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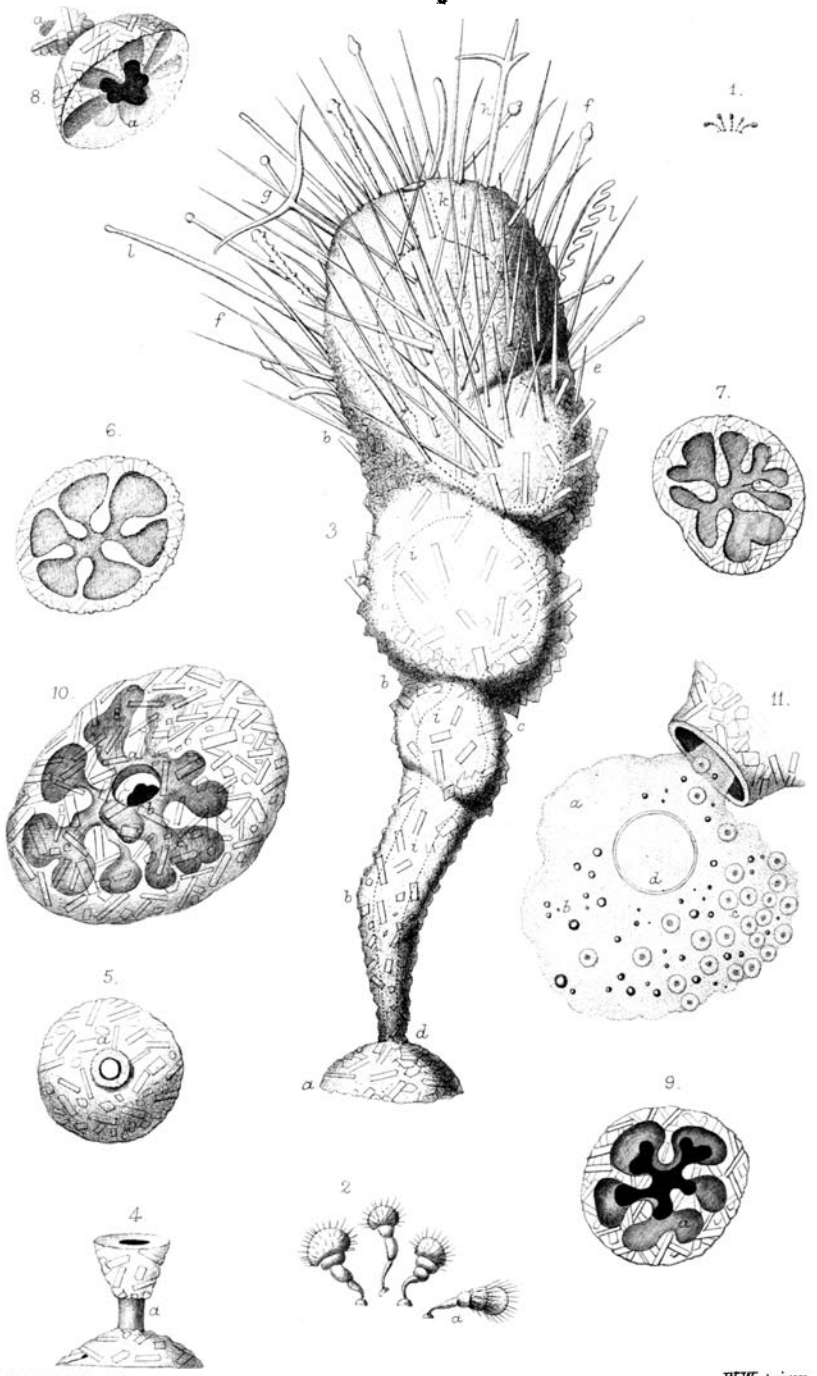
XXXIII.—*On two new Species of the Foraminiferous Genus* Squamulina; *and on a new Species of* Difflugia. By H. J. CARTER, F.R.S. &c.

[Plates IV. & V.]

THE genus *Squamulina*, according to Dr. Carpenter, was instituted by Prof. Schultze (Ueber den Organismus der Polythalamien, &c., 1854) for "a minute Monothalamion of which he found several specimens at Ancona, adhering to the surface of Algæ and to the sides of a glass vessel in which sea-water had been long kept. The shell, whose largest diameter is about 1-300th of an inch, has the form of an irregular plano-convex lens, being usually flat, or nearly so, on its attached side (which accommodates itself to the surface whereon it grows) and convex on its free side, on some part of which, usually about halfway between the centre and the periphery, is a wide orifice from which the pseudopodia issue. The shell is calcareous and opaque, and is destitute of pores; its adherent layer is very thin, and is with difficulty detached from the surface to which it is attached. The substance of the animal is of a brownish-yellow colour, as in *Gromia*; its pseudopodia, however, seem fewer and less disposed to subdivide and inosculate." (Carpenter, 'Introduction to the Study of the Foraminifera,' Ray Soc. Pub., p. 67, pl. 1. fig. 22; also Pritchard, 'Infusoria,' p. 558, ed. 1861.)

Two arenaceous forms of this genus live in the laminarian zone at Budleigh-Salterton, as their presence on certain fuci cast upon the beach during storms indicates:—one like *Squamulina lævis*, the type species of Schultze's genus just described; the other, also discoidal, but bearing a little, erect, brush-like eminence on its convexity.

For the former I would suggest the specific name *varians*, and for the latter *scopula*, from the resemblance of the eminence to a little brush or broom.



H.I.C. del. Tuffen West sc.

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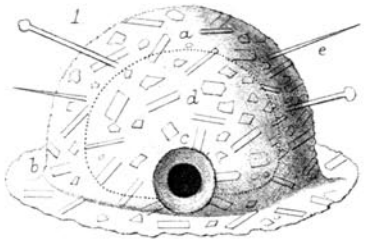

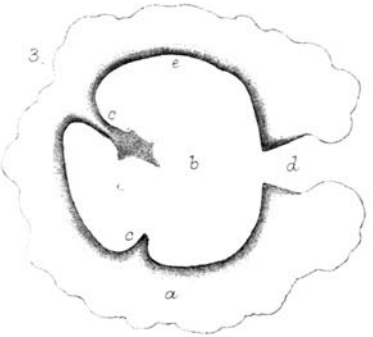

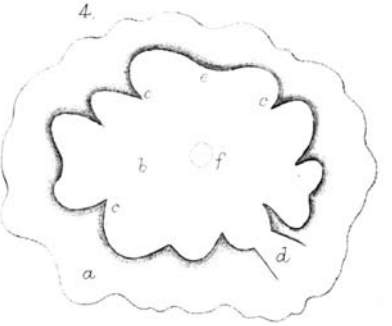

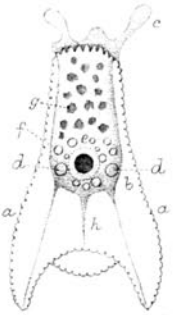

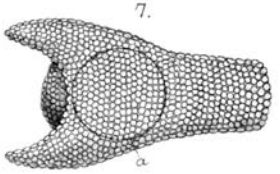

H.I.C. del. Tuffen West sc.

W. West. imp.

Let us direct our attention to a description of the latter first, as being the most interesting form of the two species.

Squamulina scopula, mihi. Pl. IV. figs. 1–11.

Test white and hollow, consisting of a pedestal (fig. 3 *a*) and columnar portion (*bbb*), the former plano-convex and the latter obversely conical, terminating in a brush-like bunch of spicules (*ff*). Pedestal subcircular, more or less raised, closed below by a discoidal portion, which, stretching across its base, forms the point of attachment between the animal and the fucus or object on which it may be located; open above, where it joins the pointed end of the columnar portion. Columnar portion erect, conical, with the pointed end downwards, consisting of a neck (*d*), body (*c*), and head (*e*); neck contracted, more or less ligamentous, connecting the lower extremity of the column with the summit of the pedestal; body increasing in size upwards, and formed of two or more dilatations; head inflated, and bristled all over with sponge-spicules. The whole composed of fragments of hyaline colourless quartz, mixed with sponge-spicules and a small portion of calcareous matter, cemented together by a chitinous substance; tessellated and almost smooth below, becoming rougher upwards, until the whole head is obscured by a heterogeneous mass of projecting spicules and other like bodies, obtained indiscriminately from all the sponges of the locality, both siliceous and calcareous, arranged in a spreading form obliquely forwards, not unlike the fibres of a little broom, whence its specific designation—but where the spicules are capitate and not pointed at each end, having the heads *outwards*; grains of quartz, for the most part, so minute and numerous that, like pounded glass, they cause the test to present a white colour when dry, which, of course, becomes greyish in water. Chitinous substance or basal cement supporting the arenaceous particles of the test outside, and inside forming a smooth surface, which lines the chambered cavity of both pedestal and column; thickest, and even fibrous, about the lower end of the column, where it connects the latter with the summit of the pedestal, and where (if not always, for a minute distance) it, in many instances, is uncovered by the arenaceous coat (fig. 4 *a*), obviously for giving that latitude of movement to the column upon the pedestal which enables the former, when fresh or wet, to be bent down almost at right angles to the pedestal without breaking (fig. 2 *a*), but, on the contrary, with the power of regaining its erect position by the resilient nature of the chitine, here presenting a fibrous structure, perhaps in the

living state under the command of some contractile contrivance obeying the instinct of the animal. Pedestal hollow, presenting septal prolongations of the arenaceous coat inwards from its circumference towards the centre, which they seldom if ever reach, but, extending upwards from the disk, along the dome of the convexity, lose themselves at last in the latter as they approach the round hole leading from its summit into the columnar portion (figs. 5–9). Columnar portion hollow, consisting of two or more chambers corresponding with the number of its dilatations (*i i i*), bound together by isthmic contractions, the last of which terminates in an aperture (*k*), about 4-6000ths of an inch in diameter, at the free end of the column, in the centre of the brush of sponge-spicules. Animal occupying the cavity of the test, consisting of semitransparent yellowish sarcode (fig. 11 *a*) charged with granules and oil-globules (*b b*), frustules of Diatomaceæ, especially *Melosira* (*d*), dark-brown bits of fucus, and reproductive cells (*c*); more attenuated and less coloured anteriorly, whence the pseudopodia are projected; bearing the frustules of Diatomaceæ and bits of fucus in the centre; and posteriorly charged with a great number of the reproductive cells, consisting of spherical, transparent, nucleated capsules, otherwise filled with a homogeneous, glairy, albuminous (?) substance. Largest test about 1-12th of an inch long; reproductive cells about $2\frac{1}{2}$-6000ths of an inch in diameter.

Hab. Sea: Laminarian zone; fixed on the purse-like root of *Laminaria bulbosa*, chiefly on and among the rootlets, also on the fronds of *Phyllophora rubens*. Often in company, on the former, with *Squamulina varians*, *Leucosolenia botryoides*, and *Grantia ciliata*.

Loc. Beach at Budleigh-Salterton, Devonshire; cast ashore by storms.

Obs. We are indebted to Dr. Bowerbank for the first description and illustration of this little organism (Phil. Trans. 1862, p. 1105, pl. 73. fig. 3; repeated in 'Brit. Sponges,' Ray Soc. Pub. 1864, vol. ii. p. 78, pl. 30. fig. 359), who gave it the name of "*Halyphysema Tumanowiczii*," adding that "it is remarkable for being the smallest British Sponge" (!). But, as mental operations are seldom so correct as visual ones, so our author, who figures the polypes on the cord of *Hyalonema* as "oscula" (Brit. Spong. vol. i. p. 287, pl. 35. fig. 374), has, in 1864, also very imperfectly figured this little Foraminiferous animal "as the smallest of British Sponges," for which Schultze had already instituted the genus "*Squamulina*," ten years previously, viz. in 1854 (*op. cit.*). I do not, therefore, hesitate to use Schultze's generic name with a new specific

one of my own, in order that henceforth all connecting *Squamulina scopula* with the sponges may be abandoned. How Dr. Bowerbank could have placed it among the sponges, when he states that he was unable "to detect either oscula or pores," and observed that the "globular heads" of the spicules were outwards (*op. cit.*), I am at a loss to conceive. At the same time this mistake points out to us how very careful we should be when we come to the nice distinctions that exist between the Foraminifera and the Sponges, especially in the minuter forms, where deciding upon mere resemblances is as dangerous as denying the presence of pores or oscula in either class where we cannot immediately see them with our microscopes.

I first found *Squamulina scopula*, on *Phyllophora rubens*, in November last (1869), and, after drying the specimens for examination with the microscope, was struck with the septated appearance of the bottom or discoidal part of the pedestal, which generally adheres to the fucus when the test is broken off in the dried state—an appearance so like the septal divisions of a coral-polype that I began to think that the organism must in some way be allied to these animals.

Resolved, therefore, to take the earliest opportunity of further prosecuting this inquiry, I in vain sought for more specimens of this little organism on pieces of *Phyllophora*; and, seeing the ordeal to which they must be exposed in passing through the "hurly-burly" of pebbles, waves, and sand, before they could reach the shore in safety, I had nearly given up all idea of success, when, one day in January last, I discovered it on fresh specimens of the purse-like root of *Laminaria bulbosa*, especially on and about the rootlets projecting from the part next the rock on which it grows—the only position, perhaps, except by mere chance, in which it could be landed intact—and after this, obtained an abundant supply from these roots, all in a *living* state, but, of course, much washed by having undergone the exposure to which I have alluded.

By the different aids which those accustomed to the examination of microscopic objects are in the habit of applying, I have been able to analyze this little organism, so as to obtain the facts given in the above description.

Examined in the wet way while living, or preserved in spirit and water, by crushing and sectioning, examined in the dried state, and with parts mounted in balsam, all these facts may respectively be obtained; but here, as in every thing else, patience, endurance, and perseverance are necessary to success, bearing always in mind that every specimen when examined, in part or entire, will probably afford something

new, and that therefore he who examines most will, *cæteris paribus*, be able to describe the object most correctly.

Although I have often sought for the pseudopodial prolongations of the sarcode from the aperture of *Squamulina scopula* when in sea-water and in a living state and apparently under favourable circumstances as regards rest &c., yet I have never been able to see them. But it should be remembered that they could only be viewed as opaque objects by reflected light, with, at the nearest, only ½-inch compound power, while in general these prolongations can only be just seen by transmitted light with ¼-inch, and then only under the most favourable circumstances as regards fresh sea-water, undiminished vitality, and with little or no molestation—a coincidence of conditions so difficult to obtain that I could hardly expect, with the power first mentioned, to be successful.

What, however, I could not obtain in this way while the animal was entire, I have managed to get by dissection while fresh; and thus all but seeing the animal substance *move* has been revealed by the processes just mentioned, under which the necessary magnifying-power with transmitted light could be used with impunity.

By tearing the test to pieces, its composition can be easily ascertained; and, first, we find that it is for the most part composed of colourless hyaline grains of quartz and sponge-spicules, sometimes one preponderating, sometimes the other, the former being so small that they look like pounded glass, and, being *all* colourless, give the test its white appearance; while the latter, which may be entire or fragmentary to an equal degree of minuteness, are derived indiscriminately from all kinds of sponges of the locality, calcareous as well as siliceous. They are chiefly fragmentary about the lower extremity, where they are tessellately connected by chitinous substance exactly like the arenaceous particles on the tests of some *Difflugiæ*, and equally heterogeneous, although, like many *Difflugiæ*, there is evidently a preference here for particular objects, and especially for transparent substances *without* colour, inasmuch as, although nearly every thing else of the kind in the locality (that is, having recourse to foreign objects for the construction of its habitation) partakes of the ferruginous red material (argil and quartz) that, from the contact of the waves with the cliffs of the New Red Sandstone series here, deeply and continually tinges the sea, the animal of *Squamulina scopula* rejects all but the absolutely *colourless* grains: hence it is always pure white.

Further up the column the fragments of the spicules are

longer and more projecting, until we arrive at the head, which is one mass of *entire* sponge-spicules of all kinds, arranged very much like pins in a pincushion, viz. with the obtuse or capitate ends, as the case may be, always *outwards*, those only being pointed which are pointed at both ends, *ex. gr.* the spicules of *Halichondria panicea*, Johnston, which, either from its being the most plentiful sponge in the locality, or from preference of the *Squamulina*, or both, so far exceed the rest in number, that the animal may be inferred to prefer points to obtuse ends, when it can get them, for its spiculiferous head.

Not content with grains of quartz and sponge-spicules, we frequently observe other objects, such as chitinous tentacles or setæ of sea-animals, and even filaments of *Melosira*, incorporated with the rest of this heterogeneous assemblage. In short, the animal appears to clothe itself with every thing of this kind that comes in its way, only confining the *entire* spicules chiefly to the head or free extremity, where one of their purposes is evidently to act as strainers, catching fragments of soft bodies, living or dead, which impinge upon them by sinking or current-influence, and thus probably entrapping food after the manner of a spider's web, which the pseudopodia then can easily envelope and draw into the body of the *Squamulina*.

Carbonate of lime also enters into the composition of the test; but this is so trifling in quantity that it is impossible to say if the effervescence does not arise from the presence of fragments of calcareous spicules. Even when dilute nitric acid is applied to the thin disk which is left on the dry fucus, after the superstructure may be broken off, the diminution in bulk of the white material appears to be so trifling, although there has been effervescence, that, when dried again, the deficiency cannot be appreciated.

The chitinous substance in which the arenaceous material is fixed is thicker below than it is above, and about the junction of the column with the summit of the pedestal (that is, about the neck) presents a fibrous structure which binds the former to the latter by a material at once so tough and resilient that the erect or columnar portion may, in the living or wet state, be bent down at right angles to the summit of the pedestal in all directions without breaking or losing its natural elasticity, which, on the other hand, when the pressure is withdrawn, brings the column back to its erect position. Moreover this part, in some specimens, is visibly uncovered for a short distance by the arenaceous coat (fig. 4*a*), and, I think, as the latitude of its movements in every instance indicates, is always so just at the line of junction with the pedestal. How

far the animal may make use of this latitude of movement in bending the head this way or that by living contractile power, as the occasion may require, I do not pretend to say; but the head is frequently bowed down on one side or the other, as if the movement had been effected by the animal (fig. 2 *a*).

The base of the pedestal, which is the bond of attachment between the *Squamulina* and the fucus or body on which it may be located, and, although not so thick, is also chiefly composed of the same material as the walls of the other parts of the test, presents a radiated structure which, in a morphological point of view, becomes so interesting that I shall postpone it for more particular description and consideration hereafter (figs. 6 & 7).

Meanwhile, the cavity of the test, like the test itself, consists of two portions, viz. that of the pedestal and that of the column. That of the pedestal more or less corresponds with its external shape, presenting a circular hole at the summit (fig. 5 *a*), which makes it continuous with the cavity of the column, but is modified, in the rest of its extent, by a variable number of pseudo-septal divisions of different lengths, five or six of which, but generally five, are more prominent than the rest, radiating inwards from the circumference of the pedestal towards its centre, short of which they stop, to leave a central area, but are continued upwards, so as partially to divide the cavity of the pedestal into five or more circumferential compartments, the septal prolongations between losing themselves upon the dome of the pedestal as they approach the circular aperture at its summit, and thus causing the central area to form a common cavity with the circumferential compartments, while it is in direct continuation with that of the column.

At the point where the cavity of the pedestal joins that of the column, the union of the two is chiefly effected by chitinous substance *only*, to admit of the motion of the column on the pedestal to which I have alluded—a fact which, although thus indicated, is only now and then satisfactorily seen, when for some little distance at this point the outer or arenaceous coat is absent (fig. 4 *a*).

The cavity of the column itself (*iii*) consists of a chain of two or more chambers linked together by isthmic constrictions corresponding to the dilatations and contractions respectively of the column, which in full growth do not exceed three or four of the former, as my illustration will show (fig. 3), terminating at last at the summit of the column in the centre of the head of spicules, by a constricted canal like those joining the dilatations, and ending ultimately on the surface in a small aper-

ture (*k*). This aperture, however, can very seldom be well seen, owing to the forest of spicules which surround and intercross obliquely over it in the dried state; but occasionally it is perfectly visible; and when not so, it is frequently marked by a brownish bit of sarcode which fills the opening, and, contrasting in colour forcibly with the white mass of spicules surrounding it, enables the position of the aperture to be easily ascertained.

The animal substance (fig. 11, *a*), which is of a pale yellow colour when living, occupies the cavity of the test, and resembles that of the Foraminifera generally, in consisting of granuliferous sarcode more or less charged with oil-globules. It may be divided into three parts, viz. anterior, middle, and posterior—or into pseudopodial, ventral, and ovigerous. The former, which, like that of *Difflugia*, is more attenuated and less granuliferous than the rest, also furnishes the pseudopodial prolongations; the next division is charged with the frustules of Diatomaceæ, especially the disks and filaments of *Melosira*, minute Algæ like *Rivularia* (*Euactis*?), and bits of dark brown matter from the decaying portion of the root of *Laminaria bulbosa*, near which *Squamulina scopula* likes to congregate, the latter causing the ventral sarcode to assume so much the appearance of the sarcode of *Æthalium* that it may be worth while to allude also to this again more particularly hereafter. Last of all comes the posterior division, which is more or less charged with spherical, transparent, nucleated cells (fig. 4*c*), such as are commonly found in both Foraminifera and the testaceous freshwater Rhizopoda, and which I have often and long since figured and described in these organisms respectively in the pages of this periodical. This portion is a little denser than the rest, occupies the posterior or lower part of the cavity of the column and pedestal, and, when dry and contracted, presents a dark brown colour.

When the column is detached from the pedestal in the living state, the ventral and ovigerous sarcode may be easily pressed out of the lower end of the former (fig. 11), and thus examined under a high power, when the facts which I have mentioned may be easily verified.

In form, the test of *Squamulina scopula* differs very much, first, by age and growth, and, secondly, by some parts being more developed in some specimens than in others. Thus, if young, it may be short, the dilatations only amounting to one or two; or if old, to four or five: hence one of the latter has been chosen for the illustration (fig. 3). The pedestal, also, may be more or less atrophied; and its circumference may, instead of a circular, have a more or less undulating margin.

Absolutely circular it seldom is, from the presence of a slight indentation at one part, which seems to correspond to that seen on the circumferential line of nautiloid Foraminifera, with which we shall presently endeavour to identify it.

Then the columnar part may be erect, sloping, or bent down to one side (fig. 2 *a*), or more or less irregular in form; but all these differences are so slight, that, whether young or old, straight or crooked, deformed or symmetrical, there is no difficulty in recognizing the animal as the same, when once the nature and general form of *Squamulina scopula* has been ascertained. In some cases, too, this may be modified by the injury to which this delicate little organism must be exposed when hurled upon the shore; for the head in some specimens is much larger than in others, owing frequently, although not always, to the extent to which the fragile spicules have been broken off by the waves. Indeed it has often seemed to me wonderful that any of these delicate little objects of the Laminarian zone should ever reach the shore in safety. Certainly myriads of them must be ground to powder, and thus disappear amidst the sand and pebbles with which they are tossed about in the land-wash, long before any of them are thrown up beyond the reach of the sea. Yet, but for heavy gales of wind, combined with head-growth and frequent decay of the roots of the fuci, we should never know what much of this zone contains in the way of either animal or vegetative life, since the dredge cannot be used among the rocks, and the constant waving to and fro of the fronds of the fuci, even in an almost motionless sea, defies all attempts to recognize any thing minute much below the surface, and renders every effort to obtain it direct from this zone almost useless.

Food.—I have stated that the spicular head might strain the water passing through it, and thus collect much soft material of a nutritive nature, either living or dead, so that the animal would only have to extend its pseudopodia up the spicules to seize and draw it into its body. But, in addition to this, there is hardly an instance in which remnants of Diatomaceæ are not present in the interior, consisting (for the most part certainly, as before stated) of the disks and filaments of *Melosira*, together with portions of the decaying fucus, thus indicating a power of obtaining food beyond that which may be provided by the straining arrangement of the spicules. Indeed, prior to the formation of the head of spicules at all must be the formation of the pedestal and lower part of the column, which distinctly points out that the animal, from the very commencement, has the means of catching those particles which, floating by it, are found best subservient

to the purpose of nutrition and for the formation of its test respectively.

Returning, now, to the pseudo-septal division of the pedestal, let us consider for a moment this structure with reference to its comparative morphology.

When the specimens of *Squamulina scopula* are dried, they are very prone to fall off from their attachment to the fucus; and then they invariably leave the bottom or disk of the pedestal adherent to the former—which at once enables us to see the disk on the fucus (figs. 6 & 7), and the vault of the convex pedestal still connected with the broken-off column (fig. 8 *a*).

If we first look at the disk adhering to the fucus (figs. 6 & 7), we shall observe that it is more or less white, being composed of the same material as the test, and presenting a more or less uneven ring, from which several processes of unequal length radiate inwards. Five or six, but generally five, of these, as before stated, are much more developed than the rest; constricted towards the circumference and inflated towards the centre of the disk, which they do not reach, but leave, as also before stated, a central area, which forms, with the interspaces between the radii, a single common chamber, continuous, through the aperture of the summit of the pedestal (fig. 5 *a*), with the general cavity of the column. The interspaces of the disk are more chitinous perhaps than arenaceous; that is to say, the test is not near so thick here as in other parts.

Turning to the corresponding portion of the pedestal still attached to the column (figs. 8 & 9), we observe that these radiated portions of the disk belong to as many pseudo-septal divisions which, extending upwards, at last lose themselves upon the dome of the pedestal, near the margin of its aperture, and that, in the dried state, a contracted mass of dark brown sarcode (*a*) at this point presents, in its still lobed form (fig. 9 *a*), the indication of its once (when living) having occupied the interspaces between the septal divisions of the pedestal.

Now this radiated disk undoubtedly has very much the appearance of the radiated septa of a coral-polype; but it has a still nearer affinity to the septal divisions of a nautiloid foraminiferous test; and when we compare the whole structure of the pedestal with the latter, we cannot help seeing that the septal divisions are homologous with the septa of a nautiloid foraminiferous test, and that the central area corresponds with the initial or primary cell of a nautiloid individual, which, on being prolonged upwards, in *Squamulina scopula*, developes a column at the expense of the spire.

Following up this view, I by chance found a pedestal *alone*, which I have mounted in balsam and drawn as one of the

illustrations (fig. 10), showing so plainly and so unmistakably the remains of the nautiloid chambered spire with an opening in the position of the initial or primary cell, that no doubt can now be entertained of the foregoing conclusions.

I am not quite certain whether this disk, which had fallen off a portion of fucus bearing a number of both species of *Squamulina* (viz. *scopula* and *varians*), preserved in spirit, belongs to the former or to the latter species; for the former *always* has a hole in the summit of its pedestal, and the latter may or may not have it there, as will be seen presently, when it is described; but whether it belongs to one or the other, the observations on the comparative morphology apply equally to both species; and thus the specimen is as conclusive of the homology of *Squamulina scopula* with the nautiloid forms of Foraminifera as it will be found conclusive of the same fact in the description of *Squamulina varians*, the latter being, as it were, merely the pedestal of the former increased in size and somewhat altered in shape by the absence of the columnar portion.

Thus, however much in the first instance we find the radii in the disk of the pedestal of *Squamulina scopula* like the septal divisions of a coral-polype, we shall presently see, in *S. varians*, that where they are altogether absent they leave a simple globular chamber, and that where, on the contrary, they are more or less developed they only present a step further towards the pedestal of *Squamulina scopula*, which is but a transitional form to a nautiloid foraminifer, and not to a coral-polype; that is to say, that the simplest form of *Squamulina* passes thus into a nautiloid form of Foraminifera, and not direct into that of a coral-polype.

Lastly, I alluded to the presence of the dark-brown bits of decaying fucus in the ventral portion of the animal of *Squamulina scopula* as resembling similar contents in the body of an *Æthalium*. I do not mean to identify *Æthalium* in its massive amœboid state (that is, before it comes to maturity, dries up, and developes its sporidia) with a foraminiferous animal; but I mean to say that bits of brown decaying wood and resinous matter may be seen in an *Æthalium*, evidently incepted from the woody tissue in or among which it had been living, much the same as we see the bits of decaying fucus in the ventral portion of *Squamulina scopula*—and, further, that the reproductive cells of *S. scopula* and the Foraminifera that I have examined in a living state are very like the reproductive cells of *Æthalium*, in form and in crowded number, just before the latter pass into the matured or dried state, and become black or otherwise deeply coloured.

Further, also, it might here be added that, whenever specimens of *Leucosolenia botryoides* are wanted, the most likely place to find them will be about the decaying parts of the roots of *Laminaria digitata* and *L. bulbosa*—that *Grantia clathrus*, Schmidt, seeks the same habitat, and that in one specimen (which I possess) the latter has, for some inches in diameter, so densely netted itself over the vault and throughout the branches of the root-bunch of a large specimen of *L. digitata*, that, at first sight, I was doubtful whether I had not one of the Myxogastres before me; so intimately allied in aspect, form, and habitat (the former being, of course, marine, and the latter terrestrial) do these sponges appear to be to this family of Fungi.

Finally, I might add that, in two living specimens of a sponge obtained from different localities, and bearing spicules like those of *Halichondria panicea*, John., but possessing a faint purple tint, I found the purple colour to be produced by its being densely charged with smooth spherical cells so like the sporidia of the Myxogastres, that, but for the presence of the spicules and the specimens being fresh and living, I should have concluded that these cells came from one of the Myxogastres, and did not originally belong to the sponge.

At present it seems to me, from the above observations, that if we are to propose any class-arrangements between the Sponges and the Corals, the Foraminifera must take an intermediate position as the transitional form, unless they be all viewed as branches from a common palæogenetic stock.

Besides *Halyphysema Tumanowiczii* (now our *Squamulina scopula*), Dr. Bowerbank adds another species, to which he has applied the specific designation of "*ramulosa*," and which he states does "not exceed two lines in height and about the same in breadth, and in this space there are eight branches" (Brit. Spong. vol. ii. p. 79). The specimen appears to be unique; and, in the absence of illustration and description of the manner in which the branches come off, this species, although in other respects almost the same as *Squamulina scopula*, must remain in abeyance, until chance favours some one with another specimen, who will give an illustration and a more detailed account of it.

Under the genus *Polytrema*, Dr. Carpenter (*op. cit.* p. 236) alludes to an arborescent specimen which was "completely covered over with a membranaceous sponge, the spicules of which seemed to radiate from the extremities of the branches," and then adds, "Of the parasitic character of the sponge I entertain no doubt whatever."

Can there be any connexion between this and Dr. Bowerbank's branched species of his *Halyphysema*?

Squamulina varians, mihi. Pl. V. figs. 1–5.

Test white, more or less circular, plano-convex, raised or depressed, or conical vertically or horizontally—in short, presenting all kinds of forms from a symmetrical dome-shaped body with circular base to an amorphous mass fringed out, amœba-like, at the circumference into every variety of indentation; possessing a single circular aperture at the base or summit, or anywhere between the two, widening outwards; sometimes crescentic and lateral, at others produced in a circular form on a short neck; composed of colourless grains of quartz and sponge-spicules, fixed or tessellated more or less smoothly in a chitinous substance, which, extending across the base, fixes the test to the surface of the fucus or object on which the animal may be located; evidencing, by effervescence with acid, a slight admixture of calcareous matter, and sometimes, when the fragments of the spicules are long and pointed, or capitate, allowing these to project more or less beyond the surface, the capitate ones with their obtuse ends *outwards*. Base or discoidal portion outwardly extending beyond the body of the test, and terminating in a thin edge, which may be circular, subcircular, or more or less indented; and internally (that is, in the chamber of the test) presenting, at its point of union with the body, a circular, subcircular, or wavy outline, more or less dentated by pointed prolongations of the test inwards, which, after being continued up the side for a little way, cease to appear above the surface of the interior long before arriving at the summit of the dome. Chamber lined by chitinous substance, which chiefly composes the base or disk and thus forms the bond of attachment between the test and the fucus or body on which it may be located. Animal substance occupying the chamber, and consisting of granuliferous sarcode, of a light yellow colour while living, charged with oil-globules, frustules and filaments of Diatomaceæ, chiefly of *Melosira*, and reproductive cells. Size very variable, seldom more (and frequently less) than 1-30th inch in diameter.

Hab. Sea: Laminarian zone, on *Phyllophora rubens* and the purse-like inflation of the root of *Laminaria bulbosa*, in company with *Lagotia viridis*, Wright, chiefly inside, and with *Squamulina scopula*, *Leucosolenia botryoides*, and *Grantia ciliata*, chiefly outside.

Loc. Beach at Budleigh-Salterton.

Obs. This species appears to be so like Schultze's *Squamulina lævis*, that, but for the test being composed of grains of quartz and fragments of sponge-spicules, instead of calcareous

matter, I should have said it was one and the same. The arenaceous character of the test, however, makes the difference, if not also its pseudo-septal prolongations into the interior of the chamber. Schultze's calcareous form, which also appears to be much more minute, I have not seen.

S. varians closely resembles in every way the plano-convex portion or pedestal of the foregoing species; we have only to take away the columnar portion of *S. scopula* to have the more simple form of it which appears in *S. varians* when the aperture is in the summit, and the base internally denticulated.

Like the plano-convex portion of *S. scopula*, also, it varies much in its circumferential outline, as it does in the amount and extent of its pseudo-septal radiate prolongations internally, being sometimes without any of the latter, and thus presenting a simple single chamber (fig. 1); while at others it is more or less crenulated throughout by the inward denticulations of the test, approaching the many-chambered form of the nautiloid Foraminifera (fig. 4).

It also varies very much in shape and size (compare fig. 1 with fig. 5), but is always characterized by snow-whiteness, from the minutely comminuted state of the colourless grains of quartz of which the test is composed—thus resembling in this respect, like *S. scopula*, the whiteness of powdered glass.

Sometimes pointed and capitate portions respectively of pin-like spicules are observed to be present, and to project some distance beyond the surface of the test (fig. 1), still further allying it in this respect to *S. scopula*.

There do not appear to be any pores about the surface, and only one large aperture, which varies in position, as above stated, being most conspicuous when on the summit or side of the test.

Occasionally light yellow spots are seen on the test; but this is where the chitinous substance is devoid of the arenaceous material.

The internal contents are also above noticed. It seems to feed mostly on *Melosira*, as there is hardly a specimen which does not contain the disks, both singly and in filament, of this Diatomacean.

Besides, occasionally I found a number of granulated plastic cells, which appeared to me to be a stage in advance towards development of the spherical nucleated reproductive ones (otherwise absent), which might thus be born in the state of *Amœbæ*. Analogy favours this view.

As with *S. scopula*, one cannot help seeing, in the smooth tessellated test, composed especially of quartz-grains &c., a resemblance to the tests of *Difflugia*—and in the selection of

those grains only which are colourless, that character where the *Difflugia* chooses one particular object only for the construction of its covering.

The test of this species is even more simple than that of *S. scopula*; for among its varieties is the symmetrical hollow dome with a single aperture, passing gradually into that form with more or less crenulated interior which simulates the nautiloid one of Foraminifera (to say nothing of the variety of external forms)—at the same time that this early signification might associate it, in a morphological point of view, with the radiated septal divisions of the coral-polypes.

I have not been able to see its pseudopodia, for the same reason as stated above for not having been able to see them in *S. scopula*. Nor have I ever been able to prove that it is or is not locomotive. It certainly adheres firmly to the fucus or object on which it may be located, but, when fresh, comes off entire by slipping a sharp knife under it, although, in the dried state, as with *S. scopula*, the body, when broken off, generally (if not always) leaves its disk on the fucus. Schultze's calcareous ones were locomotive, and thus, by being much smaller and creeping up upon the sides of the glass vessel in which they were kept, no doubt enabled him to see, by transmitted light, their pseudopodia. I could have done the same probably with *S. scopula* and *S. varians*, respectively, if I could have applied a high magnifying-power to them, with transmitted light, in their living state.

What vast numbers of free sponge-spicules of all kinds, fragmentary and entire, there must be floating about at the bottom of the sea, in the Laminarian zone, for these little Foraminifera, both *S. scopula* and *S. varians*, to avail themselves of them so plentifully and so indiscriminately for the construction of their habitations!

Difflugia.

Having had by me for a year past the description and figure of a new species of freshwater *Difflugia*, it seems not inappropriate that I should take this opportunity of communicating it; and, from its shape laterally not being unlike that of a plucked goose or other bird of that kind without wings (fanciful as this comparison may be), it may also not be inappropriate to designate it by the following appellation.

Difflugia bipes, mihi. Pl. V. figs. 6–9.

Test oblong, somewhat compressed, expanded posteriorly, narrowed anteriorly (fig. 7); lateral view lageniform, with the body somewhat inflated (fig. 8); posterior extremity obtuse,

convex, accompanied on each side by a cruriform conical extension of the test; anterior extremity narrow, terminating in a contracted oral orifice bordered by pointed scales, which, in a circular form, slightly overlapping each other, cover the whole of the test in great uniformity.

Animal composed of colourless granular sarcode, emitted anteriorly in obtuse pseudopodial prolongations (*c*) for progression and the capture of food; ventral portion more or less charged with fragments of Algæ and oil-globules (*g*); posterior extremity containing a large nucleus and nucleolus (*e*), several reproductive (?) cells, and one or more contracting vesicles (*f*, *d*). Body tied by three sarcodal filaments (*h*) to the posterior part of the test and to the extremities of the hollow, conical, leg-like appendages respectively. Molestation causing the body to assume a spherical form, synchronously with which it is suddenly retracted by the sarcodal filaments to the posterior end of the test (fig. 7 *a*). Size about 1-182nd of an inch long by 1-353rd in its broadest part.

Hab. Freshwater pool in heath-bog. Living on minute Algæ (*Oscillaria* &c.). Progressing after the manner of *Difflugiæ* generally, with the test vertical and fundus uppermost.

Loc. Budleigh-Salterton.

Obs. I found three or four specimens of this *Difflugia* about a year since, in the surface-pool of a heath-bog about a mile from this place, viz. on the 29th of January 1869.

There were other *Difflugiæ* present; and I sketched a large one having *oval* and *square* plates upon its test heterogeneously mixed up with grains of sand—showing that the oval and square plates, which frequently and respectively form the coverings of Difflugian tests exclusively, are derived from external sources, and may be taken up by some of the *Difflugiæ* indiscriminately, with grains of sand and other like objects, although they (the oval or the square plates, as the case may be) are frequently selected for the covering of the test, to the exclusion of all other objects, and consequently that the presence of one or the other is of no specific value. (See Dr. Wallich's excellent and elaborate paper, with illustrations, on the Difflugian Rhizopods, Annals, ser. 3. vol. xiii. p. 215 : 1864.)

One cannot help noticing in this mixture an analogy with the arenaceous forms of *Squamulina* just described, which animal, although preferring grains of quartz and sponge-spicules, is not particular in taking up any thing of the kind for the formation of its covering which it may find appropriate.

The light yellow colour of the test of *Difflugia bipes*, together with its obtuse pseudopodia, cause it to differ from *Euglypha*, where the test is colourless and the pseudopodia

pointed. Otherwise it much resembles *Euglypha*. Nor does the sudden retraction of the animal by means of the three sarcodal cords attached to the posterior part of its body characterize it as a distinct species less than the peculiar form of the test.

EXPLANATION OF THE PLATES.

Plate IV.

Fig. 1. *Squamulina scopula*, natural size.

Fig. 2. The same, full-grown tests, magnified five times: *a*, inclined position.

Fig. 3. The same, full-grown test, 1-15th of an inch long, greatly magnified, to show structure and cavity: *a*, pedestal; *b b b*, column; *c*, body; *d*, neck; *e*, head; *f f*, brush of spicules; *g*, triradiate spicule of *Grantia ciliata* (calcareous); *h*, trifid spicule of *Pachymatisma* (?); *i i i*, dotted line indicating shape and size of chambered cavity; *k*, aperture; *l l*, tentacular (?) appendages of marine animals.

N.B. This and the seven following figures (viz. 4 to 10, inclusively) are drawn strictly on the scale of 1-24th to 1-1800th of an inch, to show their relative size individually and the relative size of the parts of which they are individually composed; latitude only being given to the spicular detail, wherein the different spicules of the head are intended to represent some of the varieties that may be seen in many, rather than all together in one specimen.

Fig. 4. The same, summit of pedestal, with portion of column truncated close to neck, to show, *a*, circular aperture and chitinous lining.

Fig. 5. The same, upper portion of pedestal with part of column attached, lateral view, to show chitinous lining just about the neck, uncovered by arenaceous coat.

Figs. 6 & 7. The same, disks of the pedestal left on the fucus after the test has been broken off, showing the form of the pseudo-septal divisions prolonged inwards from the margin, but ending short of the centre, so as to leave an open area there.

Fig. 8. The same, pedestal with portion of column attached, broken off from the disk (dried specimen), showing that the pseudo-septal divisions are continued up into the dome: *a a*, portion of animal substance dried, showing, by its lobed form and position, that it occupied the central area and the interspaces between the septal divisions when fresh.

Fig. 9. The same, direct view of the pedestal under the same circumstances, showing the same facts more satisfactorily: *a*, dark portion representing the dried animal substance.

Fig. 10. The same, upper view of the pedestal, showing the chambered form of the interior through the test; test chiefly formed of the fragments of sponge-spicules: *a*, aperture of the summit; *b*, dried animal substance; *c c c*, chambered cavities, lined with chitinous substance.

This specimen, which I have mounted in balsam, indubitably homologizes the "pedestal" with the test of a Nautiloid Foraminiferous animal, together with the development of the "column" from the initial or primary cell.

Fig. 11. The same, lower part of column broken off from the pedestal at

the neck while living, and the animal substance forced out by pressure, showing that it is composed of:—*a*, granular sarcode; *b b*, oil-globules; *c c c*, reproductive cells about $2\frac{1}{2}$-6000ths of an inch in diameter; *d*, disk of *Melosira*.

N.B. All the parts of this figure are relatively magnified on a larger scale than the foregoing, viz. on that of 1-24th to 1-6000th of an inch.

Plate V.

Fig. 1. *Squamulina varians*, mihi, greatly magnified, to show the structure and cavity of the test; elevated convex form, lateral view: *a*, body; *b*, expanded margin of the disk by which it adheres to the fucus; *c*, aperture; *d*, dotted line indicating the form of the chamber; *e*, projecting ends of spicules. Height of body about 1-69th of an inch, base about 1-54th of an inch in diameter.

N.B. This and the three following figures (viz. 2 to 4 inclusively) are strictly drawn upon the same scale as *S. scopula* (viz. 1-24th to 1-1800th of an inch), to show the relative size of the corresponding parts in each species (*S. varians* corresponding to the pedestal of *S. scopula*) and of their own parts individually, latitude of delineation only being allowed, as in *S. scopula*, to the spicular detail.

Fig. 2. The same, discoidal portion of fig. 1, showing:—*a*, expanded margin; *b*, dark shade indicating width of wall and attachment of body to disk; *c*, dark line indicating chitinous lining; *d*, central or internal portion of disk; *e*, aperture.

Fig. 3. The same, outline of a disk showing, by the pseudo-septal prolongations, a tendency to trilocular division: *a*, expanded margin; *b*, central or internal area of disk; *c c*, pseudo-septal prolongations; *d*, aperture; *e*, chitinous lining of chamber.

Fig. 4. The same, outline of a disk showing a tendency to multilocular division: *a*, marginal expansion; *b*, central or internal area of disk; *c c c*, pseudo-septal prolongations of the test, causing the basal outline of the chamber to assume a crenulated appearance; *d*, aperture; *e*, chitinous lining of chamber; *f*, disk of *Melosira*, relatively magnified.

Fig. 5. The same, amœboid form of test: *a*, aperture. (Scale 1-48th to 1-1800th of an inch.)

This figure, on half the scale of the foregoing, is to show the extreme variation of form, in this species, which may exist between the simple, symmetrical, dome-shaped figure 1 and the amœboid form, figure 5.

Fig. 6. *Difflugia bipes*, mihi, outline of test, with animal in the interior, greatly magnified: *a*, test; *b*, animal; *c*, pseudopodia; *d d*, contracting vesicles; *e*, nucleus; *f*, oil-globules and other reproductive (?) cells; *g*, fragments of incepted food (Algæ); *h*, sarcodal retractile filaments. (Scale 1-24th to 1-6000th of an inch.)

Fig. 7. The same, test empty, showing uniformity of arrangement in the scaly covering; also, *a*, circular line indicating form and position of animal when suddenly retracted. Greatest length of test 33-6000ths of an inch, greatest width 17-6000ths.

Fig. 8. The same, test empty, lateral view: *a*, imaginary position of pseudopodia.

Fig. 9. The same; scales more magnified, to show their circular form and mode of arrangement on the test.