authorize me in regarding the *Ceratium* of the Lake of Geneva as the *Ceratium hirundinella*, O. F. Müller, described by Bergh, and further in seeing in *Ceratium reticulatum*, Imhof, only a simple member of the cycle of variability to which this old species, like so many others, is subject.

EXPLANATION OF PLATE XII. Figs. 4–9.

(All the figures enlarged 300 diameters.)

Fig. 4. Cuirass of a *Ceratium hirundinella*, seen from its dorsal surface. *a*, anterior horn; *b*, posterior horns; *c*, cincture; *d*, ventral aperture.

Fig. 5. *Ceratium hirundinella*, seen from its dorsal surface. Only the outlines of the cuirass are drawn. *ex*, exoplasm; *en*, endoplasm; *gl. r.*, red globules; *gl. g.*, fatty globules; *n*, nucleus; *nu*, nucleolus.

Fig. 5 *bis*. Nucleus of a *Ceratium hirundinella* treated with picro-sulphuric acid and stained with acetic carmine.

Fig. 6. *Ceratium hirundinella*, drawn in the living state and then fixed, seen from the ventral surface. *f*, flagellum.

Fig. 7. *Ceratium hirundinella*, seen from the dorsal surface.

Fig. 8. *Ceratium hirundinella*, drawn in the living state, seen from the ventral surface. *s*, furrow in the cuirass.

Fig. 9. A *Ceratium hirundinella* in which a part of the cuirass is deficient, drawn in the living state and seen from the ventral surface. *pr*, naked protoplasm; *c*, cuirass.

XLII.—*Critical Observations on Prof. Leidy's "Freshwater Rhizopods of North America," and Classification of the Rhizopods in general.* By Surgeon-Major Wallich, M.D.

[Continued from p. 334.]

It has been already shown ('Annals,' Nov. 1885) that Prof. Leidy does not dispute the fact of the animal of "*Quadrula*" being in every respect identical with the animal of *Difflugia*. We must therefore not place too implicit credence in the statement made at p. 143 of his work, that "*Quadrula symmetrica* is the only representative of its genus." For Prof. Leidy has yet to explain upon what other basis than the generic *non*-identity of an organism with any other known genus, he considers it legitimate to dissociate *Difflugia symmetrica* from *Difflugia*; and, further, how he can reconcile the creation of a new genus for the reception of that form with those "investigations" which (he tells us at p. 6) "rather confirm the view that we can only regard the more conspicuous and prevailing forms as so many *nominal*

species, in likeness with the species of higher organic forms, more or less intimately related, and by intermediate forms or varieties merging into one another."

Having got rid of every question connected with the characters of the animal, it is, at all events, satisfactory to feel that the present inquiry is reduced to the, comparatively speaking, narrow issue of determining whether the characters of the test in *Quadrula* are, or are not, sufficiently unique and constant to warrant the creation of a new genus for the reception of *Difflugia symmetrica*.

As we have already been made acquainted with the characters of "*Quadrula*" *symmetrica* as laid down in Prof. Leidy's work, let us now turn our attention to the characters therein given of the genus *Difflugia*, bearing in recollection, however, that a genus is little better than an abstract conception, and that it behoves us to assure ourselves, at every step of the investigation, that the characters assigned to this particular genus as a whole, neither exceed nor fall short of the aggregate characters of the several species included in it. It will be understood as we proceed why this caution is considered necessary in dealing not only with the new genus *Quadrula*, but with the equally questionable new genus *Nebela*.

And here let me observe that, owing to the unusual length and vagueness of many of Prof. Leidy's definitions and descriptions, however desirable it may be to epitomize them to the utmost, the end in view would be defeated were any passages struck out which the author might consider essential to the due comprehension of the points at issue. When it is stated that thirty-two pages of letterpress are devoted to the genus *Difflugia* as a whole, seven to *D. pyriformis*, and the remaining twenty-five to *D. globulosa*, *D. urceolata*, *D. cratera*, *D. acuminata*, *D. lobostoma*, *D. arcula*, *D. corona*, *D. constricta*, and, lastly, *D. spiralis* (of which at least half are, on Prof. Leidy's own showing, most variable species), the difficulties in the way of condensation beyond a certain point will, I venture to think, become apparent.

The characters given of the genus *Difflugia* are:—"Shell very variable in shape, usually composed of extraneous angular particles of hyaline quartz-sand, sometimes mingled with other bodies, such as diatom-cases, sponge-spicules, &c.; the same forms sometimes composed of chitinoid membrane incorporated with scattered extraneous particles, or composed in part or entirely of intrinsic particles of peculiar character. Mouth inferior, usually terminal. . . . . Pseudopods usually up to half a dozen or more, cylindrical, simple or branching, commonly round at the ends, sometimes spreading and pointed." —*Op. cit.* pp. 95, 96.

The characters given of *Difflugia pyriformis* are :—"Shell *pyriform*, *flask-shaped* or *ovoid*, with the narrower pole prolonged into a neck of variable length, of uniform transverse diameters, *or more or less compressed*; fundus obtusely rounded or subacute, or more or less expanded and variably produced into from one to three conical processes; neck gradually and evenly narrowed to the oral end, cylindroid, *sometimes constricted*; mouth inferior, terminal, circular, or *slightly* oval. Structure of the shell usually of angular particles of quartz-sand, sometimes mingled with diatoms; less frequently composed of chitinoid membrane with variable proportions of diatoms and sand.

"Var. 1. *D. pyriformis*; the ordinary characteristic form with the opposite diameters uniform.

"Var. 2. *D. compressa*; like the preceding, but more or less compressed.

"Var. 3. *D. nodosa*; usually a large form like the latter, but with the fundus variably produced into from one to three eminences.

"Var. 4. *D. cornuta*; pyriform, with the fundus provided with one or two pointed conical processes.

"Var. 5. *D. vas*; like the ordinary form, but with the neck defined from the body by a constriction.

"*Difflugia pyriformis* is one of the most common *species*, and it presents much variety of shape and size. The shell is ordinarily flask-like or balloon-form, or, as indicated by the specific name, pear-shaped, with an oval or ovoid body, more or less gradually prolonged into a neck, which tapers to the mouth or is cylindroid, and of variable proportionate length. . . . . *Difflugia pyriformis* by gradual transition merges into *D. globulosa*, *D. acuminata*, &c."—*Op. cit.* pp. 99 to 105.

For reasons stated at great length by the author (pp. 99 to 105), but which are nevertheless far from being clear, *Difflugia proteiformis* is altogether excluded from his list of established species. At p. 113 he says :—"The name *D. proteiformis* is exceedingly indefinite in its application." And further on the characters of *D. proteiformis* are again cursorily referred to and followed by the remark that "Dr. Wallich uses the name of *D. proteiformis* in a sort of generic sense, and regards all other forms of the genus ordinarily recognized as transitional subspecies and varieties."

With reference to the last remark I can only say, in all good faith, "I own the soft impeachment," and, notwithstanding the inference it involves, I prefer still to adhere to my own definitions given below, as being more to the point,

somewhat shorter, and, at all events, less hampered by all round alternatives than those furnished in Prof. Leidy's work, which render his definitions practically useless. I therefore request attention to the subjoined extract from the synoptical list of the Difflugidæ, at p. 240 of the 'Annals' for March 1864, confining myself, however, to those forms only which bear on the question before us.

"Genus DIFFLUGIA (Leclerc).

"*Characters.* Animal a testaceous Amœban. Pseudopodia cylindrical or digitate. Test chitinoid, or chitinoid with additions of mineral matter.

"Species 1. *Difflugia proteiformis.*

"*Characters of Test.* Form of embryonic test subspherical, from 1 to $\frac{1}{8}$ of the diameter in one direction being truncated and constituting the aperture. Form of mature test extremely variable.

"Subspecies 1. *Difflugia mitriformis.*

"*Characters.* Test mitre-shaped, more or less inflated at posterior extremity, and without any fixed ratio between length and breadth.

"Var. *a. D. acuminata.* Apex of test acuminate.

"Var. *β. D. spiralis.* Anterior third of test bent back upon its body, so as to present a retort-shape.

"Var. *γ. D. pyriformis.* Shape varying from the pear- to the balloon-shape."—*Annals*, March 1864, p. 240.

Referring to this arrangement Prof. Leidy has drawn marked attention to my having referred the transitional (or, as I think they may be more correctly termed, the metamorphic) series, described and figured in the 'Annals' for March 1864, to *Difflugia pyriformis*. The following are my reasons for having done so.

Taking the characters of "*Quadrula symmetrica*" in the order in which Prof. Leidy records them, we find this organism described as being "remarkable for the construction of its shell, which is *compressed pyriform*." Both of these characters are to be found in his definitions given above of *Difflugia pyriformis*, and also its variety, No. 2, *D. compressa*. But this is not all. If we turn to plate xxiv. of Prof. Leidy's work, which is devoted to "*Nebela*" and "*Quadrula*," we shall see two tests of *Nebela*, figs. 11 and 12, which, without looking at the explanation list, we can at once recognize as constituting an inseparable bond between *Nebela* and *Quadrula* on the side of incipient mineral metamorphism, and *Nebela* and *D. pyriformis* on the side of outline. In the explanatory remarks

these are described as "transitional to the compressed variety of *D. pyriformis*." Again, if we turn to pl. xii. of *Difflugia pyriformis*, figs. 10, 11, 12, and 13, we shall see that these might, without the least incongruity, have been inserted in pl. xxiv. as additional, and, in reality, *better* representations of the metamorphism shown in figs. 11 and 12 of that plate. A dozen such examples might be added to these were it necessary. I must, however, draw particular attention to the very important fact that these six figures also agree (as closely as any half-dozen specimens of the same forms of Difflugidæ can agree with each other) with fig. 30, plate xvi., of my series of transitional metamorphic forms of *Difflugia pyriformis*, to which I refer them, as the *first link in the chain* of varieties which lead up to *Difflugia symmetrica*. The woodcuts Nos. 3 and 4 at pp. 469, 470 of this paper are in reality specimens of *D. pyriformis*, so far as mere form is concerned; fig. 3 being the ordinary variety with the test made up of angular mineral fragments, nearly always more or less transparent. When the test is covered to this extent with large and angular mineral particles of varying sizes and shapes, it has passed the stage at which metamorphic action, or, in other words, the combinaton of the siliceous material impacted into the yielding chitinoid basis of the test, can enter into colloidal combination with it. In fig. 2 (at p. 468 of this paper) the metamorphic combination has gone as far as it generally does in such a form; attention is drawn to it now chiefly with a view to prove that the pyriform or mitriform "compressed" shape, said to be characteristic of the shell of *Quadrula symmetrica*, is one of the typical characters recorded of *Difflugia pyriformis* and its variety *D. compressa* at p. 99 of Prof. Leidy's work. Now if we look at figs. 10, 11, 12, 13 of pl. xii., representing *Difflugia pyriformis*, and figs. 4 and 12 of pl. xxiv. representing *Nebela collaris*, the truth at once bursts on us, that the figures from pl. xii. of *D. pyriformis* might be transferred to pl. xxiv., and the figs. of *Nebela collaris* from pl. xxiv. to pl. xii. of *D. pyriformis*, without even an expert in the history of the testaceous freshwater Rhizopods being able to assert positively that the whole of the six specimens were anything else than average specimens of *Difflugia pyriformis*. I contend therefore that there is nothing in the *shape* of the test in *Difflugia symmetrica* to distinguish it from the test of *D. pyriformis*, or certain metamorphic forms of *Nebela collaris* of which I shall have to speak hereafter in reference to another character.

Figs. 27 to 33 of pl. xvi. appended to my paper in the 'Annals' for March 1864, which Prof. Leidy says I "described as transitional forms of *Difflugia symmetrica*," I have

already shown have nowhere been so described by me. Those figures represented forms which were regarded by me in 1864 (and I have certainly not yet seen any reason for not so regarding them) as fairly typical varieties around which every heretofore known published variety of the metamorphic series might with propriety be grouped. These seven types, with *Difflugia symmetrica*, seem to me to cover the whole of Prof. Leidy's *Nebelæ*, excepting the horned varieties, but only as varieties. To make species, even in the widest sense, on such a basis can, I think, hardly be considered in keeping with the spirit of modern classification as applied to the Protozoa.

The next characters given of *Quadrula* are :—" Shell transparent, colourless, composed of thin* square plates of chitinoid membrane arranged in transverse or more or less oblique series, in consecutive or alternating order. . . . The general arrangement is like that of *tiling with variable regularity*. . . . They [the plates] are not entirely disposed with the symmetry expressed by their name, for frequently smaller plates break the regular succession of larger ones, and sometimes one angle of a plate replaces that of a contiguous one."—*Op. cit.* pp. 142, 143.

I have already ventured to express the opinion that Prof. Leidy's views as regards the test of *Difflugia symmetrica* (or, as he would prefer to call it, "*Quadrula*" *symmetrica*) being " composed of thin square plates of chitinoid membrane " is erroneous, so far at least as I can speak concerning my own specimens, which, I may add, have been procured over a tolerably wide geographical area. Of course Prof. Leidy's specimens may be quite correctly described, inasmuch as the degree of consolidation attained by every test of the kind in which there is an admixture of siliceous or any other soluble mineral substance with the chitinoid basis, must depend on the quantity of that substance present in the water or mud of the particular locality in which it was produced. But, for reasons about to be assigned and which are gleaned from Prof. Leidy's own statements, it appears in the highest degree improbable that the " square plates " in *Quadrula* can be truly described as being " composed of chitinoid membrane "—if we are to understand the term "*chitinoid*" in the sense in which he applies it to the tests of certain varieties of *Nebela* and *Hyalosphenia*, namely, as being exclusively composed of hardened sarcode altogether unconsolidated by any mineral ingredient which has entered into colloidal combination with it. Thus Prof. Leidy describes the test of "*Hyalosphenia cuneata*," a member of another very inter-

* The word "*thin*" was, by a mistake of mine, omitted at p. 332 of the 'Annals' for November, line 2 from bottom.

esting group of testaceous Amœbans, as consisting "of delicate, transparent and colourless chitinoid membrane, without trace of definite structure." In "*Hyalosphenia tincta*" and "*H. papilio*" the tests are said to be pale yellow. I have never to my knowledge fallen in with *Hyalosphenia*, but am nevertheless able to attest the occurrence of equally delicate chitinoid tests as occurring in one of the commonest forms when developed under favouring conditions, namely *Arcella vulgaris*.

But Prof. Leidy's view appears improbable for another and more substantial reason. It is this, that although the plates of *Quadrula* are described as above in the letterpress, there is not in any of the six figures (nos. 20 to 25) of plate xxiv. of his work, representing different views and forms of the kind of tests referred to, a single plate that even conveys the idea of having been intended to represent a true rectangular figure. On the contrary, with the exception of perhaps five or six plates out of some two hundred and fifty which nearly answer to the description of being square, all are more or less irregular both in their outlines and angles, and in these respects yield no such evidence of an approach to crystalline form *as is to be seen in some of the other tests represented in Prof. Leidy's work as belonging to true Difflugidæ.*

Moreover, nearly all the plates in the figures of *Quadrula* (pl. xxiv. figs. 20–25) are drawn as having more or less convex external surfaces, another character not met with in any specimens that have fallen under my notice. Indeed, it was the apparent perfect accuracy of the rectangles and the tabular surfaces and very definite margins of the plates in my specimens that led me to suspect their being due, in some degree at least, to crystalline agency, although I was fully alive to the fact that crystallization under ordinary circumstances is interfered with instead of being promoted in presence of colloids.

In Prof. Leidy's plate x. fig. 26, said to represent a shell of *Difflugia pyriformis*, composed "of *chitinoid membrane incorporated with thin siliceous plates*," some of these are really rectangular; but I should feel inclined to regard them as rectangular rods, as their length as compared with their width in most of the forms exhibiting them varies apparently from 4 to 1, to 10 or 12 to 1, or even more; the elongated form in such examples being in all likelihood the natural consequence of the siliceous constituent being derived from diatoms, many of which are of similar proportions. Some plates also, on "a shell of *D. arcula*, in pl. xv. fig. 36, and in figs. 16, 17, 18, and 19 of the same plate, representing *D. lobostoma*, are in

like manner rectangular. Again, in pl. xvi. fig. 22, representing *Difflugia globulosa*, we have a test described as being "composed of rectangular plates, together with a few * diatoms." This is a most interesting specimen, inasmuch as the entire external surface of the test (an oblate spheroid) is closely studded over with rectangular elongated plates, a broadly ovate valve of a diatom (apparently a *Cocconeis*) being faintly visible as adherent to the exterior of the plates, though so hyaline as not to obscure the plates on the part of the test covered by it. This form must be regarded not as a transitional variety between *Difflugia symmetrica* and those forms of test made up of an admixture of metamorphic bodies (such as were stated to be present on the test figured in Prof. Leidy's plate x. fig. 26, *suprà*), but as a form which is essentially a *second* "representative" of the so-called genus *Quadrula*, and is actually inserted in a plate devoted exclusively to six forms of *Difflugia*, viz. *globulosa*, *lobostoma*, *arcula*, *urceolata*, *cratera*, and *pyriformis*. To deny this because the figure of one is "pyriform compressed," whereas the other is a compressed spheroid, or because the rectangular plates in one are true squares, whereas in the others they are parallelograms, or even because in *Difflugia symmetrica* there is a close approach to symmetrical arrangement of the square plates, whereas in the other the elongated rectangular plates are not so symmetrically arranged, would be too absurd, when it is borne in mind that we are discussing the predominating characteristic so conspicuously manifest throughout the whole of the vast series of testaceous Rhizopods, namely an infinite tendency to variation—a tendency which even Prof. Leidy himself admits while making a new genus out of *Difflugia symmetrica*. The only matter for surprise is that so keen an observer as Prof. Leidy should not, at the first glance, have detected the intimate connexion just indicated between "*Quadrula*" and the specimen of *Difflugia globulosa* to which I refer. Curiously enough, Prof. Leidy figures, side by side with this specimen of *D. globulosa*, a second specimen of the same form (fig. 21), almost identical in size and quite identical in figure, in which there are no rectangular plates or disks of any kind, but the entire test is covered with diatoms as large as the *Cocconeis* in fig. 22. The diatoms in fig. 21 are, however, pointed ellipses, and they are as yet metamorphosed only to the extent of obliterating their generally very coarse striation or cellulation, another significant circumstance in

* Only *one* diatom-valve is visible on the test in fig. 22. There must therefore be some inaccuracy in the explanatory note.

this case and also in that of the single *Cocconeis* valve, which, however, still exhibits the median line and its nodules.

In plate xxii., representing *Nebela collaris*, figs. 13, 18, 19, and 20 (the two last "magnified 850 diameters"), are to be seen perfectly rectangular rods (called "linear *plates*" in the descriptive note), together with oval and round plates of various sizes, the larger ones exhibiting the curves of oval and circular diatom-valves. The two highly magnified figures (19 and 20) show the perfect angles of the rectangular plates and the tabular surface of the ovate and circular ones. But the most important piece of evidence is furnished by the test (fig. 18), described as "shell of narrow rectangular and oval plates, from which a broad strip was broken away, *showing that the fracture follows the intervals of the plates.*" It must be remembered that the test is a large one, and the fractured aperture extends diagonally nearly from its apex to its base, not a single plate appearing to be broken across, but the irregular outline consisting of zigzags, each of which answers *pro tanto* to a side or end view of the plates. Hence we may reasonably assume that the whole of these plates are identical with the plates of *Difflugia symmetrica* in being perfectly rigid, strong enough not to yield to considerable force, and therefore necessarily composed of a large percentage of siliceous or other mineral matter in combination with the colloidal basis of the test.

But the nearest approach to the perfectly square figure of the plates in *Difflugia symmetrica* occurs in a specimen of *Nebela flabellulum*, represented in plate xxiii. fig. 19, a broad balloon-shaped variety, on the front of which there are eight perfectly-formed "*square plates*" scattered irregularly among a crowd of "circular, oval, and linear plates." In size and appearance the square plates exactly resemble those of *D. symmetrica*. Prof. Leidy (at p. 153) remarks:—"Occasionally I have found specimens in which *quadrate plates, like those of Quadrula symmetrica*, were mingled with the more usual structural elements as seen in fig. 19," *i. e.* in the figure I have been referring to. Nevertheless, we know Prof. Leidy has in his definition of "*Quadrula*" declared that the test is "composed of thin square plates of *chitinoid membrane*," apparently forgetful of the following very circumstantial statement made by him in reference to *Nebela collaris*, the very form in which '*the quadrate plates, like those of Quadrula symmetrica*,' occasionally occur."

"In breaking the shell," he observes, "the line of rupture follows the outlines or intervals of the disks and plates. The shell [of *Nebela collaris*] *appears to be silicious, as it remains unchanged when exposed to the action of heated sulphuric and*

nitric acids " !—*Op. cit.* p. 151. Indisputable proof being here afforded by Prof. Leidy of these disks and plates being siliceous, was it wise to assert that those in *Difflugia symmetrica* are merely composed of chitinoid membrane?

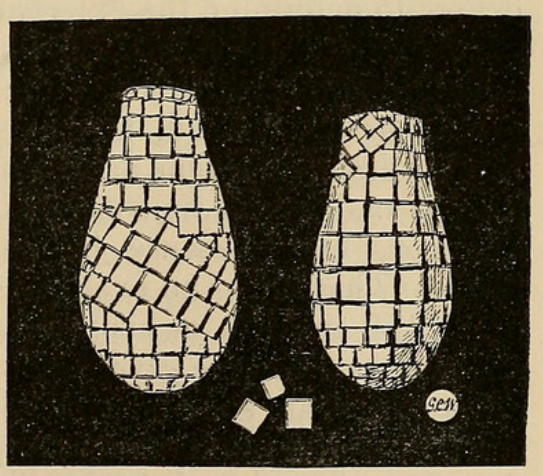
It now only remains for me, before passing on from the question of the generic status of *Difflugia symmetrica*, based on the figure and composition of its test, to draw attention to two or three collateral questions bearing upon what has gone before. The first relates to a very interesting experiment made by me with a view to find if rectangular plates resembling those on its test could be produced artificially. The experiment was eminently successful. It consisted in placing in a suitable phial finely pulverized organic silica in the form of " tabasheer " (a substance well known as a product formed within the joints of the bamboo) with an alkali and a mixture of glycerine, gum, the albumen of egg, potassium chlorate, and, lastly, distilled water, the alkali in solution being kept apart from the rest of the ingredients by a parchment diaphragm, and some cotton wool being placed loosely at the bottom of the phial for any crystalline or other formation to form or subside on. The phial and its contents were kept, at the ordinary atmospheric temperature of summer, in a glazed bookcase, where they could be examined without being in anywise disturbed. After about five weeks, to my intense satisfaction, distinct rectangular (square) plates were visible with a powerful pocket-lens, having already attained a size as large as the medium-sized plates usually found in *Difflugia symmetrica,* and in every respect resembling them. I would add that I did not attempt to follow any precise quantitative formula, but simply went by " the rule of thumb," looking on the first effort as merely tentative and likely to give me some clue to more accurate measurements on a future occasion. I do not doubt, therefore, that any chemist would be able to repeat the experiment with perfect success and without the least difficulty. Of course I cannot but regard the experiment as bearing in a very important degree on the validity of my hypothesis regarding the colloidal metamorphism observable in the plates and disks of the more marked forms, and the chitinous pellets and cylinders observable on the tests of the less highly metamorphosed forms, such as *D. spiralis* and others.

As regards Prof. Leidy's remark that the plates in *Difflugia symmetrica* are not so symmetrically arranged as the name would imply, I have only to state that although I unquestionably employed the term to indicate the arrangement of the plates in regular series, I also applied it to the perfect mathematical figure of the plates themselves.

That any real disregard for accuracy was manifest in employing the specific name *symmetrica* I deny, for if such hypercritical accuracy were indispensable in treating of such organisms as the tests of the Rhizopods, some of Prof. Leidy's statements, such, for example, as that about the "chitinoid membrane," would, I fancy, not fail to invoke some rather more hypercritical. But, apart from this, I maintain that every one of the specimens I have ever seen indicates all that is needed to justify the term *symmetrica*, inasmuch as tendency towards a definite and symmetrical arrangement is perfectly clear, the deviation from symmetry being obviously the result of accident rather than inherent tendency. And we must not ignore the fact, for it is a fact, that the cases are almost always exceptional in the organic world in which perfect symmetry is observable, the honeycomb being one of the most familiar examples. But what then? The bee is only the tool working out a figure which is controlled and directed by other physical forces and tendencies than those that are inherent in it. And so it is, I contend, with those "thin square plates of chitinoid membrane," which nevertheless happen to be silicious and able to withstand heated acids.

The two figures here given of *Difflugia symmetrica*, though somewhat roughly drawn, are nevertheless sufficiently accurate representations of the specimens from which they were taken. In the larger test it was my desire to show how accidentally applied disturbing causes, whether operating from without, or disturbance caused by the pseudopodia or chitinosarc of the animal, may occasionally break the regularity of the serial order of the plates. In no specimen have I ever seen a truncate angle; and where there has been any overlapping of plates its character has plainly pointed to disturbance of some sort acting from without. Both figures, I venture to think, inculcate this lesson. The three separate plates convey a fairly correct idea of their symmetrical form.

Fig. 1.



At p. 151 of his work Prof. Leidy says:—"Dr. Wallich, referring to the structure of the transitional forms of *Difflugia symmetrica*, which, as previously intimated, I suspect to

belong to *Nebela collaris*, calls the peculiar elements colloid disks and plates. He remarks that they are derived from the animal, and not directly from the medium in which it lives. He supposes, however, that they are formed through the coalescence of diatoms and other mineral elements with the chitinoid basal substance of the shell, which then undergo metamorphosis into all the colloid forms that occur."

Before proceeding with my observations on the "*Nebelæ*" I must make some comments upon the above statement in relation to the whole of the series of transitional and metamorphic forms referred by me to the genus *Difflugia*. The first point on which I lay emphasis is the extraordinary fact that this short paragraph contains nearly if not quite all the information Prof. Leidy has vouchsafed to publish concerning the *grounds* on which the conclusions in question were based. The second point is one upon which I would lay still greater emphasis, namely, the fact that, without any explanation whatever on Prof. Leidy's part, the whole of the metamorphic forms described and figured by me were bodily consigned, as in the case of *Difflugia symmetrica*, to a new genus. For, with exception of the short paragraph above quoted, from the first page of his work to the last, he has abstained from drawing attention to my reasons for maintaining that influences in nature extrinsic as regards the animal, serve in a principal degree to determine the external structure and constitution of the ectosarc of the naked Rhizopods, and notably the external structure and constitution of the tests of the testaceous forms.

On the other hand, he has several times gone out of his way to direct attention to conclusions of mine which he leaves it to be understood he considers erroneous, but which appear erroneous only because he has completely misrepresented them. That this is no exaggeration will be seen on reference to pp. 150 and 151 of his work, where, in the course of four-and-twenty lines, he gives the subjoined two versions of the same inaccurate statement in relation to the *Nebelæ*:—

"The series of specimens represented by Dr. Wallich in figs. 27 to 33, pl. xvi., vol. xiii. Ann. & Mag. Nat. Hist. for 1864, and described as transition forms of *Difflugia symmetrica*, appear to me to pertain to the same animal as *Nebela collaris*."

"Dr. Wallich, in referring to the structure of the shell of the transitional forms of *Difflugia symmetrica*, which, as previously intimated, I suspect to belong to *Nebela collaris*, calls the peculiar elements colloid disks and plates."

And yet a few pages before, namely at p. 145, he had already stated in his definition of the genus *Nebela*, that

"in form, constitution, and arrangement" the sarcode is as in DIFFLUGIA, &c.!

Had my facts and conclusions on the subject been controverted, or had sufficient reason been assigned for withholding them, the matter would have been intelligible. But no such case has been made out and no such reasons have been furnished. And what has been the result? Why, that during the last four years the forms specially constituting the subject of this paper have been mentioned in scientific works and journals in this country and abroad associated only with Prof. Leidy's name, and unaccompanied by any accurate characters of importance that had not been already assigned to them in papers published by me fifteen years previously.

In the bibliographical list appended to my name at the end of the letterpress of Prof. Leidy's work, the following is the sole reference to the transitional forms:—

"Transition forms, figs. 27 to 33=NEBELA COLLARIS."

This line furnishes its own commentary *.

In these circumstances I must be permitted to furnish a somewhat fuller *résumé* of the facts upon which the conclusions were based which Prof. Leidy summarized as above, since they directly bear on the status of the *Nebelæ*. I must, however, preface what I have got to say by mentioning that, until very recently, I was unaware of the fact that Prof. Ehrenberg had described and figured an organism under the name of *Difflugia collaris*, which must in all probability have been one of Prof. Leidy's *Nebelæ*, in the 'Proceedings of the Berlin Academy' for 1848 (p. 218). But although very imperfectly described by the eminent German microscopist, no doubt owing to the imperfect lenses then available, his title to priority of discovery ought to be respected just as much as in the case of *Difflugia symmetrica*. Nevertheless this fact affects Prof. Leidy's views and mine on these two genera in very different ways. It adds another powerful reason, in addition to those already furnished, against the transfer of the forms included in them to newly created genera; in Prof. Leidy's case particularly, since his reference to Ehrenberg's

* The following errors and omissions in relation to the points under investigation occur in the text of Prof. Leidy's work. At p. 142, under *Quadrula*, reference is made to "*D. proteiformis*, var. *symmetrica*, 'Annals,' 1863, pl. x." It ought to be pl. viii.

At p. 145, under *Nebela*, reference made to *D. symmetrica*, Wallich, 'Annals,' vol. xiii. 1864, pl. xvi. figs. 27–33. No reference to text given, and no reference to paper of Dec. 1863, where same form is described.

In the same list appended to *Nebela* no reference at all is made to the "transition forms."

observations on this organism in the year 1848 show he was aware of Ehrenberg having discovered and drawn attention to the form in question (*vide* Leidy, p. 150). But it also adds another powerful reason to those I have already adduced why the transition forms referred by me to *Difflugia* should be retained in this genus*. It will be seen that Ehrenberg described the test as "*pyriform.*"

After having stated ('Annals,' May 1864) that no vegetable or extrinsically derived substances are, in my experience, employed for the consolidation of the Difflugian tests, I alluded to the selective faculty of the animals as being so remarkable that colourless mineral particles, sometimes quartzose, sometimes felspathic, sometimes micaceous, seem to be always chosen, as one or other of those minerals happens to be present in the mud of the locality inhabited by them, and that the particles are impacted into the chitinoid matrix in so workmanlike a manner as to leave only the smallest intervals between adjoining masses and as little overlapping as possible. Reference was next made to the fact that the testaceous forms when living in streamlets, where they incur a risk of being swept away, reduce this risk to a minimum by loading their tests with as large particles of mineral matter as they can utilize. It was also stated that the mineral particles used are not always of inorganic origin, diatoms of various kinds being promiscuously employed in some tests, whereas in others a selection has been made of one kind only out of the various forms present in the same habitat. And, finally, I remarked on the metamorphic forms of Difflugidæ, belonging for the most part to the mitriform and pyriform series, in which the chitinoid matrix of the tests presents no appreciable admixture with unmetamorphosed mineral matter, but is more or less closely covered over with composite bodies of various forms and sizes. The whole of the forms now referred to were minutely described as they present themselves to us in the metamorphic series, of which figures are given in the plate attached to my paper above referred to.

My reasons were then expressed for arriving at the conclusion that, except in the case of a few permanent varieties which present a type capable of being hereditarily transmitted, the whole of the varieties of Difflugian tests may be regarded as the result, first, of modifications in figure, dependent sometimes on the inability of the test to sustain its

* Ehrenberg's definition of *D. collaris* is as follows:—"*D. collaris*, n. sp. *D.* lorica sub ostio in colli formam attenuata, pyriformi, subclavata recta, superficie irregulariter *cellulosa* (!), cellulis parvis æqualibus, colli angustioribus, apertura integra" (Monatsb. 1848, p. 218).

own weight, and sometimes on the tendency to curvature or obliquity from the pressure of running water; secondly, of modifications in the materials of which the tests are constructed, sometimes depending on the kind of mineral substances procurable in particular localities, sometimes on a hitherto unrecognized and remarkable union between the chitinoid basal substance (which is an exudation from the animal) and the mineral particles, which that substance serves in the first instance merely to cement together; thirdly, of modifications in size, depending probably on the age, the perfect or imperfect nutrition of the animal, and also on the capability of the test to alter its form after having become consolidated to a certain extent by addition of mineral matter; fourthly, and lastly, of modifications in colour, arising partly from the nature of the food taken by the animal, partly from the external incrustation of organic or inorganic débris, and partly from the tint acquired by the chitinoid basal substance.

I next went on to state that the true nature of the rectangular plates of *Difflugia symmetrica* would become manifest as I proceeded with the description of the transitional forms that intervene between the most aberrant which is represented by *that form*, and the least aberrant form, viz. *Difflugia pyriformis* and its immediate varieties, which are represented by such very partially metamorphosed forms as are depicted in figs. 30 and 31 of the plate accompanying my paper. As already stated, in none of my papers on the subject of these Difflugidæ have the metamorphic series been described as transitional forms of *D. symmetrica*, as alleged by Prof. Leidy. On the contrary, in the explanatory notes annexed to pl. xvi. 'Annals,' March 1864, fig. 26 is thus described:—"*D. symmetrica*, showing the rectangular hyaline plates: *a*, form of aperture; *b*, a more compressed specimen, in which the aperture (*e*) is nearly closed; *d*, a few detached plates.

"Figs. 27 to 33 represent the series of forms *exhibiting the transition* from the ordinary mineral and chitinoid elements of the test to the evolution of the colloid disks."

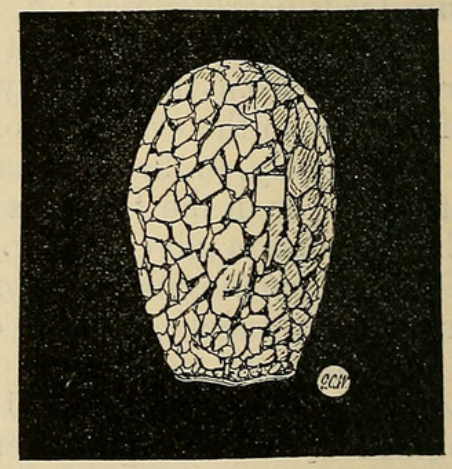
And, lastly, in the explanatory remarks appended to pl. viii. of my paper in the 'Annals' for Dec. 1863, the following is the description given of fig. 16, pl. viii., p. 467:—"Test of *Difflugia pyriformis*, var. *symmetrica* (Wall.), showing symmetrical arrangement of the crystalline plates."

As some of the readers of the 'Annals' may not have access to the volumes for 1863 and 1864, in which typical figures of all the most remarkable Difflugian forms were given, I have been enabled through the courtesy of the editors to insert a few figures in illustration of special characters to

which I wish to draw attention in connexion with the forms to which reference has been made in the present and last month's instalment of this paper. The first figure in my list represents in outline one of the simplest and most common forms of Difflugian test, namely the mitriform—simplest because it approaches most closely to the spherical form (which there is reason to regard as the archetype of the entire Difflugian series) and constitutes also the earliest stage of most of the varieties of Difflugian tests which in the adult stage bear scarcely any resemblance to it: the tendency to variation in outline being, according to my view, neither resident in the animal nor in the test, *but in the varying external conditions*, which give the first impetus to change of figure when the young test has not as yet lost its purely membranous character, and is therefore still perfectly plastic. Once set in motion, the same external forces or influences (for some are really forces, whereas others are merely influences) continuing to act in the same direction naturally tend to stereotype and extend the characters first impressed on the young test. It is in this way, I contend, that whereas we have but one *type* of animal to deal with, we have an almost infinite *variety* of tests. It follows, therefore, that if we attempt to do more than group together the various most closely related varietal forms and kinds of test on some definite system based on a knowledge of the forces or influences which observation teaches us are the most effective agents in the results produced, we are simply the victims of an old-world illusion that may serve to amuse, but cannot instruct, those who indulge in it.

The annexed figure (fig. 2) must, for present purposes, be looked at without reference to the rectangular plates seen imbedded at its centre. As a matter of fact, this particular sketch was made to illustrate a point in connexion with *Difflugia symmetrica*, of which mention will be made presently. Apart, therefore, from the presence of those plates and a slight deviation from the original outline, which is by no means uncommon, the figure might represent a varietal form either of *D. mitriformis* or of *D. pyriformis*.

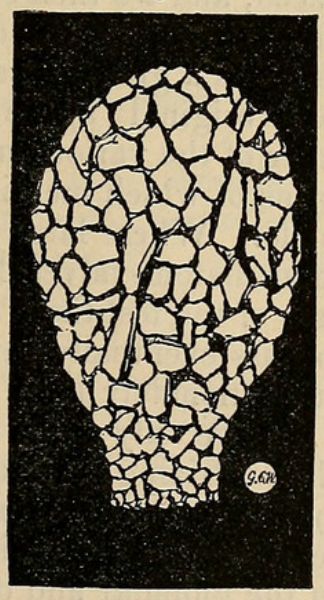
Fig. 2.



If we now take fig. 2 of *D. mitriformis* as we find it, with its admixture of rectangular plates, we shall recognize in the presence of the latter and the barely perceptible undulation at the margin of the mouth of the test, distinct evidence of metamorphism from the ordinary to the transitional type, of which (as has before been stated) *Difflugia symmetrica* is the *most pronounced and aberrant* variety. But I would particularly mention that, even as the figure stands, it was not selected to illustrate the earliest and most frequent aspect of metamorphism, of which a representation was given in fig. 30 of the series included in the 'Annals' plate of 1864, showing the whole of the small quartzose particles or minute diatom-valves plainly melting, as it were, into the substance of the chitinoid and colloid basis of the stratum on which they rest. The occurrence of these siliceous plates in the midst of insoluble mineral particles proves that they originate only in mineral substances capable of entering into colloidal combination with the chitinoid basis of the test. Hence they furnish clear evidence that there exists no intrinsic tendency in *Difflugia symmetrica* towards the development of these plates, which is not shared equally by the other varieties of the series. This, I venture to think, is confirmed by the specimens figured in Prof. Leidy's work to which attention has already been drawn in this paper.

Fig. 3 is a representation of the common form of *Difflugia pyriformis*, in which the massiveness of the angular mineral particles is such as to render them apparently proof against metamorphic agency. It will be seen on reference to the two figures of *Difflugia symmetrica* at p. 463, that they both partake of the pyriform curve, though never to a very marked extent—this being my reason for describing the figure of the test in *D. symmetrica* as corresponding most closely with *D. mitriformis*.

Fig. 3.



The two next sketches (figs. 4 and 5) represent very perfect specimens of highly-developed metamorphic forms, almost identical in every respect with those represented in figs. 32 and 33 of my 'Annals' series. Fig. 4 shows the test covered with round colloidal disks of nearly uniform size, placed in more or less regular order, but invariably resting upon their flat sur-

faces, the entire intervals being studded with much more minute disks or globules (for it is almost impossible to determine positively which they are). We have in this and also in fig. 5 typical examples of the pyriform test of *Difflugia pyriformis*, the only difference between them consisting in the degree of inflation in the body of the test—a difference which is shown to extend still further in pls. xxii. and xxiii. of "*Nebela collaris*" in Prof. Leidy's work. In fig. 5 (a Greenland form) very minute specimens of a diatom, probably an *Eunotia*, take the place of some of the colloid disks. It is, however, in the series of tests which are chiefly built up of diatoms that a clue is found to the formation of the large and small colloid disks, and rectangular siliceous plates derived from this source. In some tests the process of metamorphism can be very distinctly traced, and we then see in different specimens and different varieties a gradual passage from their original figure to one or other of the various metamorphic forms of which mention has been made. Where large oval or circular diatom-valves have formed part of the test these appear, in some of Prof. Leidy's figures, to pass eventually into true circular or oval hyaline plates of proportionately large dimensions.

Fig. 4.

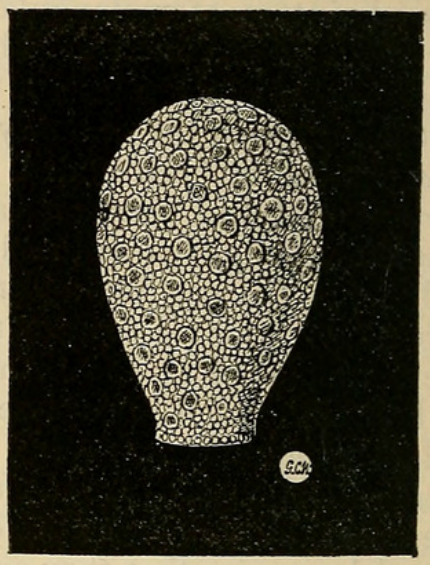
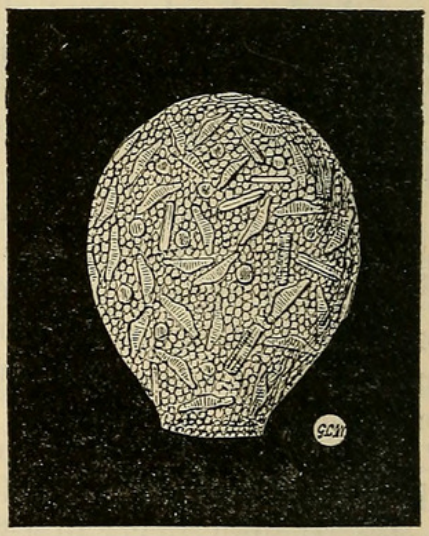


Fig. 5.



I have only space to add that the appearances described as characterizing the metamorphic series are not confined to the mitriform and pyriform varieties, though they would appear to reach their climax in them. They are likewise observable in the globular and oblique, or, as I have termed it, the marsupiiform series, of which *Difflugia spiralis* and *D. cassis* are offshoots. In the former of these two the chitinous pellets and cylinders, whether straight or bent, seem to arrive at their maximum of development. But, strange to say, I have never

met with a single example anywhere in which there occurred so close an approach to distinct siliceous rods and plates as is to be seen in pl. xix. of Prof. Leidy's series. I have nevertheless met with specimens of *D. cassis* in which there was a row of circular colloid disks surrounding the aperture of the test.

Before bringing my remarks on the Difflugian Rhizopods to a close, I must point out that, although Prof. Leidy has paid me the compliment of adopting nearly every fact and conclusion of mine in relation to the forms he has transferred to his new genus *Nebela*, the only direct reference made by him to my previous writings on these forms is contained in the following brief paragraph at p. 151 of his observations on the Nebelidæ; and even here the scope of the remark he is quoting is very materially impaired by his having cut short the sentence at the word "occur":—

"Dr. Wallich, in referring to the shell of the transitional forms of *Difflugia symmetrica*, calls the peculiar elements colloid disks and plates. He remarks of them that they are derived from the animal and not directly from the medium in which it lives. He supposes, however, that they are formed through the coalescence of diatoms and other mineral elements with the chitinoid basal substance of the shell, which then undergo metamorphosis into all the colloid forms that occur. Of this process I have been unable to satisfy myself; but the exceedingly varied specimens which have come under my notice, of shells composed of elements apparently intrinsic and of regular but widely different forms, of others apparently of extrinsic elements, regular and irregular, with many others of a transitional character, *would appear to justify the conclusion of Dr. Wallich.*"—*Op. cit.* p. 151.

The sentence quoted from p. 234 of the 'Annals' for March 1864 concludes as follows:—"*from the first alteration in shape of the mineral particles themselves, to the development of the crystalline tablets which were first described.*"

The genus *Nebela* is thus defined by Prof. Leidy:—

"Shell usually compressed pyriform, transparent, colourless, with or without appendages, composed of cancellated membrane, or of peculiar intrinsic structural elements of variable form and size, mostly of circular or oval disks, of narrow rectangular plates or rods, or of thin, less regular, angular plates, often almost exclusively of one or the other, sometimes of two or more intermingled in variable proportions, sometimes of chitinoid membrane incorporated with more or less extrinsic elements, and sometimes of these entirely, as in *Difflugia.*

Mouth inferior, terminal, oval. *Sarcode colourless, in form, constitution, and arrangement as in* Difflugia, Hyalosphenia, &c."—*Op. cit.* p. 145.

"In composition the shell [of *Nebela collaris*] is of extraordinary character, from the variety in form and arrangement of its elements. Most frequently it is composed of oval or circular disks. The disks usually hold no relationship in size with that of the shell; . . . . sometimes the shell is almost entirely composed of circular disks, sometimes of oval disks, and frequently the two kinds are intermingled. Sometimes they are of pretty uniform size; at others, they are intermingled, of different sizes. Most frequently the larger disks occupy the fundus and body and the smaller ones the lower part or neck of the shell. Sometimes the larger disks are more or less scattered, with some approach to uniformity, and the intervals are occupied by smaller ones. Indeed, there exists almost any conceivable arrangement of the round and oval disks in the construction of the shell."—*Op. cit.* p. 147.

"Not unfrequently there are found, in association with the usual more characteristic varieties of *N. collaris*, *individuals which have the same form of shell, but with its structure rather related with that of the ordinary forms of Difflugia.* In some specimens the shell is composed of thin and irregularly angular silicious plates as represented in fig. 12."—*Op. cit.* p. 148.

"Sometimes narrow rectangular plates in different proportions are intermingled with the disks, and occasionally the former greatly predominate. Occasionally I have found specimens in which quadrate plates, like those of *Quadrula symmetrica*, were mingled with the more usual structural elements."—*Op. cit.* p. 153.

"The specimens vary greatly in the form of the component *silicious plates*, which consist of variable proportions of the kind just described, *with others which are more regularly rectangular*, or in the form of rods, and sometimes with diatoms and round or oval plates, like those which ordinarily compose the shell of *Nebela collaris. Through such specimens the latter would appear by transition forms to merge into* Difflugia compressa!"—*Op. cit.* p. 148.

"The nature of the singularly varied shell of *Nebela collaris* I have not been able to determine with any satisfaction. In the characteristic forms, the elements of structure, the disks and plates, appear to be intrinsic, and not of a foreign character. They appear to be cemented together or conjoined at the borders, and not implanted upon or incorporated with a distinct chitinoid membrane. In breaking the shell the line of frac-

ture follows the outline or intervals of the disks and plates. The shell appears to be silicious and remains unchanged when exposed to the action of heated sulphuric and nitric acids."—*Op. cit.* p. 151.

The encystation of the naked and testaceous Amœbans, the process of "coagulation" and "consolidation" of the ectosarc by which the membranous structure of the encysting sac is produced, the formation of the *diaphragm* by which the mouth of the testaceous Amœbans is closed during their encystation, and the characters each of these parts assume, will be found described by me in the 'Annals' for May 1863, pp. 367 to 369; 'Annals,' Nov. 1863, p. 336; 'Annals,' Dec. 1863, p. 462; and 'Annals,' March 1864, p. 235.

It only remains for me to say that more admirably and truthfully executed figures of the freshwater Rhizopods have never been issued than those contained in Prof. Leidy's work. In no other publication have such indisputable proofs ever been brought together of the process of natural evolution from one end to the other of a very extensive and complete series of Protozoan organisms. Had Prof. Leidy dwelt somewhat more fully and distinctly than he has done on this the most striking feature in his researches he would indeed have conferred benefits of no ordinary magnitude upon the branch of science of which he is so distinguished an expositor*.

XLIII.—*Descriptions of three new Species of* Geckos.

By G. A. Boulenger.

Gecko pumilus, sp. n.

In habit similar to *Lepidodactylus Guppyi*. Head small, body elongate, limbs moderate. Snout once and one third the diameter of the orbit, which equals the distance between the latter and the very small, round ear-opening; forehead scarcely concave. Head covered with small granules, which are considerably larger on the snout; rostral quadrangular, not quite twice as broad as long, with a short cleft above; nostril pierced between the rostral, the first labial, and three nasals; twelve upper and ten lower labials; three or four

* I have but recently seen Mr. Romyn Hitchcock's "Synopsis" of Prof. Leidy's great work, and can confidently recommend it as a most useful compendium of information on the freshwater Rhizopods in general.

Wallich, George Charles. 1885. "XLII.—Critical observations on Prof. Leidy's "Freshwater Rhizopods of North America," and classification of the Rhizopods in general." *The Annals and magazine of natural history; zoology, botany, and geology* 16, 453–473. https://doi.org/10.1080/00222938509459911.

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