On the Organization *of* Grantia ciliata.

By J. S. Bowerbank, LL.D., F.R.S., L.S., &c. (Pl. V.)

(Read March 30th, 1859.)

Some years since, I had the honour of reading before this Society a paper "On the Ciliary Action of the Spongiadæ," which was subsequently published in the 'Trans. of the Micr. Soc.,' vol. iii, p. 137. In this communication the subject of investigation was *Grantia compressa*. This sponge, which is of a compressed saccular form, has its parietes constructed of a series of large, angular interstitial cells, disposed at right angles to the long axis of the sponge, and these cells are lined with minute tesselated cells, each being furnished with a single cilium. The action of these cilia, lashing slowly backward towards the distal end of the interstitial cell, and rapidly forward toward the proximal end, induces at the same time the imbibition of the surrounding water through the porous system at the surface of the sponge, and the expulsion of the excurrent fæcal streams through the oscula at the proximal end of each cell into the great cloacal cavity in the middle of the sponge, and which extends from its base to its apex, whence the fæcal stream is discharged. To this extent I was enabled to trace the vital actions of inhalation and exhalation, and to verify the admirable observations of Dr. Grant on these subjects; but from the nature of the sponge under examination, I was unable to obtain a view of the porous system, nor could I detect any positive action in the oscula during the course of the rapid passage of the excurrent stream through these orifices; but on a subsequent occasion I was enabled to satisfy myself that both the oscula and the pores in other species of Spongiadæ were capable of being partially or entirely opened or closed at the will of the animal, and that there were two conditions of inhalation and exhalation, beside a state of complete repose; the first condition being gentle and continuous, and equivalent to the operation of breathing in the higher classes of animals, while the second was rapid and forcible, and is analogous to the

process of nutrication in other beings. The latter observations are published in the 'Reports of the British Association' for 1856, p. 438, and for 1857, p. 121.

In the cases of vital action in the Spongiadæ, to which I have briefly alluded, the movements of the sponge have been of the simplest possible description, consisting only of the ciliary action and the contraction and dilatation of the membranous structures. But in another species of calcareous sponge, *Grantia ciliata*, in addition to these capabilities, we find a very much more intricate structure, and a complexity and extent of motion in its parts, which I have observed in no other sponge with which I am acquainted. In all the species of Grantia we find, to a greater or less extent, contrivances for the protection of the sponge from the attacks of its enemies; and in the great cloacal cavity of nearly all of them spicula are projected from the surface, slightly curving towards the mouth, in such a manner as effectually to oppose the entrance of annelids or other predaceous creatures; and the porous system is usually either overshadowed by groups of spicula, or covered by large spicula disposed in a longitudinal direction; but in none of the other species of Grantia with which I am acquainted, have I ever observed the elaborate and beautiful modes of protection of the incurrent and excurrent orifices that are apparent in the species I am about to describe, nor have I ever observed so great an amount of voluntary motion as exists in the organs of this sponge in any member of the Spongiadæ.

The species varies in size from two or three lines in length to upwards of two inches, and is usually of an elongate oval form, having a single cloaca extending from the base of the sponge to its apex, where the excurrent stream is discharged by a large orifice.

In the living condition the surface of the sponge, when examined with a lens of two inches focus, appears to be completely covered with minute conical papillæ, from which a few slender, sharply pointed spicula are projected. When dried, these conical papillæ appear as attenuated pencils of long spicula, and the whole sponge assumes a very hirsute appearance. The bundles of spicula are often seen in the dried specimens, reclining on the surface of the sponge in every imaginable direction.

If we divide the sponge into equal parts through its long axis we readily obtain a view of the interstitial cells and their peculiar terminal apparatus. In the greater number of allied species they are of nearly the same diameter throughout their whole length, but in this sponge the distal extremity is

always more or less of a conical form; and if we examine under favorable circumstances a section of one of these cells, made so as to allow of an oblique view of the inside of its conical termination, the pores may be seen occupying all parts of the cone, and are best observed by the aid of a Lieberkühn and a power of about 150 linear. They are rather numerous, and I have seen four in the space that would be occupied by one of the triradiate spicula. The outside of the cone is encircled by a number of long, slender acerate spicula, which are firmly cemented to it for a considerable length of their basal portions, while their apices are projected outward. In specimens which are dead, or in a state of quiescence, we usually find the terminal cone of the interstitial cell considerably elongated and gradually attenuated at that part of its parietes where the proximal ends of the ciliary spicula are attached, and this gradual inclination of the side of the cell towards its long axis necessarily effects a corresponding inclination of the circle of ciliary spicula, which has the effect of concentrating the whole of their distal terminations at a point considerably above the conical end of the interstitial cell, thus forming a beautiful hollow cone of spicula for the defence of the pores during the state of repose, or of the gentle inhalation subservient to aeration when pure water only is required to be admitted to the interior of the animal. But when the vigorous action necessary for nutrication commences, a striking alteration in the conditions of all these organs immediately takes place—the rapid imbibition of the water distends the interstitial cells to their fullest extent, and the distal terminations (attenuated cones in the quiescent state) assume the form of cylinders having hemispherical terminations, the basal attachment of the circle of ciliary spicula are thus brought into the positions of lines parallel to the long axes of the cells, and instead of forming a conical shield to the porous systems, they now become cylindrical tubes of spicula, freely admitting nutrient particles of matter for imbibition by the pores of the sponge. We have thus, by the agency of ciliary action, combined with the beautiful adaptation of the distal portion of the interstitial cell to the purposes contemplated, an amount of action and reaction fully equivalent to that which is effected by muscular force and by nervous energy in the more highly constituted animals.

If we now turn from the inhalent to the exhalent system, we find a very similar series of beautiful contrivances provided for alternate action and repose.

The normal form of the sponge, as I have before stated, is

always more or less elongated and oval, and the mouth of the great central cloacal cavity is furnished with a circular ciliary fringe, composed of very long, slender acerate spicula. We find, also, that although the cloaca gradually enlarges towards its distal extremity, the distal end of the parietes of the sponge decreases in its diameter, and this is effected by successive diminutions in the lengths of the interstitial cells, as they approach the termination of the sponge, where the neck of the cloaca consists of a stout membranous tissue and interlacing spicula only; and here we must pause to consider the admirable construction of this tissue for the purposes it is destined to perform. The mode of the disposition of the equiangular triradiate skeleton spicula, in all parts of the sponge, allows of a very considerable latitude for expansion and contraction of the membranous tissues to which they are attached; but in the neck of the cloaca, where a great amount of dilatation is necessary, there is an especial provision for this effect, both in the form and mode of arrangement of the spicula, which are now found to be rectangular triradiate, and to be disposed in regular bands, having the two rays in the same plane of each spiculum always placed at right angles to the long axis of the sponge, while the third, or angulating ray, is parallel to the long axis, and this form, combined with the position, admirably adapts them for their purpose, for while the lateral radii allow of almost any amount of motion of the membranous tissues over their surfaces, they are rigidly maintained, each in its own place, by the resistance of the angulating radii, which invariably remain in accordance with the long axis of the sponge. But this is not the sole office that is effected by these curious spicula, for many of them produce a fourth or spicular ray at right angles from the junction of the other three, and this spicular ray is projected inward, and always more or less curved towards the mouth of the cloaca, thus becoming a formidable weapon of defence against the encroachments of intruders. The bases of the numerous and very slender ciliary spicula are attached to the membranous neck of the cloaca for more than half its length, and the exterior surface of the neck is strengthened and supported by numerous short, but very strong, fusiformi-acerate spicula. In a state of repose, or of gentle inhalent action only, the neck of the cloaca maintains its greatest amount of contraction, and the apices of the long ciliary spicula are all concentrated at a point very considerably above the membranous neck of the cloaca, forming a dense cone of parallel spicula, through which nothing but fluid could enter. But as soon as the

energetic nutrimental action commences, every osculum pours forth a powerful stream into the cloaca, and the expansive force of the current thus produced distends the neck of that organ, and speedily changes its somewhat truncated conical form into a cylindrical one, and the elongated cone of ciliary spicula also becomes changed into a cylindrical tube, through which the excurrent stream passes with considerable rapidity and force.

Thus we see that the incurrent and the excurrent actions of this highly organized sponge are both effected on the same principle, with such modifications of structure in the respective organs as adapts each to its especial office. The amount and regularity of motion induced by the effects of ciliary action only, without apparently the slightest aid from nervous or muscular agency, is truly remarkable.

The defence of the interior of the sponge from the incursions of predaceous annelids and other enemies is not confined to the long ciliary fringe of spicula at the mouth of the cloaca, nor to the spiculated, rectangular triradiate spicula of its mouth; for we find on the inner surface of the cloaca spicular rays frequently projected from the equiangular triradiate spicula, with which it is abundantly lined. These rays are always more or less curved, and have their points directed towards the mouth of the cloaca. Dr. Grant detected these quadriradiate spicula in *Grantia nivea* many years since, during the course of his investigation of the calcareous sponges, and mentioned them as one of the distinctive characters of *G. nivea*, but they are by no means peculiar to this species; but, on the contrary, they are found to a greater or a less extent in every calcareous sponge in which the oscula are discharged into a common cloaca.

There is yet another mode of defence against any attempt at an entrance into the cloaca, which appears to be resorted to occasionally and under peculiar circumstances, and that is the capability of entirely closing the base of the neck of the cloaca by the extension of a membrane across its base. I have found this membrane in two cases, and in both of them it was not merely a clean film that might possibly have been formed by a small bubble of sarcode shed from the animal during or after death, but, like the other membranes of the sponge, there were numerous spicula imbedded in its surface, and in this, and in other respects of appearance and position, the membranes in both cases were alike.

In conclusion, I may observe that not the least remarkable part of the history of this sponge is the number and variety of forms of spicula that compose its skeleton and defences,

and the admirable adaptation of each to its especial purpose. The triradiate spicula, however modified by size or form, are essentially skeleton spicula; while the simple acerate form appertain more especially to the defences of the animal.

In both classes of spicula great latitude in size prevails, to adapt them to their situation and purposes in the structure of the animal.

On DIATOMACEÆ *collected in the* UNITED STATES.

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(Read March 30th, 1859.)

AVAILING myself of the kind offer of F. C. S. Roper, Esq., to lay before you any facts relating to the family of the Diatomaceæ that I might forward to him, I now present a list of the species I have detected during my searchings for the last three years. I am in hopes that the fact of these being lists of species found in the United States, N. A., will excuse the otherwise unimportant nature of the investigations made. I have no new facts to adduce, nor any new species to describe, but one or two curious forms have been found that will serve to illustrate the great variability of outline in some of the species of the Diatomaceæ. When bringing forward these facts, I lay down no rules and attempt to manufacture no new laws to govern the formation of species, nor do I wish to mix myself up with the very complicated discussions now going on among microscopists on this subject. That many false species have been manufactured by superficial observers cannot be denied. This interesting and important branch of science has thus been much complicated, and botanical works crowded with worse than useless synonyms. No species can be firmly established from an examination, however careful, of frustules prepared by means of acid, and its natural history can only be studied from the living plant. In such cases as the examination of the Charleston Harbour-mud, mentioned below, only well established species are set down, the doubtful ones having been omitted, for the reason I have given below.

The first gathering I shall mention is one taken from around the roots of *Valisneria spiralis* at Fishkill Creek,

DESCRIPTION OF PLATE VII,

Illustrating Dr. Bowerbank's paper on the Organization of *Grantia ciliata*.

Fig.

1.—*Grantia ciliata*, natural size, having the mouth of the cloaca open.

2.—*Grantia ciliata*, natural size, having the mouth of the cloaca completely closed.

3.—Six of the intestinal cells from the front of a longitudinal section of the sponge mounted in Canada balsam, showing the mode in which the terminal cones of spicula fall on one side in a state of repose.

a. One of the cells in the condition of active inhalation.

b. A cell, having the terminal spicula in a partially closed condition.

4.—A portion of the large ciliary fringe of spicula from the mouth of the cloaca of the sponge, in the closed condition; showing the mode of the disposition of the rectangular, triradiate, and spiculated rectangular spicula, near the base of the long, slender, acerate spicula forming the ciliary cone for the defence of the mouth of the cloaca.

5.—Spicula of *Grantia ciliata*.

a. Equiangular triradiate spiculum of the skeleton.

b. Acerate spiculum from the defensive cone of the inhalent system.

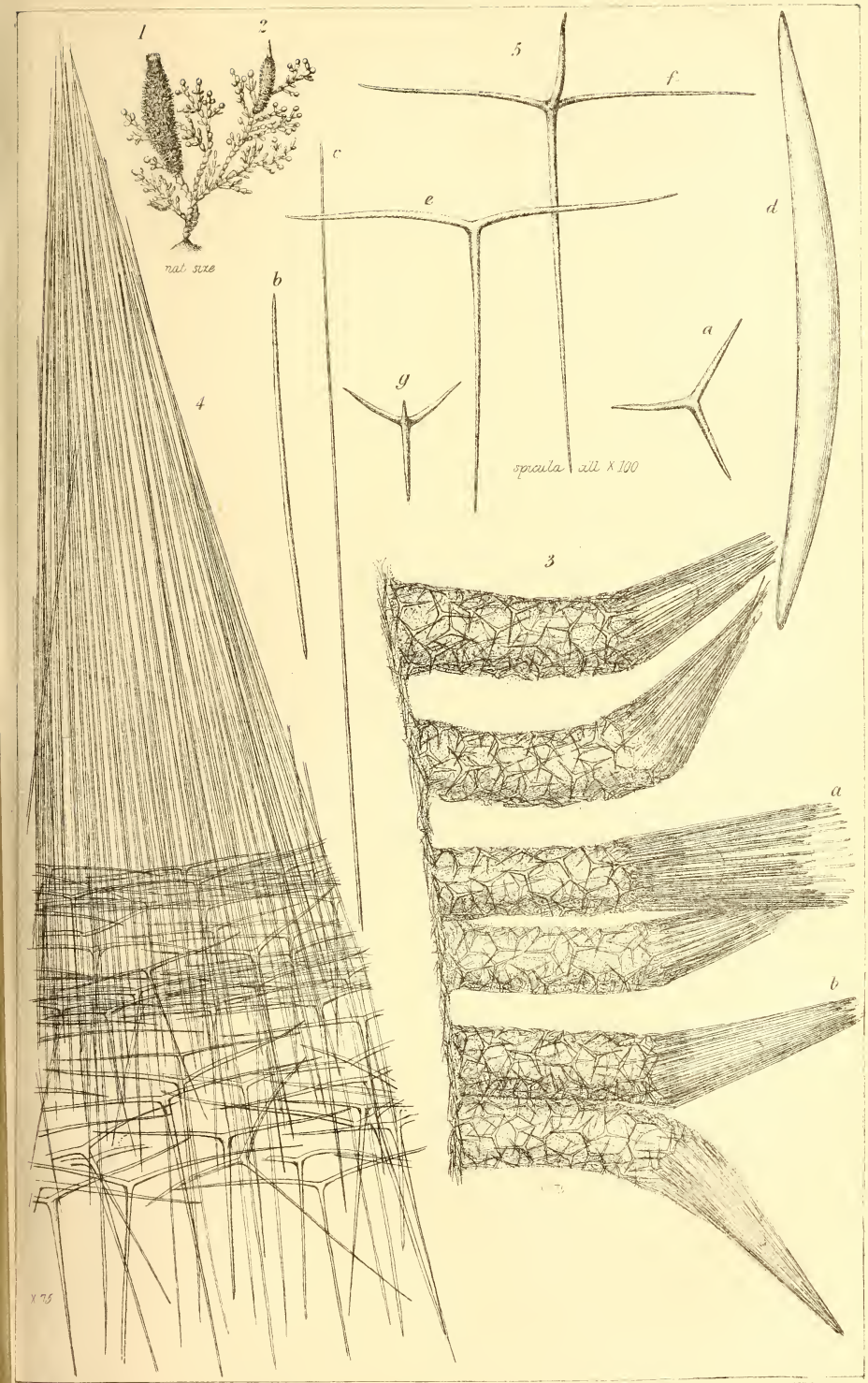
c. A portion of a long, attenuated, acerate spiculum from the defensive ciliary fringe of the mouth of the cloaca.

d. One of the large fusiformi-acerate spicula supporting the base of the ciliary fringe of the mouth of the cloaca.

e. A rectangular triradiate spiculum from near the base of the ciliary fringe of the mouth of the cloaca.

f. A spiculated, rectangular, triradiate, defensive spiculum from the base of the ciliary fringe of the mouth of the cloaca.

g. A spiculated, equiangular, triradiate, defensive spiculum from the interior surface of the cloaca.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