attacks, which increased until his death. He was never perfectly well after 1835, and his strength was so much exhausted that the progress of the dropsy, which from the month of June rapidly increased, could no longer be opposed with effect. He died at six o'clock in the evening of the 9th of September [1841], having lost his consciousness several hours earlier.

By his will of the 20th of February of the present year [1841] he left his library and his collection of plants to his son, with the condition that they should be open, as before, to the inspection of botanists, as if in a public establishment, and that students should have the use of them until the end of their term of study. The filial devotion of the son has made the fulfilment of these conditions a sacred duty. Many distinguished botanists have promised their aid for the completion of a work which transcends the powers of any individual. DeCandolle bequeathed to the Society of Natural History of Geneva the sum of 2400 francs, the interest of which is to be distributed in prizes for botanical monographs. The right of publishing new editions of his 'Théorie Elémentaire' and of his 'Organographie,' he left to his friend and scholar Guillemin* in Paris; the same right with regard to the 'Flore Française' and the 'Essai sur les Propriétés Médicales des Plantes,' he bequeathed to Prof. Dunal in Montpelier.

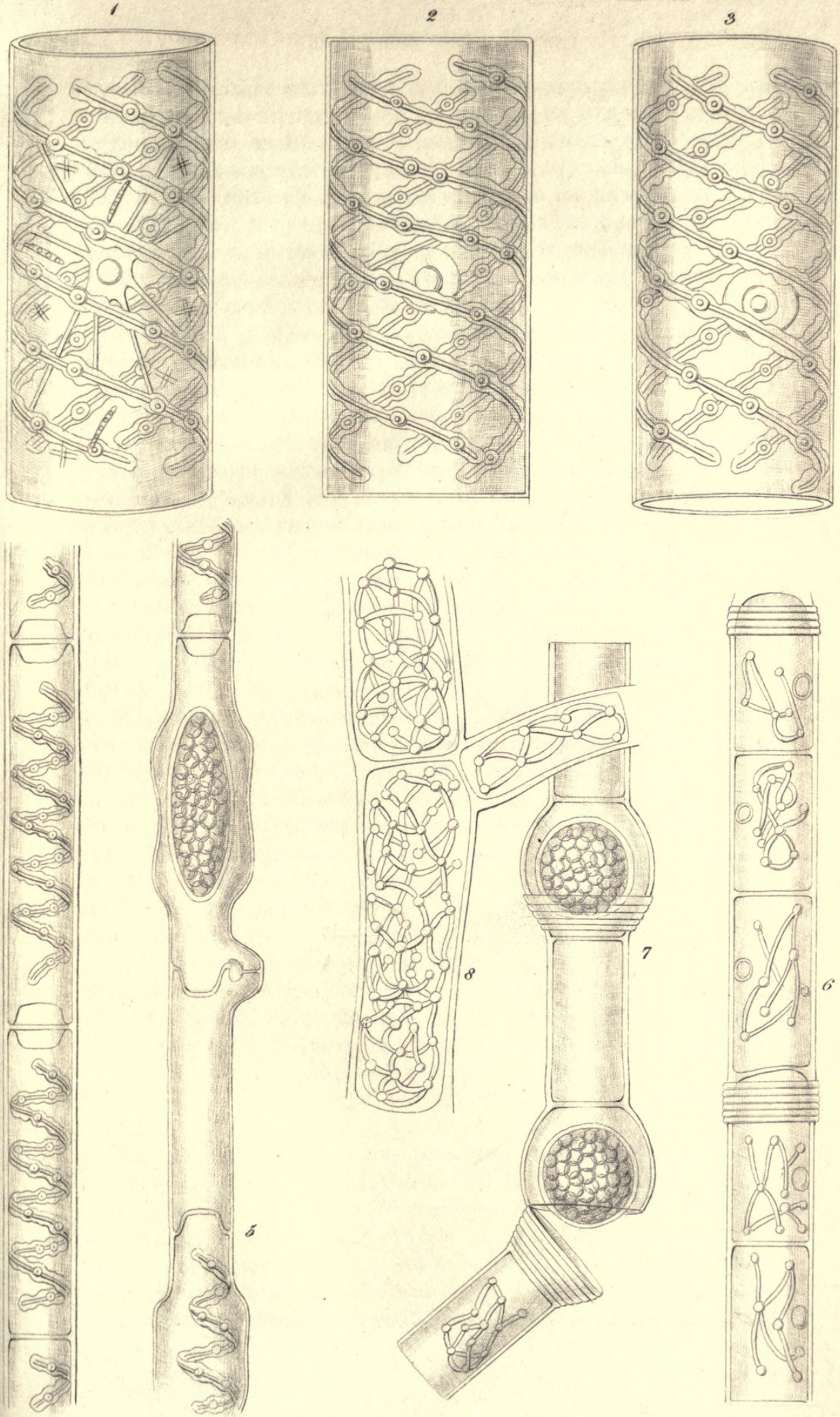
This is the image, in its essential features, of one of the most excellent men which the century has presented to receive the honours of science. In botany, that CANDOLLEA, the Australian shrub to which Labillardière has affixed his name, is not required to keep him fresh in the memory of his botanical associates: he has inscribed his own name on every page of the system of plants. Neither does posterity require the monument which his native city proposes to erect to his memory, nor the new "*Rue DeCandolle*" next to the botanical garden in Rochelle, in order to say how great has been the influence of DeCandolle in our time. *Exegit monumentum ære perennius.*

II.—*Observations on some Points in the Anatomy and Physiology of the Freshwater Algæ.* By ARTHUR HILL HASSALL, Esq.

[With a Plate.]

On Cytoblasts in the Algæ.—From the high development of the cells of many Algæ, both marine and freshwater, as well as from their extreme transparency in many species, it might have been supposed that the first discovery of those curious organs termed

* [This favourite pupil did not live even to commence the undertaking thus committed to his charge: he died early in the spring of 1842.—A. G.]



A.H. Haßall del.

J.D.C. Sowerby sculp.

cytoblasts, which exercise an influence so mysterious on the development of cells, and whose presence in cellular structure is so constant as to lead to the suspicion that the association of the two organisms is universal, would have been made in this extensive tribe of Nature's exhaustless works; so far however from this being the case, they have not as yet, from what I can learn, been noticed in any species of Alga; a description of them therefore, as they occur in two genera of freshwater Confervæ, *Zygnema* and *Vesiculifera*, cannot fail to be of interest.

In the first of these genera, *Zygnema*, their structure is exceedingly complicated. Each cytoblast is solitary, and usually occupies a central situation in each cell of a *Zygnema*. It consists generally of two membranes, but sometimes there are three; the innermost of these being either circular or elliptical (the form varying with the species itself as well as its condition) and presenting a nucleated appearance, and all are separated from each other by distinct intervals which are filled with fluid. The surface of the inclosed membrane or membranes is smooth, while that of the external is rendered irregular by the giving off of numerous tubular prolongations or radii which terminate in the spiral threads formed by mucous endochrome and large bright granules, which I regard as the unfertilized zoospores (Pl. I. fig. 1).

Wishing to have a corroboration of my views respecting the structure of the cytoblastic organ described above, and also to learn as much respecting its anatomy as possible, I forwarded a specimen of *Zygnema nitidum* to that able and most obliging observer J. S. Bowerbank, Esq., whose opinion of its structure exactly coincides with my own, that gentleman having in particular satisfied himself of the tubular nature of the prolongations sent off by the external membrane, and of their termination in the spiral threads.

The structure of this curious organ explains with apparent satisfaction one of the offices which it is destined to discharge, viz. that of a laboratory or *stomach*, in which the materials necessary for the growth and vitality of the cell and its contents are received and digested, and from which they are conveyed by means of the tubular radii to those organs by which the materials are to be assimilated.

The cytoblast, therefore, is at first fixed in the centre of the cell by the prolongations which proceed from it; but it happens, that at a certain epoch these radii disappear, and then the cytoblast floats freely within the cavity of the cell; the disappearance of the rays, the cessation of the growth of the cells, and the assumption of the characters of reproduction being almost contemporaneous, or, at any rate, events immediately consecutive on each other, and

the two latter being readily accounted for by the disappearance of the radii (Pl. I. fig. 2 and 3).

The circumstance of the increased development of the cytoblastic body, subsequent to the removal of the radii, gives weight to the opinion that this organ has yet another office to perform in addition to that of presiding over the growth of the cells; for were it not so, it might be expected that on the disappearance of the rays it would shrivel up and at length become absorbed, as is the case with other organs, their allotted duties having been performed; and the office which I would attribute to it is one even of more importance than that previously remarked upon, it being no other than the fertilization of the brilliant granules entering into the formation of the spiral threads, and which I regard, as before noticed, as the unfertilized zoospores.

But it may be asked, if this be so, what is the purpose of the union of the filaments of the *Conjugatæ* and intermingling of the contents of two cells, phænomena which present themselves so frequently amongst the Confervæ? This question is not unanswerable; but whether the answer now to be given shall be deemed satisfactory, must depend upon future observation.

It may be that the combination of the material of two cells is necessary in the cases where true spores are to be found, although it would appear that no such combination is requisite in those Confervæ whose sole mode of reproduction, as in the greater proportion of the branched species, is by means of zoospores, fertilization in these being effected by means of the organ described in this paper.

But I must confess, that from circumstances which have recently come to my knowledge, and which I hope to be enabled to make the subject of a detached communication ere long, my faith in the existence of a double mode of reproduction, viz. by true spores and by zoospores in some Confervæ, has been considerably shaken, and my present belief is, that the only method which exists is that by zoospores; in which case the commingling of the contents of two cells, and the formation of large spherical or elliptical bodies furnished with membranes by such commingling and union, might be thus explained. The combination might be regarded merely in the light of an act of œconomy on the part of nature, whereby a saving of organization is effected, and the bodies themselves as so many sporangia filled with zoospores.

The adoption of the view which supposes the fertilization of the reproductive bodies by means of the organ whose complicated anatomy has been dwelt upon, would have the effect of removing some grand difficulties in the way of the complete understanding of these most interesting productions. Thus, first, by furnishing a definite organ whereby fertilization is occasioned, it removes

the inability which has hitherto been felt to explain in what way the intermingling of bodies in all respects so similar in organization and appearance as the bright granules of the Confervæ seem to be, can be regarded as giving origin to fertility; secondly, it does away with the anomaly, which has always appeared to me so strange, that a combination of the matter of two cells should invariably take place in certain divisions of the Confervoid tribe of productions, while in other divisions of the same tribe, which could not be supposed to differ fundamentally from the former, no such phænomenon has hitherto been recognised, by showing that this combination is not an essential to the perpetuation of the species; and thirdly, it explains the permanence of species which have perished before union of the endochrome and formation of spores have taken place.

I do not wish to assert that the above opinions rest in their entirety upon conclusive facts, but would merely remark that they are opposed to no known established fact in the history of the Confervæ, and that instead of adding to the difficulties which envelope some points in the physiology of these productions, they have the advantage of removing several obscurities. Their true value must however be developed by extended observation*.

I have detected cytoblasts in numerous *Zygnemata*, but the best species in which to examine them are the larger kinds, such as *Zygnema maximum*, *Z. nitidum* and *Z. belle*. Of the genus *Vesiculifera* I have also found it in several species: they cannot always be seen in these, owing to the cells not being transparent; I doubt not however but that they are general in it as well as in other genera of Algæ, whether marine or freshwater. For its appearance in this genus, see Pl. I. fig. 6.

In conclusion it may not be out of place here to observe, that Mr. Bowerbank was enabled to detect in the *Zygnema* which I transmitted to him, *Z. nitidum*, two other minute organs, both of which I have since myself more than once observed; the one

* Since the above passage was written I have several times encountered a *Zygnema*, in which all the spores are formed without either union of the filaments or commingling of the contents of two cells; that is, they are formed separately in each cell. This observation, the accuracy of which does not admit of the slightest doubt, is therefore, in a high degree, corroborative of the opinion that the central organ in each cell of *Zygnema* and other Confervæ is that by which fertilization of the zoospores is effected. To this species I have given the name of *Z. mirabilis*. In a species of the genus *Mougeotia*, *M. notabilis*, spores are also formed in each cell. Another fact may be here alluded to, which confirms in a manner no less strong this opinion, which is, that although the filaments of *Mougeotia genuflexa*, *M. compressa* and their allies conjugate even without the intervention of transverse tubes, yet *no transference of endochrome ever takes place and no formation of sporangia occurs*. This curious particular is the result of continued observation for two successive years.

is cruciform and adherent to the interior wall of the cell. It, Mr. Bowerbank remarks, is probably the vegetable structure which secretes the raphides. The other body is small, elongated, somewhat curved, and attached to or lying upon the plant. This, Mr. Bowerbank observes, is certainly a "string of minute cytoblasts; and similar bodies, but more curved, are observed in the soft parts of the young lips of shells, both land and freshwater." More than one of each of these organs may be found in each cell. For representions of these see fig. 1.

The Rev. M. J. Berkeley has kindly favoured me with an abstract of a paper by Hugo Mohl on the genus *Anthoceros*, published in 1839 and inserted in 'Linnæa,' vol. xiii. p. 273, in the cells of which an organ occurs bearing a considerable external resemblance to the radiated structure met with in the cells of *Zygnema*.

The following is a brief outline of the mode of formation of this structure in the genus *Anthoceros*. When an immature cell of one of the species of this genus is examined, a portion of its interior is seen to be occupied by a layer of green granules, through which may be seen a cytoblast, the other portion of the cell being colourless. Treated with iodine, the layer formed by green granules, as also the colourless part of the cell, becomes yellow, showing that the whole is really lined with a sort of quasi membrane. Gradually the green layer becomes concentrated into two masses, which commence to advance more and more towards the middle of the cells, and the edges of these masses spreading in various degrees over the inner wall of the cell, leave intervals of various sizes, which give to them a cellular appearance. "The nucleus or cytoblast," Mohl observes, "has no part in this formation. Frequently it is so concealed beneath the green granular mass that it cannot be seen without some trouble; sometimes it lies near to or between both divisions of the green mass and then more easily comes into sight, but at the same time it is observable that it remains unaltered and is foreign to the whole of the slimy structure described above. The latter seems only so far to have a relation to it, that its point of concentration is always at the place where the nucleus lies, and indeed between it and the walls of the mother cell."

Subsequently, the two masses become divided into four, and the reticulated appearance produced by the spreading of the masses subsides into radii, which are similar in aspect to those emanating from the cytoblast in the *Zygnemata*, each arising separately from the masses and terminating on the inner surface of the cell. Finally, each radiated mass becomes a perfect spore or cell, separated from each other by distinct cellular walls, in which changes similar to those just described take place for the production of

other spores. The great similarity in the structure of the incipient spores in the genus *Anthoceros* with that of the radiated organs in *Zygnema*, would lead to the supposition that they were identical in their nature; so far however from this being the case, I consider that all analogy between them terminates with the outward resemblance. The difficulties in the way of regarding the structure in *Zygnema* as an incipient germ or spore appear to me to be insuperable; for the question would immediately arise, wherefore is it, that since the contents of *two* cells generally go to form a single spore in the genus *Zygnema*, and since this radiated organ is present in *every* cell, that the one is suppressed, while the other is destined to give birth to the future *Zygnema*? Supposing however a satisfactory solution of this difficulty to have been made, still another arises. It is far from being an incontrovertibly established fact, that the elliptical body formed in *Zygnema* by the concentration of the matter of two cells, and usually denominated a spore, does really contain but a single germ. It is far more consistent with known facts to suppose that they are sporangia filled with fertilized sporules; for this is certain, that numerous zoospores are formed within each cell, and which may even be seen through the membrane of the sporangia themselves by the aid of a good glass, these zoospores being also identical with the brilliant granules of the Algæ.

The highly interesting observations of Mohl on the genus *Anthoceros*, the accuracy of which is in no respect questioned by me, do not therefore occasion any modification of the views expressed of the functions of the radiated organ in *Zygnema*.

On Tubular or Vascular Structure in the Freshwater Algæ.—In the genera *Vesiculifera*, *Zygnema*, *Microspora*, and doubtless in many other Algæ, the zoospores up to a certain period of the development are connected with each other, and probably with the central cytoblast, by means of a tubular or vascular network, in the angles formed by which the zoospores are situated. This structure is most manifest in *Conferva crispata* and its allies (see fig. 8), and requires, in order that it may be clearly seen, that the development of the species should be considerably advanced and the zoospores somewhat scattered. It may, generally, however be easily detected in the genera *Vesiculifera* and *Zygnema*: in the latter the tubular formation is not arranged in a reticulated manner, but occupies the centre of each spiral thread (Pl. I. fig. 1, 2, 3). It is by the inosculation of the tubular radii given off by the central cytoblast with this vascular structure that a direct communication is established between that organ and the zoospores: now presuming that the cytoblast in the other Algæ in which it occurs presents at some period of its existence a similar formation to that which it exhibits in the genus *Zygnema*, and adopting the

view before expressed of its office in presiding over the development of the cells, it is clear that this tubular apparatus is designed to facilitate the transmission from zoospore to zoospore of the elaborated nutriment transmitted by the cytoblast. The organic mucus and endochrome, from their appearance and limitation in the genus *Zygnema*, may be supposed to have passed by exudation from the interior of the tubes to their surfaces. See fig. 1, 2, 3.

On the Formation of Spores (*Sporangia*?) *and their investing Membranes.*—The following would appear to be some of the steps in the formation of spores. The material, whether consisting of the contents of one or two cells, out of which each spore is to be formed, first consolidates itself in the centre of those cells in which it is to be elaborated; the zoospores, which continue to increase in size, retire from the surface of the mass so as to leave only organic mucus surrounding them; this then assumes the form of spore peculiar to the species, its surface, lastly, becoming hardened into a compact membrane or membranes.

Observations on the genus Zygnema.

The species of the genus *Zygnema* readily resolve themselves into two divisions or subgenera, which are to be distinguished from each other by the conformation of the cells.

In the first of these subdivisions, which for the most part includes the long-celled species of the genus, such as *Zygnema elongatum* and *Z. quadratum*, &c., the opposed extremities of *all those cells which have attained maturity* are considerably inverted, and which inversion may be compared to that of the finger of a glove (Pl. I. fig. 4); while in the second, which embraces the short-celled examples, as *Zygnema maximum*, *Z. nitidum* and very many others, the cells are not inverted, but touch each other by their plane surfaces.

The form of this inversion is, in all the species in which it occurs, identical and extremely regular, its circumference being circular and its base somewhat flat; no membrane intervenes between the spores formed by this indoubling in contiguous cells, which spaces therefore communicate directly with each other.

At the period of reproduction, and at no other, one of the two indented and opposed extremities of certain cells becomes everted and protruded into the cavity of the other (Pl. I. fig. 5).

The cause of this protrusion, and the reason why it only occurs at the precise period of the reproduction of the cells, are easily accounted for, and both arise from unequal internal pressure of the contiguous cells on each other, which inequality of pressure is produced by the emission of the endochrome of one cell into a neighbouring cell either in the same or different filaments; thus,

when a cell has discharged its contents its cavity is empty, and no resistance can be offered by it to the protrusion of the inverted portion of the adjacent cell or cells, replete as it or they are with fluid and endochrome. This explanation applies likewise to the fact, that when a number of cells have either emptied themselves of their contents or have been the recipients of those of other cells *at the same time* no eversion takes place, for in this case there is no inequality of internal pressure.

But while a correct exposition may be given of the cause of this protrusion and intromission, it is not so easy to offer a satisfactory explanation of the purpose to be attained. The eversion doubtless assists in effecting the dislocation of the cells, and thus, reproduction being perfected, hastening the destruction and dispersion of the species; processes, which, from the greater length of the cells and consequent continuity of the enveloping sheath, would possibly occupy, were it not for some special provision of the nature indicated, a much longer time than in the short-celled species. A subordinate and not unimportant use of this provision is, the assistance which it affords in the determination of allied species.

It is remarkable that no similar conformation presents itself to our notice in the genera *Tyndaridea* and *Mougeotia*, so closely allied to *Zygnema*, for in these the cells terminate by plane surfaces, which however may be either everted or inverted to a slight extent.

This peculiar formation of the cells of some *Zygnemata* was first noticed by me in the spring of 1842, but its true nature only became apparent to me in the early portion of the present year. When viewed through a low power of the microscope, and in a *Zygnema* whose filaments are as yet separate, it exhibits the appearance of two curved knife-blades slightly approximating to each other at their apices, near to which usually lies the divided spiral thread, and strongly impressing the superficial observer, from the position and aspect of these blades, with the idea that they are the instruments which effect its separation, and reminding him of the beautiful provision whereby the section of pollen granules is brought about.

On transmitting a short time since a specimen of the *Zygnema* now figured (*quadratum*), in a state of reproduction, to the Rev. M. J. Berkeley and Mr. Ralfs, but unaccompanied by any remarks in reference to the structure of the cells, both these gentlemen noticed their peculiar conformation, and from the former I received correct sketches of their appearances.

The structure of the joints in *Zygnema* was long since noticed in one species of the genus by Mohl, who thus describes it in his paper upon the multiplication of cells by division inserted in the

'Flora':—"In *Z. elongatum*, Ag., the dissepiments have a very peculiar structure, which I have found in no other species. The terminal surface of each cell is not even, but elongated into a blunt conical process. This process can only be observed in its true state when two joints are separated one from the other; when, on the contrary, the threads are unbroken the process is generally introverted like the finger of a glove, and exhibits the form represented at Pl. I. fig. 8. *a, b, c.* This is the common condition, and in most threads no joint is found otherwise constructed. But I have now met with a single thread in which a part of the articulations have the ordinary length, while another part has joints only half as long. In these shorter articulations it was normal that only the alternate dissepiments had the structure peculiar to this species (so that by these dissepiments the thread was divided into articulations of the ordinary length), while, on the contrary, the intermediate dissepiments exhibited the form usual in Confervæ*."

The observation, that "this process can only be observed in its true state (that is, everted) when two joints are separated the one from the other," is inaccurate, for the cells may be separated and yet the processes inverted, the eversion of them having nothing whatever to do with the separation of the cells, and never being in any case the result of it, but depending, as explained already, upon unequal internal pressure, and occurring chiefly at the period of reproduction. The effect of the eversion is, as already observed, to occasion the dislocation of the cells.

Again, in every filament of those *Zygnemata* which exhibit the inverted structure, cells may be observed terminating in the ordinary manner of Confervæ, viz. by plane surfaces, the presence or absence of the inversion depending upon the period of the formation of the dissepiments; the older ones, or, as observed in the beginning of this notice, the more mature ones only presenting it. Thus it follows that the *opposed extremities* of cells always exhibit the *same* structure, and that this alternation in form supplies evidence the most conclusive of the multiplication of cells throughout the *entire filament* of a Conferva by division.

Observations on the genus Vesiculifera.

The genus of freshwater Confervæ which I have denominated in a previous article *Vesiculifera,* in addition to the characters indicated in the definition of it given therein, such as the attachment, attenuation and slight mucosity of the filaments of the species composing it, as well as the formation of true spores by the intermingling and union of the contents of two cells in the same

* Flora, 1837, vol. i. p. 29.

filament, is particularly distinguished by the presence of a peculiar and regular annulation of the enveloping membrane of the cells, which would appear at a certain epoch to be intimately adherent to the tissue of the cells themselves (Pl. I. fig. 6).

This annular disposition of the sheath of the cells does not occupy its whole extent, but corresponds only to certain cells and determinate portions of those cells; the cells around which it is disposed being those in which the spores are destined to be formed, and the portion of these which it invests being the extremities through which no endochrome passes from the contiguous cells for the formation of the true spores, or rather perhaps sporangia.

The number of annuli which correspond to each fructiferous cell varies considerably according to the species, and is more considerable in the long-celled species; it would appear however to be never less than two, or more than eight or ten.

The use of this interesting structure is much more apparent than that of the provision already noticed as belonging to one section of the genus *Zygnema*, and admits of a most satisfactory explanation, it being manifestly designed to afford an outlet to the imprisoned spores, which it may be supposed to do in the following way. As soon as the species has reached its maturity and the spores have become perfected, the annuli, which are intimately united to the cells, contract, most probably from the arrest of growth and diminution of vitality of the plant which occur towards the completion of the process of reproduction, drawing along with them, and thus rupturing, the slightly elastic membrane of the cells (Pl. I. fig. 7).

Without some such beautiful and effectual provision, it will be evident, on reflection, that the spores would have to remain immured within their narrow cells for an indefinite length of time, even until, perhaps, their vitality had ceased and the cells had become their coffins; for occupying, as the spores do, but a portion of the space of the cells, and enveloped as they are in membranes, they can themselves, of course, exert no influence in producing the rupture of the walls of those cells.

In all the Confervæ with which I am acquainted, some special means are provided for the escape of the spores or zoospores, their liberation never being left to the sole agency of decomposition of the tissue of these plants; thus, in the majority of the branched Confervæ, and in the species of the genus *Sphæroplea* as well as in many other Confervæ, their liberation is effected by the rupture of the cells in which they are contained, which rupture is occasioned by the development of the zoospores while still inclosed within the cells; in *Conferva* (*Microspora*) *glomerata* a special aperture exists for the escape of the zoospores at the period of re-