II.—*On* Plectronella papillosa, *a new Genus and Species of Echinonematous Sponge.* By W. J. Sollas, M.A., F.G.S., &c.

[Plates IV.–VII.]

Plectronella papillosa* (nov.).

(Examined in the dried state.)

Sponge (Pl. IV. figs. 1, 2) attached; stem short, thick, irregular, dividing into a number of once- or twice-bifurcated branches; branches cylindro-conical, curving irregularly, uniting where grown in contact, consisting of a central axis and a number of conical papillæ proceeding from it; papillæ $\frac{1}{5}$ inch long, $\frac{1}{25}$ inch in diameter, with simple, or bifid or trifid ends, arranged along the axis of the branch more or less spirally and at right angles to it, very numerous, producing the general outline of the sponge. Oscules and pores?

Colour drab or soft fawn-colour.

Skeleton composed of three kinds of spicules:—(1) those of the interior; (2) those of the surface; (3) those of the sarcode.

1. Spicules of the interior fusiform acerates, curved or straight, ·00125 inch in diameter and 0·0225 inch long (Pl. V. fig. 1), arranged in a confusedly fibrous manner, forming the chief skeleton of the sponge. Spicular fibres of the stem numerous, longitudinal, undulating, bifurcating and anastomosing, composed of acerate spicules lying longitudinally, frequently crossed by transverse ones, curving at intervals towards the exterior to supply a single fibre for the axial skeleton of each papilla (fig. 1, p. 18). Surface of the stem and papillæ echinated by the forward projection of some of the acerate spicules.

2. Spicules of the surface (Pl. V. figs. 2, 21) triradiate; two rays smooth, abruptly pointed, equal in length, diverging at equal angles from the third, which is longer, spined, especially towards the end, and terminated either by a sharp point or a rounded surface. Spines conical, usually bent backwards, talon-like. Length of the smooth rays, measured from the centre of the triradiate canal, 0·0028 inch, of spined ray 0·0055. Spicules arranged echinately, the pair of smooth rays seated on or immediately below the surface of the spicular fibre; the spined ray projecting obliquely forwards.

3. Flesh-spicules extremely fine filaments, 0·005 inch long, straight, or curved once, twice, or three times (Pl. V. figs. 3, 4);

* πλῆκτρον, a spur.

very numerous, frequently collected into longitudinal bundles (fig. 5).

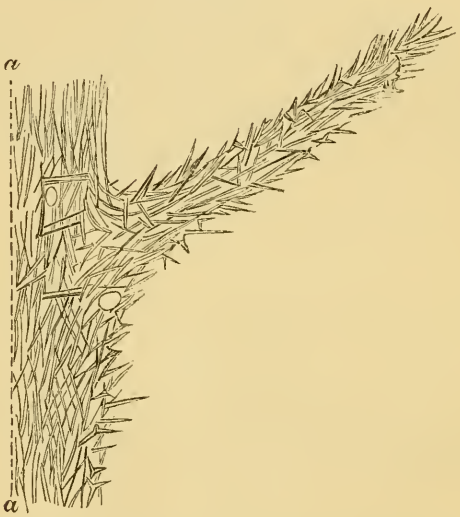
Hab. Marine.

Loc. (?). Collection, Bristol Museum.

Obs. Two of the most important characters of this sponge are, first, the triradiate form of its echinating spicules, and, next, the extreme tendency to variation which these display.

That the normal echinating spicule is truly triradiate, just as, say, a characteristic Hexactinellid spicule is sexradiate, is proved by the triradiate form of its axial canal. In spicules

Fig. 1.



Diagrammatic section taken longitudinally through a papilla and one half of the stem of the sponge: *a*, *a*, axial line of the stem.

which have not been subjected to any chemical treatment the canal is only just discoverable; but by boiling them for three or four minutes in caustic alkali it becomes enlarged and is then very obvious. The cavity from which the three arms of the canal originate is frequently globular in shape, and exceeds the canals in diameter; it represents the position of the young spicule-cell before it had budded to produce the adult form; and it may very conveniently be used as a fixed point within the spicule from which to measure the length of its diverging rays.

To produce the normal form of echinating spicule, two buds must have sprouted from the inner or proximal face of the spicule-cell, and by growing obliquely into the sponge have

given rise to the smooth paired rays, while a third bud must have started from its outer or distal face, and by growing outwards have produced the third unpaired ray. From the sides of the third ray additional offshoots have been developed forming the spines, into each of which a branch from the axial canal of the ray on which they occur is continued.

As it is very probable that the spines of spinose spicules in many other kinds of sponges are solid, and not provided with lateral diverticula from the axial canal, it may become necessary to distinguish between two kinds of spines, those with and those without a central canal, just as one distinguishes between those spines of plants which are mere epidermic outgrowths and those which are true aborted branches. Indeed, since writing the preceding sentence I have been able to verify the existence of solid non-canaliculated spicular spines in several instances, one of which will be described in a forthcoming paper on a new species of *Plocamia*.

The variations from the average form of echinating spicule are exhibited by some 4 or 5 per cent. of these spicules, and extend over a very wide range. In figs. 17 and 18, Pl. V., we have a form possessing two rays only, one of the proximal rays having disappeared and the remaining one grown backwards in the same line as the distal ray. Fig. 20 is another case of a similar kind, but with the single proximal ray inclined at an angle of 125° with the distal one.

Thus figs. 17 and 18 are biradiate but uniaxial forms, and in this respect resemble ordinary straight acerate spicules; while fig. 20 is biradiate and biaxial as well, and thus resembles a curved acerate, which is both biradiate and biaxial and therefore cannot, either in a strict or even in a wide sense, be said to be monactinellid: the only truly monactinellid spicules are the pin-headed ones and some other (but not all) forms of acuates. The variations shown in figs. 22, 24, 27, and 31 exhibit changes in the relative length of the three rays, and in the angle which the paired rays make with each other and with the third ray. Thus in fig. 27 the three rays are inclined at nearly equal angles of 120° with each other, and are all of nearly the same length; in fig. 22 one smooth ray continues the direction of the single ray, and the other projects at right angles from it, producing a form which recalls that of some commonly occurring hexactinellid spicules. In fig. 31 both paired rays diverge nearly at right angles from the third; in fig. 24 one smooth ray points forwards and the other keeps its normal backward direction; in some instances, not figured, both smooth rays point forwards.

Figs. 23 & 25 illustrate variations in the terminations of the

rays. Normally the paired rays are pointed, though somewhat abruptly, so as to resemble in optical section the point of a lancet, while the third ray may be either rounded off at the end or prolonged into a conical point, terminating one way just as often as the other. In the exceptional form, fig. 23, one of the smooth rays is rounded off at the end hemispherically, the other retaining its pointed termination; in fig. 25 both paired rays are terminated hemispherically. These last two variations are of some importance, as showing the possibility of acerate spicules passing into acuate ones: in a sponge containing only uniaxial acerate spicules, for instance, an acuate variety, if it occurred, might be taken for an intruder from some other sponge; but with such a spicule as fig. 25 such an explanation is obviously impossible.

In figs. 28, 29, & 32 we have varieties with four rays, a third smooth one having put in an appearance. These are true quadriradiate spicules, and thus seem to lead on to the Tetractinellid type. It must be observed, however, that they differ in one important particular from the quadriradiate pronged spicules of such sponges as *Geodia*, since in the latter the single bud produced from the spicule-cell grows inwards towards the centre of the sponge, while the three buds which form the prongs grow outwards away from the centre—just the very reverse of what occurs in *Plectronella*, where the three rays grow inwards towards the axis of the stem or papilla (on whichever the spicule is seated), and the fourth grows outwards away from the axis. An intermediate case is seen in *Dercitus Bucklandi*, where the four rays of its quadriradiate spicules are equal as regards length, and indifferent as regards direction of growth.

The quadriradiate spicules of *Plectronella* remind one also of the quinqueradiate spinicruces which echinate the spicular fibre of *Meyerina*, *Hyalonema*, and some other Hexactinellids.

As regards the acerate spicules of our sponge, they likewise are very apt to sport into new varieties; bifurcation of the spicule with an accompanying bifurcation of its canal is not uncommon; and spines occasionally sprout from the sides.

Of the flesh-spicules one need not say much here; they appear to result from the fibrillation of the contents of a spicule-cell, and to be set free from it in some manner unknown; they are of such tenuity that under a magnification of 1000 diameters they appear no thicker than pencil-lines; and one need not add that they exhibit no axial canal.

On passing in review the numerous departures from the normal spicule-forms figured in Pls. V. and VI. one becomes able to formulate the following propositions:—

(1) The group of spicules comprising the bifid form and all

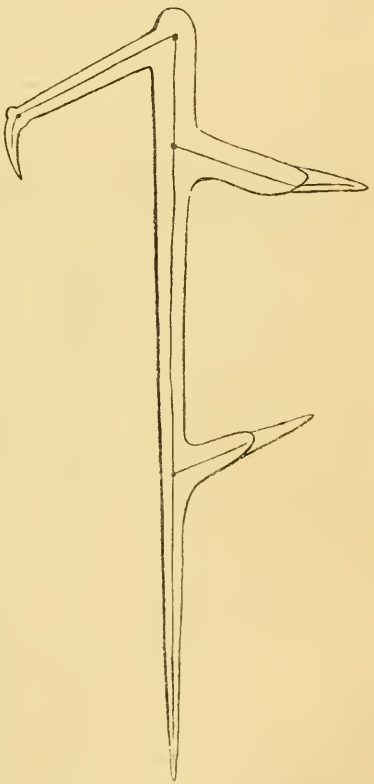
its varieties result from the tendency to continued variation displayed by an organ or organism in which a variation has once been initiated.

(2) The overwhelming preponderance of the bifid spicule of figs. 2 & 21 is an instance of the survival of the fittest; this form has been selected from the great diversity of related forms because it best satisfied the requirements of the sponge.

(3) The biaxial and uniaxial biradiate varieties, whether regarded as "reversions" or survivals of an ancestral form which a not very rigorous or not long-enough-continued selection has overlooked, serve in any case to establish a passage from an originally uniaxial spicule to the normal triradiate one.

(4) The quadriradiate forms, which illustrate the tendency to progressive variation, shadow forth the spicules which, under different conditions, have established themselves as the fittest survivors amongst the Pachastrellidæ and Pachytragidæ.

Fig. 2.



(5) The bifurcation of the acerate spicules of *Plectronella* appears to indicate a tendency to give rise to a triradiate form.

The difference between a bifurcated acerate and a true triradiate spicule lies in the fact that in the former a biradiate growth of the spicule-cell has already taken place before the third ray is produced, and that this then takes its origin, not from the original spicule-cell, but from one of the rays which have issued from it; so that the third ray arises as a secondary instead of a primary bud. That this difference may be bridged over appears, however, from a consideration of such abnormal spicules as that of *Dercitus Bucklandi* represented in fig. 36, Pl. VII., and of a *Stelletta* of which a sketch is given here (fig. 2).

From these we see that spicules which are usually produced by the immediate radiation of four arms from a mother cell may pass into varieties in which the origin of some of the rays is postponed till the spicule-cell has assumed a linear growth and so made it impossible for fresh rays to appear except as secondary instead of primary radiations—a change analogous to that which sometimes occurs in the vegetable kingdom, where a whorl of leaves may exceptionally become elongated into a branch. Conversely a spicule in which bifurcation took place after the spicule-cell had produced an acerate form might easily pass into one in which the bifurcation took place at the commencement of growth, and thus rise to a truly triradiate form.

If the acerate and triradiate spicules of *Plectronella*, widely different as they now are, did originally branch off from a common ancestral form, one is led to inquire whether the same may not be the case with the still more diversified spicular groups belonging to other kinds of sponges. We cannot attempt to enter into this question now; but it may be interesting to examine a few other sponges with a view to determining whether they present us with analogous variations to those exhibited by *Plectronella*. A few hours' examination of two specimens of *Dercitus Bucklandi* has furnished us with the variations of its quadriradiate spicules figured on Plate VII. The commonest variety is that of fig. 43, where one of the four rays is bent, near its termination, about 30° from its normal course. Sometimes two or even three of the rays may be similarly modified, giving us, in the last case, a figure very like that of the Manx arms. This flexure is almost invariably the forerunner of a bifurcation of the ray, owing to the appearance of a second termination to the ray, as if to maintain its symmetry (fig. 40). The secondary rays so produced may themselves become flexed and eventually bifurcated (fig. 39). When three out of the four rays of a spicule are thus bifurcated, we are carried a long distance on towards the branched spicules of the more complicated Tetractinellidæ.

On the other hand, the fourth ray is sometimes completely suppressed; and the triradiate form (fig. 33) is then produced. Again, the third ray may not arise immediately from the young spicule-cell, but from one of the arms of a biradiate spicule (fig. 36); or the third ray may wholly disappear, when we have a biradiate form, bringing us back to a curved acerate spicule. Unfortunately the only instance I have observed of this was lost before I could sketch it; but there is no doubt that a more extended examination would reveal other examples.

In fig. 38 we have a true quinqueradiate spicule, very similar to the quinqueradiate spicules of *Euplectella* and other Hexactinellids. This may be regarded as related to fig. 40 as fig. 33 to fig. 36. It seems to show a tendency for bifurcation to work its way back towards the initial cell, till it results in biradiation. The remaining figures are merely intended to illustrate the great tendency to vary in all directions which the quadriradiate spicules of *Dercitus Bucklandi* display, except in the case of fig. 46, which is a genuine case of ankylosis, two quadriradiates having fused together by two of their arms (*a* and *b*).

A cursory examination of *D. Bucklandi* thus reveals just the same class of facts as we met with in *Plectronella*. We have:—first, a great general tendency in the spicules to vary in numerous directions; next, the selection of one variety (the equal-armed 4-radiate) as the average form; thirdly, a number of varieties leading back to the acerate type; and, lastly, others leading on to the higher Tetractinellidæ in one direction and to the Hexactinellidæ in another.

The Hexactinellidæ, again, present us with variations of a similar kind. One has only to refer to the series of figures 153–157 (pl. vi.) and 175–183 (pl. vii.) in Dr. Bowerbank's 'Monograph of the British Spongiadæ' (vol. i.) to discover a complete passage from the ordinary cylindro-cruciform spicule of *Hyalonema mirabile* to a spined uniaxial cylindrical spicule, and from the attenuated rectangulated sexradiate of *Euplectella* to a triradiate something like the abnormal form, fig. 22, of our *Plectronella*. On the other hand, the fossil Hexactinellid *Hyalostelia Smithii*, from the Carboniferous Limestone, furnishes us with spicules in which the number of rays has multiplied beyond the normal six, and amounts to eight* or even more. It is also noticeable in this sponge that the rectangularity which is so marked a feature of ordinary sexradiate spicules is very frequently and widely departed from.

In conclusion, regarding the various kinds of sponge-spicules as resulting from a variously modified cell-growth, we may attempt to embody in the following diagram (fig. 3, p. 24) the relations subsisting between the chief of them.

1. An elongate growth of the original cell in two opposite directions at equal rates gives us the ordinary acerate spicule (fig. 3, 1), which is biradiate (diactinellid) but uniaxial.

2. A retardation of growth in one radius gives the acuate spicule of fig. 3, 2.

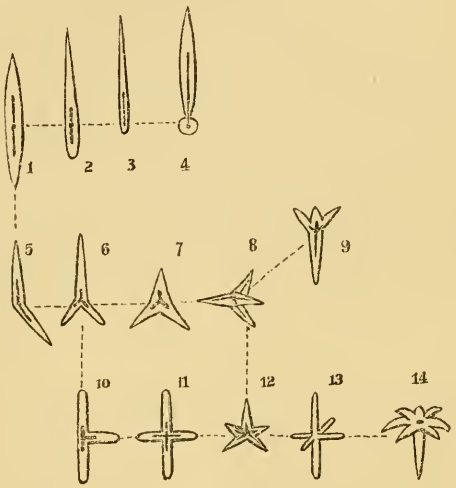
3. A linear growth in one direction only gives the acuate

* Carter, Ann. & Mag. Nat. Hist. ser. 5, vol. i. pl. ix. figs. 7, 10, 11, pp. 132, 133.

(fig. 3, 3); if accompanied by increased concentric growth of the initial cell, then the pin-headed acuate (fig. 3, 4) is produced.

4. An elongation of the cell in two directions inclined to each other at a less angle than 180°, gives us the curved acerate (fig. 3, 5), which is both biradiate and biaxial.

Fig. 3.



5. The inclination of the two rays in fig. 3, 5, is followed by the appearance of a third in fig. 3, 6, where we have the triradiate spicule of *Plectronella*. In this spicule two of the radii arise from the proximal face of the cell and grow inwards towards the axis of the fibre on which it is situated, and the third ray arises distally and grows outwards away from the axis.

6. A growth of the cell in three directions making equal angles with each other, and having no determinate relations to any symmetrical line within the sponge, gives us the equiangular triradiate spicule (fig. 3, 7), which occurs abnormally in *Dercitus Bucklandi*. (Triradiate spicules also occur as varieties in *Eccionema*, Bwk., and *Normania*, Bwk. ('Monograph of British Spongiadæ,' vol. iii. pl. ix. figs. 4, 5, and pl. lxxxi. figs. 6, 8), and as a normal form in *Sphinctrella horrida* (Schmidt, 'Spongien d. atlant. Gebietes,' pl. vi. fig. 7) and in *Pachastrella connectens*.)

7. A quadriradiate growth of the cell in directions having no determinate relations to the form of the sponge gives us the normal spicule of *Dercitus Bucklandi* (fig. 3, 8).

8. The cell gives off three buds from its distal face, which grow outwards away from the sponge, and a fourth from its proximal face, which grows inwards, and we have the forked forms of *Geodia* and the like (fig. 3, 9).

9. The cell grows in five directions along three axes at right angles to each other, which are not determinately related to any lines of reference within the sponge (*Dercitus Bucklandi*), or which are so related (*Euplectella* and other Hexactinellids), and we have the quinqueradiate form (fig. 3, 12).

10. In fig. 3, 6, the growth of the three rays is along directions inclined somewhere about 120° with each other; if two of the rays grow in opposite directions, and the third at right angles to them, fig. 3, 10, results (a form abnormal in *Plectronella*, frequent among the Hexactinellidæ).

Fig. 3, 11, requires no comment.

Fig. 3, 13, is the result of a sexradiate growth of the cell along three axes at right angles to each other, and represents the typical Hexactinellid spicule.

Fig. 3, 14, is an octoradiate form, seven buds having grown out radiately in one plane and the eighth at right angles to them; it occurs in the fossil *Hyalostelia*.

The foregoing remarks have arisen out of our description of *Plectronella papillosa*, which was the main object of this paper; but the variability of sponge-spicules is far too important a subject to be treated thus incidentally, and might furnish material enough for a lengthy memoir. No sponge that has come under my observation has failed to exhibit numbers of spicules departing more or less widely from the average type; frequently the range of variability is extreme; and no doubt, when a large number of specimens of allied species of sponges come to be carefully compared, we shall find not only in their external form, but in the details of their internal structure as well, easy passages from one to the other, and links will be discovered uniting together types of sponge-structure that now appear widely separated from one another.

Taxonomical position of Plectronella.—The existence of distinct fibres echinated by characteristic spicules places this sponge in Carter's fifth order, the Echinonemata.

In the general structure and arrangement of its fibres and the position of its echinating spicules it most resembles the genus *Dictyocylindrus* (Bwk.).

In the form of its echinating spicules it appears to approach the crutch-shaped spicules of the group Baculifera (Carter), founded on Savile Kent's *Caulospongia*. In the Baculifera, however, the crutch-shaped spicules form the core as well as echinate the surface of the fibre, while it is only exceptionally

that a spur-like spicule is found wholly inside the fibre of *Plectronella*.

If there were no spur-shaped spicules in *Plectronella*, the projection of its acerate spicules beyond the surface of the fibre would place it in the Axinellid family; but since they are present and characteristically seated on the fibre, its proper place is clearly enough with the Ectyonida, amongst which it will take rank, on account of the unique form of its echinating spicule, as the representative of a distinct group, the Plectronina.

Order ECHINONEMATA, Carter.

Family **Ectyonida**, Carter.

Group *Plectronina*, Sollas.

Genus Plectronella.

Species *Plectronella papillosa*, Sollas.

EXPLANATION OF THE PLATES.

Plate IV.

Plectronella papillosa.

Fig. 1. The entire sponge, seen from above. $\frac{1}{2}$ natural size.
Fig. 2. Sponge seen from below. $\frac{1}{2}$ natural size.

Plate V.

Plectronella papillosa.

Fig. 1. Acerate spicule from the interior of the fibre.
Fig. 2. Spur-shaped spicule (when *in situ* echinating the fibre).
Fig. 3. Flesh-spicule. (Figs. 1–3 all drawn to the same scale, $\frac{140}{1}$.)
Fig. 4. Flesh-spicules, straight and curved.
Fig. 5. A sheaf of flesh-spicules. (Figs. 4 & 5 × 400).
Figs. 6–10. Varieties of the acerate spicule (× 140). *Fig.* 6 a form frequently assumed when the acerate spicule projects from the fibre echinately.
Fig. 11. Two acerates ankylosed together; ends broken.
Figs. 12, 13. Bifurcated acerate spicules. × 140.
Fig. 14. Young form of echinating or triradiate spicule. × 140.
Fig. 15. Variety of acerate. × 140.
Fig. 16. A spicule not belonging to the sponge, but met with in its examination; it presents a cylindrical shaft terminated at each end by a microspined globular head. × 315.
Fig. 17. Biradiate uniaxial variety of echinating spicule.
Fig. 18. Similar variety, showing axial canal.
Fig. 19. Biradiate biaxial variety; rays inclined at 90° to each other.
Fig. 20. Similar variety but with single smooth ray taking the same direction as it would if its fellow were present.
Fig. 21. Normal form of echinating spicule. (Figs. 17–21 × 315.)

Fig. 2.

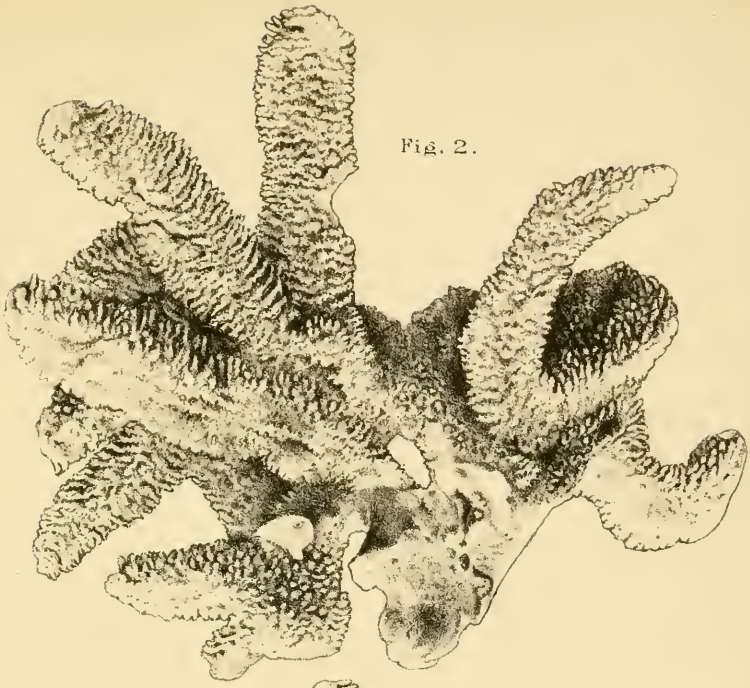
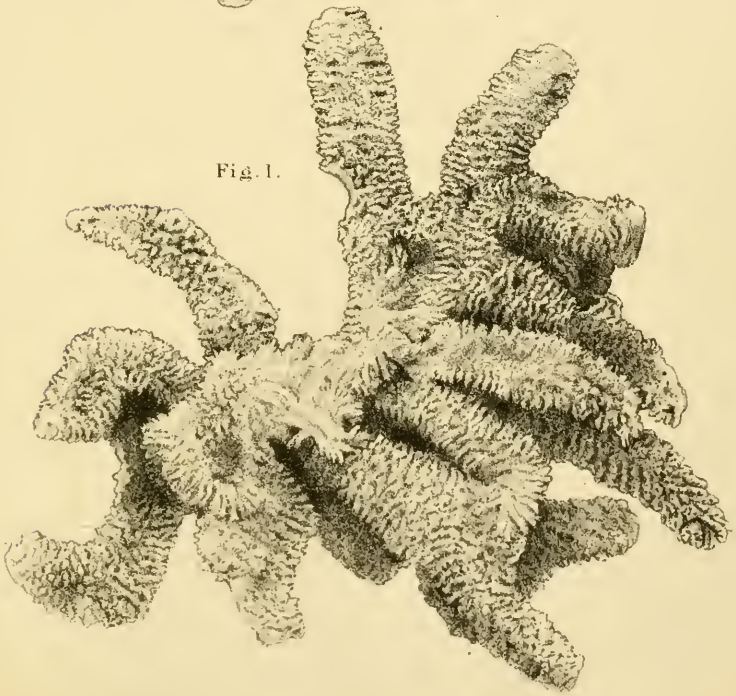


Fig. 1.



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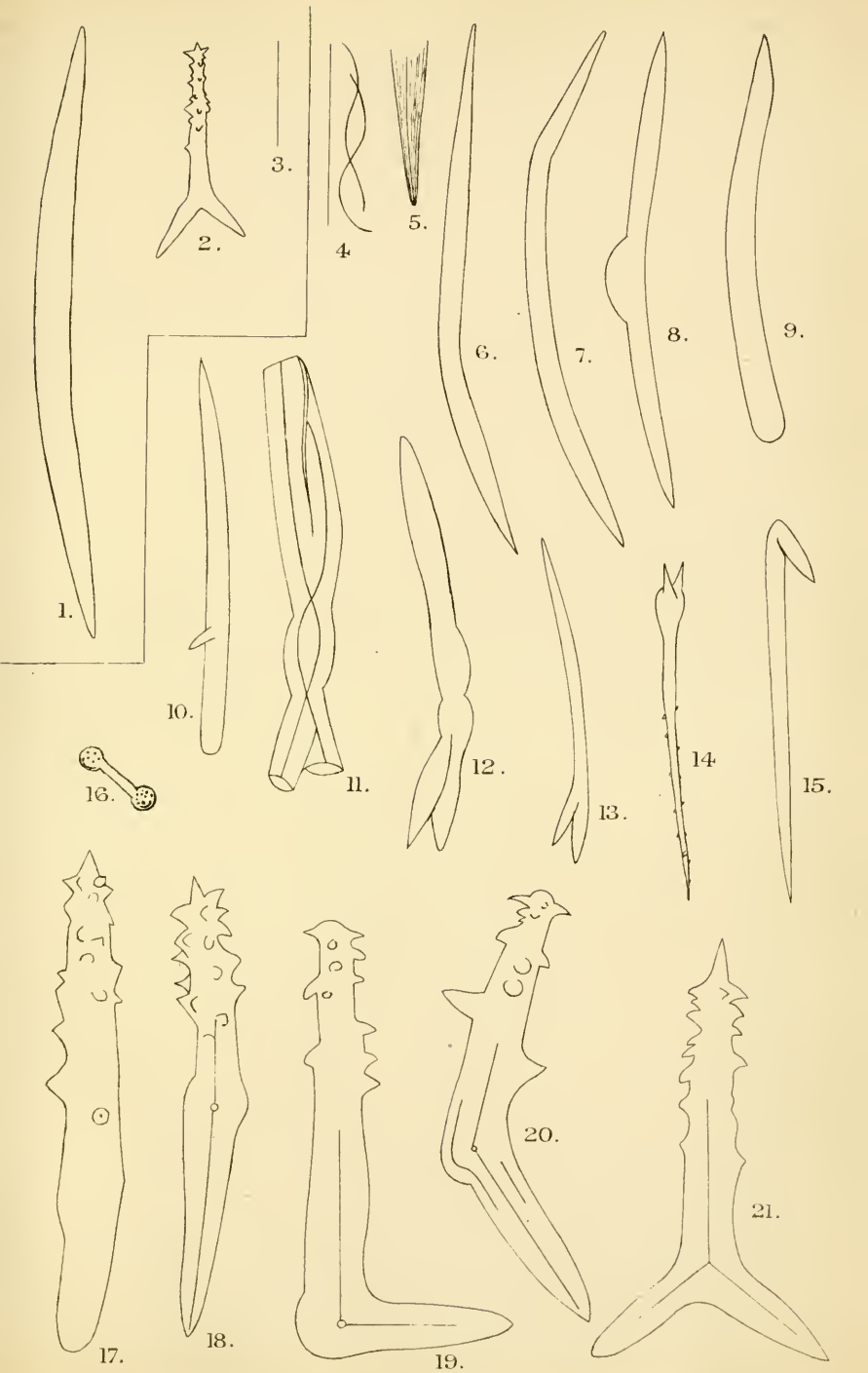

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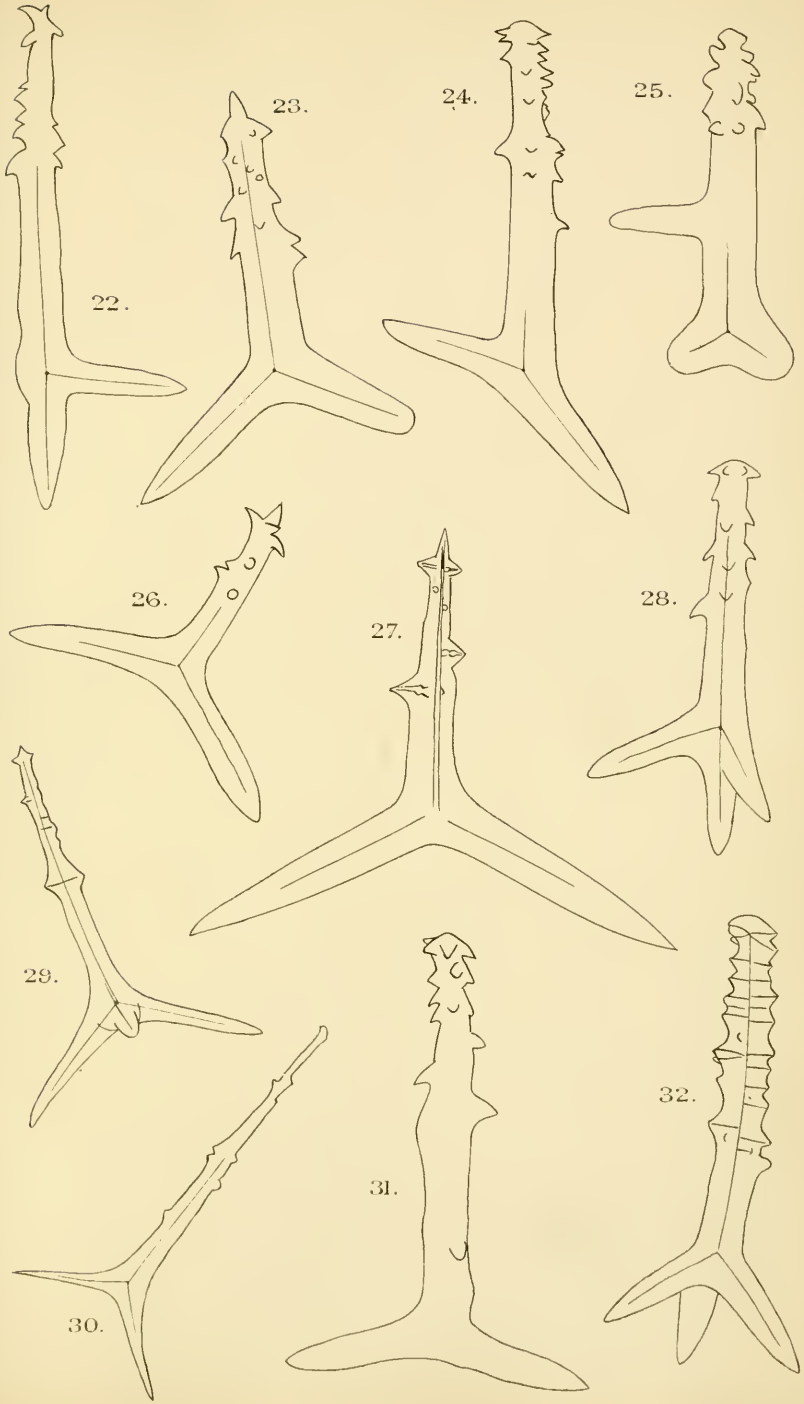
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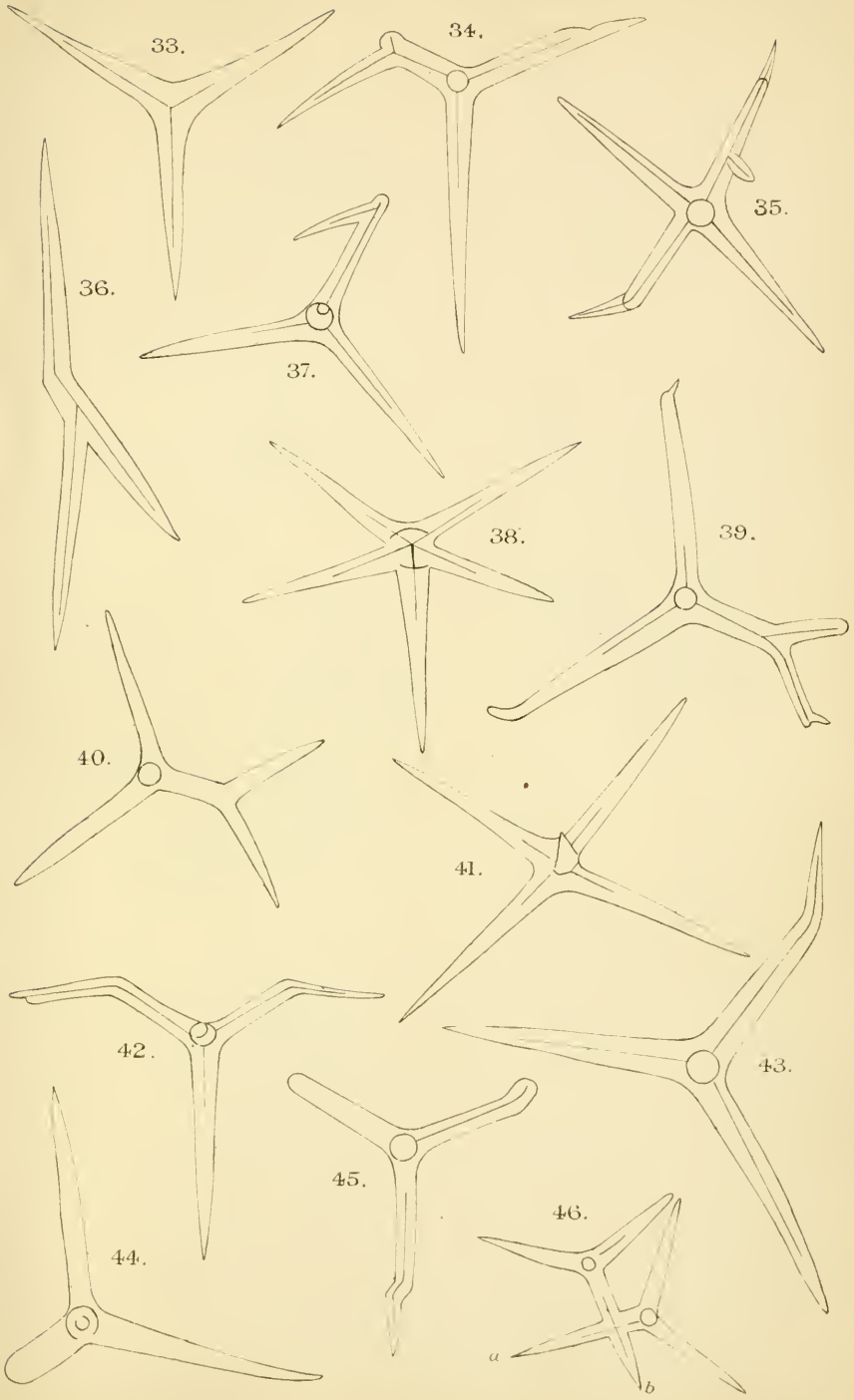
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