to the right, and is formed at the expense of the hexagonal subanal plate and the posterior and right genital plates, which are the smallest. The disk is pentagonal, and the madreporic plate is slightly the largest. Next in size is the plate to the left. The ocular plates are well developed, the three anterior being the largest. The anus has a membrane, and under it plates supporting small spines. All the surface of the apical system is crowded with short, blunt, cylindrical, round-tipped, reticulate, and lobose processes, between which are pedicellariæ; the processes are found on the anal margin, on the anal membrane, and they project from the free surface and edges of the plates.

EXPLANATION OF PLATE VII.

Fig. 1. *Salenia profundæ*, Dunc., $\times \frac{3}{2}$.

Fig. 2. Anal opening, magnified.

Fig. 3. An ocular plate and part of a generative plate, magnified.

Fig. 4. Club-shaped spines and a pedicellaria, magnified.

Fig. 5. A short serrate spine, magnified.

Fig. 6. A spine at the peristome end of an ambulacrum, magnified.

Fig. 7. A tentacle of a pore, magnified.

Fig. 8. Diagram of the apical disk.

Fig. 9. A pair of buccal tentacles, pedicellariæ, and membrane, magnified.

Fig. 10. A gill.

Fig. 11. A large spine, slightly magnified.

XXXIV.—*Studies on Fossil Sponges*.—I. *Hexactinellida*.

By KARL ALFRED ZITTEL*.

Systematic Position of the Hexactinellida.

Among the numerous discoveries of O. Schmidt in the department of spongology, none has acquired such widely influential importance, from a palæontological point of view, as the establishment and definition of the orders Hexactinellida and Lithistida†. Wyville Thomson‡ had indeed previously indicated the relationship of the Ventriculites of the English Chalk to certain living siliceous sponges; but it was only after Schmidt had shown that the so-called "glass-sponges" (*Vi-*

* Translated by W. S. Dallas, F.L.S., from a separate copy of the memoir in the 'Abhandlungen der k. bayer. Akad. der Wiss.' II. Cl. Band xiii. 1877, communicated by the author.

† 'Grundzüge einer Spongienfauna des Atlantischen Gebietes,' Leipzig, 1876.

‡ 'The Depths of the Sea,' Royal Dublin Society, April 1869, and 1873, p. 483.

trea) of Wyville Thomson included two fundamentally different types, the Hexactinellida and Lithistida, each of which possesses numerous fossil precursors, that a foundation upon which one may go on building was afforded to palæontology.

As I have already shown in a previous memoir*, the suggestions of these naturalists were but little attended to by palæontologists, who continued as before to stick to the unsuccessful systems of D'Orbigny and Fromental; and although timid attempts had already been made by Etallon†, F. A. Römer‡, and most recently by Pomel§ to take into account the structural conditions even in fossil sponges, these remained without results, owing to the macroscopic method of investigation which had been hitherto almost exclusively employed.

In the meanwhile the knowledge of the recent Hexactinellida and Lithistida has been so essentially advanced by Carter||, W. Marshall¶, Saville Kent**, Bowerbank††, Wyville Thomson‡‡, Wright§§, and others, that these orders of sponges, comparatively late as was their discovery, are now amongst the most carefully studied.

As to the separation of the Hexactinellida and Lithistida, which had been united by Gray as Coralliospongia, by W. Thomson as Vitrea, and by Bowerbank as "Siliceo-fibrous Sponges," no noteworthy difference now exists between most students of living sponges. The differentiation of the two orders is indeed remarkably sharp, and may be carried out with equal certainty for the fossil forms.

In the Hexactinellida the siliceous skeleton consists of elements founded almost without exception upon three axes crossing each other at right angles; while in the Lithistida the axes generally come together at an angle of 120° |||, and in this way chiefly form quadriradiate bodies, which are united

* "Ueber Cœloptychium," Abh. d. k. bayer. Akad. II. Cl. Band xii. Abth. iii. 1876.

† 'Actes de la Société Jurassienne d'émulation pendant 1858,' Porrentruy, 1860, p. 129.

‡ "Die Spongitarier des norddeutschen Kreidegebirges," Palæontographica, xiii. 1864.

§ Paléontologie de la Province d'Oran, 5^e fasc. Spongiaires, 1872.

|| Ann. & Mag. Nat. Hist. 4th ser. vol. xii. 1873, pp. 349 and 437.

¶ Zeitschr. für wiss. Zool. Bd. xxv. Suppl., and Bd. xxvii. p. 113.

** Monthly Microsc. Journ. 1870, vol. iv. p. 241.

†† "Monograph of the Siliceo-fibrous Sponges," Proc. Zool. Soc. 1869, pp. 66 and 323; 1875, pp. 272, 503, 558; and 1876, p. 535.

‡‡ Ann. & Mag. Nat. Hist. 4th ser. vol. i. 1868, p. 119; Depths of the Sea, 1873; and Phil. Trans. 1869, p. 701 (on *Holtenia*).

§§ Quart. Journ. Microsc. Sci. vol. x. 1870, p. 4.

||| Not 130° , as stated in my monograph on *Cœloptychium*, p. 45, in consequence of a misprint.

with each other in a peculiar manner, as will be shown in a subsequent memoir.

Together with the triaxial and quadriaxial fundamental forms, uniaxial spicules occur in abundance both in Hexactinellida and Lithistida, as well as multiaxial siliceous bodies more isolatedly*.

O. Schmidt, Carter, and Marshall find no close relationships between the Hexactinellida and the other existing sponges. The order is quite isolated, and shows no transitions towards other families in any direction. It is true that Saville Kent at first thought he had found a point of union between Hexactinellida and Tethyida in the genus *Dorvillia*†; but it afterwards turned out‡ that the six-rayed spicules observed by Kent had got accidentally into the body of the sponge, and that consequently the genus *Dorvillia* had to disappear from our literature, as a synonym of *Tethya*.

The fossil Hexactinellida are no less sharply separated than the living ones from all other sponges, and especially even from the Lithistida. This statement contradicts the opinions expressed in my monograph of *Cæloptychium*§, which I founded upon the occurrence of free siliceous structures in the skeleton of *Cæloptychium*. I believed then that, from the occurrence and the state of preservation of these multiform bodies, I might conclude that the genus *Cæloptychium* possesses spicules of uniaxial, triaxial, quadriaxial, quinquiaxial, and multiaxial type; but the continuation of my studies on fossil sponges taught me that it is only in rare cases that the free siliceous structures are still so intimately united to the coherent skeleton that they can be made available for systematic purposes.

In certain localities we frequently find perfectly different sponge-bodies filled with the same spicules; and an examination of the surrounding rock almost always shows a superabundance of the corresponding structures. Petrogenetically sponge-spicules in general play a much more important part than has hitherto been supposed||.

As regards the free siliceous spicules figured in my monograph of *Cæloptychium*, I believe now that I may refer the forms represented on pl. vii., and especially the irregular ones with the short axial canals, for the most part to definite

* The latter have been demonstrated with certainty only in Lithistida.

† Monthly Microsc. Journ. 1870, p. 293.

‡ Ann. & Mag. Nat. Hist. 4th ser. vol. vii. 1871, p. 37, and vol. x. 1872, p. 209.

§ *Loc. cit.* pp. 34, 49, 53.

|| See also Rutot, Ann. de la Soc. Malacologique de Belgique, ix. 1874.

Lithistid genera. The majority of the anchorates and quadri- and octoradiates figured in pl. vi. may also belong to the same order.

In general, I am now inclined to adopt Carter's views, and to ascribe to a multifarious origin the free siliceous structures which occur, probably as accidental additions floated into the Cœloptychian framework. By this means, as a matter of course, the basis is taken away from my systematic conclusions*, founded upon the nature of the free spicules.

O. Schmidt, in a phylogenetic Table†, derives the living Hexactinellida from the fossil Ventriculitidæ. If the latter denomination is used merely to express a difference of age, there is nothing to be objected to this. But as a systematic conception the Ventriculitidæ, at least in the sense adopted by O. Schmidt, must disappear, as they in every respect belong to the true Hexactinellida.

Nor can the so-called "Vermiculatæ," which O. Schmidt regards as the precursors of the Lithistida, be with any more propriety separated from the latter. The designation Vermiculatæ, moreover, would have to be suppressed for the further reason that among the fossil sponges "with vermiform tissue" there are not only true Lithistida, but also Calcispongiæ with anastomosing fibres.

Whether the Lithistida have proceeded as a lateral branch from the Hexactinellida, as W. Marshall‡ seeks speculatively to show to be probable, must for the present remain an open question. From the palæontological point of view scarcely any thing can be adduced in favour of this hypothesis; for, although little that is reliable has been published on the distribution of the fossil Lithistida, yet they were certainly by no means first developed in the Cretaceous period, as Marshall supposes. I am acquainted with many typical Lithistida from the Jura; nay, they even appear as an independent stock (*Aulocopium*), side by side with the Hexactinellida, as early as the Silurian epoch.

Hitherto, therefore, the investigation of living and fossil Hexactinellida appears to demonstrate a sharp demarcation on all sides of this order.

State of Preservation of the Fossil Hexactinellida.

Considering the surprising morphological agreement of many fossil and recent forms, it must appear rather strange

* *Loc. cit.* p. 53.

† *Loc. cit.* p. 83.

‡ "Ideen über die Verwandtschaftsverh. der Hexactinelliden," *Zeitschr. für wiss. Zool.* xxvii. p. 134.

that their close affinities have been hitherto entirely misunderstood by palæontologists. The chief cause of this consists in the former defective, purely macroscopical method of investigation adopted by palæontologists. On the other hand, however, it must not be concealed that, until quite recently, with the exception of *Farrea*, only those forms of living Hexactinellida (*Hyalonema*, *Euplectella*) were known which, as the most highly differentiated offshoots of the entire group, show the least agreement with its fossil representatives. To this must be added, further, the extremely peculiar state of preservation of very many fossil Hexactinellida, which of necessity must have given rise to erroneous conceptions of the chemical composition of these sponge-bodies. A glance at palæontological literature, therefore, even in the most recent times, shows us the most divergent opinions as to the original constitution of the fossil sponges, to which we have here to give a close consideration.

By the older authors (Guetard, Parkinson, Münster, Goldfuss, &c.) the petrified sponges were regarded either as transformations of horny skeletons or as originally calcareous skeletons. Toulmin Smith described the original condition of the Ventriculite as "membranaceous." D'Orbigny, Etallon, Quenstedt, Pictet, and Fromental regard nearly all fossil forms as calcareous sponges (Petrospongia). Of the authors who have more recently been active in the spongological province, Pagenstecher, Capellini, Rosen, Sinzow, Harvey, Holl, Kayser, &c. adopt the opinion that the fossil skeletons are calcareous or siliceous pseudomorphs of a body originally composed of horny fibres. Only F. A. Römer and A. Pomel ascribe a siliceous skeleton to at least a number of fossil forms.

This uncertainty as to the original chemical constitution may well excite our surprise, especially as we have to do with a substance so resistant as silica. That certain sponges from the White Chalk of England and North Germany (*e. g.* from the Quadratus Marls of Ahlten, Coesfeld), and especially from the Malm of the Franconio-Swabian Jura can be freed from the containing rock by treatment with dilute muriatic acid so completely that the skeletons appear quite clean, as if just taken out of the sea, has long been known, at least for the Jurassic forms. But these beautiful skeletons were generally none the less regarded as products of the metamorphosis of horny or calcareous sponges. The reason for this assumption was, that in the deposits which contain such sponges many other fossils with originally calcareous shells (Mollusca and Echinoderms) generally occur silicified. Moreover it was

found that in many cases half or a small portion of a sponge-body could be admirably prepared by treatment with dilute acid, whilst the whole remainder of the mass, although apparently of the same constitution, was completely dissolved. By the preparation of thin slices it was ascertained that such completely soluble sponges in fact possess a skeleton consisting of calcspar.

In the Franconio-Swabian and Swiss Jura, sponges which perfectly agree morphologically with the living Hexactinellida are more frequently furnished with a calcareous than with a siliceous skeleton. At other localities, on the contrary, as near Nattheim, Oerlingen, Muggendorf, Engelhardsberg, &c., the sponges, like all the other fossils, appear in a roughly silicified state, which, however, has evidently been produced under the influence of the process of fossilization.

In the Upper Cretaceous deposits of Ahlten, Linden, and Lemförde, in Hanover, and of Coesfeld, in Westphalia, the Hexactinellid sponges are likewise almost without exception siliceous. But while the skeletons from Nattheim and the last-mentioned Jurassic localities have acquired a semicrystalline, rough texture, and, when examined under the microscope, no longer exhibit the finer structural characters (such as axial canals and ornamentation of the fibres), the Cretaceous forms behave under the microscope exactly like macerated skeletons of living Hexactinellida.

A corresponding constitution is also possessed by the siliceous parts of those sponges in which a portion of the skeleton consists of calcspar, or which are derived from beds in which calcareous and siliceous skeletons occur together. Here belong especially the forms from the true Spongitenkalk of the White Jura, γ and δ , in Swabia and Franconia. In such cases it can hardly be determined beforehand whether when treated with acids the skeleton will be completely destroyed or beautifully macerated. The siliceous skeletons here obtained, sometimes in a beautiful state, sometimes quite fragmentary, yield but little to the living Hexactinellida as regards the preservation of the finest ornamentation and the distinctness of the axial canals. Optically, however, they show a peculiar behaviour.

Thus, if small fragments obtained by corrosion or thin slices be mounted in Canada balsam, or in any other resin with a similar coefficient of refraction, a very indistinct image is obtained when they are examined by the microscope. The outlines are not sharply marked, and scarcely any of the more delicate ornamentation makes its appearance. The object stands out but little from the enclosing substance, and evidently presents exactly the same conditions of refraction as

the Canada balsam. But, on the contrary, if we treat the same object with glycerine or water, the image leaves nothing to be desired in the matter of clearness and sharpness. All preparations derived from such sponges must therefore be mounted in glycerine. Many Cretaceous sponges from the North-German and Bohemian Pläner, in which also only particular parts of the skeleton still consist of silica and remain after the action of muriatic acid, behave in the same way.

With living siliceous sponges, as also with fossil skeletons from the above-mentioned localities of the Cretaceous formation; where the hexactinellid sponges always present a siliceous composition, Canada-balsam is the best medium for mounting preparations. On the other hand, if living or Cretaceous sponges which furnish beautifully clear images in Canada balsam are put into glycerine, the same phenomenon is observed as when the Jurassic sponges are treated with Canada balsam. The image loses all its sharpness and clearness; and, indeed, under some circumstances it is so obliterated that with tolerably bright illumination scarcely any thing can be seen.

In correspondence with these remarkable phenomena, there is also a divergent behaviour under polarized light. All recent siliceous sponges, whatever the form of the parts of the skeleton may be, consist of simply refractive, amorphous silica. This is the case also with many Cretaceous forms, which must be mounted in Canada balsam. But if we bring a preparation of the Jurassic forms above described, mounted in glycerine or water, under the polarizing apparatus, the most vivid colour-phenomena are obtained on turning the Nicol's prism. The fragments of the framework or spicules show the spotted many-coloured iridescence so characteristic of quartz, and, indeed, often quite as strongly as small quartz-grains, which may have got accidentally into the preparation. I know of no other similar optical behaviour in organized silica. Sometimes, indeed, in Diatomaceæ or Radiolaria, we observe faint colours on the rotation of the prism, but never a phenomenon of such intensity as in the case of these Jurassic or Cretaceous sponges. Between this decidedly doubly refractive silica and the unaltered amorphous silica there are, however, many stages of transition. The siliceous sponges from the *Quadratus* chalk of Linden, near Hanover, for example, are visible both in Canada balsam and in glycerine; and with these, in a certain position of the prism, slight colour-phenomena are also obtained in the polarizing microscope.

This singular optical behaviour indicates distinctly that in the older siliceous sponges a physical alteration has occurred, by which the originally singly refractive silica has been con-

verted into doubly refractive silica. Whether this phenomenon has been produced by strong fission and numerous small clefts or by a change in the position of the molecules, as in the slow conversion of amorphous into crystalline sugar, or whether chemical influences have intervened in this case, I am unable at present to decide*. At any rate, however, the optical properties of the above-mentioned fossil siliceous sponges prove that a certain alteration has taken place in the substance of the skeleton. This fact is further confirmed by their constitution in other respects.

When examined by direct light, they do not appear with a bright glassy lustre and transparent, like living siliceous sponges, but dull, white, and opaque. Of the thin concentric layers of which the siliceous structures of the sponges are composed, nothing can be detected even under the highest powers; and the whole surface is more or less corroded by innumerable small depressions and elevations. It is true that by means of Canada balsam or glycerine the originally turbid fragments may be rendered completely or more or less transparent, but still without attaining the limpidity of the recent glass-sponges.

As these phenomena are most strikingly observed at those localities where at the same time fossil *Hexactinellida* or *Lithistida* occur with calcified skeletons, the idea of a physical alteration presents itself irresistibly. The behaviour with caustic alkalies also leads to the same conclusion. Thus, whilst amorphous silica dissolves pretty readily in solution of potash or soda, the Jurassic *Hexactinellida* with double refraction are but little attacked even by strong boiling, and only dissolve after long digestion, when they leave a very small residue. The less altered Cretaceous siliceous skeletons with single refraction are a little more easily soluble.

The opinion has been orally expressed by those whose opinion is worthy of consideration, that among the fossil sponges there may have been forms which indeed perfectly agreed morphologically with certain existing *Hexactinellida* or *Lithistida*, but in which the skeleton was originally composed not of silica but of carbonate of lime.

A microscopic examination of the calcified *Hexactinellida* at once does away with this notion. In the case of a sponge from the White Jura of Streitberg, for example, half calcified, half siliceous, if we examine a thin slice of the calcified por-

* Similar optical phenomena in flint, which, however, certainly, like the singly refractive menilite, has originated from amorphous silica, lead to the assumption of a metamorphosis of the same kind even in the massive siliceous segregations in the chalk.

tion, we find that the trabeculæ, which cross each other at right angles and form cubical meshes, consist of crystallized calcspar. In their general form the calcareous parts of the skeleton are undistinguishable from the siliceous parts; but while in the latter the axial canals are most distinctly preserved in the interior of the trabeculæ, the calcareous parts prove to be completely solid: the calcspar forms a homogeneous, undifferentiated mass. The absence of the axial canals in the calcareous and their presence in the siliceous parts of one and the same sponge-body, appear to me to furnish incontrovertible proof that silica formed the *original* substance of the skeleton, and that the Hexactinellida and Lithistida composed of calcspar have changed their chemical constitution only in consequence of the process of fossilization; calcspar has consequently taken the place of the amorphous silica which was originally present.

This somewhat unusual pseudomorphosis implies that previous to the penetration of the carbonate of lime the siliceous skeleton was dissolved and carried away. Considering the comparatively easy solubility of amorphous silica in water impregnated with alkaline substances, this process presents nothing startling, especially if we consider what an extended surface the siliceous parts, furnished with axial canals and composed of concentric layers, presented to the solvent.

The occurrence of Hexactinellida and Lithistida in which either a part or the whole of the siliceous framework has been removed, and in which the place of the siliceous fibres is occupied by hollow tubules, forming a network of meshes in the penetrated mass of rock, is, in fact, quite an ordinary phenomenon. Toulmin Smith has already described examples of it from the White Chalk of England; and this state of preservation shows itself still more frequently in the sponges from the ferruginous and sandy Upper Chalk of Saratow, in Russia. By treatment with dilute acid, separate and, indeed, generally small parts of the skeleton of such sponges are beautifully macerated, whilst by far the greater part of the fossil is entirely dissolved. Examination with the lens then shows immediately that in the soluble parts the siliceous framework is replaced by fine cavities, which furnish a true picture of the original skeleton*.

Not unfrequently the cavities produced by the removal of the siliceous fibres are entirely or partially filled with rust-

* Upon this point see Rosen, 'Ueber die Natur der Stromatoporen,' Dorpat, 1867, pp. 16 *et seq.* That the explanation of this state of preservation attempted by Rosen is erroneous, must appear from the above statements.

coloured hydrated peroxide of iron. This state of preservation is especially frequent in the North-German and Bohemian Pläner; rarer in sponges from the White Chalk, the Sandstone of Saratow, and the White Jura.

The filling of the cavities with crystallized calcspar occurs chiefly in the Spongitenkalk of the Upper Jura in Switzerland, Württemberg, Bavaria, and Poland. Here there are localities in which the whole of the siliceous frameworks are entirely converted into calcspar (Würgau, Boll, Oberbuchsitzen); whilst in others (*e.g.* Schauergraben near Streitberg, Wodna near Cracow) the original siliceous substance is preserved, but has acquired the optical nature already mentioned.

If we regard the above explanation of the different states of preservation as correct (and, from the morphological identity of the fossil and living *Hexactinellida*, other hypotheses which ascribe to the sponges under consideration an originally horny or calcareous skeleton are plainly inadmissible), the question arises, what has become of the dissolved silica of the sponge framework?

In the White Chalk this question offers no particular difficulties. The occurrence of massive flint nodules is pretty generally explained by a concentration of the silica obtained by the lixiviation of siliceous organisms and especially of sponges. In the Spongitenkalk of the White Jura also such siliceous segregations are not entirely wanting, although they are present in less abundance than in the White Chalk. In certain regions, indeed (the sponge-beds of Boll, Streitberg, &c.), we seek in vain for flint-nodules; and nevertheless in such localities, side by side with but slightly altered siliceous skeletons, there are numerous specimens converted into calcspar. In such cases the dissolved silica was frequently employed in the silicification of other fossils; for it is exactly in the immediate vicinity of sponges that we find the most shells of Mollusca and Echinoderms converted into silica. Moreover the dissolved silica appears to be distributed through the rock in another form. Thus in the treatment of entirely or partially calcified Jurassic sponges we frequently obtain, in the residue of corrosion, innumerable rounded rough siliceous disks, furnished with deep impressions, or perfectly irregular vermiform bodies*.

Besides the states of preservation already described, we sometimes find the whole sponge-body penetrated by iron-pyrites, and partly converted into brown ironstone. Such

* Such a body is figured by Oscar Schmidt (Spong. Atl. Oc. Taf. ii. fig. 19).

examples, like the roughly silicified specimens, only present us with a picture of the external form; they are quite unfitted for the investigation of the structural characters.

Attempts at Classification by Saville Kent, Carter, and Marshall.

All previous attempts to express the relationships of the Hexactinellida in a systematic classification were necessarily confined to the living representatives of the group, on account of the complete want of knowledge of the minute structure of the fossil forms. As Bowerbank includes under the "Fibrosiliceous Sponges" both the Hexactinellida and the Lithistida, and his monograph, which appeared in small divisions, really consists only of descriptions of species, it cannot receive any particular consideration here.

The first attempt at a system is due to Saville Kent*. According to this author the Hexactinellida are divisible into two suborders:—

CORALLIOSPONGIA, Gray.

Sponge-body with a skeleton consisting of interwoven or isolated spicules, never reticulate and coherent. Gemmules without spicules.

CALICISPONGIA, S. Kent.

Sponge-body with an anastomosing or coherent reticulate skeleton. Reproductive gemmules membranous, without spicules.

W. Marshall† has already given expression to the doubts that exist as to the systematic estimation of the gemmules, about which so little is known. With fossil forms this character is, of course, useless. But the grouping of the genera also appears not to be natural. Thus in the first suborder we have *Euplectella* and *Habrodictyon*, together with *Farrea* and *Aphrocallistes*; whereas the first two evidently show much nearer affinities to *Hyalonema*, *Askonema*, *Holtenia*, &c. That the Lithistid genus *MacAndrewia*, Gray, still finds a place among the Coralliospongia, is probably due to an oversight.

A complete revision of the living Hexactinellida known up to the year 1873, with a systematic arrangement, was published by Carter in two excellent memoirs on Hexactinellida

* Monthly Microsc. Journ. vol. iv. p. 242.

† *Loc. cit.* xxv. p. 146.

and Lithistida *. This distinguished Spongologist in the first place points out the distinction between the "skeleton-spicules," which form the true siliceous skeleton and usually possess a tolerably uniform character, and the so-called "flesh-spicules," which are always freely imbedded in the sarcode and are generally remarkable for their minute size and extraordinary multiplicity of form.

Carter divides the Hexactinellida into the following three groups † :—

1. VITREOHEXACTINELLIDA. Spicules united by silicified fibre.

Dactylocalyx, *Myliusia*, *Euplectella aspergillum*, *Aphrocallistes*, *Aulodictyon*, *Farrea*, *Sympagella*.

2. SARCOHEXACTINELLIDA. Spicules united by amorphous sarcode.

Askonema, *Crateromorpha*, *Rossella*, *Habrodictyon*, *Hyalonema*, *Phoronema*, *Meyerina*.

3. SARCO-VITREOHEXACTINELLIDA. Spicules united partly by siliceous fibre, partly by amorphous sarcode.

Euplectella cucumer.

The first two families break up into several subdivisions, characterized partly by the external form of the sponge-body and partly by the nature of the "flesh-spicules" and especially of the so-called "rosettes."

It will be seen that Kent and Carter, in the limitation of their primary groups, lay the first importance on the question whether the skeleton consists only of isolated spicules, or the different parts are amalgamated with each other and form a coherent framework. But, many as are the advantages that Carter's classification possesses over that of Saville Kent, it cannot satisfy us when forms so evidently allied as *Euplectella aspergillum*, *Habrodictyon*, and *Euplectella cucumer* are placed in three different families. A further defect of Carter's system appears to me to be that too much importance is ascribed to the nature of the flesh-spicules, and too little to that of the true skeleton.

W. Marshall's first memoir ‡ is divided into a general and a special part. In the former Marshall in the first place gives a critical revision of the previous works on the Hexactinellida, then a description of their external form and distribution, which he follows with a very careful description of the sarcode

* Ann. & Mag. Nat. Hist. 1873, ser. 4, vol. xii. pp. 349 & 437.

† Ibid. 1873, xii. p. 367, and 1875, xvi. p. 199.

‡ "Untersuchungen über Hexactinelliden," l. c. Bd. xxv.

and skeleton of these sponges. The section treating of the siliceous skeleton possesses especial interest. In this Marshall demonstrates that all Hexactinellida consist of spicules which in their form follow the axial system of an octahedron. The multifariously complicated or reduced siliceous structures may be derived from the cleavage or abortion of individual rays or entire axes.

In the simplest forms, the rod spicules, the cruciform arrangement of the three rectangularly crossing axes very frequently still shows itself in the axial canals. These axial canals are therefore of particular importance in the Hexactinellida. Marshall describes in detail the characters which the axial canals and their cylinders, where such are present, display in the different forms. In general the axial canals are considerably wider in the Hexactinellida with coherent frameworks than in those with isolated spicules.

Marshall has further paid particular attention to the union of the siliceous parts in the sponge-body. This is effected, according to Marshall, in three ways: 1, the spicules are united only by sarcode and remain isolated; 2, they are *soldered together*; or, 3, they *grow together*.

In the "soldering" (*Verschmelzung*) the spicules are only superficially cemented together by layers of siliceous substance, the axial canals remaining isolated and never flowing together. In *Euplectella aspergillum* the cementation takes place by laminar new formation of silica, which establishes bridge-like unions between two neighbouring spicules. In *Farrea*, *Aphrocallistes*, and *Eurete*, two approximated axial canals are generally surrounded by a common siliceous cylinder. Carter had already called attention (in opposition to Bowerbank) to this peculiarity; but while the English spongologist denies the occurrence of connected axial canals in neighbouring spicules in the Hexactinellida, Marshall thinks he has observed a connected canal-system in the united sexradiates in a single form (*Sclerothamnus*). This phenomenon is described as "growing together" (*Verwachsung*), and a special phylogenetic significance is ascribed to it.

In the special part the detailed description of a new *Euplectella* (*E. Oweni*) with free spicules is of the most interest, because here Marshall most convincingly shows that the cementation of all the spicules or of individual spicules in *E. aspergillum* and *E. cucumer* possesses only a quite secondary significance, and that in the three forms the closest agreement prevails in all essential characters (in the external form and the form and arrangement of the skeleton- and flesh-spicules), so that their generic separation is quite inadmissible.

By this demonstration Carter's classification of the Hexactinellida is essentially shaken. Marshall, in a second memoir*, endeavours to replace it with a new one. In this he lays great stress on the growing together of the axial canals in *Sclerothamnus*. He conceives the Hexactinellida as having originated from sponges like *Olynthus*, in which parallel lines of sarcode, crossing each other at right angles, were formed in the syncytium, and thus produced a latticework with cubical meshes. This sarcodic latticework was afterwards solidified by deposition of silica; and, according to Marshall, there were formed originally connected frameworks with continuous axial canals (*Sclerothamnus* and fossil Hexactinellida?), which subsequently broke up more or less completely into separate sexradiate spicules.

In accordance with this conception, Marshall divides the Hexactinellida into two groups:—

1. SYNAULOIDÆ.

The lumen of the tubes of the different spicules is continuously connected like the latter themselves, so that the whole latticed tissue of the sponge is permeated by a likewise connected tubular system.

Sclerothamnus, Marsh.

II. ASYNAULOIDÆ.

The lumen of the different spicules is never connected; each spicule, so far as the central fibre is concerned, is an independently developed individual.

The Asynauloidæ are again divided into three families:—

a. *Monakidæ*, with a single form of spicule, the pure sexradiate. *Eurete*, Marsh.

b. *Pleionakidæ*, with the principal mass of the skeleton consisting of pure, fully developed sexradiates, but with these brush-forked spicules, or rosettes, or both. The cubical form predominates in the meshes of the skeleton.

1. Spicules not soldered together: *Lanuginella*, *Askonema*.

2. Spicules soldered together: *Farrea*, *Dactylocalyx*, *Periphragella*, *Aulodictyon*, *Fieldingia*, *Aphrocalistes*.

c. *Pollakidæ*. Hexactinellida with numerous forms of spi-

* "Ideen über die Verwandtschaftsverhältnisse der Hexactinelliden," l. c. Bd. xxvii.

cules, with a special dermal skeleton and lining to the stomach-cavities, usually with a root-tuft. The simple square form predominates in the meshes, especially of the dermal skeleton.

Holtenia, *Crateromorpha*, *Rossella*, *Sympagella*, *Placodictyon*, *Euplectella*, *Habrodictyon*, *Labaria*, *Pheronema*, *Semperella*, *Hyalonema*.

No one will fail to recognize the advantages possessed by the grouping of the genera proposed by Marshall. The establishment of the family Pollakidæ especially seems to me an exceedingly happy idea. It undoubtedly embraces the most differentiated, multifarious, and elegant Hexactinellida, which depart most widely from their precursors. Although there was nothing to prevent the preservation of these forms, no remains of them have hitherto been found in the fossil state. The whole group appears to be confined to the present epoch; and its late appearance would consequently indicate even for the Hexactinellida a progressive development from the imperfect to the more perfect.

In other points, indeed, I am not able to adopt Marshall's conceptions. If the assumption were correct that a latticework consisting of soft sarcodic threads preceded the solid Hexactinellid skeleton, the older fossil Hexactinellida must necessarily have belonged, as indeed Marshall presupposes, to the Synauloidæ. But this is by no means the case. My investigations of the fossil forms show that the connected latticeworks without exception consist of sexradiates soldered together, the axial canals of which certainly often lie one over the other, and then apparently form coalescing tubes; but in reality they are always separate, and usually, as in the existing genera *Farrea*, *Eurete*, and *Aphrocallistes*, lie side by side in such a manner that the axial threads belonging to the different sexradiates appear distinctly separated. This condition of the fossil forms induced me to make a renewed examination of the genus *Sclerothamnus*, for a fragment of which I am indebted to the kindness of Dr. Marshall. The optical conditions of the material at my disposal are unfortunately very unfavourable, inasmuch as the axial canals only make their appearance under a certain illumination, and even then very indistinctly. But after boiling the skeleton in sulphuric or nitric acid the excessively fine canals surrounded by axial cylinders appear rather more distinctly; and we may then ascertain that in *Sclerothamnus* also the latticework has been produced by the soldering together of distinct sexradiates, the axial canals of which meet each other and frequently lie over one another in such a

fashion that they *apparently* form a single tube, although they do not actually coalesce. But this renders the section Synauloidæ superfluous*, and *Sclerothamnus* enters the group Pleionakidæ.

There remain therefore the three sections of the Monakidæ, Pleionakidæ, and Pollakidæ, which are based upon the greater or less differentiation of the parts of the skeleton.

Whether there are any Monakidæ among living Hexactinellida seems to me to be doubtful. Of the only genus referred to this position, namely *Eurete*, Semp., only a "very much bleached and washed specimen" exists. Now, as the connected siliceous skeleton agrees perfectly with *Farrea*, and Bowerbank † has proved that in *Farrea fistulata* (which is perhaps identical with *Eurete simplicissima*, Marsh.) "spicula are present in great numbers wherever the skeleton is covered with dark brown sarcodæ, but that not a single spicule is to be seen where the sarcodæ is wanting," I regard the group of the Monakidæ in Marshall's conception as doubtful.

To the palæontologist every classification founded upon the free spicules is useless, as only in very rare cases can the connexion between Hexactinellid skeletons and the neighbouring "flesh-spicules" be proved. Moreover, as I have already shown in my monograph on *Cæloptychium*, uncommonly few spicules of the Hexactinellid type occur among the free fossil siliceous structures. Especially I have never been able to detect any trace of "rosettes, fir-trees, and broom-forks," and of the other certainly very minute and very fragile forms upon which Carter particularly relies in the separation of his genera.

If, however, a preponderant systematic importance is given to the "flesh-spicules," not only the fossil Hexactinellida, but also all those existing forms, the skeletons of which are washed and no longer clothed with sarcodæ, remain undeterminable.

But, leaving out of consideration this practical objection, there are internal reasons opposed to any such principle of classification. The flesh-spicules form, to a certain extent, the external adornment of the sponge-body; they may be compared with the plumage of birds and the dermal coverings of fishes, reptiles, and mammals. If we take our stand on the ground of the transmutation theory, we certainly have before us in the flesh-spicules those parts of the sponges which change most readily by adaptation, and therefore most easily throw off

* Dr. Marshall, as he informs me by letter, has also convinced himself of this fact, and will withdraw the Synauloidæ in a memoir very shortly to be published.

† *Op. cit.* part iii. (April 6th, 1875) p. 276.

the original type. It is quite otherwise with the skeleton-spicules. Even their well-chosen name indicates that a similar significance belongs to them as to the bony framework of the Vertebrata. The skeleton-spicules of the Hexactinellida form the most conservative part of the body of these characteristic sponges. With extraordinary tenacity they stick to the fundamental type of the sexradiate; and although in the highest ramifications of the stem, the Pollakidæ, many aberrant forms are produced by reduction of the rays, they can always be referred back to the sexradiate.

[To be continued.]

XXXV.—*On some new and little-known Spiders from the Arctic Regions.* By the Rev. O. P. CAMBRIDGE, M.A., C.M.Z.S., &c.

[Plate VIII.]

THE spiders comprised in the following notes have been received at various times during the last few years:—two from Spitzbergen, from the Rev. A. E. Eaton; others from Mr. E. Whymper, from North Greenland; and, more lately, those found by Capt. H. W. Feilden and Dr. Hart during the Arctic Expedition in search of the North Pole, in the years 1875–76.

Descriptions and notes of four of the species received from Mr. E. Whymper in 1870 (two of them, *Erigone Whymperi* and *Dictyna borealis*, being considered new to science) were printed about six or seven years ago; but their publication, as part of an intended faunistic work on North Greenland, appears to have been postponed *sine die*. Of the thirteen species here recorded, five belong to the genus *Erigone*, Sav., two to *Linyphia*, two to *Lycosa*, and one each to the genera *Dictyna*, *Tegenaria*, *Thanatus*, and *Tarentula*. Three species of *Erigone*, one of *Linyphia*, the *Tegenaria*, *Dictyna*, and *Tarentula* appear to be undescribed.

ARANEIDEA.

Fam. Dictynides.

Gen. DICTYNA, Sund.

Dictyna borealis, sp. n. Pl. VIII. fig. 1.

Adult female, length $1\frac{1}{2}$ line, length of the cephalothorax $\frac{3}{4}$ line; relative length of the legs 1, 2?, 4, 3.