporangial rays 10–16, not calcified at all, narrow, club-shaped, not vesicularly inflated, 3–4 times as long as broad. Hair-scars mostly three on the coronal processes.

Size: diam. of cap 10 mm.

Hab. Fremantle, West Australia (*Clifton*, Hb. Trin. Coll. Dubl., spec. orig.; Hb. Brit. Mus.).

I am convinced, from the examination of the original specimen kindly sent to me, that no sharp distinction can be drawn between this form and the usual *A. Peniculus*. Its characters are found here and there in specimens of the typical form, in patches of which single caps exhibit the habit of *Polyphysa Cliftoni*. Now the pairs and now the triple hair-scars prevail for each coronal segment; but precisely on the specimens collected by Clifton, which agree more than any others with the original of *P. Cliftoni* in appearance, I find usually only pairs of hair-insertions.

12. ACETABULARIA EXIGUA, n. sp. Minime brevipedunculata. Disci radii pauci soluti, elongato-ovati, obtusi, sursum curvati. Coronæ superioris processus rotundato-convexi, pilis ternis in triangulum dispositis præditi.

Small, 5–6 mm. high, short-stalked and immersed in the coral substratum; disc formed of few rays, 6–10, with basal portion constricted on both sides, bearing the knob-shaped roundish coronal segment with three hair-scars; sporangial rays seated on basal portion and communicating with it, cucumber-shaped, curved upwards with long drawn-out points.

Size: diam. of cap 2·25 mm.; breadth of coronal processes measured radially 0·046 mm. (Plate II. figs. 1, 4.)

Hab. Tropical Eastern Asia, Macassar, Celebes: a few sterile specimens sent me, sub 926, by Mrs. Weber van Bosse; Sikka, on the south coast of Flores, no. 1199 (*Mrs. Weber van Bosse*). The latter specimens, which were fertile, were obtained from a piece of coral on which *Neomeris dumetosa* was growing, after its decalcification.

I am unable to say anything more definite as to the calcification of the sporangial membranes of this species, than that the few sterile specimens from Macassar were uncalcified. The others came under my observation only after lengthened treatment with acid. However, their sporangial rays are so widely separated from each other that a union of these by means of lime-incrustation is scarcely likely. On this account the plant finds its right place here. It is distinguished with the greatest ease from

A. Peniculus by the quite aberrant form of its sporangial rays. I was able to study the disposition of the hair-tufts in a young sterile specimen, thanks to its having been preserved in spirits. On each coronal segment one of these is produced, which springs from one of the two outer insertions. The other two hair-processes are stunted and appear as simple unicellular knobs.

B. Rays of the disc united by strong calcification of the side-walls.

a. Coronal segments roundish knobs with three hair-insertions.

13. ACETABULARIA PARVULA, n. sp. Minima, brevipedunculata, disco plano rotato. Radii ad septa tantum incrustati, inde subcoherentes, vesiculiformes, clavati, obtusi, apiculo perpusillo instructi. Coronæ superioris processus subtriangulari-rotundati, pilis ternis ad angulos dispositis instructi.

Small, short-stalked, with a terminal, flat expanded, wheel-like disc; rays few in number (about 16), very little calcified on upper and under sides, but strongly on the side-walls and thereby connected; lime layers between the rays at the outer margin projecting in the form of emarginate buttons. Sporangial rays thick, vesicular, clavate, obtusely rounded, with minute apiculum, seated on a basal portion constricted on both sides, which bears the knob-shaped coronal process with the three roundish triangular hair-scars.

Size: diam. of cap 2.12 mm.; breadth of coronal process measured radially 0.042 mm. (Plate II. figs. 3, 5.)

Hab. Tropical India; collected at Macassar (Celebes) with *A. dentata* by Mrs. Weber van Bosse.

β. Upper surface of coronal segments radially elongated, and with an elliptical group of numerous hair-insertions.

14. ACETABULARIA POLYPHYSOIDES, Crouan, in Mazé et Schramm, Essai de Classification des Algues de la Guadeloupe, 2nd ed. p. 84. Minime brevipedunculata, disco rotato parce incrustato. Radii pauci, vesiculosi, obtuso-rotundati, subliberi. Coronæ superioris processus pilorum octonorum vel novenorum seriem verticem ellipticum circumdantem gerentes.

Diminutive plant, with short stalk and circular expanded disc, and the side-walls slightly calcified. Sporangial rays few in number (12–15), seated on the small constricted basal portion, vesicular and swollen, obtuse and rounded, with rudimentary or absent apiculum. Segments of the corona knob-shaped, radially elongated upwards, with oval, apical surface, on which there are 8–9 hair-insertions, forming an elliptical figure. Hair-tufts short and copiously branched.

Size: radius of the disc 1.75 mm.; breadth of the coronal knobs measured radially 0.15 mm. (Plate IV. figs. 2, 6.)

Hab. Guadeloupe, Pointe-à-Pitre. ("Ilôt à Cochons, sous la batterie O; mêlé à des *Centroceras* en tapis sur des roches ensablées qui ne restent à découvert qu'aux plus basses marées. Vert brillant à l'état de vie. En Février 1861 très rare."—Mazé, ser. i. no. 223.) Specimen in British Museum, Hb. Thuret.

From the numerous hair-insertions there arise mostly clavate hair-knobs; only the middle ones appear to bear fully developed hair-tufts, which are very dense, but are remarkable for their smallness and shortness.

γ. Coronal segments knob-shaped, with roundish upper surface and a circular group of numerous hair-scars.

15. ACETABULARIA MÖBIÏ, n. sp. Minima, brevipedunculata. Disci radii vesiculares, rotundato-obtusi, breves, septis tantum incrustatis. Coronæ superioris processus pilorum quinquorū circiter seriem gerentes, verticem circularem circumdantem.

Diminutive, short-stalked plant, with rugose stalk showing several diaphyses; disc terminal, with about 15 rays, rarely two above each other, and in such case without any intervening hair-tufts; sporangial rays inflated, arising from a basal portion constricted on both sides, twice as long as broad, with obtuse rounded ends; outer walls of the rays not calcified, lateral walls united by strong calcification with nodular emergences at the margin; coronal knobs with roundish apex bearing a circle of about five hair-insertions; hair-tufts copiously branched, dense, but very short.

Size: length of disc-rays 1.37–1.62 mm.; breadth of coronal knobs radially measured 0.09 mm. (Plate IV. fig. 1.)

Hab. On coral reefs, Mauritius (*Möbius*; *Pike*, no. 168, Hb. Kew, Hb. Brit. Mus.).

This plant is nearly allied to the East Indian *A. parvula*, with which it completely agrees in the mode of calcification and in habit, but is distinguished by the numerous hair-scars of the coronal knobs forming a circular group. Möbius collected only one plant and preserved it in spirits. It bore two caps above each other, which I have not seen in the few specimens of Colonel Pike. It bore farther, on the hair-insertions, very thick-walled short hair-rudiments, while on Pike's specimens only the hair-scars were to be recognized, and these were very delicate. Whether there may be other differences, farther investigation on the spot must decide.

II. HALICORYNE, Harv.

Clavis analytica Specierum.

- | | |
|---|-------------------------|
| 1. Rami sporangiales patentes vel flexi; sporæ liberæ | 1. <i>H. Wrightii</i> . |
| 2. Rami sporangiales suberecti; sporæ in massam irregularem conglutinatæ..... | 2. <i>H. spicata</i> . |

The upright axis clothed with alternate differently formed whorls of branches, of which the one consists of few branches—8—longish, tufted, branched hairs, the other of mostly 16 branches, simple, longish ovate, pointed, almost pod-shaped vesicles, slightly curved inwards above and completely free and fructifying in the adult plant. These fertile branches, on the fructifying plant, inclined towards each other upwards and separated from the small vestibule only by a basal partition-wall, bearing on the upper side, not far from the base, a small protuberance which is furnished with one or two diminutive, rudimentary hairs, reduced to an oval cellule. In the fertile state the upper part of the vesicle is cut off by a thick partition-wall from the cylindrical basal portion immediately in front of this hair-decked protuberance. In this so separated sporangial

ray a small number of spores are formed, distinguished by their very strongly calcified membranes; spore-membrane stratified, with a definite lid; calcification of the axis only in the outer layers, forming irregular warty flakes consisting exclusively of carbonate of lime; the pod-shaped sporangial rays are also covered externally with a thin areolated incrustation of lime.

Whether repeated diaphysis occurs in this genus as in other calcified *Dasycladaceæ* I cannot definitely say, since I have been unable to obtain the very young plants on which alone this could be determined. As soon as the plant once fructifies, it appears then to have reached the end of its development. On a specimen of *H. spicata* examined with this view an active growing point was no longer present, and above the last fertile whorl, which, like the next, contained small spores, the axis ended in a flat surface with thickish walls. In the copiously branched basal portion there was no protoplasm to be found to indicate the probability of a new shoot.

1. HALICORYNE WRIGHTII, Harv. in Proc. Amer. Acad. iv. p. 333 (1859). Verticilli steriles horizontales, demum deflexi. Radii fertiles sporas liberas continentes, membrana crasse incrustata instructas.

Sporangial rays of the young plant extended at right angles, ultimately drooping backwards along the axis. Sporangia and spores somewhat large, the latter globular, fairly numerous, with very strongly calcified membranes, completely free and in no way united or adhering.

Size: mature plant 3–4 cm. high; length of disc-ray with basal portion 2·2 mm.; of the basal portion 0·18 mm.; spore diam. 0·18–0·22 mm., of which the thickness of the membrane is 0·02–0·03 mm.; breadth of lid 0·11 mm. (Plate IV. figs. 4, 5, 8, 10.)

Hab. On the Loo-ehoo Islands, first collected in 1856 by the French naval officer Thomas (ins. Nawa), Hb. Thuret; in the same place by Wright on the muddy shore (Hb. U.S. North Pacific Explor. Exped. no. 13), and described from these specimens by Harvey, Hb. Thuret. At Mactan, Philippines, May 1876, by Moseley ('Challenger' Exped., Hb. Brit. Mus., Hb. Kew.).

All the specimens of Wright examined by me, and also those of the 'Challenger' Expedition, are young and sterile, and I was able to study the fruits only on those collected by Thomas. Agardh appears, however, to have obtained fertile specimens from Wright's material. His statements are on the whole correct; he found the small hair-protuberances on the sporangial rays as well as the traces of the alternating hair-whorls. The calcification of the spore-membrane has escaped his notice.

2. HALICORYNE SPICATA, Kütz. Verticilli steriles sursum convergentes. Radium fertiliū sporæ in massulam irregularem conglobatæ, membranis incrustatis instructæ.

Sterile sporangial rays of the young plant, erect, converging, the fully grown ones not much more than half the length of those of the preceding species; spores few in number and cohering in a mass not quite filling the ray, irregularly polygonal, with strongly calcified membranes.

Size: length of the disc-ray with basal portion 1·37 mm.; spore diam. 0·15 mm.; thickness of spore-membrane 0·022 mm. (Plate IV. figs. 3, 7, 9, 11.)

Polyphysa spicata, Kütz. Tab. Phyc. vol. xvi. t. i. fig. 2 (1866).—*Pleiophysa spicata*, Sond. in F. v. Mueller's Fragment. Phytogr. Austr. Suppl. (solum nomen).

Hab. On the shores of New Caledonia, mouth of the River Massioncoué (*Balansa*, no. 2640), Hb. Thuret; on madrepores at Ina, 1863 (*Vieillard*, N. Cal. no. 1961, Hb. Thuret, Berlin; *Vieillard*, N. Cal. no. 13 in Hb. Brit. Mus.).

This species is very similar to the other, but is to be distinguished by the smaller number and the cohering of its calcified spores, which appear in a fresh state like a small fragment of lime of irregularly rounded form. The young plant also has a somewhat different habit, but I have seen it only in a few individuals (*Vieillard*, 1901).

III. CHALMASIA, nov. gen.

Discus fertilis terminalis e radiis liberis incrustatione tantum coalitis formatus. Corona inferior nulla; sporæ liberæ membrana crassa valde incrustata insignes.

Fertile cap terminal, composed of free, wedge-shaped rays, united only by the calcification; corona inferior wanting; segments of the corona superior not touching each other laterally, knob-shaped, and not sharply delimited towards the base; spores free, with thick, much calcified membrane, and coarse cuticularized outer layer.

1. CHALMASIA ANTILLANA, sp. unica, char. gen.

Cap infundibuliform, rays free, 26–32, with cylindrical basal portion which bears the coronal prominences in the form of an elevated ridge: this has the hair-scars either a pair obliquely or three in a triangle on the laterally compressed point. Sporangium covered externally all round with thin, irregularly outlined, easily detachable flakes of incrustation, vesicular and inflated, cut off at the outer margin, with an obtuse bulging projection: spores filling the whole sporangium, approximately globular, chalk-white from the strong calcification of the membrane.

Size: diam. of cap about 6 mm.; breadth of corona 0·18 mm.; spore diam. (measured after decalcification) 0·15 mm. (Plate III. figs. 2, 3, 5.)

Hab. West Indies (*Agassiz*!). (Hb. Thuret, misit *Farlow*.)

The few specimens of this very remarkable plant unfortunately lack precise localization*. They are besides very imperfect, and consist merely of completely ripe, torn-off fertile whorls, to which is attached a longer or shorter stalk. Its habit is that of *Acetabuloides*—indeed they were called *A. crenulata*. In the absence of the corona inferior they agree with *Polyphysa*, but in spore-structure completely with *Halicoryne*. On account of the general structure of the fertile shoot, however, the plant cannot well be placed in the latter genus.

IV. ACICULARIA, D'Archiac, in Mém. de la Soc. géol. de France, vol. v. pt. 2 (1843).

Discus fertilis terminalis e radiis inter se conjunctis formatus, coronis et inferiore et superiore præditis, sporæ massa mucosa calce incrustata coalitæ, pro radio spiculam solidam cuneatam formantes.

* *Farlow* writes to me that he received them from Comte Pourtalès, who accompanied *Agassiz* on one of his expeditions, and could only obtain this information with them,—that they were dredged south of the coast of Florida.

Clavis Specierum.

- a.* Forma unica viva 1. *A. Schenckii*.
b. Formæ fossiles.
 1. Disci fragmenta septis crassissimis cavitatis sporarum subtus et supra
 biseriatae..... 2. *A. Andrussowi*.
 2. Spiculæ sporigeræ tantum rotæ aciculares.
a. Spicula extus rotundate convexa..... 3. *A. miocenica*.
β. Spicula extus profunde emarginata..... 4. *A. pavantina*.

Fertile whorl terminal, consisting of wedge-shaped rays united laterally with each other; corona inferior and superior developed, approximately of the same shape; spores adhering in a cluster from the strong calcification of the outer membranes and filling the whole sporangial ray, through the upper surface of which the spores appear. The calcified substance is a homogeneous slime, in which, after decalcification, no trace can be demonstrated of a cuticuloid layer. In the cavities of this slime-mass are situated the easily detachable spores enclosed within a thin, sharply-contoured membrane with a lid.

a. Living Forms.

1. ACICULARIA SCHENCKII, Solms. Unica species adhuc viva, char. gen.

Stalk thin-walled, somewhat stout as if inflated, flabby, with scars of hair-whorls and terminal fertile disc flat or infundibuliform; rays 30–50, fairly closely united, wedge-shaped, as if cut off straight at the margin, with sharp, somewhat projecting angles, and seated on well-developed vestibules; segments of the corona superior crowded together, deeply scolloped externally, irregularly bilobed, and with much thickened membrane, bearing two hair-scars, one behind the other; corona inferior of the same shape; the lime-spiculæ enclosing the spores obtusely quadrangular in section, pointed inwards, enlarged outwards, and ending in an obtuse arch, on all sides revealing the spores; incrustation distinctly composed of the lime-layers of the spores, so that each spore-cavity appears to be surrounded by its peculiar ring of lime; these rings united with each other at the surfaces of contact, and, between them, here and there in the angles, gusset-shaped cavities.

Size: diam. of the disc about 6 mm.; breadth of corona 0·13 mm.; spore diam. 0·06 mm. (Plate III. figs. 4, 9, 11, 12, 14, 15.)

Acetabularia Schenckii, Möbius in 'Hedwigia,' vol. xxviii. 1889, p. 318.

Hab. Martinique (misit *Lenormand*, Herb. Berol.); Guadeloupe (*Vivier Boissard*, 1860, Herb. Thuret); Brazil, Cabo Frio, Prov. Rio de Janeiro. In shallow lagoons, May 1887 (*H. Schenck*, Hb. Schenck). Goebel has recently collected magnificent specimens at Curaçao (Mus. Bot. Monac.).

The specimens I have seen of this interesting species agree in the main in all respects. The specimens from Martinique are distinguished by the great delicacy and fragility of the sporangium-walls, not noticeable to the same degree in the others. This may have arisen from their being collected when over-ripe and beginning to decay, so that it was difficult to obtain for examination a cap that continued to hold together. Fragments of such, and especially beautiful, intact lime-spiculæ, are to be found abundantly in the mass

of mud, small sea-stars, and remains of algæ forming the dried specimen. Schenck's specimens from Cabo Frio in Brazil are, on the other hand, well preserved, and are found on mussel- and snail-shells. If Möbius did not observe the spiculæ and took the plant merely for an *Acetabularia*, it was probably because he examined it only after decalcification.

b. Forms known only in a fossil state.

Of these only the lime-spiculæ with the spores were known for a long time. These, however, are sometimes several together, when also the remains of the partition-walls of the chambers are preserved. But quite recently a form belonging here or to *Chalmasia* with complete caps and fragments was found by Andrussow and described by him as *Acetabularia miocenica*. In placing it in the genus *Acicularia* it cannot retain this specific name, since an *Acicularia miocenica*, Reuss, exists already. It may therefore be called *Acicularia Andrussowi*. The spores have vanished in all cases from the spiculæ of the fossil *Aciculariæ*, and cavities usually opening outwards mark their places. These holes are either equally distributed all round the spiculæ or they are present only on the upper and under surfaces. The species of the former kind are equivalent to d'Archiac's genus *Acicularia*, those of the latter to the genus *Briardina*, Mun.-Chalm., as kindly communicated to me in writing by Munier-Chalmas. I am doubtful whether it be expedient to separate both groups generically on so slight a distinction. From the fragments I have seen and Carpenter's figures I perceive that *Acicularia* contains a large number of fossil species, and among them some of those treated of by Carpenter fall under the type *Briardina* (compare his plate 29. fig. 11). I must refrain from a description of these, owing to the scarcity of material at my command. It is to be hoped that Munier-Chalmas himself will deal with them at no distant date. Only those species can be mentioned here that have obtained a place in the literature of the subject, and it must be expressly stated that their position in the genus *Acicularia*, as understood here, is by no means certainly determined. The mere spiculæ of *Halicoryne* of the type of *H. spicata* would be, were they fossil, indistinguishable from those of a true *Acicularia*, though they come from a plant of wholly different structure, and from the constitution of both the species of *Halicoryne* it appears not to be impossible that at an earlier period there may have existed also *Chalmasiæ* with clustered spores, which in that case would come under the parent genus *Acicularia*.

2. ACICULARIA ANDRUSSOWI, Solms.

Fertile discs circular, flattened, with up to 90 peripheral, very narrow ray-chambers with obtuse ends. The partition-walls dividing the chambers extraordinarily thick, sometimes as broad as the chambers themselves, sometimes a little less. Spore-cavities in two rows on both the upper and under sides of the spicula, filling the chambers. Corona superior and inferior, according to Andrussow, in the form of flat bands. (Plate III. fig. 13.) *Acetabularia miocenica*, Andr. In the Miocene (2nd Mediterranean bed) of the Crimea, singly in the Tschokkrak lime of the peninsula of Kertch, rock-forming in white lime with

Ostræa digitalina, *Pecten Gloria-maris*, Bryozoa and Serpulæ in the ravine of Karanj, not far from the Monastery of St. George, south of Sebastopol.

3. ACICULARIA MIOCENICA, Reuss, in Sitzber. d. k. Akad. d. Wissensch., Math.-nat. Cl. Bd. xliii. Abth. 1 (1861), p. 7, figs. 5–8 d.

Spicula wedge-shaped, obtusely round at outer margin, pressed flat, consisting of two layers of roundish spore-cavities; spore-cavities on the two sides almost wholly wanting, surrounded by a circular wall.

In the Miocene beds of the district of Vienna (Nussdorf), in the Transylvanian Tegel at Lapugy, in the Salzthon [Permian] of Wieliczka, abundantly in the Leithakalk of Kostel in Moravia.

This species is extremely like the recent *A. Schenckii*, but may be sufficiently distinguished from it by the more flatly compressed spiculæ and the almost total absence of the open spore-cavities on sides of the partition-walls.

4. ACICULARIA PAVANTINA, d'Archiac, Description géologique du Département de l'Aisne, Mém. de la Soc. géol. de France, vol. v. pt. ii. 1843, p. 386, t. 25. fig. 8.

Spicula wedge-shaped, deeply emarginate in two lobes at the outer edge, of round or oval section: spore-cavities narrowing wedge-fashion towards the centre, opening outwards equally all round without a wall-like border.

Michelin, Iconogr. zoophytologique, p. 176, t. 46. fig. 14; Reuss, loc. cit. figs. 1–4. *Ovulites Pavantina*, d'Orbigny, Prodr. de Paléont. stratigraphique, ii. p. 405, no. 1292; Pictet, Traité de Pal. édit. ii. vol. iv. p. 484; Bronn, Lethæa geognostica, ed. iii. vol. iii. p. 259.

In the Eocene of the Paris basin; Grobkalk [Middle Eocene] of Pisseloupe at Pavant, Étréchy at Étampes.

In the characters described this species departs from the recent species much more than *A. miocenica*. With reference to the peculiar pointed converging form of the spore-cavities I am unable to express an opinion, since I have seen only one complete spicula in the possession of Prof. Steinmann, of Freiburg, and I have not seen cross fractures.

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EXPLANATION OF THE PLATES.

PLATE I.

- Fig. 1. *Acetabularia crenulata*, Lamour. The fertile shoot with several caps cut in half vertically; on the corona of the highest the branched hairs still remain. Between each two caps there is a whorl of scars which had borne a sterile crown of hairs. Slightly magnified.
2. Ditto. Apical view of the corona superior, with two hair-scars, one behind the other, on each portion. ×.
3. Ditto. Longitudinal section of a ray of the cap, showing the vestibule and the prominences of the coronæ superior and inferior, the former provided with hair outgrowths: *a*, the central portion of the disc: *b*, the sporangium. ×.
4. *Acetabularia mediterranea*, Lamour. Longitudinal section of a cap during development. At *a* the globular, raised apex of the shoot; at *v* the vestibule, of which the partition-wall towards the ray has been formed; at *b* the portion of the corona superior with developing hairs, below which, and without doubt laterally, the sporangium *c* begins to shoot out. ×.
5. Ditto. Longit. section through a ray of an almost mature cap, showing vestibule, coronæ superior and inferior: *a*, the central portion of the disc; *b*, the sporangium. ×.
6. *Acetabularia Kilneri*, Agardh. Side view of two cap-rays, showing the peculiar thickenings characteristic of the species. ×.
7. *Acetabularia mediterranea*, Lamour. Longit. section of young cap during development of sporangium. This (*a*) has already pressed the apex and the portion of the corona superior into a lateral position; *b*, the corona superior; *c*, the central portion of the disc. ×.
8. Ditto. Longit. section of a very young cap which scarcely shows the differentiation of corona and sporangium. ×.
9. *Acetabularia Suhrii*, Solms. Corona superior from above. ×.
10. *Acetabularia caraibica*, Kütz. End of sporangial ray filled with spores. ×.
11. *Acetabularia dentata*, Solms. Ends of two cap-rays. ×.
12. *Acetabularia mediterranea*, Lamour. External view of the cap during development. (From the same specimen as fig. 8.) ×.
13. *Acetabularia Suhrii*, Solms. Disc seen from below: at *a*, the vestibule; at *b*, the corona inferior; at *c*, the sporangia.

PLATE II.

- Fig. 1. *Acetabularia exigua*, Solms. Side view of a complete decalcified specimen. ×.
2. *Acetabularia Peniculus*, R. Br. Longit. section of a specimen with two caps, one above the other; of which the lower one is anomalous in producing on its branches secondary caps of more or less completeness; *a* represents their sporangia. ×.
3. *Acetabularia parvula*, Solms. View of the corona superior from above. ×.
4. *Acetabularia exigua*, Solms. View of the cap from above. Only the bases are drawn of the sporangia and of the hairs in the coronal prominences. ×.
5. *Acetabularia parvula*, Solms. Cap seen from above, showing the abundant calcification of the partitions between the rays. ×.

6. *Acetabularia Peniculus*, R. Br. Longit. section of a ray : *b*, the vestibule ; *c*, the central portion of the disc ; *d*, the coronal process with one of the two transversely placed hair-sears ; *a*, the sporangium. ×.
7. Ditto. A cap-ray seen from above ; lettering as in fig. 6. ×.

PLATE III.

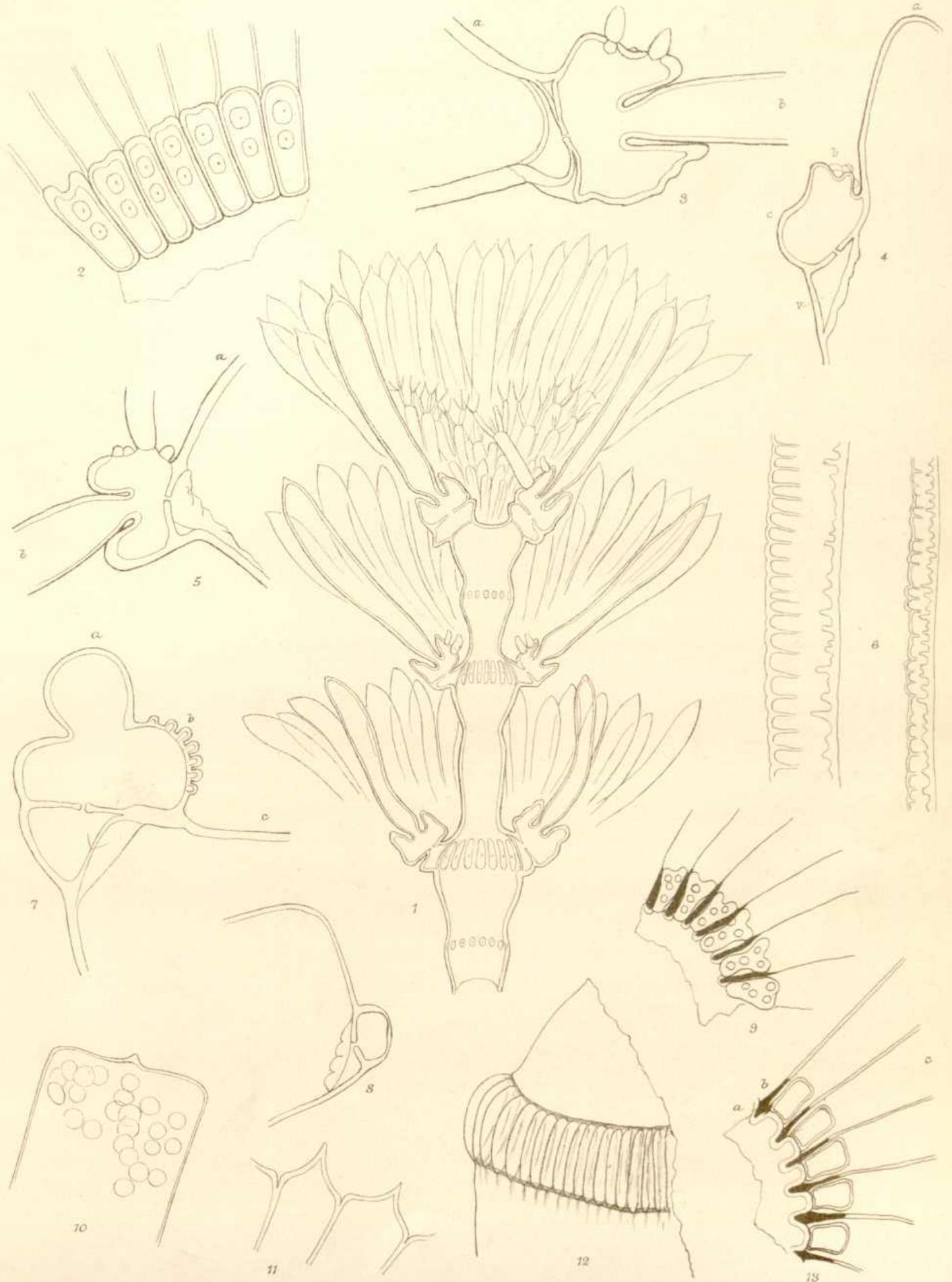
- Fig. 1. *Acetabularia Farlowii*, Solms. View of the fertile cap. ×.
2. *Chalmasia antillana*, Solms. View of the corona superior from above. ×.
 3. Ditto. View of the cap. ×.
 4. *Acicularia Schenckii*, Möbius. View of the corona inferior from lower side of cap ; at *a* transverse section of the stalk. ×.
 5. *Chalmasia antillana*, Solms. A cap-ray in profile : *a*, the cut-off sporangium ; *b*, the coronal prominences ; *c*, the central portion of the disc. ×.
 6. *Acetabularia Calyculus*, Quoy et Gaimard. Profile view of cap-ray full of spores : *a*, the sporangium ; *b*, the corona superior ; *c*, the corona inferior ; *d*, longit. section of wall of stalk. ×.
 7. Ditto. View of corona superior from above. ×.
 8. *Acetabularia exigua*, Solms. Emptied gametangia, showing the lid apart. ×.
 9. *Acicularia Schenckii*. Fragments of spore bearing lime-spicula : in several spores the lid is visible as a circular line. ×.
 10. *Acetabularia Calyculus*, Quoy et Gaim. Part of cap from below, showing the corona inferior. ×.
 11. *Acicularia Schenckii*, Möbius. Profile view of cap-ray. ×.
 12. Ditto. View from above of corona superior. ×.
 13. *Acicularia Andrussowii*, Solms. Surface view of the marginal portion of a fertile cap ; in each chamber a lime-spicula with two rows of spore-cavities. ×.
 14. *Acicularia Schenckii*, Möbius. View of group of plants growing on a shell—brought from Brazil by Schenck.
 15. Ditto. Uninjured lime-spicula from the cap-ray, with its spore-cavities. ×.

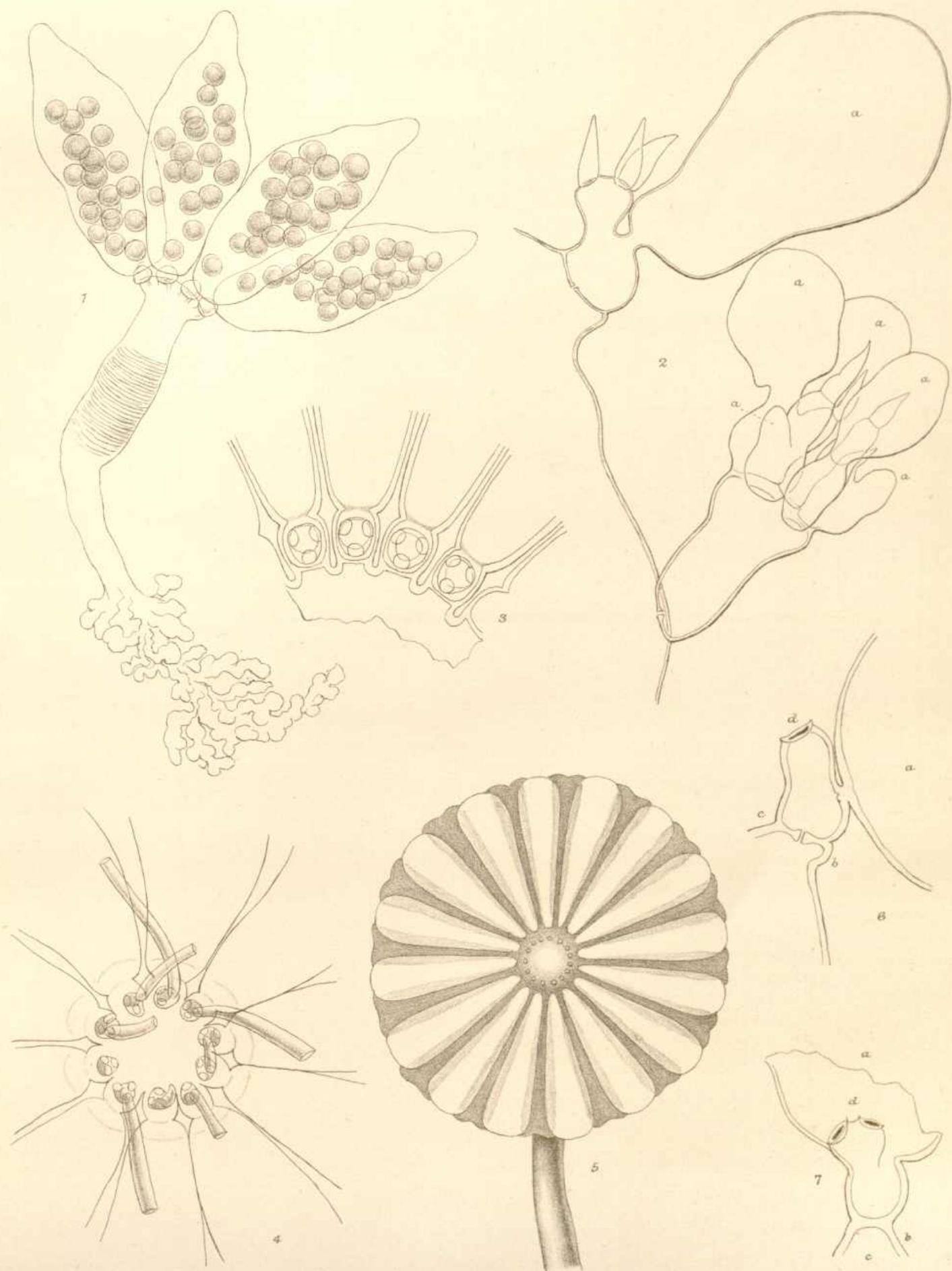
PLATE IV.

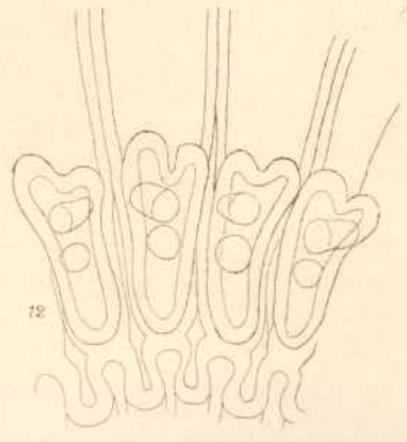
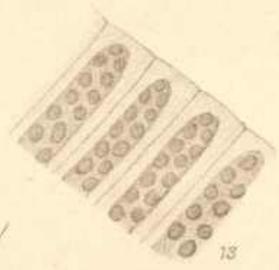
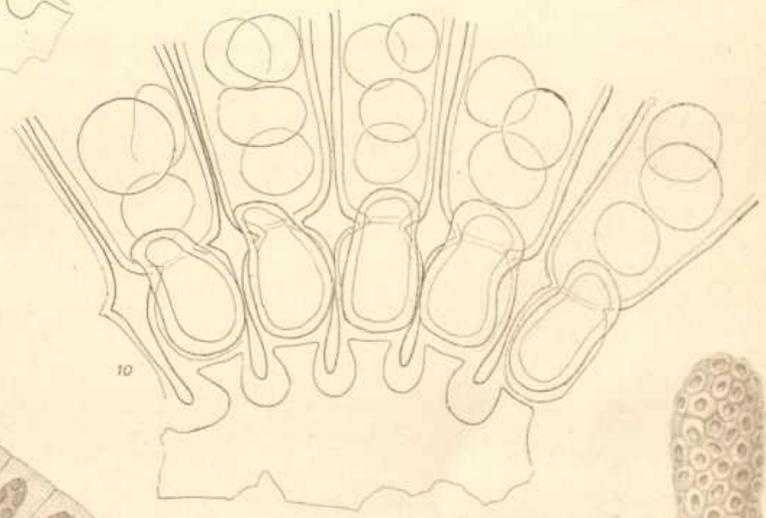
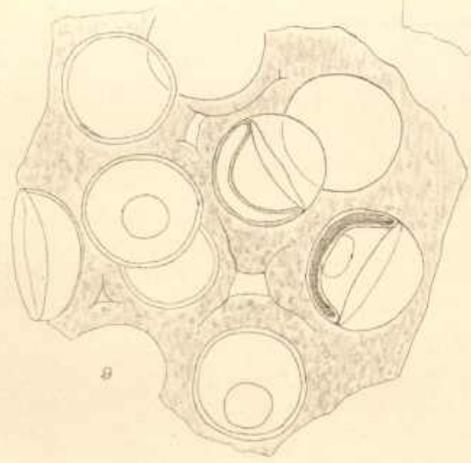
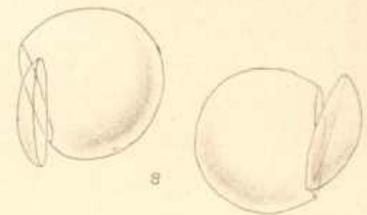
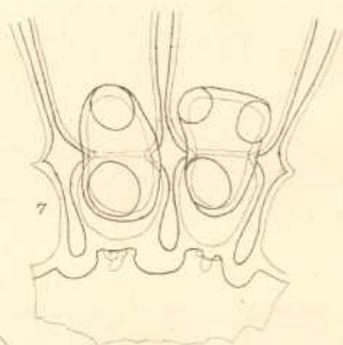
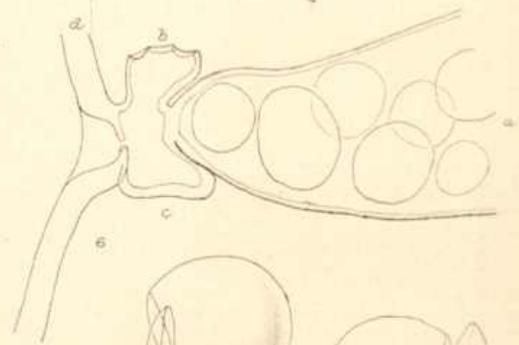
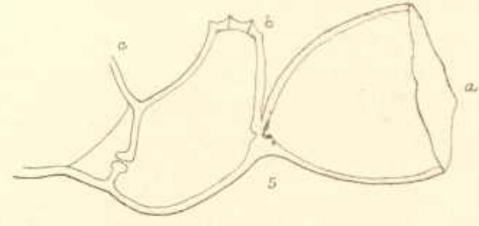
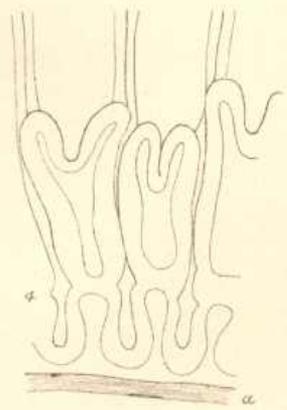
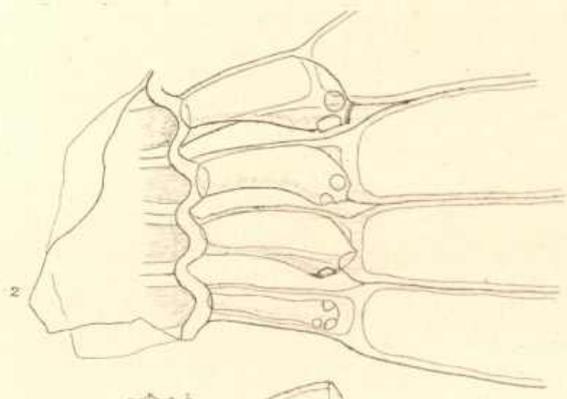
- Fig. 1. *Acetabularia Möbii*, Solms. Longit. section of a specimen with two superposed caps. From a spirit-specimen collected by Möbius at Mauritius. ×.
2. *Acetabularia polyphysoides*, Crouan. Side view of the corona superior. ×.
 3. *Halicoryne spicata*, Kütz. Chalk-spicula containing spores taken out of sporangium. ×.
 4. *Halicoryne Wrightii*, Harv. Profile view of the fertile whorl : *a*, the sporangium ; *b*, the coronal prominences ; *c*, the basal portion.
 5. Ditto. View of the apical region of a young plant from a dried specimen (from Maetan, Philippines, collected by 'Challenger' Expedition) in the British Museum. Sterile hair-bearing and fertile whorls regularly alternating. The hair-whorls situated above are not drawn in so as to permit the main axis to appear. This terminates in a cupola-like apex above the youngest hair-whorl.
 6. *Acetabularia polyphysoides*, Crouan. Profile view of a cap-ray from a dried plant (whence the collapse of the sporangium) ; *a a b*, corona superior : *c*, the central portion of the disc. ×.
 7. *Halicoryne spicata*, Kütz. Single spore after decalcification, showing the thick stratified cell-membrane and the lid. ×.

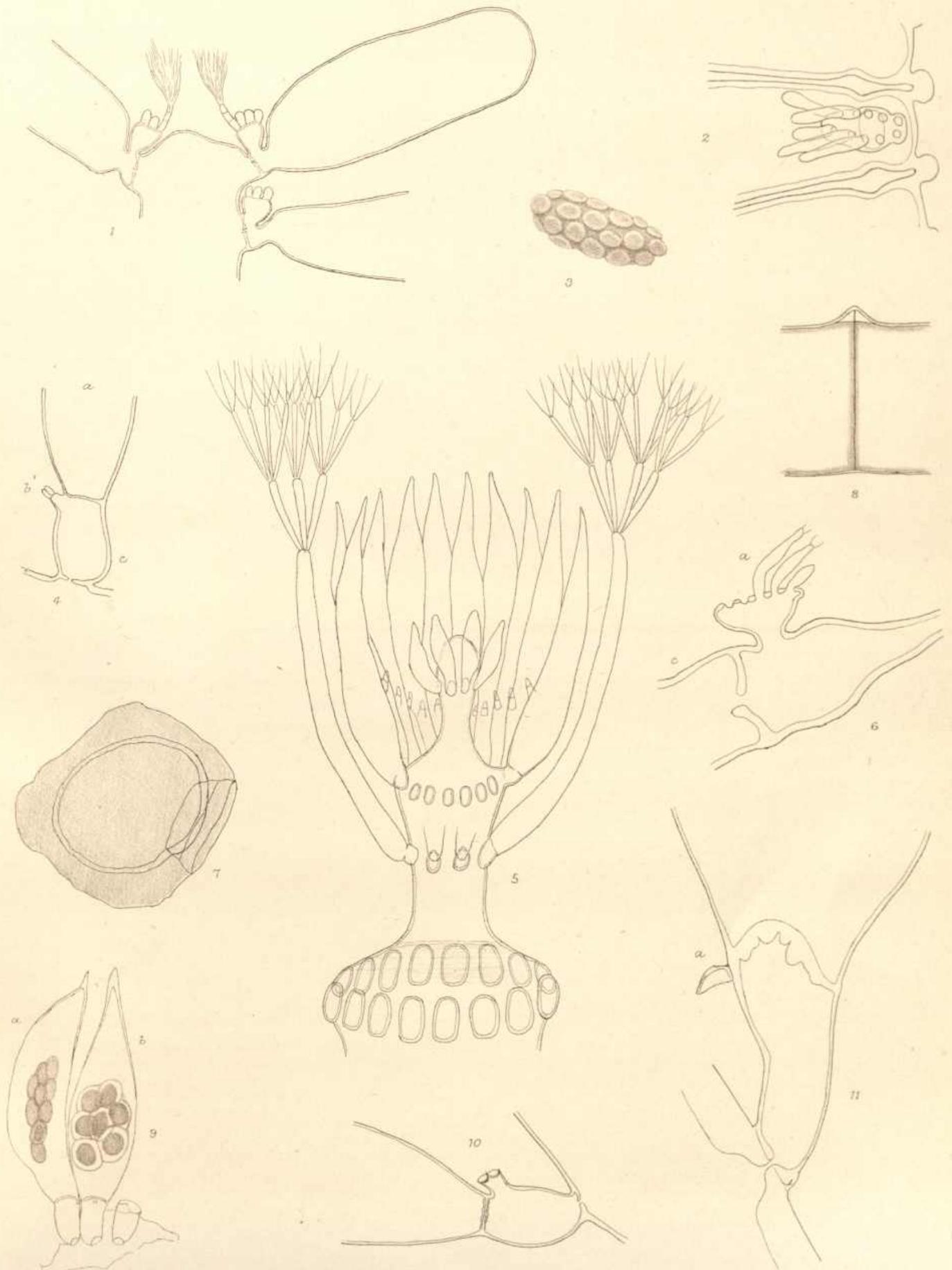
8. *Halicoryne Wrightii*, Harv. Transverse section of the spore-membrane through the edge of the lid, after careful decalcification, drawn without a prism and very strongly magnified.
 9. *Halicoryne spicata*, Kütz. Fragment of a fertile whorl with two complete rays, of which one, *a*, is seen obliquely from the side, the other, *b*, from above. ×.
 10. *Halicoryne Wrightii*, Harv. Similar view as fig. 4; same lettering.
 11. *Halicoryne spicata*, Kütz. Basal portion of a ray from a fertile whorl with a hair-rudiment, *a*, preserved, marking the position of the coronal prominence, which is not visible.
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[*Note to p. 12.*—Whilst this paper was passing through the press, I received from Professor Cramer a memoir on *Halicoryne Wrightii* [7] in which the facts are correctly stated, so far as the yet unfruiting plant is concerned. He found solitary dichotomously-branched hairs on the coronal prominences; in my specimens these were all uniformly reduced to small unbranched processes.—*May* 20, 1895.]









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