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XXXVI.—*On the Excavating Powers of certain Sponges belonging to the genus* Cliona; *with descriptions of several new Species, and an allied generic form.* By ALBANY HANCOCK, Esq.

[With four Plates.]

WHILE engaged in investigating the method by which the *Mollusca* bury themselves in stone, wood, and other hard substances, I was naturally led to examine the chambers inhabited by *Cliona*; and having arrived at the conclusion that they are not the deserted abode of worms, or cavities accidentally formed by erosion or otherwise as has been stated, but that they are worked out by this curious production itself, I asserted such to be the case in a paper communicated by me to the last Meeting of the British Association. Since then I have gone more fully into this subject, and as the prevailing opinion appears to be adverse to that expressed by myself, I purpose now giving a detailed account of the facts, which I trust will be deemed sufficient to justify my former statement.

My investigations have led to the discovery that *Cliona celata* does not stand alone as an aberrant type, but that it is, in fact, a member of a large group of beings, hitherto almost entirely overlooked, which play apparently a most important part in the œconomy of nature. I have determined upwards of fifty species of this curious sponge, all inhabiting more or less diversified chambers in calcareous substances, and in other respects well-characterized. Of these species twelve belong to the British seas; the rest are from various parts of the world. I have also ascertained that *Cliona* existed during several geological periods, and with the assistance of Mr. W. K. Loftus have determined that it occurs in the crag, in the London clay, in the Paris basin, in the chalk, in the greensand, and in the oolite; and Mr. Alder has detected it in specimens of *Pecten Islandicus* from a raised beach on the coast of Bute. In most instances the characters of the

chambers are so well preserved in the fossil shells of these formations that the species may be determined.

A new generic form has also been discovered: it is closely related to *Cliona*, and like it conceals itself in calcareous bodies. Two or three species have occurred: they and several of the more characteristic species of *Cliona* that have come under my notice will be described in the sequel of this communication: the others are reserved for some future occasion.

It is now upwards of twenty years since Professor Grant's paper on *Cliona celata* appeared in the 'Edinburgh New Philosophical Journal'; and in 1840 M. Duvernoy described in the 'Revue Zoologique' another species inhabiting the shell of *Ostrea hippopus*. These I believe are the only species hitherto known, though extensive traces of the genus are to be found in every cabinet of shells, and probably on every shore of the British islands.

Professor Grant believed *Cliona* to be polypiferous. Such belief, however, has not been confirmed by subsequent observations, which seem on the contrary to prove that this production is truly a sponge, differing but little in internal structure from *Halichondria*. I have examined with much care the papillæ of *Cliona* when just removed from the sea, but have not succeeded in detecting any polypes. The propriety, nevertheless, of retaining it as a distinct genus would appear evident; for though it undoubtedly possesses many characters in common with *Halichondria*, yet *Cliona* differs widely from it in its habits, and particularly in its contractile power,—a quality surely of great importance, raising *Cliona* in the scale of creation high above the sponges in general.

From this striking character it perhaps might be inferred that *Cliona*, and likewise *Thoosa*, by which name I propose to designate the new generic form, are closely related to *Tethea*, which is stated to be irritable; and as the two former are both provided with siliceous bodies or granules on the surface, as will be afterwards shown, they would also appear to be allied to *Geodia*, the external covering of which is composed of siliceous globules.

The numerical extent of the species of *Cliona* cannot at present be estimated. Those now recorded are the result of a very limited investigation. That they are very numerous is evinced by the fact, that from a single specimen of *Tridacna gigas* a dozen species at least have been obtained. They are not merely specifically numerous, but are likewise individually so; and they attack inorganic as well as organic bodies. They appear to be pretty generally diffused over the surface of the globe, though most numerous in warm climates: none have been yet procured from the Polar regions.

On the coast of Northumberland the surface of almost every piece of limestone near low-water mark is riddled by *Cliona*: old shells, whether univalves or bivalves, are filled with it; it inhabits nullipores; and in southern latitudes it buries itself in corals. Its ravages are very extensive and appear to be rapidly effected. I have seen half-grown living oysters with *Cliona* extending from the umbones almost to the ventral margin, and in one or two instances it even reaches that margin. In these cases it is evident that the growth of the sponge must have been more rapid than that of the shell; for the work of destruction could not commence until the oyster had attained to some size; and had its growth been even equal to that of the sponge, the shell ought to have reached its full development before the sponge had gained the lower margin.

When a shell is once attacked, the operations of these creatures never cease until they have extended throughout its entire substance. The middle portion soon becomes almost completely excavated, small pieces only remaining to divide the chambers or branches. A thin plate is left on the outer and inner surfaces to protect the parasite; and even these plates are ultimately riddled with numerous circular holes, which are the only indication of the work of destruction beneath, until some slight external influence ruptures the protecting walls, or the increasing growth of the tenant bursts them asunder; when the whole system of elaborately wrought chambers becoming exposed soon gives way, and *Cliona*, Sampson-like, perishes amidst the ruin produced by its own energy.

The excavating sponges abound in the Tropics, where they will keep in check the rapid increase of calcareous matter. The coral reef is built up by particles, and so by particles will it be reduced by the antagonism of these ever-working, all-pervading beings: the huge massive *Tridacna* falls in pieces subjected to the insidious encroachments of *Cliona*; and the limestone rock, almost bidding defiance to elemental influences, crumbles beneath the touch of this the lowest of animated beings.

It is difficult to say whether certain species of these parasites confine their ravages or not to certain shells or other calcareous bodies, though the fact of twelve species occurring in a single individual of *Tridacna* would appear to contradict such an opinion. Three or four distinct species are likewise found in the common oyster, and one of them occurs in limestone: *Fusus antiquus* has also supplied three good species. On the other hand *Cliona radiata* would appear to be confined to *Triton variegatus*, in two or three specimens of which it occurred abundantly; *Murex regius* is frequently affected by the operations of *Cliona*, and always, as far as I have been able to ascertain, by the same

species. And the three individuals of *C. corallinoides* that I have procured are buried in as many specimens of *Pecten maximus*. All these cases, however, may arise from similarity of locality, and not from any partiality to the species.

The boring sponges, as far as I have examined them, are branched, or are composed of lobes united by delicate stems; and all more or less anastomose according to the species: many of them are beautifully arborescent and of great delicacy*. They all bury themselves in shells or other calcareous bodies, and communicate with the water by papillæ or oscula protruding through circular holes in the surface of the containing substance or matrix. In dead shells the papillæ pass through both surfaces, but in living ones rarely penetrate the innermost layer, though occasionally they do so. When a mollusk is thus wounded it deposits calcareous matter over the orifice, and generally succeeds in excluding the intruder. The species vary considerably in form, and in *Cliona* might be divided into two or three distinct groups. In some the branches are almost linear, and anastomose only to a very slight degree; others form a complete network with the meshes so small that very little of the matrix remains between the branches; some have the branches moderately lobed; and others again have the lobes large and crowded upon each other in all directions, and united by fine, very short stems. In most the terminal twigs are very minute, and exhibit in a decided manner the mode of growth. In *C. gracilis*, for example, we perceive that they are cylindrical, and divide dichotomously, and that afterwards they augment in thickness gradually and pretty regularly, there being only slight indications of a lobed structure. In *C. corallinoides*, Pl. XV. fig. 1, the twigs are excessively minute, passing onward for some distance through the sound shell; and as they increase they become gradually lobed, the lobes ultimately attaining considerable size and becoming quadrate. This mode of growth is common to a great number of species: in some it is beautifully modified, as we see in *C. spinosa*, Pl. XIII. fig. 5; here the terminal twigs are mostly short and pointed, resembling spines thrust out from all sides of the close-set lobes; which spines or twigs in their turn swell out and become lobes. But of all the excavating sponges, *Thoosa cactoides*, Pl. XIII. fig. 1,

* Dr. Johnston describes *C. celata* as "without beauty or definite form;" but the specimens he examined may have been of abnormal growth, resulting perhaps from the entire destruction of the substance which had inclosed them. The Doctor's species however appears to be distinct from the *C. celata* of Grant, judging by the spicula, which, according to the figures of them by Mr. Bowerbank, are perfectly straight. In the species described by Professor Grant they are stated to be "slightly curved and a little fusiform in the middle."

as perhaps the most remarkable: in this the terminations of the branches have a divided dendritic appearance; they divide pretty regularly into two portions, which send off on all sides numerous, minute, linear twigs. The two principal portions soon swell out and form into oval lobes similar to those of the stems, which are seen likewise to give off linear twigs. These twigs and those of the terminal branches are so much alike, that it is impossible to doubt that the lobes of the stems have at one time been themselves terminal branches.

Thus as the form of the excavating sponges varied, and the chambers they inhabit modified; each species being always found in the same-formed cavities; that is, those with the same kind of spicula, and with papillæ of the same size, number and arrangement, are always found to branch and to anastomose in a similar manner, and to have the terminal twigs of the same character. This surely could not happen, did *Cliona* take up its abode in cavities caused by decay, or in excavations formed by worms, and were its shape dependent upon such accidental circumstances.

The cavities in shells occupied by *Cliona* have at once, without examination, been attributed to worms; and as inquiry was thus easily satisfied, the matter has remained up to the present time in obscurity. Those naturalists, however, who have paid particular attention to the subject appear inclined to a contrary opinion. Professor Grant says, the chambers "have probably been perforated by some worms;" though at the conclusion of his communication before alluded to on the subject, it is stated that "it may be questioned whether the sharp siliceous spicula and constant currents of its papillæ do not exert some influence in forming or enlarging the habitation of this zoophyte." By Johnston's work on the British sponges it also appears that Mr. Wm. M'Calla, who found *Cliona celata* in Birterbuy bay, states that this animal "is very destructive to the shells that come within its reach," and that in several instances "he had found large specimens of *Pecten opercularis* killed by the encroachments of this parasite." And so satisfied was M. Duvernoy that the species described by him excavated its own habitation, that he gave to it the specific denomination of *terebrans*. The prevailing belief is as before stated, however, that *Cliona* does not excavate the chambers in which it is found; but that they are formed by worms or by decay, or are produced in some other accidental manner; and that the shape of the sponge depends on that of the cavities it may chance to inhabit. Were this belief correct, the chambers would occasionally occur only partially occupied. This never happens; for *Cliona* always completely fills the various chambers and ramifications even to

the end of the most minute twigs. To this we have the testimony of Professor Grant, who says that the form of *Cliona* "depends on that of the cavities *which it fills*; it insinuates itself into the minutest ramifications, and adheres so closely to their smooth parietes, that it cannot be separated without tearing."

From what has already been said respecting the form and mode of growth of these sponges, it is pretty evident that they must form their own habitation. But to put this in a still clearer light we have only to examine in detail any one species: we will take *C. gorgonioides*, Pl. XIV. fig. 1, as an example. The principal stems of this species take a zigzag direction, sending off at the angles lateral branches which pass on to unite with the neighbouring stems: the terminal twigs are delicate and bifurcate, one of the divisions going immediately to form its junction with the adjoining stem. This mode of growth goes on until the entire substance of the shell in which the *Cliona* is lodged is completely filled with a network of branches; the anastomosing increasing all the while by the addition of twigs from the main stems until very little of the shell is left to separate the various parts of the sponge. Now in all this there is nothing having the appearance of accident. Where the *Cliona* is not, the shell is perfectly sound and untouched: the terminal twigs are all alike delicate and of similar character, penetrating the hard perfect substance; the main stems become gradually and proportionately thick, and the anastomosis, though somewhat irregular, is identical throughout. And this takes place whether the specimen is buried in *Fusus*, in *Buccinum*, in *Ostrea*, or in limestone, in all of which this species occurs.

Now if we assume for a moment that these sponges are incapable of excavating the chambers in which they conceal themselves, how shall we account for the formation of the beautiful dendritic cavities occupied by the terminal twigs of *Thoosa cactoides*, Pl. XIII. fig. 1, and the regularly anastomosing and lobed chambers filled by its branches? How are the arborescent channels and quadrate chambers of *C. corallinoides*, Pl. XV. fig. 1, formed? and what excavated the numerous, regular chambers, with their pointed spine-like offsets, of *C. spinosa*, Pl. XIII. fig. 5? How shall we answer these questions, unless we can assert that the sponge inhabiting those systematic cavities formed them? They are evidently not the result of decay, neither are they the burrows of worms; which, when in shell or other hard calcareous substance, are always linear, sometimes cylindrical, often depressed, never lobed, and frequently double, that is, with two channels divided by an elevated ridge. And so different are they in their general appearance, that it is very easy to point out which is the excavation of the worm, and which that of *Cliona*,

when the burrows of the two interfere with each other, which not unfrequently occurs.

There is, however, a very certain character which never fails to determine the habitation of the burrowing sponge, even though every particle of the animal be removed. If the parietes of the chambers and ramifications are viewed through an ordinary lens, they are found to be distinctly punctured in a peculiar manner, resembling what might be supposed to be the impress of shagreen, only much more minute. In some species this puncturing is much finer than in others, and occasionally it varies a little in character; but is always to be observed on the walls of the burrows of these sponges, whether they be in shell, limestone, coral, or nullipore. This puncturing therefore cannot be caused by the structure of the material in which the chambers are excavated, but must result from the character of the surface of their inhabitant. So certain a test is this, that by it alone the nature of the excavations in fossil shells may be determined with the greatest confidence. No other excavation, whether of worm or mollusk, presents a surface anything like that of the burrows of these sponges. And were no other proof at hand, this puncturing would be sufficient to establish the fact that these sponges possess the power of enlarging their habitation; but when taken in connexion with what has already been said, little doubt can exist of the fact that *Cliona* entirely excavates its abode: indeed after an examination of the form of these beings, and of the branched, lobed and systematic cavities they occupy, it would seem impossible to arrive at any other conclusion. On this point, however, I possess, if possible, still stronger evidence.

Through the kindness of Mr. Fryer I have had the examination of an individual of *Placuna placenta*, in the shell of which there are imbedded numerous specimens of a very beautiful *Cliona* exhibiting every stage of development from the earliest to maturity. This shell is so transparent, that even the minutest twigs are seen with the greatest precision. At first the young *Cliona* is a mere circular speck just visible to the naked eye; Pl. XIV. fig. 4 *a*, represents it in this stage sunk within the substance of the shell, through which there is a papillary puncture almost as large as the individual itself: afterwards the circle increases in size around the papilla, and becomes irregular in form, *b*; a thin linear branch is then pushed out from one side, *c*, and throws up through the shell another papilla. A branch from the opposite side now makes its appearance, *d*; a third and a fourth succeed, *e*, *f*; these are now seen to divide gradually into lobes, and to increase in thickness; numerous papillæ, *f*, being added, which penetrate the surface of the shell, and the terminations of

the branches bifurcate;—in short the young *Cliona* has now assumed the character of the mature sponge (fig. 2). Thus we can trace *Cliona* from its earliest stage of growth,—not larger than the gemmule of *Halichondria* and resembling it in form,—up to its perfect development, step by step, excavating its complicated habitation in sound shell, within which it lies closely imbedded, but unobscured by its pearly envelope which is perfectly free from decay and is untouched by worms: to neither of which by any constrained imagination can the chambers in this instance be attributed;—*Cliona* makes them for itself. And now having, I trust, established this fact, we shall endeavour to ascertain the nature of the apparatus by which these sponges work out their abode,—a subject of much difficulty.

The mollusks being furnished with a shell, the investigation into the nature of their excavating instrument is much complicated. The burrowing sponges, however, having no such hard covering, we have in them only the animal to look to for an explanation. The excavations of *Cliona* and *Thoosa* can only be effected by the surface of the sponge, aided either by some minute mechanical instruments in connexion with it, or by a solvent: unless, indeed, the water-currents of the papillæ, as hinted by Professor Grant, be thought equal to perform the task. But were these currents of sufficient magnitude to penetrate rapidly into shell or hard limestone, it is difficult to see how they could be brought into effective operation. The papillæ are closely adherent to the sides of the orifices through which they protrude; and here the water could have no effect; and yet these orifices are at first small, and are afterwards considerably increased in size. And at those points where the water is drawn into the sponge, the currents, of course, cannot be supposed to act in the way proposed. To show, however, how inadequate these minute currents are to work out the chambers of *Cliona*, which we have seen are formed very rapidly, we have only to reflect on the comparatively slow action of the enormous currents of the sea,—of the tidal currents, and of those resulting from the lashing of the waves. The puncturing of the sides of the chambers also seems unfavourable to such an hypothesis. We shall not therefore stop to discuss this branch of the subject further, but at once inquire how far a solvent is likely to be the agent.

The extreme simplicity of the organic structure of these beings forbids a belief in the existence of a special secreting apparatus. If therefore a solvent fluid be the agent, it must be supposed to exude from the entire surface of this humble animal. The character of the excavations would also lead to the same conclusion; for it is evident that the form of the sponge is influential in determining that of the chambers it inhabits. The test then can be easily applied; and were the secretion of an acid nature, there could be little difficulty, one would think, in detecting it; particularly as *Cliona* appears to work perpetually—at least so long as it continues to grow. I have completely failed, however, in detecting an acid.

I took *C. gorgonioides* alive fresh from the sea, and breaking up the stone in which it was lodged removed the creature by piecemeal, and placing each portion on litmus-paper pressed the fluids out of it between plates of glass; but not the slightest alteration occurred. I continued trying piece after piece for several hours, and contrived to remove portions of the animal with the surface entire; but all was in vain,—no indications of an acid solvent could be obtained.

In a specimen of the *Strombus gigas* in the Newcastle Museum penetrated by a species of *Cliona*, the papillæ have passed through the strong horny epidermis, drilling it with great precision; the holes are quite circular, and of the same size as those in the shell. This could hardly be achieved by an acid solvent.

When a portion of the fresh *C. celata* is carefully removed from the chambers and placed in a little acetic acid, a distinct effervescence takes place as if calcareous matter mingled with the tissue. The same result occurs when a little of the dried substance adhering to the sides of the excavations of *Thoosa* is removed and treated with the same acid. From these facts we may conclude, perhaps, that no acid solvent had been employed; while it is likely, were the excavations effected by mechanical means, that the surface and tissue would be charged with calcareous particles. Indeed such particles may generally be observed strewed along the branched channels in the shell of the oyster when inhabited by *C. celata*. I have also seen similar calcareous particles adhering to the animal of *C. gorgonioides* when removed from its chambers in limestone. These particles are large enough to be detected with a pocket lens, and will be more fully described further on. At present they are alluded to, as they afford a pretty strong proof of mechanical agency.

The excavations would then appear to be effected by mechanical, and not by chemical means. What is the instrument, and how is it applied?

With respect to *Cliona*, it is well known to possess siliceous spicula; some of the points of which penetrate the surface of the animal, and might be supposed capable of reducing the calcareous bodies in which these creatures bury themselves. But other and apparently more efficient agents have been discovered, covering the surface of the sponge.

The superficial covering of the animal of *C. celata*, Pl. XIII. fig. 3, is liable to adhere to the sides of the excavations. If a portion of this is carefully removed and placed between plates of glass with the external surface uppermost and treated with strong nitric acid, large crystalline bodies of a peculiar character are discovered scattered over it (Pl. XII. fig. 1). These bodies are of a pale straw colour, and of the most brilliant lustre and gem-like beauty; the largest measuring $\frac{1}{600}$th of an inch across: they are mostly irregularly six-sided, depressed, and scale-like; but stout and frequently thickened in the centre, the upper surface being covered with numerous, elevated, lozenge-shaped points, each generally having an expanded base of a squarish form slightly raised above the common surface (fig. 2). These bodies are frequently congregated into groups, and are occasionally placed together side by side. Strong nitric acid does not the least affect them after many days' immersion, the sharp angularity of the elevated points remaining unimpaired, and their brilliancy undiminished. From these facts, and from the manner in which these bodies refract light, there can be little doubt that they are composed of silex, or some other substance equally dense. Besides these other crystalline bodies crowd the surface, which bodies are as brilliant as the former, and like them resist strong nitric acid. These are mostly minute, being generally $\frac{1}{6000}$th of an inch wide; they vary, however, considerably in size, and are occasionally very much larger: they are mostly angulated, have an expanded scale-like base, and much resemble the lozenge-shaped points of the larger bodies. These smaller ones are crowded together into dense masses, forming as it were a sort of silicified epithelium; occasionally they become united by the blending of their expanded bases, and then the combined mass has considerable resemblance to the larger forms before described.

Similar minute siliceous granules have been observed in all the species examined. The allied genus *Thoosa*, too, has the surface provided with siliceous bodies of a very peculiar and novel appearance. This genus is unfurnished with spicula in the interior, but has occasionally radiating ones supplying the surface, which is almost entirely composed of the siliceous bodies just alluded to.

If a portion of the animal adhering to the chamber-walls of *Thoosa* be removed and placed with the surface uppermost, and examined in the microscope as an opake object, it is seen to be covered with a whitish semi-pellucid crust of a granular appearance; on increasing the power to about 200 diameters, this crust is seen to be composed of a multitude of crystalline bodies formed of nodules. On examining these bodies by transmitted light with a still higher power (400 diameters), they are observed to rest on a thin membrane distinct from the substance

below, which is almost entirely made up of tubes. The form of these bodies, Pls. XII. & XIII. fig. 10 *a*. & fig. 2 *b*, is now observed to be somewhat like that of the mulberry, and on closer examination they are found to be composed of a stout central axis, near each extremity of which is placed a whorl of six or eight large, irregularly quadrate nodules; the extremities of the axis being each formed of a nodule similar to those of the whorls. These bodies measure $\frac{1}{175}$th of an inch long, are colourless, refract light powerfully, and are as brilliant as the spicula, and in like manner are unaffected by strong nitric acid, how long soever subjected to its action.

It is to the above-described peculiar siliceous bodies on the surface of the excavating sponges that I attribute the power they possess of burying themselves in calcareous substances. The spicula may perhaps assist in *Cliona*; but they seem ill-adapted for the purpose in *Thoosa*, and indeed are not always present. In the former they undoubtedly penetrate the surface, and originally I was inclined to look upon them as the chief agents employed. The discovery of the mulberry-like bodies on the surface of *Thoosa* led me to examine more closely that of *Cliona*, and after finding there those beautiful gem-like crystals, so well adapted for cutting, their homology cannot be doubted; and I am compelled to adopt the view just expressed.

The surface then of these animals will very much resemble what I have elsewhere described the cutting surface to be in the boring mollusks; in the former as in the latter every portion of it will cut with the keenness of glass-paper; and as *Cliona* is admitted on all hands to be highly contractile, there can be no difficulty respecting the capabilities of the excavating apparatus as just described. All that is necessary is, that each siliceous granule, or cluster of granules, should be put in motion. Action,—very limited,—not more extensive than that of vibratile cilia, would be sufficient; and it would seem not at all improbable that it may be of the same nature. From Ehrenberg's investigations it would appear that the motion of these minute organs is produced by a contractile tissue on which they are based, and that in some of the animalcules they have a rotatory motion. Now if we suppose these siliceous bodies of *Cliona* and *Thoosa* to be in connexion with a similar contractile tissue, the whole surface of the sponge would be composed of thousands of minute drills quite able to cut into calcareous substances of the hardest nature.

Were the action of this character, the walls of the chambers would be drilled full of little holes, and would present just the appearance we have already seen they possess. And as the calcareous particles were removed they would be carried away by the

ordinary currents, which setting in from the surface of the sponge would convey the reduced matter into the principal channels, by which it would soon find an exit through the efferent papillary apertures. I have before alluded to calcareous particles found strewed along the channels inhabited by *C. celata*. These particles, measuring $\frac{1}{200}$th of an inch long, are apparently too large to escape through the pores of the sponge, and are evidently not the scourings of the excavation; they are much too large to arise in this way; but are pieces probably cut out by a combination of the minute drills just described. To understand how this may be effected, we have only to suppose that numerous punctures are made through a thin, slightly attached plate or lamina of the oyster-shell, and that interspaces are left between the punctures; and it is clear that as the drilling goes on, many of these interspaces will become detached in the form of depressed, many-sided, angulated bodies. And such are those that are found in the channels of the excavations. Those particles of a similar nature occurring in the chambers in limestone are undoubtedly produced much in the same manner.

In the siliceous granules on the surface, and in the contractility of these sponges, we thus find an explanation of their excavating powers.

We shall conclude this communication with the description of a few of the species, premising that the figures of the spicula represent them drawn to a scale, so that at a glance a pretty correct idea may be obtained of their relative sizes. And it is as well perhaps to observe, that in every instance the full-developed spiculum has been measured and figured.

Cliona celata, Grant. Pl. XIII. figs. 3 & 4.
C. celata, Grant, Edin. New Phil. Journ. vol. i. p. 78.
C. celata, Johnston, Br. Sponges, p. 125?

Sponge of a clear yellow-ochre colour occasionally inclining to olive, composed of a large open network of branches; the meshes irregularly angulated, frequently five- or six-sided, and occasionally half an inch wide; the branches stout, often $\frac{3}{10}$ths of an inch thick, distinctly nodulous and generally depressed: papillæ large, some measuring $\frac{1}{10}$th of an inch in diameter*; for the most part in a single row along the branches, but penetrating the surface of the matrix without much apparent order, and placed rather far apart from each other: terminal twigs rather short, delicate, almost linear, and generally bifurcated. Spicula very long, measuring upwards of $\frac{1}{30}$th of an inch in length, a little

* In this and in the following descriptions the diameter of the papillæ has been determined by that of the papillary punctures.

bent, not particularly stout, and sometimes slightly inclined to fusiform, but tapering pretty gradually to a sharp point at one end; the other furnished with a well-defined globular head approaching to ovate with generally a terminal point.

This appears to be the most destructive species to oyster-shells, and abounds in the Frith of Forth. It is undoubtedly the *C. celata* of Grant: the form and large size of the spicula are sufficient to distinguish it. The *C. celata* of Dr. Johnston, however, is most likely another species, as the spicula are somewhat different.

C. insidiosa. Pl. XV. fig. 5.

Sponge when dry of a brown colour, branched; the branches about $\frac{3}{10}$ths of an inch thick, irregular, anastomosing: papillæ distant, irregularly arranged, rather small. Spicula $\frac{1}{117}$th of an inch long, stout, sometimes slightly fusiform, but generally tapering gradually to a fine sharp point at one end, towards which it is generally slightly bent; the other extremity is furnished with a large globular head separated from the shaft by a distinct dusky line, and mostly a little flattened like the head of a pin.

This species, which occurs in *Tridacna gigas*, appears related to *C. gorgonioides*; like it this has only one kind of spicula, and in both they are furnished with a rounded head. A cross section of the excavations of this form has much the appearance of a similar view of those of that species. I have not been able to trace the terminations of the cavities, and therefore cannot speak to their form. The short, stout spicula of *C. insidiosa* with their large pin-like head are very characteristic, and readily distinguish it from its congeners.

C. gorgonioides. Pl. XIV. figs. 1 & 6.

Sponge of a brownish yellow colour, branched, anastomosing; the principal branches stout, sometimes nearly $\frac{1}{8}$th of an inch thick, irregularly rounded, or depressed, placed somewhat parallel to each other, and much zigzaged, giving off lateral branches at the angles, which branches unite with those adjoining: terminal twigs thin, tapering to a fine point and bifurcating: papillæ large, frequently almost $\frac{1}{10}$th of an inch in diameter, penetrating the surface of the shell or other matrix without apparent order, and placed considerably apart from each other. Spicula very numerous, large and stout, measuring $\frac{1}{54}$th of an inch in length; at one end there is an oval swelling which is frequently some little distance from the extremity: from thence the shaft gradually tapers to the other end, which is sharply pointed and is generally much bent, particularly towards the

enlarged extremity; and sometimes the pointed end is a little recurved, giving to the spiculum a slight S-like twist.

This species is common on the coast of Northumberland, where almost every piece of limestone at low-water mark has the surface riddled by it: it likewise occurs in the shell of *Fusus antiquus* and *Buccinum undatum*. I have obtained it also in oyster-shells from Prestonpans. The walls of the burrows of this form are strongly punctured, and every here and there are drilled with small conical holes. When in the thin shell of *Fusus* or *Buccinum*, the branches are all confined to the same plane, and then this species has considerable resemblance to a *Gorgonia*. But when it takes up its abode in limestone, the branches frequently pass vertically to some depth into the substance of the rock, giving to the sponge a very complicated structure.

In old specimens the branches become less regular, increasing much in thickness and number until very small spaces divide them: the external walls are now liable to give way, and the sponge being thus exposed must either perish or sink deeper into the matrix.

C. radiata. Pl. XV. fig. 3.

Sponge delicately branched in a radiating manner; the branches being $\frac{1}{10}$th of an inch thick and divided at unequal distances into elongated lobes: terminal twigs simple, minute, linear: papillæ rather variable in size, frequently very small, placed in a single close-set row along the branches; in the central axis where the branches unite there is one much larger than the rest. Spicula $\frac{1}{38}$th of an inch long, stout, straight, frequently a little bent; one end with a large ovate head widest at its junction with the shaft, which is a little constricted at the point of union, and from which it is strongly defined by a dusky shadow.

This form buries itself in the shell of *Triton variegatus*, and is easily recognized on the surface by the radiating lines of minute close-set papillary punctures. It is very destructive to the shells it attacks: at first it is composed of a few simple radiating branches; these afterwards enlarge, and send off lateral shoots which anastomose with the adjoining branches, and ultimately fuse, as it were, towards the centre, which becomes one mass of sponge frequently an inch wide; all the shell, of course, at this part being entirely removed.

C. gracilis. Pl. XIV. fig. 7.

Sponge composed of a few long, slender, linear branches, rarely if ever anastomosing, extending in length upwards of 5 inches, and only $\frac{1}{16}$th of an inch thick, with a few distant, indistinct constrictions indicating an approximation to a lobed structure:

terminal twigs regularly bifurcating, the branches have consequently a dichotomous arrangement: papillæ placed rather far apart, small, of equal size, and arranged in a single row along the branches, the direction of which they distinctly indicate on the surface of the matrix. Spicula of two kinds; the larger about $\frac{1}{77}$th of an inch in length, generally a little bent, stout and inclining to fusiform, with the pointed end gradually tapering; the opposite extremity provided with a rounded head, somewhat elliptical, and merging imperceptibly into the shaft. The smaller spicula are about $\frac{1}{3}$rd the length of the larger ones, and are less stout; they bend gradually in the centre, from whence they taper to a fine point at each end.

I have seen only one specimen of this species; it is in *Pecten maximus*, most probably from Orkney, and extends from the beak to the ventral margin. The spicula somewhat resemble those of *C. corallinoides*, but are considerably stouter; and though the heads are large and well-formed, they are not so distinctly marked as in that species; and the smaller ones bend less abruptly: the character of the branches is also remarkably different.

The walls of the excavations of this species are rather finely punctured.

C. muscoides. Pl. XV. fig. 11.

Sponge formed of numerous delicate, much-divided, closely and irregularly anastomosing branches, with the terminal ones very slender and composed of an open network; the principal branches about $\frac{1}{10}$th of an inch thick, and distinctly seen ramifying throughout the general interlacement of the sponge: papillæ small, very numerous, approximating, and where the anastomosis is extensive, without apparent order; towards the terminal branches however they run in rows, and betray the course of the branches on the surface of the shell in which the specimen is buried. Spicula of two kinds, one with heads, the other with both ends pointed; the former, measuring $\frac{1}{110}$th of an inch in length, are generally straight, proportionately stout, and with two globular heads, one terminal, though not always perfectly so, and one placed at a little distance down the shaft; occasionally there is an additional head a little way below the second; from this end the shaft tapers gradually to a sharp point at the opposite extremity, towards which there is frequently a slight bend. The other kind of spicula are fusiform and as stout as those with heads, but only half their length; they taper gently to both ends, which are finely pointed, and bend abruptly in the centre, where there is frequently a nodulous swelling; there is also occasionally another indistinct nodule or two on each side of the centre one and at some little distance from it.

I have seen only one specimen of this interesting species; it occurs in the shell of *Monoceros fusoides* in the Newcastle Museum. It has injured nearly the whole surface of the body-whorl, and has extended its ravages over most of the spire.

C. Howsei. Pl. XIV. fig. 8.

A small delicately branched and closely anastomosing species with the branches slightly lobed or nodulous: terminal twigs slender, long, linear, and rather acutely bifurcating, and anastomosing widely for a considerable length backwards; afterwards the meshes become very much reduced in size by the addition of branches. In the older parts, where the anastomosis is very dense, the meshes being about $\frac{1}{12}$th of an inch wide, the lobes or nodules are most distinct; they rarely exceed $\frac{1}{16}$th of an inch in diameter: papillæ very fine and close-set, running in a single row along the branches, and generally so disposed that the anastomosis can be easily followed by the perforations they make in the surface of the matrix, but from their minuteness might readily escape observation. Spicula very delicate and about $\frac{1}{100}$th of an inch long; there are two kinds; one is generally straight and tapers to a very fine, slender point at one end, and has at the other a well-marked terminal head, which is short and broadly ovate, with the apex at the extremity, and sometimes a little prolonged: the other kind of spicula is generally a little longer than the preceding, and is mostly somewhat bent, but is likewise slender and gradually diminishes to a fine point at one extremity; the other is most commonly furnished with two heads; one is terminal or nearly so, the second is placed about $\frac{1}{3}$rd down the shaft: it also frequently happens that the terminal head is wanting.

This species is so very distinct in all its characters, that it cannot well be confounded with any other British form. Its slender, delicate branches, small and regular papillary punctures arranged in anastomosing lines, and its characteristic two-headed spicula at once distinguish it. Only two specimens have occurred, one in *Fusus antiquus* from the Dogger-bank, the other in a nullipore procured from the beach at Tynemouth. For these and for several other specimens I am indebted to Mr. Richard Howse, after whom this species is named.

C. Northumbrica. Pl. XIV. fig. 5.

Sponge when dry of a pale yellow colour, branched, closely and irregularly anastomosing and indistinctly lobed; the larger lobes being sometimes $\frac{1}{8}$th of an inch across: papillæ rather small, seldom more than $\frac{1}{30}$th of an inch in diameter, placed considerably apart along the branches, but appearing numerous,

regularly distributed and rather closely set on the surface of the matrix. Spicula of two kinds; one, much the larger, measures $\frac{1}{77}$th of an inch in length; it has at one extremity a large rounded head, is straight, and tapers gradually to a sharp point at the other: the smaller spicula are scarcely more than $\frac{1}{4}$th the length of the former, are rather stout, fusiform, sharp and gradually pointed at both ends, and much and suddenly bent in the centre, where they are thickest.

I have seen only two specimens of this species: they occur in individuals of *Fusus antiquus* brought from the Haddock grounds by the Cullercoats' fishermen. This may be at once distinguished from *C. gorgonioides* by the spicula, that species having only one kind, this two: but the form of the larger kind, which is common to both species, is sufficiently distinct; its head in those of *C. Northumbrica* is almost always quite circular and is at the extreme end; and moreover they are rarely bent, and when so only very slightly. The branches too are indistinctly lobed in this species, but are never so in *C. gorgonioides*, and the papillæ are smaller and more numerous. Unfortunately I have not seen the terminal twigs, as the only two specimens procured of this species had entirely overrun the shells they had attacked. In both instances, the shell being dead, the papillæ had perforated each surface.

C. Alderi. Pl. XV. fig. 9.

Sponge branched, irregularly and widely anastomosing, and strongly lobed; the lobes for the most part irregularly rounded, frequently $\frac{1}{6}$th of an inch wide, placed close together, and united by a much-constricted stem: terminal twigs very fine, frequently linear for a considerable length, and bifurcating somewhat irregularly: papillæ small, rather variable in size, the largest about $\frac{1}{40}$th of an inch in diameter, placed rather far apart in a single row along the branches on the surface of the matrix; they appear occasionally to run in lines. Spicula of two sorts; one $\frac{1}{116}$th of an inch long, moderately thick, slightly bent, with a small oval head near one end, and tapering to the other extremity: the second kind is scarcely shorter than the former and has one end truncate, the opposite pointed, and is decidedly bent in the centre. The puncturing of the walls of the chambers is distinctly visible with a low magnifying power.

This species is named after my friend Mr. Alder, who took several specimens of it in *Pectunculus pilosus* on the coast of the Isle of Man: as yet it has occurred in no other locality.

C. corallinoides. Pl. XV. figs. 1 & 2.

Sponge freely and distinctly branched, slightly anastomosing, and regularly and strongly lobed; the lobes about $\frac{1}{8}$th of an inch

wide, and somewhat obtusely quadrate, a little longer than wide, placed end to end and united by a slender, central, cylindrical stem: terminal twigs exceedingly slender, almost linear, giving off lateral shoots, and irregularly bifurcating: papillæ variable in size, some being nearly $\frac{1}{24}$th of an inch in diameter, while others are very much smaller, arising from the lobes without order; some of the lobes having only one papilla, others three or four. Spicula $\frac{1}{70}$th of an inch long, slender, generally bent in the centre, tapering gradually to a sharp point at one end, and at the other furnished with an elliptical head defined at its junction with the shaft by a dusky line. Besides these there are other spicula of a different form which are equally numerous with those just described, but are much smaller and very delicate, measuring scarcely $\frac{1}{3}$rd their length: these smaller ones are fusiform, with both extremities sharply pointed, and are suddenly bent in the centre.

This beautifully branched species occurs in British specimens of *Pecten maximus*, but the exact locality is not known. Three examples have been procured. In all the papillary punctures are very variable in size, and indistinctly indicate on the surface of the shell the various ramifications of the sponge; and in all the specimens the branches could be perfectly distinguished likewise on the inner surface. Here the sponge had made innumerable minute punctures, which the mollusk had endeavoured to close up by an accumulation of calcareous matter, covering the entire track of the branches with small granules.

The walls of the excavations of this species are strongly and regularly punctured.

C. Fryeri. Pl. XIV. figs. 2, 4 & 9.

Sponge formed of lobed branches arranged in a somewhat radiating manner, and irregularly anastomosing, with a few scattered, spine-like processes; the lobes about $\frac{1}{10}$th of an inch wide, considerably elongated, with the ends truncate, and united by a much-constricted central stem: terminal twigs short, almost linear, bifurcating: papillæ small, arranged in a single row along the branches, generally two or three to each lobe. Spicula of two forms: one, considerably larger than the other, generally measuring $\frac{1}{116}$th of an inch in length, is straight, and furnished at one end with an oval head; from thence it tapers imperceptibly to the other extremity, which is finely pointed. The other form of spiculum is almost cylindrical, slightly curved, with the ends brought abruptly to sharp points.

This beautiful species is imbedded in the shell of *Placuna placenta*, in the possession of J. H. Fryer, Esq. of Whitley House, after whom it is named, and to whose interesting and extensive collection I am indebted on this, as on a former occasion, for much valuable assistance.

On account of the transparency of the shell the whole of the sponge is exposed to view, as well as a series of the young exhibiting every stage of development. The walls of the chambers of this species are strongly punctured.

C. spinosa. Pl. XIII. figs. 5 & 7.

Sponge branched, regularly anastomosing; the branches along their entire course swelling into large lobes measuring nearly $\frac{1}{12}$th of an inch wide: terminal twigs minute, tapering, having a spine-like appearance, generally simple, but frequently a little branched: papillæ numerous, for the most part small, with one here and there very much larger than the rest; the largest about $\frac{1}{12}$th of an inch in diameter. When the sponge is in a growing state, the papillæ penetrate the surface of the matrix in single rows in a somewhat branched manner, but as the growth matures and the anastomosis goes on, this arrangement is lost; and ultimately the papillæ are pretty regularly distributed over the whole surface. Spicula of two kinds; one has a globular head at one end, is rather stout, straight, $\frac{1}{87}$th of an inch long, and tapers gradually to the opposite extremity, where it terminates in a fine sharp point: the other kind is fusiform, and is scarcely $\frac{1}{3}$rd as long as that with a head, and is much less stout; it is bent suddenly in the middle, and from thence tapers gradually to the ends, which are very sharp and a little recurved.

Of this species I have seen at least four individuals in the valves of *Perna femoralis* and *Placuna sella*, and these I have been able to examine with great facility, on account of the transparency of the inner layer of shell through which the lobed branches with their terminal twigs are most distinctly visible, the internal puncturing giving to them a pretty silvery appearance, and rendering the whole under a lens an object of great beauty. In the *Placuna*, which measures 6 inches wide, the ramifications of the sponge have passed from side to side, and have done much damage to the surface of both valves. For these specimens I am indebted to Mr. Robert Currie of Newcastle: those in *Perna*, from which the figures are taken, are in the Newcastle Museum.

C. cervina. Pl. XV. fig. 8.

Sponge formed of numerous branches, anastomosing, and enlarged into many rounded, and sometimes elongated lobes which are crowded upon each other, and measure each $\frac{1}{10}$th of an inch wide: terminal branches or twigs rather stout, slightly tapering, bifurcating pretty regularly, and frequently with lateral branches giving to them not a little the appearance of antlers: papillæ

generally small, numerous, disposed with a good deal of regularity, and having a few very much larger than the rest intermingled; the larger ones $\frac{1}{24}$th of an inch in diameter. Spicula of two forms; one $\frac{1}{100}$th of an inch long, sometimes quite straight, but generally a little bent, particularly towards the end which is sharp-pointed; from thence it gradually enlarges to the other extremity; this terminates in a large, strongly defined, globular head, which is generally somewhat flattened like that of a pin; the shaft being mostly a little constricted at the point of union with the head. The other form of spiculum is only about $\frac{1}{4}$th the length of the former, is irregularly tuberculated, and very stout and squat, bends rather suddenly in the centre, and tapers abruptly to the ends which are obtusely pointed.

This species is very like *C. spinosa* in general habit, but the terminal twigs are not so delicate, and are more regularly bifurcated: the lobes too are larger, and the papillæ less than they are in that species. The spicula are also very different, and are quite sufficient to remove all doubt if such existed.

Two or three specimens of *C. cervina* have occurred in the valves of *Meleagrina albina*? to which they have done much damage, and through the pellucid inner substance of which the sponge is distinctly revealed. These specimens are in the Newcastle Museum.

C. dendritica. Pl. XII. fig. 5. and Pl. XV. fig. 4.

Sponge minutely branched, slightly and irregularly anastomosing; the branches swelling at intervals into rounded or elongated lobes about $\frac{1}{24}$th of an inch wide: terminal twigs frequently very long, and freely and elegantly divided like the branches of a tree: papillæ small, not numerous. Spicula not more than $\frac{1}{175}$th of an inch long, proportionately stout, straight, occasionally a little bent; one end with a globular head, sometimes inclined to ovate, and tapering gradually to the other extremity, which is very finely pointed: there are likewise fusiform spicula; these are considerably smaller than those with heads, and bend suddenly in the centre; from thence they taper and terminate at each end in a sharp point.

Several individuals of this pretty species have been observed in a specimen of *Patella Mexicana* in the Newcastle Museum. These are clearly seen through the pellucid enamel of the inside of the shell, and have a very distinct dendritic appearance.

C. Canadensis. Pl. XIV. fig. 10.

Sponge composed of a dense anastomosing mass of strongly lobed branches; the lobes large in proportion to the central stem, but rarely exceeding $\frac{1}{10}$th of an inch wide, somewhat rounded,

though irregular in form, and on account of their crowded state the mode of branching scarcely distinguishable, except towards the terminal twigs, which are linear, very minute and irregularly bifurcated: papillæ small, numerous, and passing through the surface of the matrix without apparent order, though pretty equally distributed and closely set; towards the margin of the sponge they occasionally run in lines. Spicula rather stout and short, being $\frac{1}{140}$th of an inch in length, somewhat suddenly bent in the centre, with one end generally a little enlarged and rounded, the other tapering gradually to a sharp point. There is also another kind of spicula which appear to be more numerous than those just described, but not quite so long; these are sharply pointed at each end, and suddenly bent in the centre where they are thickest; at this point, too, there is frequently a decided nodule, and occasionally two or three.

Only one specimen of this species has been obtained; it is in the shell of *Ostrea Canadensis.* In general appearance this sponge has considerable resemblance to *C. lobata*; the lobes, however, are rounder and smaller, and the spicula at once distinguish it from that species, and from all others with which I am acquainted.

The puncturing in the sides of the excavations of *C. Canadensis* is minute and somewhat obscure, and less regular than usual.

C. millepunctata. Pl. XII. fig. 9.

Sponge composed of an intricate interlacement of minute branches not more than $\frac{1}{50}$th of an inch thick, being throughout made up of close-set, irregularly rounded lobes, except towards their terminations, where they are linear and much less crowded: papillæ minute, close-set, and exceedingly numerous: spicula $\frac{1}{140}$th of an inch long, linear, very slender, frequently much and abruptly bent in the centre, sometimes more gradually arched towards one end which is sharply pointed; the other termination is furnished with a large elliptical head.

I have seen only one example of this distinct species; it is in the shell of *Cassis tuberosa*, and spreads almost entirely over it; the surface is crowded with the minute papillary orifices, and on rubbing a little of it away the substance beneath is found to be completely riddled with the sponge, and to present a pretty regularly punctured appearance caused by the chambers occupied by the lobes. The principal branches, however, can be distinctly traced ramifying in various directions.

C. lobata. Pl. XII. figs. 4 & 8.

Sponge branched, anastomosing; the branches composed of a series of comparatively large, rounded, somewhat transversely

oval, and occasionally irregularly angulated lobes about $\frac{1}{12}$th of an inch wide, and united by a small central stem: terminal twigs short, linear, and bifurcated: papillæ small, numerous, and distributed on the surface of the matrix without apparent order. Spicula $\frac{1}{100}$th of an inch long, not very slender, mostly a little bent, and brought gradually to a sharp point at one end; the other with an irregularly rounded head, sometimes slightly elliptical, and generally not exactly terminal.

The puncturing of the chamber-walls of this species is strong and decided, and the branches in old specimens are much confused on account of the frequent anastomosis and the crowding caused by the lobes. Towards the terminal twigs the character of the branches is however quite distinct. The *C. lobata* is not to be confounded with any other of the British forms, and is undoubtedly distinct from the various foreign species that have come under my notice. It occurs in *Haliotis* from Guernsey. I have seen two specimens affected by it, and in both cases very extensively; in one the whole external surface is crowded with the minute papillary punctures.

C. vastifica. Pl. XV. fig. 12.

Sponge formed of a close and intricate anastomosis of strongly lobed branches; lobes irregularly angulated, frequently $\frac{1}{8}$th of an inch wide, and united by a delicate stem: terminal twigs not long, linear: papillæ small, rarely exceeding $\frac{1}{30}$th of an inch in diameter, very numerous, close-set, and pretty regularly distributed over the surface of the matrix. Spicula of two kinds, one much larger than the other; the former $\frac{1}{87}$th of an inch in length, straight, rather slender, and diminishing imperceptibly to a very fine point at one end; the other terminating in a perfectly globular head. The smaller kind of spiculum is about $\frac{1}{3}$rd the length of the larger, and is much thinner; it is stoutish in the centre, where it rather suddenly bends a little, and from thence tapers gradually towards the ends, which are sharply pointed.

When the outer surface of the shell containing this species is removed, a complete close network of chambers is revealed, containing the lobes of the sponge; and on a closer examination they are seen to be united by small circular passages for the accommodation of the uniting stems. The only specimen I have seen of this species is in the shell of an oyster from Prestonpans?, the surface of which had suffered much injury by the influence of this parasite. The puncturing of the sides of the cavities of this species is finer than usual.

C. rhombea. Pl. XII. fig. 7.

Sponge when dry of a pale straw colour, composed of numerous, small, imperfectly lozenge-shaped lobes, about $\frac{1}{16}$th of an inch wide, crowded on each other and united each to its neighbours by small cylindrical stems, four or five passing from each lobe: terminal twigs short and linear: papillæ large in comparison with the lobes, measuring nearly $\frac{1}{25}$th of an inch in diameter, rather numerous, and disposed on the surface of the matrix without order. Spicula of two forms, one much larger than the other, being upwards of $\frac{1}{87}$th of an inch long, straight, stout, and generally tapering to a fine point at one end; the other termination is furnished with a globular head, a little inclined to oval. The other form of spiculum is not more than half as long as those with heads, but is only a little inferior in thickness: it is fusiform, tapering gradually to a sharp point at each end, and is abruptly bent in the centre.

This species occurs in *Tridacna gigas*; the lobes appear to be arranged in a somewhat branched manner, but on account of their close approximation the order is obliterated. Some of the uniting stems are larger than the rest, and most probably indicate the main branches.

C. purpurea. Pl. XII. fig. 6.

Sponge made up of numerous, close-set, somewhat elongated and angulated lobes or nodules about $\frac{1}{10}$th of an inch in length, united by several delicate, cylindrical stems; and when dry of an obscure purple colour: terminal twigs short, linear: papillæ small, not very numerous, passing through the matrix without apparent order. Spicula numerous, of two sorts; one is larger than the other, $\frac{1}{100}$th of an inch in length, linear, slightly and regularly bent, with the ends a little enlarged and rounded. The other kind of spiculum is about half as long as the preceding, and resembling it in form, with the exception that the extremities are not enlarged; it is likewise irregularly spinous throughout its entire length.

This species is readily distinguished by its purple colour and by the peculiar characters of its spicula. In general form there is considerable resemblance between it and *C. nodosa*; the lobes, however, are much smaller than they are in that species, and the stems that unite them are less numerous; they are likewise elongated. The *C. purpurea* occurs in *Tridacna gigas*.

C. angulata. Pl. XV. fig. 13.

Sponge formed of a few irregularly shaped and angulated lobes or nodules, sometimes measuring $\frac{1}{8}$th of an inch wide, placed close together, and united by a few small, short, cylindrical or flattened stems: terminal twigs rather short, simple, small and linear: papillæ not very numerous, irregular in size and arrange-

ment, the largest about $\frac{1}{24}$th of an inch in diameter. Spicula stout, nearly $\frac{1}{117}$th of an inch long, slightly and regularly curved, gradually tapering to a sharp point at one end, and with an oval swelling at the other, but not quite terminal, and frequently ill-defined.

This species inhabits red coral from the Mediterranean, and completely destroys it; the interior being reduced to a few large irregularly angulated chambers divided by very thin walls, while the surface remains comparatively uninjured, showing no signs of the ravages within except a few circular punctures of no great size, and at first so small as scarcely to attract attention. The puncturing of the walls of the chambers is very strong and regular in this species, and the spicula are characteristic, and stouter than usual: the stems that unite the lobes are comparatively few.

C. quadrata. Pl. XV. fig. 6.

Sponge composed of large, irregularly quadrate lobes, $\frac{1}{6}$th of an inch wide, with the angles obtuse, connected without apparent order by several small, cylindrical stems passing irregularly from all sides, occasionally in pairs; sometimes enlarged and flattened and arising from a depression in the side of the lobe: terminal twigs rather short, fine and linear: papillæ not very numerous, about $\frac{1}{24}$th of an inch in diameter, and placed rather far apart. Spicula very large and stout, measuring $\frac{1}{70}$th of an inch in length, in form somewhat resembling a nine-pin; the shaft fusiform, swelling in the centre to an extraordinary degree, and tapering gradually to a fine point at one end; the other terminates in an exactly rounded head, very large, and distinguished from the shaft by a dusky shadow caused by its rotundity.

The animal of this species when dry is of a dark brown colour, and may at once be recognized by the enormous development of the spicula, which possess the utmost brillancy, and are very striking objects in the microscope. The excavations are also characteristic; their squareness of form, and numerous orifices for the passage of the connecting stems arranged frequently in pairs and flattened, sufficiently distinguish this species. Only one or two individuals have occurred, and those in *Tridacna gigas*.

C. nodosa. Pl. XV. fig. 10.

Sponge formed of a congeries of large, irregularly angulated lobes disposed without apparent order, each measuring $\frac{1}{6}$th of an inch wide, and united to each other by several delicate, very short, cylindrical stems: terminal twigs slender, a little produced, cylindrical: papillæ not numerous, considerably apart from each other, the largest about $\frac{1}{24}$th of an inch in diameter. Spicula

stout, fusiform, $\frac{1}{173}$th of an inch long, much bent in the centre, and tapering towards the ends, which are sharp-pointed.

The animal of this species when dry is snuff-coloured, and is readily distinguished from its congeners by its simple-formed spicula. When the shell in which it is concealed is broken across, the numerous, large, angulated chambers containing the lobes, separated only by thin walls, have much the appearance of honey-comb, lacking a little of its symmetry and perfect angularity. The *C. nodosa* is one of several species found in a large specimen of *Tridacna gigas*, and is evidently very destructive; large portions of the strong ribs of the shell having given way in several places under the influence of this parasite.

C. labyrinthica. Pl. XV. fig. 7.

Sponge composed of an irregularly reticulated mass, the interlacing being exceedingly minute, and so intricate that it is impossible to determine the order of the parts: papillæ not very numerous, minute, without apparent order. Spicula numerous, fusiform, $\frac{1}{233}$rd of an inch long, rather stout, nearly cylindrical, slightly and regularly bent from end to end, with each termination suddenly brought to a sharp point.

When dried this species is of a pale straw colour: it occurs in *Tridacna gigas*, to the shell of which it is very destructive. Several specimens have occurred; one of them has sunk upwards of an inch deep into one of the ribs of the shell, and has extended its ravages four or five inches in length and nearly two in breadth, passing, in fact, from side to side of the rib, and giving to the entire substance the appearance of the central cellular structure of bone; and this resemblance is rendered the more perfect on account of a thin layer of the surface being left almost sound.

Genus Thoosa*.

Sponge branched or lobed, buried in calcareous bodies; the interior with anastomosing tubes, and devoid of spicula; the surface with a crust of nodulous, crystalline bodies composed of silex.

This genus by its general form and habit is closely related to *Cliona*, from which it differs chiefly in the character of the siliceous bodies on the surface, and in the absence of spicula from the interior. Two or three species have occurred; they are all from the tropics, and vary considerably in form; one or two of them have radiating spicula mixed with the siliceous bodies of the surface.

T. cactoides. Pl. XIII. figs. 1 & 2.

Sponge branched, strongly lobed, regularly and widely ana-

* A sea-nymph.

stomosing; the meshes frequently more than $\frac{1}{4}$th of an inch wide; lobes elliptical, about $\frac{1}{3}$th of an inch broad, and giving off numerous, minute, linear twigs: terminal branches dividing dichotomously and furnished on all sides with twigs similar to those of the lobes: the dichotomous arrangement may be traced throughout the branches. Siliceous bodies of the surface very numerous, measuring $\frac{1}{175}$th of an inch long and $\frac{1}{2\,5\,4}$th of an inch broad, composed of two whorls, each comprising six or seven squarish nodules; the whorls being placed a little apart from each other near the ends of a stout central axis which terminates at each extremity in a nodule like those of the whorls.

This is one of the largest and most beautiful of the excavating sponges; only one individual has occurred: it is buried in the substance of a large valve of *Meleagrina margaritifera* which has been in my collection many years. The branches extend from side to side of the shell, and reach from the beak almost to the ventral margin, measuring in length six or seven inches. The outer surface of this valve has unfortunately been removed, and the papillary punctures consequently destroyed: the ramifications of the lobed branches, however, are completely exposed, so that they can be traced throughout. But a considerable number of the terminal twigs remain imbedded in the shell, and are distinctly seen through the inner transparent layer.

The puncturing of the walls of the cavities of this species is so strong that it may be seen even with the naked eye; and they are likewise penetrated with numerous small orifices for the passage of the minute twigs which come from the underside of the lobes. Whether similar twigs pass from the upper surface I have not been able to determine, on account of the destruction of the external portion of the shell. Those from the lower surface puncture the innermost layer of the valve; and as pearly matter has accumulated around each orifice, the inside of the shell is ornamented with numerous clusters, corresponding to the lobes, of minute pearl-like points, the beauty of which has probably led to the preservation of the shell.

T. bulbosa. Pl. XII. fig. 10.

Sponge composed of a few large, irregularly shaped, and somewhat depressed lobes, occasionally inclining to square, but always more or less rounded; united by a slender stem mostly flattened and variable in form: papillæ not large, few, penetrating the surface of the matrix without order; apparently not more than one or two from each lobe. Siliceous bodies of the surface like those of *T. cactoides*, but a little less. In addition to these bodies the surface is provided with triradiate and quadriradiate spicula, the rays, measuring $\frac{1}{2\,0\,3}$rd of an inch long, are straight, diverge

at various angles, and each tapers gradually to a fine point; at the place of junction there is generally a slight swelling.

Several individuals of this species are buried in the specimen of *Tridacna gigas* so often mentioned. In some of them the lobes attain a great size, measuring half an inch in diameter. The walls of the chambers are much more minutely punctured than in *T. cactoides*; and in one of the specimens examined the spicula differ from those above described. In the specimen alluded to they are multiradiate and triradiate of a peculiar character, the latter, Pl. XIII. fig. 8, having one of its rays cut short—little more than a squarish tubercle indicating the point of union: the other two rays bend from each other rather abruptly near the middle and afterwards taper gradually to fine points. The multiradiate spicula, Pl. XII. fig. 11, are about three times the length of the nodulous bodies, and are rare and very complicated: they are formed of two whorls of six or more rays each, the whorls being placed rather near together on a central axis which is much produced at the ends; the rays are straight, and, tapering gradually to sharp points, have generally a rounded swelling near the extremity.

I have not yet been able to determine whether the specimen provided with these curious spicula is distinct or not, though I am inclined to believe that it is.

EXPLANATION OF PLATES XII. XIII. XIV. AND XV.

Plate XII.

Fig. 1. A portion of the surface of *Cliona celata* as seen in the compressor, magnified about 400 diameters, exhibiting crystalline bodies.
— 2. Large crystalline bodies from the same more highly magnified.
— 3. Small crystalline bodies also from the same, highly magnified.
— 4. Chambers of *C. lobata* exposed by removing the surface of the matrix:—one half larger than nature:—*a*, papillary punctures.
— 5, 5. Portions of *C. dendritica* four or five times the size of nature, exhibited as seen through the transparent substance of the matrix.
— 6, 6. Spicula of *C. purpurea* much enlarged: *a*, a spiculum still more highly magnified.
— 7, 7. Spicula of *C. rhombea* much enlarged.
— 8. Ditto *C. lobata* ditto.
— 9. Ditto *C. millepunctata* ditto.
— 10. *a*, Crystalline nodulous bodies from the surface of *Thoosa bulbosa*; *b*, triradiate and quadriradiate spicula from the same.
— 11. Multiradiate spicula from the surface of *Thoosa bulbosa*?: *a*, an end view of a spiculum; *b*, one of the rays more highly magnified.

Plate XIII.

Fig. 1. A portion of the branches and terminal twigs of *Thoosa cactoides* of the natural size.
— 2. *a*, A portion of the surface of the same magnified about 200 diameters, exhibiting nodulous crystalline bodies; *b*, two of these bodies more highly magnified.

Fig. 3. The branched chambers of *Cliona celata* exposed by the removal of the surface of the matrix: *a*, papillary punctures.
— 4. Spicula of *C. celata* much enlarged.
— 5. *C. spinosa* as seen through the transparent matrix, magnified two times.
— 6. A portion of the surface of the matrix exhibiting the papillary punctures:—natural size.
— 7. Spicula of *C. spinosa* much enlarged.
— 8. Triradiate spicula from the surface of *Thoosa bulbosa*?

PLATE XIV.

Fig. 1. Chambers of *C. gorgonioides* exposed by the removal of the surface of the matrix, a little enlarged: *a*, papillary punctures.
— 2. *C. Fryeri* as seen through the transparent matrix; one half enlarged.
— 3. Surface of the matrix of the same, exhibiting the papillary punctures.
— 4. A series exhibiting the development of *C. Fryeri* considerably enlarged: *a*, represents the first stage; *b*, *c*, *d*, *e*, *f*, the succeeding stages.
— 5. Spicula of *C. Northumbrica* much enlarged.
— 6. Ditto *C. gorgonioides* ditto.
— 7. Ditto *C. gracilis* ditto.
— 8. Ditto *C. Howsei* ditto.
— 9. Ditto *C. Fryeri* ditto.
— 10. Ditto *C. Canadensis* ditto.

PLATE XV.

Fig. 1. Chambers of *C. corallinoides* exposed by the removal of the surface of the matrix: *a*, papillary punctures.
— 2. Spicula of *C. corallinoides* much enlarged.
— 3. Ditto *C. radiata* ditto.
— 4. Ditto *C. dendritica* ditto.
— 5. Ditto *C. insidiosa* ditto.
— 6. Ditto *C. quadrata* ditto.
— 7. Ditto *C. labyrinthica* ditto.
— 8. Ditto *C. cervina* ditto.
— 9. Ditto *C. Alderi* ditto.
— 10. Ditto *C. nodosa* ditto.
— 11. Ditto *C. muscoides* ditto.
— 12. Ditto *C. vastifica* ditto.
— 13. Ditto *C. angulata* ditto.

XXXVII.—*On the Mode of Growth in* Calothrix *and allied Genera.* By JOHN RALFS, M.R.C.S., Penzance*.

IN my former communication I remarked that in *Oscillatoria* the division of the filament is accompanied by that of its sheath, whilst in *Microcoleus* the sheath is so inflated as not to interfere with the process of division. I shall now endeavour to prove that the appositional branches in *Calothrix* and other genera are the results of modifications of that mode of division which we see in *Oscillatoria* and *Microcoleus*.

* Read before the Botanical Society of Edinburgh, 8th March, 1849.

In *Scytonema*, *Calothrix*, *Arthronema*, &c. the sheath is somewhat cartilaginous and closely surrounds the contained filament. As its texture is comparatively firm, it admits only a slight degree of dilatation: it neither separates as in *Oscillatoria*, nor allows the bundling of the filaments as in *Microcoleus*.

In all these genera the structure of the filament, irrespective of the sheath, is alike, and consists of a single, longitudinal series of disciform cells which are often confluent or have indistinct dissepiments.

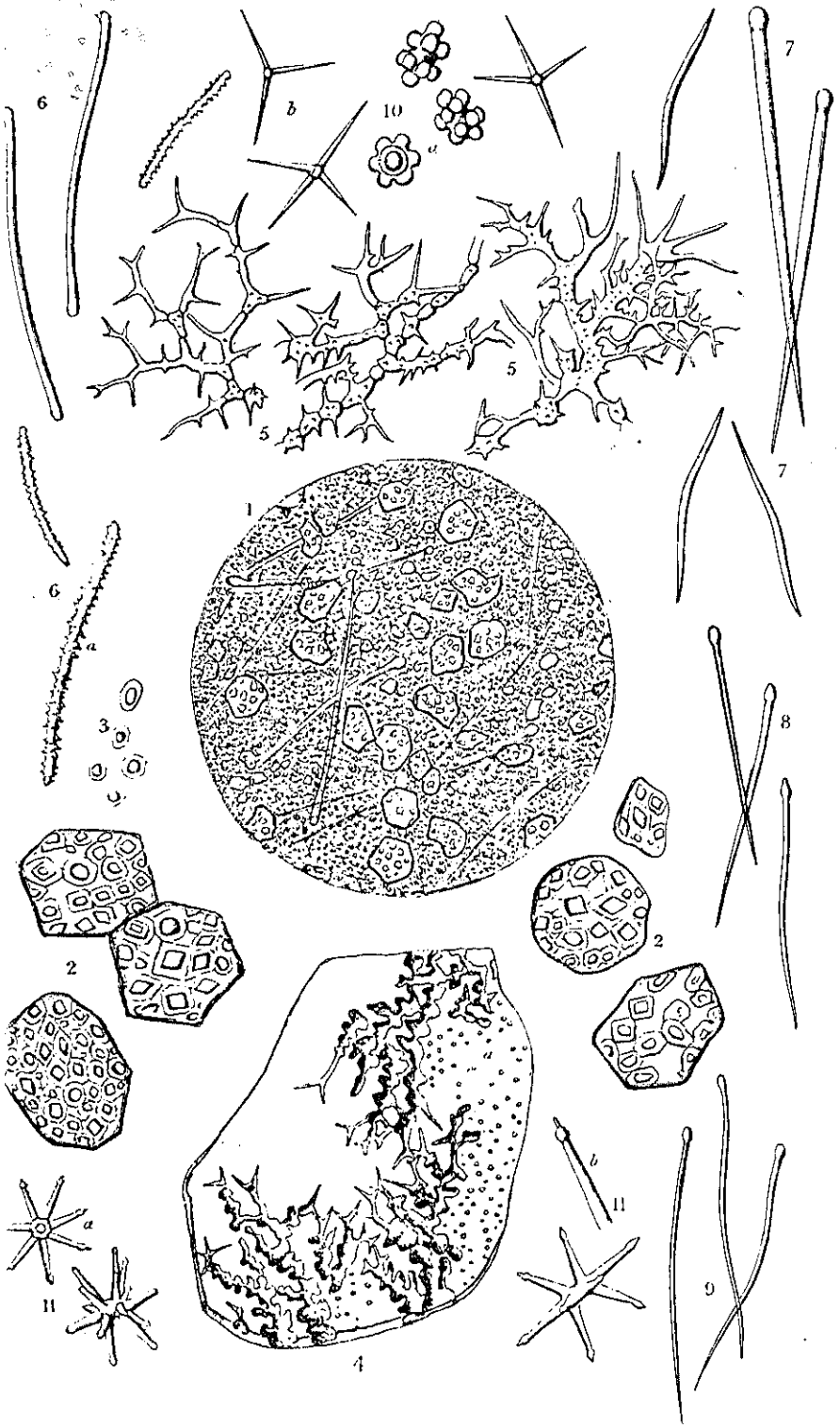
If a specimen of *Calothrix* or *Cænocoleus* be examined we may frequently observe, especially near the extremities of the branches, short separated portions of filaments in every respect similar to those which sometimes occur in *Oscillatoria*. At first such a portion is separated from the original filament by a short interval; but as there is no division of the sheath and both portions continue to elongate, they are soon in contact again. In the act of passing each other the extremities sometimes become attenuated. In this state the filament looks as if it had divided obliquely, and the upper portion becoming impacted between the filament and the sheath presents the appearance of a branch. From this explanation it will be evident that the branches in these genera are produced, not by an adhesion of other filaments, but by a dislocation of the filament itself.

Both portions continue to elongate upwards, and branches are thus repeatedly formed by dislocation. The upper portions or branches, however, always retain their original advantage and extend beyond the trunk. This fact seems to me a strong proof of the correctness of the view I have given, for it could scarcely be constant if the branches originated in any other manner.

The frond or sheath is itself truly branched or divided in the ordinary way. Sometimes, as in *Calothrix*, it is forked as soon as the upper portion becomes impacted, and the plant presents no peculiarity to the eye in its mode of branching except that the branches at the base are not united to the trunk.

In *Cænocoleus* the branching of the sheath does not occur at the same spot as the dislocation of the filament. Upon this circumstance depends the peculiar character of the genus, for after the dislocation the inferior portion as it elongates necessarily pushes itself up by the side of the superior one. Sometimes the filaments are again branched by dislocation before the sheath divides, and thus from two to four (or even more) filaments pass up side by side within a common sheath. Where the sheath forks the filaments are in general equally distributed between its branches.

From what I have stated it will be seen that in *Calothrix* and *Cænocoleus* the dislocated ends pass each other without any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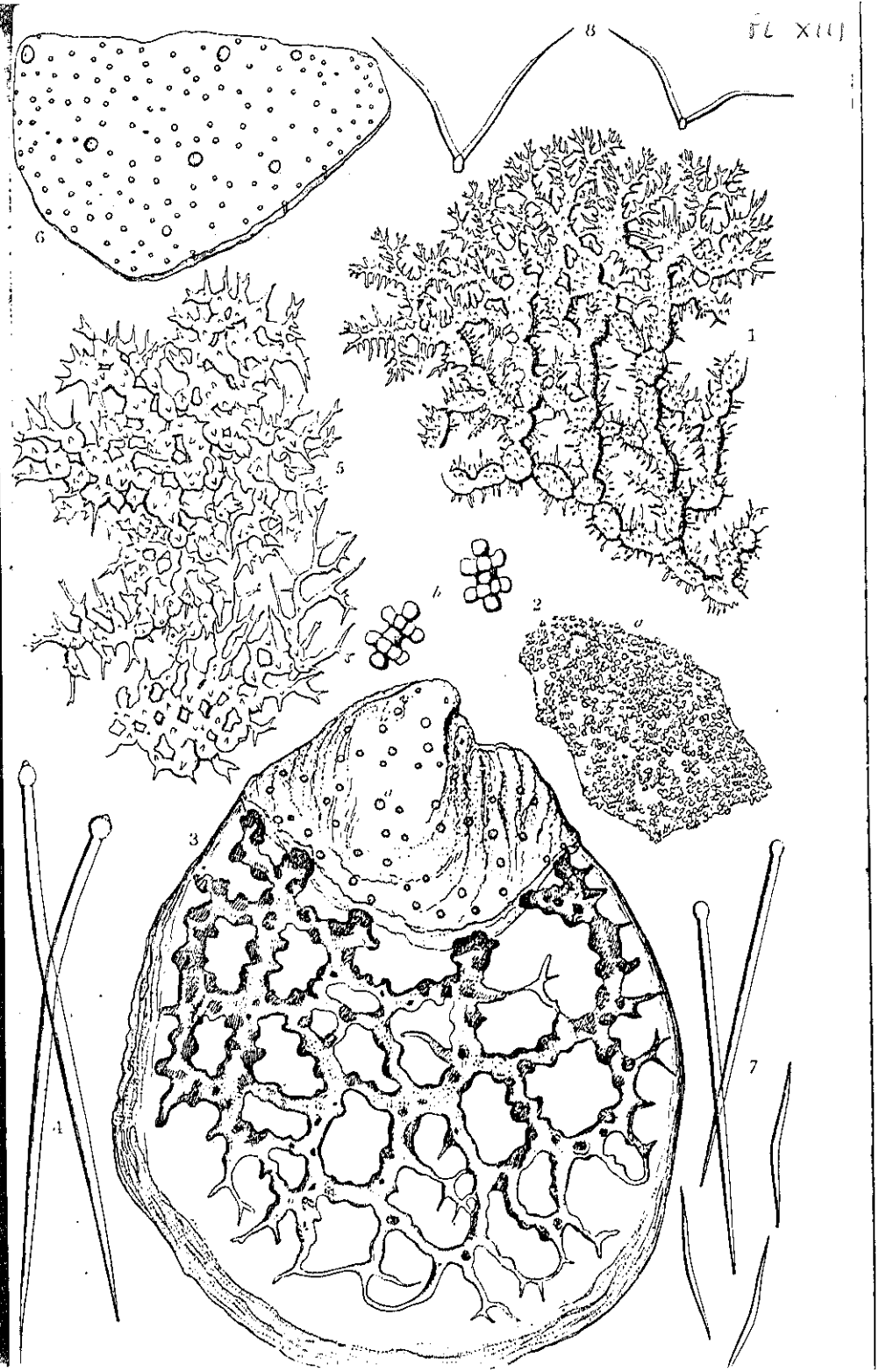
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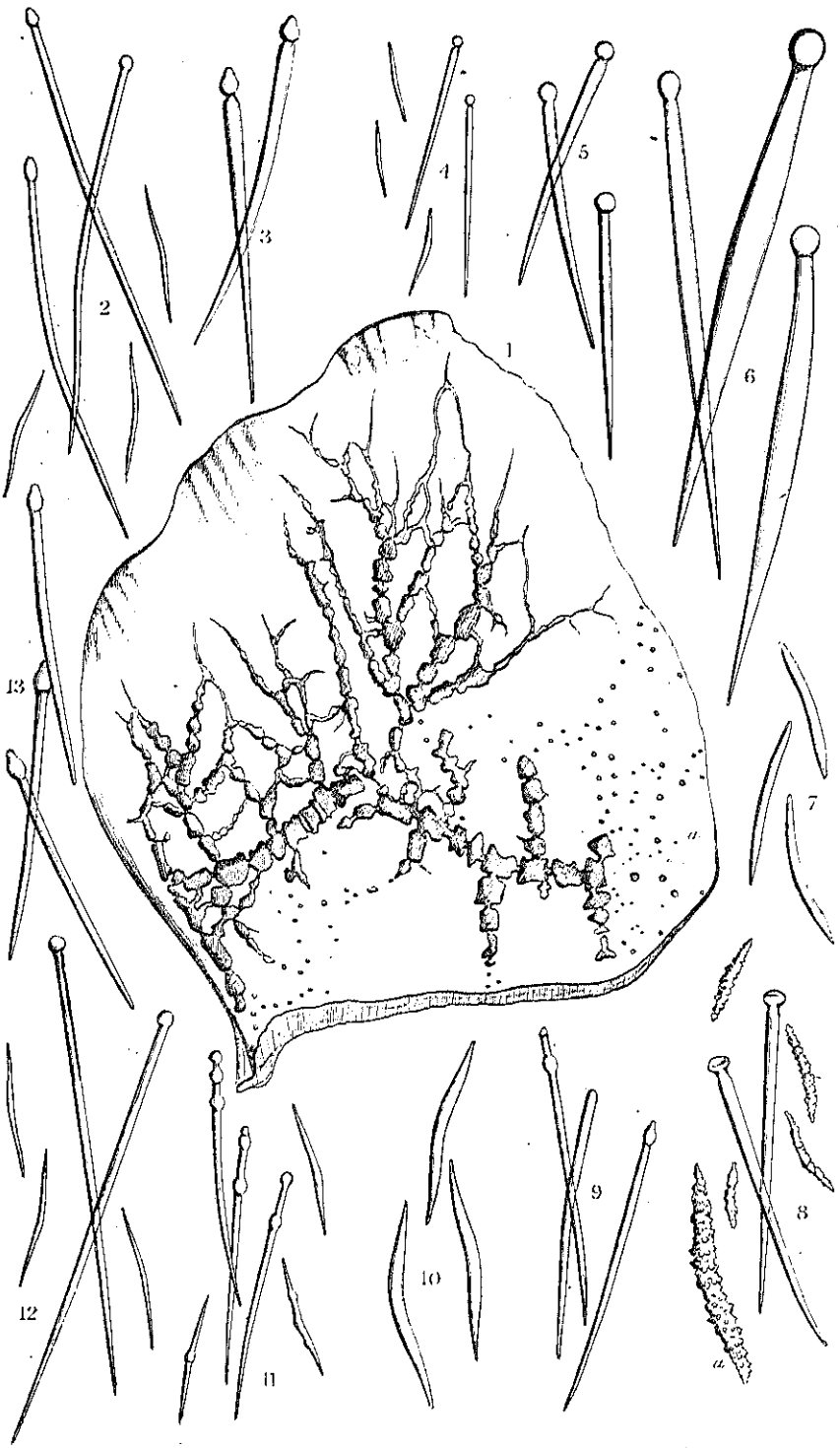
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