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III.—*Further Observations on the so-called "Farringdon Sponges"* (Calcispongiæ, *Zittel*), *followed by a Description of an Existing Species of a like kind.* By H. J. Carter, F.R.S. &c.

[Plate I.]

Through the great kindness of Dr. G. J. Hinde, F.G.S., I have not only received a copy of his "Notes on Fossil Calcispongiæ" (*, No. 14), but have been permitted to examine

* Publications to which reference is made in the following communication:—

1.—1864. Monograph on the British Spongiadæ. By J. S. Bowerbank. Vol. ii., with 37 plates, vol. iii. 1874, and vol. iv. 1883.
2.—1872. Die Kalkschwämme. Von Ernst Häckel. 3 vols., including Atlas.
3.—1874. "Development of the Marine Sponges from the earliest recognizable appearance of the Ovum to the perfected Individual." By H. J. Carter. Ann. & Mag. Nat. Hist. vol. xiv. p. 321, with 3 plates.
4.—1876. Mémoire sur l'Embryologie de quelques Éponges de la Manche (Thèse). Par Ch. Barrois. With 16 plates.
5.—1877. "On a Holorhaphidote Sponge from the Cambridge 'Coprolite' Bed." By W. J. Sollas. Quart. Journ. Geol. Soc. for May, vol. xxxiii. p. 242. With 1 plate.
6.—1878. "Mr. James Thomson's Fossil Sponges from the Carboniferous System of the South-west of Scotland." By H. J. Carter. Ann. & Mag. Nat. Hist. vol. i. p. 134. With 2 plates.
7.—1878. Petrefactenkunde Deutschlands (Schwämme). Mit einem Atlas von 28 Tafeln in-folio mit c. 1000 Abbildungen. Von F. A. Quenstedt.
8.—1878. "Studien über fossile Spongien: Monactinellidæ, Tetractinellidæ, und Calcispongiæ." Von K. A. Zittel. With 1 plate. Translated by W. S. Dallas, F.L.S. Ann. & Mag. Nat. Hist. vols. iii. and iv. pp. 304 and 364, and 61 and 120 respectively.
9.—1878. "On the Structure and Affinities of the Genus *Catagma*." By W. J. Sollas. Ibid. vol. ii. p. 353. With 1 plate.
10.—1879. "On *Holasterella*, a Fossil Sponge of the Carboniferous Era, and on *Hemiasterella*, a new Genus of Recent Sponges." By H. J. Carter. Ibid. vol. iii. p. 141. With 1 plate.
11.—1879. "Note on the so-called 'Farringdon (Coral-Rag) Sponges' (Calcispongiæ, Zittel)." By H. J. Carter. Ibid. vol. iv. p. 431.
12.—1880. "On Fossil Spicules from the Carboniferous Strata of 'Ben Bulben,' near Sligo." By H. J. Carter. Ibid. vol. vi. p. 209. With half a plate.
13.—1882. "Pharetronen Studien." Von Dr. Gustav Steinmann. Neues Jahrbuch f. Mineralogie, Geologie, und Palæontologie, 11. Band, p. 139. Mit 4 Tafeln. (Separat-Abdruck thankfully received, on the 26th August, 1882.)
14.—1882. "Notes on Fossil Calcispongiæ, with Descriptions of new Species." By Dr. G. J. Hinde. Ann. & Mag. Nat. Hist. vol. x. p. 185. With 3 plates.

the specimens and preparations from which they were compiled, whereby I have been able to confirm all that he has stated respecting them. Not only this, but in a slice of a specimen of *Verticillites* (Defr.) *anastomans*, Mant., from Farringdon, in my own cabinet, I see similar spicular structure to that which Dr. Hinde has represented in his *V. D'Orbignyi*; as also in one from a specimen of *Sestrostomella* (Jura), which Prof. Zittel kindly sent me, in which the pitchfork-like (two-pronged) spicules of Dr. Hinde's two *Sestrostomellæ* are also present, and have been identified, as he has identified them before, with the representations of the existing calcispicules to which the late Dr. Bowerbank gave the name of "inequi-furcato-triradiate" (No. 1, vol. i. p. 268, pl. x. fig. 237), subsequently found by Häckel in Calcisponges from the coast of South Australia and the Indian Ocean (No. 2, Atlas, Taf. xxiii. fig. *h*, and vol. ii. pp. 127 and 166). Hence there can no longer be any doubt, with this additional knowledge, that there are, in Prof. Zittel's order of fossil Calcispongiæ, at least some genera whose fibre bears spicular forms which are identifiable with those of existing Calcispongiæ. Further than this, in the prepared slice of *Peronella multidigitata*, Mich., kindly sent me for conviction by Prof. Zittel, not only are the triradiates identical, as I have before stated, but their peculiar arrangement I now see, in one part at least, is equally identical, with that of existing Calcispongiæ.

Still, although the spiculation in many instances, especially in that problematical form *Verticillites*, may so far aid us in identifying these fossils with the Calcisponges of the present day, there are others in which it appears to be of so little service in this respect that, if these are also to be regarded as Calcisponges, they must also be considered extinct, so far as our knowledge of existing forms go; for there is no Calcisponge of the present day with which such spiculation can be directly identified.

Thus in *Manon macropora*, Sharpe, = *Elasmostoma*, From. (No. 8, vol. iv. p. 130), Prof. Sollas, who has examined its fibre microscopically in the usual way (that is, by extremely thin slices mounted in Canada balsam and viewed by transmitted light through the microscope), has noticed and delineated slender thread-like forms, triradiates, quadriradiates, and even quinqueradiates, together with bifurcated arms and truncated shafts or branches (No. 9, vol. iii. p. 354, pl. xiv. figs. 2, 5, 14, 7, 11, 12, and 19 respectively), the slender thread-like forms, or "filiform spicules," as they are afterwards termed, chiefly occupying the outer part of the fibre, and the "multiradiates" the axis; also that while "in some

instances the rays are scarcely of larger diameter than the filiform spicules, in others they are several times as large, and appear giants by comparison" (No. 9, p. 355).

Now, as these are forms which I have more or less witnessed myself under similar examination, and we are only on the threshold of our knowledge respecting them, partly from the want of observers, but principally perhaps from the difficulty of the subject, it may not be unacceptable to state what I myself have seen.

Thus the "filiform spicules" which I find very numerous in the fibre of my specimens of ? *Manon peziza* (No. 7, Taf. cxxxii. fig. 30) and ? *Scyphia perplexa* (No. 7, Taf. cxxv. fig. 63), wherein, on account of their regular parallel outlines and flexuous course, they look very much like the filaments of Confervæ, are for the most part truncated by the thinness of the slice, and thus present themselves in a fragmentary state, in which it is difficult to find one with a natural termination. Where the section has caused them to be truncated horizontally (that is, where the fibre has been cut directly across and they appear under the microscope as if ascending from below), their ends are seen to be circular and to present a punctum in the middle, indicative of an axial canal. They occupy the outer part of the fibre, and thus frequently become entwined round the axis of a colossal shaft ("giant by comparison," as Prof. Sollas expresses it), which we shall find by-and-by to be a characteristic feature of the spiculation in some of these sponges; or the axis may present a comminuted appearance, in which they often appear to have their origin, which "comminuted appearance," partly obscured in flocculent matter, appears to be the remains of a half-dissolved chain of triradiates, rendered still more indistinct perhaps by being on their edges and having their arms cut off both above and below by the section. But be this as it may, to obtain the entire forms of the spicules in this fibre by such thin slices can only be the result of accident extended over long periods of examination, being almost as difficult as discovering the form of a knot of twine by a thin slice through its centre.

As the filiform spicules pursue their course along the reticulated fibre, they not only cross each other obliquely, so as to sheathe as it were the axis, but partly surround the fenestral openings in the fibre itself in such a manner as to give an appearance of great original flexibility, while together they must thus have formed a densely filiferous cord by intertwining with each other, and this, through anastomosis, must also of itself have produced a reticulated self-supporting structure without the calcitic incrustations which now invest it.

In diameter the filiform spicules somewhat vary above and below the four-thousandth part of an inch, which is much beyond that of the arms of many triradiates in existing Calcisponges; but, from their long and flexuous course, subjecting them to truncation in a thin slice I have only been able to find one or two instances of an attenuated natural termination, and that, too, only at one end of the fragment. Instances are not uncommon where they may be inferred to terminate in this way in one direction, viz. in a point; but this may be so simulated by oblique-sectioning or descending out of focus, that it would be hazardous to go beyond an opinion in the matter. On the other hand, there is also often evidence of simple or multiple division, as in *Peronella dumosa*, from Farringdon ('Handbuch der Palæontologie,' Zittel, p. 190, fig. 108), wherein the filament may be observed to divide into two or more arms radiating from the same point, one or more of which may be elongated beyond tracing (*i. e.* filiform), or one or more short and pointed, mixed with regular or equiarmed triradiates that are free; but it is often impossible to substantiate this, from the presence of the flocculent material produced by the fossilization giving rise to a cloudiness in the fibre, which obscures the very part which it seems desirable to be able to follow with certainty; in short, it is only by the happy coincidence of a sharply defined object occurring in a clear place that such a point can be satisfactorily determined.

Difficult, however, as it is to follow the "filiform" spicules to their extremities in the fossils above mentioned, chiefly from their great length and undulating course, a key to their interpretation seems to be afforded by the fibre of Prof. Zittel's preparation of *Peronella multidigitata* (to which I have alluded), wherein, being of the same kind but shorter, they can be clearly seen to be the arms of a triradiate. Perhaps this slice may have been taken from an unusually favourable specimen for the purpose; but be that as it may, not only *this* identity, but an identity in form and arrangement between the triradiates themselves and those of existing Calcisponges can be witnessed, as I have before mentioned. It is true that in many instances the third ray is more or less reduced by arrest of development to a mere tubercle, as pointed out by Dr. Hinde in his *Verticillites D'Orbignyi* (No. 14, p. 193, pl. xi. figs. 15–22, &c.); yet in many cases all three rays are perfect and unmistakable in their form and arrangement.

As regards the "colossal" spicules (a term borrowed from Häckel in existing species) of the axis, so well shown in Dr. Hinde's illustration of the fibre of his *Sestrostomella rugosa* (No. 14, pl. xii. fig. 1, *a*), all that I need say after an exami-

nation of his preparations is that, here and there, these spicules present a short, thick, conical process or spur, which seems to be the equivalent of a *ray*, and that, if the whole of the spicule could be seen at once, it is not improbable that it would be found to be a colossal tri- or quadriradiate, whose arms are diverted from their usual arrangement when free to that which is required of them when forming the axis of reticulated fibre; for certain it is that the presence of calcisponge triradiates and the "pitchfork-like spicules" with these colossal spicules do so far identify them with existing species that, as Dr. Hinde has shown in this remarkable discovery (No. 14, pl. xii.), there can be no doubt as to their original nature, however different the colossal spicule may render the *Sestrostomellæ* from any thing that has hitherto been shown to exist in the Calcispongiæ of the present day. Still I think that I shall be able to show hereafter, by the description of a new species of Calcisponge from the south-west coast of Australia, that the principle of this spiculation still exists, if not traceable, already in Häckel's "colossal" spicules. To the crenulated structure which immediately surrounds the colossal shaft in *Sestrostomella* (No. 14, pl. xii. figs. 1 and 2) I shall return presently.

Meanwhile I would call the reader's attention to a little cylindrical fossil from Farringdon, which in my "Note" on these sponges (No. 11, p. 434) I briefly described under the idea that it was a "calcified Lithistid," but which, it will soon be seen, turns out to be a species of *Scyphia* (Pl. I. figs. 1–3)—? *S. cylindrica*, var. *baculata*, Quenstedt (No. 7, Taf. cxxiii. fig. 11), allied to *Sestrostomella* inasmuch as its fibre is provided with a colossal axial spicule bearing here and there a short conical process or spur in concentrically laminated fibre (fig. 9, *a*, *b*, &c.). Unfortunately, however, the fibre here is not in such a good state of preservation as that of Dr. Hinde's *Sestrostomella rugosa*; but sufficient remains to show that it presents a Lithistid aspect (fig. 4), although the many-armed spicules of which it is composed were not naked as in a Lithistid, but surrounded by the concentrically laminated fibre to which I have just alluded, like the siliceous envelope which similarly forms the fibre of a Hexactinellid (fig. 6, *a*, *b*, &c.),—moreover that the colossal axial spicules often present here and there, and apparently without any regularity in size or distance, a short conical arm or spur like those of *Sestrostomella* (figs. 5, 7, 9, &c.), that the outlines of their surface as seen in the section may be even or crooked or crenulated (figs. 7–12, &c.), and that the spur itself is sometimes sparsely covered with short vertical spines (fig. 5)—also that the sheath or concentrically laminated fibre enclosing these colossal spicules may

be composed of a variable number of layers to which the same observations apply, with the exception that the outlines in the section show that they were much more irregular in form (figs. 6–12) and themselves here and there threw out a spur (fig. 8, *b*), while in some instances the surface of the outer layer was evidently tubercled (fig. 6, *b*). Hence the fibre might be tuberculated as well as spurred here and there. Also in one part of the slice there are two long straight rays like those of an existing calcispicule, which, but for their point of union and divergence being close to the edge, and therefore broken away, would probably have been accompanied by a third if not a fourth arm (fig. 11); and these evidently form the axis of the sheath, which on one arm is continuous with that of the neighbouring mesh (fig. 11, *c*); so that we may fairly infer that the colossal spicule of the axis of the fibre throughout was a tri- or quadriradiate, although contorted (we might almost say distorted) and modified in the form of its arms to meet that of the meshwork.

Although the crenulated structure immediately surrounding the colossal spicule in *Sestrostomella rugosa*, to which I have above alluded, is not so striking in *Scyphia cylindrica*, still it has occurred to me, from observing an intermediate condition in my specimen of *Sestrostomella* from the Jura, that it might in like manner be the result of a section of the crenulated laminæ of the sheath, which, to a certain extent, might also have been influenced by the form of the original spicule in the first place; still I observe in some fossil spicules of a Lithistid from the Upper Greensand that have been mounted in Canada balsam the *straight* lines of a shaft *internally*, while the *outside* is tuberculated, illustrating what I have long since stated, viz. that the ornamentations of a spicule are put on last upon an originally plain shaft—that is, simply that the spicule begins in this form and may end in a complicated one. In some parts, where the fibre is in good preservation and therefore solid, a transverse section shows that the axial spicule was composed also of concentric layers (fig. 10, *a*), which often seem to merge into the subsequent layers of the sheath. The latter, however, must not be considered homologous with the sheath in *Verticillites* &c., where it is simply a fossil adjunct, while in the genus *Sestrostomella* &c. it appears to have been part of the original structure, however much it may have become altered by subsequent fossilization.

In no instance have I been able to see, in *Scyphia cylindrica*, the free triradiates and "pitchfork-like spicules" present *in* the fibre of *Sestrostomella*.

Thus we have an extinct structure which, curiously enough,

is a mixture between that of a Lithistid and a Hexactinellid in a calcareous sponge! Nor is the structure more like that of a Lithistid (fig. 4) than the general form of this little fossil (figs. 1–3), which, being subcylindrical, furrowed or not as the case may be at the aperture (fig. 2), and pierced to the bottom by a continuous cloacal canal, into which the larger branches of the excretory system entered laterally (fig. 3), adds to the delusion.

If it be identical with Quenstedt's *Scyphia cylindrica*, var. *baculata*, to which Zittel has given the generic name of "*Peronella*" (No. 8, vol. iv. p. 69), then *S. cylindrica* and *P. cylindrica* are totally different in their spiculation, as Zittel's slide, to which I have alluded, and his representations of the latter, compared with what I have stated of the former, point out—a fact which shows that resemblance in general form alone is no more to be trusted in fossil than in existing sponges, and thus the necessity of studying *each form* through translucent slices under the microscope to obtain the spiculation, which I fear must be long before it is generally accomplished, since it not only involves the necessity of procuring a favourable specimen, but time and ability, on the part of the operator, if not the employment of a lapidary. What spongologist without this would have said that the little fossil form called "*Verticillites*" had been a Calcisponge, which Dr. Steinmann has virtually *denied*, evidently for want of a favourable specimen in which to see the triradiates (No. 13, p. 165).

I have given several illustrations from the fibre of *Scyphia cylindrica*, var. *baculata*, which for the most part have been drawn under a power of about 300 diameters, with copious measurements, so that they may be almost viewed as facsimiles.

With reference to the "multifid" spicules figured by Prof. Sollas from the fibre of *Manon macropora*, &c. (*op. et loc. cit.*) and those by Dr. Steinmann from his *Cryptocœlia Zitteli* (No. 13, p. 177, pl. viii. fig. 5), I can only state that the same kind of *facies* is presented by slices of the fibre of my specimen of *Spongites* from Farringdon (? *Spongites sella*, No. 7, Taf. cxxvi. figs. 58, 59), wherein, however, it is evident that the spiculation is chiefly composed of the common equiarmed triradiate of different sizes, accompanied by modified forms in which the arms appear to be much extended, if not branched also; while one spicule much larger than the rest often presents itself under the form of a simple straight shaft in the axis of the fibre, like that of *Sestrostomella*, although not nearly so colossal, being similarly inflated at the extremities, at one of which it may present a short spur, while in other respects they appear to be connected with other shafts of a

modified tri- or quadriradiate which extended into the adjoining portions of fibre, but have been cut away by the sectioning. Still the structure is very badly preserved; but whatever the spiculation may hereafter in a more favourable specimen prove to be, I can only regard it, from the presence of the triradiates &c., as allied in spiculation to the foregoing species, and therefore in no way connected with the Echinonemata, as suggested by Prof. Sollas (No. 9, p. 359), or with the Alcyonidæ, as proposed by Dr. Steinmann (No. 13, p. 177). Indeed the indistinctness arising from a partial dissolution of the spicules, rendered, as before stated, still more deceptive by the thinness of the section, led me to characterize it formerly as "?Lithistid-branched" in my "Note on the Farringdon Sponges" (No. 11, p. 433), which, now that I am better informed in all respects regarding these fossils, must be repudiated in favour of Prof. Zittel's original and sounder views.

The result of a similar examination of *Oculospongia dilatata* from Farringdon (another of Zittel's genera) shows that its fibre also is composed of a chain of triradiates, but apparently without any large axial spicule, while that of *Peronella cylindrica* in Prof. Zittel's slide evidently possesses one; and the echination produced by the triradiates outside, so faithfully represented in his published illustration (Handbuch der Palæontologie, p. 190, fig. 107), will be easily distinguished from that of a siliceous Echinonematous sponge, when the new species of Calcisponge from South-west Australia, to which I have alluded, comes to be described, in which the peculiarly formed colossal spicules of the fibre *internally* are bound down by a number of smaller equiarmed triradiates whose arms project *externally*.

While, however, there are spiculations among Zittel's fossil Calcisponges which indicate a more remote alliance with existing Calcisponges than others, there are some which have not the least resemblance to them in this respect; and hence, if we are to maintain the latter among the former, it must be by some other evidence than that of the presence of tri- or quadriradiates. I allude to the genera *Stellispongia* and *Pharetrospongia*, in both of which the fibre is entirely made up of acerate or monactinellid spicules "dove-tailed" in between each other so as to form an anastomosing, cord-like, reticulated structure. In the former the spicule *appears* (for the minute structure of the specimen is clouded, and therefore not well defined) to have been undulating, and in the latter (where it is clear) to have been slightly curved; but both were smooth, fusiform, and pointed at each end, although the general aspect

of the former (that is, in *Stellispongia*) is short, cylindrical, and obtuse; but this seems to arise from the pointed ends in most instances being hidden beneath the undulations. In *Stellispongia variabilis*, from the Upper Keuper of St. Cassian in the Tyrol, the spicules appear to have consisted of about two bends, and to have been about 18 by 2-6000ths, and in *Pharetrospongia Strahani*, from the Greensand of Folkstone, where the spicule is simply curved, about 66 by $2\frac{1}{2}$-6000ths inch in their greatest dimensions respectively. I am indebted to Dr. Steinmann, of Strassburg, who has published a good photograph of it (No. 13, Taf. ix. fig. 2), for the preparation of the former, and to Prof. Sollas for an entire specimen of the latter, which is thoroughly described and illustrated in the 'Quarterly Journal of the Geological Society' (No. 5, p. 242 &c., pl. xi.), both of which I have had by me for some years past.

Having stated above that neither the spicular form in *Stellispongia* nor that in *Pharetrospongia* bears the "least resemblance" to that of existing Calcisponges, I of course mean in the absence of tri- and quadriradiates; but, to prevent cavilling, I would add that in only one or two instances among existing Calcispongiæ is there a distinct resemblance to the monactinellid spicule of *Pharetrospongia Strahani*, and in these they are subsidiary—that is, in great minority. Thus they are scattered horizontally over the surface and throughout the body, otherwise made up of radiate spicules, of the British species called by Dr. Bowerbank "*Leucogypsia Gossei*" (No. 1, vol. i. pl. xxvi. figs. 349, 350) = *Leucandra Gossei*, Häckel (No. 2, Atlas, Taf. xxxii. fig. 2, *f*), also in Häckel's *Leucandra bomba* (No. 2, Taf. xxxviii. fig. 4); while a slight resemblance to the undulating form of *Stellispongia variabilis* may be seen in his *Ascandra reticulum* (No. 2, Taf. xiv. fig. 4, *f*), and *Leucortis pulvinar*, var. *indica* (No. 2, Taf. xxix. figs. 16–18), respectively.

On the other hand, precisely the same form of monactinellid spicule as that in *Pharetrospongia Strahani*, and no other, may be seen to form precisely the same kind of fibre in *existing* species of Renieræ, as Prof. Sollas has shown in his faithful account of this sponge (No. 5, pl. xi. fig. 12), where, of course, the mineral composition is siliceous. There is no sheath here as in *Sestrostomella* and *Scyphia cylindrica*, no colossal axial spicules, triradiates, or "pitchfork-like spicules," but one single form of monactinellid spicules, which, "dove-tailed" into each other with great plurality, form a round spiculo-fibre similar to that of similar spicules in a vast number of siliceous sponges of the present day. If, then, these sponges are to be considered fossil Calcispongiæ, some other means

must be found of proving this than the absence of the radiates &c.; at the same time it must be evident to all, that if we admit the *radiates* to be an indication of Calcisponge nature, the same argument holds good as to the form of the *monactinellid* above described being *by itself* an indication of a siliceous one.

I do not think that we can place much confidence in the ontogenetic argument; for although Dr. Charles Barrois, in his Inaugural Thesis (No. 4, p. 27), asserts, upon the authority of Metschnikoff and F. E. Schulze, together with his own observations, that in the development of the sponge-ovule the monactinellid spicules appear *first*, and views my observations, which are *opposed* to it, as of no "great importance," because they were made in a single instance (No. 3, pp. 392, 393, pl. xx. fig. 16), it is just possible that, if I had considered it necessary to go further, I might, with the material at my command, have found fifty; while, in the figure of the *still swimming* and *unfixed* state of the embryo of an *Esperia* represented in the following plate (fig. 25), I have shown that the *whole* complement of the spiculation of the species, viz. one skeleton- and three forms of flesh-spicules, may already be seen, as perfect in their forms, although in miniature, as in the fully developed sponge—neither one nor the other, so far, appearing first. Thus I do not think the priority of existence of *Pharetrospongia* among the Calcisponges can claim any support from our present knowledge of the development of the sponge-ovule.

Prof. Zittel lays much stress on the disappearance of "every trace of minute structure" in several of his Calcispongiæ when followed by their conversion into silica, as being indicative of an originally calcareous nature (No. 8, vol. iii. p. 368), which seems to accord generally with what I will now mention, viz.:—A short time ago I received two fragments of flint, each from 2 to 3 inches in their longest diameter, one of a black colour coming *directly from* the "chalk," and the other brown, from the stony detritus of once overlying "greensand and chalk" in this locality (Budleigh-Salterton, S. Devon), in which the remains of all kinds of sponges are innumerable, although of course much worn. In both fragments there is a fossilized portion of a branched sponge whose digitations were about 5-12ths inch in diameter. This in the black flint appears under the form of a white anastomosing reticulated fibre, that can be seen *in* the latter through its transparency; but there happens to be a portion of it *outside* the flint which never could have been in it, and which must have been directly in the chalk; and this fibre,

averaging 1-60th inch in diameter, is composed of opaque, waxy-looking, yellowish calcite, axiated by a core not more than half its size of monactinellid spicules. (How comes this calcitic investment?) In form the spicule is slightly curved, fusiform, smooth, and pointed at each end, apparently about 15 by 1-1800th inch in its greatest dimensions, and the *whole* soluble in nitric acid. The same appears to be the case with the reticulated fibre *inside* the flint; but when a fragment of this has been subjected to the influence of nitric acid and examined under the microscope, a small portion of the *spicular core in which the spicules are evident* is seen to remain, showing that *in* the flint it is partially silicified.

On the other hand, in the "brown flint" from the detritus of the greensand &c. a mould only of the fibre generally exists; but here and there *fragments* of thin siliceous fibre bearing the same form of spicule, only a little smaller than that in the black flint, partially occupies the cavity which, had there been any calcite present as in the chalk-flint, might have been entirely filled. Thus, although not wholly, Prof. Zittel's statement seems to be generally demonstrated. The successively inflated form of the branch in this fragment and its round extremity, together with the form of the spicules, is so like an existing species of *Chalina*, that it is almost impossible to view it otherwise than as a fossilized specimen of that kind of sponge.

It is in the wax-like, yellowish calcitic mineralization similar to what has been described in the reticulated fibrous structure *outside* the "black" flint that the fibre of *Pharetrospongia Strahani* presents itself in the pure chalk, as shown me in several instances by Dr. Hinde in the geological collection of fossil sponges at the British Museum, where also there is a specimen, almost identical with that which I have described in the "black flint," that also effervesces with acid, as also shown to me by Dr. Hinde—all seeming to demonstrate that these specimens have been calcareous from their *origin*. But have they been so? for this is the "vexata quæstio."

Let us turn our attention to what has taken place in this respect during the fossilization of the Hexactinellid called *Acanthospongia Smithii*, and the Holorhaphidote sponge *Pulvillus Thomsoni* respectively, both from the "mountain-limestone" of the Carboniferous series in the neighbourhood of Glasgow (No. 6, vol. i. p. 128, pls. ix., x.). It may fairly be inferred from the intimate resemblance in form of the spicules of these two species with those of the present day, together with their minute structure (which has been faithfully preserved in the limestone), that they were originally

siliceous; it may be easily seen that as they lie in the grey compact limestone (now before me) they present themselves under a smooth form, which, on being carefully extricated and placed in nitric acid, dissolves away *completely* with strong effervescence; and on boiling a portion of this limestone so charged, it is found that many of these spicules come out in the form of a ragged cylinder of silex, which, in the rotten or decomposed parts of this limestone, present themselves in the state of *chalcedony* fretted out by rhomboidal cavities (No. 6, pl. ix. fig. 14, *a*, *b*, *c*).

Now the "mountain (Carboniferous) limestone" is analogous in this series to the "chalk" in the Cretaceous System; and if the double change in mineral composition has taken place in the former, why may it not have done so in the latter, in some although not in all instances? Thus, why might not *Pharetrospongia Strahani* have been siliceous in the first instance, just as much as *Acanthospongia Smithii* and *Pulvillus Thomsoni*?

It is not my business here to deal with the processes of transitionary mineralization and their why and wherefore (I know nothing about them comparatively, any more than of mineral metamorphism in general, or the elevation and depression of whole continents), but to deal with facts; while Zittel himself cautions us, in these instances, against the employment of arguments based on chemical reasoning (No. 8, vol. iii. p. 366).

Having got so far as, in my opinion, to throw some doubt over the original nature of *Pharetrospongia Strahani* and the like being calcareous, we have now to ask ourselves, what evidence there is of the existence of any fossil sponges, like those of the Monactinellid series of existing ones now in the Zoological Department of the British Museum, which of themselves as much outnumber the existing Hexactinellida and Lithistida there as the latter do the former in the fossil collection of the Geological Department—indeed more so; for I do not know of a single instance where an undisputed example is to be found in the latter—considering *Pharetrospongia Strahani* and the like spiculations calcareous.

If we consult some of the highest authorities on the *entire* forms, we find, as in Quenstedt's 'Petrefactenkunde' (No. 7), nothing in this way but Hexactinellida, Lithistida, and the so-called Calcispongiæ. If on their *minute structure*, we find in Zittel's elaborate and invaluable investigations nothing beyond a comparatively insignificant mention of the Monactinellidæ, under his genera *Opetionella* and *Scoliorhaphis*, together with *Cliona*, which, being an excavating sponge, is recog-

nized by the casts of its borings alone (No. 8, vol. iii. pp. 305, 306); while his Tetractinellidæ, which do not concern us so much here, hardly fare a bit better. Again, in the British-Museum collection the same thing is repeated. Nothing meets one's eye to correspond with the great number of existing Monactinellid sponges in the Zoological Department.

If we are not to infer the original nature of fossil sponges from the resemblance of their spicules to those of existing ones (that is, the presence of the peculiarly formed tri- and quadriradiates to indicate a calcareous, and that of a monactinellid spicule, such as in *Pharetrospongia Strahani*, to betoken a siliceous spicule, like that of a Renierid among my Holorhaphidota), we must fall back upon the mineral composition; and we have seen how misleading this may be. It is true that a calcareous spicule may remain calcareous under the influence of a calcareous lye; but this may not be the case with a siliceous one. Witness the calcareous condition of the Hexactinellid *Acanthospongia Smithii*, and, still more to the point, the "pinlike spicule" in Mr. Holl's specimen of *Verticillites* (see "P.S."). Again, if we confine all the fossil sponges to the Hexactinellida, Lithistida, and Calcarea, together with a few Pachytragid and Pachastrellid species, what become of the fossil representatives of the great body of existing monactinellid sponges to which I have alluded? Are we prepared to even conjecture that they are all recent introductions, when we find some of their spicular forms already so far back as the Carboniferous period (No. 6, vol. i. pl. ix. fig. 19, pl. x. fig. 5; and No. 10, vol. iii. pl. xxi. fig. 11, also in No. 12, vol. vi. pl. xiv. fig. 14) at least?

I think not, and therefore, for the present, prefer considering such fossil sponges as *Pharetrospongia Strahani*, although at present calcareous, to have originally been siliceous and allied to the existing Monactinellida, to which I have alluded, rather than to the Calcispongiæ, among which Zittel has placed them.

Returning to the latter for a moment, I cannot help observing that the important confirmation supplied by Dr. Hinde respecting the kind of spicules of which that unique little form *Verticillites* was composed, cannot be overrated; nor can his discovery of the peculiar kind of spiculation in *Sestrostomella*, together with the presence of the pitchfork-like spicules (two-pronged) identified with those of existing species, as before mentioned, be considered otherwise than as opening up an entirely new although fossil character, which must become most useful in classification.

To the sheathed form of this spiculation I have already

alluded; and the colossal size of the axial spicule has been most faithfully described and portrayed by Dr. Hinde (*l. c.* No. 14),—all of which led me to ask myself if I could not find some lingering existence of it in existing species, when I remembered that I had by me a little Australian Calcisponge that had, from its peculiar spiculation, been put by for opportune description. On turning to it I observed that its spiculation, although not identical with that of *Sestrostomella*, nevertheless presented the same principle; that is, it consisted of comparatively colossal triradiates of a peculiar form, covered in by much smaller equiarmed ones of the staple kind. This species, as it is new, I will describe under the name of

Leucetta clathrata, n. gen. et sp. (Pl. I. figs. 13–17.)

Small, flat, sessile, cake-like in form, more or less subcircular, slightly convex (Pl. I. fig. 13, *a*). Texture firm. Colour now light yellowish white. Consisting of a fibro-clathrous spicular structure which, spreading upwards from a continuous layer adherent to the frond of the foliaceous coralline (*Udotea*, sp.) on which it has grown, terminates above in a free surface that presents a solid vermiculo-reticulation in prominent relief (fig. 14), of which the interstices communicate with the clathrous structure throughout, while the summit is devoted to the osculum (fig. 14, *a*), which is but an enlarged interstice of the vermiculo-reticulated surface, the rest in the fresh state probably having been covered by a thin layer of dermal sarcode in which the pores or *in*halant orifices were situated. Spicules all triradiate, but of two distinct forms, viz.:—one of great size comparatively, consisting of three stout arms of equal length and thickness, bent downwards from a dome-like summit and everted at the extremities so as to form a kind of tripod, averaging in its largest size about 31-6000ths inch high and 38-6000ths inch at the base, with a thickness of 9-6000ths inch in the largest part of the arms (fig. 16); the other much smaller, consisting of an equiarmed equiangled triradiate, averaging in its largest size about 18-6000ths by $2\frac{1}{2}$-6000ths inch in the greatest dimensions of its arms (fig. 17). The former, few in number comparatively, are confined to the free surface, where their summits alone are chiefly visible (fig. 15, *a a*) along the lines of the vermiculo-reticulation, while their arms, being directed inwards, are concealed by the smaller triradiates which in infinitely greater numbers form the rest of the structure, and thus echinate the surface with their projecting rays (fig. 15, *c c*). Size of largest specimen about 2-12ths inch in diameter by 1-48th inch in thickness.

Hab. Growing plentifully on the fronds of a foliaceous coralline (*Udotea*, sp.).

Loc. S.W. coast of Australia.

Obs. This little specimen, which I am pretty sure was sent from Freemantle to the late Dr. Bowerbank by Mr. G. Clifton, is contained in a small flat pill-box bearing no other label than a note of interrogation. It will therefore hereafter be found among the existing Calcisponges in the British Museum, to which collection I have already added several specimens. The peculiar form of the large triradiate is characteristic of the species; and the solidity of the vermiculo-reticulation, which is *not hollow* like that of the contorted tube of *Clathrina*, Gray, = *Grantia clathrus*, Schmidt, although very much like it in external appearance, characterizes the genus; while the latter resembles the appearance of Zittel's fossil Calcispongiæ generally, and the former the *spiculation* of his genus *Sestrostomella*. Following Häckel's arrangement of the Calcispongiæ (No. 2, zweiter Band, p. vi) it belongs to his second family, viz. Leucones, and is thus closely allied to his genus *Leucetta*, in which the spicules are all triradiate; but as he mentions no instance of a "*solid* vermiculo-reticulation" we must view this species as the type of a new genus, and hence I have called it *Leucetta clathrata*, where, curiously enough, it will be located close to his *Leucetta pandora* and *Leucandra pulvinar* (No. 2, zweiter Band, pp. 127 and 166 respectively), both of which come from the west and south coasts of Australia, and possess, as before mentioned, the same kind of pitchfork-like spicules discovered in *Sestrostomella* from the Cretaceous at Vaches Noires, near Havre, by Dr. Hinde, and confirmed by myself in the specimen from the Jura, kindly sent me some time since by Prof. Zittel. The specimens of *Leucetta clathrata* which I have, although numerous, are all small; but there is no reason why much larger ones may not exist, if not be found hereafter.

Protosycon, Zittel.

Although there can be little doubt from Quenstedt's representations (No. 7, Taf. 131. figs. 24–27) and the preparation which Prof. Zittel kindly sent me, that his *Protosycon punctata* was one of Häckel's Sycones, notwithstanding Zittel's want of success in displaying through thin slices the "tri- and quadriradiate spicules" of which it seems to have been composed (No. 8, vol. iv. p. 135), the preparation kindly set before me by Dr. Hinde shows a distinct triradiate in the interspaces, which would not have been there had it not come

from a Calcisponge, which most probably was the *Protosycon* itself. *Verticillites* was also a Sycone, and *Peronella dumosa* a Leucone.

Before concluding these "observations," it might be as well to direct our attention for a few moments to the structure of the fibre in the fossil Calcispongiæ. Thus in *Sestrostomella* and *Scyphia cylindrica* the large axial spicules are ensheathed in a variable number of layers, which appear to be more or less concentric and to have originated in the spicule itself, thus causing the fibre to resemble, as before stated, that of the vitreous Hexactinellida, while the pitchfork-like spicules and smaller triradiates being *in* the midst of this fibre recalls to mind what I long since pointed out in the fibre of *Aphrocallistes Bocagei* ('Annals,' 1873, vol. xii. pl. xvi. figs. 1, &c.), wherein an analogous structure is witnessed *. On the other hand, in *Verticillites* &c. there is no investment of this kind, but one of crystalline calcite, which seems to have arisen from the presence of a calcifying *lye*, probably produced by a partial dissolution of the calcispicules themselves; for this is the condition in many instances, where hardly enough of the triradiates remain to verify their existence.

P.S. Since writing the above I have had the pleasure to receive from Dr. Harvey B. Holl, of Claines, near Worcester, four slides of *Verticillites anastomans*, showing that the reticulated structure of this little fossil is formed of triradiate spicules arranged around polygonal interstices, precisely like and almost identical in size with those of a specimen of *Grantia compressa* now before me, and exceedingly well shown in Dr. Bowerbank's illustration (No. 1, vol. i. pl. xxi. fig. 313). This, then, besides confirming Dr. Hinde's discovery of a similar structure in his *Verticillites D'Orbignyi* (No. 14, vol. x. p. 192), shows that a true Calcisponge like those of existing species, although extinct in general form, may, as Zittel was the first to proclaim, be fossilized. Whatever doubts, therefore, that I have before expressed respecting this must now be repudiated.

But Mr. Holl's preparations show more than this, and were kindly forwarded to me to point out that the fibre in *Verticil-*

* Can it be possible after all, that this concentric lamination is mineral and not organic—that is, that the calcareous layers are but a reproduction in *form* of the original spicules, which, during fossilization, have become dissolved and furnished this solution for the new structure (as often seen in the chalcedonization of the vitreous sponges, or as agatoid layers round a grain of extraneous matter? The examination of another slice of my specimen of *Sestrostomella* from the Jura strongly inclines me to this view.

lites anastomans was confronted by *pinlike* spicules situated in the outer layer of calcite, with their points directed *inwards* towards the core of triradiates, and their heads *outwards*.

Now, as I have long since asserted—and have endeavoured subsequently to show in *Rhaphidotheca Marshall-Hallii*, Kent ('Annals,' 1878, vol. i. p. 170; and Journ. Roy. Microscop. Society, 1879, vol. ii. p. 497, pl. xvii. *a*)—that the *points* and *not* the heads of spicules are *always* directed outwards in the Spongida when they have been formed by the sponge itself, it follows that these little pinlike spicules have, in all probability, been in like manner appropriated by the *Verticillites*, and therefore form no part of its original spiculation.

But as no pinlike spicules have ever been found among existing Calcispongiæ, while they are abundantly present among the Silicispongiæ, it also tends to the conclusion that these were also siliceous, but have been transformed into calcite by the calcareous *lye* which, as I have before stated, in most instances half dissolved the spicules of the Calcisponge itself.

These pinlike spicules are about 30-6000ths inch long by 1-6000th inch thick in their greatest dimensions, and in appearance very much like those of *Terpios fugax* ('Annals,' 1882, vol. ix. p. 355, pl. xii. fig. 29); only the latter are a little thinner and longer, besides being slightly curved, which the former do not appear to have been. This sponge, or one allied to it, might, as it is of extreme thinness, have been supposed to have grown over the surface of the *Verticillites*, as it is its wont to do over corals &c. of the present day; but then the points would have been *outwards*, which is not the case in Dr. Holl's specimen. They are not figured by Dr. Hinde as present in his *Verticillites D'Orbignyi*; nor have I seen such in *my* specimens of *Verticillites anastomans* from Farringdon.

EXPLANATION OF PLATE I.

N.B.—No. 4 is on the scale of 1-48th to 1-1800th inch; Nos. 5-12, on the scale of 1-48th to 1-6000th; No. 13, magnified eight times; No. 15, a diagram on the scale of 1-24th to 1-1800th; Nos. 16 and 17, on the *same* scale, viz. 1-48th to 1-6000th inch, to show their sizes *relatively*.

Fig. 1. ? *Scyphia cylindrica*, var. *baculata*, Quenstedt. Lateral view. Natural size.

Fig. 2. The same. Aperture of cloacal canal. (This is grooved in some specimens and plain in others. Nat. size.)

Fig. 3. The same. Vertical section of the lower third, showing the end of the cloacal canal and the larger branches of the excretory system which opened into it. Nat. size.

Fig. 4. The same. Fragment of the fibre, as seen in a polished surface of the fossil under a microscopic power of about 150 diameters.

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Fig. 5. The same. Fragment of fibre in a thin slice, mounted in Canada balsam, as seen by transmitted light under a microscopic power of about 125 diameters. *a*, shaft of axial spicule (? of a colossal radiate); *b*, short conical arm, or spur, projecting from it, showing in this instance that it is *spiniferous*; *c*, edges of the laminæ, forming the fibre outside the axial spicule, crenulated.

Fig. 6. The same. Showing that the outer layer of the fibre may be tubercled. *a*, axial spicule; *b*, edges of fibre-laminæ.

Fig. 7. The same. Showing two rays or spurs near each other on the same axial spicule. *a*, axial spicule and spurs; *b*, edge of fibre-lamina.

Fig. 8. The same. Showing that the fibre-laminæ may also project spurs. *a*, axial spicule, bearing one spur; *b*, fibre-laminæ, bearing two spurs near each other.

Fig. 9. The same. Showing that the fibre-lamina follows the form of the spur on the axial spicule. *a*, axial spicule and spur; *b*, fibre-lamina.

Fig. 10. The same. Showing that the axial spicule is composed of concentric laminæ. *a*, axial spicule; *b*, fibre-laminæ.

Fig. 11. The same. Showing the arms of a tri- or quadriradiate spicule in the axis of the fibre. *a*, radiate spicule; *b*, fibre-lamina.

Fig. 12. The same. Showing spurs and crenulated laminæ close to the axial spicule. *a*, axial spicule; *b*, fibre-lamina.

Fig. 13. *Leucetta clathrata*, n. sp., on a foliaceous coralline. *a*, Calcisponges. Nat. size.

Fig. 14. The same. Magnified eight diameters, to show the vermiculo-reticulation of the clathrous structure on the surface. *a*, osculum.

Fig. 15. The same. Surface of vermiculo-reticulation, to show that it is composed of spicule No. 16, covered in by No. 17. *a a*, summits of No. 16; *b b*, lateral view of the same; *c c*, No. 17.

Fig. 16. The same. Colossal triradiate or tripod spicule. Lateral view.

Fig. 17. The same. Smaller triradiate of the staple kind. Horizontal view. (Both of the average largest size, magnified equally, to show their relative dimensions.)

IV.—*On Specimens of the Gephyrean* Hamingia arctica, *Kor. and Dan., from the Hardanger Fjord.*

By E. Ray Lankester, M.A., F.R.S., Professor in University College, London.

In the 'Zoology (Gephyrea) of the Norwegian North-Atlantic Expedition,' published at Christiania in 1881, the distinguished Norwegian naturalists Koren and Danielssen, who have so long and so well worked together, describe, amongst other interesting novelties, a very remarkable Gephyrean allied to *Bonellia*, of which a single specimen came into their hands, having been dredged two hundred miles north of the North Cape. They gave to this the name *Hamingia arctica*. Later in the same year (1881) Dr. Horst, of Leyden, described (Niederl. Archiv für Zoologie, Supplementband i.)