XXXII. *On the Anatomy and Physiology of the Spongiadæ.*—Part II.

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Keratode

Is the substance of which the horny elastic fibres of the skeleton of the officinal sponges of commerce are composed. It has, correctly speaking, no relationship either chemically or structurally with horn, and Dr. Grant has judiciously rejected the term "horny fibre" as applied to the sponges of commerce, and has substituted that of keratose by way of distinction; and in accordance with that term I propose to designate the substance generally as keratode, whether it occurs in the elastic fibrous skeleton of true *Spongia*, which are composed almost entirely of this substance, or of those of the Halichondraceous tribe of Spongiadæ, where it is subordinate to the spicula in the construction of the skeleton, and appears more especially in the form of an elastic cementing medium. In a dried state it is often extremely rigid and incompressible, but in its natural condition it is more or less soft, and always flexible and very elastic. It varies in colour from a very light shade to an extremely deep tint of amber, and it is always more or less transparent. In its fully developed condition, in the form of fibre, it appears always to be deposited in concentric layers; but in the mode of the development of these layers there are some interesting variations from the normal course of production. As we find in *Aranea diadema*, the common Garden Spider, that the creature has the power of modifying the deposit of the substance of its web so that the radiating fibres dry rapidly while the concentric ones remain viscid for a considerable period, so we find in the production of the young fibres of the skeletons of the Spongiadæ in some species, as in those of commerce, there is no adherent power at the apex of the young fibre, excepting with parts of its own substance; while in *Dysidea*, and in some other genera, the apex of the newly-produced fibre is remarkably viscid, adhering with great tenacity to any small extraneous granules that it may happen to touch in the course of its extension; but this adhesive character appears to be confined to the earliest stages of its production only, as exhibited at the apices of the newly-produced fibres, the external surface immediately below the apex exhibiting no subsequent adhesive property.

Lehman, in his 'Physiological Chemistry,' Cavendish Society's edition, vol. i. p. 401, states that *Spongia officinalis* of commerce consists of 20 atoms of fibroin, 1 atom of iodine, and 5 atoms of phosphorus; and in treating of the physiological relations of fibroin as regards sponges, he observes, "Its chemical constitution affords one of the arguments why the *Spongia* should be classed among animals and not among plants, since in the vegetable kingdom we nowhere meet with a substance in the slightest degree resembling fibroin."

From the general physiological characters of the skeletons of the Sertularian and other Zoophytes, I had long suspected that their component parts were identical, or very nearly so, with those of the skeletons of the Spongiadæ, and I therefore applied to my friend Mr. GEORGE BOWDLER BUCKTON to assist me in determining this point, and he very kindly undertook to make comparative qualitative analyses of two species of Zoophytes, *Sertularia operculata* and *Flustra foliacea*, with the fibres of *Spongia officinalis* and of raw silk, and I cannot do better than quote entire the report of the results of his examination:—

"I have examined the Zoophytes you sent me, and have compared their deportment under chemical agency, with that shown by white silk and the fibre of ordinary sponge.

"All the specimens were treated in a similar manner, being purified from foreign matter, as far as possible, by boiling for two hours in water, and subsequently for the same period in strong acetic acid. With the exception of *Flustra*, the substances exhibited by this treatment little change in their outward appearance. Carbonate of lime enters so largely into the composition of *Flustra*, that its disintegration by acids ought to cause no surprise.

"From the results of the first seven experiments, which for convenience I have arranged in a Table (see next page), I conclude that all these bodies contain the same, or a very similar animal principle, which I suppose to be identical with MULDER'S fibroin. The varying colours of the precipitates from tannic acid and ammonia, I think are probably due to the traces of sesquioxide of iron present in the fibres, and the difference in shade is simply caused by the greater or less preponderance of that metal.

"Although I have not been able to obtain fibroin in a state of chemical purity, I would state that, to my knowledge, there is no vegetable principle which behaves itself towards reagents in a manner similar to that shown by the substance of silk, sponge, &c.

"MULDER and CROOKEWIT'S analyses show silk and sponge scarcely to differ in composition.

Fibroin from silk.	
Carbon	48·5
Hydrogen	6·5
Nitrogen	17·3
Oxygen, Sulphur, &c. &c.	27·7
	100·0

Fibroin from sponges.		
Carbon	46·5 to	48·5
Hydrogen	6·3	6·3
Nitrogen	16·1	16·1
Oxygen, Sulphur, Phosphorus, Iodine	31·1	29·1
	100·0	100·0

"SCHLOSSBERGER has recently expressed his doubts of the identity of composition of these bodies, from the circumstance that silk is readily soluble in strong ammonia, saturated with oxide of copper, whilst sponge is scarcely, or not at all, affected by long maceration. My own experiments prove the same fact, yet it is not impossible that the minute quantities of iodine, phosphorus, and sulphur present in sponge may modify the solubility of the fibre.

"Under the supposition that a resinous gum might act as a protection, portions of sponge were boiled in benzol, ether, and alcohol, but these solvents did not modify the characters in any noticeable degree.

	Flustra foliacea.	*Sertularia operculata.*	*Spongia officinalis.*	Silk from *Bombyx.*
Ignited.	Yields a nitrogenous odour. —— Leaves much ash, in the form of a facsimile of the frond. Chiefly composed of carbonate of lime.	Yields a nitrogenous odour. —— Leaves much ash, but much less than the preceding.	Yields a nitrogenous odour. —— Leaves a white ash in some quantity.	Yields a nitrogenous odour. —— Leaves much ash.
Boiled in water and subsequently in acetic acid.	Acid disengages much carbonic acid. —— The zoophyte disintegrates and leaves a brown flocculent residue.	Apparently unaffected. —— Form unchanged.	Apparently unaffected. —— Form unchanged.	Apparently unaffected. —— Form unchanged.
Washed and boiled in concentrated hydrochloric acid.	Greater part soluble in the acid. —— A brown gelatinous mass remains.	Almost entirely dissolved after ten minutes' boiling.	Almost entirely dissolved. —— The residue is gelatinous.	About $\frac{3}{4}$ soluble in the acid. —— Gelatinous residue.
Tannic acid added to the hydrochloric acid solution.	A white precipitate, insoluble in acetic, but soluble in oxalic acid.	A white precipitate.	A white precipitate.	A rather copious white precipitate.
Potash added to the hydrochloric acid solution. —— Ammonia gives similar reactions.	Precipitation of a few flocks.	No precipitate of any consequence.	Small quantity of a gelatinous precipitate.	A few flocks precipitated.
Tannic acid added to the above neutralized solution.	An abundant yellowish precipitate. —— If alkali in excess, the precipitate is violet.	Abundant precipitate, —— which turns reddish purple by excess of alkali.	Abundant precipitate. —— Coloured by excess of alkali.	Copious precipitate, which takes a flesh tint by excess of ammonia.
Bichloride of mercury added to the hydrochloric solution.	Slight white precipitate.	Slight precipitate.	Slight precipitate.	Precipitate rather more copious than that from sponge.
Boiled in a solution of oxide of copper in ammonia.		Insoluble.	Insoluble.	Perfectly soluble; not again precipitated by acetic acid.

"I consider, however, that this difference between sponge and silk in no wise affects the question of the former substance being a product of the animal kingdom, which the other experiments, I think, satisfactorily prove."

In considering the results of these analyses with a view to proving the animal nature of the Spongiadæ, the evidence afforded by the coincidence of its structural character and its chemical constituents with those of *Sertularia operculata*, is still more conclusive than that derived from the chemical constituents of silk; and, in truth, the action of the chemical agents on the zoophyte and the sponge, as might naturally be expected, are almost in perfect accordance.

Membranous Tissues.

These structures may be divided into two classes.

1st. Simple membranous tissue.

2nd. Compound membranous tissue.

The first is a simple, apparently unorganized, thin pellucid tissue. It is evidently not composed of an extension of keratode, as it is rapidly decomposed after the death of the animal. It is found in abundance filling up the areas of the network of the skeleton in a great variety of sponges, and it appears to be capable of secreting sarcode on both its surfaces when thus situated; on the dermal membranes the sarcode is found on the internal surface only.

Compound Membranous Tissue.—These structures consist of simple membranous tissue combined more or less with primitive fibrous tissue. Their most simple forms exist in the membranes lining the interstitial cavities of the sponge, and in the dermal membranes.

It is difficult in some cases to discriminate between this class of tissues and simple membranes, unless it be by the aid of their functional characters, as the compound tissues are frequently quite as pellucid, although not so thin, as the simple ones.

In dermal membrane, and the membranous linings of the internal cavities of the sponge, they are thin and very translucent; but on careful examination with high microscopic powers and transmitted light, with the aid of polarization, we frequently detect the elastic primary fibrous tissues incorporated with the structure. In the contractile membranes forming the oscular diaphragms in *Grantia*, and in those at the base of the intermarginal cavities in *Geodia* and *Pachymatisma*, they attain a greater degree of thickness, and especially in the two latter genera of sponges. In *Alcyoncellum*, Quoy et Gaimard, the organization of their tissue is still more complex, and we there find them constructed of repeated layers of membranous structure, abounding in primitive fibrous tissue disposed in parallel lines in each layer, the fibres disposed so closely together as to completely cover the membrane beneath, and the direction of the fibres being at various angles to the axis of the great cloacal appendages of the sponge, so as most effectually to aid in the contraction or expansion of that organ. They are so closely packed together and so intermingled, that I could not ascertain their length; but from the gradual attenuation of some of their terminations, they would seem not to be continuous for any considerable distance. On some of the layers of this compound membrane the fibres were disposed in an even and continuous stratum, while on others they were gathered into broad, flat, parallel fasciculi. When the compound structure consists of several layers of fibro-membranous structure, the disposition of the fibres on the different layers is not coincident. In some cases they cross each other at right angles, while in others the angle does not exceed 45 degrees. The latter mode of arrangement appears to prevail in the membranes connecting the great longitudinal fasciculi of spicula, forming to a great extent the skeleton of the cloacal appendages of the sponge; while the arrangement at right angles appears also in the tissues immediately surrounding the great skeleton fasciculi.

This fibro-membranous tissue abounds in the dermal and interstitial structures of the sponges of commerce, but the greatest development of this structure is exhibited in the genus *Stematumenia*.

Fig. 4, Plate XXVII. represents a small portion of the lining membrane of one of the great excurrent canals of the common honeycomb sponge of commerce, in the condition in which it came from the sea. The primitive fibrous tissue is seen arranged in a single layer in parallel lines at right angles to the long axis of the canal, but partially obscured by the stratum of sarcode on the membrane.

Fig. 3, Plate XXVII. represents a small portion of the dermal membrane of a *Stematumenia*, in which the primitive fibres are seen wandering in every direction over the surface of the membrane.

Figs. 1 & 2 in the same Plate represent portions of a stouter and a more compound membranous structure, from the walls of one of the great cloacal projections from the surface of *Alcyoncellum robusta*, Bowerbank, MS. In this case the membrane is strengthened by two or more layers of primitive fibrous structure, the parallel fibres of each crossing the others at various angles.

Fibrous Structures.

There are two well-characterized classes of fibrous structure.

1st. Primitive fibrous tissue.

2nd. The fibres of the skeleton.

1. *Primitive Fibrous Tissue.*

The first of these tissues is exceedingly minute. The fibres are cylindrical in form, and are usually of considerable length; but where they are fully developed, they occur in such numbers, and in such a matted condition, that I have been unable to separate an unbroken one from the mass. They continue through the whole of their length as nearly as possible of the same diameter, and there rarely appears to be any attenuation towards their terminations, which are usually obtuse. They are evidently very elastic and contractile. When partially separated from their attachments to the membranes, the free ends seldom remain straight, and most frequently they curl considerably in different directions. They appear to be perfectly solid; I could not by the aid of polarization discover the slightest indication of a central cavity. They vary in diameter in different species of sponge, and frequently even in the same individual. In a species of *Stematumenia* from the Mediterranean, I measured an average-sized fibre which was $\frac{1}{4166}$ inch in diameter, while a smaller one, closely adjoining, measured $\frac{1}{9375}$ inch. In this genus these fibres are more fully developed and larger in size than in any other sponges with which I am acquainted. In the sponges of commerce, in the membranes of which they are exceedingly numerous, they are much more slender. In one of the excurrent canals of the common honeycomb sponge, one of the largest measured $\frac{1}{10000}$ inch in diameter, and one of the smallest $\frac{1}{17647}$ inch. In the dermal membrane of the best Turkey sponge they were still less, not exceeding $\frac{1}{18000}$ inch.

This description of fibre is not an absolutely necessary constituent of a sponge, and in many of the Halichondraceous tribes it is exceedingly difficult to find even a single straggling fibre on the interstitial or dermal tissues, while in other genera, as in *Spongia*, *Stematumenia*, and *Alcyoncellum*, they form an important element in the structure of the compound membranous tissues, in which they are closely disposed in parallel lines, occasionally giving off branches, but never appearing to anastomose with each other like the larger fibres of the skeleton.

These fibro-membranous tissues were described by me in the 'Annals and Magazine of Natural History,' vol. xvi. p. 406, plate 14, figs. 1, 3, 4 & 5, in my description of the genus *Stematumenia*.

If a small portion of the dermal membrane of a young Stematumenia be carefully removed from the surface of the sponge, the primitive fibres will be seen projecting from the edges of the membrane in considerable numbers; and occasionally they may be seen to be furnished with a terminal bulb, the greatest diameter of which is about three times that of the fibre. The bulbs are variable in form; sometimes they are largest at the base, or pear-shaped, at other times regularly oval, or nearly globular. By far the greater number of fibres exhibit no bulbs at their terminations; those which have them are always less in diameter than the general average of the fibres. Sometimes, but not very frequently, the bulb exhibits faint traces of a nucleus. On examining the dermal membrane by transmitted light and a linear power of 666, I found numerous globular cells collected in groups on various parts of its inner surface, many of them having a well-defined central nucleus; and among these cells I found the bulbs imbedded with the fibres emanating from them, and in no respect differing in appearance from the non-fibrous cells around them (Plate XXVII. fig. 5, *a*, *a*). On carefully observing a number of these bulbous fibres that had been removed from their positions on the membrane, I found that the part of the fibre nearest to the bulb was frequently flexuous, as if in a tender and immature condition, and in these cases the marginal line of the fibre was continued without the slightest break or interruption into and around the bulb, as represented in Plate XXVII. fig. 6, *a*. At this period of the development the young fibre does not measure above half the diameter of a mature one, and there is no indication of an ultimate separation from the bulb; but when the fibre has attained nearly the full size the separation is then distinctly indicated; the basal end of the fibre immersed in the bulb becomes hemispherical, and a constriction appears at the junction of the fibre with the exhausted cell. Sometimes, when thus affording indications of their ultimate separation, the cell still retains its rotundity, but all indication of its nucleus has disappeared, and it is perfectly transparent, as represented in Plate XXVII. fig. 6, *b*; while in other cases it is visible only as a collapsed and shrivelled vesicle adherent to the hemispherical termination of the fibre, as represented in Plate XXVII. fig. 6, *c*. I could not find the slightest indication of bulbs amid the matted mass of fibres lying on the inner surface of the membrane, and it was only at the torn edges of the pieces of membrane under examination, or among the groups of cells, that the bulbs in connexion with the fibres were to be discovered.

2. *Keratose Fibrous Tissue.*

General character of the keratose fibres of the horny skeleton.—The essential character of the fibres of the horny skeleton is, that their normal form is always that of a cylinder, while the network of the skeletons of the Halichondroid sponges, which approach nearest in structure to that of spiculated keratose fibre, is always more or less irregular in shape; and in the fully developed state, generally compressed to a very considerable extent; but a careful examination of the youngest portions of the two forms of skeleton-tissue will always render the difference in the two structures apparent. In the spiculated keratose fibre the keratode is always the predominant element, and the spicula the subordinate one; while in the skeletons of the Halichondroid sponges the spicula always predominate, and the keratode is merely the secondary or surrounding medium. In the former structure, in the extension of the terminations of the skeleton, the keratode is the leading element, while in the latter the spicula take the lead.

The fibre is formed of a succession of concentric layers, its increase in diameter being apparently effected at the external surface. Its longitudinal extension appears to be caused by a progressive elongation of their terminations, and new fibres are frequently to be seen pullulating from the sides of the mature ones. In the dried state it is often extremely rigid and incompressible, but in its natural condition, notwithstanding there is frequently an internal axis of extraneous matter or of spicula, it is often remarkably soft and flexible. The spicula, although immersed in the fibre, evidently possess a considerable amount of mobility within the surrounding medium.

The colour of the fibres is always amber-yellow, varying in different species from a very light to a deep yellow brown tint, and it is always semitransparent. In the living state, when the fibres happen to touch each other, whether by their terminations or laterally, they appear at all times to unite.

The keratose skeleton-fibres vary in their organization to a very considerable extent, but the whole of them may be comprised in the following eight typical forms:—

1. Solid simple keratose fibre.
2. Spiculated keratose fibre.

3. Multi-spiculated keratose fibre.
4. Inequi-spiculated keratose fibre.
5. Simple fistulose keratose fibre.
6. Compound fistulose keratose fibre.
7. Regular arenated keratose fibre.
8. Irregular arenated keratose fibre.

1. *Solid Simple Keratose Fibre.*

The typical form of this description of fibre is that which forms the skeleton of the Turkey sponges of commerce, the structure of which I described in a paper read before the Microscopical Society of London, and published in vol. i. p. 42 of its 'Transactions.' The mature fibre is perfectly solid, and no vestige of a central cavity can be observed in any part of it, either when viewed by transmitted light, or in transverse sections of the fibre, by the aid of a Lieberkuhn. Occasionally, but very rarely, I have seen, in young and immature fibres, faint and irregular indications of there having been a very small central cavity in perhaps the earliest period of their development, but in the mature fibre I have never been able to trace such cavities (fig. 7, Plate XXVII.).

This description of fibre is occasionally surrounded by a membranous sheath, on which is imbedded a beautiful system of hollow fibrils or vessels, which sometimes wind round the skeleton-fibre in a spiral direction, at others assume a longitudinal course, giving off short cæcoid branches, or form a complex and irregular network. In an Australian sponge in my possession, the latter mode is the only form in which they occur. In some of these minute fibrils or vessels I observed numerous minute globules, which were rendered moveable by a slight pressure on the glass under which they were exhibited. The mean diameter of these tubes or vessels was $\frac{1}{9346}$ inch. This tissue is of rare occurrence, and I have been unable to determine whether it is a specific character, or whether it is due to a peculiar condition of the sponge. Fig. 9, Plate XXVIII. represents a portion of fibre from the skeleton of one of the sponges of commerce. Fig. 10, Plate XXVIII. is from a rigid species of Australian sponge. This singular tissue is described more fully in a paper which I read before the Microscopical Society of London in 1841, and which is published in their 'Transactions,' vol. i. p. 32, plate 3.

2. *Spiculated Keratose Fibre.*

This structure is essentially a solid form of keratose fibre, no central cavity ever being visible in its axis. The normal form of the fibre is cylindrical, but it is occasionally more or less compressed, and always contains a thin central line or axis of spicula arranged in longitudinal series. The spicula are secreted within the fibre, and are nearly uniform in size, and always of the same shape in the same species of sponge. In the production of the young fibres, the projection of the new keratode and the secretion of the new spicula appear to be simultaneous. In this class of structure the keratose fibre is the predominant element, and the spicula the subordinate one, and we accordingly frequently find the fibres destitute of spicula for short distances; but these occurrences are the exceptions, and not the rule of the structure. Fig. 8, Plate XXVII. represents a portion of a longitudinal section of the skeleton of *Halichondria oculata*, JOHNSTON.

The mode of the progressive development of this form of fibre is interesting. In a young specimen of *Halichondria Montagui*, JOHNSTON, I observed that when a new fibre was projected from the skeleton it usually contained a single spiculum, thinly covered by keratode at the apex, and more thickly so towards the basal end. Another spiculum followed the first, the terminations of each overlapping the other; and at the junction of the two, the keratode was accumulated in the form of a plumber's joint, as represented in Plate XXVII. fig. 9, so as to give additional strength to the junction of the spicula, while the middle portion of the second spiculum remained very thinly covered by keratode. When the distal end of the new fibre has attained its proper length, or has become cemented to the side of another fibre, the remaining portion of the keratode is produced, and the fibre then assumes a regular cylindrical form.

3. *Multi-spiculated Keratose Fibre.*

This description of fibre is literally a cylindrical mass of spicula cemented together by keratode, and surrounded by a thin case of the same substance. The spicula are exceedingly numerous, and very closely packed in parallel lines in accordance with the axis of the fibre. They are nearly uniform in size, and always of the same shape in the same species of sponge. In this structure the spicula are the predominant element, and the keratode the subordinate one. Fig. 10, Plate XXVII. represents a fibre from the skeleton of *Halichondria œgagropila*, JOHNSTON.

4. *Inequi-spiculated Keratose Fibre.*

This form of fibre is composed of an infinite number of spicula disposed in every possible direction, cemented together by keratode, and surrounded by a sheath of the same material. The spicula agree in form in all parts of the sponge, and are nearly of the same size. In these fibres the spicula are the predominant element, the keratode the secondary one. In the only sponge in which this form of structure has yet been found, *Raphyrus Griffithsii*, BOWERBANK, MS., the fibre is very unequal in size and much varied in its form, frequently becoming very much flattened and expanded. Fig. 11, Plate A. represents a longitudinal section of a small portion of a fibre from the skeleton, showing the irregular disposition of the spicula within it.

5. *Simple Fistulose Keratose Fibre.*

This form of fibre is usually very much larger and more rigid than the solid keratose fibre. It is cylindrical, and continuously fistular. The great central cavity of the fibre usually occupies about one-third of its diameter. It is nearly uniform in its size, but occasionally it is dilated considerably for a short space, and then resumes its original diameter. In the young state the cavity is as large, or nearly so, as in the adult fibres, while the enveloping keratode assumes the form of a thin transparent amber-coloured coat, which in the mature state becomes frequently twice or three times the thickness of the diameter of the central cavity.

This great fistular space is lined with a thin pellucid membrane, which, in specimens that have been dried, appears to have been thickly covered with minute semi-opake granules. At the time of my first description of this form of fibre, published in the 'Annals and Magazine of Natural History,' vol. xvi. p. 403, I believed that in the natural condition of the fibres the central cavity was an open tube; but subsequent observations on specimens which have never been dried, have led me to the conclusion that the whole of the central space is filled with a minutely granulated substance which presents all the characteristics of sarcode.

There is no communication between the great central fistular canal and the interstitial cavities of the sponge, the projecting ends of the fibres of the skeleton being always hermetically sealed. Fig. 12, Plate XXVII. represents a fibre from the specimen of *Spongia fistularis*, LAMARCK, in the Museum at Edinburgh, given to me by Professor GRANT.

6. *Compound Fistulose Keratose Fibre.*

In its external characters this description of fibre is not, under ordinary circumstances, to be distinguished from simple fistulose fibre, and it is only when submitted to a microscopic power of about 100 linear that its peculiar character can be detected. We then find that the fibre is not only furnished with a large continuous central cavity, but that it also has numerous minute cæcoid canals radiating from the central one at irregular distances, at nearly right angles to its axis. These secondary canals are very unequal in length, and very few of them reach to near the external surface of the fibre, and none of them appear to perforate it. Their direction is usually in a straight line from the parent canal; a few assume a tortuous direction, and a still fewer number bifurcate or branch. Within the central tubes of the fibres there are frequently one or two minute simple tubular fibres; when more than one they do not unite, but they divide and traverse each a separate cavity, when they happen to reach one of the anastomosing points of the great skeleton-fibre. The structures are described more at length in the 'Annals and Magazine of Natural History,' vol. xvi. p. 405, under the head of "*Auliskia*," a new genus of sponges, founded principally on the compound fistulose structure of its skeleton-fibres. Fig. 13, Plate XXVII. represents a portion of compound fistulose keratose fibre as seen with a linear power of 100. Fig. 14, a portion of a similar fibre under a power of 300 linear.

7. *Regular Arenated Keratose Fibre.*

This description of fibre under ordinary circumstances has very much the appearance of simple fistulose fibre, but when examined by transmitted light with a linear power of about 100, we find in the centre of the fibre a series of grains of extraneous matter, occupying the place of the large continuous canals of the fistular forms of fibre. The series of extraneous matters is not always continuous, and when an interruption takes place the fibre becomes solid, or faint traces only of a central cavity remain. The mode of the inclusion appears to be due to the extreme terminations of the young fibres being viscid, and thus seizing on any extraneous particles that happen to come in contact with them. The growing keratode quickly envelopes them, and proceeding on its course of extension, seizes in like manner on other particles of sand or solid matter, and thus a continuous and regular chain of extraneous material is imbedded in the axis of the fibre, as represented by figs. 1 & 2, Plate XXVIII. This description of fibre is found in a great variety of keratose sponges, and especially among the coarse rigid skeletons of the Australian species, as represented by fig. 1, Plate XXVIII.; and among the flexible sponges, as represented by fig. 2, Plate XXVIII.

8. *Irregular Arenated Keratose Fibre.*

I have described this form of fibre in a paper descriptive of two species of *Dysidea*, read at the Microscopical Society of London, Nov. 24, 1841, and subsequently published in vol. i. p. 63 of their 'Transactions.'

The adult and fully produced fibre is frequently half a line or more in diameter. It is built up in all parts of its substance of grains of extraneous matter, each one being separately enveloped in keratode. The adhesive power in the young progressing fibre not being confined to its apex only, its sides also seize upon the surrounding grains of solid matter, and the keratode speedily passing round and enveloping them, the whole fibre becomes a solid cylinder of irregularly imbedded molecules. There is a great variety of substances imbedded in these fibres, dependent, as a matter of course, on the amount of material surrounding them at the period of their development. The skeleton of *Dysidea fragilis*, JOHNSTON, a British species very common on the south coast of England, presents one of the best types of this form of fibre. And single grains of sand are frequently to be found among the fibres of the surface of the sponge, elevated on short pedicels of the rapidly growing young fibres, sometimes entirely, and at others only partially enveloped by the progressing keratode. Figs. 3, 4, & 5, Plate XXVIII., represent portions of fibre from the same individual.

This genus of sponges appear, to the best of my knowledge, to be the only animals that construct an internal skeleton almost entirely of extraneous materials.

Siliceous Fibre.

This structure is widely different from any of the keratose fibres which contain either secreted silex in the state of spicula, or extraneous silex in the form of sand. The whole substance of the skeleton fibre consists of solid silex, secreted and deposited in concentric layers, exactly after the manner of the secretion of pure keratode in the fibres of the sponges of commerce. When cleansed from the sarcodous matter by which they are surrounded in a living state, the fibrous skeleton bears a striking resemblance to fibres of spun glass, and is quite as pellucid and colourless as the artificial material, and the dead sponge quite as brittle. The fibrous skeleton of *Dactylocalyx pumicea*, STUTCHBURY, in its mode of arrangement strikingly resembles that of one of the sponges of commerce; it is equally complex and irregular in its structure, and the component fibres quite as much anastomosed. In that species the fibres are smooth and cylindrical, but in others they frequently abound with minute, obtuse, wart-like elevations.

There is every indication in the skeletons that the increase in diameter, and the extension in length in the fibres are effected in the same manner as in the solid keratose fibres. The free terminations of the young fibres have the same attenuated but obtuse form, and the pullulation of the young fibres from the sides of the mature ones is quite as apparent as in their keratose congeners; but, in the young state, they never appear to be viscid, as the keratose ones frequently are; and extraneous matters are never detected at their apices, or on their substance.

There are two distinct forms of this class of fibre :—

1st. Solid siliceous fibre.

2nd. Simple fistulose siliceous fibre.

The structure of solid siliceous fibre is very similar to that of solid keratose fibre. Occasionally there are indications of a former existence of a minute central canal, but in the fully developed fibre this is rarely visible. The external characters of these fibres vary in each species. In a new siliceous sponge in the British Museum, designated by Dr. GRAY *M^cAndrewsia azoïca*, the fibres are quite smooth, as represented in Plate XXVIII. fig. 6. But in the greater number of species they are more or less tuberculated, as in Plate XXVIII. fig. 7, which represents a group of fibres from the type-specimen of *Dactylocalyx pumicea*, STUTCHBURY, a portion of which is in the possession of Dr. J. E. GRAY. In other species in my possession the tuberculation is very strongly produced, as represented in a few fibres of *Dactylocalyx Prattii*, BOWERBANK, MS., Plate XXVIII. fig. 8.

Of the 2nd form, simple fistulose siliceous fibre, I know but one example, and that is the remains of the siliceo-fibrous sponge on which the beautiful specimen of *Euplectella cucumer*, OWEN, is based.

The tubulation of the skeleton-fibre is very similar to that of some varieties of simple fistulose keratose fibre, but the central cavities are not so invariably continuous as in the keratose varieties of fistulose skeleton-fibre. Fig. 11, Plate XXVIII. represents a small piece of the spinulated simple fistulose fibres of the skeleton of Dr. ARTHUR FARRE'S specimen. The spinulation of these fibres is a remarkable character. It is the only case of the production of acute spines on the skeleton-fibre of a siliceo-fibrous sponge with which I am acquainted.

Prehensile Fibre.

In the course of my examination of the fibrous skeleton-tissues, I have found but one instance in which they have developed prehensile organs to assist in the attachment of the sponge, and this is in a minute siliceo-fibrous species, parasitical on the base of a specimen of *Oculina rosea*, from the South Sea. In this sponge the basal fibres curve downward in the form of numerous small, nearly semicircular reversed arches, from the lowest portions of each of which there is a short stout portion of fibre projected; and at about the length of its own diameter downwards, a ring of stout prominent bosses, six or eight in number, is produced, very considerably increasing its diameter at that part, immediately beneath which the fibre is attenuated to a point. These singular organs are admirably calculated to penetrate the porous cavities or fleshy envelopes of the coral, and thus to securely attach the sponge to its adopted matrix (Plate XXVIII. fig. 12).

Cellular Tissue.

The cellular structures in the Spongiadæ are few and very simple in form. We find no series of conjoined cells in the body of the sponge, as in vegetable tissues. The only forms in which true cellular structures occur in the bodies of sponges, are those of detached spherical molecular cells, and of discoid or lenticular nucleated cells. Cellular structures of the first form are found in abundance on the fibres of many species of the true sponges, and are believed by Dr. JOHNSTON to be the reproductive organs of that genus. They are very minute; an average-sized one measured $\frac{1}{11666}$ inch in diameter. They are pellucid, and afford no indications of a nucleus, either single or multigranulate.

Imbedded in the sarcodous stratum on the interstitial membranes in many of the Halichondroid tribes of sponges, we frequently find numerous compressed circular cells. In the greater number of cases they are so translucent as to readily escape observation, even with a tolerably high power; but in other species, as in *Ecionemia acervus*, BOWERBANK, MS., a new genus of sponges from the South Seas, in the collection of the Royal College of Surgeons, and in *Halichondria nigricans*, BOWERBANK, MS., a British species, these tissues are developed in a more than usually distinct condition.

In the first-named sponge they are thickly dispersed on the surfaces of the interstitial membranes, but without any approach to order or arrangement. They are decidedly lenticular in form, with a well-defined transparent nucleus, which varied in size from about one-fourth to three-fourths the diameter of the cell in which it was contained. The cells varied considerably in size; the largest I could find was $\frac{1}{3500}$ inch in diameter, and one of the smallest $\frac{1}{10000}$ inch, but the greater number were about $\frac{1}{7000}$ inch in diameter (Pl. XXVIII. fig. 13). In *Halichondria nigricans* they do not appear to be quite so convex as in *Ecionemia acervus*, nor are they so numerous as in that species, but they are somewhat larger in size; one of the largest measured $\frac{1}{2800}$ inch in diameter, and a small one $\frac{1}{5600}$ inch; they are represented *in situ* in Plate XXVIII. fig. 14.

The only instance with which I am acquainted of a conjoined arrangement of such cells exists in the envelope of the ovaries * of *Spongilla Carteri*, the species described by CARTER in his "Account of the Freshwater Sponges in the Island of Bombay," which that author believed to be *Spongilla friabilis*, LAMARCK, but which proves to be a distinct species, which I have named after its discoverer, as a slight recognition of the good services he has rendered to science by his excellent and accurate observations. These cells may be detected *in situ* after the envelope of the ovary has been submitted for a very short time to the action of hot nitric acid, so as to render the coriaceous envelope semitransparent without destroying it. The structure of its walls is then seen to consist of linear series of cells, closely packed together in lines of six or eight in each, radiating from the centre of the ovary to its external surface. They do not appear to be absolutely in contact with each other, but are usually seen to be separated by a thin stratum of a transparent substance, probably an indurated membrane or sarcode. At the surface of the envelope they frequently appear to be somewhat hexagonal from mutual compression. I could not detect a nucleus in any of them (Plate XXVIII. fig. 16). CARTER and other writers on *Spongilla* have designated the granulated forms of the sarcode in those sponges, "Sponge cells," but I cannot coincide with that opinion. I have frequently tried in vain to detect a proper coat of cellular tissue on the Amœba-like granular masses into which *Spongilla fluviatilis* resolves itself at certain periods of its existence, and neither in a healthy and active condition, nor in a state of partial decomposition, have I ever been able to satisfy myself of the existence of a surrounding membrane. It appears to me that these bodies are the result of a natural resolution of the sarcode into granular masses of various sizes, each of which, on being liberated from the parent body, becomes an independent gemmule, which is capable of reproducing the species of sponge from which it emanates. And I have long suspected that the Amœbæ found in ponds and rivers, and also in sea-water, are not in reality distinct species of animals, but that they are free portions of the sarcode of various species of Spongiadæ.

Sarcode (*Physical Character*)

is a pellucid, semitransparent gelatinoid substance, variable in colour and insoluble in water. It dries readily, and its physical characters are restored by immersion in water with little or no apparent alteration. It is usually spread thinly and rather evenly over the internal tissues, but the surface is rarely perfectly smooth; sometimes it abounds in obtuse elevations, and occasionally separates naturally into innumerable irregularly round or oval masses which are exceedingly variable in size. When examined by transmitted light with a microscopic power of 400 or 500 linear, it is always found to contain innumerable minute molecules of apparently extraneous animal or vegetable matter, the molecules being always more or less in a shrivelled or collapsed condition, and very variable in size. Occasionally it is found abundantly furnished with lenticular nucleated cells, nearly uniform in size, and often highly coloured. Fig. 1, Plate XXIX. represents a portion of

* These bodies have hitherto been termed Gemmules. For their characters as ovaries I must beg to refer the reader to the section of this paper on Reproduction.

the interstitial membrane of the honeycomb sponge of commerce, with the sarcode in its natural condition, filled with the remains of the nutrient molecules in a collapsed state. Figs. 13 & 14, Plate XXVIII., exhibit the same tissues with the addition of nucleated cells immersed in the sarcode. In the sponges of commerce it is exceedingly largely developed, and nothing can be more different in character than their soft and flexible skeletons and the animal in its natural condition. Specimens of it in this state, which have been preserved in spirit immediately on being taken from the sea, have the whole of their interior nearly as solid and firm as a piece of animal liver, the colour being a very light grey or nearly white. While the sponge, as a whole, is sensitive and amenable to disturbing causes, the sarcode does not appear to be especially so, as I have frequently observed a minute parasitic annelid which infests the interior of *Spongilla fluviatilis*, passing rapidly over the sarcodous surfaces, and biting pieces out of its substance without apparently creating the slightest sensation to the sarcode, or at all interfering with the general action of the internal organs of the sponge; and in many cases we find foraminiferous and other minute creatures permanently located in its large cavities without appearing to cause it the slightest inconvenience.

When separated from the living sponge, it has at certain periods an inherent power of locomotion; small detached masses of it may be observed slowly but continuously changing their form, and occasionally progressing in different directions; and CARTER, in his valuable 'History of the Freshwater Sponges of Bombay,' describes such detached masses of sarcode, when progressing and encountering a fixed point, as dividing longitudinally to avoid the impediment, and again uniting when it has been passed. This gliding motion appears to be dependent on an inherent contractile power, as no cilia have been detected on the surface of such locomotive masses. DUJARDIN has recorded similar movements in portions of the sarcodous substance from specimens of his genus *Halisarca*; and similar observations have been recorded by LIEBERKUHN and other writers during their observations of the Spongiadæ. I have frequently, at different seasons of the year, taken portions of the sarcode from living and healthy specimens of *Spongilla*, in which I could not by the closest observation detect these motions, which are so readily to be seen at other periods of their existence; and even at the same period of the year the sarcode of some specimens exhibits these motions, while in others they could not be detected. I have often sought for these phenomena in portions of the sarcode of *Halichondria panicea*, *Hymeniacidon caruncula*, and other marine species, but I have never yet been fortunate enough to detect them. It is highly probable that the capability of such motions exists in the sarcode of these and other marine species for a limited period, but it does not appear that such powers of motion are a constant condition of this substance.

ORGANIZATION AND PHYSIOLOGY.

Previously to entering on the subject of the organization and physiology of the Spongiadæ in detail, it will be necessary to take a brief view of the general structure of these animals. Whatever may be their form, or however they may differ from each other in appearance, there are certain points in their organization in which they all agree. In the first place, however variable in its form and mode of structure, there is always a skeleton present, on which the rest of the organic parts are based and maintained. Amidst the skeleton, and intimately incorporated with it, are the interstitial canals, consisting usually of two series; the first appropriated to the incurrent streams of the surrounding water, and the second to the excurrent streams, which they conduct from the interior of the sponge to the oscula at its surface, through which they are discharged. In the event of the absence of the excurrent system of canals, their office is served by the great cloacal cavities that are found to exist in some forms of sponges, extending from the base to the most distant parts of the animal. Beside these large cavities, there are others of a much more limited character, the intermarginal cavities, which are situated immediately below the dermal membrane, and which receive the water inhaled by the sponge and transmit it to the mouths of the incurrent canals which have their origin in the intermarginal cavities. Enveloping the entire mass of the sponge we find the dermal membrane, in which are situated the pores, for inhalation and imbibition of nutriment, and the supply of the incurrent canals; and the oscula, through which the excrementitious matter and the exhausted streams of water are poured from the terminations of the excurrent canals. These parts are indispensably necessary, and are always present in a living sponge. The attachment of the Spongiadæ to the body to which they adhere during life, is effected by a basal membrane which presents a simple adhesive surface, following the sinuosities of the body on which it is based, entering into holes or cracks and filling them up, thus securing a firm hold of the mass on which they are fixed. When it so happens that the locality consists of sand or mud, their bases frequently assume the form of branching roots, which penetrate the mud or sand to a considerable extent; but they are never instrumental to the nutrition of the animal—they are simply the anchors by which it is fixed to its locality for life.

The Skeleton.

There are two important distinctive characters for consideration in treating of the structure of the skeleton:—1st, the material of which it is constructed; and 2nd, the mode of its arrangement.

By selecting the material substance of the skeleton as the means of dividing the Spongiadæ into Orders, we obtain three well-defined natural groups, which are again readily divisible into Families, based on the mode of the arrangement of the substance of which the skeleton is composed.

The first Order, the Keratosæ, consists of those sponges in which the primary essential material of the skeleton is keratose fibre. It may be divided into three families.

1. Those which have the skeletons constructed of keratose fibre only, as in the best cup-shaped Turkey sponges of commerce.

2. Those having skeletons of arenated keratose fibre, as in the genus *Dysidea*.

3. Those which have the skeleton formed of spiculated keratose fibre, as in *Halichondria oculata*, JOHNSTON, *Chalina*, GRANT, and in the common West Indian sponges of commerce.

In the first Order no earthy material of any kind enters into the structure of the skeleton.

The sponges of the second Order, by a natural transition, pass into the nearly allied great division of the Halichondroid skeletons; the inability of the former to secrete silex in an organized form connecting them closely with the pure keratose, while the instinctive habit of appropriating extraneous matters recognizes the necessity of other material in the skeleton beside pure keratode; and the secretion of it by its own inherent power appears to be the next natural step in the development of the animals.

In the third division, those having the skeleton formed of spiculated keratose fibre, the gradual development is also well marked, as in one group we find spicula only in the primary or radiating fibres of the skeleton, while in another group they are found in both the primary and secondary fibres, and are developed simultaneously with the keratode of the young fibres of the skeleton.

The second Order, the Siliceæ, comprises those sponges in which the primary essential material of the skeleton consists of siliceous matter; and this also may be divided into three sections or families.

1. Those sponges which have the skeleton composed of solid siliceous fibres, as in *Dactylocalyx pumicea*, STUTCHBURY.

2. Those in which the skeleton consists of spicula dispersed without order on membranous surfaces, as in *Hymeniacidon caruncula*, BOWERBANK.

3. Sponges having the skeleton consisting of spicula cemented together into a network by keratode, as in *Halichondria panicea*, JOHNSTON.

The third Order, the Calcareæ, has the primary essential material composed of calcareous matter, and this division contains but one section or family:—

Spicula dispersed without order on membranous surfaces, as in the genus *Grantia* as defined by JOHNSTON.

1. Keratosæ . . .	*a.*	Keratose fibre only.
	b.	Arenated keratose fibre.
	c.	Spiculated keratose fibre.
2. Siliceæ	*a.*	Solid siliceous fibre.
	b.	Spicula dispersed on membranes.
	c.	Spicula cemented together by keratode.
3. Calcareæ . . .	*a.*	Spicula dispersed on membranes.

Spicula of the Skeleton.

The spicula in the skeletons of the Spongiadæ appear to be the homologues of the earthy deposits in the bony structures of the more perfectly developed living forms. In the higher tribes of animals we find the disintegrated condition of the earthy deposits in the first stages of the development of the bony structures in the form of minute radiating patches, which in a more advanced stage unite and form the solid mass of bone, as in the mammalian tribes of animals, while in the cartilaginous tribe of fishes these radiating centres of bony secretion never attain a higher degree of development, but remain isolated points of bony structure during the whole of the life of the animal. And in the compound tunicated animals we find the calcareous stellate and sphero-granulate forms of spicula developed in close accordance with the similar siliceous forms in various species of sponges. Thus the stellate and cylindro-stellate spicula of the sarcode in the Spongiadæ are *apparently* the homologues of the bony centres of development in the higher animals. It is so likewise with the other forms of sponge spicula. We find isolated calcareous spicula of an irregular fusiformi-acerate shape, representing the bony skeleton of the higher animals in the outer integuments of several species of *Doris*.

Messrs. ALDER and HANCOCK, in their admirable 'History of the British Nudibranchiate Mollusca,' describe calcareous spicula occurring in *Doris aspera*, *bilamellata*, and *Triopa claviger*, which *appear* to be analogous to the rectangulated-triradiate spicula of *Grantia*; and they also state that in the first-named species crucial or dagger-shaped spicula occur in the branchiæ and margins of the cloak of the animal, and forms very similar to those occur on the interstitial membranes of *Grantia nivea*, JOHNSTON. Numerous forms of tuberculated and smooth calcareous spicula are also found in the extensive family of the Gorgoniadæ. And the siliceous simple bihamate form of retentive spiculum, so abundant on the interstitial membranes of many species of sponges, are closely represented by the calcareous bihamate spicula so numerous on the tubular suckers of *Echinus sphæra*. Thus we find in the spicula only, a series of links in the chain of animal development, intimately connecting the Spongiadæ with the higher tribes of animals.

In the solid siliceous fibres of *Dactylocalyx*, and in the tubular siliceous fibres of *Farrea*, BOWERBANK, MS., and especially in the latter, we obtain a very much closer approximation to the tubular forms of the bones of the higher classes of animals.

From our knowledge of the great scheme of the natural development of animal life, the most perfectly organized sponges appear to be those which secrete carbonate of lime as the earthy basis of their skeletons, and the least perfect those which secrete no earthy matter in the skeleton; those which secrete silex taking an intermediate position; but it must also be remembered that there is no form of spiculum found among the calcareous sponges, or in the higher tribes of animal life, that is not repeated among the siliceous forms of spicula of the Spongiadæ.

The essential Skeleton Spicula.

The general configuration of the spicula, which are essentially necessary to the structure of the reticulated skeletons, is that of simple elongate and slightly curved bodies, varying in length and stoutness in accordance with the necessities of the structure in which they form so important an element. When the areas of the reticulations are large, they are generally long and rather stout, and are usually shorter when the proportions of the network are small and close. When enclosed in keratose fibre, they are most frequently smaller and shorter in their proportions than those in the Halichondroid sponges. And in those species in which they are dispersed over the membranous tissues, as in *Hymeniacidon*, Bowerbank, MS., they are generally long, slender, and frequently flexuous. In the sponges of this structure having siliceous spicula the triradiate form of spiculum occurs but rarely, while in the calcareous sponges, which consist of membranes and dispersed spicula, the triradiate forms of skeleton spicula are the normal ones.

When the skeleton is constructed of large fasciculi of spicula, as in *Tethea* and *Geodia*, they attain their greatest dimensions as essential spicula of the skeleton, frequently exceeding the eighth of an inch in length.

The greatest known length of spicula occurs in the prehensile ones of *Euplectella aspergillum* and *cucumer*, Owen, where they are found to exceed three inches in length; and in *Hyalonema mirabilis*, Gray, where, in the spiral column of the great cloacal appendage, they reach the extreme dimensions of six or seven inches in length; but in both these cases the spicula must be considered as auxiliary and not essential forms.

The larger number of forms of skeleton spicula are perfectly smooth, but in some species they are partially or entirely covered with spines.

In every case they appear in the living state to have the capability of a change of position within the fibre to a considerable extent, in accordance with the natural alterations arising from the extensions or contractions of those tissues.

The spicula are among the earliest-developed organs of the sponge. Dr. Grant, in his valuable "Observations on the Structure and Functions of the Sponge," published in the Edinburgh New Philosophical Journal, vol. i. p. 154, states that spicula are developed in the locomotive gemmules of *Halichondria panicea* (*Hal. incrustans*, Johnston) before they attach themselves for life and commence their development as fixed sponges. And in the gemmules of *Tethea cranium* they are abundantly developed even before the gemmules are detached from the parent, and some of them are of forms peculiar to the gemmule.

The growth of the spicula and their mode of extension appear to vary according to circumstances. Thus an acerate spiculum is at first short and very slender; as the development proceeds it increases in diameter, and appears to lengthen equally from the middle towards both ends; but in spinulate ones the increase in length does not appear to be effected in the same manner as in the acerate form, as we often find spinulate spicula fully developed at the base, while the shaft is exceedingly short and the apical termination hemispherical instead of acutely pointed, as in the adult state. As the shaft lengthens towards its full proportions, it attenuates; but in all the intervening stages the apical termination is usually more or less hemispherical. The progressive development from the base to the apex of the spinulate form is beautifully illustrated in the skeleton spicula of a new and very singular British sponge from Shetland, *Halicnemia patera*, BOWERBANK, MS., represented by figs. 2, 3, 4, 5, 6, & 7, Plate XXIX. The first of these (fig. 2) represents a short variety of the normal spinulate form. In the second (fig. 3) we have a bi-spinulate, and in the third (fig. 4) a tri-spinulate form. The latter two are not mere malformations, but they prevail to a great extent in the structures of the sponge, subject to variations in the distances in the development of the second and third inflations from the basal one. Figs. 5, 6, & 7 represent immature spicula in progressive stages of development, the apices having hemispherical terminations.

Auxiliary Spicula.

Beside the spicula essential to the structure of the skeleton there are several other forms of these organs, many of which, although not absolutely necessary in the structure of the skeleton, are of very frequent occurrence in subsidiary organs found in particular species and in peculiar genera. They may be conveniently classed under the following heads:—

Connecting spicula.
Prehensile spicula.
Defensive spicula.
Tension spicula.
Retentive spicula.
Spicula of the sarcode.
Spicula of the gemmules.

In the above designations of the auxiliary spicula, it must not be understood that their respective titles strictly define their offices, as it frequently occurs that under peculiar circumstances the same form of spiculum is destined to serve two, or even three distinct purposes. Thus, an external defensive spiculum will occasionally perform retentive offices for the purpose of securing prey; or internal defensive spicula will combine the offices of defensive spicula against the larger and more powerful of their enemies with that of wounding and securing their smaller ones.

The Connecting Spicula.

The normal form of the connecting spicula is that of an elongate shaft, with a ternate apical termination. But all the varieties of this form are not necessarily connecting spicula. Some of them subserve the offices of external or internal defensive organs, as I have described elsewhere. The varieties that may correctly be designated by this title are those which I have termed in the first part of this paper expando- and patento-ternate spicula, and some varieties of the recurvo-ternate form also appear to be applied to this peculiar office. Their situation in the sponge, rather than their precise form, determines their title to be thus designated. Nor is their especial purpose of connecting the dermal crust of the sponge with the great mass of the skeleton beneath, the only office they are destined to perform in the economy of the animal, as their ternate terminations are so disposed as to form a series of reticulations and areas for the support of the valvular membranes of the proximal ends of the intermarginal cavities of the sponges, in which they are best developed, as in *Geodia M^cAndrewii* and *Barretti*, *Pachymatisma Johnstonia*, and others of similar structure.

I have never seen the progressive development from a simple elongate shaft of an expando- or patento-ternate connecting spiculum, as I have those of the porrecto-ternate external defensive form, and the spinulo-recurvo-quaternate internal defensive ones, but from the great similarity that exists in their structure there can be little doubt that their mode of growth is the same; and I am very much inclined to believe that the cylindro-expando-ternate form from *Pachymatisma Johnstonia*, fig. 43 in Plate XXIII. of the Phil. Trans. for 1858, is an incompletely developed form of the mature attenuato-expando-ternate spiculum that belongs to that sponge, and which is represented by fig. 42 in the same Plate.

There is a progression of development in the ternate terminations of these spicula that is very interesting. The simplest form has three nearly straight attenuating radii. In the next stage the distal ends of the primary radii become furcated, but the secondary radii remain in the same plane as the primary ones. In the third stage of development the terminations of the secondary radii again divide into furcations, becoming dichotomo-patento-ternate (fig. 48); but in this case the radii of the extreme furcations are not all in the same plane, as appears always to be the case with those of the secondary radii, and thus we have produced an additional power for combined action. But in the whole of these varieties, in the structure of these ternate terminations, hitherto, there is no appearance, further than their general form, of their being destined to become a united structure, and in some sponges in which they do occur they rarely, or never, become thus united; but this demonstration of their destination for combined action is obtained in an irregular ternate form, as exhibited in the dermal structures of a new species of siliceo-fibrous sponge from India, *Dactylocalyx Prattii*, BOWERBANK, MS., in which we have the primary radii sinuated and flattened in such a manner as to splice together and form a strong and regular reticulated structure for the support of the dermal membrane of the sponge, as in fig. 8, Plate XXIX., which represents a few of these spicula uniting to form the reticulations of the dermal tissues, while fig. 9 represents three of these spicula separated by boiling nitric acid. By this structure, as exhibited in *D. Prattii*, there is rendered apparent a more visible and common purpose in their form and mode of development, and we are gradually conducted to the still more complete and continuous form of fibro-siliceous dermal network that exists in the beautiful harrow-shaped tissue of the dermal structures of the sponge supporting the fine specimen of *Euplectella* in the possession of my friend Dr. A. FARRE, and described by Prof. OWEN in the 'Transactions of the Linnean Society,' vol. xxii. p. 117, plate 21, and which tissue I shall describe more fully in treating on the subject of the dermal structures of the Spongiadæ.

There are two distinct purposes in the physiological application of the ternate spicula; the simplest is that of the strengthening and connecting the dermal membrane with the mass of the animal beneath. The second and more complex one, is that of forming an internal reticulating framework for the support within its areas of the valvular tissues forming the bases of the intermarginal cavities. These offices of the ternate spicula are not demonstrated in an equal degree of perfection in all sponges in which they occur. Where the organs which they subserve are best and most abundantly developed, these forms of spicula are found in the greatest quantities, and in the most regular and perfect mode of arrangement, but where the intermarginal cavities or porous areas are in a less regularly developed state, they are deficient in a corresponding degree; thus evincing the design and purpose of their structure and presence. The most perfect and beautiful illustration of their physiological purpose, in their first mode of application, is afforded by the dermal membrane of *Dactylocalyx Prattii.* Here we find their radii overlapping each other longitudinally, and cemented together by keratode, forming a continuous and regular network, upon the upper surface of which the dermal membrane reposes, and to which it is firmly united. The mode in which the radii are united, and the material with which they are cemented together indicate a unity of firmness and elasticity in the living state that is truly admirable; and this mode of structure we perceive is especially necessary to the action of the dermal membrane, as the whole of the skeleton beneath is perfectly rigid and inelastic. Thus while their shafts are deeply plunged in, and firmly secured to, the immoveable mass beneath, their ternate apices are capable of such an amount of oscillating motion as would be required for the organic expansion and contraction of the membranous structure they support. By the action thus generated each pair of the united radii would glide in a longitudinal direction upon each other, and thus, although in each separate instance the amount of motion would appear to be exceedingly small, the aggregate of the whole would afford a very considerable range of expansion, as exhibited in fig. 8, Plate XXIX.

In their second mode of application, that is to the bases of the intermarginal cavities, it appears that as their office is different, so their form and the mode in which the radii of their apices is connected are also different. Thus at the inner surfaces of the thick dermal crust of *Geodia McAndrewii* and *Barretti*, we find them forming a network equally regular and continuous as that in *Dactylocalyx Prattii*, but the mode of its construction is varied. The radii do not in these cases glide upon each other longitudinally, but they cross each other at various angles; and as the whole mass of these sponges is fleshy and very elastic, so by this mode of interlacement of the radii a very considerably greater amount of expansion and contraction of the reticulated structure is provided for, while at the same time the power of maintaining the common plane of the reticulated tissue is equally as great as in the similar structure in *Dactylocalyx Prattii.* Thus far we can trace the physiological purpose of their structure; but why in one species we find their terminations simple as in *Geodia McAndrewii*, and furcated as in *Geodia Barretti*, or still further complicated as in the dichotomo-patento-ternate form, is a question which cannot be so readily solved without a further acquaintance with the species of *Geodia* bearing these forms in a living state.

The connecting spicula are not always an essential portion of the skeleton, and they exist only in comparatively a few genera of the Spongiadæ.

Prehensile Spicula.

I have so fully described, in the first part of this paper, the prehensile spicula found at the base of the beautiful *Euplectella*, in the possession of Dr. ARTHUR FARRE, and figured in Plate XXIII. fig. 53, Phil. Trans. for 1858, as to render it necessary to say but very little more regarding them. Fig. 44, Plate XXVI. of the same paper presents so many points of structural agreement with that from *Euplectella*, as to induce a very strong suspicion of its having had a similar office to perform in the sponge from which it was obtained; but its extremely small size is against that supposition, and in favour of its being an internal defensive one. Both sponges producing these forms were parasitical on other sponges. With respect to the larger form there is no reasonable doubt of its office in the sponge, and the smaller ones may have been basal appendages to a very small species. I have searched other species of *Euplectella* in vain for similar forms.

Defensive Spicula.

The modes of defence in the Spongiadæ by means of spicula are exceedingly various, and in many cases remarkably complex and interesting. They may be divided into two great systems,—1st, those of external defence; and 2nd, those of internal defence.

If I were to attempt to enter upon a description of every variation in the mode of the application of spicula to defensive purposes, it would extend this portion of the subject to a greater length than we can afford under the present circumstances. I shall therefore confine my observations to a description of the general principles of defence as exhibited in some of the principal genera of the Spongiadæ.

In the external defences, the mode of the application of the spicula depends in a great degree on the structure of the skeleton of the sponge. The most simple cases are those where the structure of the skeleton consists of spicula radiating from the centre or the axes of the sponge, and in these cases they usually consist of the terminations of the radial lines of the skeleton, the distal spicula of which are frequently projected for a considerable part of their length through the dermal membranes, and in many sponges the surface is thus thickly studded with them; and in species where the terminal radial lines of the skeleton contain many spicula, they are frequently found at their apices to assume a radiating direction, so as to present the greatest possible number of points to their external enemies. This mode of defence is very general in the numerous British species of the genera *Isodictya* and *Chalina*, BOWERBANK, MS. Fig. 10, Plate XXIX. represents a small portion of a section at right angles to the surface from *Halichondria seriata*, JOHNSTON, *Chalina*, BOWERBANK, MS., illustrating very distinctly this simple mode of external defence.

In the genus *Dictyocylindrus*, BOWERBANK, MS., which consists principally of slender branching sponges, many of which in their living state are exceedingly fleshy in their appearance, the skeleton is formed of a central cylinder, composed of a network of spicula, from the surface of which radiate in vast quantities long, slender and acutely pointed spicula, which in the living condition project slightly beyond the dermal membrane of the sponge, so that in the event of any small fish attempting to feed upon or suck this tempting bait, instead of a mouthful of soft and grateful gelatinous matter, he would find himself assailed in every direction with an infinite number of minute points, many of which he would carry away with him deeply imbedded in the soft lining of his mouth, as the reward of his temerity and a warning against a repetition of a like assault. Fig. 11, Plate XXIX. represents a small portion of a young branch of *Dictyocylindrus rugosus*, BOWERBANK, MS., an undescribed British species, frequently found on shells and stones dredged up at Shetland, or the Orkney Islands. In the genus *Tethea*, in which the skeleton consists of fasciculi of large, stout spicula radiating from the base or centre of the sponge, the system of defence is somewhat more complicated. It is a combination of the terminations of the skeleton fasciculi with, in some species, the addition at the surface of the sponge of porrecto-ternate and recurvo-ternate spicula; the latter two forms being probably aggressive as well as defensive, subserving the purpose of entangling prey as well as that of defence.

This mode of defence is very beautifully illustrated in *Tethea cranium*. The distal ends of the skeleton fasciculi, composed of large fusiformi-acerate spicula, are projected through the stout coriaceous surface of the sponge, and in the midst of this thick coat each of the passing fasciculi is surrounded by a cluster of stout short fusiformi-acerate spicula, their distal points closely embracing the fasciculus, while their proximal terminations are spread widely out in a circle around the lower part of the skeleton fasciculus, so as to form a strong and most efficient conical buttress to sustain it in its proper position, at the same time allowing a considerable amount of elasticity to meet pressure from without. Each skeleton fasciculus terminates with from two to eight or ten porrecto-ternate spicula, and occasionally we find one or two of the recurvo-ternate ones accompanying them; but their apices are rarely projected much beyond the dermal membrane of the sponge, while the rest of the spicula extend considerably above it (fig. 12, Plate XXIX.). The same system of defences prevails also in *Tethea simillimus*, BOWERBANK, MS., from the Antarctic regions; but in this species the recurvo-ternate spicula appear to be protruded in greater numbers and in more regular order than in our northern species, *T. cranium*.

In *Tethea muricata*, BOWERBANK, MS., the skeleton fasciculi are not protruded beyond the surface, but immediately beneath it we find the heads of numerous large furcated expando-ternate spicula, with remarkably long and acute terminal radii, while the dermal membrane is profusely furnished with attenuato-elongo-stellate spicula.

In *Tethea Norvegica* and *Ingalli*, BOWERBANK, MS., and in *T. Lyncurium*, JOHNSTON, the same protection is attained in a different manner. Instead of the spicula of the skeleton fasciculi gradually converging towards a point, they diverge considerably as they approach the surface, so as to present an infinite number of minute and nearly equidistant points, and in addition to these the dermal membrane and the coriaceous coat of the sponge is supplied with an infinite number of closely packed stellate spicula.

In some species of the genus *Geodia* the system of external defences is still more complex. Thus in *G. McAndrewii* and *G. Barretti* the defences are double, one system consisting of a continuation of the great radial fasciculi of the skeleton as a protection against the assaults of the larger and more powerful assailants, and then of a secondary series consisting of an infinite number of minute acerate spicula, based immediately beneath the dermal membrane and projecting to a slight extent beyond its external surface, effectually protecting it and the porous system of the sponge from the attacks of its minute and more insidious enemies.

Similar modes of external defences exist in various species of *Pachymatisma* and *Ecionemia*, but no two species appear to agree precisely in these respects.

In the genera *Microciona* and *Hymeraphia*, Bowerbank, MS., differing widely in the structure of their skeletons from any of the sponges hitherto described, and frequently not exceeding in thickness the substance of a stout sheet of paper or a thin card, the same principles of defence are carried out, although their structure is widely different from each other. In the first genus, the skeleton of which is formed of short pedestals of keratode combined with spicula, each of the pedestals, which reach nearly to the surface of the sponge, is terminated with a radiating cluster of long curved and acutely pointed spicula, the apices of which pass through the dermal membrane in every direction, and thus form a most effectual series of external defences, while their shafts beneath serve as the framework of the intermarginal cavities of the sponge (figs. 1 & 2, Plate XXX.). In *Hymeraphia*, where the sponge is less in thickness than the length of one skeleton spiculum, and where they pass from the basal membrane of the sponge through the dermal membrane, their apices acting as external defensive organs, while their shafts form the essential skeleton of the animal, there is an especial provision for their preservation from injury. Their bases are expanded in the form of large bulbs, so as not only to afford a greater surface for attachment, but to allow them at the same time to act on the principle of a ball-and-socket joint, giving them a more than usual amount of attachment, and a power of yielding in every direction to pressure on their apices from without (fig. 4, Plate XXX.). The defence of the surface of the Halichondroid sponges is less apparent, but equally efficacious; the abundantly spiculous reticulations immediately beneath and supporting the dermal membrane, would render attacks of annelids or other small predaceous creatures exceedingly unpalatable.

In the calcareous sponges the spicular defences are exceedingly interesting. In *Grantia compressa*, the distal ends of the great interstitial cells are amply protected by numerous flecto-attenuato-acuate spicula grouped around their porous terminations, with their club-shaped ends curving in every direction over them, but in no degree interfering with the freedom of their inhalant action. In *Grantia ciliata* they are grouped in circles around the distal ends of the interstitial cells, but in this species they are acutely pointed; and when the inhalant system is in a state of repose, they are concentrated at their extreme points so as to form an elongate cone, effectually enclosing and protecting the porous ends of the cells within them; but when the inhalant action is in full activity, their apices recede from each other until they assume the form of a cylinder, and then freely admit the incurrent streams of water, but effectually repel the advances of any dangerous assailant that may attempt an entrance. The distal termination of the cloaca in this species is also abundantly protected by a marginal fringe of long and very acute spicula, and is furnished with the same simple but beautiful mechanical contrivances for opening and closing in accordance with the necessities of the animal. For a more complete description of the anatomy and physiology of this highly interesting species I must refer my reader to the 'Transactions of the Microscopical Society of London,' vol. vii. p. 79, pl. 5.

In other species of *Grantia* the same principles of external defensive action exist, but the precise mode is never exactly the same in any two species.

Internal Defensive Spicula.

The internal defensive spicula of sponges are exceedingly various in their forms and modes of application to their especial purposes; and they seem naturally to resolve themselves into three distinct groups:—1st, those which are destined simply to repel; 2nd, those which wound and lacerate as well as repel; and 3rd, those which are calculated not only to destroy but also to retain intruders.

The purposes of the first class of spicula are frequently performed by the ordinary spicula of the skeleton, which are projected more or less into the cavities immediately within the oscula and other spaces requiring such protection; but when especially formed for and appropriated to defensive purposes, they are always free from spines and usually terminate acutely; and they are frequently provided with widely extended basal radii, so as to fix them rigidly and firmly in their proper positions, as exemplified in the various forms of spiculated triradiate spicula represented by figs. 14, 15, 16, & 17, Plate XXIV., Phil. Trans. for 1858.

The best illustrations of the application of the simple defensive spicula are to be found in the cloaca in several species of *Grantia*, as in *G. ciliata*, Johnston, and *G. tessellata* and *ensata*, Bowerbank, MS. In all these species this great central cavity is abundantly furnished with spiculated triradiate spicula, such as represented by figs. 15 & 16, Plate XXIV. Phil. Trans. 1858, which are so disposed that while the basal radii are firmly cemented on the surface of the cloaca, the spicular or defensive rays are projected from its surface, not at right angles to its plane, but always at such an inclination towards the mouth of the cloaca as to present a combined series of sharp points in the best possible position of defence, so that an intruding assailant could scarcely escape being seriously wounded by them, while a retiring enemy would pass with impunity over their inclined apices. In some species, as in *G. tessellata*, the defensive ray is naturally curved to the desired angle for defence (fig. 16, Plate XXIV. Phil. Trans. 1858), and it is also of such a form as to be readily released from the creature it has wounded, either by being attenuato-acuate or ensiform, as in fig. 15, Plate XXIV. Phil. Trans. 1858, from *G. ensata*, and as represented *in situ* by a small portion of a longitudinal section of the cloaca of a specimen of *Grantia tessellata* in Plate XXX. fig. 5, in which the defensive radii are all curved in the direction of the mouth of the cloaca.

In the second division the internal defensive spicula are usually short and straight, and more or less covered with strong conical acutely pointed spines, projected either at right angles to the axis of the spiculum, or recurved considerably towards its base; generally speaking the spines are dispersed on all parts of the spiculum without any approach to order, as represented in fig. 1, Plate XXIV. Phil. Trans. 1858, while in other cases, as in figs. 2 & 3 in the same Plate, they are arranged in verticillate order on all parts of the spiculum. In each of these varieties the bases of the spicula are usually profusely furnished with spines, so as to ensure a strong and somewhat rigid mode of attachment.

There is undoubtedly a special purpose in every variation of the spination of these spicula, and in their presence generally. The short strong form and acute distal termination admirably adapt them to encounter the larger description of intruding annelids, the most dangerous internal enemies of the Spongiadæ; while the spination of their shafts presents a series of minute weapons that would prove equally formidable to those intruders that were too minute to be affected by the larger weapons of defence.

The acuate entirely spined defensive spicula are of very common occurrence in sponges, and are by no means confined to particular tribes or genera. As a general rule, when the external defences are very full and sufficient, we should not expect to find the internal defences abundant, and, on the contrary, when there appears to be a paucity of external defences, the internal ones are frequently exceedingly numerous. Thus, in the genus *Dictyocylindrus*, Bowerbank, MS., where in almost every species the surface of all parts of the sponge is bristling with the acute terminations of the radiating external defensive spicula, although in most of the species we find acuate entirely spined internal defensive ones, yet in many of the species they are so rare as to be by no means readily detected.

When the skeleton is formed of keratose fibres, we find them dispersed on their surface without any approach to order, and projected at every imaginable angle. If the skeleton be formed of any of the varieties of spicular reticulations, they are based in a similar manner on the principal lines of the reticulated structure, and sometimes, but not very frequently, they occur in groups.

I will not extend this portion of my subject to an unnecessary length by describing every mode of their occurrence, but select a few of the most interesting cases as illustrations of the general principles of their application.

Fig. 6, Plate XXX. represents a small portion of the kerato-fibrous skeleton of an Australian sponge, with the attenuato-acuate entirely spined internal defensive spicula *in situ*. Fig. 7 represents a few fibres from a kerato-fibrous sponge from the West Indies, in which the verticillately spined internal defensive spicula are dispersed over the fibres; and fig. 8 represents the same description of defensive spicula from a West Indian kerato-fibrous sponge, having the defensive spicula congregated in bundles. Sometimes, but not very frequently, they are found on the interstitial or basal membranes of the sponge, and under these circumstances many of them are prostrate in place of being erect; and in one sponge, *Hymeniacidon Cliftoni*, Bowerbank, MS., a singular parasitical species from Freemantle, Australia, this prostration appears to be effected by an especial law. This singular sponge envelopes several fan-shaped portions of a *Fucus*, and systematically appropriates the minute ramifications of its stem to the purposes of an artificial skeleton; the whole sponge abounds with short stout attenuato-cylindrical entirely spined internal defensive spicula: but the remarkable circumstance attendant on their presence is, that wherever the membranes supporting them envelope and firmly embrace a portion of the vegetable stem, they assume an erect position, and exhibit all the usual characters of defensive spicula; but where the membranes merely fill up the areas of the vegetable network, they are nearly all of them perfectly prostrate, and apparently performing the office of tension, rather than of internal defensive spicula. Their form also is singular, being attenuato-cylindrical, not having the acute termination that is usual in this description of spicula.

Fig. 9, Plate XXX. represents a small portion of the fibrous stem of the *Fucus* coated by the membranes of the sponge, and covered with spicula; those immediately over the stem being erect, while those on the membrane are prostrate. (*a*) represents one of this new form of internal defensive spiculum ×175 linear.

In *Hymeraphia stellifera*, BOWERBANK, MS., an exceedingly thin coating British sponge, the internal defensive spicula present a singular variation from the normal form. In this case they assume the shape of an ordinary Florence oil flask, with a somewhat elongate neck, and having a beautiful star-shaped apex in place of a stopper. They occur in considerable quantities; their large bulbous bases are firmly attached to the strong basal membrane of the sponge, and they are projected thence at every possible angle upward into the interstitial spaces. Their apices are crowded with stout acutely conical spines, which radiate in all directions. Fig. 3 *a*, Plate XXX. represents a group of these spicula *in situ*, elevated by a grain of sand beneath the basal membrane; and fig. 4 *b*, Plate XXX., one of the same form of spiculum, magnified 260 linear. In this form of spiculum, as in that of *Hymeniacidon Cliftoni*, their purpose seems to be the infliction of laceration, rather than that of destruction, by deep wounds. In another species of *Hymeraphia*, *H. clavata*, these spicula have the same large bulbous bases as those of *H. stellifera*, but their apices are acute, like those of the normal forms of such spicula. In all these cases we observe in their attachments the same approximation to the structure of the ball-and-socket joints of the higher tribes of animals, rendering them capable of yielding in every possible direction to the struggles of any enemy with which they may be entangled.

In the third division of the internal defensive spicula there is an especial construction for retention as well as for destruction. Their apices are usually more or less hamate, as represented in figs. 7, 13, & 12, Plate XXIV. Phil. Trans. 1858, and their attachments to the sponge are usually such as to allow of a considerable amount of flexibility or motion.

I will not attempt to describe the whole of the numerous variations in the modes of their application to defensive purposes, but select a few of the most interesting cases as illustrations of the general principles of combined internal defence and aggression.

The spinulo-recurvo-quaternate spiculum, the growth and development of which I have described in the first part of this paper (Phil. Trans. 1858, p. 293), presents an admirable illustration of the combined defensive and aggressive character of some of these internal defensive spicula. The sponge in which they occur belongs to the Halichondroid tribe, the skeleton being composed of a network of spicula cemented together by their apices, which cross each other at the angles of the areas of the reticulations. The recurvo-quaternate spicula are not dispersed on all parts of the skeleton, but are congregated in groups, frequently consisting of as many as fifteen spicula, the whole of their bases being concentrated on one of the angles of the reticulations of the skeleton, while their shafts and apices radiate thence in every direction into the interstitial spaces of the sponge; they are thus placed on the strongest and most elastic portion of the skeleton, with their hemispherical bases firmly imbedded in the cementing keratode of the skeleton, which abounds at the angles of the network, and which by its inherent elasticity and strength renders the insertion of the base of the spiculum, in strength and extent of action, quite equivalent to the powers of the ball-and-socket joints in the higher tribes of animals. A small annelid or other minute intruder entangled amidst these numerous sharp hooks would struggle hopelessly in such a situation, as the spicula, from the nature of their attachment, would yield readily to its struggles in every possible direction, and at every new contortion arising from its efforts to escape it would inevitably receive a fresh series of punctures and lacerations.

Fig. 10, Plate XXX. represents a small portion of the skeleton of the sponge bearing the spinulo-recurvo-quaternate spicula *in situ.*

In other instances, where defence alone appears to be contemplated, we do not find these beautiful adaptations for motion in every direction prevail. The bases of the spicula in those cases are abundantly spinous, and are evidently intended to maintain a firm hold by their attachments, and are destined rather to rigidly maintain their position than to yield to any struggling body with which they may be in contact. The numerous spines with which these shafts are frequently covered are calculated to wound and lacerate, rather than to retain the enemies with which they are engaged*.

* Since I wrote the first portion of this paper, I have received from my friend, Mr. J. Yate Johnson, of Madeira, a new and very illustrative instance of the combination of defence and aggression in the structure and offices of the internal defensive spicula; and in this case it is not a new organ, but an adaptation of a well-known form to a new purpose, in the shape of a contort trenchant bihamate spiculum of unusual size and structure. In the course of my examination of the results of the deep-sea soundings in the Atlantic, I found several of these spicula, and was much interested by the singularity of their structure, which at that time I could not comprehend.

The general outline is much like that of the type-form so commonly found imbedded in the sarcode, but it is somewhat less flexuous in its curves, and the shaft and hami are very much larger and stouter than those of the spicula of the sarcode. But the most singular point in their structure is, that while the curved portion of the hami and the middle of the shaft are perfectly cylindrical, the inner portion of the hooks and those parts of the shaft immediately opposed to them present sharp trenchant edges, so that each hook assumes to some extent the form of spring hand-shears. The acute termination of the hook and the opposed trenchant edges exhibit every facility for effecting an entrance through the tough skin of the victim, while

In *Hyalonema mirabilis*, GRAY, a sponge nearly related to the genus *Alcyoncellum*, QUOY et GAIMARD, we find another extraordinary series of internal defences; one portion of the spicula appearing to be destined to wound and lacerate, rather than to retain intruding enemies, while a larger and stronger series of spicular weapons bear all the evidences of being to retain rather than to repel the assailants.

The first description of spiculum I have designated entirely spined, spiculated cruciform spicula. They consist of a short stout cruciform base with a long spicular ray, ascendingly and entirely spinous, projected at right angles from the centre of the basal radii. The spines are acutely conical, and very sharply pointed. They pass off from the spicular ray at an angle of 12 or 15 degrees in the direction of its apex. The apices of the basal radii are attenuated and slightly spined. These spicula are thickly distributed on the fasciculi of the skeleton, and frequently equally so on one side of the interstitial membranes, probably that which forms the surfaces of the interstitial spaces, and they are especially abundant near the exterior of the sponge. The four basal radii appear firmly cemented to the membrane, but not immersed in its substance, as they do not appear to leave their impressions when removed from it, nor do they bring any portion of the membrane away with them. In some parts of the tissue these spicula are very much modified in form. In the ordinary cases we find the basal radii short and stout, and not more than a fourth or a fifth of the length of the spicular ray, while in other cases the basal rays are very nearly as long as the spicular one; the only difference in their structure being that the latter is very strongly spinous, while the former have the spines comparatively very slightly produced.

The second form is a large fimbriated multihamate birotulate spiculum, which occurs dispersed amid the interstitial tissues of the large basal mass of the sponge. There are usually not more than one or two together, but occasionally they occur in groups of ten or twelve, without any approach to definite arrangement.

These spicula are comparatively large and stout. They have eight rays at each end of the shaft; the two groups of radii curving towards each other to such an extent that each

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the perfectly blunt and cylindrical state of the arch of the hook bespeaks the design of retention as well as of destruction. As soon as the hook has penetrated to the inner blunt surface of the curve, it no longer cuts, and the prey, wounded in every direction, is securely retained for the nutrition of the sponge. This result is indicated not only by the form of the spicula; their position in the structure of the sponge bespeaks their office equally unmistakeably. They are not immersed in the sarcode like their congeners in form, but are firmly cemented by one hook to the reticulating lines of the skeleton, while the other ends are projected at various angles into the interstitial cavities of the sponge in such numbers and in such a manner, that it would be next to impossible for an intruder within the sponge to escape being entangled and destroyed amongst them. Fig. 1, Plate XXXI. represents a portion of the reticulated skeleton of the sponge with the trenchant contort bihamate spicula *in situ*, magnified 50 linear; and fig. 2 one of the spicula, magnified 400 linear, to exhibit the trenchant edges and the cylindrical portions of the hami and shaft.

This sponge is allied to *Halichondria* by the structure of the skeleton, and it is described by my friend Mr. J. YATE JOHNSON as being a thin coating species, spreading over the surface of rocks and stones to the extent of two or three inches in diameter.

forms the half of a regular oval figure; the opposite apices being separated to the extent of about the length of one of the radii. Each ray is in form like a double-edged blunt-pointed knife, bent near the handle in the direction of a line at right angles to one of its flat sides; and each ray is strengthened and connected with the shaft of the spiculum by a stout curved web of silex, which extends from a little below the inner surface of the ray to a point on the shaft about opposite to its middle. The shaft is cylindrical, and has short stout tubercles dispersed over all its parts when fully developed.

The structure of every part of this singularly beautiful spiculum is strikingly indicative of its office in the economy of the sponge; the form and mode of bending of the radii, with their thin edges at right angles to the line of force in a struggling animal, and the powerful web at the base of the ray enabling it to sustain an amount of stress that the unsupported flat ray would never otherwise be able to endure.

The spiculated cruciform spicula are exceedingly abundant in every part of the sponge, and no victim entangled and retained by the large multihamate spicula could avoid innumerable wounds while struggling to effect its escape; while the one held it secure within the sponge, the others, from the peculiarity of their form and mode of disposition of their acutely pointed spines, would readily release it after the infliction of every puncture, only that the wounds might be multiplied until the creature was pierced in every part, and bled to death for the nutrition of the sponge.

Fig. 3, Plate XXXI. represents a small portion of the skeleton of the sponge with the two forms of defensive and aggressive spicula *in situ*, magnified 50 linear. Fig. 4 represents one of the multihamate bihamate spicula with a power of 83 linear, displaying the adaptation of its structure to purposes of retention. Fig. 5 represents one of the spiculated cruciform spicula on the same scale as fig. 4, showing their relative proportions, and fig. 6 the same form of spiculum with a power of 260 linear, to exhibit the peculiarities of its spination.

It would be almost an endless task to describe every variety of these singularly beautiful contrivances for combined defence and offence in the interior of the Spongiadæ. Those which I have particularized are some of the most elaborate and beautiful that I have seen during the course of my researches. In many other cases, where all that is required is defence, the means employed are of a much more simple nature. We find in the Spongiadæ, as in other animals, that nature frequently economizes her means by the conversion of one organ to the purposes of another by slight adaptations or additions; thus in *Halichondria incrustans*, Johnston, and in other sponges, the skeleton spicula are made to perform the duties of internal defensive spicula, by being more or less furnished with spines, as represented in fig. 30, Plate XXIII. Phil. Trans. 1858, and in other cases we find them medially or apically spined, as in figs. 32, 33, & 34 of the same Plate.

In like manner we find the spicula of the sarcode, by the extreme profusion in which they occur in that substance near the surface of some sponges, are turned to good account for the general purposes of external and internal defence, as well as for their special purpose of the protection and support of the sarcode. So likewise in the tension spicula of *Spongilla lacustris* (fig. 21, Plate XXIV. Phil. Trans. 1858) they are made to serve as defensive organs as well as tension spicula; and, again, in the spicula of the gemmules of the Spongiadæ their skeleton spicula also perform the office of defensive organs as well, as represented by figs. 13 to 43, Plate XXVI. Phil. Trans. 1858.

As regards, then, their protection from their enemies, there appears to be almost a natural prohibition to the sponges becoming, to any great extent while alive, the food of other creatures. The keratode of their skeletons appears to be almost indestructible by maceration or digestion, and the abundance of the acutely pointed spicula that exist in so many of their bodies must render them anything rather than desirable or digestible food to the generality of other marine animals; and, in truth, I do not know of a single large fish, or other marine creature, that appears to prey upon them. The only animal in the stomach of which I have ever seen the spicula of any sponge was a *Doris*. But although appearing to enjoy almost an immunity from the common lot of animals, that of being eaten by others, they may yet serve, at their death by natural causes, to supply an immense quantity of animal molecules for the sustenance of the myriads of minute creatures that exist around them.

Tension Spicula.

The primary purpose of the tension spicula is that of strengthening and supporting the membranes, both external and internal. They are usually of the same form as those of the skeleton, but more slender and shorter in their proportions. On the internal membranes they are dispersed without any approach to order, and cross each other at every imaginable angle. They vary exceedingly in length and diameter, and are attached for their whole length to the tissues on which they repose. In some cases they are not readily to be distinguished from those of the skeleton, as they are frequently so nearly of the same size, and are intimately intermingled with them, as in the genus *Hymeniacidon*; but in other cases, as in some species of *Chalina* and *Isodictya*, they may always be distinguished by their position, and by the total absence of keratode around them, while those of the skeleton are always more or less coated by that substance.

In other cases they differ materially in form and proportion from those of the skeleton. Thus in *Halichondria incrustans*, while the skeleton spicula are stout, short, entirely spined and acuate, as represented by fig. 30, Plate XXIII. Phil. Trans. 1858, the tension spicula are smooth, slender mucronato-cylindrical, as represented by fig. 23, Plate XXIV. Phil. Trans. 1858. They are frequently dispersed on the dermal membranes, much in the same manner as they are on the interstitial ones, abounding most where the areas are largest, and where the areas are small they are few in number or entirely absent; but in other cases, as in the dermal membrane of *Halichondria incrustans*, they are congregated in flat broad fasciculi, which are disposed on the membrane with little or no approximation to order.

The tricurvo-acerate form in all its varieties is better calculated to effect their peculiar office in small and irregular spaces, and with greater economy in numbers, than the straight elongated forms; and they are also better adapted to membranes having unequal surfaces, such as those in *Microciona armata*, BOWERBANK, MS., where we see them following the undulations of the membranes and sustaining them in their proper positions around the columnar parts of the skeletons. The varieties of form in these spicula are well represented by figs. 26, 27, & 28, Plate XXIV. Phil. Trans. 1858. They are all out of the same sponge. In *Grantia compressa*, and other closely allied species, where the structure is systematically membranous, the skeleton spicula are triradiate, supporting the membranes in uniform planes in the most effectual manner; and they are, in fact, systematically tension spicula, as well as skeleton ones. In *Grantia nivea*, JOHNSTON, which is not symmetrical in its structure like *G. compressa* and its congeners, other forms of tension spicula are developed to suit their especial purposes, such as represented by figs. 30 & 31, Plate XXIV. Phil. Trans. 1858.

In siliceous sponges we also occasionally find triradiate spicula developed, and performing the office of tension spicula, in the midst of comparatively large membranous areas; but these forms, in every case under such circumstances in which I have seen them *in situ*, appear to belong to the exception, rather than the general rule obtaining in such sponges.

The foliato-peltate spicula, for a full account of the progressive development of which I must refer to page 298, Phil. Trans. 1858, appear to be a development of the apices of connecting spicula into dermal tension ones, bearing a strong resemblance in form and purpose to the bony scutes in the skins of some of the higher animals, while the extreme crenulation of their margins probably served the purpose of facilitating the action of the porous system.

In all the varieties in form which I have hitherto described, and with which I am acquainted, where they perform the office of tension spicula only, they are destitute of spines. In other cases the tension spicula not only fulfil their own especial office, but they subserve that of defensive spicula also. Thus in the dermal membrane of *Spongilla lacustris*, JOHNSTON, we find them dispersed rather numerously, covered with short acutely conical spines, as represented by fig. 21, Plate XXIV. Phil. Trans. 1858. In *Spongilla alba*, CARTER, we find the tension spicula as abundantly spinous as those of *S. lacustris*, but in this case the spines are truncated (fig. 22, same Plate). They have a similarly blunted, imperfectly produced character in those of *Pachymatisma Johnstonia*, as represented by fig. 24.

The production of tension spicula in the membranes of the Spongiadæ is by no means a peculiarity of that class of animals. We find them in numerous beautiful forms in the skins of the Holothuriadæ, varying in shape in the different parts of the animal to adapt themselves to the necessities of their situation; but the closest approximation, both in size and form, to those of the Spongiadæ are the bihamate ones that are found so abundantly dispersed on the membranous tubular suckers of *Echinus sphæra*; and I have also seen another variety of these spicula in the tubular tentacles of a large common species of *Actinia*, and in the latter case they were even more minute than those of the Spongiadæ.

Retentive Spicula.

In the first part of this paper (Phil. Trans. 1858, p. 300) I have described the varieties in form and modes of development of these spicula. However varied they may be in form, when they are in their normal positions their office appears to be purely retentive. They are generally produced singly, and are dispersed without any approach to regularity over all parts of the sarcodous membranes of the sponge, abounding in some situations to a very much greater extent than in others. Their positions on, and mode of attachment to, the membrane are exceedingly varied, but in almost every instance it is such as to render the spiculum obviously subservient to the retention of the sarcode on the membranes which it covers. In one instance only I have found the simple bihamate spicula congregated in loose fasciculi. In this sponge, a new and very interesting species, *Hymedesmia Zetlandica*, BOWERBANK, MS., they occur in great profusion. Very few of them occur singly; nearly the whole of them are found in rather loose fasciculi, and the number is generally so great in each as to render it very difficult or impossible to count them. The mode of their disposition in the bundles is symmetrical, all the hami being in the same plane and coincident in direction, as represented in Plate XXXI. fig. 8. A few bundles of reversed bihamate spicula were observed, and these in like manner were coincident in every respect like the simple bihamate ones.

When these forms of spicula are equal in the amount of the development of their terminations, and when their hami or palms are coincident in plane and direction, their normal mode of attachment is at the middle of the bow of the shaft, and the direction of their projection is at right angles to the plane of the membrane on which they are situated, so that both terminations are rendered effective as retentive organs, as represented in fig. 8, Plate XXXI., dispersed on the membrane. But when their terminations are in different planes, or unequal in amount of development, then the normal mode of attachment to the membrane is by one end of the spiculum, while the other end is projected into the sarcode above at various angles. This mode of disposition of the inequianchorate form of spiculum is beautifully illustrated in *Halichondria lingua*, BOWERBANK, MS., a new species of British sponge from the Hebrides.

In this case, as in *Hymedesmia Zetlandica*, we find these organs congregated, but in a very much more symmetrical and beautiful mode. They occur in rosette-shaped groups; the smaller palms being adherent to the membrane in a circular form, and disposed as close to each other as possible, while the larger palms radiate from the centre at angles of about 20 or 30 degrees from the plane of the membrane beneath, as represented by fig. 9, Plate XXXI.

I have selected this group for representation in consequence of its containing but a small number of spicula, and thus displaying the mode of arrangement more distinctly than a greater number would have done. In many cases these groups contain so large a number of spicula as to render any attempt to count them ineffectual, and in some instances so many are developed that the group assumes the form of a ball rather than that of a rosette. Fig. 10, Plate XXXI. represents a rosette-shaped group containing about the usual number of spicula.

Besides the rosette-shaped groups in *Halichondria lingua*, there are a considerable number of these spicula dispersed over the surfaces of the membranes; but the attachment of these spicula is more frequently at the middle of the shaft than at the smaller end of the spiculum, their normal point of attachment. In the single and separate mode of disposition they are performing the office of equi-anchorate spicula, and the mode of their attachment is varied accordingly; but under these conditions they are rarely ever so fully developed, nor do they attain the same size as those which form the radiating groups. Notwithstanding the numerous groups and dispersed spicula of the inequi-anchorate form, this sponge is also abundantly furnished with bihamate spicula of various forms, but they are never congregated like the anchorate ones.

The same radiating mode of arrangement occurs in a parasitical Australian sponge from Freemantle, but the form of the terminations of the spicula is very different from those of *Halichondria lingua*. The distal termination of each of the inequi-anchorate spicula is shortened in length, but expanded laterally to a considerable extent, and its terminal edge is furnished with three thin pointed teeth. The distal end has two small expanded and raised wings, projected in the direction of the inner curve of the spiculum, and so disposed as to cause it to resemble very closely an engineer's spanner for bringing up to their bearings projecting square-headed screws. Thus, although the forms of the termination of the two varieties of spicula vary to a considerable extent, the principles of their structure and purposes are in perfect unison. Fig. 11, Plate XXXI. represents a group of these spicula, and fig. 12, Plate XXXI. a single spiculum highly magnified to display their peculiarity of structure.

These forms of spicula appear to be peculiar to the siliceous sponges. I do not recollect having ever seen them in any species of calcareous sponge.

Spicula of the Sarcode.

The primary office of the whole tribe of multiradiate spicula is evidently that of consolidating the sarcodous substance of the sponge, nor is their presence in the exercise of this office confined to the Spongiadæ. In the soft parts of the extensive family of the Gorgoniadæ we find them in vast abundance, and in every variety of form, from an elongate tubercular spiculum to the elongo-stellate forms of the Spongiadæ, and the prevalence of the bluntly terminated radii is strongly indicative of their non-defensive character. But this latter quality does not obtain in other cases, either as regards the higher tribes of animals or the Spongiadæ. Thus we find in numerous species of compound tunicated animals their fleshy substance is crowded with sphero-granulate spicula, very closely resembling in form those of the sphero- and subsphero-stellate shapes so abundant in *Tethea Ingalli* and *T. robusta* (figs. 14 & 15, Plate XXV. Phil. Trans. 1858). In both these cases the acute termination and the peculiarities of their respective situations are indicative of their subserving the office of defensive, as well as that of consolidating spicula.

In some species of *Tethea*, where the sponge is elaborately protected by distinct systems of defensive spicules, the subsphero- or sphero-stellate forms are either entirely absent, or only represented by minute clavate or cylindro-stellate forms; but in *Tethea Ingalli* and in *Geodia carinata*, where there is an almost total absence of elongate defensive spicula at the surface of the sponge, the acutely pointed large subsphero-stellate spicula are exceedingly numerous immediately beneath the dermis, and gradually decrease in number in an inward direction until they almost cease to exist in the deeper portions of the sponge. Thus their presence in such abundance near the surface of the animal would tend materially to check the voracity of any enemy that might attempt to prey upon them. In like manner we find the smooth and abundantly porous membrane of *Tethea muricata* (figs. 14 & 15, Plate XXXI.) crowded with the elongo-attenuato-stellate form represented in Plate XXV. fig. 18, Phil. Trans. 1858; and a single glance at them, as represented *in situ*, will show how admirably they are calculated to defend the delicate tissue on which they repose from the attacks of even their most minute and insidious enemies. The mode of their disposition is also strongly indicative of their defensive functions, their long axis being, not parallel to the plane of the membrane beneath, but at right angles to it.

In *Tethea Norvegica*, BOWERBANK, MS., where the surface of the sponge is well provided with external defensive spicula, the large subsphero-stellate form is comparatively rare, but the tissues of the neighbourhood of the intermarginal spaces and canals are crowded with the minute attenuato-stellate forms, and their surfaces are bristling with the sharp points of their radii, so that no intruding annelid could either take a mouthful from their surfaces or crawl over them with impunity. Deeper in the sponge, beyond the range of penetration of such enemies, they are comparatively very few in number, and the large subsphero-stellate ones are entirely absent.

The hexradiate forms represented by figs. 24 to 36, Plate XXV. Phil. Trans. 1858, are more especially found in the siliceo-fibrous sponges. I have only seen two specimens of this class of sponges in which the sarcode was well preserved. In one of these I have observed the slender form like that of fig. 34, Plate XXV., occupying the areas of the rigid siliceous skeleton completely surrounded by sarcode, which stretched from one ray to another in thick glutinoid plates, but without touching the surrounding skeleton-fibres, excepting at one basal point connecting it with the general mass of the sarcodous tissues. From the positions and general appearances of the hexradiate spicula, it would appear that this form of spiculum has the office more especially of supporting and consolidating the sarcode, and that it is in no respect subservient to defensive purposes.

Generally speaking the slender rectangulated hexradiate spicula occur singly, but I have sometimes found them grouped together; in this case their axes were coincident, and their radii in the same plane, or very nearly so, but not always agreeing in their direction; such a framework would form a very fitting support to a large mass of sarcodous tissue partially separated from the framework of the skeleton and occupying a portion of a large interstitial space.

In the large open areas of the skeleton of *Euplectella aspergillum*, OWEN, the hexradiate forms, ranging from fig. 24 to fig. 33, Phil. Trans. 1858, are exceedingly abundant, and a considerable number of them are not developed to the extent of the full number of their radii. This may probably arise from the development of the radii being stimulated by the necessities of the mass of sarcodous tissues in which they are imbedded, and consequently where no necessity for their presence exists they would not be put forth. In the trifurcate and quadrifurcate hexradiate forms, if we may judge from the termination of their radii, they, like the simple stellate forms, are either purely consolidating, or they combine with that office that of defensive spicula also, as far as regards the sarcodous substance in which they are imbedded.

We can scarcely imagine any defensive properties in the slender and complicated but elegant forms of the floricomo-stellate spicula, and it is probable that their office is purely that of assisting in the consolidation of the sarcodous substance.

The whole of these beautiful stellate forms of spicula are siliceous, while their homologues in the Gorgoniadæ and the compound Tunicata are calcareous; and it is somewhat remarkable that hitherto none of these forms have been found in the calcareous species of sponges.

Spicula of the Ovaria and Gemmules.

We find the same laws in force regarding the spicula in the structure of the minute bodies which have been designated gemmules by previous writers on the Spongiadæ, that obtain in the sponges themselves. In some they serve the purposes of internal skeleton and defensive spicula as well. In others they combine the offices of tension and defensive organs, and frequently they are very different in form from those of the parent sponge. In the first part of this paper, in Plate XXVI. figs. 11 to 42, Phil. Trans. 1858, I have figured the varieties of form that I have hitherto found in the ovaria and gemmules, and I have shown that these bodies may be classed in three groups.

1. Those which have the spicula disposed at right angles to lines radiating from the centre of the ovarium to its surface.

2. Spicula disposed in lines radiating from the centre to the circumference of the ovarium.

3. Spicula disposed in fasciculi in the substance of the gemmule from the centre to the circumference.

In *Spongilla Carteri*, BOWERBANK, MS., and *S. fluviatilis*, JOHNSTON, our commonest British species, belonging to the first group, the external series of spicula of the ovaria are of the same form as those of the skeleton, but frequently somewhat shorter. They are disposed irregularly over the surface of the ovarium, and firmly cemented to it by the middle of the shaft, while each of their apices is projected in tangental lines. Thus their shafts perform the office of tension spicula, while their terminations become efficient weapons of defence. Fig. 11, Plate XXVI. Phil. Trans. 1858, represents the spiculum of the ovarium of *S. Carteri*.

In other cases in this group we find these spicula differing from those of the skeleton of the parent sponge; thus, the one that is represented by fig. 13, Plate XXVI. Phil. Trans. 1858, from the surface of *Spongilla lacustris*, JOHNSTON, is curved so as to accommodate it to the rotundity of the ovarium; and we do not find its apices projecting as in those of *S. fluviatilis*, but instead of the projecting apices, the whole spiculum is covered with minute spines, assimilating it in character with the general structure of those spicula which combine the office of tension and defensive spicula, but differing considerably in their proportion from the tension spicula of the same sponge, *S. lacustris*, represented by fig. 21, Plate XXIV. Phil. Trans. 1858, the one being evidently destined to sustain and protect extended membranes, while the other is especially adapted for a small curved surface by its form and small size; each of the figures being drawn with the same power, 660 linear.

On the surface of the ovarium of *Spongilla cinerea*, CARTER, we find this description of spiculum still more decidedly produced. It is of a cylindrical form and entirely spined, and has just the amount of curvature that is in unison with the curved surface on which it reposes. The spines on the middle of the shaft are cylindrical, and terminated bluntly, so as to strengthen its hold on its imbedment. Those of its apices, on the contrary, are acutely conical and recurved, and are strongly produced, so as to form very efficient weapons of defence. This spiculum is represented by fig. 17, Plate XXVI. Phil. Trans. 1858.

The birotulate and boletiform spicula of the second group appear to be more purely structural, as regards the skeleton of the ovarium. The rotulæ are very closely packed at both the external and internal surfaces of that body, and the crenulation or dentation of each rotula is as well produced on the internal as on the external ones, and it appears to be very influential in maintaining each spiculum in its proper position. In the natural condition of the ovaria these spicula are entirely imbedded in its walls, and other spicula of a truly defensive nature are superimposed for its protection. The large spines in the shafts of the birotulate spiculum from *Spongilla plumosa*, CARTER, fig. 21, Plate XXVI. Phil. Trans. 1858, are also apparently subservient to strengthening and maintaining the spiculum in its proper situation, although they are acutely terminated, as defensive spines usually are; but in the same relative position on the birotulate spicula of *Spongilla Meyeni*, CARTER, we find the spines short, stout, and cylindrical, spreading or budding at their apices, and evidently more fitted for assisting to retain the spiculum in its proper place than for defensive purposes. This spiculum is represented by fig. 29, Plate XXVI. Phil. Trans. 1858.

There is an apparent analogy between the expansions of the rotulæ and those of the folio-peltate spicula, but they do not appear, like the latter, to be derived from the ternate forms. The radiations of the canaliculi, as represented by fig. 32, Plate XXVI. Phil. Trans. 1858, are not derived from three primary rays, but each appears to emanate from a central cavity at the end of the shaft; and their number, 22, at their proximal termination is not reconcileable with any regular number of bifurcations arising from three primary rays, however short we may imagine them to be.

The progressive decline of the inner rotula in the inequi-birotulate spiculum of *Spongilla paulula* (fig. 31), and its all but total extinction in *Spongilla reticulata* and *Spongilla recurvata* (figs. 33 & 34) until the distal rotula merges in the scutulate form, with an acute external umbo in place of an internal shaft as in *Spongilla Brownii*, figs. 36 & 37, Phil. Trans. 1858, exhibit a very interesting series of gradations of development in the same description of organ.

The spicula of the third group (those having the spicula disposed in fasciculi in the substance of the gemmule) differ less in character from those of the parent sponge than either of the preceding groups. They are in reality but modifications of the external defensive spicula of the parent sponges.

The inequi-fusiformi-acerate one (fig. 39, Plate XXVI. Phil. Trans. 1858) differs from the fusiformi-acerate one of the skeleton in no other respect than in the greater proportionate attenuation towards its distal termination, which gives it a degree of flexibility that allows of its bending freely under the pressure of any comparatively large body; and I have seen them, when two gemmules have been pressed closely together, bent to the extent of semicircles without breaking. In the young gemmules these spicula are usually projected much beyond the other forms of defensive spicula that accompany them.

In like manner the small attenuato-porrecto-ternate form (fig. 43, Plate XXVI. Phil. Trans. 1858) is a modification of the similarly formed external defensive spicula of the parent sponge. In the adult gemmule the apices of these spicula rarely project beyond the dermal membrane, and it is only on pressure from without that they would be brought into effective use. The amount of the angle of their radiation at the apex of the spiculum is therefore greatly increased beyond those of the external defensive ones of like form in the parent sponge, so as to accommodate their apices to the curve of the surface of the gemmule, and to render each point equally effective; and as they are not projected beyond the dermal surface, as in the sponge, their shafts are shortened proportionally.

The unihamate, bihamate, and recurvo-ternate forms of the same gemmules (figs. 40, 41 & 42, Plate XXVI. Phil. Trans. 1858) are also modified forms of the recurvo-ternate external defensive spicula of the parent sponges, *Tethea cranium* and *simillimus*.

Of the other forms of "spicula the position of which are unknown," I can say little more than I have before stated, excepting that I have since found the subspinulato-arcuate one, represented by fig. 51, Plate XXVI. Phil. Trans. 1858, *in situ* in a new species of sponge from Freemantle, Australia, *Hymeniacidon Cliftoni*, BOWERBANK, MS., and that it is a retentive spiculum.

The Interstitial Canals and Cavities.

These organs exhibit their most complete mode of development in the genus *Spongia* and in the Halichondroid sponges, occupying nearly the whole of the masses of the animals. They consist of two distinct systems, an incurrent and an excurrent one.

The incurrent series have their origin in the intermarginal cavities immediately within the dermal membrane, and their large open mouths receive from these organs the water inhaled through the pores and convey it to the inmost depths of the sponge, ramifying continually like arteries as they proceed in their course downward until they terminate in numerous minute branches. The inhaled fluid is then taken up by the minute commencements of the excurrent series, which continually unite as they progress towards the surface of the sponge, in the manner of veins in the higher animals, until they terminate in one or more large canals which discharge their contents through the oscula of the sponge. This system is found to obtain in the whole of the genus *Spongia* and in the massive Halichondroid sponges, which have their oscula dispersed over their external surfaces. By this mode of organization the inhaled fluid, laden with nutritive particles, is poured at pleasure into the internal cavities of the sponge, flowing over extensive membranous surfaces coated with sarcode; so that the aggregated surfaces become a great system of intestinal action, fully equal in proportional extent to that of the intestines of the most elaborately organized mammal.

They do not in every genus exhibit the regularity of structure described above, and in some cases the canalicular form resolves itself into a series of irregularly formed spaces. In other cases, where a common cloaca exists, there appears to be but one system of interstitial canals, those which convey the inhaled fluid from the pores through the substance of the sponge to the parietes of the great central cloacal cavity which receives the whole of the fæcal streams, rendering the system of excurrent canals unnecessary.

In the Cyathiform sponges we find a somewhat slmilar structure. The outer portion of the cup is essentially the inhalant surface and the interior of it the exhalant one, and there accordingly we generally find a great number of small oscula dispersed on all parts of it, very often having their margins slightly elevated, that the fæcal matter that issues may be discharged free of the surrounding membrane.

The large fistular projections which form such striking and beautiful objects in the genus *Alcyoncellum* are also great cloacal organs, their dermal membranes abounding in pores, and their inner surface furnished with oscular orifices, the intervening space being occupied by the interstitial cavities, the interior forming one large cloacal cavity, which discharges its contents through a cribriform mouth at its distal end. In *Grantia* both systems, the incurrent and excurrent interstitial canals, become very nearly obsolete, the large intermarginal cavities or cells imbibing the water through their pores on the distal extremities, and becoming enlarged and elongated until they reach the parietes of the great central cloaca, into which they discharge their contents, each through a single osculum, into a short depression or cavity in the parietes of the great cloaca, and this shallow cavity represents the nearly obsolete system of excurrent canals.

The membranes lining the incurrent and excurrent canals are frequently highly organized. In the common honeycomb sponge of commerce, when in the same condition as when taken from the sea, these canals are constructed of a series of compound membranes, each consisting of simple interstitial membrane with a layer of primitive fibrous tissue beneath it; the fibrous portion consisting of a single series of fibres parallel to each other, and so closely adjoining as to touch each other through nearly their whole course (Plate XXVII. fig. 4).

When the fibres are clear of the membranous tissue they appear as simple pellucid threads, but when covered by the membrane they frequently appear as if moniliform; this character seems to be due to minute molecules arranged in linear series on the membrane immediately above them. These membranes abound in large open oval spaces, so that the tissue assumes very much the appearance of areolar tissue, as described by Professor Bowman in his treatise on mucous membrane in the 'Cyclopædia of Anatomy and Physiology.'

The layer of membrane forming the surface of the canal has its fibres disposed at right angles to the axis of the canal, while those of the layers beneath it assume various directions, usually in straight lines, excepting in the vicinity of the areas of communication, around which they curve to strengthen their margins.

In the canals deeply buried in the mass of the sponge, the sides frequently consist of but one layer of membrane and primitive fibrous tissue, and in this case also the fibres are always disposed at right angles to the axis of the canal, but they are neither so numerous nor so closely packed as in the sides of the great excurrent canals.

The interstitial membranes are also furnished with these fibres, sometimes in considerable quantity, but rather irregularly disposed, while in other cases a single fibre only will be observed meandering across the tissue.

The interstitial membranous tissues in a beautiful little specimen of *Alcyoncellum* from the North Sea, for which I am indebted to my friend Captain Thomas of the Hydrographical Survey, are very similarly constituted to those of the sponges of commerce. The membranous walls of the interstitial cavities are each formed of a series of fibro-membranous layers, the fibres of each layer being disposed at angles varying from those above and below it.

Figures 1, 2, 3, & 4, Plate XXVII. represent portions of the lining membranes of the incurrent and excurrent canals, and the mode of the disposition of the primitive fibrous structure upon them.

Intermarginal Cavities.

In the Halichondroid sponges, immediately beneath the dermal membrane, there are numerous and, comparatively speaking, large irregularly formed cavities which receive the water inhaled by the pores, and convey it to the mouths of the incurrent canals, which have their origin in the deepest portions of the spaces. These organs, from their irregularity in size and form, are not always very apparent; but if a section be made at right angles to the surface in a dried specimen of *Halichondria panicea* or *Hal. simulans*, Johnston, they may be readily detected and distinguished from the interstitial canals and spaces of the sponge.

Fig. 13, Plate XXXI. represents a section of *Halichondria panicea*, and fig. 1,

Plate XXXII. a similar section of a branch of *Halichondria simulans*, JOHNSTON, showing that, however varied the forms of the sponge may be, the interstitial cavities are the same in structure and position.

I have never been able, in the Halichondroid sponges, to detect valvular diaphragms separating these spaces from the interstitial canals and cavities beneath.

In the genera *Geodia* and *Pachymatisma* these organs assume a very much greater degree of regularity and a complexity in their organization that are never apparent in those of the Halichondroid sponges. In *Geodia Barretti*, BOWERBANK, MS., a highly organized species of the genus, they are found in the crustular dermis in great abundance. They are in form very like a bell, the top of which has been truncated. They are situated in the inner portion of the dermal crust; the large end of the cavity being the distal, and the smaller end the proximal one. The open mouth or distal end of the cavity is not immediately beneath the dermal membrane. There is an intervening stratum of membranes and sarcode, of about two-fifths the entire thickness of the dermal crust, which is permeated by numerous minute canals which convey the water inhaled by the pores to the expanded distal extremity of the cavity. The proximal end is closed by a stout membranous valvular diaphragm, which the animal has the power of opening and closing at its pleasure. It is usually entirely destitute of the characteristic dermal spicula that are found abundantly in the adjoining membranous tissues.

The action of the diaphragm of each cavity appears to be independent of the surrounding ones, the condition or degree of opening of no two adjacent ones being alike. In the greater number of cases they were in a closed state, and in this condition the membrane was filled with concentric circles composed of minute rugæ or thickened lines, and at the centre it was closely pressed together, completely closing the orifice. In some cases the membrane was only partially closed, and the orifice was either circular or slightly oval; in others it was nearly as large as the diameter of the basal end of the cavity. The pursing of the centre of the membrane of the diaphragm was always outward as regards the cavity, so that when viewed from within it appeared as a slightly funnel-shaped depression, the bottom of which was conical. The cavities are lined by a smooth and tolerably strong membrane, abundantly supplied with slender fibrous tissue, disposed in nearly parallel lines at right angles to the long axis of the cavity.

The adaptation of the skeleton to the support of these elaborately constructed organs is very remarkable. The sponge is furnished abundantly with large expando-ternate spicula, the radii of which are furcated at their apices. They occur in a series of bundles; the long attenuated shafts of each fasciculus approximate at their bases, and diverge thence until the ternate head of each is about equally distant from its surrounding neighbours, and the extremities of the rays touch or slightly cross each other, thus forming a beautiful and regular network, the meshes being six- or seven-sided, according to circumstances. The upper surfaces of the radii are firmly attached to or partially imbedded in the under surface of the crustular stratum, and the areas thus formed are occupied each with the proximal valvular terminations of one of the intermarginal cavities.

The progressive development of these inhalant areas, formed by combinations of the radii of the ternate forms of spicula, in different species of sponges is very interesting. In *Pachymatisma* they are so indefinite that they can scarcely be said to exist. The ternate spicula are few in number and very irregular in their mode of disposition, and a faint indication only of their future regular combination to form the dermal reticulation is apparent. In the more highly organized genus *Geodia* we find them in different species in progressive stages of combination, until, in *G. McAndrewii* and *Barretti*, the apices of the radii of the ternate spicula are interlaced with each other, and a continuous irregular network is formed, each area of which is filled with the proximal termination of an intermarginal cavity. In *Dactylocalyx Prattii*, BOWERBANK, MS., the structure advances another stage towards perfection.

There is the same design as that exhibited in the construction of the dermal areas in *Geodia McAndrewii* and *Barretti*, but there is a considerable difference in the application of the areas produced by the combinations of the ternate apices. In *Geodia* these areas are placed beneath the highly organized and regularly formed intermarginal cavities, and form the framework and support of their valvular proximal ends; while in *Dactylocalyx Prattii* they are situated above the distal ends of the intermarginal cavities of the sponge, which have not the regular structure and valvular appendage of those of *Geodia*, but are similar to the like organs in the Halichondroid sponges, and in this position they serve only to support and strengthen the dermal membrane, which adheres firmly to their distal surfaces. In this situation they are subject to a greater chance of pressure and disruption than the more deeply seated ones of *Geodia*, and accordingly we find extra provisions for the safety of the junctions of their radii. The shafts of these spicula are short, stout, and conical, and they penetrate but a very short distance into the substance of the sponge. They do not appear to be cemented to any part of the rigid siliceo-fibrous skeleton, but are merely plunged into a somewhat thick stratum of membranous structure reposing on the surface of the skeleton. Their radii are compressed considerably and extended laterally, so that their planes are in accordance with that of the dermal membrane, and they present a greater amount of adhesive surface than those having cylindrical radii. The ternate rays ramify irregularly. Sometimes one ramus, after slightly pullulating, remains nearly obsolete, causing the branch to assume a geniculated form like some of the ramifications of a Deer's horn, and no two appear to be exactly alike; in fact there is every appearance that each ray is influenced and modified in its development by the necessities of combination with the adjoining spicula, and their apices are directed in such a manner that they lap over each other in opposing lines, so that each two form a spliced joint, giving a much greater amount of strength than the mere crossing of the radii at various angles as in those of *Geodia*. The inhalant areas thus formed appear to differ very slightly from those of *Halichondria panicea*, in each of which several pores are opened, while those of *Dactylocalyx Prattii* seem to be devoted each to a smaller number (Plate XXIX. figs. 8 & 9).

As the ternate spicula thus united for the support of the dermal membrane would afford it little or no protection against the voracity of its smaller enemies, we find the necessary defence in innumerable short, stout, entirely spined cylindrical spicula not exceeding $\frac{1}{3000}$th of an inch in length; thus minute, there is no conceiving a predaceous creature with a mouth so small that they would not enter and become a subject of annoyance so great as to interfere seriously with its attacks on the membrane; and they are so numerous, and so closely packed together, that no portion of it equal in size to the length of a spiculum could be removed without one or two of them accompanying it.

A still further advance in this system of dermal support and defence is exhibited in the beautiful harrow tissue of Dr. A. FARRE's siliceo-fibrous sponge, to which his specimen of *Euplectella cucumer*, OWEN, is attached. In this case we have a perfect and regular quadrilateral network of smooth siliceous fibre, from the angles of which a double set of short conical spicular shafts are projected, each about $\frac{1}{120}$th of an inch in length and entirely spined. Each set are at right angles to the plane of the network, one series pointing inward, and serving the purposes of attachment to the mass of the sponge beneath, while the other set are directed outward, serving as defensive weapons; so that a small piece of this tissue beneath the microscope closely resembles an agricultural harrow, with the difference that it has two sets of teeth in opposite directions instead of one. The dermal membrane has been nearly all destroyed; but entangled with the fibres of the skeleton there are some attenuato-stellate spicula, with which it is probable the dermal membrane was amply furnished as secondary defences against its minute enemies.

I believe the surface presented to the eye in the portion represented in Plate XXXII. fig. 7 to be the external surface, as the fragments of the dermal membrane which remain all seem to cover that side of the fibres. Generally speaking there is some difficulty in detecting the double series of spicular organs at the angles of the network, but a reversal of the object beneath the microscope immediately removes all doubt on that subject.

In *Grantia compressa* and *ciliata* the intermarginal cavities appear to attain their highest degree of development, and are multiplied and expanded to such a degree as to almost supersede every other organ. The whole sponge in these species is formed of a great accumulation of elongated cells or cavities, closely adjoining each other and angular by compression. Their conical distal terminations, abounding in pores, represent the external surface of the sponge, while their valvular proximal ends form the inner surface, in conjunction with the shallow cavities, into the distal ends of which each cell discharges its contents. These shallow depressions, intervening between the intermarginal cavities and the cloaca, are all that remains to represent the incurrent portion of the interstitial systems so largely developed in the Halichondroid sponges, the great cloacal cavity entirely superseding the excurrent spaces and canals (Plate XXXIII. figs. 1 & 2).

In these species of *Grantia* there is no doubt regarding the existence of cilia, the whole of these great cavities being completely lined with them.

It is a question whether the intermarginal cavities share, in common with the interstitial canals, in the function of the assimilation of nutriment, or whether they are devoted solely to the aëration of the fluids of the animal; and this, if we consider the structure and extent of the interstitial canals in the Halichondroid sponges, is probably the case. In *Grantia* the abundant provision of cilia in those cavities at once stamps them as breathing-organs; and although cilia have never yet been satisfactorily proved to exist in the intermarginal cavities of the Halichondroid sponges, there can be no reasonable doubt of their being the homologues of the large ciliated cavities in *Grantia compressa* and other similarly constructed sponges. Now in these sponges, although the cilia may be readily seen in vivid action within the open oscula, as I have described at length in my paper "On the Ciliary Action of the Spongiadæ," published in the 'Transactions of the Microscopical Society of London,' vol. iii. p. 137, not the slightest trace of cilia exists without those organs; and this seems to indicate that the aërating functions were strictly confined in these sponges to the large intermarginal cavities.

The same mode of reasoning applies equally well to the intermarginal cavities of *Geodia* and *Pachymatisma*, to which it is probable that the cilia are in like manner confined. The great valves at the proximal ends of these cavities in this tribe of sponges appear to strongly indicate a decided separation of the functions of aëration and digestion; and if this conclusion be true in regard to the intermarginal cavities of *Geodia* and *Pachymatisma*, it will probably be so in the homologous organs in *Grantia*; and in this case we must look for the digestive surface in the shallow cavities intervening between the terminal valve of the intermarginal cavities and the parietes of the great cloaca, and of the surfaces of that organ itself. The structure and functions of the intermarginal cavities, and especially as displayed in *Geodia* and *Pachymatisma*, indicate a closer alliance with the great class Zoophyta than has hitherto been suspected to exist. In the one case we have an accumulation of individual animals conjoined in one mass; in the other a similar congregation of organs in place of individuals.

Dermal Membrane.

The dermal membrane envelopes the sponge entirely. When denuded of sarcode by partial decomposition, it has the appearance of a simple, pellucid, unorganized membrane. In the living state its inner surface is somewhat thickly coated with sarcode, and it has the appearance of, comparatively speaking, a stout, tough skin, and in many sponges it requires a considerable amount of violence to tear it. The dermal membrane of the Turkey sponge of commerce, *Spongia officinalis*, is abundantly supplied with primitive fibrous tissue. It curves round the margins of the porous areas, thickening and strengthening the whole of the dermis to a very considerable extent; but it exists to a very slight extent in the pellucid membranes of the areas in which the pores are opened. When alive, it is replete with powers of life and action of a very remarkable description.

Without the slightest appearance of nerves or muscles, it has the power of opening pores on any part of its surface and of closing them again at pleasure, without leaving a trace of their existence to indicate the spot they occupied; and there is no amount of laceration or destruction that it does not seem capable of repairing or replacing in a very short period, reproducing itself over extensively denuded surfaces in a very few hours. It also shares, in common with the interstitial membranes, the power of strongly and quickly adhering to other sponges of the same species with which it may be brought in contact, but never with those of a different species, however long the two may remain pressed against each other. In some sponges the distal extremities of the skeleton pass through and project beyond the surface of the dermal membrane, while in other cases the whole of the skeleton is confined within it.

I will not describe at length these remarkable powers of the dermal membrane, but refer the reader to a series of observations on the "Vital Powers of the Spongiadæ," published in the Reports of the British Association for 1856, p. 438, and for 1857, p. 121, in which I have described in detail a series of observations and experiments on living sponges, which demonstrate in a satisfactory manner the extent of the vital powers and capabilities of this highly sensitive membrane.

In some species of sponges the outer surface of the skeleton is especially modified to strengthen and support the dermal membrane. Thus in some of the keratose sponges of commerce, in parts of the sponge which have been in contact with other sponges, or with rocks or stones, we find a fine network of stout fibres immediately beneath the derma, as represented by fig. 9, Plate XXXII.; and *Isodictya varians*, BOWERBANK, MS., is always furnished with a fine network of spicula, the reticulations consisting of a single series of spicula only, and on this framework the dermal membrane is firmly cemented. Fig. 8, Plate XXXII. represents a small portion of this dermal reticulation, magnified 108 linear.

In *Halichondria panicea* the same description of reticulation prevails, but in this sponge the fibres of the network are always composed of numerous spicula cemented together, as represented in fig. 5, Plate XXXII., illustrating the porous system of the above-named species of sponge. But this regularity of structure is not constant even in the same individual; thus in *Hal. panicea* you will often observe one portion of the dermis beautifully reticulated, while a closely adjoining spot will be supported by a series of matted spicula without any indication of areas for the pores, and these variations in structure are evidently determined by the presence or absence of those organs at particular parts of the surface. In other cases, beside a general attachment of the inner surface of the dermal membrane to the surface of the skeleton, we find it supported by numerous flat fasciculi of spicula dispersed irregularly on its inner surface, and differing materially in size and form from those of the skeleton, as in our common British species, *Halichondria incrustans*. Great variety exists in these modes of strengthening and supporting the dermal membrane; but those which I have described above will suffice to illustrate the general principles of their application. Beside the general systems of external defence, the dermal membrane is often supplied with special defences. Thus in *Tethea muricata* (figs. 14 & 15, Plate XXXI.) we find its outer surface abundantly supplied with elongo-stellate spicula, which project externally to a considerable extent; and in *Dictyocylindrus stuposus*, BOWERBANK, MS., beside the numerous defensive spicula projected through the surface, we find the membrane filled with minute sphero-stellate spicula, which would effectually protect it from the assaults of any minute enemies that might attempt to prey upon it. Fig. 6, Plate XXXII. represents a small portion of the dermal membrane of this sponge. This mode of defence is very general in the genera *Geodia*, *Tethea*, and *Pachymatisma*, and it occasionally occurs in many other genera of Spongiadæ.

The Pores.

The pores in the Spongiadæ are the orifices or mouths through which the animals breathe and imbibe their nutriment. They are situated in the dermal membrane, and are exceedingly numerous when the imbibing powers are in full operation. In *Pachymatisma* and *Geodia*, and in some other highly organized genera, there is good reason to believe that they are permanent organs, opening and closing repeatedly in the same situations. But in the greater part of the Halichondroid types of sponges they are certainly not permanent orifices like the mouths of higher classes of animals, and in these sponges, when they are in a state of complete repose, there is not the slightest indication of their existence. Their usual form is circular, but they frequently assume the shape of an elongated oval, and within a limited range they vary to a considerable extent in their dimensions; on the whole they exhibit a very constant and universal type of form and size; however different may be the internal structure of the sponges, or however great may be the difference in size of the individuals, they always appear to maintain their normal characters. No definite law appears to prevail in their distribution over the surface of the sponge, and they are liable to appear to a greater or a less extent on every part of its external surface, wherever there are intermarginal cavities beneath. The situations where they may be expected to appear may in many instances be readily recognized. Thus in *Halichondria panicea*, wherever we see on the dermal membrane a well-defined reticulation of spicula with clear and distinct areas, there, when the sponge is inhaling, we may expect to find the open pores, as represented in Plate XXXII., fig. 5, while on spots perhaps immediately adjoining, where the dermal membrane is occupied by a thickly interwoven mass, a felting of spicula, the probability is that not a single pore can be detected.

In some of the West India fistulose sponges we find the large or primary area of the dermal surface composed of keratose fibre, and within these large areas the dermal membrane is strengthened and supported by a secondary reticulation of spicula, in the areas of which the pores are opened. In these secondary reticulations the spicula are abundant, while in other parts of the sponge the tension spicula are rather of rare occurrence. In *Grantia*, a sponge of a widely different construction from those of the Halichondroid type, they occupy the distal extremities of the large intermarginal cavities of the sponge, and they appear to open over the whole of those portions of the cavities not in contact with the adjoining ones.

In *Pachymatisma Johnstonia*, a British sponge closely allied to the genus *Geodia*, we find the dermal membrane perforated by innumerable pores, some as minute as $\frac{1}{1000}$th of an inch in diameter, while others attain the size of $\frac{1}{230}$th of an inch. They are nearly equidistant from each other, but without any order in their arrangement. Immediately beneath the dermal membrane there is a stratum of membranous structure and sarcode destitute of gemmules, and about equal in thickness to one-third of that of the whole of the dermal crust, the remaining two-thirds of which consist of a stratum of gemmules or ovaries closely packed together, but perforated at intervals by the intermarginal cavities. Through the upper stratum, destitute of ovaries, a small canal passes from each pore to the nearest adjacent intermarginal cavity, so that there are a series of them at various angles, all concentrating their streams of inhaled fluid at the distal end of the cavity, which is gradually expanded in diameter to receive them. In these sponges therefore each mouth appears to be furnished with a separate œsophagus, if I may be allowed the term, connecting it with a stomach-like cavity common to a group of mouths above it—a system of organization strikingly in unison with that of the higher classes of animals. In some cases, as in *Geodia M^cAndrewii* and *Barretti*, BOWERBANK, MS., we find the pores systematically congregated in groups, as in Plate XXXII. fig. 4, which represents four groups from the latter species, and this congregation is accounted for by the peculiarities of the form and arrangement of the intermarginal cavities of that class of sponges.

The porous organs are still further complicated in a specimen of a branched sponge from the East Indies, presented to me by my friend Mr. S. P. PRATT. This sponge, which is a single branch about a foot in length and 9 lines greatest diameter, has nearly the whole of its surface abundantly furnished with peculiar and highly organized areas, as represented in Plate XXXV. fig. 3, each of which covers and protects a deeply depressed porous area, the depth of which in many cases rather exceeds its own diameter. The protective organ covering this depression is elaborately and beautifully constructed, very closely resembling, in many respects, the spiracula of *Dytiscus marginalis* and other similarly constructed insects. Each of the depressed areas of the sponge is furnished with ten semifollicular membranous cones, the whole of them being based on a common external marginal ring of dermal membrane, from which they are projected inward in the same plane as the dermal surface until their apices nearly meet in the centre of the inhalant area. The exterior surface of each cone is perfect and continuous from the marginal ring of membrane to its apex; but on the interior surface it is only perfect for about half its length from its apex backwards, as if half of the basal portion of a conical bag had been cut away from the remainder. Fig. 5, Plate XXXV. represents the exterior half of one of these protective organs, and fig. 6 the semifollicular structure of their conical organs. The membranes of which they are constructed are abundantly furnished with tension spicula, which are dispersed without order on every part of their surface. It is the only instance I have seen of such an elaborate mode of protection of the porous areas in the Spongiadæ.

In my "Further Report on the Vitality of the Spongiadæ," published in the Reports of the British Association for 1857, I have described at length the opening and closing of the pores in *Spongilla fluviatilis*: each operation is commenced and terminated in less than a minute; they are perfectly dependent on the will of the animal; and in neither case are they simultaneous, but follow in irregular succession, in accordance with the necessities of the animal; and when once the pores are closed, they do not appear to ever open again in precisely the same spot.

In these wonderful opening and closing operations in the dermal membrane of *Spongilla*, every movement is accomplished as systematically and accurately as if there were a perfect system of nerves and muscles present, while not a vestige of fibrous structure can be detected in the thin translucent membrane and its sarcodous lining. No cicatrix remains for an instant after closing, no indication is perceived of the spot where the opening is the next moment to be effected.

In sponges exposed to the action of the atmosphere, between high and low water marks, and in dried specimens, the pores can rarely be detected. In the first case they are carefully closed on the receding of the tide, that the water within them may be safely retained during their exposure to the atmosphere; and in the latter case the violence offered to the sponge, and the shock of its removal from its native locality, are sufficient to induce an immediate closing of those organs, as I have shown in the details of my observations on these organs in *Spongilla* in the volume of the Reports of the British Association for 1857, to which I have before alluded. But should a specimen of marine sponge, after a careful removal from its place of growth, be placed in a shallow pan of sea-water, and be allowed to die of inanition, it then frequently expires with the whole or a considerable portion of the pores open, and in that state it may be readily preserved for the cabinet.

The Oscula.

The oscula are the fæcal orifices of the sponge. They are situated at the distal terminations of the single or concentrated excurrent canals of the animal. They vary considerably in form and size; sometimes they appear as single large orifices, while at others they consist of several small orifices grouped together. When the sponges are massive and solid, they are usually to be found dispersed over the dermal surface, but occasionally they are grouped on the highest portions or on the elevated ridges of the mass. In *Geodia Barretti* they are concentrated in deep depressions or pits. In other cases they are entirely hidden from view, lining the interior of elaborately constructed cloacæ situated in the centre of the sponge, as in *Grantia compressa* and *ciliata*, *Verongia fistulosa*, and a numerous series of species of fistulose sponges from the West Indies.

They are permanent organs, and are capable of being opened or closed at the will of the animal, and are subject to a considerable amount of variation in size and form, in accordance with the variations in the actions of the sponge. Thus in littoral sponges they are frequently entirely closed, and their situation even quite indeterminable, during the period of their exposure to the air; but when immersed in water, and the sponge is in the energetic action of the imbibition of nutriment, they are expanded to their full extent; but when this action ceases and that of gentle respiration only exists, many of them close entirely, and others exhibit apertures not exceeding half their former diameter while the imbibition of nutriment was in vivid action. Their expansion or contraction is not rhythmical; each can be opened or closed at the will of the sponge without any apparent effect on the others. Nor is the habit of opening and closing the oscula the same in every species. Thus in the course of my observations on *Halichondria panicea* and *Hymeniacidon caruncula* in their natural and undisturbed localities, I have frequently observed, during their exposure to the air at low tide, that while no oscula in an open condition could be found in *Hymeniacidon caruncula*, the greater portion of those on the specimens of *Halichondria panicea* were more or less in an open state.

They appear also to be subject to a considerable amount of modification as regards situation, even in the same sponge. Thus in our common British species, *Halichondria panicea*, when of small size, they are situated on the surface of the sponge, and are scarcely, if at all, elevated above the dermal surface; while in large specimens of the same species we find them collected in the insides of large elongated tubular projections or common cloacæ, and these organs vary from a few lines only in height and diameter to tubular projections several inches in height, with an internal diameter of half or three-fourths of an inch. When they attain such dimensions their parietes are often of considerable thickness, and their external surface becomes an inhalant one, like that of the body of the sponge.

In many species the oscula are always elevated above the dermal surface, and these thin pellucid elevations are permanent, while in others, as in *Spongilla fluviatilis*, the tube exists only during the course of the energetic excurrent action; and in such cases it appears to be subject to great variation in size and form, as I have shown in the description of *Spongilla* in my "Further Report on the Vitality of the Spongiadæ," in the volume of the Reports of the British Association for 1857.

Inhalation and Exhalation.

The works of the old writers on Natural History are full of vague opinions on the nature of sponges, but none of them seem to have seriously studied their anatomy, or to have kept them alive in sea-water and examined their daily habits. They appear to have excited abundant attention in the closet, and but very little in their natural localities. The ideas of those authors are so loose and indefinite that it would really be a loss of time to seriously examine and attempt to refute them; and as Dr. JOHNSTON, in his 'History of British Sponges,' has given in his Introduction, Chapter 2, an excellent digest of the various opinions of the previous writers on the subject, I shall content myself with referring my readers to the work of that eminent author for further information on these subjects, and with briefly referring to the few actual observations that appear to have been made by naturalists.

MARSIGLI, at the beginning of the 18th century, stated that he had seen contraction and dilatation in the oscula of several sponges just removed from the sea.

After MARSIGLI, ELLIS (ELLIS and SOLANDER), Natural History of Zoophytes, pp. 184, 186, and 187 (see also Zool. Journ. pp. 375, 376), enunciated similar opinions founded on his own observations on the action of the oscula and their currents; but neither of those authors was aware of the true mode of the entrance of the water into the sponge, a much more difficult problem to solve than its exit through the oscula.

CAVOLINI in his researches, although made on sponges recently taken from the sea, failed in seeing the action of the oscula as ELLIS had done, and he accordingly disputed the truth of those opinions. At a later period, Colonel MONTAGU, although actually examining sponges in the places of their growth, arrived at similar conclusions to those of CAVOLINI, and, like that author, he believed them to be animals of a very torpid nature. MONTAGU'S reasoning to prove the animality of sponges is for the most part sound and excellent; he says, "Whether motion has ever been discovered or not in any species of sponge is not, I conceive, of so much importance as some naturalists would appear to consider. Those who are solicitous in their inquiries after the animals which they have supposed to construct the vesicular fabric of sponges, and have expressed their surprise that this in age of cultivated science no one should have discovered them, must have taken a very limited view of matter possessing vitality, and have grounded their hypothesis only upon supposed analogy." He also observes, "The true character of *Spongia* is that of a living, gelatinous flesh supported by innumerable cartilaginous or corneous fibres or spicula, most commonly ramified or reticulated, and furnished more or less with external pores or small mouths which absorb the water, and which is conveyed by an infinity of minute channels or capillary tubes through every part of the body, and is there decomposed and the oxygen absorbed as its principal nourishment, similar to the decomposition of air in the pulmonary organs of what are called perfect animals."—Wernerian Memoirs, vol. ii. pp. 74, 75.

LAMOUROUX'S conclusions regarding the nature of sponges are so thoroughly vague and supposititious as scarcely to require notice.

LAMARCK has placed the Spongiadæ in a higher position than any naturalist who had preceded him, giving them precedence of the sertularian and celliferous Corallines, and even of the Corallidæ; but I cannot concur with him to the full extent of his conclusions, which, like those of most previous writers, were derived to a much greater extent from comparative reasoning than from actual observation of the animals in a living and natural condition.

Professor SCHWEIGGER'S opinions are very much more those of a practical naturalist, and it is evident that he had closely observed them in a living condition; but he too shares the erroneous opinion of his predecessors, that the oscula were the organs of imbibition, and that no water entered through the dermal surface. Professor BELL, in the 'Zoological Journal' for June 1824, states that he saw the action of the streams from the oscula, but like previous writers concluded that they were organs of imbibition as well as excurrent organs. And it was not until the excellent and accurate "Observations and Experiments on the Structure and Functions of the Sponge" were published in the Edinburgh Philosophical Journal, vols. xiii. and xiv., by Professor GRANT, that a correct notion was entertained by naturalists of the inhalant and exhalant powers of those bodies. These details by the learned Professor are so full and complete as to leave but little room for the improvement of our knowledge of this portion of their natural history. And the facts of the imbibition of the surrounding water by the pores in the dermal membrane, its circulation through the internal cavities of the sponge, and its final ejection through the oscula, have been firmly established and acknowledged by all naturalists who have studied these animals closely in a living state. Dr. GRANT has, in truth, proved himself to have been, in regard to the aqueous circulation in the sponge, what HARVEY was to that of the blood of the higher classes of animal life, the first to discover and to publish the true mode of the circulation of the water in the animal.

This learned and accurate observer says, "I first placed a thin layer from the surface of the *S. papillaris* in a watch-glass with sea-water under the microscope, and on looking at its pores I perceived the floating particles driven with impetuosity through these openings; they floated with a gentle motion to the margin of the pores, rushed through with a greatly increased velocity, often striking on the gelatinous networks, and again relented their course when they had passed through the openings. The motions were exactly such as we should expect to be produced by cilia disposed round the inside of the pores."—Edinburgh New Philosophical Journal, vol. ii. p. 127.

The same author, in describing the excurrent action, says, "The *Spongia panicea* (*Halichondria incrustans*, JOHNSTON) presents the strongest current which I have yet seen." Two entire round portions of this sponge were placed together in a glass of sea-water with their orifices opposite to each other, at the distance of two inches; they appeared to the naked eye like two living batteries, and soon covered each other with feculent matter.

Stimulated by the recital of the observations of Dr. GRANT, I have often sought these currents flowing from the oscula, and there is no species which I have had the opportunity of examining in a fresh and vigorous condition in which I have not succeeded in seeing them. In the one observed by Dr. GRANT, *Halichondria incrustans*, JOHNSTON, the oscula being few in number and very large, the excurrent streams are more than usually powerful. In the course of my investigations "On the Vitality of the Spongiadæ," at Tenby, which are published in the Reports of the British Association for 1856, and in the "Further Report" published in the same work for 1857, I have described a long series of observations of the vital actions of the Spongiadæ as displayed in *Hymeniacidon caruncula* and *Spongilla fluviatilis*, in both of which species there was a perfect accordance in the habits and modes of exertion of these vital actions.

The power of inhalation appears to be exerted in the Spongiadæ in perfect accordance with the similar vital functions in the higher classes of animals, not involuntarily and continuously as in the vegetable creation, but at intervals, and modified in the degree of its force by the instincts and necessities of the animal. And it may be readily seen that the faculty of inhalation is exercised in two distinct modes; one exceedingly vigorous, but of comparatively short duration, the other very gentle and persistent. In the exertion of the first mode of inhalation, that is during the feeding period, a vast number of pores are opened, and if the water be charged with a small portion of finely triturated indigo or carmine, the molecules of pigment are seen at some distance from the dermal membrane, at first slowly approaching it and gradually increasing their pace, until at last they seem to rush hastily into the open pores in every direction. In the meanwhile the oscula are widely open, and pouring out with considerable force each its stream of the excurrent fluid; and if the reflexion of one of the horizontal portions of a window-frame be brought immediately over an excurrent stream, it will frequently be seen that the surface of the water is considerably elevated by its action, even although the osculum be half or three-fourths of an inch beneath its surface, and this vigorous action will sometimes be continued for several hours, and then either gently subside or abruptly terminate. Occasionally a cessation of the action may be observed in some of the oscula while in others it is proceeding in its full vigour, and sometimes it will be suddenly renewed for a brief period in those in which it had apparently ceased. These vacillations in the performance of its functions are always indicative of an approaching cessation of its vigorous action. When the vivid expulsion of the water has ceased, the aspect of the oscula undergoes a considerable change; some of the smaller ones gradually close entirely, while in the larger ones their diameter is reduced to half or one-third of what it was while in full action. Simultaneously with the decline in the force of the excurrent action the greater portion of the pores are closed, a few only, dispersed over the surface of the sponge, remaining open to enable the gentle inhalation of the fluid to be continued, which is necessary for the aëration of the breathing surfaces of the sponge. The breathing state of inhalation appears to be very persistent, and I have rarely failed in detecting it when I have let a drop of water charged with molecules of indigo quietly sink through the clear fluid immediately above an open osculum. These alternations of repose and action are not dependent on mere mechanical causes, and sponges in a state of quiescence may be readily stimulated to vigorous action by placing them in fresh cool sea-water, and especially if it be poured somewhat roughly into the pan and agitated briskly for a short period; and this will take place even in specimens that have very recently been in powerful action.

No general law seems to guide the animal in the choice of its periods of action and repose, and no two sponges appear to coincide entirely in the time or mode of their actions. In fact, each appears to follow the promptings of its own instinct in the choice of its periods of feeding and repose.

In the littoral sponges there is a third condition of the animal, and that is during its exposure to the atmosphere in the intervals between high and low water, and in some sponges the pores and oscula are both completely closed. But this condition does not obtain in all species. Thus, during the course of my investigations at Tenby, I observed that while, amidst the numerous specimens of *Hymeniacidon caruncula* and *Halichondria panicea* that covered the rocks in the neighbourhood of St. Catherine's Cave, the former rarely exhibited an open osculum in the absence of the water, those of the latter species were frequently more or less open.

The most beautiful and striking view of the differences existing between vigorous action and the comparative repose of the breathing process is exhibited in *Grantia ciliata*. In this species the pores are situated on the obtusely conical distal terminations of the intermarginal cells or cavities, each of which is furnished with a long fringe of spicula surrounding its porous end, their proximal terminations being cemented, for about a third of their length, to the slightly curved surface of the base of the cone. In the state of the comparative repose of aërating inhalation, and when the base of the conical extremity of the cavity is not distended by the incurrent action, these spicula all converge to a point at the level of their own apices, and the water thus gently inhaled passes between the shafts of the spicula, forming the protective cone to the inhalant pores, and effectually preventing any extraneous matter from approaching them. But when the vigorous feeding action commences, the distention of the base of the conical portion of the cavity brings it into lines parallel to the axis of the cell, and thus the conical fringe of spicula assumes a cylindrical form, and the molecular food of the animal is freely admitted to the pores.

A corresponding action obtains in the exhalant system of this interesting sponge. The mouth of the great central cloaca is furnished with a thick fringe of very long and slender spicula, which by the contraction of its sides near the mouth are all brought to assume a conical form like those appended to the inhalant cavities; but when the inhalant action is in vigorous operation, and the oscula are all pouring their streams into the cloaca, the force of the water thus accumulated distends the mouth of the cloaca to such an extent as to cause the fringe of long spicula to assume the form of an open cylinder, or in some cases it is expanded to such an extent as to become slightly funnel-shaped, and in this condition the fæcal stream may be seen issuing from it with considerable force. There are many other interesting points in the structure of this highly organized and interesting sponge which I will not advert to at length, but refer my reader to a fuller and more complete history of its structure published by me in the 'Transactions of the Microscopical Society of London' for 1859, vol. vii. p. 79, plate 5.

Thus we find that inhalation is the primary vital operation induced by ciliary action, and that exhalation is merely a mechanical effect arising from the primary cause. We find also that these actions are separated into two distinct modes; the one exceedingly active and vigorous, exerted only at intervals and for short periods, and the other gentle and continuous. If we combine the consideration of these peculiarities of function with those of the anatomical studies, we find that the incurrent streams are always received in intermarginal cavities, and that these organs, however modified, are always present, and in some cases can be distinctly and strikingly separated from the great mass of the interstitial canals and cavities of the sponge. If we trace the course of the inhaled fluids, we find that on their entrance through the pores they are first brought into contact with the parietes of the intermarginal cavities, and passed thence into the complicated system of digestive surfaces which line the incurrent and excurrent canals and cavities of the sponge, and that the exhausted fluids charged with fæcal matters are finally discharged without the slightest return to or intermixture with the contents of the intermarginal cavities. We may therefore, it appears to me, safely conclude that the respiratory and digestive functions are separated, and that the latter has its seat in the intermarginal cavities, and the former in the interstitial canals and cavities.

The vital energy of the Spongiadæ must be very considerable, and the quantity of oxygen consumed by their respiration great, if we may judge by the effects of their presence in the vivarium, where their introduction makes sad havoc among the other inhabitants, few being able to withstand their deleterious presence, and without a large supply of water and a frequent change of it they themselves quickly expire of exhaustion.

Nutrition.

In treating on the subjects of inhalation and exhalation, I have described the energetic period of action in the sponge during the imbibition of the surrounding fluid as equivalent to the operation of feeding in the higher classes of animals. And in my "Further Report on the Vitality of the Spongiadæ," published in the Reports of the British Association for 1857, p. 121, I have described the results of feeding a small specimen of *Spongilla fluviatilis* with finely comminuted indigo in water, and I have there stated that "many of the molecules might be readily followed, as they meandered through the interior of the sponge, and were seen flowing in every direction. During the maintenance of this action in full force, when I directed my observation to the osculum, it was pouring forth a continuous stream of water, and along with it masses of flocculent matter, and many of the larger molecules of the indigo that had entered by the pores; but it is remarkable that although the finer molecules of indigo were being imbibed by the pores in very considerable numbers, very few indeed of them were ejected from the osculum; and if the imbibition of the molecules continue for half an hour or an hour, and then cease, the sponge is seen to be very strongly tinted with the blue colour of the indigo, and it remains so for 12 or 18 hours, after which period it resumes its pellucid appearance, the whole of the imbibed molecules having undergone digestion in the sarcode lining the interior of the sponge, and the effete matter having been ejected through the osculum." If we kill the sponge immediately after being thus fed, and examine the interstitial canals and cavities, we find their sarcodous surfaces thickly dotted with molecules of indigo.

The fæcal matters discharged by the oscula exhibit all the characteristics of having undergone a complete digestion; whatever may have been the condition of molecules of organized matter when they entered the sponge, their appearance after their ejection is always that of a state of thorough exhaustion and collapse.

It is difficult to decide with any degree of certainty what is really the nature of the nutriment of the Spongiadæ, but in the greater number of species it is probably molecules of both animal and vegetable bodies, either living or derived from decomposition. This appears to be the case with the greater number of the Halichondroid sponges; but even among them, as well as other genera, there are peculiarities of structure that are strongly suggestive of carnivorous habits. Thus, in the first portion of this paper published in the 'Philosophical Transactions' for 1858, p. 293, I have described among the interior defensive spicula a remarkable form, which has been hitherto found in one sponge only, the spinulo-recurvo-quaternate spiculum, which "occurs in great profusion in the cavities of the sponge; clusters of them, consisting frequently of as many as twelve or fifteen, radiate from the angles of the reticulations of the skeleton into the interstitial cavities of the animal." I have also described, while treating on the internal defensive spicula, the recurvo-ternate forms, the heads of which are found projecting their radii, more or less, into the interstitial cavities beneath the intermarginal ones in *Geodia* and *Pachymatisma*. The spinulo-recurvo-quaternate spicula, represented *in situ* in Plate XXX. fig. 10, and the recurvo-ternate ones, figured *in situ* in Plate XXXII. fig. 2, *e*, *e*, *e*, are both admirably adapted to destroy the victims entangled among them.

I have for a long time entertained the idea that these elaborate and varied forms of defensive spicula probably subserved other purposes than that of the protection of the digestive surface against the incursions of minute annelids and other predaceous creatures. They are admirably fitted to retain and make prey of any such intruders. No small animal could become entangled in the sinuosities of the interstitial cavities of sponges thus armed without extreme injury from the numerous points of these spicula, and every contortion arising from its struggles to escape from its painful and dangerous entanglement would contribute to its destruction, and it may then, by its death and decomposition, eventually become as instrumental to the sustentation of the sponge as if actually swallowed by the animal. How far this mode of nutrimentation may obtain in the physiology of these creatures it is impossible, in the present imperfect state of our knowledge of their habits to say; but, from the complex, varied, and elaborate structure of these organs, and from their evident adaptation to retain such intruders, as well as to defend the internal surfaces from injury, it is not improbable that their office extends beyond that of the mere defensive function, and that they are, in fact, auxiliary organs for securing nutriment for the use of the sponge. If this supposition, that the elaborately formed and ingeniously disposed recurvo-quaternate spicula combine the office of securing prey with that of defending the interstitial organs of the sponge, be correct, it may afford a clue to the organic purpose of the recurvo-ternate spicula with the exceedingly long and attenuated shafts that so frequently accompany the stout patento-ternate ones in *Geodia Barretti*. The apices of these spicula (Plate XXIII. fig. 45, Phil. Trans. for 1858) rarely attain the height of the plane of the true connecting spicula, and their recurved radii are most frequently projected into the large interstitial spaces immediately beneath the plane of the proximal ends of the cells of the intermarginal cavities, and may thus form subsidiary defences to those organs. Although emanating from the fasciculi of the shafts of the true connecting spicula, their form, slender proportion and position evidently indicate a different office from the spicula with which they are associated, and no other purpose for them occurs to me so probable as the one I have suggested above. Or we may carry the supposition further, and believe them to be not only defensive but aggressive organs; also, like the recurvo-quaternate spicula, their office may be to retain soft annelids that have intruded themselves through the oscula into the digestive organs, to aid in the nutrimentation of the sponge; and this idea appears the more admissible as these spicula are never observed in the intermarginal cavities, where the decomposition of animal matters would be offensive to their especial function, but always in the spaces beneath them, which are the commencements of the digestive system.

The same course of reasoning will apply to their occurrence in such considerable quantities amidst the defensive fasciculi of spicula projected from the surface of *Tethea simillimus*, and also of *T. crania*, the latter being represented in Plate XXIX. fig. 12 *c*, in which it will be seen that the recurvo-ternate heads of the spicula are always situated beneath the level of the true defensive spicula. Thus situated they would form an admirable trap for the entanglement of soft annelids that might attempt to crawl over the surface of the sponge, and thus they would be destroyed and retained for the imbibition of their particles liberated by their gradual decomposition. If this be not their especial purpose in this situation, I must confess myself at a loss to imagine their proper function, as the surface of the sponge is effectually protected by the porrecto-ternate and large acute spicula that compose the defensive fasciculi projecting in such abundance from all parts of the sponge. If we also consider the structure and positions of the ordinary forms of internal defensive spicula, the entirely spined attenuato-acuate ones, in reference to the idea of their being offensive as well as defensive organs, we shall not fail to see that, although less striking in their forms and modes of disposition than the spicula already described, they are calculated to subserve the office of retaining prey quite as effectually as the more singular ones. The abundance in which they occur, the vast number of spines with which they are covered, the apices of which are frequently long and recurved, combined with the mode in which their bases are attached to the fibres of the skeleton, exhibiting a beautiful combination of strength and flexibility, are strongly indicative of a purpose beyond that of mere repulsion.

In the two species of sponges in which are found the acuate entirely and verticillately spined defensive spicula *in situ*, represented in Plate XXX. figs. 7 & 8, one of them has the spicula collected in groups in a manner very similar to those of the spinulo-recurvo-quaternate form, and if the latter be considered as organs for the retention of prey, the physiological purpose of the grouping together of the former can scarcely be considered in any other light.

In the isolated positions of these forms of spicula, viewed in reference to some ideas regarding their physiological purposes, there are some circumstances of a very remarkable nature. These forms of spicula occur in several distinct genera of sponges, and especially in those having a strong kerato-fibrous skeleton. Their usual locality is on the fibre of the skeleton, in which their bases are firmly imbedded, and from which they are projected at various angles into the canals and cavities of the sponge, and they are very rarely seen on the membranes. In *Hymeraphia stellifera* (Plate XXX. fig. 3, *a*) and *clavata*, BOWERBANK, MS., both exceedingly thin coating species, they occur in great quantity, but only on the basal membrane; a portion of them being erect, the remainder prostrate. But in another sponge, a remarkably curious parasitical species of *Hymeniacidon*, which, having no fibrous skeleton of its own, covers and appropriates a small fibrous *Fucus*, and converts its anastomosing vegetable stalks into an artificial skeleton, closely coating each stalk of the plant with its membranous structure, so as to cause them at first sight to be readily mistaken for keratose sponge fibre, the whole of the membranous structure abounds with attenuato-cylindrical entirely spined defensive spicula; but they are all prostrate and intermingled with the skeleton spicula of the sponge when not in contact with any part of the fibres of the vegetable, but wherever they are in contact with the plant they instinctively, as it were, assume the erect position, and the false skeleton is bristling with them to as great an extent as if it were truly a keratose fibrous structure. This feature in the habit of the sponge is very remarkable, and highly suggestive of a capability of adaptation to circumstances that we should scarcely have expected to find. By the two instinctive habits, first, that of converting the plant into an artificial skeleton, and then erecting its spinous spicula on its fibres, it at once simulates the habits of a kerato-fibrous sponge, and becomes capable of the carnivorous habits that I have attributed to those sponges that are so strikingly adapted for preying on intruding annelids or other such small creatures. In the species above described, *Hymeniacidon Cliftoni*, BOWERBANK, MS., Plate XXX. fig. 9, the erection of the spicula on the adopted skeleton is an established habit, and it may be said to be instinctive in the species, but I have observed the same fact in sponges not habitually parasitical. I have a specimen of *Microciona carnosa*, BOWERBANK, MS., a British species, in my possession in which some small fibres of a tubular zoophyte have been accidentally included during its growth, which the sponge has coated with its own tissues, and from these adopted columns defensive spicula are projected in a similar manner to those of the columnar skeleton of the sponge. In this case we have an instinctive adaptation of an extraneous substance in a sponge in which the introduction of foreign substances is the exception, and not, as in other tribes of sponges, the rule.

In *Hyalonema mirabilis*, GRAY, a sponge nearly related to the genus *Alcyoncellum*, we find another extraordinary series of internal defensive spicula, the structure of which I have described at length under the head of 'Defensive Organs.' These elaborately and wonderfully formed weapons are evidently destined for other purposes than that of simple repulsion. The spiculated cruciform spicula, with their short stout basal radii planted firmly on the lines of the skeleton, and projecting from their centre at right angles to their own plane, the long spiculated ray furnished with numerous strong sharp recurved spines, it will be at once seen, are eminently fitted to retain annelids or other such prey, and to cause every motion of the struggling victim to contribute to its own laceration and destruction, while the structure and mode of attachment of the cruciform base is admirably calculated to resist the force and motions it has to sustain in such encounters. But these spicula, although exceedingly numerous, are not the only organs capable of retaining intruders into the body of the sponge with which it is furnished: there are, in addition, numerous large multihamate birotulate spicula dispersed in various positions on the sides of the interstitial cavities of the sponge, each of the rotulæ consisting of seven or eight stout recurved flattened radii, which if immersed in any struggling animal would be capable of sustaining a vastly greater amount of force than many of the spiculated quadriradiate ones combined could endure without injury; and that their especial office is that of auxiliary retentive organs is well demonstrated by the fact that the trenchant edges of the flattened radii are all at right angles to the line of force required to tear away their hold of any body in which they may have been inserted. Thus they appear destined by nature to secure the prey, while its own struggles among the lacerating organs contribute to its destruction (Plate XXXI. figs. 3, 4, 5, 6 & 7).

In the modification of the structure of the contort bihamate spicula, and their peculiar adaptation to the retention and destruction of intruders within the sponge, which I have described when treating on the internal defensive spicula, and which is represented in Plate XXXI. figs. 1 & 2, we have precisely the same physiological principle carried out, but by means widely different from those I have previously described.

If we consider the whole of these extraordinary organs to which I have referred in relation to each other, we cannot fail to see that, however varied their forms may be, there is every appearance of perfect harmony of design in the purposes they are destined to effect in the economy of the Spongiadæ.

The Cilia and Ciliary Action.

Our knowledge of the cilia of the Spongiadæ is, comparatively speaking, very small. Dr. Grant is, I believe, the first author who has seen and described these organs *in situ*. This learned and accurate observer, in his paper "Observations on the Structure and Functions of the Sponge," has described the origin and gradual development of the ova or gemmules of *Spongia panicea* (*Halichondria incrustans*, Johnston). After the liberation of these bodies from the sponge, he writes, "The most remarkable appearance exhibited by these ova is their continuing to swim about, by their own spontaneous motions, for two or three days after their detachment from the parent, when they are placed separately in vessels of sea-water, at perfect rest. During their progressive motions they always carry their rounded broad extremity forward, and when we examine them under a powerful microscope we perceive that these motions are produced by the rapid vibration of cilia, which completely cover over the anterior two-thirds of their surface." And he further states that they are "longest and exhibit the most distinct motions on the anterior part," and that they "are very minute transparent filaments, broadest at their base, and tapering to invisible points at their free extremities; they have no perceptible order of succession in their motions, nor are they synchronous, but strike the water by constantly and rapidly extending and inflecting themselves." The author describes the attachment and spreading out into a thin disk of the ovum or gemmule, and the cessation of action and gradual disappearance of the cilia; and he further observes, "although all visible cilia have ceased to move, we still perceive a clear space round the ovum, and a halo of accumulated sediment at a little distance from the margin." This observation is important, as tending to prove the existence of ciliary action, although the organs themselves were too minute to be detected.

DUJARDIN, in his work on the Infusoria, in plate 3, fig. 19 *b*, represents what are apparently the detached cilia and their basal cells, and which were probably from *Grantia compressa.*

If portions of a living sponge of this species be torn into small pieces, and placed in a cell in sea-water under a power of about 400 linear, groups of the detached cilia and their basal cells will be readily seen at the margins of the specimen; they are usually thus clustered together, and have a tremulous and indistinct motion. If a small specimen of the sponge be slit open and placed in a cell with fresh sea-water, with the inner surface of the sponge towards the eye so as to command a distinct view of the oscula, the cilia will be seen in the area of that organ in rapid motion, and the extraneous molecules attached to them exhibit the extent and nature of their oscillations very distinctly (Plate XXXIII. fig. 2). If the sponge be carefully torn asunder in a line at right angles to its long axis, and the torn surface be placed in a cell with a little fresh sea-water, we occasionally obtain a favourable longitudinal section of some of the large cells of the sponge, and we then see the cilia *in situ* and in motion (Plate XXXIII. fig. 1).

The whole length of the cell, from the inner edge of the diaphragm to its origin near the outer surface of the sponge, is covered with tessellated nucleated cells, which have each a long attenuated and very slender cilium at its outer end. They are oval in form, and have a distinct nucleus. When in vigorous condition their motions are rapid and cannot readily be followed; but in some in which the action was languid, the upper portion of the cilium was thrown gently backward towards the surface of the sponge, and then lashed briskly forward towards the osculum, and this action was steadily and regularly repeated. Their motions are not synchronous—each evidently acts independently of the others (Plate XXXIII. fig. 3, *a* & *b*).

The numbers, situation, and peculiarities of their actions fully account for the continuous and powerful stream that issues from the great cloacal aperture of this and other similarly constructed sponges. The natural rate of the motions of these organs must not be estimated from the sections last described, but the estimate must be made from the appearances manifested at the oscular orifices at the inner surface of the sponge. A more detailed account of these investigations is published in the Transactions of the Microscopical Society of London, vol. iii. p. 137. Figs. 1, 2, 3, & 4, plate 7, represent a longitudinal section of the intermarginal cavities of *Grantia compressa* with the cilia *in situ*. A view of the small portion of the inner surface of the sponge, exhibiting the oscular orifices and the appearance of the cilia in motion within them, and detached cilia and cells from the same sponge, are also represented by figs. 1, 2, 3 & 4, Plate XXXIII.

In the course of my endeavours to detect the cilia in Halichondroid sponges, I have frequently observed, in slices of the sponge taken from the surface, that the incurrent action has continued for a considerable period, while in sections of the same sponge taken from deep amid the tissues no such action of the currents could be detected. In sections from the surface in which the inhaling process was in vigorous condition, when the inside of the section was examined, that peculiar flickering appearance was often visible in the cavities immediately beneath the dermal membrane which is so characteristic of minute cilia in very rapid motion; and although many molecules were rushing inward with considerable velocity, others might be seen which continually waved from side to side but made no progress forward; in fact they presented precisely the appearance that I have described as taking place in the oscula of the proximal ends of the great intermarginal cells of *Grantia compressa*; and I have no doubt, in my own mind, that those of the Halichondroid sponges were also extraneous particles of matter adhering to the apices of the minute cilia, rendering their motions apparent, while the cilia themselves were perfectly invisible.

Carter, in his paper on "Zoosperms in *Spongilla*," published in the 'Annals and Mag. Nat. Hist.' vol. xiv. Second Series, p. 334, describes ciliated bodies from a *Spongilla* from the water-tanks of Bombay, somewhat similar to those of *Grantia compressa*, but the basal cell appears to be proportionally larger and the cilium shorter than in those of *G. compressa*. The author, in describing the detached cells and cilia, says, "At first the polymorphism of the cell and movements of the tail are so rapid, that, literally, neither 'head nor tail' can be made out of the little mass. Presently, however, its power of progression and motion begins to fail, and if separated from other fragments it soon becomes stationary, and after a little polymorphism assumes its natural passive form, which is that of a spherical cell. During this time the motions of the tail become more and more languid, and at length cease altogether." The author continues, "If, on the other hand, there be very large fragments in the immediate neighbourhood, or an active sponge-cell under polymorphism sweeps over the field, it may attach itself to one or the other of these, when its cell becomes undistinguishable from the common mass, and the tail floating and undulating outwards is all that remains visible." This observation is important, as it accounts in a great measure for our inability to find the cilia *in situ* in the living and active condition of the *Spongilla*; and if the structure and imbedment of the basal cell in the marine sponges be like those in that genus, the same results would probably arise in the marine species, rendering it extremely difficult, if not impossible, to detect these organs *in situ* and in action.

Lieberkuhn, in his paper in Müller's 'Archiv,' 1856, pp. 1–19, 319–414, gives an account of the cilia and their cells *in situ*. He describes them as forming a single layer of spherical cells, $\frac{1}{300}$ millim. in diameter, and which, though touching each other, are not in such contact as to lose their rounded figure. LIEBERKUHN'S description of the mode of disposition of these cells in *Spongilla* would serve equally well for those in *Grantia compressa*. Professor HUXLEY, in a paper "On the Anatomy of the Genus *Tethya*," published in the 'Annals and Mag. Nat. Hist.' vol. vii. p. 370, describes cells and cilia from an Australian sponge, which he designates spermatozoa, and which he describes as having "long, pointed, somewhat triangular heads, about $\frac{1}{300}$th of an inch in diameter, with truncated bases, from which a very long filiform tail proceeds." These bodies are figured in vol. vii. plate 14. fig. 9.

On a careful consideration of the descriptions of the ciliated cells seen by the authors I have quoted above, it strikes me forcibly that the so-called zoosperms and spermatozoa of CARTER and HUXLEY are identical in origin and purpose with the similar organs described by LIEBERKUHN and those found *in situ* and in action in *Grantia compressa*, and, in truth, that they are the homologues of the breathing and feeding organs of the zoophytes and more highly organized animals.

Reproduction.

The ovaria in sponges exhibit considerable variety in shape and structure. The most familiar form is that of *Spongilla fluviatilis*, represented in Plate XXXIII. fig. 5, in its natural condition.

These bodies have hitherto been usually designated as gemmules, but this term appears to be inappropriate. Each of them contains numerous minute vesicular, round or oval molecules, which are discharged from the foramen in succession, and each of these appears to be capable of producing a sponge. The terms ovarium and ova are therefore more in accordance with the rules of modern nomenclature, and this alteration in their designation is the more necessary, as I shall hereafter be enabled to show that, at least in *Tethea lyncurium*, propagation by true external gemmation really exists. I propose, therefore, for the future that all such large vesicular organs containing numerous molecules or ova capable of reproducing the species, and of being successively ejected from the sponge, should be designated ovaria and ova, and that the term gemmule should be restricted to the isolated bodies which pullulate from the internal or external surfaces of the parent, and by ultimate separation become each a distinct individual.

The reproductive powers of the Spongiadæ have been treated of to a considerable extent by preceding authors, and the amount of our information on this subject is, I believe, both extensive and accurate. I will not attempt a recapitulation of all that has been written on their reproduction, but content myself with a slight sketch of our knowledge of the various modes of propagation that have been well ascertained and described. From the researches of the various authors who have written on the structure and development of *Spongilla* and on the marine Spongiadæ, it appears that there are three well-established modes of propagation: 1st, by ova; 2nd, by gemmation; and 3rd, by spontaneous division of the sarcode. The terms ova and gemmule have been used so indiscriminately by authors, that it seems to me advisable to endeavour to define and limit their application in such a manner as to distinctly separate the one form of reproductive body from the other.

On a careful review of the results of the labours of previous observers and of my own researches, it appears that the following may be considered as the varieties that exist in the modes of the propagation of the Spongiadæ:—

1st. By ova without an ovarium.
2nd. By ova generated within ovaria.
3rd. By gemmules secreted within the sponge.
4th. By gemmules produced externally.
5th. By spontaneous division of the sarcode.

On the first mode of propagation, by the means of ova generated in the sponge without the presence of ovaria, very little seems to be known; and this mode appears to be confined to the true sponges, the genus *Spongia*. If we examine microscopically the fibres of the sponges of commerce in the condition in which they come into the hands of the dealers, and before they have been soaked, cleaned, and prepared for sale, we frequently find the fibres covered with innumerable minute irregularly ovoid vesicular bodies, nearly uniform in size, dispersed evenly over the surface of the fibres, and imbedded in a thin stratum of sarcode that coats the membranous sheath that surrounds them. These bodies Dr. JOHNSTON believes to be "the matured gemmules or sporules," and I feel strongly inclined to agree with him in the conclusion that they are the reproductive bodies of that tribe of sponges, and no other reproductive bodies have, I believe, been discovered in the true sponges; but in arriving at this conclusion we must not fail to remember that our knowledge of these animals in the fleshy and solid condition in which they are when alive is so limited, and so few observations have been published regarding them in that state, that we must not attach too great a value to these conclusions.

In size and form these ovoid vesicles are very similar to the ova liberated from the well-characterized ovaria of other marine species of Spongiadæ, and, like them, they present no appearance of a nucleus. They are somewhat irregular in their form, and vary to a slight extent in size; an average-sized one measured $\frac{1}{11666}$th of an inch in diameter. Fig. 6, Plate XXXIII. represents a portion of a fibre from a Bahama sponge under a power of 400 linear, and fig. 7 a part of the same fibre $\times 1250$ linear.

Until very recently, our knowledge of the vesicular ovaria of the Spongilladæ has been confined to two European species; but CARTER, in his excellent account of the Spongillas found in the water-tanks of Bombay, has described several new and interesting varieties of these organs; and I have also become acquainted with eight new species from the River Amazon, through the kindness of Mr. BATE, and of three undescribed species from North America, through the kind and liberal assistance of Dr. ASA GRAY, Professor LEIDEY, and Professor DAWSON, of McGill College, Montreal, Canada. The greater portion of these organs resemble each other very closely in their natural condition, presenting generally the appearance of a more or less spherical coriaceous body; but the structure of their walls, when developed by treating them carefully with hot nitric acid, is so varied and strikingly characteristic of their organic and specific differences, as to render it necessary that I should enter somewhat minutely into their history. Their structual peculiarities naturally divide them into two great groups.

1st, those in which the walls of the ovaria are strengthened and supported by birotulate or unirotulate spicula radiating in lines from the centre to the circumference of the ovarium; and 2nd, those having the walls of the ovaria supported by elongate forms of spicula, disposed on or near its surface at right angles to lines radiating from the centre to the circumference of the ovarium; and, fortunately, the types of these two forms of spicular arrangement on the cortex of the ovarium are admirably illustrated in the two European species of *Spongilla*, the first mode existing in *Spongilla fluviatilis*, and the second one in *S. lacustris*. After having described the ovaria of these two species as types of their respective groups, I shall, in my future descriptions of these organs, confine my observations rather to their anatomical structure than to their external characters, excepting when the latter are of an unusual description. These bodies occur in great profusion in the basal portions of *S. fluviatilis*; they are spherical and of an average diameter of $\frac{1}{60}$th of an inch, and they are furnished with a circular foramen at their distal extremity of about $\frac{1}{833}$rd of an inch in diameter. In their natural condition they exhibit very slight indications of the birotulate spicula imbedded in their coriaceous-looking envelope. In the dried state they become cup-shaped by the contraction of the upper half inward during the process of desiccation, and in this condition the foramen appears at the bottom of the cup. The edges of the cup being thick and round in consequence of the presence of the birotulate spicula beneath the fold of the membrane, the surface becomes pitted with numerous minute lacunæ, which are produced by the adhesion of the inner surface of the envelope to the distal extremities of the birotulate spicula. Immersion in water for an hour restores them to their spherical form, but does not obliterate the lacunæ produced by desiccation; and I have several times observed that, under these circumstances, the expansion of the ova within has forced one or more of them through the foramen.

If we take several of the ovaria, either in the living condition or in the expanded state I have described above, and place them in a test-tube with a little nitric acid, and raise the temperature of the whole until the ovaria become of a bright yellow colour and semitransparent, and then arrest the operation of the acid by immediately pouring in a quantity of cold water, we shall have preserved their form and have retained the spicula in their natural positions, and have rendered the whole so transparent, as to exhibit their form and arrangement in the walls of the ovarium, either in water or mounted in Canada balsam, in a very beautiful and satisfactory manner. They are packed very closely together, their shafts being in lines radiating from the centre of the ovarium to the circumference; their distal rotulæ supporting the outer surface of its wall, while the proximal rotulæ sustain the inner one. Fig. 8, Plate XXXIII. represents a portion of one of these prepared ovaria, and fig. 8 *a* one of the detached spicula. Two views of this form of spiculum are also represented in Plate XXVI. figs. 27 & 28, Phil. Trans. 1858, and a perfect ovarium prepared by acid by fig. 9, Plate XXXIII.

Carter, in his paper "On the Freshwater Sponges in the Island of Bombay," in describing the birotulate spicula of the ovaria of *Spongilla Meyeni* and *plumosa*, species with ovaries of very similar structure to those of *S. fluviatilis*, states that the spaces between the rotulæ are "filled up with a white siliceous amorphous matter, which keeps them in position." I am indebted to the kindness and liberality of the author for specimens of these species, and I have frequently subjected their ovaries to the action of hot nitric acid, but I have never succeeded in finding any intervening siliceous matter, nor have I ever found any such siliceous cementing material in any other similarly constructed ovary of a *Spongilla*.

In the second group of ovaries of the Spongilladæ, represented by those of *S. lacustris*, in which the walls of the ovarium are supported by elongate forms of spicula disposed at right angles to lines radiating from its centre, the ovaria, in their natural condition, exhibit but very slight traces of the spicula imbedded in their walls. When dried, they cup inward like those of *S. lacustris*; but the margin of the cup is thin and sharp compared with that formed in a similar manner by those of *S. fluviatilis*, and they expand also in like manner when immersed in water. When treated with hot nitric acid they display an abundance of short, stout, entirely spined, subarcuate acerate spicula, one of which is represented in Plate XXVI. fig. 13, Phil. Trans. 1858. These spicula are in many instances exceedingly numerous; they are disposed without order, and overlie each other at various angles, forming, in their imbedment in the envelope, a strong and very efficient irregular network of spicula. A portion of one of these prepared ovaria is represented in Plate XXXIII. fig. 10.

In the ovaries of the different species of *Spongilla*, to be arranged hereafter in accordance with their structural peculiarities, there is a considerable amount of general resemblance, but accompanied with such permanent variations in the structure of the spicula, and in other portions of the development of these organs, as to render a somewhat detailed description of them necessary. Thus, in the development of the birotulate spicula, the ovaries of *Spongilla plumosa*, Carter, exceed any other known species. The thick walls of these organs are filled with them in the state represented by fig. 21, Plate XXVI. Phil. Trans. 1858, and the intervals between their shafts appear to be filled with indurated sarcode or keratode. In *Spongilla Meyeni*, Carter, the walls of the ovaria are strikingly similar in their structure to those of *S. fluviatilis*, and the form of the spicula the same, with the exception of the shafts being very much more spinous, and the size of the spiculum twice that of *S. fluviatilis*. Fig. 29, Plate XXVI. Phil. Trans. 1858, represents a spiculum from an ovary of *S. Meyeni*. The smallest and most simple development of birotulate spicula exists in *Spongilla gregaria*, Bowerbank, MS., from the River Amazon, represented by figs. 23, 24, 25 & 26, Plate XXVI. Phil. Trans. 1858.

A gradual transition from the birotulate form to that of the unirotulate one takes place in the ovaries of *S. paulula* (fig. 31) and *S. reticulata* (fig. 33), until we obtain the perfect and beautiful unirotulate form in the ovaries of *S. recurvata*, represented by figs. 34 & 35 in the Plate quoted above. In all these species there is a general accordance in the mode of their structure.

The gradual transition from the birotulate to the unirotulate form of spiculum in the ovaries of *Spongilla reticulata* is not the only characteristic difference that exists between it and its congener. The form and structure of the ovarium also exhibit marked peculiarities of character, and it is also furnished with a beautiful reticulated spicular envelope or case. In its natural condition the ovary fills the reticulated case, and the coriaceous external surface is pressed into the areas of the network.

It is usually oviform, but it varies to some extent in its shape. When treated carefully with hot nitric acid, the outer coriaceous substance of the ovarium is dissolved, leaving the inner membrane and the boletiform spicula *in situ*; their larger terminations being applied to the distal surface of the membrane, while their smaller clavate or stellate ends are projected outward, reaching, in the natural condition, to very near the external surface of the ovarium. The foramen is situated at the small or distal end of the ovary, and differs from that of any other form of the organ with which I am acquainted, inasmuch as it exhibits a tubular elongation outward of the lining membrane equal in length to about its own diameter, causing the ovarium, when prepared with nitric acid, to appear like an oil-flask with a very short neck. Fig. 13, Plate XXXIII. represents one of the ovaria prepared with acid, and fig. 12 one of the cases in which they are contained.

In *Spongilla Brownii*, BOWERBANK, MS., there is a still further deviation in the structure of the spicula of the ovary. The shaft entirely disappears, and the spiculum is reduced to the umbonato-scutulate form. They are situated on the outer surface of the inner membrane of the ovarium, with the umbones of the scutellæ outwards. This mode of disposition obviously renders them inefficient for external defence, and the ovaries have therefore been further defended by being enclosed within an elaborately constructed case of reticulated acerate spicula. The gemmule is closely embraced by this envelope, and small elongate masses of its outer surface are projected through some of its interstices, causing it to be more or less tuberculous; and, from the smallness of the interstices, the tubercles of the envelope of the ovary are much greater in length than in thickness. The spicula of the case are disposed in a close and irregular network, seldom exceeding two spicula in thickness. By a careful treatment with hot nitric acid, the thick coriaceous outer portion of the ovarium may be removed, and its thin lining membrane, with its stratum of umbonato-scutulate spicula, becomes an exceedingly beautiful object. The same mode of operation displays the structure of the reticulated case of the ovary very much more distinctly than when viewed in its natural condition. Fig. 11, Plate XXXIII. represents two of the cases after treatment with acid, one of them (*b*) having the ovary very much reduced in size by the dissolution of the thick coriaceous portion of its structure.

In the second group of the ovaries of the Spongilladæ there is also a strong general resemblance in structure to the type-form of *S. lacustris*, but each species is distinctly characterized by peculiarities of form and arrangement of the spicula.

The normal form is spherical, and the walls of the ovaries, in six out of the seven species with which I am acquainted, are comparatively thin. In the seventh species, *S. Carteri*, Bowerbank (*S. friabilis*, Carter), they are very thick and abundantly furnished with cellular structure, arranged in lines radiating from the centre to the circumference; each line consists of nine or ten cells, the length of each being about equal to the diameter. They are very closely packed together, and are irregularly angular by compression. Their combined length varies from about one-fifth to one-sixth the length of the diameter of the ovarium. This is the only species in which I have detected this description of cellular structure. Fig. 16, Plate XXVIII. represents a portion of the surface and a view of the cells *in situ*.

Although the spiculated coriaceous form of ovarium prevails so constantly among the freshwater sponges, it is one of extremely rare occurrence among the marine species; and I have met with only one instance of its occurrence, and that is in a new genus of sponges from Shetland, for which I am indebted to my indefatigable friend Mr. Barlee. The specimen incrusts a portion of the valve of a *Pecten*, covering a space about half an inch in length and the eighth of an inch in breadth, and it does not exceed half a line in thickness. The ovaries are numerous and closely packed together, and are distinctly visible to the unassisted eye, looking like very minute cocoons of some terrestrial insect. There were nearly thirty in an area equal to about a quarter of an inch. They are attached by the sides to one or more branches of the fibrous portion of the skeleton.

The wall of the ovary is very thin, and appears to consist of a single membrane profusely furnished with acerate spicula, like those of the skeleton. They cross each other in every possible direction, and occasionally appear to assume a somewhat fasciculated arrangement. The ovaries are not uniform in shape, some being regularly oval, while others are more or less ovoid. I could not detect any trace of a foramen in those I subjected to examination. I have designated this interesting species *Diplodemia vesicula* in my MS. description of it. Fig. 1, Plate XXXIV. represents two of the ovaries in their natural condition after immersion in Canada balsam, magnified 83 linear.

In the genera *Geodia* and *Pachymatisma* ovaria are produced in great abundance. They agree in form very closely with those of *Spongilla*, but their structure is widely different, and the soft animal matter that enters so largely into the structure of those of the freshwater sponges scarcely makes its appearance in the ovaries of *Geodia*, their walls being composed of closely packed spicula, firmly cemented together by silex. Their situation in the animal is also different from those of *Spongilla*, in which they are dispersed amid the interstitial tissues, but principally towards the base of the sponge, while in *Geodia* and *Pachymatisma* they are congregated in large quantities immediately beneath the dermal membrane; and when they have shed their ova they permanently retain their situation, forming a thick crustular dermis for the protection of the softer portions beneath: a few only are found dispersed in the interstitial membranes of the sponge. The progressive development of this kind of ovarium is very nearly the same in every species of *Geodia* or *Pachymatisma* in which I have had an opportunity of examining them. In an early stage they appear as a globular body of fusiformi-acerate spicula, radiating regularly from a central point in the mass. As the individual spicula increase in diameter there is a corresponding distention of the ovarium, and as the spicula do not lengthen in proportion to their increase of diameter a central cavity is produced, in which the incipient ova very shortly appear. The spicula of the wall of the ovary continue to increase considerably in diameter, but very little in length, and their distal terminations become gradually less acute as they approach the period of the full development of the ovary. When this organ has attained its greatest diameter, their distal extremities cease to lengthen, and a gradual change in the form of the spicula is effected, their apices extending in diameter and assuming a truncated form, and the whole of them becoming firmly cemented together, so as to form a common flat smooth surface to the siliceous skeleton of the ovarium, each spiculum having now changed from the acerate to the acuate form, their proximal acute terminations forming the common inner surface of the cavity of the ovarium, which is now filled with an opake mass of ova. A single conical orifice or foramen has also been produced in a portion of the wall, through which the ova are destined to be ejected. The proximal end of this foramen is very much the smaller of the two, so that, as soon as an ovum has fairly entered this conical tube, there is no longer any impediment to its ejection; and the manner in which this is effected is very interesting, and appears to be as follows. When the ova have attained maturity, the proximal terminations of the spicula which have not been cemented together like their distal ones, are progressively and simultaneously lengthened, thereby encroaching on and gradually lessening the diameter of the cavity within, so that the ova are compressed and forced through the foramen; and this process appears to be continued until the whole of them have been ejected, and the cavity becomes completely filled by the continued encroachment of the proximal ends of the spicula of the walls of the ovarium.

In fig. 6, Plate XXXIV., two ovaries from *Geodia McAndrewii* containing ova are represented: (*a*) contains about the greatest quantity of ova that is found within these organs. In this one the distal terminations of the spicula of the skeleton are still somewhat rounded, and slightly elevated above the common surface; while in (*b*), which has been partially exhausted of the ova, the spicula have their distal terminations flat and somewhat angular, and they are level with the general surface, thus indicating a greater age and a fuller development than obtain in the one represented by (*a*), and not a less amount of secretion of ova, as might possibly be imagined. These circumstances are strongly indicative of the fact that the ovaria, both in an active and an effete state, are permanently seated in the sponge, and that the ova only are discharged from it. So in like manner the existence of the ovarium in *Spongilla reticulata* and *Brownii*, confined within a strong spicula case firmly incorporated with the skeleton, is strong presumptive evidence of their also being permanent organs, and not of the nature of gemmules which separate from the body of the sponge when they arrive at maturity and are ejected through the great fæcal orifice.

Many other species of *Geodia* with which I am acquainted afford these ovaria in great abundance, and with some variations in size and form from those in *G. M^c^Andrewii*, but in no other sponge are they so large and so completely developed.

Fig. 2, Plate XXXIV. represents an adult ovarium from *Geodia M^c^Andrewii* with the conical foramen on its summit, and the distal ends of the skeleton spicula flat and angular. Fig. 3 represents a small portion of the surface of the same specimen as seen with a linear power of 308, exhibiting the flatness and angularity of their distal apices. Fig. 4 represents a portion of a young ovarium having the distal ends of the skeleton spicula disunited and acutely conical. Fig. 5 represents a portion of a section of an ovarium of *G. M^c^Andrewii*, exhibiting the radial arrangement of its component spicula.

In *Pachymatisma Johnstonia*, BOWERBANK, a British species common on the rocks in the neighbourhood of Torquay, and which I described in a paper read before the Microscopical Society of London in 1841, these organs assume an oval form; they are also considerably depressed. In a young specimen of this species of sponge in my possession, the progressive development of the ovaria is very strikingly illustrated. Fig. 7, Plate XXXIV. represents an adult ovarium. Fig. 8, one in a semideveloped state, and fig. 9, one of the same organs in a very early stage of development. In another species of sponge from the South Seas we find a singular variety of this class of ovarium. It is oval in form, the length being to the breadth as five to three, but it is so much depressed as to appear rather like a dermal spicula plate than an ovarium; but the radiate arrangement of its component spicula is perfectly visible with a power of 666 linear, and their distal terminations as separate and distinct as those of *Geodia* or *Pachymatisma*. The situation of the foramen is also well defined in many of them. Fig. 10, Plate XXXIV. represents a mature ovarium; fig. 11, a fragment of one to exhibit its degree of thickness; and fig. 12 represents one of the same species of ovarium in an early stage of development. I have seen four species of sponge which have this description of ovarium; in one it is very considerably longer in its proportions than that represented by fig. 10, Plate XXXIV., and in another species it is somewhat shorter.

Since the preceding portion of the account of the ovaria was written I have received a very remarkable specimen of these organs, which differs materially in its structure from any of the forms that I have previously described. The sponge consists of a small portion of basal membrane, closely resembling that of a Halichondraceous species. It was found by my friend Mr. J. YATE JOHNSTON coating rocks and stones at Madeira.

The remains of several exhausted ovaria are dispersed over the surface of the membrane, a few only retaining their original form and proportions. They do not appear to have had a spicular skeleton, but to have consisted of a coriaceous envelope strengthened and supported by a reticulated skeleton of apparently keratose structure. They are nearly globular, and are firmly cemented to the membrane by a broad basal attachment. Although themselves apparently in an effete state, the membrane on which they are seated was in a decidedly living and active condition. It is thickly coated with sarcode, and abundantly furnished with equi-anchorate spicula. Numerous slender acuate or subspinulate spicula are also dispersed over its surface, which are occasionally fasciculated after the manner of the first indications of the formation of a Halichondraceous skeleton. But the most interesting feature of the membrane is, that at intervals over the whole of its surface, and especially at those parts most free from the dispersed spicula, there are small detached groups of spicula, each consisting of two or three irregular fasciculi crossing each other at various angles, resembling in every respect the early stages of development of the gemmules or ova so graphically described by Dr. GRANT in his account of the gemmules of the sponge he has designated *Halichondria panicea*. The presence of these early developments of the ova is precisely in accordance with the discharged and effete condition of the ovaries, and is just such an effect as might naturally be expected under such circumstances. Fig. 13, Plate XXXIV. represents one of these ovaria seen by a microscopic power of 108 linear; fig. 14, a small piece of the reticulated wall of the ovarium with a power of 308 linear; and fig. 15 represents the development of one of the ova and the surrounding equi-anchorate spicula with a power of 108 linear.

Gemmules.

If we adopt as a definition that a gemmule is a body not containing ova, but that it is a vital mass separated from the parent and capable of being ultimately developed into a single individual possessing the same specific characters and capabilities as the parent mass, we must consider the reproductive bodies so ably and minutely described by Dr. GRANT in his paper "Observations on the Structure and Functions of the Sponge*," not under the designation of ova, but rather under that of gemmules; and indeed the learned author seems to have entertained some doubt of their being correctly designated by the former term, as in speaking of them in a subsequent portion of his paper in page 14, he says, "since these germs or so-named ova are, &c.;" I have therefore been induced to arrange them under the designation of Gemmules.

Dr. GRANT describes their first appearance in the sponge in the months of October and November "as opaque yellow spots visible to the naked eye, and without any definite form, size, or distribution, excepting that they are most abundant in the deeper parts of the sponge and are seldom observable at the surface;" he also states that "they have no cell or capsule, and appear to enlarge by the mere juxtaposition of the

* Edinburgh New Philosophical Journal, vol. i. p. 16, plate 2, figs. 24–29.

monad-like bodies around them. As they enlarge in size they become oval-shaped, and at length in their mature state they acquire a regular ovate form." When they have attained a fully-developed condition, they separate from their attachment to the parent and pass out of the fæcal orifices. At this period of their existence the learned author states that they are endowed with spontaneous motion, in consequence of their larger extremity being furnished abundantly with cilia, which the author describes as "very minute transparent filaments, broadest at their base, and tapering to invisible points at their free extremities." After floating freely about for a period, they attach themselves to some fixed body, adhering firmly to it, and spreading themselves out into "a thin transparent convex circular film." The author further states that "when two ova in the course of their spreading on the surface of a watch-glass come into contact with each other, their clear homogeneous margins unite without the least interruption, they thicken, and produce spicula: in a few days we can detect no line of distinction between them, and they continue to grow as one ovum."

I have never had the good fortune to see the living gemmule with its cilia in action, as described by Dr. Grant, but I have frequently found Halichondraceous sponges with an abundance of these gemmules attached to their tissues; and I have in my possession a beautiful little specimen, dredged off Shetland, for which I am indebted to my kind friend Mr. Barlee, which is very illustrative of Dr. Grant's description of the mode of the development of the young sponge after the ovum or gemmule has attached itself. On a fragment of a bivalve shell there are more than twenty or thirty of Dr. Grant's ova or gemmules, which are all in the same early stage of development, each forming a small group of extremely slender spicula. The groups are separate from each other, but very closely adjoining. The diameter of one of the largest does not exceed $\frac{1}{300}$th of an inch, and their distance from each other is about half or once the diameter of one of them. In their present state, as represented by six of them in Plate XXXIV. fig. 16, it is evident that they are separate developments, and it is equally evident that a slightly further amount of extension would have caused them to merge in one comparatively large flat surface of sponge. We see by this instance that a sponge is not always developed from a single ovum or gemmule, but, on the contrary, that many ova or gemmules are often concerned in the production of one large individual, and this fact may probably account for the comparatively very few small sponges that are to be found; a few days probably serving by this mode of simultaneous development to form the basal membrane of the sponge of considerable magnitude, as compared with the individual ovum or gemmule, or with a sponge developed from a single ovum only. This mode of reproduction appears to have a very wide range. It is common to several distinct genera of Halichondraceous sponges; and I have observed it also in a siliceo-fibrous sponge, *Iphiteon panicea* of the Museum of the Jardin des Plantes, Paris. Fig. 17, Plate XXXIV. represents a small piece from the interior of the skeleton of *Iphiteon panicea*. Although the latter sponge is so widely different in structure from the Halichondraceous tribes of sponges, its mode of propagation by gemmation seems to be in perfect accordance with them. In *Tethea cranium* the same mode of reproduction by gemmules obtains, but the form of the organ is different, and there are other peculiarities in its growth and development that are extremely interesting.

The form of the gemmules is regularly lenticular; and there are two distinct sorts of them, which are always grouped together. The first is rather the smaller of the two, and has a nucleus of slender curved fusiformi-acerate spicula only. The bases of the spicula cross each other at the centre of the gemmule, and the apices radiate in all directions towards the external surface, but do not, in the fully developed state of the gemmule, project beyond it. The second sort of gemmule is furnished with three distinct forms of spiculum. The first are like those of the gemmule described above, slender fusiformi-acerate; the second are attenuato-porrecto-ternate, the radii being given off from the apex at about an angle of 45 degrees; and the third form is attenuato-bihamate or unihamate, and the hooked apices of this form are projected further than either of the other two forms, but do not pass beyond the inner surface of the tough dermal envelope of the gemmule when in the adult state. I have examined a great number of these gemmules, and could never find in the form first described any indication of either ternate or hamate spicula, and I am therefore satisfied that they are separate descriptions of gemmule, and that the first form is not a transition state from the young and undeveloped to the fully developed one. In like manner I have closely observed the second form, and have always found it uniform in character, and furnished with the whole three forms of spicula that characterize it. It is highly probable that this marked difference in structure is sexual, and, from the more highly developed condition of the second or large form, that it is the female or prolific gemmule; but on this point we must at present be satisfied with conjecture only, as although I have searched diligently for spermatozoa in both forms of gemmule and in the surrounding sarcode, I have not been able to detect anything resembling them. But that such bodies do occur in some species of *Tethea* appears to be the case, Professor HUXLEY having described and figured bodies which he believed to be spermatozoa in a paper published in the 'Annals and Mag. Nat. Hist.' Second Series, vol. vii. p. 370, plate 14, as occurring in a species of *Tethea* found in one of the small bays in Sydney Harbour, Australia. The group of gemmules represented by fig. 1, Plate XXXV., consists of (*a*) one of the larger and supposed prolific gemmules, and three (*b*, *b*, *b*) of the presumed male gemmules *in situ*, $\times 108$. Wherever the former occurs the latter appear always to accompany them in the proportion of about two or three to one. They are not seated like the ovaria of *Geodia* at the surface of the sponge, but are always found on the interstitial membranes at a considerable depth within the sponge. The immersion of the specimen in Canada balsam has rendered the marginal lines of the gemmules undistinguishable from the surrounding sarcode, but their natural boundaries would be just beyond the extreme points of the spicula.

Fig. 2, Plate XXXV. represents one of the larger gemmules in its natural condition and separated from the sponge, by direct light and a linear power of 50. Figs. 39, 40, and 43, Plate XXVI. Phil. Trans. 1858, represent the spicula of the larger description of gemmule of *Tethea cranium*, after separation by nitric acid.

The reproductive bodies in the *Tethea* described by Professor HUXLEY do not resemble those in *T. cranium*; no spicula are either described or figured as existing in them, and in this respect they appear much more to resemble the reproductive organs described by Dr. GRANT as existing in the Halichondraceous sponges of the Firth of Forth. But I am not surprised at this discrepancy, as in *Tethea simillima*, BOWERBANK, MS., in the collection of the Royal College of Surgeons, from the Antarctic regions of the South Sea, a species very closely resembling *T. cranium*, the gemmules are so like those of the latter species as not to be readily distinguished from them in their natural condition; but when microscopically examined, not the slightest trace could be found of the smaller, and what I conceived to be the male gemmule in *T. cranium*. I have several other species of *Tethea* in my possession, but I have not yet found gemmules in the interior of any of them.

External Gemmulation.

In *Tethea Lyncurium* we have gemmules produced externally, which are perhaps much more entitled to that designation than any of the reproductive organs previously described. The fasciculi near the base of the *Tethea* are protruded considerably beyond the surface of the animal, and at the termination of each there appears a small mass of sarcode, which assumes a more or less globular form. If their bodies be immersed in Canada balsam and examined microscopically, they will be found to contain not only the spicula projected from the parent, but a second series, which have been secreted in the mass, and which have assumed the mode of disposition so characteristic of the skeleton of the parent *Tethea*. I am indebted to my friend Mr. T. H. STEWART for this interesting fact, and for the specimens illustrating it. They were found in Plymouth Sound.

Fig. 19, Plate XXXIV. represents one of these gemmules with a portion of the skeleton fasciculus on which it is produced, under a linear power of 50.

Propagation by Sarcodous Division.

The fact of the resolution of the sarcode of the interstitial tissues of *Spongilla* into small masses of unequal size and variable form has long been known to naturalists, and that when separated from the parent body each becomes capable of locomotion, and of ultimately becoming developed into a perfect sponge. CARTER, in his valuable paper published in the Journal of the Bombay branch of the Royal Asiatic Society, No. 12, 1849, has given a minute account of their structure and motions when separated from the species which form the subjects of his paper, and his descriptions are in perfect accordance with the similar bodies separated from our European species *S. fluviatilis*, which I have had frequent opportunities of observing, and of confirming the history given by him of their locomotive powers and continual inherent motions. The author designates these bodies "sponge-cells," and treats of them as if they had a well-defined cell-wall, while their eccentric changes of form are perfectly inconsistent with such a structure. LIEBERKUHN, in treating of these bodies under the name of motile spores, states that he has never succeeded in discerning a "cell-membrane" around these particles, and my own observations are in perfect accordance with his experiences. The truth appears simply to be, that any minute mass of sarcode, whether separated voluntarily or involuntarily, has inherent life and locomotive power, and is capable of ultimately developing into a perfect sponge; and in the course of this process the dermal membrane is produced at a very early period, and this, surrounding an agglomeration of minute masses of sarcode, may have been mistaken by CARTER for a cell-membrane. The same author, in his observations "On the Species, Structure, and Animality of the Freshwater Sponges in the Tanks of Bombay," states, "that when the transparent spherical capsules which contain the granules within the seed-like bodies are liberated by breaking open the latter under water in a watch-glass, their first act is to burst; this takes place after the first thirty-six hours; and their granules, which will presently be seen to be the true ova of a proteaniform infusorium, varying in diameter from about the $\frac{1}{4300}$th part of an inch to a mere point, gradually and uniformly become spread over the surface of the watch-glass. On the second or third day (for this varies) each granule will be observed to be provided with an extensible pseudo-pediform base; and the day after most of the largest may be seen slowly progressing by its aid, or gliding over the surface of the watch-glass in a globular form by means of some other locomotive organs."

This description is strikingly similar to the same author's account of the masses of sarcode separated from the sarcodous lining of the interstitial canals of *Spongilla*: but it must be observed that, in the development of the egg, the first act is to liberate itself from the membranous envelope; and the contents thus hatched become moving masses of free sarcode, but without the locomotive cilia that are found on the so-called ova or gemmules of the marine sponges, so minutely and accurately described by Dr. GRANT in his papers "On the Structure and Functions of the Sponge" in the 'Edinburgh New Philosophical Journal,' vol. ii. p. 129. This author describes the ovum or gemmule of *Halichondria panicea* (*Hal. incrustans*, JOHNSTON), after having floated freely about for a period by means of the cilia around its larger extremity, as attaching itself to a fixed body by its smaller end and then gradually settling down in the form of a broad flat mass, and, after losing its cilia, being gradually developed in the form of the parent sponge. Thus every description by these close and accurate observers tends to the conclusion that the multiplication of the sponge is effected by the origination in the ovum, or by the agglomeration in the form of gemmules, of particles of sarcode. The action of the minute masses of sarcode liberated by the bursting of the envelope of the ovum, and their subsequent development, are precisely those of the so-called sponge-cell liberated from the mass of the sarcode lining the interstices of the sponge, and of the gemmules described by GRANT, when sessile: each moves independently at first; each unites with its congeners into one body; and the results, both in means and end, are precisely the same: but their origin is different. The one is a gemmation of sarcode within a proper membrane in the form of an egg, while the others are the production of a gemmule by independent growth, or by spontaneous division of the sarcodous substance of the sponge.

Both these modes of propagation occur in the same species, *Spongilla fluviatilis*, but I have never yet seen them both well developed in the same individual. Where the ovaria were abundant, the sarcode appeared even and consistent in its structure; and, on the contrary, if it exhibited manifest symptoms of granulating, very few or none of the ovaria could be detected. This double means of propagation is by no means uncommon among the Zoophytes.

I have never seen the spontaneous granulation of the sarcode in any living marine species of sponge; but as the vital powers and general physiological characters of that substance appear to be the same in all the Spongiadæ, however varied in form and structure, it is highly probable that perpetuation by spontaneous or accidental separation of minute masses of sarcode is by no means confined to *Spongilla*, and that, from the concurrent testimony of all who have investigated the subject, every molecule of sarcode, however minute, has inherent vitality, and the power of uniting with its own congeners whenever they may chance to come in contact.

Growth and Development of Sponges.

The growth of the sponge does not appear to be continuous, but periodical, as we may observe in the branching species, and especially in *H. palmata*. If the sponge be held up between the eye and a lighted candle, as many as five or six of the former pointed terminations of the sponge in succession, from near the base to the apex, may be seen; and the former lateral boundaries are also equally distinct, the oscula being most frequently, but not always, continued through the new coating of the lateral development of the spongeous structure. New branches are also frequently thrown out during the last period of development at various parts of the stem where no indication of branches existed previously. In all these newly-developed parts, it may be observed that the primary lines of the structure of the skeleton, or those radiating at nearly right angles to the axis of the sponge, are those which are first developed; and at the extreme points of the branches they are frequently seen projecting for, comparatively, a considerable distance in the form of single unsupported threads or filaments; but as we trace these lines inward, we find the secondary or connecting fibres increasing in number, and the network becoming closer and more fully developed. The same mode of development may be traced in *Halichondria oculata*, Johnston, but not to such an extent as in *H. palmata*, Johnston. In the sessile massive species of Halichondroid sponges the same mode of development seems to obtain, as I have frequently traced the different stages of growth in sections at right angles to the surface of the sponge.

Explanation of the Plates.

PLATE XXVII.

Fig. 1. Fibro-membranous tissue in which the layers of fibre cross each other at various acute angles, from *Polymastia robusta*, Bowerbank, MS., ×308 linear: page 751.

Fig. 2. Fibro-membranous tissue in which the layers of fibre cross each other at about right angles, from *Polymastia robusta*, Bowerbank, MS., ×666 linear: page 751.

Fig. 3. Fibro-membranous tissue from the dermal membrane of a species of *Stematumenia*. The fibres are disposed without order, ×183 linear: page 751.

Fig. 4. Fibro-membranous tissue containing a single layer of parallel fibres on a portion of the membrane from an excurrent canal of one of the common honeycomb sponges of commerce, ×666 linear: page 751.

Fig. 5. A portion of the dermal membrane of a young *Stematumenia*, with cells which produce the primitive fibres dispersed on its inner surface:—*a*, *a*, cells *in situ*, which have each produced a fibre, ×666 linear: page 752.

Fig. 6. Three fibres in progressive states of development:—*a*, exhibiting no indications of an ultimate separation from the basal cell; *b*, showing the mature termination of the fibre previous to separation; *c*, exhibiting the collapsed remains of the exhausted basal cell, ×666 linear: page 752.

Fig. 7. Solid keratose fibre from a cup-shaped specimen of the best Turkey sponge of commerce in the condition in which it came from the sea, ×175 linear: page 754.

Fig. 8. Fibres of the skeleton of *Halichondria oculata*, Johnston, illustrating spiculated keratose fibre, ×175 linear: page 755.

Fig. 9. A young fibre of *Halichondria Montagui*, Johnston: *a*, the apical spiculum, ×175: page 755.

Fig. 10. A fibre from the skeleton of *Halichondria œgagropila*, Johnston, illustrating the structure of multispiculated keratose fibre, ×108: page 755.

Fig. 11. A longitudinal section of a small fibre of the skeleton of *Raphyrus Griffithsii*, Bowerbank, MS., showing the irregular disposition of the spicula within it, ×90 linear: *a*, one of the spicula, ×175 linear: page 755.

Fig. 12. Simple keratose fistulose fibre from *Spongia fistularis*, Lamarck, ×108 linear: page 756.

Fig. 13. Compound fistulose keratose fibre from the skeleton of an *Auliskia*, ×100 linear: *a*, *a*, the minute tubular fibres traversing the central cavity of the skeleton-fibre: page 756.

Fig. 14. A portion of one of the skeleton-fibres of *Auliskia*, exhibiting the secondary canals radiating from the primary ones, ×300 linear: page 756.

PLATE XXVIII.

Fig. 1. Regular arenated keratose fibre from the skeleton of a coarse rigid Australian sponge, ×90 linear: page 757.

Fig. 2. Regular arenated keratose fibre from a flexible sponge, one of the common Bahama sponges of commerce, ×175 linear: page 757.

Figs. 3, 4, and 5. Portions of skeleton-fibre from a specimen of *Dysidea fragilis*, JOHNSTON, illustrating the varieties of form of irregular arenated keratose fibre, ×108 linear: page 757.

Fig. 5. Showing the mode by which the apex of the fibre attaches itself to a single grain of sand, ×108 linear: page 757.

Fig. 6. Smooth solid siliceous fibre, with young fibres pullulating from the adult ones at *a*. From the skeleton of *McAndrewsia azoïca*, GRAY, ×175 linear: page 758.

Fig. 7. Tuberculated solid siliceous fibre from the skeleton of *Dactylocalyx pumicea*, STUTCHBURY, ×108 linear: page 758.

Fig. 8. Tuberculated solid siliceous fibre, very prominently tuberculated, from *Dactylocalyx Prattii*, BOWERBANK, MS., ×175 linear: page 758.

Fig. 9. Fibrillated sponge-fibre from the skeleton of one of the sponges of commerce, ×308 linear: page 754.

Fig. 10. Fibrillated sponge-fibre from the skeleton of an Australian sponge, ×175 linear: page 754.

Fig. 11. Spinulated simple fistulose siliceous fibre, from a sponge in the collection of Dr. ARTHUR FARRE, *Farrea*, BOWERBANK, MS., ×108 linear: page 758.

Fig. 12. Cidarate prehensile fibre from a parasitical siliceo-fibrous sponge from the South Sea, showing the position of the prehensile organs at the base of the sponge, ×83 linear: page 759.

Fig. 13. A group of cells on a portion of the interstitial membrane of *Ecionemia acervus*, BOWERBANK, MS., ×666 linear: page 759.

Fig. 14. Cells on a portion of the interstitial membrane of *Halichondria nigricans*, BOWERBANK, MS., ×308 linear: page 759.

Fig. 15. Detached nucleated cells from a new species of sponge from Freemantle, Western Australia, ×308 linear: page 759.

Fig. 16. A view of the upper stratum of cells of one of the ovaria of *Spongilla friabilis*, CARTER, ×308 linear: page 760.

PLATE XXIX.

Fig. 1. A piece of an interstitial membrane from the honeycomb sponge of commerce in the condition in which it came from the sea, exhibiting the sarcode on its surface, and the imbedded semi-digested minute molecules, ×666 linear: page 760.

Fig. 2. A spinulate spiculum from *Halicnemia patera*, BOWERBANK, MS., ×175 linear: page 766.

Fig. 3. A bispinulate spiculum from the same sponge, ×175 linear: page 766.

Fig. 4. A trispinulate spiculum from the same sponge, ×175 linear: page 766.

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Fig. 8. Inner surface of the dermal crust of *Dactylocalyx Prattii*, showing the manner in which the apices of the radii of the ternate spicula are spliced on each other to form the areas for the intermarginal cavities, ×108 linear: page 767.

Fig. 9. Three of the ternate spicula of *Dactylocalyx Prattii*, exhibiting the variations in form and the compressed condition of their radii, ×108 linear: page 767.

Fig. 10. A portion of a thin section at right angles to the surface of a specimen of *Halichondria seriata*, JOHNSTON, illustrating the mode of external defence by the prolongation of the radial lines of the skeleton, ×108 linear: page 769.

Fig. 11. Part of a small branch of *Dictyocylindrus rugosus*, BOWERBANK, MS., exhibiting the radiating structure of the defensive fasciculi, ×50 linear: *a*, a part of the central axis of spicula: page 770.

Fig. 12. A portion of a slice at right angles to the surface from *Tethea cranium*, showing the fasciculi of defensive spicula (*a*), and the mode in which they are supported by buttresses of spicula beneath the surface of the sponge at *b*: *c*, the recurvo-ternate spicula, ×50 linear: page 770.

PLATE XXX.

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Fig. 4. *a*, The basal portion of one of the skeleton-spicula of *Hymeraphia stellifera*, with its large bulbous base, ×260 linear: *b*, one of the stelliferous internal defensive spicula, ×260 linear: page 771.

Fig. 5. A small portion of a longitudinal section through the cloaca of a specimen of *Grantia tessellata*, BOWERBANK, MS., showing the positions of the internal defensive spicula, and their curvature towards the mouth of the cloaca, ×108 linear: page 772.

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Fig. 7. Verticillately spined internal defensive spicula dispersed on keratose fibres of the skeleton, from a West Indian sponge, ×175 linear: page 773.

Fig. 8. Verticillately spined internal defensive spicula from a keratose sponge from the West Indies. Congregated in fasciculi, ×175 linear: page 773.

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Fig. 10. A portion of the reticulated skeleton of the sponge, with the radiating fasciculi of spinulo-quaternate internal defensive spicula *in situ*, ×108 linear: page 775.

PLATE XXXI.

Fig. 1. A portion of the reticulated skeleton of a sponge from Madeira, the fibres armed with trenchant contort bihamate spicula, ×50 linear: page 776.

Fig. 2. One of the trenchant contort bihamate spicula, showing the cylindrical form at the curves of the hook and the middle of the shaft, and the trenchant edges of the rest of the inner surfaces of the spiculum, ×400 linear: page 776.

Fig. 3. A portion of the skeleton of *Hyalonema mirabilis*, GRAY, showing the mode of disposition of the multihamate birotulate and spiculated cruciform spicula in the body of the sponge. In the collection at the British Museum, ×50 linear: page 777.

Fig. 4. A multihamate birotulate spiculum, magnified 175 linear, to exhibit the peculiarities of its structure: page 777.

Fig. 5. A spiculated cruciform spiculum, to show the relative proportions of the two forms of defensive spicula, ×175 linear: page 777.

Fig. 6. The same form of spiculum as fig. 5, showing the peculiarities of its spination, × 260 linear: page 777.

Fig. 7. A small portion of the skeleton of *Hyalonema mirabilis*?, GRAY, from a specimen in the Bristol Museum, showing the reticulations of the skeleton to be abundantly supplied, in some parts, with a small variety of multihamate birotulate spicula: *a*, one of the large spicula, of the same form as those in fig. 5, *in situ*, × 108 linear: page 777.

Fig. 8 represents a small portion of the inner surface of the dermal membrane of *Hymedesmia Zetlandica*, BOWERBANK, MS., showing the fasciculation of the simple bihamate spicula, the equi-anchorate ones dispersed singly on the membrane, and the large attenuato-acuate entirely spined defensive ones *in situ*, × 308 linear: page 780.

Fig. 9. A young circular group of inequi-anchorate spicula, situated on one of the interstitial membranes of *Hymeniacidon lingua*, BOWERBANK, MS., × 308 linear: page 780.

Fig. 10. A larger and more complete circular group of inequi-anchorate spicula, containing about the usual number of spicula, from the same sponge as the group represented by fig. 9, × 308 linear: page 781.

Fig. 11. A circular group of torqueato-tridentate inequi-anchorate spicula from the interstitial membranes of a new species of *Hymeniacidon* from Freemantle, Australia, × 308 linear: page 781.

Fig. 12. A single spiculum, from a group similar to that represented by fig. 11, exhibiting the singular structure of the base and the tridentate apex of the spiculum, × 400 linear: page 781.

Fig. 13. A section of *Halichondria panicea*, JOHNSTON, showing the intermarginal cavities at *a*, *a*, immediately beneath the dermal surface, × 108 linear: page 787.

Fig. 14. A small portion of the dermal membrane of *Tethea muricata*, BOWERBANK, MS., exhibiting the pores in an open condition, × 108 linear: page 782.

Fig. 15. The lower portion of the same piece of membrane, highly magnified, to show the positions of the elongo-stellate defensive spicula on the external surface of the dermal membrane, × 183 linear: page 782.

PLATE XXXII.

Fig. 1. A section at right angles to the surface of a branch of *Halichondria simulans*, JOHNSTON, exhibiting the form and position of the intermarginal cavities, × 108 linear: page 787.

Fig. 2. A section, at right angles to the surface, of *Geodia Barretti*, BOWERBANK, MS.:—*a*, *a*, longitudinal sections of two of the intermarginal cavities; *b*, *b*, the basal diaphragms of the intermarginal cavities; *c*, *c*, imbedded ovaria, forming the dermal crust of the sponge; *d*, *d*, the large patento-ternate spicula, the heads of which form the areas for the valvular bases of the intermarginal cavities; *e*, *e*, *e*, recurvo-ternate defensive and aggressive spicula within the summits of the great intercellular spaces of the sponge; *f*, *f*, portions of the interstitial membranes of the sponge, crowded with minute stellate spicula; *g*, *g*, portions of the secondary system of external defensive spicula, × 50 linear: page 788.

Fig. 3. View of a small portion of the inner surface of the dermal crust of *Geodia Barretti*, BOWERBANK, MS., with three of the valvular membranes of the proximal ends of the intermarginal cavities:—*a*, *a*, valves closed; *b*, a valve partly open; *c*, *c*, the radii of the patento-ternate spicula, imbedded in the tissues,

and forming the areas for the support of the valvular terminations of the intermarginal cavities, × 50 linear: page 788.

Fig. 4. Four groups of inhalant pores in the dermal membrane, situated immediately above the distal ends of the intermarginal cavities of *G. Barretti*, × 83 linear: page 794.

Fig. 5. A portion of the dermal surface of *Halichondria panicea*, Johnston, showing the multispicular network for the support of the dermal membrane, and the open pores in the areas, × 108 linear: page 793.

Fig. 6. A small portion of the dermal membrane from *Dictyocylindrus stuposus*, Bowerbank, MS., exhibiting the number and position of the minute sphero-stellate defensive spicula with which it is armed, × 308 linear: page 793.

Fig. 7. A small portion of the quadrilateral siliceo-fibrous network of the dermis of the sponge upon which Dr. A. Farre's specimen of *Euplectella cucumer*, Owen, is based, showing the double series of entirely spined spicular organs projected from its angles, × 108 linear: page 790.

Fig. 8. A small portion of the single-seried dermal spicular network of *Isodictya varians*, Bowerbank, MS., × 108 linear: page 792.

Fig. 9. A piece of reticulated kerato-fibrous tissue, for the support of the dermal membrane of one of the species of the common West Indian sponges of commerce, × 108 linear: page 792.

PLATE XXXIII.

Fig. 1. A longitudinal section of the intermarginal cavities of *Grantia compressa*, showing the cilia and their basal cells *in situ*, × 500 linear: page 806.

Fig. 2. A view of a small portion of the inner surface of *Grantia compressa*, exhibiting the oscula open, and the appearance presented at their orifices by the cilia within in action, × 500 linear: page 806.

Fig. 3. Two detached tessellated cells and their cilia, (*a*) in the position of inaction, (*b*) in the position of action, × 1250 linear: page 806.

Fig. 4. A group of detached tessellated cells from the interior of the intermarginal cavities of *Grantia compressa*, × 1250 linear: page 807.

Fig. 5. An ovarium of *Spongilla fluviatilis* in its natural state, exhibiting the foramen, × 83 linear: page 808.

Fig. 6. A small piece of a fibre of the skeleton of one of the common Bahama sponges of commerce, with numerous ova imbedded in its surface, × 400 linear: page 809.

Fig. 7. A small piece of the fibre represented by fig. 6, exhibiting the varieties in form and proportion of the ova, × 1250 linear: page 809.

Fig. 8. View of a section at right angles to the surface of a fragment of the skeleton of the ovarium of *Spongilla fluviatilis*, prepared with nitric acid, exhibiting the

relative positions of the spicula in the skeleton:—*a*, a spiculum from the same ovarium, detached, × 308 linear: page 811.

Fig. 9. A perfect skeleton of an ovarium of *Spongilla fluviatilis*, prepared with nitric acid, × 183 linear: page 811.

Fig. 10. A skeleton of an ovarium of *Spongilla lacustris*, prepared with nitric acid, exhibiting the spicula *in situ* and the foramen, × 183 linear: page 811.

Fig. 11. Two of the reticulated cases of the ovaria of *Spongilla Brownii*, BOWERBANK, MS.:—*a*, an empty case; *b*, a case containing the skeleton of an ovarium, × 50 linear: page 813.

Fig. 12. A reticulated case of an ovarium of *Spongilla reticulata*, BOWERBANK, MS., × 175 linear: page 812.

Fig. 13. Skeleton of an ovarium of *Spongilla reticulata*, BOWERBANK, MS., without its case, prepared with nitric acid, × 175 linear: page 812.

PLATE XXXIV.

Fig. 1. A perfect ovarium of *Diplodemia vesiculata*, BOWERBANK, MS., and a portion of a second one, showing the interior and the thickness of its walls in its natural state, × 83 linear: page 813.

Fig. 2. An ovarium of *Geodia McAndrewii*, BOWERBANK, MS., in very nearly an adult state, showing the structure and position of the conical foramen for the discharge of the ova, natural condition, × 183 linear: page 815.

Fig. 3. A small portion of the surface of a fully-developed ovarium of *Geodia McAndrewii* in its natural state, showing the distal ends of the spicula flat and angular, and firmly cemented together, × 308 linear: page 815.

Fig. 4. A portion of a young ovarium of *Geodia McAndrewii*, with the distal ends of its spicula acutely terminated, and unconnected, × 308 linear: page 815.

Fig. 5. A portion of a section through nearly the centre of a mature ovarium of *Geodia McAndrewii*, showing the radiation of its spicula from near the centre to its circumference, × 308 linear: page 815.

Fig. 6. Two ovaria of *Geodia McAndrewii*, (*a*) containing about the maximum of ova, (*b*) after a great part of the ova have been discharged, × 108 linear: page 814.

Fig. 7. A mature ovarium of *Pachymatisma Johnstonia*, BOWERBANK, exhibiting the cuneiform spicula of the foramen, × 308 linear: page 815.

Fig. 8. A young ovarium of *Pachymatisma Johnstonia* in course of development, × 308 linear: page 815.

Fig. 9. A young ovarium of *Pachymatisma Johnstonia* in a very early stage of development, × 308 linear: page 815.

Fig. 10. An ovarium from a sponge from Madeira closely allied to *Pachymatisma*, exceedingly depressed and much elongated, × 308 linear: page 815.

Fig. 11. A fragment of a similar ovarium to that represented by fig. 10, the fracture showing its extremely thin condition, × 308 linear: page 815.

Fig. 12. A young ovarium of the same species as that represented by fig. 10, in an early stage of development, × 308 linear: page 815.

Fig. 13. A reticulated ovarium *in situ*, on the fragment of a sponge from Madeira, ×108 linear: page 816.

Fig. 14. A portion of the reticulated structure from an ovarium of the same description as represented by fig. 13, × 308 linear: page 816.

Fig. 15. An ovum in course of development into a young sponge on the same membrane as that on which the ovarium represented by fig. 13 is seated, × 108 linear: page 816.

Fig. 16. A group of ova or gemmules in course of development into young sponges, found, with many others, on the inner surface of a fragment of a large *Pecten* from Shetland, × 108 linear: page 817.

Fig. 17. A small portion of the skeleton of *Iphiteon panicea* in the Museum of the Jardin des Plantes, Paris, with gemmules *in situ*, × 183 (*Dactylocalyx*, STUTCHBURY): page 817.

Fig. 18. A gemmule detached from *Iphiteon panicea*, × 666 linear: page 817.

Fig. 19. A gemmule extruded from near the base of a specimen of *Tethea Lyncurium*, on the distal extremity of one of the skeleton fasciculi, × 50 linear: page 819.

PLATE XXXV.

Fig. 1. A group of internal gemmules *in situ*, on the interstitial membranes of *Tethea cranium*:—*a*, one of the larger and most completely organized gemmules; *b*, *b*, *b*, three of the smaller and more simple gemmules which always accompany the larger ones. In Canada balsam, × 108 linear: page 818.

Fig. 2. One of the larger description of gemmules of *Tethea cranium*, in its natural state, removed from the membrane and viewed by direct light, × 25 linear: page 818.

Fig. 3 represents a portion of the sponge from the East Indies, furnished with numerous depressed porous areas with protecting organs, natural size: page 794.

Fig. 4. Two of the inhalant areas, connected by the dermal network:—*a*, the external protective organ in a perfect condition; *b*, having the external protective organ removed to exhibit the deeply depressed porous area, × 50 linear: page 794.

Fig. 5. Half of one of the external defensive organs, highly magnified, to exhibit the disposition of the spicula on the follicular radiations of the organ, × 108 linear: page 794.

Fig. 6. A view of the interior surface of half of one of the external defensive organs, exhibiting the structure of the semifollicular radiations of the organ, × 108 linear: page 794.

Supplement to Part I. "On the Anatomy and Physiology of the Spongiadæ," by J. S. BOWERBANK, *LL.D., F.R.S., F.L.S. &c.—Descriptions of New Forms of Spicula that have been discovered since the publication of the First Part* (*Phil. Trans.* 1858, *p.* 279).

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Spicula of the Skeleton.

FARCIMULO-CYLINDRICAL (Plate XXXVI. fig. 1).—This is the shortest and stoutest form of skeleton-spiculum I have yet seen. It forms the entire skeleton of *Spongilla coralloides*, BOWERBANK, MS. A new species from the River Amazon. In the collection of the Royal College of Surgeons of London.

INEQUI-ACERATE VERMICULOID (Plate XXXVI. fig. 2).—These spicula are found dispersed in great numbers in the basal membrane of *Hymeraphia vermiculata*, BOWERBANK, MS. A new species of British sponge from Shetland. No two of them agree in the form or amount of their contortions, but all of them are more or less inequi-acerate.

NODULATED CYLINDRICAL VERMICULOID (Plate XXXVI. fig. 3).—The sponge whence this spiculum is derived has not yet been found. It occurs along with inequi-acerate vermiculoid and other well-known forms of sponge-spicula in the soundings from the Atlantic, in 2070 fathoms, and, like the last-named form, no two of them agree in the mode or amount of their contortions.

ELONGO-EQUIANGULATED TRIRADIATE (Plate XXXVI. fig. 4).—An auxiliary skeleton-spiculum from the surface of *Grantia striatula*, BOWERBANK, MS. From Madeira. The elongate ray is always disposed in accordance with the long axis of the sponge.

EXFLECTED ELONGO-EQUIANGULATED TRIRADIATE (Plate XXXVI. fig. 5).—From the surface near the base of *Grantia striatula*, BOWERBANK, MS. From Madeira. The elongated ray in this form, as well as the one represented by fig. 4, varies considerably in its proportions.

DOLIOLATE CYLINDRICAL (Plate XXXVI. fig. 6).—From a portion of the skeleton of a sponge nearly related to *Ecionemia*, BOWERBANK, MS. Locality unknown.

BIFURCATED EXPANDO-TERNATE (Plate XXXVI. fig. 7).—From the same sponge as fig. 6; the shaft of the spiculum assisting in the formation of the skeleton, while the ternate terminations act as external defensive spicula.

PORRECTO-TERNATE (Plate XXXVI. fig. 8).—From the same sponge as fig. 6; the shaft belonging to the skeleton and the ternate apex acting as an external defensive spiculum.

EXPANDO-TERNATE (Plate XXXVI. fig. 9).—From the same sponge as fig. 6; the shaft acting as a skeleton-spiculum, while the ternate apex serves as a defensive spiculum.

Geniculated expando-ternate (Plate XXXVI. fig. 10).—From *Tethea Collingsii*, Bowerbank, MS. Sark. The shaft acts as a subsidiary skeleton-spiculum, and the ternate apex as a defensive one.

Abbreviato-patento-ternate (Plate XXXVI. fig. 11).—From a sponge allied to *Pachymatisma*, in the Museum of the Royal College of Surgeons, London. External defensive. The example figured is a fully-developed spiculum.

Inflato-fusiformi-acerate, ascendingly hemi-spinous (Plate XXXVI. fig. 12).—From *Hyalonema mirabilis*, Gray. British Museum. These spicula are projected in great numbers from the dermal surface of the body of the sponge, the smooth basal half being immersed in the tissues beneath the dermal membrane, and the spinous distal portion projected beyond it. The form and mode of disposition of the spines indicate its purely defensive character.

Verticillately spined cylindrical (Plate XXXVI. fig. 13).—This spiculum is very abundant on the dermal and interstitial membranes of an undescribed sponge from Freemantle, Western Australia. It is both externally and internally defensive.

Sub-attenuato, entirely spined cylindrical (Plate XXXVI. fig. 14).—From *Hymeniacidon Cliftoni*, Bowerbank, MS. Freemantle, Western Australia. Internal defensive.

Spiculated inequi-angulated triradiate, with cylindrical entirely spined radii (Plate XXXVI. fig. 15).—From a fragment of a sponge presented to me by Mr. Vickers of Dublin, who thinks it probably came from the West Indies. This spiculum is an external defensive one. The triradiate rays are imbedded immediately beneath the dermal membrane, and the spicular ray is projected through it at right angles to its plane; they are very numerous.

Spiculated attenuato-equiangular triradiate, verticillately spined (Plate XXXVI. fig. 16).—From an undescribed sponge. Freemantle, Western Australia. I have not seen the sponge whence this spiculum is derived, but, reasoning from our knowledge of the form and situation of the spiculum represented by fig. 15, there can be little doubt of its being an external defensive one.

Spiculated cylindro-equiangular triradiate, verticillately spined (Plate XXXVI. fig. 17).—From a fragment of sponge from Freemantle, Australia. This spiculum occurs in the same slide of sponge-spicula as the form represented by fig. 16. It was sent to me by my friend Mr. George Clifton, of Freemantle. There can be little doubt of its being an external defensive organ.

Inequi-furcato-triradiate (Plate XXXVI. figs. 18 & 19).—These forms of spicula are from a new species of calcareous sponge, probably a *Grantia*. They were sent to me, mounted in Canada balsam, by my friend Mr. George Clifton, of Freemantle, Australia. They occur loosely fasciculated, and their mode of disposition is very similar to those represented by figs. 4 & 5, Plate XXXVI. They differ considerably from each other in length and in the width of the prongs of the fork apart, but they all have them unequal in length. It is probably an auxiliary skeleton and external defensive spiculum.

ELONGO-RECURVATE DENTATO-BIROTULATE (Plate XXXVI. fig. 20).—From *Hyalonema mirabilis*, GRAY. This spiculum is from the same sponge as that represented by fig. 4, Plate XXXI. Part II. It is an extreme variety of that form. Fig. 7, *a*, in the same plate, appears to be an intermediate variety.

ELONGO-RECURVATE DENTATO-BIROTULATE (Plate XXXVI. fig. 21).—From soundings in the Indian Ocean, 2200 fathoms. The smooth shaft and the widely-spread teeth of this spiculum render it very probable that it belongs to an unknown species of *Hyalonema.*

RECURVO-ACUTELY DENTATE BIROTULATE (Plate XXXVI. fig. 22).—From soundings in the Indian Ocean, 2200 fathoms. The thin smooth shaft and the acutely-terminated teeth of this form indicate probably a species of *Hyalonema* unknown to naturalists at present.

RECURVO-DENTATO-BIROTULATE (Plate XXXVI. fig. 23).—From soundings in the Indian Ocean, 2200 fathoms. The fragment represented is most probably from another unknown species of *Hyalonema.* It is the only specimen of this form that has, I believe, been found.

ATTENUATO-CYLINDRICAL, VERTICILLATELY SPINED (Plate XXXVI. figs. 24 & 25).—These spicula are found dispersed in abundance on the interstitial and dermal membranes of *Hymeraphia verticillata*, BOWERBANK, MS. A new British species, brought up by the sounding-line from 100 fathoms, off the Western Coast of Ireland, by the officers of H.M. ship 'Porcupine.' It is remarkable as being the only verticillately-spined spiculum that has been found in a British species of sponge, and also for exhibiting the mode of development of that class of spicula. In the earliest stage the spiculum is long, slender, and perfectly smooth; as the growth proceeds, two or three slight inflations appear near the middle of the shaft, and others are successively developed beyond them, until the spiculum assumes the moniliform appearance represented by fig. 25. As the inflations increase in number and size, a few incipient spines appear in a circumferential line at their greatest diameter; and as the growth proceeds, the spines increase in number and size, and the spaces between the inflations are filled up by the expansion of the shaft; and this mode of development is continued until the adult spiculum assumes the form represented by fig. 24. This form appears to act both as a tension and a defensive spiculum.

Spicula of the Sarcode.

TORQUEATO-BIDENTATE INEQUI-ANCHORATE (Plate XXXVI. fig. 26).—From an undescribed species of sponge. Freemantle, Western Australia. Sent to me, mounted in Canada balsam, by Mr. GEORGE CLIFTON. This is closely allied to the one represented by fig. 12, Plate XXXI. Part II.

Bicalcarate bihamate (Plate XXXVI. fig. 27).—This singular and minute form of spiculum has hitherto been found only in *Isodictya Normani*, Bowerbank, MS. A new British species.

Expando-tridentate equi-anchorate (Plate XXXVI. fig. 28).—From an undescribed sponge in the British Museum. The shaft of this minute spiculum is frequently curved to the extent of nearly a semicircle. Expando-bidentate forms are also mingled with the tridentate ones.

Tridentate fimbriated equi-anchorate (Plate XXXVI. fig. 29).—From *Isodictya fimbriata*, Bowerbank, MS. Shetland. The singular fimbriation of the shaft of the spiculum has never been observed in any other anchorate spiculum. In this sponge the spicula of this form may be traced from the earliest stage of development to the fully fimbriated form exhibited by the one represented by fig. 28. They are very abundant on the interstitial and dermal membranes, and mixed with them; there are many that are only bidentate, but are as completely fimbriated as the tridentate ones. The fimbriæ are very delicate and translucent, and require a careful management of the light to render them apparent.

Quadrihamate (Plate XXXVI. fig. 30).—From *Hyalonema mirabilis*, Gray. These very minute spicula are dispersed in considerable numbers on the interstitial membranes of the sponge.

Inequi-trirotulate (Plate XXXVI. fig. 31).—From an undescribed sponge in the cabinet of my friend Mr. George Clifton, of Freemantle, Western Australia. In Plate XXVI. fig. 38 I have figured a more fully developed specimen of this form, and described it in the 'Philosophical Transactions' for 1858, page 319, believing at that time that it was probably derived from the ovarium of a *Spongilla*. From the structural differences of the two specimens, it is probable that the former one is not from the same species of sponge as the latter.

Eccentric trirotulate (Plate XXXVI. figs. 32 & 33).—From the same sponge as fig. 31. Fig. 33 presents the fully-developed axial eccentricity, while the axis in the spiculum represented by fig 32 is both centrical and eccentrical, and these variations in the mode of the development of the rotulæ are exceedingly common.

Cylindro-cruciform (Plate XXXVI. figs. 34, 35, 36, 37).—From *Hyalonema mirabilis*, Gray. British Museum. These four forms occur in considerable numbers, either imbedded in, or immediately surrounding the thick coriaceous sheath which envelopes the spiral column that is projected from the base of the sponge through its centre. All the imaginable varieties of form between figs. 34 and 37 are found mixed together; and they appear to be especially abundant around that part of the column which is imbedded in the midst of the sponge. The cylindrical form represented by fig. 34 is of rare occurrence without a slight indication near the middle of the absent third and fourth rays of the perfect cruciform spiculum.

Spiculated cylindro-cruciform (Plate XXXVI. fig. 38).—From *Hyalonema mirabilis*, Gray. British Museum. This spiculum is from the sheath of the same sponge as the previously described forms; the ordinary cruciform spiculum being converted into an external defensive one by the projection of a spicular ray from its centre.

DENTATO-CYLINDRO-HEXRADIATE (Plate XXXVI. fig. 39).—From a unique and very beautiful branching sponge from Nichol Bay, Australia, sent to me by Mr. GEORGE CLIFTON, of Freemantle. The dentation of the radii of these spicula varies considerably in form and size; the number of teeth at the apices of the rays is usually two or three, occasionally four, and very rarely five. The spicula are nearly uniform in size, and extremely abundant on all parts of the interstitial membranes.

EXTER-SPINULATED ARCUATE (Plate XXXVI. fig. 40).—From a small massive sponge from the Bahamas, presented to me by my friend Mr. M^cANDREW. They are very abundantly dispersed over all parts of the interstitial membranes, are uniform in size, and vary to some extent in the degree of spinulation. In Part I. of this paper I described and figured a minute spiculum of the same arcuate form (Phil. Trans. 1858, p. 322, Plate XXVI. fig. 51). I was not aware at that time from what part of the sponge it had been obtained. I have since found the same form abundantly dispersed on the interstitial membranes of a new species of sponge from Freemantle, sent to me by my friend Mr. GEORGE CLIFTON.

SPINULO-MULTIFURCATE HEXRADIATE STELLATE (Plate XXXVI. fig. 41).—This beautiful spiculum forms a connecting link between the spinulo-quadrifurcate hexradiate stellate form and the floricomo-stellate one, described and figured in the first part of this paper (Phil. Trans. 1858, p. 312, Plate XXVI. figs. 2, 3, 4). A careful examination of the specimen presents indications of there having been as many as eight secondary radii at the termination of the primary ray which exhibits the greatest number of secondary ones in the figure; and it is probable that this was the full complement of those parts.

MULTIANGULATED CYLINDRICAL (Plate XXXVI. fig. 42).—From a sponge in the British Museum. This spiculum had been accidentally included in the sponge. It is distinctly different from one of the same form described and figured in the first part of this paper, Phil. Trans. 1858, p. 314, Plate XXVI. fig. 10. It most probably belongs to the sarcode of a *Geodia.*

SPINULO-MULTIANGULATED CYLINDRICAL (Plate XXXVI. fig. 43).—Found among the extraneous spicula of the same sponge as the spiculum represented by fig. 42. This sponge is one of the Johnstonian Collection. It is designated *Halichondria sanguinea*, and its register is 47, 9, 7, 19.

INFLATO-ACERATE, WITH INSCISSURATE TERMINATIONS (Plate XXXVI. fig. 44).—From *Hymeraphia verticillata*, BOWERBANK, MS. A new species of British sponge from the Western Coast of Ireland. A terminal portion only of this spiculum is represented by the figure, the inscissurate character being the only novelty in the form. The inscissuration varies in degree to a considerable extent in different spicula, in some cases being very slightly produced, in others rather beyond that represented by fig. 44. The rudiments of a third ray are sometimes apparent. This form is an auxiliary skeleton-spiculum. They are found thickly clustered around the primary spicula of the skeleton. They differ essentially from porrecto-ternate spicula in having both ends cleft or radiate, which is never the case in any of the ternate forms.

Explanation of PLATE XXXVI.

Spicula of the Skeleton.

Fig. 1. Farcimulo-cylindrical, from *Spongilla coralloides*, Bowerbank, MS., ×108 linear: page 830.

Fig. 2. Inequi-acerate vermiculoid, from *Hymeraphia vermiculata*, Bowerbank, MS., ×175 linear: page 830.

Fig. 3. Nodulated cylindrical vermiculoid, ×175 linear: page 830.

Fig. 4. Elongo-equiangulated triradiate, from *Grantia striatula*, Bowerbank, MS., ×108 linear: page 830.

Fig. 5. Exflected elongo-equiangulated triradiate, from *Grantia striatula*, Bowerbank, MS., ×108 linear: page 830.

Fig. 6. Doliolate cylindrical, ×175 linear: page 830.

Fig. 7. Bifurcated expando-ternate, ×108 linear: page 830.

Fig. 8. Porrecto-ternate, ×108 linear: page 830.

Fig. 9. Expando-ternate, ×108 linear: page 830.

Fig. 10. Geniculated expando-ternate, from *Tethea Collingsii*, Bowerbank, MS., ×108 linear: page 831.

Fig. 11. Abbreviato-patento-ternate, ×108 linear: page 831.

Defensive Spicula.

Fig. 12. Inflato-fusiformi-acerate, ascendingly hemi-spinous, ×108 linear: page 831.

Fig. 13. Verticillately spined cylindrical, ×666 linear: page 831.

Fig. 14. Sub-attenuato, entirely spined cylindrical, ×400 linear: page 831.

Fig. 15. Spiculated inequi-angulated triradiate, with cylindrical entirely spined radii, ×308 linear: page 831.

Fig. 16. Spiculated attenuato-equiangular triradiate, verticillately spined, ×666 linear: page 831.

Fig. 17. Spiculated cylindro-equiangular triradiate, verticillately spined, ×666 linear: page 831.

Figs. 18 & 19. Inequi-furcato-triradiate, ×183 linear : page 831.

Fig. 20. Elongo-recurvate dentato-birotulate, ×308 linear: page 832.

Fig. 21. Elongo-recurvate dentato-birotulate, ×308 linear: page 832.

Fig. 22. Recurvo-acutely dentate birotulate, ×308 linear: page 832.

Fig. 23. Recurvo-dentato-birotulate variety, ×308 linear: page 832

Fig. 24. ATTENUATO-CYLINDRICAL, VERTICILLATELY SPINED, ×183 linear: page 832.

Fig. 25. The same form of spiculum as that represented by fig. 24, in an early stage of development, ×183 linear: page 832.

Fig. 26. TORQUEATO-BIDENTATE INEQUI-ANCHORATE, ×308 linear: page 832.

Fig. 27. BICALCARATE BIHAMATE, ×1250 linear: page 833.

Fig. 28. EXPANDO-TRIDENTATE EQUI-ANCHORATE, ×1250 linear: page 833.

Fig. 29. TRIDENTATE FIMBRIATED EQUI-ANCHORATE, ×666 linear: page 833.

Fig. 30. QUADRIHAMATE, ×1250 linear: page 833.

Fig. 31. INEQUI-TRIROTULATE, ×666 linear: page 833.

Fig. 32. ECCENTRIC TRIROTULATE, ×666 linear: page 833.

Fig. 33. ECCENTRIC TRIROTULATE, ×666 linear: page 833.

Fig. 34. INCOMPLETELY DEVELOPED, CYLINDRO-CRUCIFORM, ENTIRELY SPINED, ×175 linear: page 833.

Fig. 35. CYLINDRO-CRUCIFORM, PARTLY DEVELOPED AND ENTIRELY SPINED, ×175 linear: page 833.

Fig. 36. CYLINDRO-CRUCIFORM, APICALLY SPINED, ×175 linear: page 833.

Fig. 37. CYLINDRO-CRUCIFORM, ENTIRELY SPINED, ×175 linear: page 833.

Fig. 38. SPICULATED CYLINDRO-CRUCIFORM, ×175 linear: page 833.

Fig. 39. DENTATO-CYLINDRO-HEXRADIATE, ×666 linear: page 834.

Fig. 40. EXTER-SPINULATED ARCUATE, ×1250 linear: page 834.

Fig. 41. SPINULO-MULTIFURCATE HEXRADIATE STELLATE, ×666 linear: page 834.

Fig. 42. MULTIANGULATED CYLINDRICAL, ×400 linear: page 834.

Fig. 43. SPINULO-MULTIANGULATED CYLINDRICAL, ×666 linear: page 834.

Fig. 44. INFLATO-ACERATE, WITH INCISSURATE TERMINATIONS, ×666 linear: page 834.

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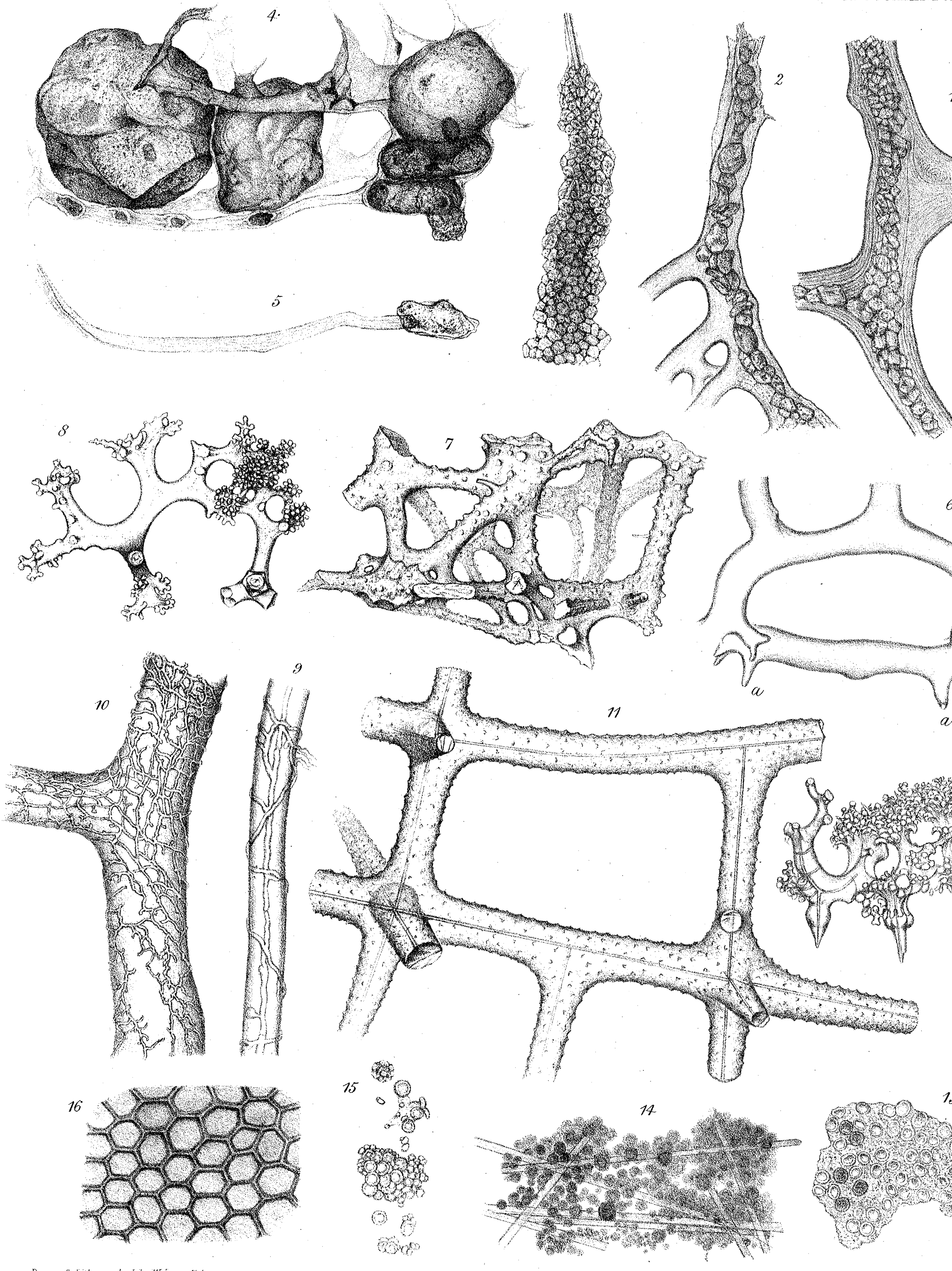

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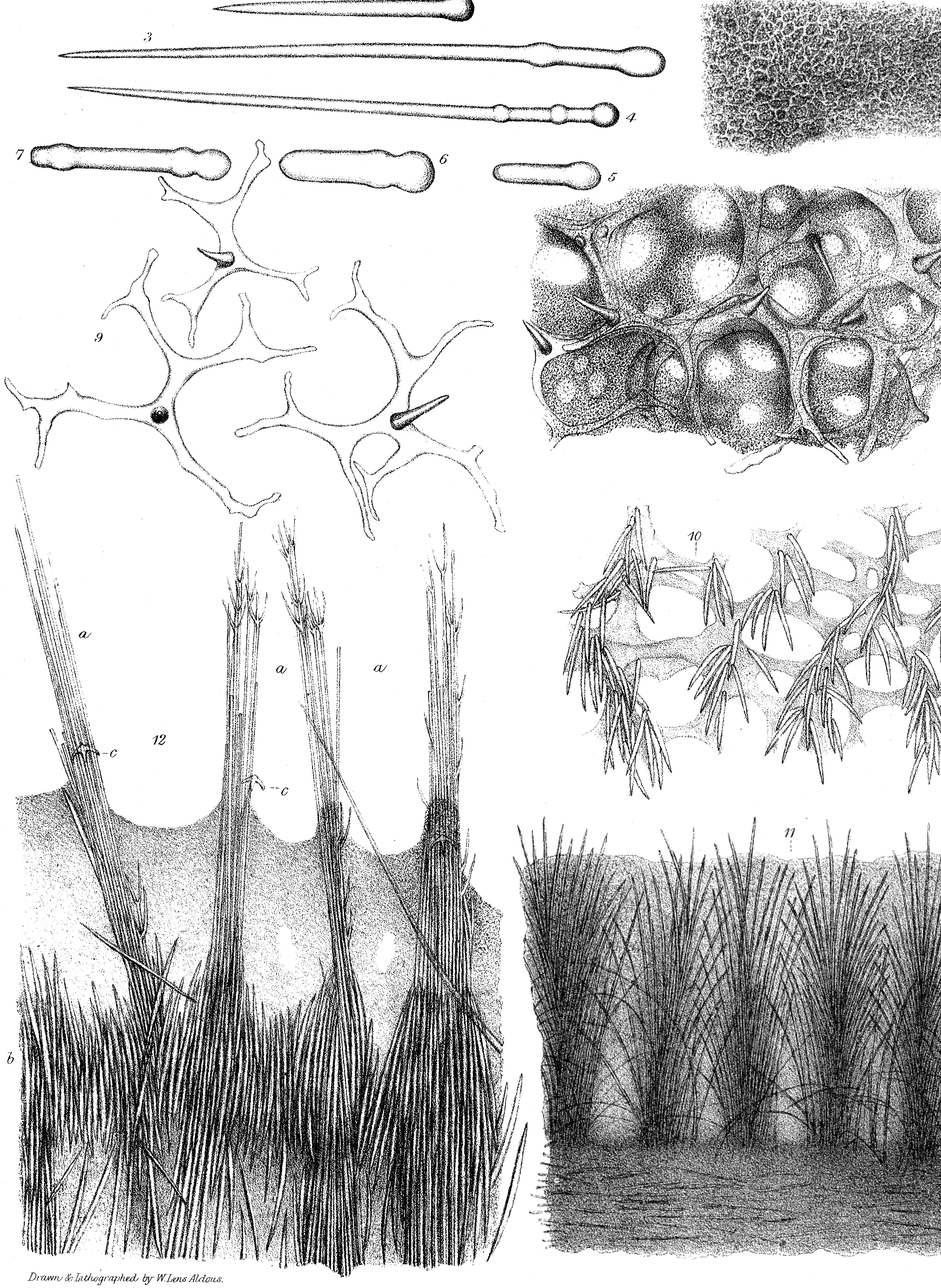

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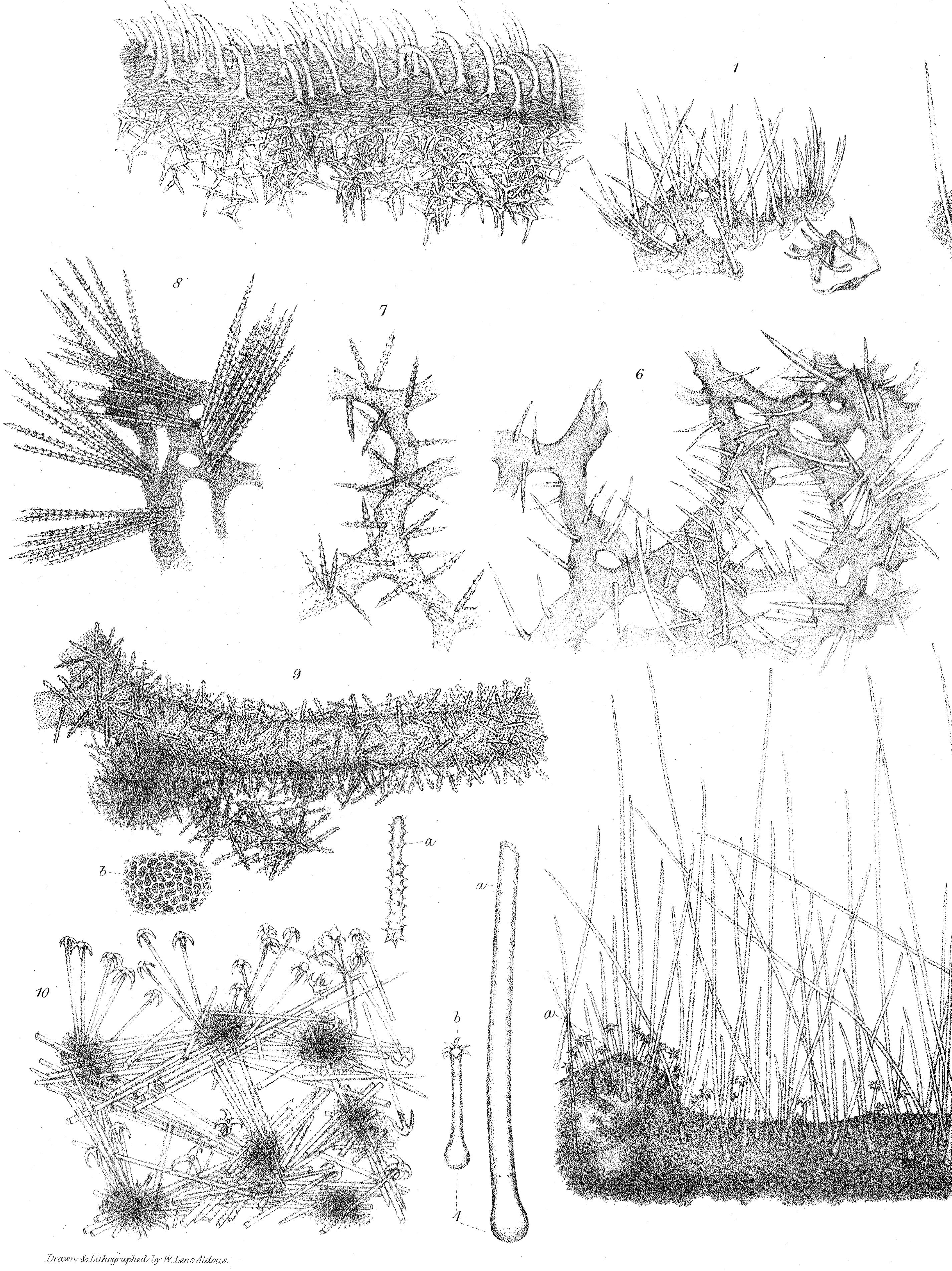

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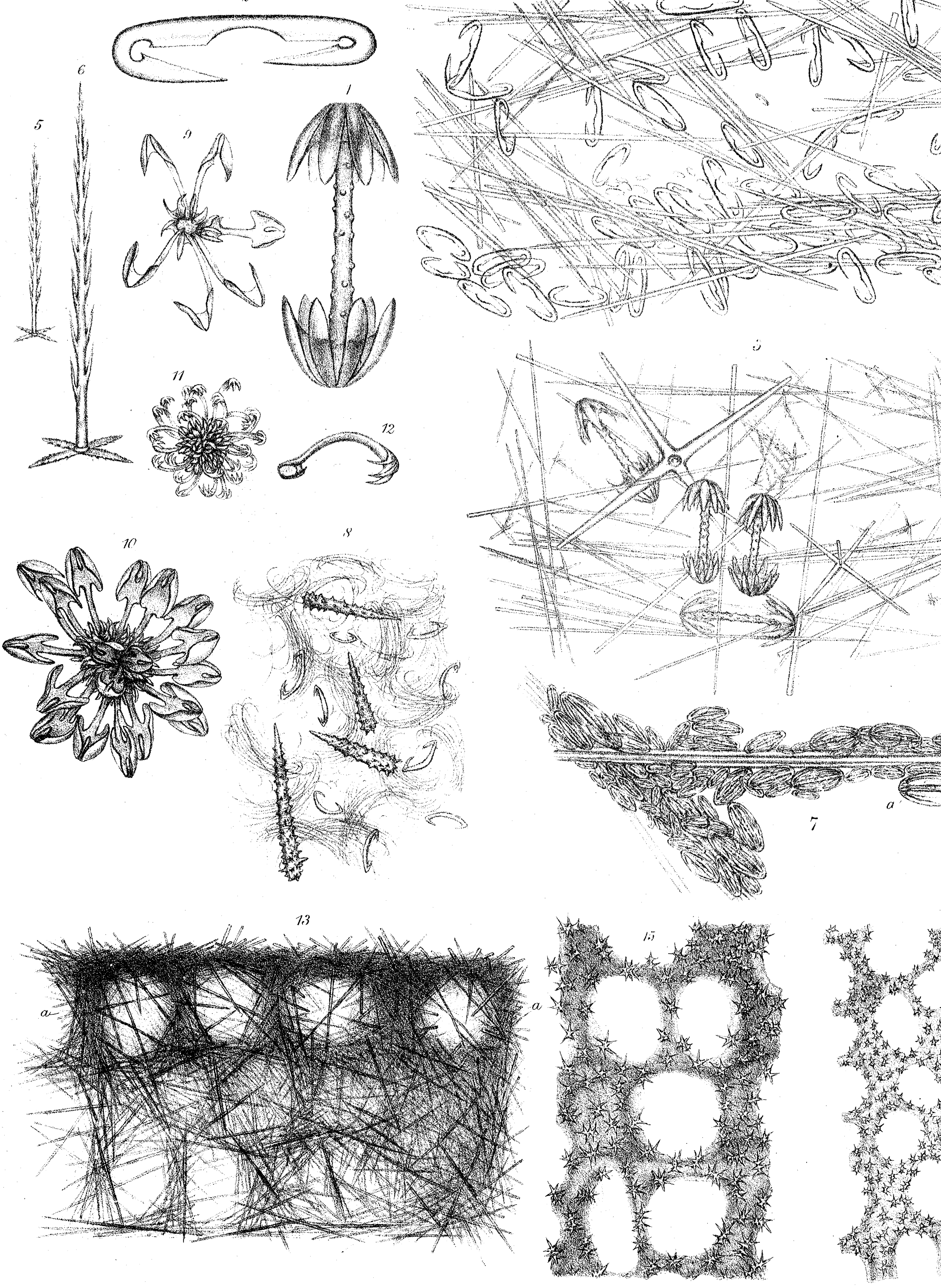

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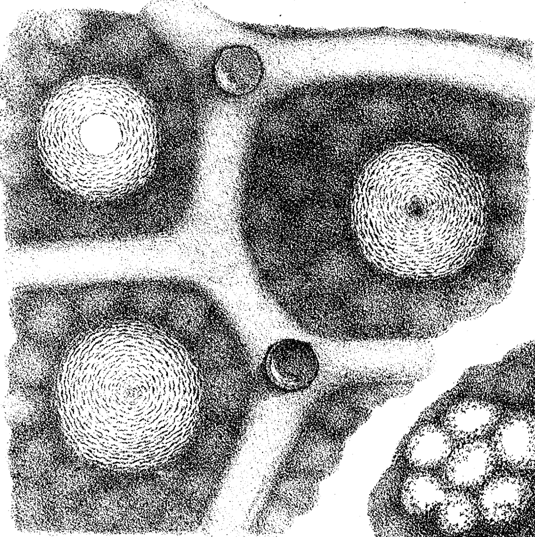

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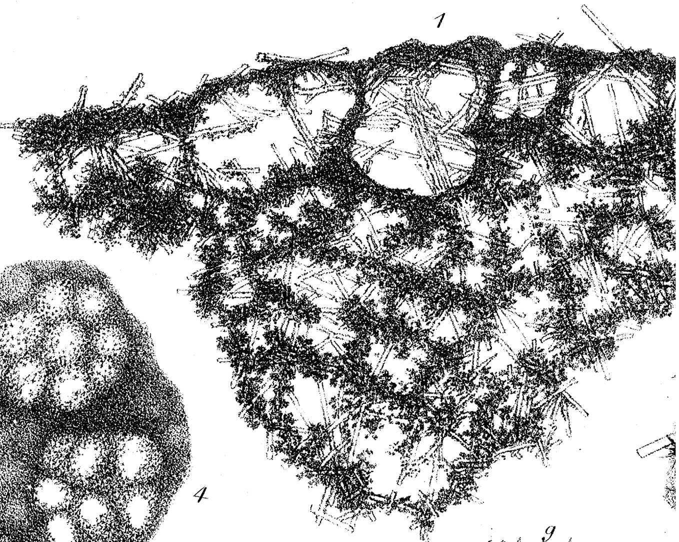

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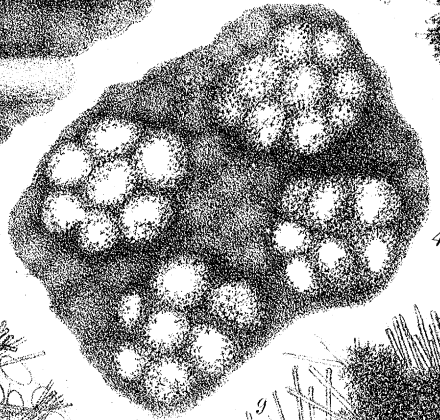

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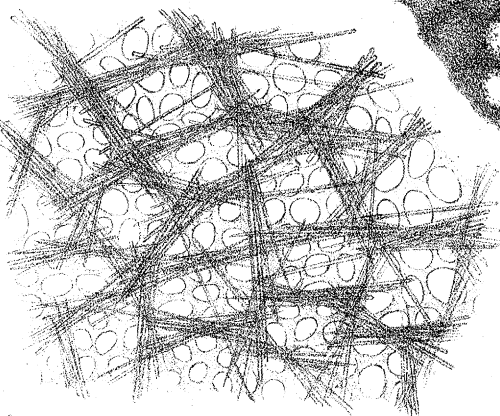

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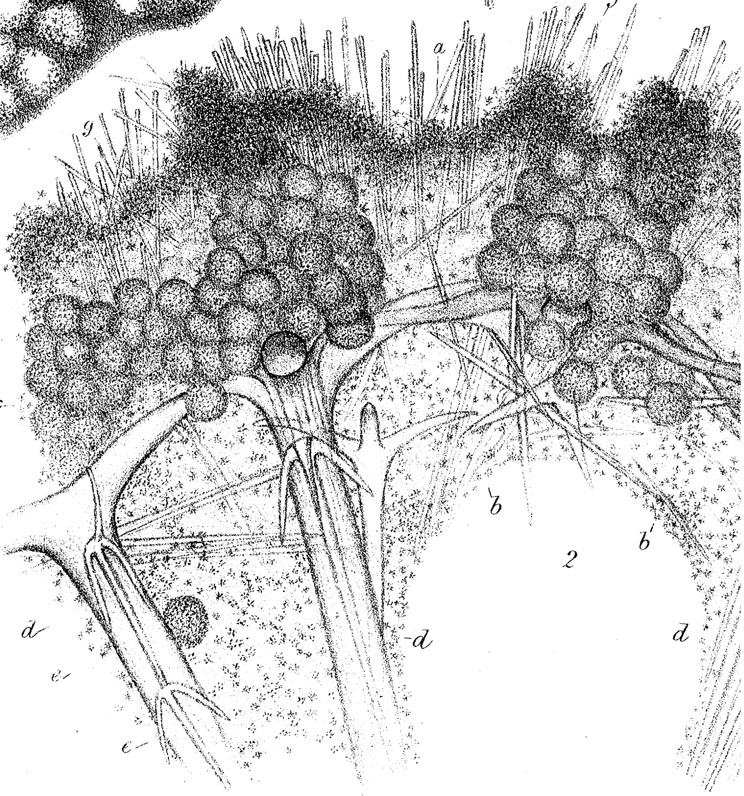

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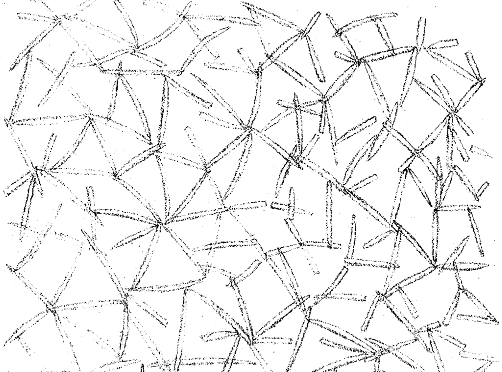

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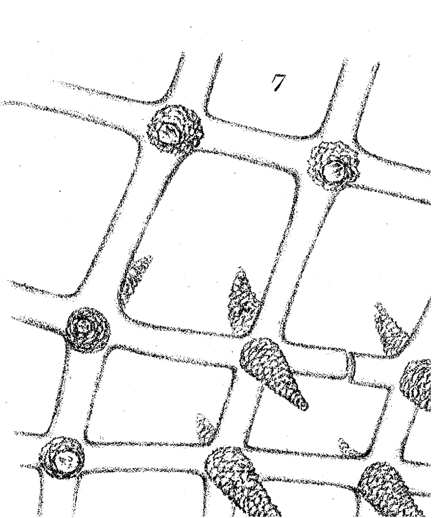

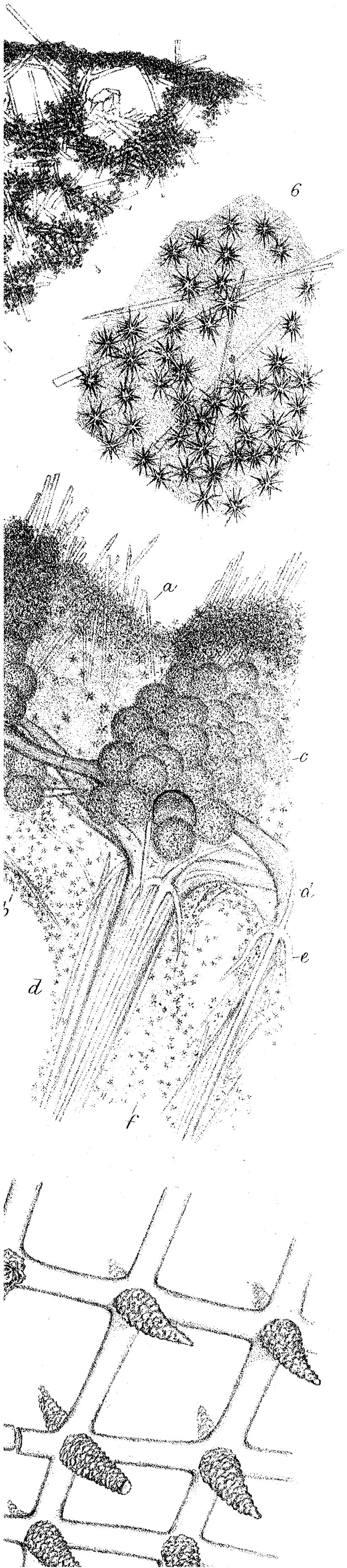
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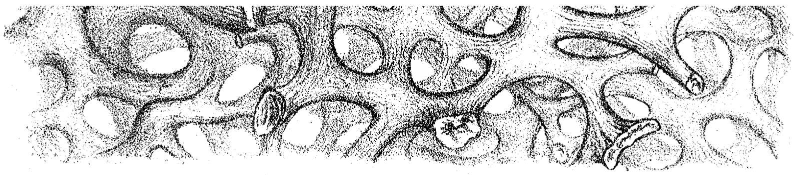

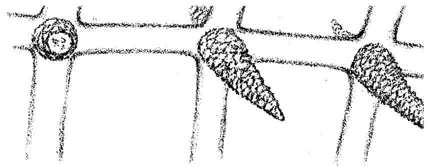

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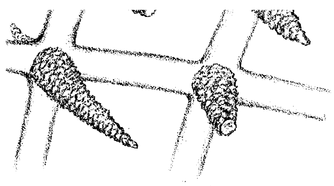

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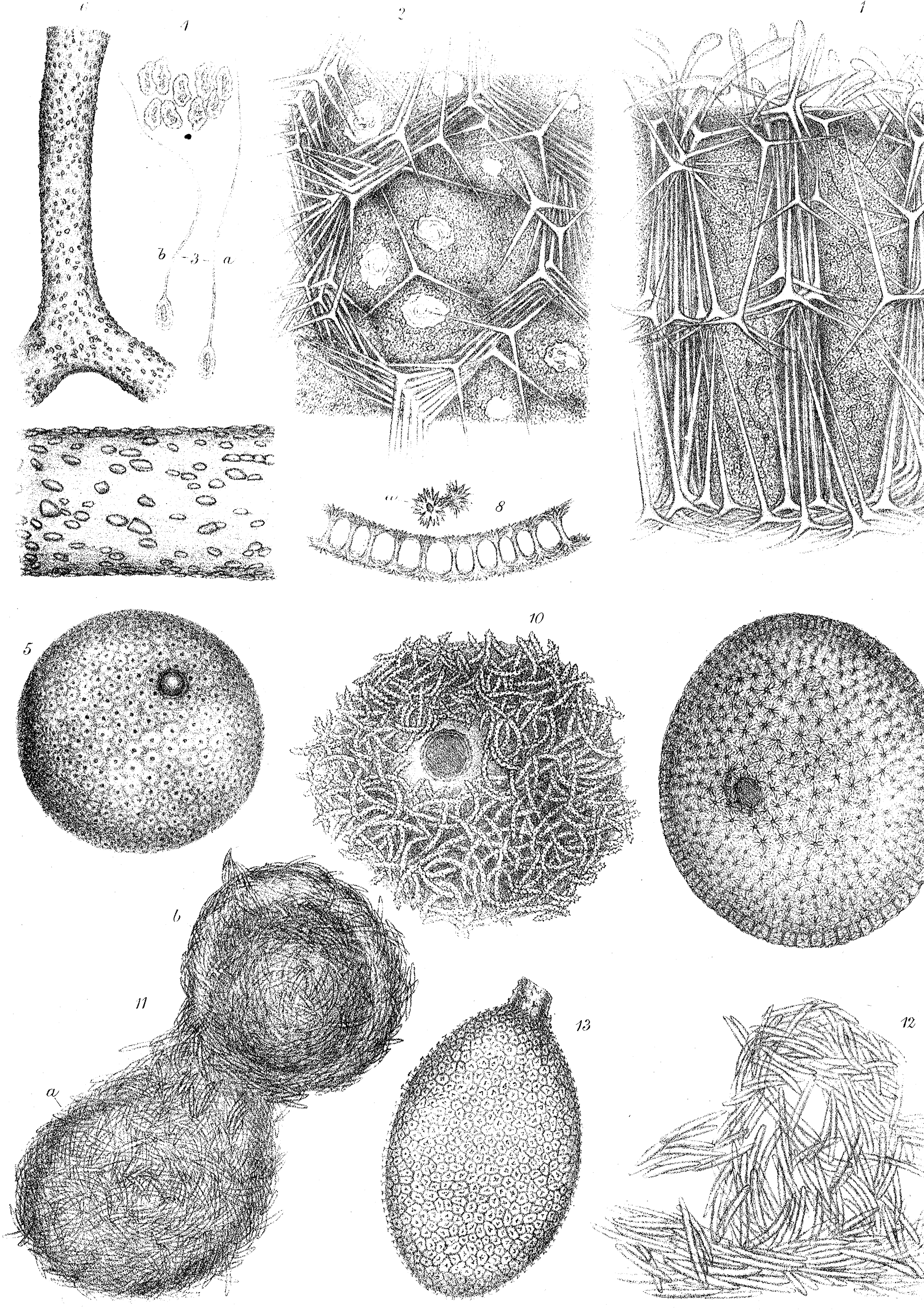

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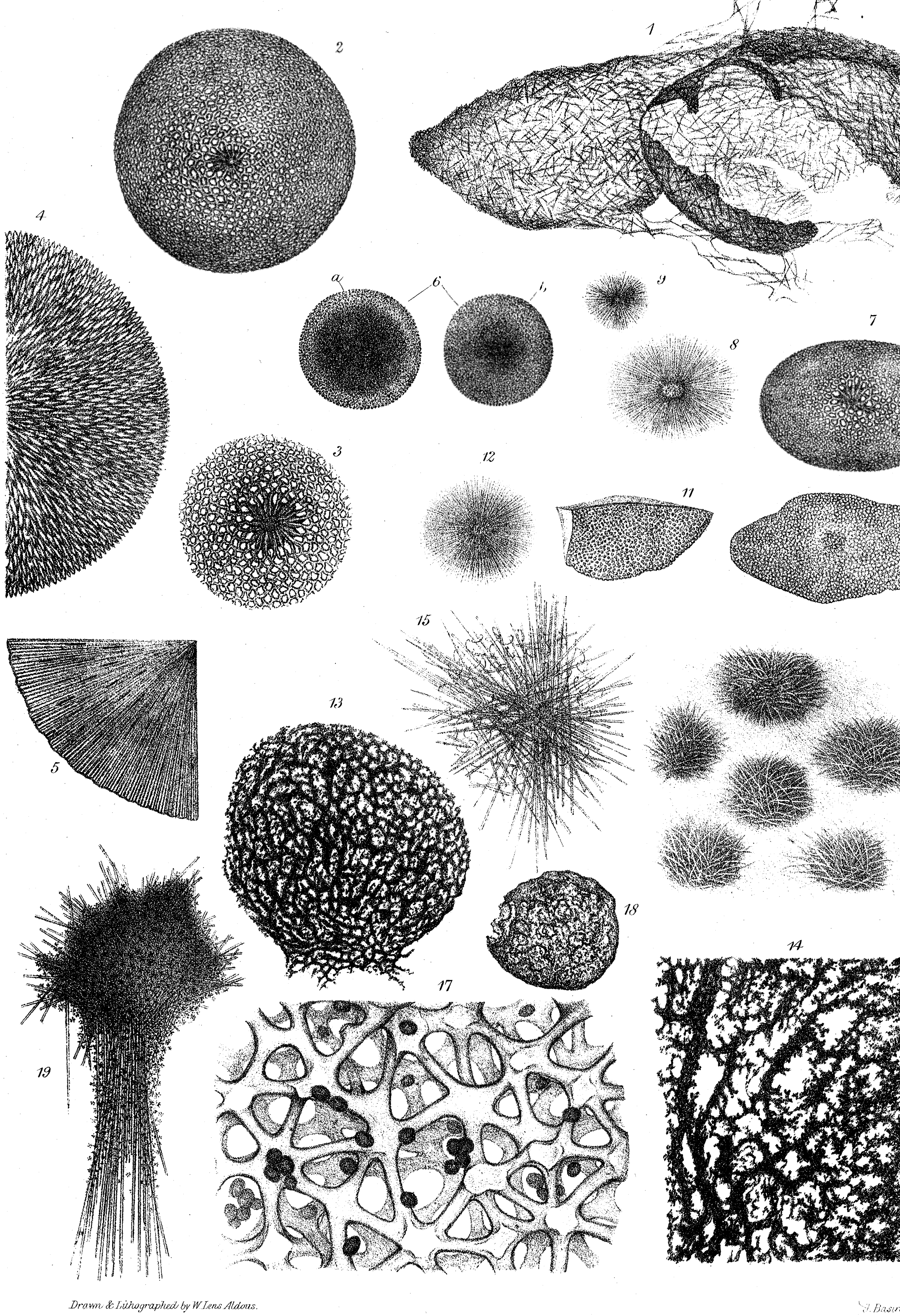

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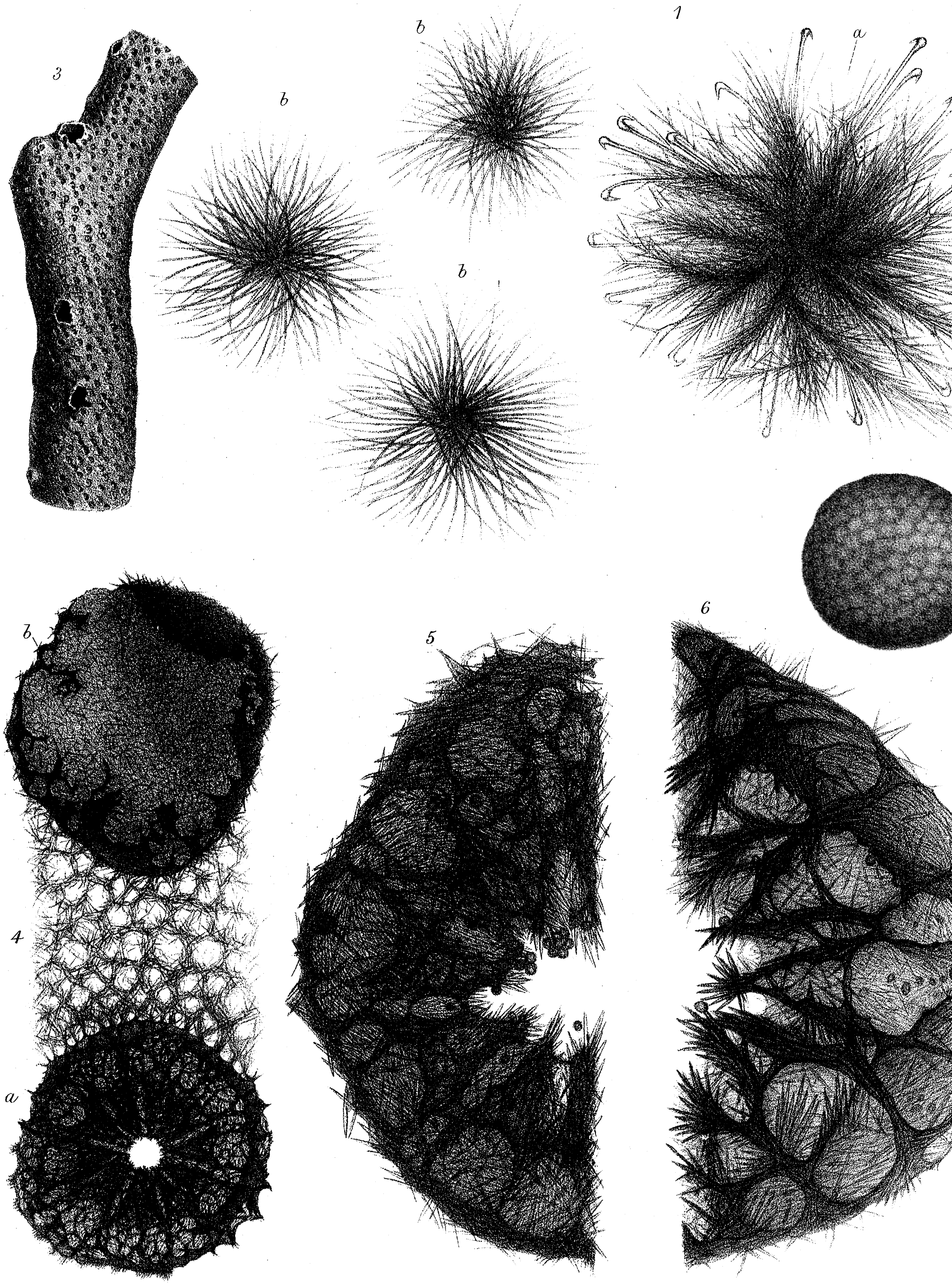

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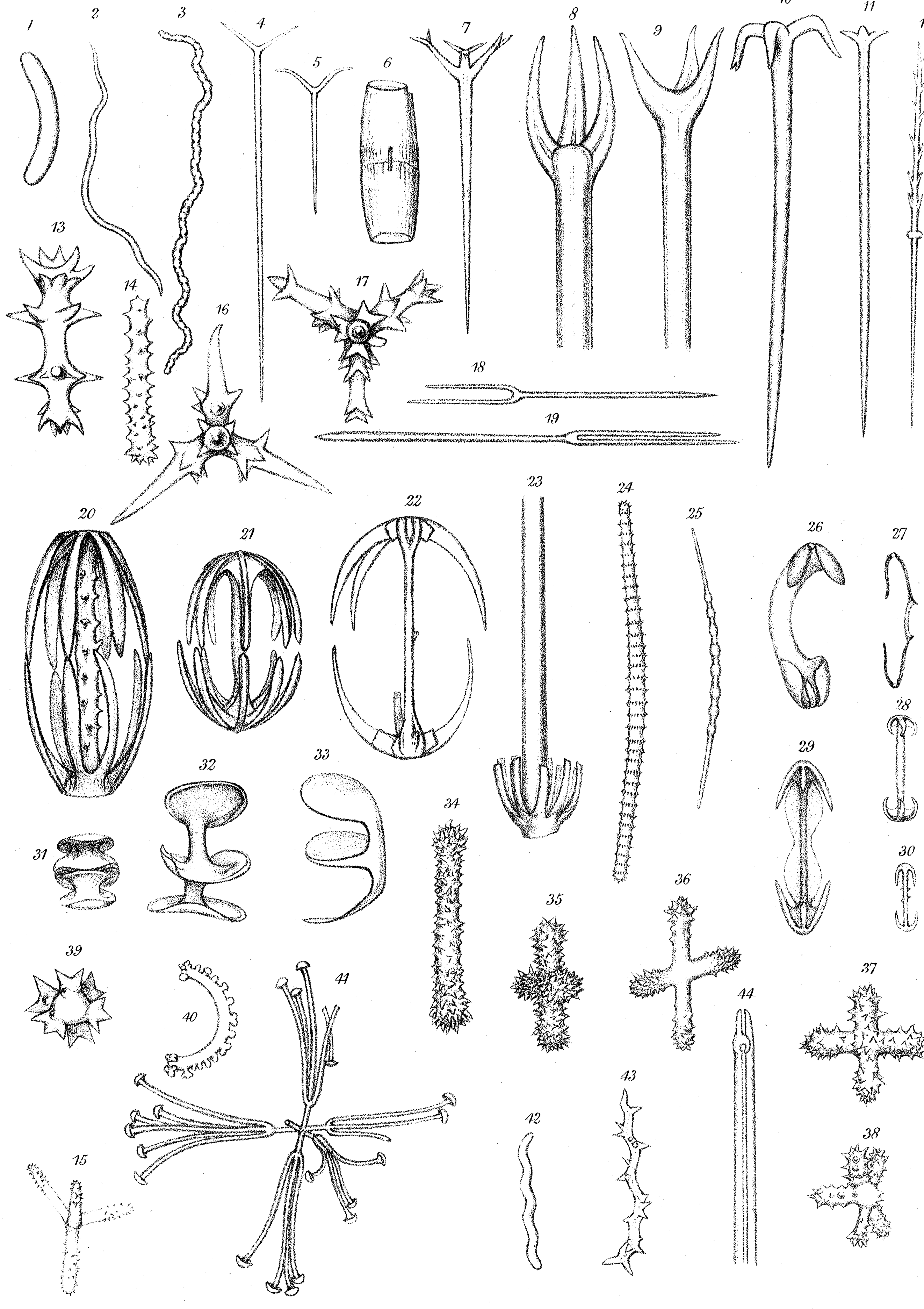

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