VI. — *On the Keratose or Horny Sponges of Commerce.*

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UNTIL the publication of the valuable papers by Dr. Grant in the 'Edinburgh New Philosophical Journal' for 1827, but very little can be said to have been known of the true structure and functions of the sponge tribe. In the descriptions there given of the examination of numerous British species, the learned Professor has not only made us intimately acquainted with their general forms and structure, but he has developed the mode of their propagation, and shown it to approximate so nearly to that of the coral tribe, as to leave but little reasonable doubt of the truth of their animal nature. I will not repeat the evidences of the author to establish these facts, as the papers containing the proofs are so easily accessible. It will be sufficient to observe that he has proved that the whole of these poriferous animals are composed of a minute reticulated structure, which derives its support from a thread whose structure is either horny or cartilaginous, hence called keratose; or from the dispersion through its substance of numerous siliceous or calcareous spicula. Accordingly as each of these modes of structure prevails, the sponges are divided into various genera, and among these there is one which contains the sponges of commerce and other keratose species, which are said to consist of tubular horny fibres, and to be destitute of spicula. It is this tribe that I purpose making the subject of this communication.

The investigations of Dr. Grant were in a great measure confined to those orders of sponges which contain in great abundance either calcareous or siliceous spicula: of these the only known British species (*Spongia pulchella*) has been published by Sowerby in the 'British Miscellany,' as occurring on the southern and western coasts of England. Dr. Fleming, in his 'British Animals,' p. 524, has thus described the genus *Spongia*: — "Porous, the cartilaginous skeleton simple, or destitute of earthy spicula."

I was induced to investigate this tribe in consequence of having recently received from my friend Rupert Kirk, Esq., of Sydney, Australia, about forty species of various genera of sponges, among which were many exhibiting every appearance of being true keratose sponges, and which, on a superficial examination, might reasonably have been expected to be destitute of spicula, but upon examining small

fragments of them with a power of 300 linear, I was much surprised to find many of them with well developed spicula embedded in the centre of the horny fibres; and on extending my observations to other species, I found that there were few or none of these keratose sponges in which spicula were not to be detected in some of the fibres; although it often required a considerable degree of patient research to find them, and very frequently the first intimation of their presence in the sponge, was only to be obtained by burning, comparatively, a considerable mass before the blow-pipe, subjecting the ash to the action of dilute muriatic acid, and then examining the residue. But in all cases where their presence was thus detected they were afterwards by patient investigation found *in situ*.

From the results of the examination of the Australian species I was naturally led to suspect that siliceous spicula might possibly be detected in the sponges of commerce; and that I might investigate them as nearly in their natural state as circumstances would permit, I applied to a large importer of sponges, who very kindly supplied me with the species and varieties of the sponges of commerce, before they had undergone the usual process of cleaning and bleaching.

The principal sources for the supply of the European market with sponge is the Mediterranean and the West India islands, and especially the Bahamas. The former is of a finer texture than the latter, and is designated Turkey sponge. Upon carefully examining a considerable number of specimens of this description with the microscope, I found two well-marked species. The West Indian sponge also proved to be a species distinct from either of the Turkey ones.

The two species of Turkey sponge are so similar in external character as to render it impossible to distinguish them from each other by a superficial examination; but in their anatomical structure there is a distinct and very striking difference. The common form—the *Spongia officinalis* of Lamarck—is so familiar to every one as to render a lengthened description of its external characters unnecessary; but it must be remarked that in the state in which we usually receive it, it has been carefully cleaned by maceration in water or a weak solution of acid, from all remains of the mucous or fleshy coating of the horny fibre; and if we examine a fragment of such a specimen beneath the microscope, we shall perceive the fibres to be totally free from all remains of this fleshy coat, and in this state it has the appearance of a smooth light amber-coloured fibre: but if we examine a specimen which has not been thus treated, the thread, especially that of the interior of the sponge, is seen to be coated with a thin and

somewhat rugose film containing minute granulations, the whole being of a darker colour than the mass of the fibre, as represented in fig. 1, Pl. iii. which exhibits a portion of the fibre of *Spongia officinalis* deprived of its mucilaginous or fleshy coat, and fig. 2, which represents a fibre upon which it has been retained; and also in fig. 14, which is from a fibre of the West Indian species.

It is probable that these granules are the incipient gemmules of the sponge, for in some instances I have found pellucid circular bodies, containing a central nucleus, embedded in a fine membrane that coated the fibre. There is much difficulty in finding these bodies *in situ*, in consequence of their great transparency, but when the membrane happens to have been disturbed and partially removed they become very apparent, and present the appearance represented in fig. 3, Pl. iii. when viewed with a power of 1000 linear. When these nucleated bodies were observed upon the fibre, the granulated appearance seen in fig. 2, Pl. iii. was not apparent, and as the nucleated bodies are considerably larger than the granulations, there is a great degree of probability that they are the gemmules of the sponge in an advanced stage of their development.

I am not aware that any author has described the gemmules of the keratose sponges, but those of numerous species of *Halichondria* have been so minutely examined and described by Dr. Grant in the 'Edinburgh New Philosophical Journal,' and they agree in their general character with the bodies under consideration, so closely, as to leave but little doubt in my own mind that they are really the gemmules of the sponge in one of their earliest stages of development; but this is a question which cannot be satisfactorily determined without an examination of the living sponges under the most favorable circumstances.

The greater part of the fibres consists of cylindrical transparent threads, frequently anastomosing, and varying very considerably in their size. This portion of the tissue is destitute of spicula; but there often occur, dispersed amid this form of tissue, large flattened fibres running in a straight direction, and not anastomosing so frequently as the surrounding cylindrical threads; and it is in this portion of the tissue that the spicula are found, embedded in its centre, as represented in fig. 1 a, Pl. iii.

Sometimes there is only a single spiculum embedded in the centre of the fibre, while at others two, and occasionally three or more, are grouped together, and here and there one will project a third or half its length from the side of the fibre.

The spicula vary very considerably in their size and proportions,

some of them being slender, much elongated, and terminating acutely, while others are short, thick, and terminating at both ends abruptly in a point. The central cavity in all the forms is distinctly to be seen, (Pl. iii. fig. 4—9). These varieties in form of the spicula are most conveniently obtained by burning small fragments of the sponge before the blow-pipe, and treating the ashes with diluted muriatic acid. All the authors, I believe, who have hitherto treated of this sponge, have described the fibre as consisting of a series of horny tubes. Probably this error has arisen in the first place from their great transparency, and secondly from the want of microscopical combinations that would admit of their being examined in such a manner as to allow of their true nature being discovered. For it is only by a careful examination of their structure as opaque objects, by the aid of a Lieberkuhn, and with a power of about 500 linear, that the solidity of the fibre can be exhibited with certainty. This examination is much facilitated if a small mass of sponge be tied firmly round with thread, so as to compress it into the form of a cylinder; and then if a section at right angles to its axis be made with a sharp knife, the transverse sections of the fibres will be readily seen, presenting exactly the same appearance that we observe in a similar section of any somewhat softened horny substance. The face of each section is covered with parallel streaks or lines, occasioned by the passage of the knife, but not the slightest appearance of a central orifice can be detected, and the results are precisely the same, whether the specimen under examination be dry or saturated with water; (Pl. iii. fig. 10). It is somewhat singular that in the latter case, when the fibre was supplied with water while beneath the object-glass, it did not present any sensible increase of substance or the slightest variation in form. Upon examining in the same manner the second species of Turkey sponge, and the West Indian species from two localities, the results were precisely the same;—not a single tubular fibre could be detected in any of the numerous specimens subjected to examination.

If we examine fragments of these sponges as transparent objects, with the same amount of microscopic power (500 linear), we never observe any partial injections of air in the interior of the fibre, which would certainly be the case if they were composed of tubular instead of solid threads.

The second species of Turkey sponge, as I have before stated, is so similar in its form and external characters to *Spongia officinalis*, as to render it difficult, if not impossible, to distinguish one from the other without the aid of high microscopic powers; but immediately we sub-

ject them to this test, the difference becomes at once apparent. The mode of arrangement and size of the fibre of the new species is very similar to that of the former one, and the large irregularly formed tissue containing spicula occurs as frequently as in *Sp. officinalis*. The striking character in this species is its possession of a beautiful vascular tissue, which surrounds, in great abundance, nearly every fibre of its structure; which, when it is immersed in water and viewed as a transparent object with a power of 500 linear, presents the appearance represented at figs. 11 and 12 Pl. iii. where the vessels are seen meandering over the surface of the fibres in every direction. Sometimes they proceed for a considerable distance in a line nearly parallel to the axis of the fibre, giving off frequent lateral branches at right angles, some of which terminate immediately in cœca, while others embrace half or two thirds of the diameter of the fibre before they terminate; other branches thus given off continue their course for a considerable distance, either running parallel to the parent vessel, or passing in spiral lines round and round the fibre; the direction of the spire sometimes being from right to left, and at others from left to right. Occasionally they expand to twice their original diameter, and again contract to their former size. This beautiful tissue is not imbedded in the horny mass of the fibre, but is contained in a sheath, which closely embraces it, and it frequently occurs in the preparation of a fragment of the sponge for examination, that the horny fibre is withdrawn from this sheath, leaving it in the form of a thin membranous tube, in the substance of which the vascular tissue is imbedded. Fragments of the vascular coat are also often seen partly adhering to the fibre from which they have been torn. The vessels are completely imbedded in the sheath which contains them, as no projection of their surface appears when they pass round the fibre. It might at the first view be imagined that they were merely excavations or canals in the substance of the sheath surrounding the horny fibre, but this is proved not to be the case, by their often being torn out from the substance in which they are imbedded, and exhibited as a detached network. So in like manner it might be thought they were but a tissue of solid fibres imbedded in the outer coat of the structure; but their tubular character is established by the frequent occurrence of alternations of air and water within their cavities. Little doubt therefore can remain of their being a true vascular tissue, destined to perform an important office in the economy of the animal during its life.* In one instance

* Since this paper was read, my friend Mr. G. Busk, of the Dreadnought Hospital

(Pl. iii. fig. 12, a) I observed in some of the vessels numerous minute globules, exhibiting every appearance of being globules of circulation analogous to those found in the blood of the higher classes of animals. They are circular, and vary in size from each other to about the same extent that the blood-discs in man and animals do. The largest of these globules was $\frac{1}{16666}$ of an inch in diameter, the smallest $\frac{1}{30000}$ of an inch. The mean diameter of the vessels was $\frac{1}{3346}$ of an inch; and the fibre of the sponge upon which they ran was $\frac{1}{388}$ of an inch in diameter.

A similar vascular tissue exists in a considerable number of the keratose sponges from Sydney; in some it is as distinctly apparent as in the Turkey sponge (as in fig. 13), while in others, although equally abundant, it is scarcely to be distinguished from the horny mass of the fibre. In some of the Australian species, where it is extremely well developed, the centre of the horny fibre abounds in spicula. In some specimens of *Spongia officinalis* also, there are faint traces of a similar tissue occasionally to be seen. Upon making sections of small cylindrical bundles of the Australian species, in the manner before described, and viewing them as opaque objects with a power of 500 linear, and with the aid of a Lieberkuhn, they proved to be of as solid a texture as the sponges of commerce: no indication of a cavity existing in the fibre being apparent, excepting where spicula had been formerly imbedded, and which had been displaced by the passage of the knife. The only truly tubular sponge that I have yet seen is *Spongia fistularis*, described by Dr. Grant in one of his papers in the 'Edinburgh New Philosophical Journal.' I am indebted to the learned Professor for a specimen of this interesting species, he having kindly shared with me the few remaining fibres in his possession. Upon examining these, immersed in water, with a power of 500 linear, I found the interior of the horny filaments to be truly tubular. The filaments, unlike those examined by Dr. Grant, were quite empty, no dark granular matter being visible; and in several of them I saw the air gradually expelled by the entrance of the water, thus proving the truth of their tubular nature beyond a doubt. I cannot take leave of this subject without a few observations on the nature of the spicula which are found in such abundance in these curious bodies.

Professor Grant, in his 'Outlines of Comparative Anatomy,' p. 5,

Ship, whose skill in the injection of fine vascular tissues is so well known, has succeeded in filling these minute vessels with coloured pigments, in the most complete and satisfactory manner.

says — “The skeletons of poriferous animals consist of separate minute, earthy, crystalline spicula, connected together by a condensed, elastic, cellular substance; or of tubular elastic filaments of a horny consistence. These parts are developed internally through the whole cellular tissue of the body, and are often protruded through the surface to protect the pores or the large vents. The earthy spicula in most of these animals are siliceous, in many they are calcareous, and, like the horny filaments of other species, they appear to be tubular, like many natural crystals.” Professor Rymer Jones, in his ‘General Outlines of the Animal Kingdom,’ p. 14, says,—“Crystallized spicula of this description form a feature in the structure of the sponge which is common to many vegetables, resembling the formations called raphides by botanical writers.”

I am not aware of the existence of any true crystals which naturally present a central orifice similar to that of the general mass of the spicula of sponges. The normal characters of a true crystallized body appear to me to be solidity and angularity; while, on the contrary, the prevailing form of the earthy deposits in the animal kingdom is that of the hollow cylinder. In this respect, therefore, the spicula of sponges, whether they consist of siliceous or calcareous materials, always present themselves in the shape of a true cylinder, or of some modification of that form. In further confirmation of the probability of their animal origin, it may be stated that when siliceous spicula are exposed for a considerable length of time to the action of the blow-pipe, and then examined with a power of 500 linear, it is usually apparent that the internal tubular cavities of the spicula are coated with a film of carbonaceous matter, strongly indicating the existence of a thin coating of animal substance within the spicula, (Pl. iii. fig. 4—9). The external surfaces of the spicula also frequently exhibit a carbonaceous filmy coat when incineration has not been continued too long, which gives them the appearance of having been covered with a thin film analogous to the periosteum of true bone.

The raphides, in many instances where I have had the opportunity of observing them, have presented a truly crystallized and angular form. They are solid, and, in no case that I have observed, cylindrical like the spicula of sponges. Nor do these curious bodies occupy the same relative situation in the plant that the spicula do in the sponge. The latter are truly a portion of the organization of the animal, while the former can be considered but as a secretion deposited in the cellular or inter-cellular structures of the plant. Under this view, therefore, they cannot be adduced as a link connecting the

sponges with the vegetable kingdom. It is also worthy of observation that the normal form of the spicula of sponges is the same, whether they be composed of silex or carbonate of lime, which would still further seem to indicate that they were truly an animal deposit; and indeed Dr. Grant, in a subsequent sentence in the same page of his 'Outlines of Comparative Anatomy' that was before quoted, says — "they are formed from materials due to the vital energies of the animals, and they form normal and necessary parts of its structure, like the solid skeletons of higher animals."

The solidity of the fibre of the sponges of commerce, and of the whole of the keratose species from Australia that I have examined, will render it necessary that *Spongia fistularis* should be removed from this groupe, and I therefore beg to suggest the propriety of making it the type of a new genus to be denominated *Fistularia*; and this is the more necessary, as, among the fossil sponges, tubular species are found in very considerable numbers.