On a Remarkable Pharetronid Sponge from Christmas Island.

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(PLATES 10 AND 11.)

The foundation of our knowledge of the Pharetron sponges was laid by Zittel in 1879 (9, p. 11). He found, when classifying the fossil sponges, that after the Dictyonines, Lithistids, Tetractinellids, and Monaxonellids had been sorted out, there still remained numerous specimens, mainly calcareous, and ranging from the Devonian to the Cretaceous formations, in which the skeleton was formed of a network of anastomosing calcareous fibres with a very finely fibrous structure.

In 1872 Haeckel (3A, vol. 1, p. 341) had declared that no fossil sponges belonging to the order of Calcisponges had been found, nor were ever likely to be, judging from the delicate texture of known Calcisponges.

At first Zittel regarded the fossil "Calcispongia fibrosa" or "Fibrous sponges" as members of a wholly extinct order, in no way related to that of the true Calcispongiæ. Some regarded the fibrous sponges as fossil horny sponges, others as altered siliceous sponges, others again as corals. Zittel found, however, in the course of his investigations, that the fibrous markings in the fibres were due to the presence of uniaxial or three- or four-rayed spicules. This discovery led him to regard the fibrous sponges from a wholly new point of view, viz., as true Calcareous Sponges.

As the fossil Calcarea known at that time were, with one exception, apparently very different from the recent sponges belonging to Haeckel's three families (Ascones, Sycones, Leucones), and as they seemed to be a more or less homogeneous group, Zittel included them in a new family, the Pharetrones.* His conclusions were at first disputed, and it was thought that the spicules composing the fibres were originally siliceous bodies, which had undergone calcification in the course of becoming fossilised.

In 1882 Hinde (4, p. 185) described several very well preserved Pharetrones, in which not only were the spicules visible in the fibres, but also separate three- and four-rayed spicules and "tuning-forks" could be distinguished in

* φαρέτρα, a quiver, from the fancied resemblance of the Pharetron fibre to a quiverful of arrows.

a layer on the surface of the sponge. All doubts as to Zittel's discovery were now set at rest. Neither Zittel nor Hinde attempted to arrange the numerous genera of Pharetrones into sub-groups, but described the external form, the canal system, the size, shape, and structure of the fibres, and, wherever possible, the spicules composing them.

The spicules which make up the so-called "Pharetron fibre" are closely packed, and arranged more or less parallel to each other and to the long axis of the fibre. The spicules may be rod-shaped, or nearly linear three-rayed forms, or large centrally situated three- or four-rayed forms surrounded by slender rods or triradiates.

The composition of the Pharetron fibre has been the subject of much discussion. Dunikowski (3, p. 299) and Rauff (7, p. 204) considered that the spicules were, in the living sponge, simply in apposition and not cemented together, and that the present fused vitreous condition of the fibres has resulted from fossilisation. Steinmann (8, p. 111), on the other hand, considers that the spicules were joined together by a cement formed by the living sponge. Dunikowski regarded the Pharetrones simply as a sub-family of Haeckel's family of Leucones. Rauff, who thought that Dunikowski had gone too far in so doing, retained the family Pharetronidæ, on account of the spicules being arranged into fibres, the spicules of the Leucones not being so arranged.

In 1892 (1, p. 143) and 1898 (2, p. 15) Döderlein described a remarkable recent stony calcareous sponge (*Petrostroma schulzei*) from Japan. The main skeleton was constructed of large four-rayed spicules cemented together so as to form a firm solid meshwork, the spicules in the older parts being more or less completely surrounded with calcareous cement; also there was a dermal layer of loose three- and four-rayed spicules and separate small bundles or "fibres" of "tuning-forks." Döderlein placed *Petrostroma* in a new group, the Lithones.

In 1893 Rauff (7, p. 204) classified all the Calcarea, fossil and recent, into two orders, Dialytina, with separate spicules, and Lithonina (including only *Petrostroma schulzei*, Död.), with spicules joined by zygosis into a solid framework (like the desmas of Lithistida). It was not known at the time that the spicules of *Petrostroma* were joined together by cement, as was explained by Döderlein (2, p. 15) in his second communication on that genus. Rauff placed the Pharetronidæ next to the Leuconidæ.

Whether Rauff's division of Calcarea into two groups, viz., one with separate spicules and one with zygosed spicules, could have been retained or not, it is now needless to enquire; but it could hardly be maintained that the Calcarea should be divided into two orders, viz., one without cemented spicules, and the other with cemented spicules. Among siliceous sponges the mere presence or absence of cement (spongin) is not of much importance. In *Halichondria* we may find separate scattered spicules, in *Reniera* they are often joined into a network cemented at the nodes with spongin, the strands being formed either of one spicule or of a bundle; in *Chalina*, the bundles of spicules are wholly enveloped in spongin, and in certain horny sponges derived from Chalininæ the spicules have gone, and a network of spongin fibres alone remains. So in Calcarea, the spicules are separate and irregularly arranged in the parenchyma in *Leucandra;* in *Plectroninia* the spicules of the main skeleton are joined chiefly at the ends; in *Petrostroma* and *Minchinella* the calcareous cement in the older parts of the sponge completely envelopes the spicules, and in the sponge described below a network of cement alone remains.

In 1900 Minchin (6, p. 110) included the Pharetronidæ as one of the five families of the Heterocoela, characterised by the possession of tuning-fork spicules; and divided it into two sub-families, viz., (i) Dialytinæ, Rauff, with uncemented spicules, (ii) Lithoninæ, Döderlein, with body-spicules united by cement into a rigid framework.

Doubtless some of the genera placed among the Dialytinæ will be found to belong to the Lithoninæ, and possibly others to the Sycettidæ and Grantidæ of Dendy.

Steinmann's classification (8, p. 112) is nearly the same as Minchin's; for he divides the Pharetrones into (i) Lithonina, and (ii) a group including Inozoa (Dialytina pars), massive sponges with leuconoid canal-system, and Sphinctozoa, moniliform sponges with syconoid canal-system; but Steinmann could not employ the term Dialytinæ, for he regards the Pharetron fibre as a bundle of cemented spicules.

The classification used in this paper is that of Minchin, with an additional new sub-family. The specimens about to be described were obtained by Dr. C. W. Andrews during his second visit to Christmas Island. On one occasion, the steamer which plies between Singapore and the island got its anchor fixed among the rocks in 46 fathoms off the shore of the latter place. After tugging for a long time with full steam on, the ship at last got free. The anchor brought away a mass of rock on which were found four specimens of the new sponge. The specimens were detached from the rock a little time after capture, and put into methylated spirit.

The sponges were found to belong to a new genus and species of Pharetronidæ, which family now includes six recent species. The new species will certainly prove to be of very great interest both to the student of recent sponges and to the palæontologist, for not only is the rigid main skeletal network entirely devoid of spicules, but the surface of the sponge is covered with a dermal armour of large calcareous scales.

I propose to name the genus and species *Murrayona** *phanolepis*,† and to place them in a new sub-family Murrayoninæ below and next to the Lithoninæ.

Description of Murrayona phanolepis, *gen. et sp. nov.*

The specimens are in the form of small pear-shaped or massive stony nodules, either sessile or with a very short thick stem, and are attached by a flat expanded base to the rock. Two of the specimens are complete (Plate 10, figs. 3, 3A), and the other two (Plate 10, figs. 1, 2) macerated out and devoid of both a dermal layer and of soft tissues. The largest is about the size of a small Barcelona nut (Plate 10, fig. 2).

The best preserved specimen, A, has been kept entire, and the second complete specimen used up for sections of soft tissues and skeleton. Specimen A (Plate 10, figs. 3, 3A, 3B) is in the form of a minute, pear-shaped nodule, 8 mm. high and 7 mm. broad, with a very short thick stem 1 mm. high and 2 mm. in diameter, expanding below into a flattened disc of attachment. The colour is pale yellow, and the surface glistening. Under a lens an areolated pattern, formed by imbricating scales, can be seen.

A little to one side of the summit is a small oscule about 0·4 mm. in diameter, and above the middle of the opposite aspect is an equatorial groove (figs. 3A, 3B) extending a little more than half-way round the sponge. Besides the oscule and pores of this poral groove there are no other openings into the sponge, the rest of the surface being covered with an impenetrable coat of scales (fig. 3B).

The edges of the scales are free, that is to say there is no continuous membrane passing from edge to edge. Beneath the semi-translucent layer of scales can be seen, under a low power, the more or less parallel edges of the surface-lamellæ of the main skeletal framework, which form supporting beams to the roof of scales; and here and there between the scales and main skeleton very minute triradiate and tuning-fork spicules are visible. The poral groove shows a network of small meshes formed by bundles of triradiates.

The *canal-system* belongs to the leuconoid type. The pores are limited to a groove situated on one side of the sponge about midway between the summit and base (Plate 10, fig. 3B). The groove, which is about 8 mm. long,

* In honour of Sir John Murray, K.C.B., F.R.S., who has made a very generous donation towards the expenses of a small dredging expedition to Christmas Island.

† φανός, bright, glistening; λεπίς, scale.

1 mm. deep, and 2 mm. broad, is divided into two nearly equal parts by a narrow vertical band of scales. The rounded or polygonal meshes of the network of triradiates are about 0·2 mm. in diameter, and one pore is contained in each mesh (Plate 10, fig. 8).

The pores lead into sub-dermal spaces, which either abut directly on to masses of flagellated chambers filling in the surface-meshes of the main skeletal network just below the pore-area (Plate 10, fig. 5), or are continued into canals passing into the sponge.

The flagellated chambers are oval or spheroidal, and of large size, being about $65 \times 50\ \mu$ in long and short diameters. Minute prosopyles were visible in some instances, also a circular apopyle, about $20\ \mu$ in diameter.

The chambers line the walls of tubular anastomosing canals, occupying the spaces of the main skeleton, just as in *Minchinella lamellosa*, Kirkp. (Plate 11, fig. 13). The exhalant canals pass up into the floor and walls of the single terminal exhalant canal or cloaca, which opens by the oscule. The cloaca is from 1 to 2 mm. deep.

The structure of the collar-cells and of the other soft tissues was not to be made out clearly, owing to the sponges not having been properly fixed at the moment of capture, and as there is some prospect of getting fresh material suitably preserved, no attempt has been made to describe the cell-structure.

The Skeleton.

The skeleton will be described under three heads, viz.: (1) the main body-skeleton; (2) the poral and sub-dermal spicules; and (3) the dermal scales.

The *main skeletal framework* has a structure wholly unique in sponges. It is constructed of a strong network of solid calcareous fibres, entirely devoid of spicules, either in the axis of the fibres or on the surfaces of the same. The strands of this remarkable network vary greatly in shape and size, but they are mostly laminate, *i.e.* they are thin in proportion to their breadth. An average-sized strand measured $375\ \mu$ in length, $150\ \mu$ in breadth, and $45\ \mu$ in thickness, and the oval mesh which it bounded was $375\ \mu$ long and $150\ \mu$ broad; but the meshes and strands may be considerably larger, viz., up to $500\ \mu$ long. Usually, the meshes are longer in the vertical plane of the sponge than in the horizontal (Plate 10, figs. 4, 7, 9).

At the surface of the body the skeleton tends to form longitudinal flanges with free edges which slightly overlap, and which support the dermal skeleton.

The strands show a laminate construction, as if they had been laid down in layer upon layer of flakes, and here and there sutural lines can be seen between masses of flakes. Even under a low power, the microscopic structure is seen to be coarsely fibrillar (Plate 11, fig. 16), the fibrillæ radiating usually in a fan-like manner. Sometimes the flakes are circular or long oval in shape, with the fibrillæ radiating out all round, and more or less in one plane. The fibrillæ under a high power show conical projecting ends, and are separate and distinct for a little distance below the surface (Plate 11, figs. 14, 15).

In two places in the ground-down sections of a whole specimen, an axial spicule appeared to be present in the strands, but under higher powers the appearance was seen to be due to interior flakes of elongated shape with the fibrillæ arranged on each side of a smooth central raphé. If I had found merely some relic of a spicule—but I failed to do so after a most careful search—I would still have regarded the skeleton as a new type of construction.

The *spicules* are all triradiate, but of different shapes, viz. :—

(*a*) Equiangular, equal-rayed or nearly equal-rayed, pyramidal, that is, with the ends resting on a plane different from the meeting-point of the rays. The rays are 55 μ long, and 10 μ thick at the base, with blunt or rounded ends. These spicules are mostly found in the poral area, where they form a polygonal network (Plate 11, figs. 17, 18), but they also occur in the layer beneath the dermal scales.

(*b*) Nearly sagittal, and irregular triradiates with unequal rays and angles (Plate 11, figs. 19, 23, 24). Plate 11, fig. 19, shows a spicule with rays 130, 98, and 65 μ in length, by 10 μ thick. Plate 11, fig. 23, shows a form transitional between an ordinary triradiate and a tuning-fork.

(*c*) Tuning-fork spicules, found isolated or united into little "fibres" of two or three below the dermal scales. These spicules vary greatly in form, some being very *bizarre* (Plate 11, figs. 20–22, 25, 26). Fig. 20 has the short prongs curved and bent inwards, the total length is 87 μ, the prongs being 18 μ long and 10 μ thick at the base ; in another example one prong is only 16 μ long, and the other 65 μ. Spicules *a*, *b*, *c*, form a thin scattered layer between the dermal scales and main skeletal framework.

Plate 10, fig. 6, shows the under surface of a scale with a few "fibres" or bundles each composed of two or three tuning-forks adhering to it.

The remarkable *dermal scales* or plates are imbricated so that the free edges are directed either towards the oscule or the poral groove (Plate 10, fig. 3B). Some, however, are wholly uncovered by others. The scales are mostly nearly circular in outline, though some are oval and a few triangular with rounded angles (Plate 10, fig. 6, and Plate 11, figs. 10, 11).

They vary considerably in size, a large nearly circular one being 525 μ in diameter and 20 μ thick in the centre, and with sharp, thin edge. A smaller oval one measured $375 \times 300\ \mu$, with a thickness of 15 μ.

The scales have commonly a convex outer surface marked with smooth tubercles and ridges, and a flat smooth inner surface, so that they are plano-convex. The inner surface is so remarkably transparent as to be almost invisible, the scale appearing like a thin concave object, but foreign particles on the inner surface or, still better, a vertical section show that it is a thick plano-convex disc.

On the inner surface of some of the scales an epithelial layer of cells with round nuclei was clearly seen; and a few such cells were found on the outer surface, which latter was often covered with the hyphæ or threads of some fungus or alga. In the vertical section of a stained, decalcified portion of sponge the outline of folds which included the scales could be distinguished. The scales are very probably formed by dermal folds of epithelium, and not as products of single cells.

Systematic Position.

Murrayona differs greatly from any previously described Pharetronid sponge. In spite of the absence of spicules from its main skeleton, it clearly shows affinities with the Lithoninæ, especially with *Petrostroma schulzei*, Död., in having bundles of tuning-forks in its scattered and scanty sub-dermal layer of spicules, and in having a firm main skeletal framework. The Lithoninæ have an axial core of spicules surrounded by cement. In *Murrayona*, apparently, the sponge has given up forming this axial core. I had stated (5, p. 510) concerning *Merlia normani*, K., which I had at first supposed to be a Pharetronid sponge :—" In the sub-family Lithoninæ the framework is constructed on the *béton armé* principle; in Merlinæ the *béton* is not *armé*, the axial stiffening of spicules being dispensed with."*

What was said of Merlinæ applies to the new sub-family Murrayoninæ, within which it is proposed to place *Murrayona*. Among the siliceous Chalinid sponges the skeleton is formed of horny fibres with an axial core of siliceous spicules. In many instances gradations can be traced from such sponges to purely horny sponges from which the core of spicules has disappeared. The same principle holds as in *Murrayona*. The spongin-cement was, in such cases, originally formed to hold together the bundles of spicules, the latter being finally dispensed with.

The reasons in favour of the theory put forward above concerning the

* I now have the clearest evidence that *Merlia* is a sponge with a siliceous and calcareous skeleton, and that it is in no way related to the Pharetron sponges.

body-skeleton of *Murrayona* seem to me very strong. In the Lithonine sponges *Petrostroma schulzei*, Död., and *Minchinella lamellosa*, Kirkp., the firm skeletal network is constructed of large four-rayed spicules cemented together. In the older parts of the skeleton the calcareous cement becomes more and more developed, so that it is difficult to trace the spicules in the thick strands of the network.

In fact the *rôle* of the cement becomes increasingly important, and that of the axial core of spicules practically negligible. As the cement became more rapidly and abundantly deposited, it would become increasingly difficult for the enclosed scleroblasts to retain their functions.

The dermal scales may have arisen owing to the tendency of so many Pharetronid sponges to form wrinkles and folds, a tendency so marked that Zittel (10, p. 63) gives it in his diagnosis as one of the characters of the group—"a smooth or corrugated dermal layer frequently present." Sometimes the wrinkles are concentric. The tendency to form these calcareous surface-plates may be correlated with the richness of the sponge in cement-building cells.

Murrayona is of interest to the palæontologist, because he must take into consideration the possibility that some fossil Pharetrones, in which he has been unable to detect spicules, may never have possessed them. Hitherto, the absence of spicules has been attributed to fossilisation, and this may be the true cause in many instances, especially in those cases where the spicules are found in some parts of the sponge and not in others.

In *Corynella* (*Myrmecium*) *gracilis*, Münster, the skeletal network consists of thin anastomosing fibres, in which neither Zittel nor Hinde have been able certainly to recognise spicules, though certain wavy lines and other doubtful markings were regarded possibly as being spicules. Zittel (9, Plate 12, fig. 5) gives a figure of a section of *C. gracilis*, showing the fibres with spheroidal rayed crystalline structure. The fibres of *Murrayona* have fan-shaped or circular groupings of fibrillar markings, rather than spheroidal (Plate 11, fig. 16).

The diagnoses of the new sub-family, genus and species, are as follows:—

Sub-family Murrayoninæ (n. sub-fam.), Pharetronidæ with a firm main skeletal network entirely devoid of spicules.

Murrayona (n. gen.), Murrayoninæ with a dermal covering of scales.

Murrayona phanolepis, n. sp. With solely triradiate spicules, and with the poral area limited to a semicircular equatorial groove.

The six known recent species of Pharetronidæ are the following:—

Family Pharetronidæ, Zittel.

Sub-family i. Dialytinæ, Rauff.

With spicules not cemented, but united into strands or bundles, which may be separate or may anastomose to form a network.

1. *Lelapia australis*, Gray. Australia (shallow).

2. *Kebira uteoides*, Row. Red Sea (shallow).

Sub-family ii. Lithoninæ, Zittel.

With spicules cemented together to form a solid network.

3. *Petrostroma schulzei*, Döderlein. Japan, 109–218 fathoms.

4. *Plectroninia hindei*, Kirkp. Funafuti, 50 fathoms.

5. *Minchinella* (? *Rhaphidonema*) *lamellosa*, Kirkp. New Hebrides, 70 fathoms.

Sub-family iii. Murrayoninæ, n. sub-fam.

With firm main skeletal network devoid of spicules.

6. *Murrayona phanolepis*, n. gen., n. sp. Christmas Island, 46 fathoms.

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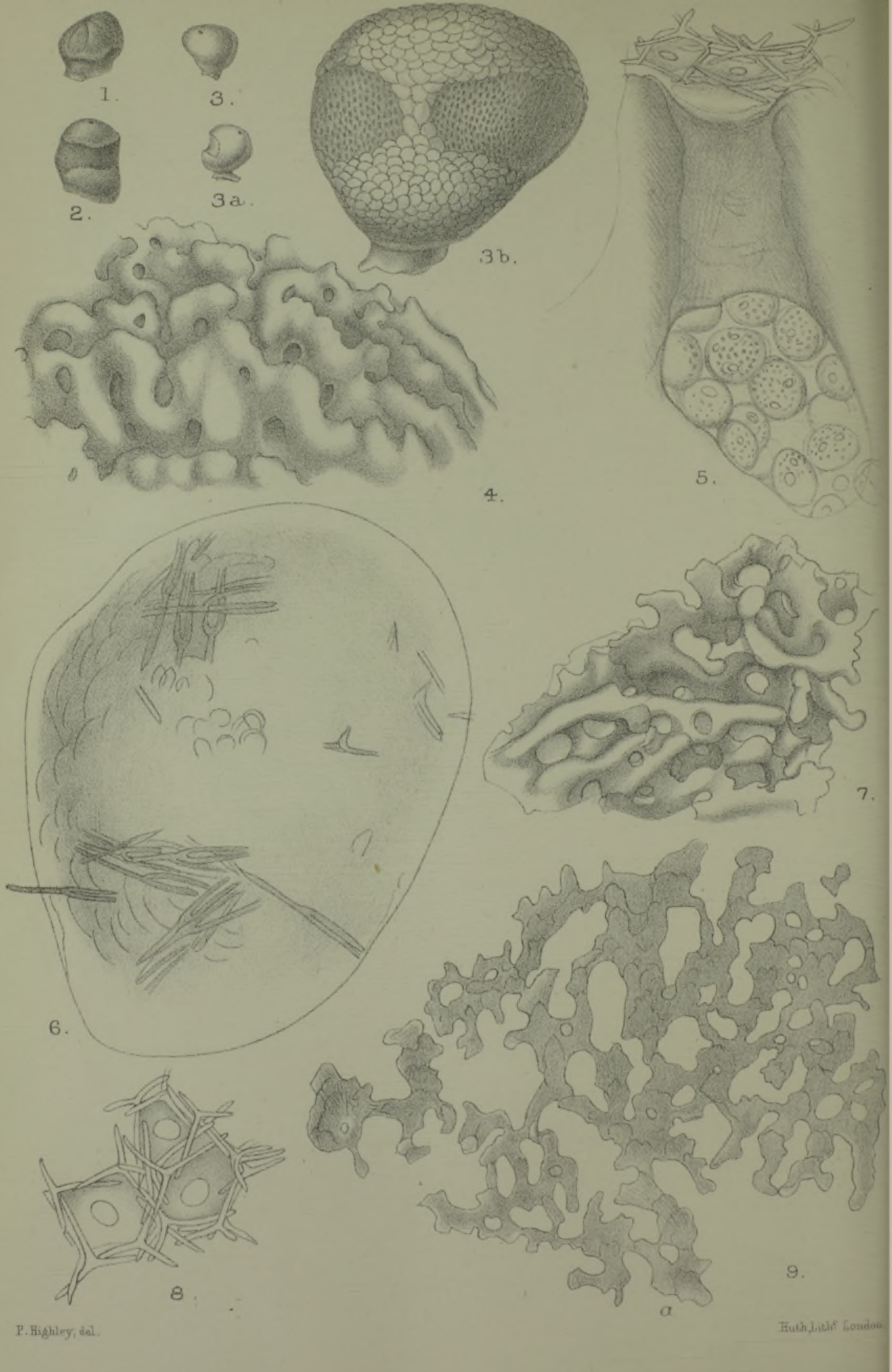

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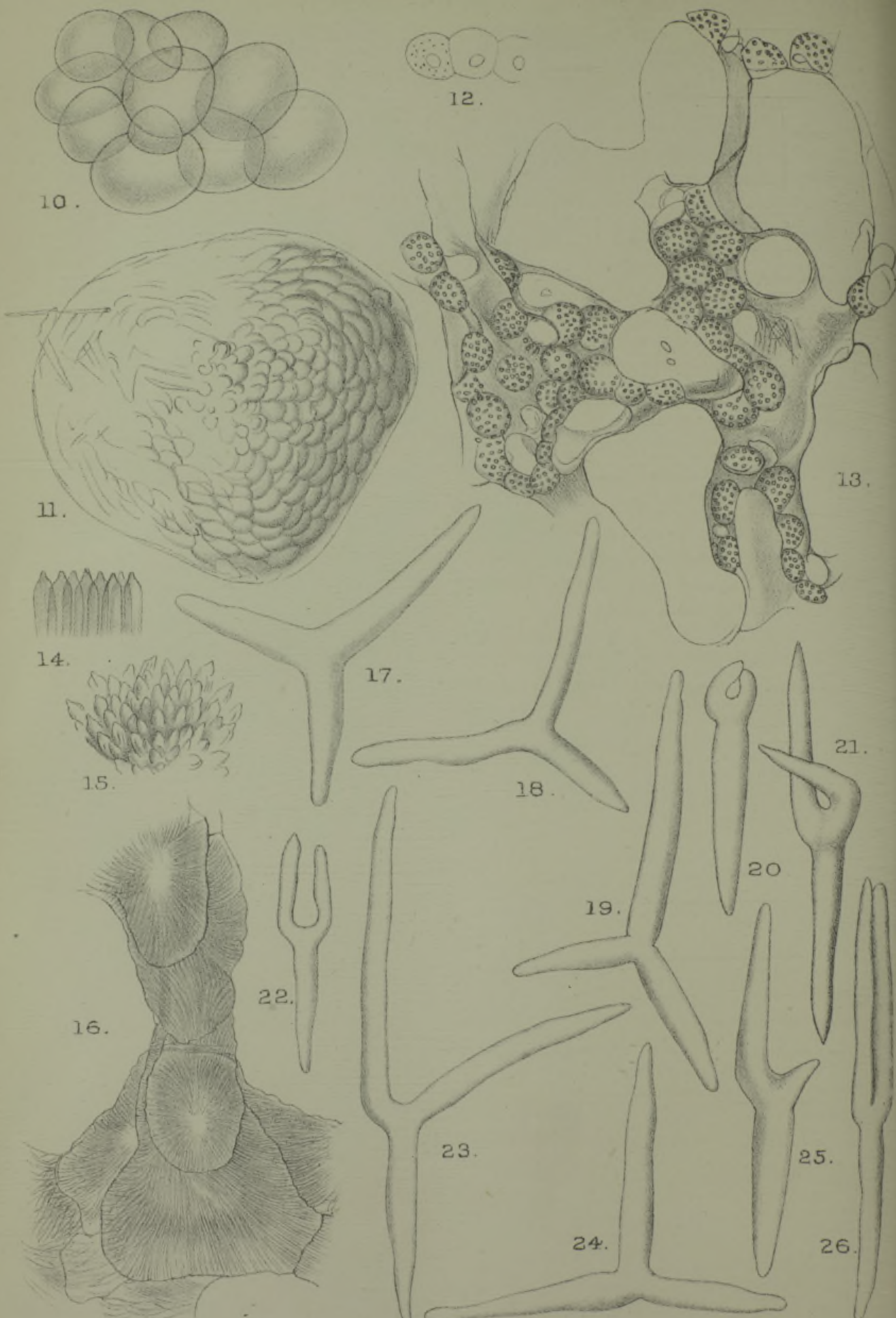

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EXPLANATION OF PLATES.

Plate 10.

Fig. 1, 2.—*Murrayona phanolepis*, gen. et sp. nov. Specimens B, C. Nat. size.
" 3.—Specimen A, showing oscule. Nat. size.
" 3A.—The same, showing pore-area, inside view. Nat. size.
" 3B.—The same, showing pore-area and scales. × 5.
" 4.—Surface of portion of firm skeletal framework. × 20.
" 5.—Fragment broken off from pore-area, showing surface-pores, a sub-dermal space, and a surface-cluster of flagellated chambers, with prosopyles and—on deeper plane—apopyles.
" 6.—Under surface of a dermal scale, showing tuning-forks loosely adherent. × 125.
" 7.—Broken fragment of same. *a*, canal. × 20.
" 8.—Portion of pore-area, showing 3 pores. × 125.
" 9.—Ground-down section of skeletal network. *a*, oscular region. × 12.

Plate 11.

Fig. 10.—Dermal scales. × 12.
" 11.—Dermal scale. × 125.
" 12.—Flagellated chambers, showing apopyles. × 125.
" 13.—Section of canals and flagellated chambers. × 125.
" 14.—Section of a strand of the firm framework, showing fibrillæ. × 1150.
" 15.—Surface of a strand of same, showing ends of fibrillæ. × 1150.
" 16.—Portion of skeletal framework, showing the flake-like structure and fibrillæ.
" 17, 18, 19, 23, 24.—Triradiate spicules. × 425.
" 20, 21, 22, 25, 26.—Tuning-fork spicules × 425.