## IX.—Report on Sexuality in the Lower Cryptogamia.

It was at first intended in this Report to have recapitulated the principal discoveries with regard to sexuality in the Cryptogamia generally; but two reasons suggested themselves against the adoption of this course:—one was the great length to which the report must have been extended; but the other and principal reason was, that the main facts with regard to the sexuality of the Higher Cryptogamia are already accessible to the English reader in the Report of the late Professor Henfrey to the British Association in the year 1851, and in the translation of Dr. Hofmeister's Treatise on the Higher Cryptogamia, published by the Ray Society in 1862.

This Report has, therefore, been limited to what are usually styled the Lower Cryptogamia, viz., the Lichens, Fungi and Algæ.

The Lichens may be disposed of in a few words—for our knowledge as to their sexuality may really be said to be *nil*. The function of the small bodies called "*spermatia*," (which are so very generally present in special conceptacles on the thalli of Lichens), does not appear to be fecundative as has been supposed by some botanists; and the notion of their being male organs is now, we believe, very generally abandoned, although Dr. Stitzenberger, in the Ratisbon Flora for 1862, speaks of them as "männliche Befruchtungsorgane." We must, however, mention Karsten's recent statements with regard to *Cœnogonium Andini*.

At the end of his essay on Parthenogenesisare to be found some observations on the development of the apothecia in that Lichen, which, if correct, would show that the latter originate in a free central cell, contained in an organ similar to the archegonia of the higher cryptogams. This central cell he states to be impregnated in a manner almost exactly similar to what occurs in *Coleochæte* and *Saprolegnia* amongst the Algæ. If Karsten's observations were to be relied upon, the problem of sexuality in the Lichens would have been solved, for it could hardly be doubted that what was alleged to have been seen in *Cœnogonium* would speedily have been discovered in other Lichens, when observers were put upon the track. Karsten's observations, however, have not been confirmed by any other botanist; and Dr. Schwendener, in the Flora for 1862, meets them with a positive contradiction. We have not space to give more than Dr. Schwendener's concluding remarks; but he says: "Whether the

"mother-cells of the spores or some other cells are impregnated, is a "question still unsettled, and which will probably occupy many an "observer until the right solution is arrived at. As matters stand "at present, however, the assumption of an impregnation of the "young asci is the most probable one. It is easily seen that in many "apothecia, tolerably wide canals lead down from the upper surface "of the *lamina proligera* to the apex of the asci; and moreover, "that the membrane of the older asci exhibits at this spot (which is "usually thickened and gelatinous), a pore, which traverses the inner "layers, extending often as far as the so-called primary membrane. "May it not be suspected that these circumstances have some con-"nexion with the impregnation?"

We cannot venture to say yes or no to this inquiry: the question remains an enigma for Lichenologists, and we now pass on to the consideration of the Fungi.

The speculations as to the existence and nature of the sexual organs of Fungi have been numerous, and of the most various kind. It would be merely a matter of historical curiosity to follow out the different suggestions which have from time to time been made, and we would refer those who wish to acquaint themselves with the literature of the subject to the 9th chapter of Tulasne's "Selecta Fungorum Carpologia." Of all the speculations above referred to, that which held its ground the longest, and which is as old as the time of Micheli, is the theory which attributed sexual functions to the so-called "cystidia," which are large overgrown vesicles occurring upon the gills of many of the Agaricini, as well as upon *Boletus*. The idea of the sexuality of these organs has been supported by Bulliard, and (long after him) by Klotzsch; but of recent writers, Corda has been the most decisive in its favour. He called the organs in question *antheridia* or *pollinaria*, and considered each of them equivalent to a pollen-grain: he thought that a granular fluid emerged from their apices, the diffusion of which stimulated the formation of spores. He was of opinion that the antheridia differed so much in their structure and partial distribution from the paraphyses of the Ascomycetes that the two could not have the same function. Phœbus,* on the other hand, alleges that the cystidia are a peculiar kind of altered paraphyses or basidia, and that although they are more often absent from the Agaricini than paraphyses are from the ascophorous stratum

* Nova Acta, vol. xix. and Deutschland's Kryptogamische, Gift-gewächse.

of the Discomycetes, still that they serve the same purpose of protecting the shorter fertile basidia with which they are mixed. M. de Seynes, in his recent work, "Essai d'une Flore mycologique de la region de Montpellier et du Gard," has some remarks upon the nature of the cystidia which deserve careful consideration. He describes the cystidium as a cell generally larger than the basidium, and which varies much in its form: growing from the parenchyma at the same level, as, or rather below, the other elements of the hymenium, it protrudes sometimes as a simple barren cell of somewhat larger size than the others, sometimes in the shape of a more or less elongated cone, sometimes bearing a small sphere at its extremity, sometimes becoming lageniform. After stating that it is not found in all the Hymenomycetes, nor even in all Agarics, he alludes to Corda's notion of its being a male organ, and then gives his own views as follows. He says: "It is difficult to accept this (Corda's) interpre-"tation. Numerous observations upon these organs, some made "even before I was aware of Corda's hypothesis, lead me to quite "a different conclusion, and I consider these cystidia to be nothing "more than organs remitted to vegetative functions by a sort of "hypertrophy of the basidium. Corda asserts that impregnation is "effected by means of a viscous fluid issuing from these organs; but "if we remark that the instances of this sort of impregnation are "taken from fungi (*Ag. rutilus*, Schæff. *viscidus* Fr., *mucosus*, Bull.), "in which all the vegetative portions are viscous, or have a tendency "to become so in wet weather, we shall see nothing surprising in "the fact of one of their cells having the same property, and thus "becoming attached to the spores: on the contrary, we shall be "rather led to suppose that the cystidia are simple vegetative organs. "In the milky Mycenæ (*Ag. galopus*), which have the organs of "reproduction very different from those of the Lactarii, the cystidia "are identical with those of the Lactarii; in the division Pluteus "they are so like the basidia that but for their size they would be "taken for the latter; being divided at the apex into short horns "they even seem to have retained the sterigmata. In other cases "their form is like that of the cells of the parenchyna; in a new "Agaric (*Ag. sulcatus*, Dun,) I have observed the cystidia forming "small cylinders with a swollen spherical extremity, and this is pre-"cisely the form which the vegetative cells assume in the pileus and "gills. These observations have led me to consider these organs, "which are scattered over the gills, or frequently crowded near the

"margin, as basidia which have become hypertrophied and resumed "the character of vegetative organs, as one sees abnormally a carpel "become a leaf. We are thus brought back to Micheli's first con- "ception, who called them barren flowers, using the terms, however, "in a sense diametrically opposite to his. The cystidia seem to me to "fulfil, with regard to the gills, the same function as the ring does "with the pileus and stipes; these two organs send out prolonga- "tions which bind them together: the gills, organs of the same "nature and contiguous, have a tendency to send out prolongations "to bind one another together. A certain number of basidia obey- "ing this law elongate and are diverted from their primitive function, "but in like manner as the ring may be very much developed, or so "fugacious and rudimentary that its existence may be only just "ascertainable, and may seem to be altogether wanting; in like man- "ner the cystidia may be wanting, or may be so well-developed as to "be visible to the naked eye. In some cases they fulfil this function "of 'ties' so well that in separating the lamellæ of a partially "expanded specimen of *Ag. atramentarius*, Bull., the gills separate "into two longitudinal portions instead of the corresponding faces of "two different gills parting from one another. This phenomenon is "so apparent that Delile, who was ignorant of the cystidia, had "noted the existence of fibrous prolongations binding together the "gills of this Agaric."

In the "Botanische Zeitung" (Vol. xiv. p. 153), Hoffman noticed the occurrence of small corpuscles scattered about the mycelium of certain Agarics. They were said not to germinate, and to be like the spermatia of the Discomycetes and Lichens. They do not, however, appear to be male organs. Tulasne says of them:* "Fecunda si qua vis eis impertitur, saltem in sporis priusquam germinent sicuti docuerunt experimenta ad hoc instituta non exercetur; utrum vero mycelio recenti quodammodo prosint, hactenus prorsus ignoratur."

In the "Botanische Zeitung" for April 5th, 1861, (Vol. xix. p. 89), Dr. De Bary states that he has observed in *Peronospora calotheca* and *P. alsinearum* small curved clavate cells, springing from the mycelium, which press with their upper end against the wall of the large vesicular spore-cells observed by Tulasne and Caspary. He considers these latter cells to be one-spored oogonia,

* Sel. Fung. Carp. Vol. i. p. 168.

and the small clavate cells to be antheridia. The spore-cells in their early stage exhibit an accumulation of granular matter in their interior, not at first clothed by a membrane. As soon as this ball of granular matter is formed, the antheridium emits a delicate prolongation (similar to those of the antheridia of *Saprolegnia*) which pierces through the wall of the oogonium, and reaches the granular ball. The latter then becomes immediately clothed with a delicate, colourless membrane, and thus forms an oospore. The contents of the prolongation are similar to those of the main body of the antheridia, and no traces of spermatozoa are visible. He then describes the production of the outer membrane of the oospore of *P. alsinearum*, which is formed from the surrounding plasma within the oogonium.

Pringsheim's Jahrbücher für wissenschaftliche Botanik, Vol. ii., contains some observations by Hofmeister, with regard to what he considers indications of sexuality in *Tuber*. He noticed that the terminal cell of the delicate threads which surround the ascus in *Tuber*, and which appeared to him to spring from the stalk of the ascus, became firmly united to the outer membrane of the ascus itself. At the point of junction, and sometimes at other points also, he observed a depression in the membrane of the ascus; and he suggests the possibility of the terminal cell being, in fact, an antheridium. In the Selecta Fungorum Carpologia,* the MM. Tulasne, in noticing these observations of Hofmeister, say, "We "remember, whilst studying the Truffles, having often observed "very delicate filaments which adhered so pertinaciously to the asci "that it was difficult to detach them . . . . . what these fila- "ments were, we did not then understand, we now agree with "Hofmeister in looking to *Saprolegnia*† for an explanation of the "phenomenon." De Bary, in his recent work—"Ueber die Fruchtentwickelung der Ascomyceten"—suggests doubts as to the sexual nature of the threads in *Tuber;* but although his doubts may be valid, his reasons for them have not been considered conclusive.‡

Further indications of sexuality have also been suggested by De Bary as occurring in *Erysiphe cichoracearum*, DC. In his work just mentioned—"Ueber die Fruchtentwickelung der Ascomyceten"—he traces the origin of the perithecium of *Erysiphe cichoracearum*,

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* Vol. i. p. 176, 177.

† As to *Saprolegnia*, see the latter part of this Report.

‡ See Nat. Hist. Rev. Vol. iv. p. 231.

DC., from its earliest state up to the formation of the single ascus and spores. In this process he notices two cells as being always present and visible from the earliest period, one of which he calls the "Ei-zelle," and the other the "Antheridium." The former afterwards divides, and the ascus is the result of this division. De Bary admits that the evidence of the sexuality of these organs is not strong. "However," he says, "it is certain that the cell by "the division of which the ascus and its coating are formed, only "develops itself when it has been in contact, and therefore probably "in some sort of intercommunication with the antheridium, which "latter organ is never wanting, is always of the same form and size, "and originates in the same manner." He adduces the Phænogams as showing that impregnation may take place by mere contact, and concludes that it may be assumed as very probable that the "Ei-zelle" is impregnated by the antheridium, and that the perithecium of *Erysiphe* (excepting the outer wall) is the product of sexual impregnation.

We are not aware of any other recent observations with regard to the sexuality of the Fungi; and we pass, therefore, to the consideration of the Algæ, in which family the greatest discoveries in relation to impregnation have been made.

Dr. Cohn, writing in the year 1855, says, "Until last year, few botanists believed in the sexuality of the Algæ;" and although this remark went rather too far, when we consider that Thuret's observations were made in the year 1845, it tends to show how little was known ten years ago in comparison with our present knowledge.

We will notice, in the first place, M. Thuret's observations on the Fucaceæ. It is to him that botanists are principally indebted for a knowledge of the facts relative to sexuality and fecundation in that tribe.* The organs of fructification of the Fucaceæ are enclosed in cavities under the epidermis of the frond, and which open on the surface of the latter by a little pore or ostiolum. These cavities contain two different kinds of organs. The one kind consists of large bodies of an oval form, and an olive colour, attached to the walls of the cavities by a short pedicel. These bodies are in some genera simple, in others are divided into two, four, or eight spores.

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* See Comptes Rendus, t. xxvi. p. 745; Memoires de la Société des Sciences naturelles de Cherlourg, t. i. p. 161; Annales des Sc. Nat. 4 Ser. Vol. ii. p. 197, and Vol. vii. p. 35.

The other organs are small sacs inserted on the hairs which line the walls of the cavities. The sacs contain a number of hyaline corpuscles, enclosing a red granule, which, after their escape from the sac, move rapidly in the water by means of two vibratile cilia. Some Fucaceæ are diœcious, others hermaphrodite. For instance, *Fucus serratus*, L., *Fucus vesiculosus*, L., and *Fucus nodosus*, L. are diœcious, *Fucus platycarpus*, Thur., *Fucus canaliculatus*, L. and *Fucus tuberculatus*, Huds. are hermaphrodite. *Fucus vesiculosus*, L. is the species to which M. Thuret has devoted the most attention, and his account of his observations and experiments is shortly as follows :—An examination of the young female conceptacles of this species shows that the sporangia originate in small protuberances forming the wall of the cavity. These mamillæ, which are at first unicellular, become bi-cellular by the formation of a transverse septum, the upper one of the two cells thus formed becomes the sporangium, the lower one the pedicel. The dark coloured contents of the sporangium at length divide into eight segments, and by the rupture of the sporangium the divided body or "octospore," escapes, enclosed in a hyaline membrane (epispore) which keeps the eight segments closely pressed together. Within the epispore is another extremely delicate membrane extending over the octospore. By the dissolution of the upper portion of the octospore and the rupture of the delicate membrane just mentioned, the octospore becomes free, and separates into eight spherical spores which have no integument. Thus far the observations have reference to the female organs. The process which takes place in the male fronds is very similar. The small sacs or antheridia become detached from the walls of the conceptacle and escape in vast quantities through the orifice of the latter. Shortly after their escape they burst and emit swarms of spermatozoa, which move about in sea water with great rapidity, their motion lasting sometimes for upwards of two days.

When the spores and spermatozoa, are placed in water together, the latter attach themselves to the former in great numbers, and by means of their vibratile cilia communicate a motion of rotation sometimes extremely rapid.* After lasting for a time, but rarely

* M. Thuret does not consider this rotation to be of much importance, for although seen plainly enough under the microscope he thinks it never occurs in nature, and that it is in no way necessary for impregnation. The fact of its

more than half an hour, the rotation ceases: the motion of the spermatozoa lasts somewhat longer, but is less active, and they also eventually become quiescent.

After the spores have been in contact with the spermatozoa the former become clothed with a plainly visible membrane,* and shortly afterwards septa are formed and germination commences. Those spores which have not been in contact with spermatozoa remain unchanged for some days and ultimately decompose. Sometimes a membrane is formed over them, and a kind of imperfect germination commences, but this only lasts for a few days, after which the spores decay in the same way as those in which no membrane was formed.

*Fucus serratus*, L. and *Fucus nodosus*, L. (*Ozothallia vulgaris*, Dene and Thur.) yielded M. Thuret the same results, except that in the latter species the contents of the sporangium form four, not eight spores as in *F. vesiculosus*.

The intermixture of the spores of *F. nodosus* with the spermatozoa of *F. serratus* and *vesiculosus*, and of the spores of the two latter with the spermatozoa of the former yielded no results, although the spermatozoa attached themselves to the spores and produced the ordinary movement of rotation. Neither could the spores of *Himanthelia lorea* be impregnated by the spermatozoa of *Fucus nodosus* or *F. serratus*. The spores of *F. serratus*, could not be fertilized by the spermatozoa of *F. vesiculosus*, but strange to say, on the inverse operation, *i. e.*, when the spores of *F. vesiculosus* were mixed with the spermatozoa of *F. serratus*, the spores germinated. Upon these facts, M. Thuret observes, that *F. nodosus*, *Himanthelia lorea*, and *F. serratus*, are very constant in their form, whilst *F. vesiculosus* is extremely variable, and he thinks it not improbable that the great variability is owing to the facility with which the latter species is

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occurring when spores are examined under the microscope he explains by attributing it to the concentration of a much greater number of spermatozoa than could ever be found in the same space in nature. At the same time he considers the rotation as not altogther accidental, for he found that the spermatozoa of *Fucus* communicated no rotation to some spores of Florideæ, which were small enough, and round enough to have been easily set in motion, and as a matter of precaution in experiments he recommends the application of a sufficient number of spermatozoa, to render the rotation manifest.

* The formation of this membrane, is said to commence six or eight minutes after the contact of the spore with the spermatozoa. See *Deuxième note sur la fecondation des Fucacées*. A. S. N. 4. Ser. Vol. vii. p. 35.

hybridized by its congeners. *F. platycarpus* and *F. ceranoides* exhibit the same variability.

M. Thuret remarks, that he finds nothing to support the supposition of those observers who believe that the spermatozoa effect an entrance into the spore: he has always seen them on the surface, never within the substance of the spore.*

We have next to consider the division of the Chlorospermeæ or Zoosporeæ, in which very important results have been arrived at, principally from the observations of Dr. Pringsheim.

The plant upon which some of his earliest observations were made, was the well-known *Vaucheria sessilis*,† which from the simplicity of its structure offers peculiar facilities for observations of this nature. From the tubular filament of which this plant is composed, two papillæ in close proximity are produced. One of these becomes ultimately developed into a horn-like organ, more or less spirally twisted, in the middle of which, but at no very definite point, a septum is formed, cutting off the apex from the base. The other papilla forms a lateral protuberance, at first symmetrical, but which afterwards throws out a beak-like process (*rostrum*), on the side turned towards the horn. A septum is then formed at the base of this protuberance, cutting it off from the parent tube. After the formation of the septum in the hornlet, minute rod-like bodies are seen imbedded in its colourless mucous contents. In the meantime an internal layer of colourless substance, called by Pringsheim the cutaneous layer, increases to such an extent, especially in the fore-part of the rostrum, that at last the membrane of the latter is ruptured, and a portion of the cutaneous layer escapes.

Just at this period the horn opens at it apex, and the contents escape in the form of very minute rod-like corpuscles, which enter the orifice of the sporangium, and penetrate the portion of the cutaneous layer which remains. After this a membrane is formed around the contents of the sporangium (which were previously bare), and thus a *cell* is formed, which completely fills the sporangium—the embryonic cell of the plant. This embryonic cell, which is at first green, becomes colourless, with one or more dark-brown bodies

* See Ann. des Sc. Nat. Vol. vii. p. 43.

† A summary of these observations was given in the Quarterly Journal of Microscopical Science, Vol. iv. p 63, and 124.

On the same subject, see Schenk on *Vaucheria*, Würz. N. Z. Vol. ii. p. 201 and Nachtrag zur Kritik, &c. (Pringsheim) in "Jahrbücher für wiss. Bot." Vol. ii. p. 470.

in its interior. It then becomes detached from the parent plant by the decay of the membrane of the sporangium, and after some time suddenly resumes its green colour and grows into a young *Vaucheria*, exactly resembling the parent plant.

Before dismissing *Vaucheria*, we may mention that fifty years before Pringsheim's publication, Vaucher had suggested the sexual nature of the horns, which he considered to be the anthers of the plant through which the pollen was discharged.

Dr. Pringsheim's observations on *Vaucheria*, were shortly afterwards followed by those of Cohn upon *Sphæroplea annulina*.* This somewhat rare Conferva was found by Dr. Cohn, covering a field of potatoes which had been overflowed by the river Oder. It forms long filaments, composed of more or less elongated cellules placed end to end. The endochrome of some of these cellules becomes transformed into a number of small spherical bodies, consisting of a green substance, with some grains of starch. Each of these bodies is clothed with a delicate smooth layer of plastic matter, but not with a cellulose membrane. They are called by Cohn *primordial-spores*. During, or before the formation of these primordial-spores, the membrane of the cellules, in which they are contained has become perforated with minute apertures. At the same time the colour of the contents of other cellules of the same filament changes from green to a reddish-brown, and the contents themselves become transformed into an innumerable multitude of cylindrico-elongated corpuscles, which escape through small apertures in the membrane of the cellules. These corpuscles, which are in fact the spermatozoa of the plant, enter the cellules, which contain the primordial spores, by means of the apertures existing in the membrane of the latter cellules. One or two of the corpuscles attach themselves by their cilia and beak to the end of the primordial spores and remain attached, after which the latter speedily assume a true cellular membrane. Thus, as Dr. Cohn remarks, we distinguish in the component cellular tissue of *Sphæroplea* male cellules and female cellules, which may be called antheridia and sporangia, and we recognize the fact, that in the impregnation, if not of the Algæ generally, at least in that of the Fucaceæ, Vaucheriæ, and *Sphæroplea*, the one essential circumstance, viz. the direct contact of spermatozoids with a primordial cell as yet devoid of

* See Ann. des Sc. Nat. xx. 4, Ser. Vol. v. p. 188.

any investing membrane. There is also in *Sphæroplea*, the very remarkable fact, that whilst in *Fucus*, the unimpregnated spores are dispersed over the surface of their thallus where the spermatozoa must come in contact with them, and whilst in *Vaucheria* the orifice of the antheridium almost joins that of the sporangium, the *Sphæroplea* have to search out a female cellule, sufficiently developed, and often at a distance, and have then to effect an entrance through narrow apertures designed for the purpose. What the force may be which guides them to their destination, Dr. Cohn pronounces to be a veritable physiological enigma.

In *Œdogonium* and *Bulbochæte** impregnation is also effected by the action of spermatozoa upon the contents of the female cells or sporangia. The contents of these female cells (*Oogonia* of Pringsheim) shortly before impregnation part from the wall of the cell and become contracted into a globular mass, called by Pringsheim the "*Befruchtungskugel*," which is a membraneless rudimentary spore. An opening is formed in the wall of the oogonium, and the nature of this opening as well as the form of the rudimentary spore varies in different species. The simplest and most frequent opening is by a small oval hole in the membrane of the oogonium, formed at the same time as the rudimentary spore. The portion of the latter which adjoins the opening is covered with a colourless protoplasm, which projects as a papilla. The spermatozoon touches and becomes intermixed with the papilla, which then retracts itself into the oogonium and the impregnation of the spore is effected.

The most remarkable point in the impregnation of the Œdogenieæ is the different mode in which the spermatozoa originate in different species. In some species of *Œdogonium* they are produced directly from certain cells which are true antheridia—the antheridia and oogonia occurring in most cases upon separate plants, but in some instances upon the same plants. This is quite similar to what occurs in other Algæ. But in other species of *Œdogonium*, and in most, if not all, of *Bulbochæte*, the antheridia are produced by certain bodies to which M. Pringsheim has given the name of *androspores*. These androspores are produced in cells differing from the ordinary vegetative cells only in their small size. The androspores differ hardly at all from the ordinary zoospores of the plant except in being of smaller size, and after their escape from the parent cell they

* See Jahrbücher für wiss. Bot. Vol. i. p. 1.

swim about freely in the water. They are oval, nearly filled with a green substance, but having a transparent beak surrounded by cilia. After some time the androspores attach themselves by the beak to the oogonia, the cilia fall off, and they then commence a true vegetative growth and become transformed into an organ which produces spermatozoa. In some cases the cavity of the androspore gives immediate birth to two spermatozoa; in other cases a septum is formed dividing the androspore into two cells, the upper one of which produces two spermatozoa: in other cases again several septa are formed giving rise to several cells in each of which cells two spermatozoa are produced.*

The point to which we have alluded in speaking of the Fucaceæ—viz., whether impregnation is effected by contact merely, or whether the spermatozoa are absorbed in the rudimentary spore has been much discussed in the case of the Œdogonieæ. Pringsheim, De Bary, and Petrowski being ranged on the one side, and Vaupell on the other.

In the Jahrbücher für wissenschaftliche Botanik, Vol. ii. p. 1-36, Dr. Pringsheim gives the results of his observations on the genus *Coleochæte*. Here again we meet with oogonia and spermatozoa, the former being impregnated by the latter so that the sexuality of these plants also may be considered to be established.†

With regard to the nature of the Saprolegnieæ much difference of opinion has existed and still exists, some botanists considering them to belong to the Fungi, others to the Algæ. Mr. Berkeley's opinion (and none could be more valuable) was, and we believe still is, in favour of their being submerged conditions of mucedinous Fungi, but we think the majority of botanists still rank them as Algæ.‡ However this may be, the observations of Pringsheim and De Bary show that impregnation is effected by the operation of active spermatozoa upon membraneless "primordial spores," a process precisely analogous to what we have already stated to take place in *Fucus*, *Œdogonium*, and *Sphæroplea*. We have not space to enter into details with regard to the structure of the oogonia and antheridia, but it is worthy of remark that in all the three genera of the family—viz., *Saprolegnia*, *Achlya*, and *Pythium*, the spermatozoa reach the contents of the oogonia (*i.e.*, the so-called *primordial spore*)

* In *Œdogonium curvum*, Pr. it appears that only one spermatozoon is produced in each antheridial cell.

† On the peculiarity of the fructification of the Coleochæteæ and their relations to the Mosses and Characeæ, see the papers above cited, pp. 24-29.

‡ See Jahrb. für wiss. Bot. Vol. i., p. 284, Vol. ii. pp. 169 and 205.

by passing through holes in the membrane of the oogonium, a mode of access which we have already seen to occur in *Sphæroplea*.

We must not part with the Zoosporeæ without mentioning the observations of M. Cohn and Mr. H. J. Carter* on reproduction in the Volvocineæ. Although these two writers are at variance with regard to the monæcious or diæcious nature of *Volvox globator* (the species which has received the greatest amount of attention) there seems no reason to doubt that the sexual process corresponds exactly with that which has been observed in other Algæ—viz., That it consists in the impregnation by spermatozoa of a previously membraneless "primordial spore."

In the Florideæ the knowledge of the phenomena of impregnation is far less advanced than in the other two divisions. The organs of fructification are of three kinds, 1st, the tetraspores consisting of an oblong or globular external cell enclosing four spores, each of which is capable of germination and of reproducing the plant directly; 2nd, antheridia, containing corpuscles which have been regarded as spermatozoa, but the nature of which is as yet extremely doubtful.

It is stated in Mr. Berkeley's Introduction to Cryptogamic Botany, that the plants of this division produce antheridia filled with active spermatozoa; but although some observations to this effect have been recorded by Derbès and Solier, they have not been confirmed by other botanists. Dr. Pringsheim, at the meeting of German Naturalists at Bonn, in the year 1857 (a report of which is to be found in the Botanische Zeitung for 1857, p. 784), unhesitatingly denies the existence of spiral or motile filaments. Since that time Dr. Gustav Venturi has described† certain organs occurring in *Wrangelia penicillata*, *Polysiphonia elongata*, and *Callithamnion vesicolor*, which have the appearance of being antheridia. He did not, however, find true spermatozoa, although in *Callithamnion versicolor* the upper cells of the so-called antheridia contained minute cellules in which slight movements were observed, but which movements might possibly have been only molecular.

"Thirdly, besides the tetraspores and the so-called antheridia, the Florideæ produce spores grouped in definite masses, and usually, but

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* See Annales Sc. Nat. 4 Ser., Vol. v. p. 323. Ann. and Mag. of Nat. Hist. Jan. 1859.

† See "Beobachtungen über die Fructifications-organe der Florideen." Wien Z. B. V. Vol. x. p. 583.

not always, enclosed in special cells or conceptacles. M. Pringsheim long since suggested* that these conceptacular spores, called cystocarps by Nägeli, are either true female sexual organs, or that they produce, like the spores of ferns, an organ which performs in some way the female sexual functions. It would seem, however, that he has since seen reasons for changing this opinion, for in the Botanische Zeitung (*loc. cit.*) he is reported to say that the conceptacular fruit does not differ essentially from the tetraspores; that it is, in fact, only a more divided form of the latter; that in *Ptilota plumosa* the transition from one to the other may be followed out; and that the spores often germinate within the capsule, in which case impregnation is out of the question. In a paper on the Ceramiaceæ in the Reports of the Bavarian Academy,† Nägeli has some observations on the nature of the fruit of the Florideæ. They occur in the course of some comments upon a proposed subdivision of the Order by J. Agardh, who separated two groups, viz. the Spyridieæ and the Wrangelieæ, on the ground of the different formation of their cystocarps. Nägeli says: "In most Florideæ both cystocarps and tetra-"spores are found; in some, however, the one or the other kind "of fruit is wanting. Their physiological import is still uncertain. "I have expressed the opinion that the tetraspores are the "female fruit, and that they are impregnated by the antheridia; "the cystocarps, on the other hand, are the asexual germs. Up "to this time, I find no reason to give up this opinion, and until "it is confirmed or set aside, it is for many reasons the most "probable. Irrespective of the striking resemblance between "the cystocarps, and the gemmæ and receptacles of the mosses "and liverworts, two points relative to the Ceramiaceæ may be "mentioned. In the first place, the tetraspores and the antheridia "are constant in their relative position, and therefore agree in their "morphological signification, whilst the cystocarps vary. The "second circumstance to be noted is the distribution of the three "reproductive organs upon different individuals. Triæciousness is "most usual, so that one plant bears only antheridia, another only "tetraspores, a third only cystocarps. Exceptionally, however,

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* See Ann. des Sc. Nat. 4 Ser. Vol. iii. p. 376.

† Beiträge zur Morphologie und Systematik der Ceramiaceæ. Sitzungsberichte der konigl. Bayerischen Acad. der Wiss. zu München; Jahrgang 1861. Band ii. p. 297.

" tetraspores and cystocarps occur upon the same plant, as has been " seen by the MM. Crouan in a species of *Callithamnion;* antheridia " and cystocarps have been seen by Bornet upon *Lejolisia;* and " antheridia and cystocarps have also been seen by myself upon " *Callithamnion bipinnatum*, Crouan, and *Herpothamnion hermaphrodi-* " *tum*, Nägeli. These observations point to the fact that the Florideæ " are normally diœcious, and that the plants with cystocarps may " really be male and female individuals, in which, for the support of " the neutral organ, the formation of the sexual organs (antheridia " and tetraspores) has been suppressed.

" If my opinion as to the nature of the cystocarps is correct, " they might possibly be wanting in certain Florideæ, whilst the tetra- " spores must occur in all. It might be objected that there are " probably more Florideæ, in which the tetraspores are unknown than " in which the cystocarps are unknown. This, however, is not con- " clusive, inasmuch as the former are usually invisible to the naked " eye, whilst the latter are easily seen and collected. There are some " Ceramiaceæ very generally distributed, and occurring in places " where indefatigable algologists reside, in which tetraspores have " been found, but no cystocarps have yet been observed, e.g. *Rhodochor-* " *ton Rothii* and *R. floridulum* and *Antithamnion cruciatum*."

The result at which Professor Nägeli arrives is that the cystocarps ought not, in the classification of the Cerämiaceæ, to be used even for subordinate divisions ; and if he is right in his views they must be considered as asexual organs of very little importance. Whether botanists will accept this conclusion time alone can show. At present we can only say, as M. Vaillant has remarked in his recent work,* that the notions of botanists as to the Florideæ are very undefined, and that although the nature of their organs may lead to the supposition of sexuality, further observations are indispensable before the existence of male and female Florideæ can be looked upon as anything more than a vague supposition.

We must not close this report without referring to the disputed question as to the nature of the conjugation which takes place in the Zygnemaceæ and other allied Algæ. As far as we are aware it is not yet settled whether this conjugation is a sexual process. We cannot here discuss the point, and must refer those who are interested in the question to Dr. De Bary's Essay, " Untersuchungen über die

* " De la fecondation dans les Cryptogames," p. 53.

Familie der Conjugaten," and particularly to the second chapter "Ueber die Bedeutung der Copulation und ihre Verbreitung."

## Note.

Since this report went to press we have seen a paper by Sollman in the Botanische Zeitung for September 2, 1864, in which that author professes to have discovered a true process of impregnation in *Nectria Lamyi*, De Not. Without venturing any opinion as to the correctness of his observations, we append the conclusions with which he sums them up. He says:—

1. *Nectria Lamyi* has a manifest mycelium, out of which the stroma is formed, and upon the latter the perithecia are developed.

2. The perithecia consist of three layers of cells. The innermost layer is the fructifying layer.

3. Upon this layer, in young perithecia, are situated the processes which bear the spermatia, and which, after the spermatia are separated from them, become developed into paraphyses.

4. The spermatia penetrate the fructifying layer, and reach the cavity of the rudimentary asci, which are in process of development.

5. In the double-walled asci eight cytoblasts originate, into which the spermatia penetrate and amalgamate with their contents, so as to form a uniform mass.

6. After the penetration of the spermatia the cytoblast assumes a visible smooth membrane, and becomes a spore capable of reproducing the plant.

7. The species of *Nectria* are hermaphrodite.

8. The bodies supposed to be granules of protoplasm in the young asci of Sphæriæ, are the particles of disintegrated spermatia.

9. They effect the impregnation of the spores.