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TRANSLATIONS.

On the MULTIPLICATION and REPRODUCTION of the DIATOMACEÆ. By the CONTE AB. FRANCESCO CASTRACANE DEGLI ANTELMINELLI.

(From the 'Atti dell' Accademia pontificia de' Nuovi Lincei,' April 19, 1868.)

THE numerous improvements in the microscope, of late years, have made us acquainted with an infinite number of new forms belonging to the lower divisions of the vegetable kingdom, and especially to the Diatomaceæ, the known number of which has advanced from the two or three species which had been distinguished at the end of the last century, to not less, according to Brébisson, than 2000 at the present time. But however great this addition to the number of facts serving to elucidate the natural history of these most interesting organisms may have been, the same cannot, unfortunately, be said regarding our knowledge of their organic development and general economy. This lamentable condition of things must be attributed to the too natural desire which observers entertain to associate their name with the discovery of a new form, to which end, consequently, the majority devote themselves. And an additional reason may be found in the difficulties which are met with in the investigation of the mode of development of organisms of such astonishing minuteness, which renders it almost a matter of chance when we are able to observe the various phases of the organic life of the Diatomaceæ. Whence arises the necessity of examining with the utmost attention everything that is presented in the field of the microscope, and especially in the case of living diatoms, which should be daily observed at all seasons to enable us to watch all the epochs of their development.

The apparent function of the Diatomaceæ in the economy of nature, viz. to vivify, as it were, the immensity of the ocean, as well as all fresh and brackish waters, decomposing, as they do, carbonic acid under the influence of light, and

consequently giving off oxygen, is sufficient to show that organisms of such excessive minuteness must be endowed with an extraordinary reproductive capacity in order to supply, by their number, the vast scope of the office they are destined to fulfil. Their most obvious mode of reproduction or multiplication is by a process of spontaneous division or *fissiparity*, similar to that which is seen to take place in the unicellular algæ and *protophyta* generally, and as may also be said to be universal in the vegetable cell. This process of division is effected in the same way as in the *Desmidiæ*, commencing with an internal movement in the granular substance or endochrome, which exhibits a tendency to separate into two portions. These separate portions become applied to the extremities of the cell, that is, to the two valves, whilst at the same time may be observed the secretion of two siliceous *lamellæ* or valves, which are probably invested with a delicate mucous layer (or membrane) on either surface. These two siliceous *lamellæ* are the counterparts of the two primitive valves, and exhibit the same markings and structural peculiarities. In this way the primitive cell ultimately becomes divided into two cells, each formed of an old and new valve, and each having a siliceous border or *cingulum*, in the way I have on another occasion observed, at any rate, in the genera *Navicula*, *Pinnularia*, *Stauroneis*, *Eunotia*, and *Grammatophora*.

In some species the two frustules or individuals after division remain free, and enjoy an individual, independent life, and in turn undergo a new division. In many other species the two new frustules continue more or less adherent to each other at one of the angles, as takes place in *Diatoma*, *Grammatophora*, *Tabellaria*, *Isthmia*, and *Biddulphia*; or closely applied side to side, as in *Odontidium*, *Himantidium*, *Denticula*, *Meridion*; or, finally, remain imbedded in an amorphous mucuous substance, or disposed in tubes or fronds.

This process of multiplication in the *Diatomaceæ* is a generation and an extension of the individual life, of which an infinitude of instances will at once present themselves to any one accustomed to consider the general laws of the vegetable kingdom. But every plant which is capable of multiplication, by gemmation or offsets, is more commonly reproduced by seed. It cannot, therefore, be supposed that the highly interesting class of the *Diatomaceæ* is not also capable of true and proper reproduction by seeds or by germs. With respect to this, we may refer to the statement contained in the classical work of Mr. W. Smith, 'Synopsis of British Diatomaceæ,' founded on his own observations, and on

those of Thwaites, Griffith, and Carter. According to these observers, cases of conjugation have been noticed in the *Diatomaceæ* similar to that which occurs in the *Desmidiæ*, and this in thirty-one distinct species belonging to seventeen *genera*; and from which conjugation resulted the formation of one or two *sporangia*, and of one or two sporangial frustules.

According to Mr. Smith, the various conditions which accompany the state of conjugation may be ranged in four classes—1. From the two conjugate frustules are produced two *sporangia*, as in the *genera Epithemia, Cocconema, Encyonema, and Colletonema*. 2. From the conjugation of two frustules arises a single sporangium, as is witnessed in *Himantidium*. 3. The two valves of a single frustule separate, the contents increase rapidly in volume, and finally become condensed into a single *sporangium*, as has been observed in *Cocconeis, Cyclotella, Melosira, Orthosira, and Schizonema*. 4. Lastly, from the two valves of a single frustule as above, results, by a process of conjugation, the formation of two *sporangia*, as in the *genera Achnanthes and Rhabdonema*.

The formation of one or of two *sporangia*, the result of the process of conjugation, can only be regarded as a reproduction of the species by germs, which is the most ordinary mode by which plants are propagated, the *sporangium* in the present case being considered as the organ destined to elaborate and emit the fecundated germs. But all this is at the present time involved in such obscurity that the author of the 'Synopsis of British Diatomaceæ' merely observes that it "seems to him" that the result of the *sporangium* may be the production of a swarm of diatoms.

Nor does Dr. Carpenter, in his valuable work, 'The Microscope and its Revelations,' appear to be more explicit on this point, saying only that he is inclined to believe in the multiplication of the Diatomaceæ by the subdivision of the endochrome in the *gonidia*, from which they emerge either in the active condition of zoospores or in the state of hypnospores. For this doubtful observation he relies upon the authority of Focke, who, in relating certain observations relative to the multiplication by germs, makes use of the argument from analogy with what takes place in other protophytes, which, besides possessing the faculty of organic multiplication by fission of the cell, are also capable of being formed by the ordinary method proper to all organisms, both vegetable and animal, in which reproduction is effected by sexual conjunction.

Moreover, various observations have already been recorded,

from which it appears to me that it may be concluded and positively admitted beyond all doubt that in the *Diatomaceæ* reproduction takes place by means of germs emitted from the *sporangia* and sporangial frustules. And in the first place it should be remarked that, whilst the existence of sporangial frustules, very easily distinguishable by their unusual size, can be recognised, we may at the same time note their paucity in proportion to the ordinary frustules—a circumstance that (if I am not wrong) appears to indicate their partial and transitory scope for the elaboration of the reproductive germs. Besides which Rabenhorst, in his work on the ‘Freshwater Diatoms,’ noticed in 1853 a *Melosira* with sporangial frustules, from one of which, from a lateral aperture, he witnessed the escape of the germs, an occurrence of which he gives a figure in pl. x. In the Sixth Volume of the ‘Quart. Journ. Mic. Sci.’ it is stated that, at the meeting of the Dublin Natural History Society on the 7th of May, 1858, the excellent microscopist Mr. O’Meara read an account of a circumstance which he had for the first time observed some days before in a recent gathering containing *Pleurosigma Spencerii*. In these diatoms the endochrome, instead of the usual colour, was of a beautiful green, with scattered granules of a bluish green. These individuals were seen to move with sudden starts to the lower part of the vessel, until first one or two, then others, and at last seven or eight individuals, at some distance from the diatoms, were seen to be furnished at the extremity with vibratile cilia moving with great activity. On the following day the appearance of the frustules was changed, inasmuch as but few granules were visible, and the colour of the endochrome had become olive green, whilst, instead of being disposed across the cell, it appeared collected in narrow bands along the two sides of the valves.

These two observations of Rabenhorst and of O’Meara conclusively prove the formation of the germs of the *Diatomaceæ* in the sporangial frustules, and their exit from the interior of the cell. Moreover, other instances have been noticed in which numerous minute diatoms have been observed within a cyst, a circumstance which was recorded by Mr. Smith in April, 1852, in a gathering of *Cocconema cistula*, in which instance he remarked the perfect resemblance between the included frustules and the surrounding ones, amongst which some of the most minute, both of those contained in the cysts and the rest, presented every gradation in dimension up to those of the adult form and in the state of conjugation. Similar cysts were observed in October, 1851, by Mr. Christopher Johnson, in a gathering of *Synedra*

radians, and by Smith in November of 1853 in the same species; and I had myself an opportunity of making the same observation in the spring of 1856 in a gathering of *Cocconeis placentula* made near Palazzuolo, under the aqueduct of the Fountain of Albano.

But it appears to me impossible longer to entertain any doubt as to the reproduction of the Diatomaceæ by germs after the observations which I have been able to make during the months of February and March last (1868). With the view of studying the development of these organisms I commenced by exposing to the light a cup of water of Trevi, in which on the 10th of February I had immersed a small piece of a green pellicle, which was picked by the point of a lancet from a small mass of refuse. This little *aquarium*, covered with a piece of glass and exposed in the window, at the end of a few days presented a beautiful vegetation of minute green masses, many of which rested on the bottom of the *aquarium*, whilst others coated its sides, and some were seen floating on the surface. On the 26th of February one of the minute floating masses was subjected to microscopic observation under a thin glass cover. It exhibited an innumerable multitude of beautiful green spherical spores, inclosed in a granular substance, in which might be perceived some nuclei or rounded corpuscles of a bluish or glaucous green colour. All the spores did not present the apparently uniformly granular contents, many exhibiting, together with a gradual disappearance of the granular aspect, some in more and some in less degree, a disposition to become organized into various distinct masses, with such gradations as to show the identity of nature between the granular spores and the very numerous hyaline cysts which were visible in the same mass. These cysts included two, three, or more navicular forms, furnished with a glaucous green endochrome and with two large vesicles, probably oily from their strongly refractive aspect. It was impossible to entertain any doubt as to these bodies being diatoms, for, having slightly moved the covering-glass, some of the cysts were ruptured, and allowed the escape of the navicular corpuscles, which, as they were carried away by the current, exhibited alternately the elliptical *side* and rectangular *front* of the frustules. Besides this some valves were noticed deprived of their endochrome, which, when attentively examined, plainly showed the usual median line and central nodule.

Amongst the numerous hyaline cysts in a state of quiescence enclosing diatoms I noticed two which exhibited a gyrating motion, which was at first extremely active, and

gradually became slower, and at last scarcely apparent. Some minute floating corpuscles in proximity to these active cysts were suddenly attracted, as it were, into a vortex whence I concluded that the movement of the two cysts in question was due to vibratile *cilia*. In fact, I discovered two excessively delicate *cilia* in both of the cysts, disposed in opposite directions, in the most lively motion, and longer than the diameter of the cyst, which, from the presence of these appendages, was proved to be a true zoospore.

I have since omitted no opportunity of making further observations respecting the circumstances accompanying the production of the *Diatomaceæ*, being persuaded that, from an exact knowledge of these conditions, we may probably be able to deduce laws serving to fix the limits of the species at present so uncertain, by distinguishing in the various forms of the diatoms the true diagnostic characters from the variations, affording either temporary indications of the age of the individual or abnormally arising from a monstrous production determined by accidental circumstances, amongst which may be enumerated the place of birth and the development of the diatom. Among the different observations I have made, and the peculiarities I have noticed, I would relate that, having placed another of the little green masses, taken from the same *aquarium*, in an apparatus in which an object could be retained in water for many days without being disturbed, after some time the glass with which the preparation was covered began to exhibit a considerable extent of surface sprinkled over with extremely minute green corpuscles. Some of these appeared as round points, whilst others were slightly oval, amongst which the smallest appeared to be composed of a green substance, whilst others, of larger size and more developed, presented the aspect of an oval cell enclosing two distinct masses, and the largest exhibited no difference from a very small *Navicula*.

These observations respecting the reproduction of diatoms from isolated germs is in no way opposed to the endogenous mode above referred to, according to which they are organized within a cyst, since the different mode of reproduction might indicate specific differences, and in any case the occurrence of such apparent anomalies in the reproduction of the lowest members of the vegetable kingdom is familiar to any one engaged in their study.

A more constant character, that I have observed on every occasion in which I have noticed diatoms in the nascent or young condition, is the peculiar colour of the endochrome.

This colour, from the bright green hue of chlorophyll, passes into a glaucous or bluish-green, olive-green, and yellow, until it assumes the rusty yellow or ochraceous tint belonging to the endochrome of the perfect or adult diatom. This observation of mine accords with a circumstance noticed by Mr. O'Meara in *Pleurosigma Spencerii*, which at the moment of emitting the germs exhibited a green colour, which, on the following day, had become olivaceous. This seems to me confirmatory of the view that the endochrome of the Diatomaceæ is composed of chlorophyll, which takes on the ferruginous yellow or ochraceous colour in proportion as it assimilates iron, the presence of which metal in the Diatomaceæ has been proved by the analyses conducted by Professor Frankland at Manchester. And the identity thus proved of the endochrome of the diatoms with chlorophyll affords a further insuperable argument in favour of their vegetable nature.

After these observations I was further desirous of subjecting to the action of nitric acid some of the green masses in the *aquarium* above mentioned, and which I judged to contain nascent diatoms, with the view of proving the presence of silica in them, and possibly of determining the period at which that mineral element is developed. I conducted the experiment with the utmost care I could bestow, so as, in the repeated necessary washings, I might lose as little as possible of these delicate corpuscles. From the minute traces of siliceous matter thus procured as the ultimate product I mounted a preparation in Canada balsam; and although the embryonal forms had been inevitably lost, I was able clearly to distinguish, though unusually small, *Nitzschia minutissima*, *linearis*, and *amphioxys*, *Pinnularia radians*, and an *Amphora*. But in order to discern these I was obliged to employ an oblique illumination, to which was adapted an excellent objective No. 10, with correction for immersion, by Hartnach. In the same preparation, besides others of difficultly recognisable forms, were some of extreme minuteness, in which I was unable to distinguish any details on the surface of the valves; and others, again, which I was able to determine, are of such astounding minuteness as I have hitherto never witnessed in all the numerous circumstances under which I have studied these species.

This would be the place to consider the question whether the frustule, when once formed, is capable of further development or growth, and if new striæ continue to be added to the valves; or if, on the other hand, those already existing may become wider apart, so that in a given space of the

valve a smaller number of *striæ* may be counted. Although my opinion may not agree with that of any one of the most distinguished microscopists, I am at present inclined to the belief that the *Diatomaceæ*, like any other organism which is produced from a germ, is born of small size, and grows as it passes through the various stages of life. And I believe that this growth may take place in various ways in different species. But as an inquiry of this kind is ultimately connected with the very thorny question of the true limits between the genera, species, and varieties of the *Diatomaceæ*, I will reserve it for a future occasion.

On the STRUCTURE of the LACHRYMAL GLANDS.
By FRANZ BOLL.

RECENTLY, in histological researches, peculiar star-shaped cells have been noticed in the aciniferous glands. Krause was the first man who isolated these, in the case of the *parotid* of a cat, by means of maceration in vinegar. He is inclined to treat them as nervous organs. Henle also describes stellate cells in the walls of the rennet glands, as well as the parotid and mammæ. He also thinks that they are most likely of a nervous character, although he has never seen any connection with the nerve-fibres. Pflueger describes multipolar cells in the salivary glands of the rabbit. He holds them to be multipolar ganglion-cells, and observed on one side their connection with the fibres, and on the other side with the secretory epithelial cells. Finally, Kölliker has made closer researches concerning the cells in question in the salivary glands. He considers them to be simply forms of the covering structure of the alveolus, which seem to him to represent a kind of reticulum.

I began to give my attention to these doubtful objects whilst examining the lachrymal glands in the summer vacation of 1867, and continued in Bonn later on to do so.

The lachrymal glands of the pig, sheep, calf, and dog, also the submaxillary of the rabbit, calf, and dog, and the parotid of the cat and rabbit, served me as objects of examination. The following are the methods of isolating these cells:—Maceration in vinegar (Krause); treatment with bichromate of potash (Henle); with 33 per cent. liquor potassæ (Pflueger); and placing in a solution of iodine, later on



