

43. *On the STRUCTURE and AFFINITIES of the Genus SIPHONIA.*
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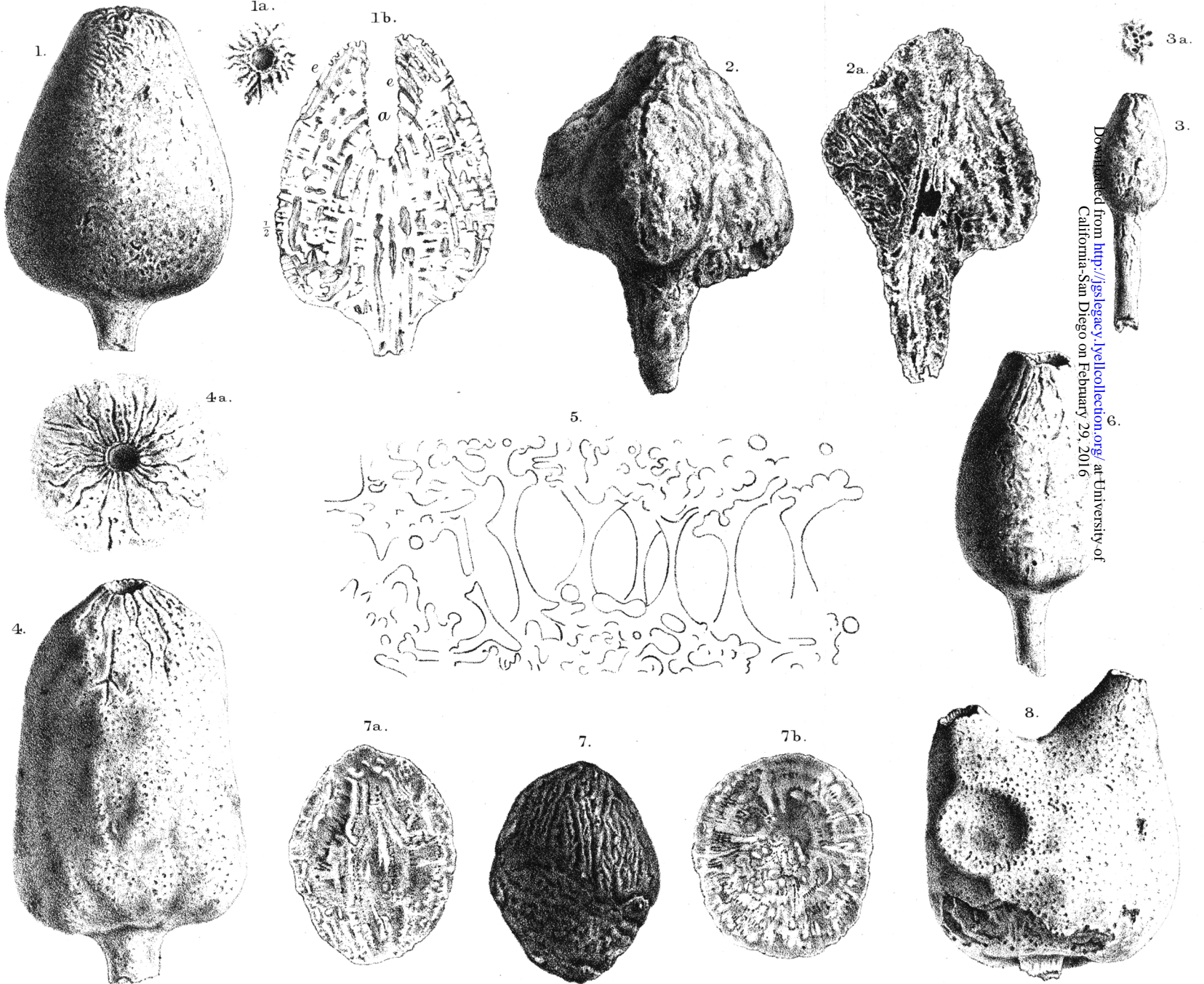
[PLATES XXV. & XXVI.]

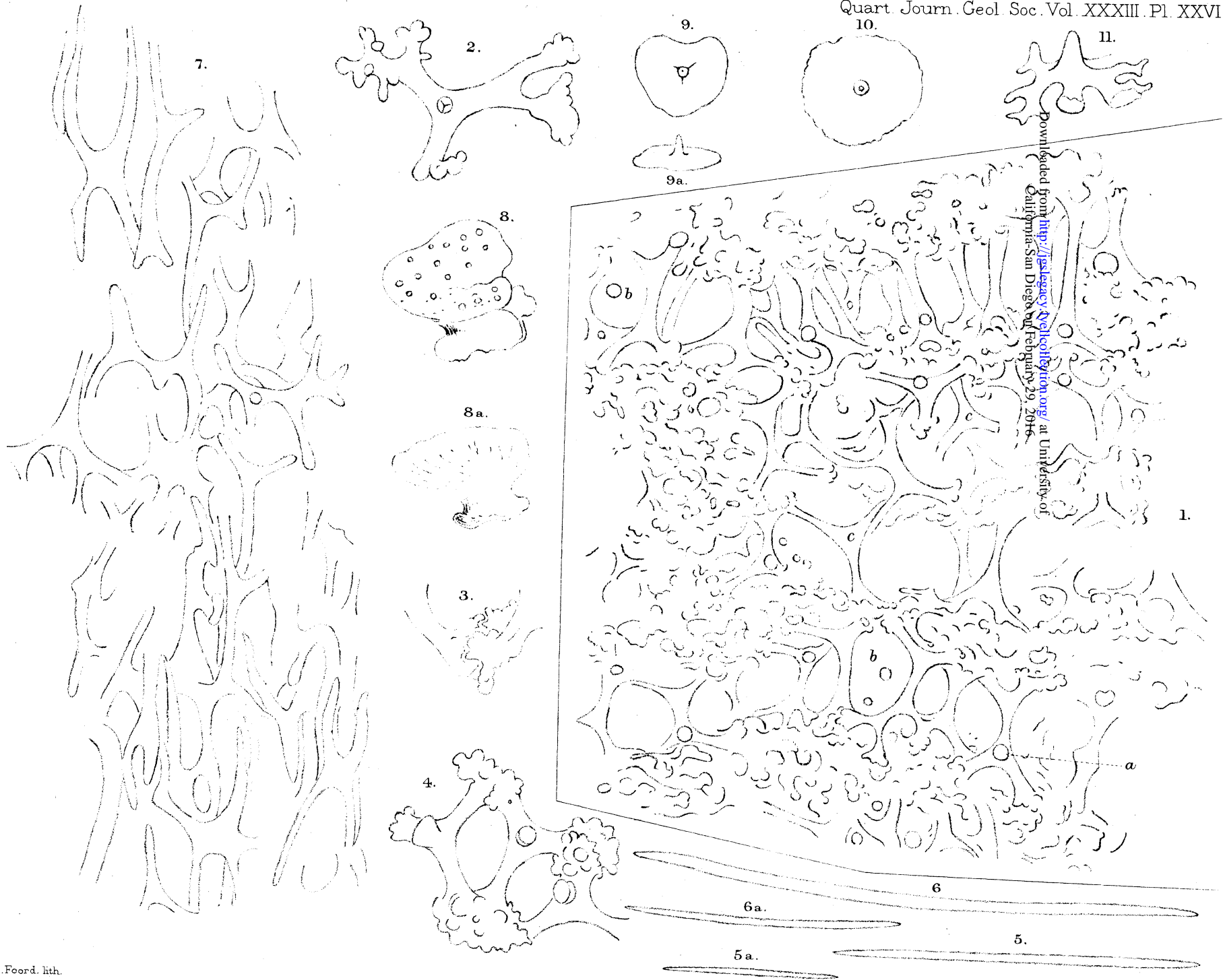
1. INTRODUCTION.

SOME years ago my friend and tutor Mr. Bonney was kind enough to procure for my examination a collection of phosphatic nodules from the Gault of Folkestone, amongst which were included several specimens of what I considered to be species of *Siphonia* in a phosphatized condition. Knowing well, from a previous investigation of phosphatized Ventriculites from the Cambridge Greensand, how perfectly sponge-structure is sometimes preserved in this state, it occurred to me that I had here a good opportunity of determining the minute structure of this sponge and its relations to recent forms.

Accordingly I requested Mr. Cuttell, of 52 New Compton Street, Soho, to prepare a series of transparent slices from my specimens; and on examining under the microscope the beautiful sections he made for me I saw displayed, in all its details, the characteristic structure of a Lithistid sponge. I then submitted my preparations to my kind friend Mr. Carter, who not only confirmed my observations, but gave me the benefit of several valuable suggestions, and generously sent me pieces of the recent *Discodermia polydiscus*, Bocage, for comparison. Subsequently Mr. Vicary, with great kindness, put a large number of siliceous specimens of *Siphonia* from the Blackdown Greensand at my disposal, and I obtained from Mr. Bryce Wright an example of *Siphonia* (*Hallirhoa*) *costata*, Lamx., from the Greensand of Wiltshire. Finally my friend Mr. Moore afforded me every facility for the examination of the beautiful collection of Choanites preserved in the Liverpool Free Museum; and transparent slices taken from specimens of that genus were sent me from the Woodwardian Museum, Cambridge, by the courtesy of Professor Hughes.

After a thorough examination of the material I had thus acquired, my next step was to work out the literature of the subject; and this proved to be a more laborious and unsatisfactory undertaking than could have been expected. A knowledge of the minute structure of fossil sponges is the first essential towards determining their natural affinities; and of this minute structure palæontological works tell us little or nothing. As a general rule, all one can learn from published figures and descriptions relates to external form and coarse structure only; and consequently without a personal examination of the forms described one is not always in a position to determine whether they are rightly assigned to a particular generic group or not. Moreover the external form of the same species of sponge is often so variable that when one has





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decided as to the genus of a particular form, one is still not at all sure as to whether it should rank as a distinct species or not. In the face of these difficulties one must either restrict one's self to mentioning those species only which have fallen under one's own immediate attention; or otherwise, in giving a complete history of the group, with each of its described species, one must be prepared to reserve judgment on a large number of forms, leaving their definite determination to future research and other observers. The former is the less laborious of the two alternatives; the latter, however, is more thorough; and though it leaves us in a state of indecision on many points, it indicates on the other hand the *lacunæ* which remain to be filled up, and by supplying a reference to each described species serves to save time in future inquiries. These reasons appear to me sufficient to justify its adoption in the following account.

2. HISTORY.

Descriptions of fossils more or less resembling *Siphonia* occur in the works of Langius, Scheuchzer, Bourguet, and various other early writers on petrifications; but the first important paper on the subject we owe to Guettard.

1751. Guettard. 'Hist. et Mém. de l'Acad. Roy. des Sci.' (Paris), tom. lxiv. p. 239.

In a paper entitled "Mémoire sur quelques corps fossiles peu connus" several specimens which are evidently *Siphonia* are described and figured (plate i. figs. 1-4, plate ii. figs. 1-4, plate iii. fig. 1) as possessing a more or less globular body, supported on an elongated conical stalk below, and excavated at the summit to a greater or less depth by a large circular cavity, into which smaller radiating canals open. It is shown that these are not fossilized fruits, as the common people of Normandy and Touraine imagined, and as, indeed, some of the labourers in Devonshire believe even now; and that they differ in important respects from the organism to which Scheuchzer compared them—the *Alcyonium ficus*, Linnæus, described by Marsilli as "Figue de substance d'Éponge et d'Alcion," which Guettard considers, justly enough, to be a sponge, while the "petrified pears" (our *Siphonia*) he assigns to the corals.

1758. Baier. 'Oryetographia Norica' (Norimbergæ), J. J. Baier, p. 46, and Supplement, p. 59.

In the body of this work the "fossil figs" (tab. i. figs. 30, 31) are considered to belong to his division "*Lusus Nature*;" but subsequently in the Supplement they are referred to fossilized marine vegetables resembling the *Alcyonia* (tab. vii. fig. 12).

1769. Walch. 'Das Steinreich systematisch entworfen' (Halle), J. E. J. Walch, p. 196, tab. xxiv. fig. 3 b.

Under the name "Corallinischen Feigen" our fossils are here referred to a group of marine Fungites.

1770. Guettard. 'Mém. sur les Sci. et Arts,' tom. ii. p. 100, "De la structure des Polypites ou Polypiers fossiles;" p. 317, "Arrangement méthodique des Polypites."

In these papers a very full and accurate description, illustrated with numerous figures, is given of various *Siphoniae*. They constitute as "Caricoides" the first genus of the class of polypites, which are defined as "marine fossil bodies of various forms, branched or not, pierced by simple or stellate holes, and which in their original state were formed by polyps contained in these holes."

After a definition of the genus very similar to that of 1751, a number of species are described and figured, including among them a "Caricoïde with five or six ribs," which is a veritable *Siphonia costata* (*Hallirhoa*, Lamx.).

Altogether, in Guettard's hands, the Caricoides form a very natural group.

1778. Schröter. 'Vollständige Einleitung in d. Kenntniss u. Geschichte d. Steine u. Versteinerungen,' vol. iii. p. 431.

To this work I have unfortunately not succeeded in obtaining access.

1808. Parkinson. 'Organic Remains of a Former World,' vol. ii. p. 95, plate ix. figs. 4, 7, 8, 11, 12, 13, plate xi. fig. 8.

Parkinson considers that we must in most cases give up every idea of distinguishing between *Alcyonia* and sponges in the fossil state. He refers Guettard's forms to one or the other without deciding which, and at the same time regards some of them, *e. g.* that figured by him on plate ix. fig. 4, as presenting, along with characteristic differences, a very striking resemblance to *Alcyonium ficus*, Linn.

Parkinson's contributions to our knowledge of the genus consist chiefly of quotations from Guettard, and of figures of sections taken longitudinally and transversely through the sponge (plate ix. figs. 7, 12, 13).

1814. T. Webster. 'Geological Transactions,' ser. 1, vol. iii. p. 378, pls. 27-30.

In a letter to Sir Henry Englefield, dated Aug. 21, 1811, this author describes some silicified remains of sponges, one form of which he names "tulip-alcyonium." This consists of a head, composed of a group of more or less parallel tubules, without a central cloaca at the summit, and supported below on a slender stem some four or five feet in length; it occurs abundantly in the Greensand of Western Lines, Isle of Wight.

This form appears to be a true *Siphonia*, though it possesses no central cloaca, and as a consequence its excurrent canals are arranged in a longitudinal fascia, and open on a plane area at the summit—an arrangement which is usually regarded as diagnostic of *Jerea*.

1821. Lamouroux, J. 'Exposition méthodique des genres de l'ordre des Polypiers (des Zoophytes, Ellis et Solander),' pp. 72 and 79, tab. 78. figs. 1, 2, 3.

Lamouroux describes certain Siphonian forms (*S. Websteri*, Sow., *S. piriformis*, Goldf. (?), *S. costata*, Lamx.) under his two genera *Jerea* and *Hallirhoa*, differentiating the latter from the former on the ground that it possesses a central cloaca, which *Jerea* does not. *Hallirhoa* is made to include two species, *H. lycoperdoides* (tab. 78, fig. 2), a smooth form, possibly corresponding to Goldfuss's *Siphonia piriformis*, and *H. costata* (tab. 78. fig. 1), distinguished by its longitudinal ribs. The ribs are said to vary in number and size, and to be of merely specific importance; their elevation to the rank of a generic character was a mistake of subsequent writers. *Jerea* is represented by but one species, *J. pyriformis*, probably identical with *S. Websteri*.

Lamouroux refers both *Jerea* and *Hallirhoa* to the last of his three divisions of the Polypiers; but he does not include them in the same order; on the contrary, while *Hallirhoa* goes into the eighteenth order, or Alcyonées, *Jerea* is placed, along with *Montilivaltia*, *Chenendopora*, &c., in the twentieth order; or Actinaires.

1822. Mantell. 'Fossils of the South Downs,' p. 178, tab. xv. fig. 2; tab. xvi. figs. 19, 20, 21.

The genus *Choanites*, of Mantell, which is in this place very vaguely defined by him, professes to be founded on *Alcyonium ficus*, Linn., as a type, and consequently embraces several of the Alcyonites referred by Parkinson to the same alliance. The forms specially claimed by Mantell are represented on pl. ix. figs. 1, 3, 4, 6(?), 8, pl. xi. fig. 8, of Parkinson's 'Organic Remains.'

Two species of the genus are described and figured: one, *Choanites subrotundus* (tab. xv. f. 2.), from the Upper Chalk of Lewes, is a true Myliasian, or lantern-jointed Hexactinellid, previously and correctly described by Toulmin Smith as *Cephalites subrotundus*; the other form, from the chalk flints of Lewes, appears to be a large conical *Siphonia* without a stem, and is named *Choanites Königii* (tab. xvi. figs. 19, 20, 21).

An *Alcyonium* (?) *pyriformis* is mentioned as occurring at Hamsey, South Bourne, near Beachey Head, in grey Chalk marl.

1826. Goldfuss. 'Petrefacta Germaniæ,' pp. 16-18, 97, 98, 221; pl. vi. figs. 7 to 11; pl. xxxv. figs. 10 to 12; pl. xlv. figs. 13 and 14.

The *Siphonia* of Goldfuss is simply Guettard's genus *Caricoides* under another name, and (since it is made to include Lamouroux's genus *Jerea*) with a slightly wider definition; and yet, without any reason being alleged, its authorship is assigned to Parkinson. But that Goldfuss quotes Guettard's memoirs on this subject, I should imagine he had never seen them.

The genus is classed with the Polypites, its polyparium stated to

be polymorphic, fixed or free, with thick fibres, which were probably subgelatinous (!) in the living state; the distinction of its canals into two groups is noticed, the one longitudinal, and opening into a central ostiole or upon a plane surface, and the other transverse, terminating in the ostioles scattered on the lateral surface.

Nine species are described and figured, all of them, with one exception, which is assigned to Münster, being claimed as new.

TABLE OF SPECIES.

				p.	Pl.	fig.
<i>S. ficus</i>	Goldf.	Quader Sands.	Quedlinburg.	221	65	14
„ <i>punctata</i> ...	Münst.	„	Goslar.	„	„	13
„ <i>piriformis</i>	Goldf.	{ Chalk (?)	Chamont.	16	6	7
		{ Jura Kalk*.	Streitberg.	97	35	10
„ <i>excavata</i> ...	„	? ?	?	17	„	8
„ <i>præmorsa</i> ...	„	? ?	?	„	„	9
„ <i>pistillum</i> †.	„	Firestone.	Paris, Courtagnon.	„	„	10
„ <i>incrassata</i> ...	„	Greensand.	Coesfeld, Westphalia.	„	32	5
„ <i>cervicornis</i>	„	? ?	18	6	11
„ <i>ampullacea</i>	„	98	35	11
				„	„	12

1831. Deshayes. 'Description des Coquilles caractéristiques des terrains,' p. 255, pl. xi. figs. 1 and 3.

This author simply notices the occurrence of *Siphonia costata* and *S. pyriformis* in the Cretaceous strata.

1831. Benett. 'Catalogue of Organic Remains of Wilts,' pp. 8, 9, pl. 1 to 8.

Miss Etheldred Benett describes and figures a large number of fossil sponges, including several forms of *Siphonia*, from the greensand of Wilts. They are all placed in the same genus *Polypothecia*, Benett, a somewhat heterogeneous mixture of forms, grouped together apparently on insufficient grounds of resemblance, and separated into species on insufficient degrees of dissimilarity in external form. Her drawings, however, are very valuable, since they present us with what appear to be two gradational series of *Siphonia*, diverging from *S. pyriformis* into *S. costata* on the one hand, and into *Polypothecia expansa* on the other. The latter series is the least complete; but it appears to mark a passage from *S. pyriformis*, through an open cup-like form (*P. complexa*) resembling a *Siphonia costata* opened out, to a wide shallow saucer-shaped species *P. expansa*, which resembles, at least superficially, some forms of *Corallistes*. The other series commences with *P. spheroccephala*, which is simply a smooth ovoid specimen of *S. pyriformis*;

* The occurrence of this species in the Jura Kalk, of which the figure leaves us in no doubt, is a very interesting observation. Goldfuss remarks that it is one of the very few fossils common to the Chalk and Jura Kalk.

† This is subsequently identified with *Jerea pyriformis*, Lamx.

this is succeeded by a true *S. pyriformis*, but with faintly longitudinally wrinkled sides; then follows *P. biloba* (*S. costata*), which shows the incipient lobation of the preceding in a more advanced stage; from being irregular and vague, it has become definite, and exhibits two regular longitudinal ribs. The lobation thus commenced is continued by specimens with from three to six or even seven lobes: so great, indeed, is the tendency of this form to lobation, that in *P. triloba* the three principal folds are in one specimen subdivided into secondary ones by a depression running longitudinally down each; and in a variety of *P. sexloba* the six chief ribs are also separated into secondary ones, but in this case by transverse instead of longitudinal constrictions. So easy do the transitions between the varieties in this series appear to be, as to leave great doubt in one's mind as to the specific distinction between the extreme forms of *S. pyriformis* and *S. costata*.

1832. Passy. 'Description géologique du département de la Seine-Inférieure, p. 339, pl. xvi. fig. 9.

In this work we merely find a notice of the occurrence of a form which the author calls *Choanites pyriformis*, a variety of *C. Königii*. It is from the Upper Chalk in the department of the Eure, and appears from the figure to be a small form of *C. Königii*.

1830-37. Fischer-de-Waldheim. 'Oryctographie du Gouv. de Moscou,' pp. 178, 179, tab. xlviii. figs. 3 and 4.

The genus *Siphonia* is here included with the Polypiers, and Goldfuss's definition is repeated. A new form is figured and described as *S. radiata*, a variety of *S. pyriformis*, from Bouchevoë, ten miles from Moscow, in Upper Chalk.

1834. Blainville. 'Manuel d'Actinologie,' p. 536, pl. 95. fig. 1.

Blainville defines the genus according to Goldfuss, and enumerates as its species *S. pyriformis*, *excavata*, *præmorsa*, *pistillum*, *incrassata*, and *cervicornis*. A recent sponge from the Mediterranean, exhibiting a certain superficial resemblance to *Siphonia*, is referred by Blainville to this genus, and not only so, but constituted its type, under the name of *Siphonia typum*, De Blainv., pl. 95. fig. 1, Mers de Sicile.

Now, in the first place, this *S. typum* appears to me to be identical with the *Alcyonium ficus*, Linn., described by Count Marsilli, and considered by Scheuchzer and Parkinson to be the living representative of *Siphonia*, for which reason they referred *Siphonia* to Alcyonia. Thus this particular species (*S. typum*) has considerable interest for us, especially as it was adopted so recently as 1867 by the late Dr. Gray, who introduced it into his proposed arrangement of the sponges as a member of the Keratacea (Proc. Zool. Soc. 1867, p. 509). The fossil *Siphonia*, however, is, as we shall show, a Lithistid sponge; and it would certainly be curious if a recent

Lithistid had been known to Blainville in the shape of *S. typum* at this early date; there is a strong *à priori* improbability about such a supposition; and what is better, we have certain information which decides this point, since Mr. Woodward informs me that a section of the original so-called *S. typum* has been prepared and examined microscopically by Mr. Savile Kent, and that this exhibits the structure of a Renierid sponge; *i. e.* its skeleton consists of acerate spicules bound together into fibres. This fact, which was known to Dr. Gray, and appears in the MS. correction of his original classification in the possession of Mr. Carter, clears up the whole matter. In the first place *Siphonia typum* is not a *Siphonia* at all, since it belongs to the Renieridæ, while the *Siphonia* belong to the Lithistidæ, an altogether different order of sponges; thus the error of Blainville is rectified; and next, if *S. typum* be the same thing as *Acyonium ficus*, as I firmly believe it is, then Parkinson's mistake is also indicated, and the clear insight of Guettard, who plainly saw and insisted on the important differences in general structure between *Caricoides* (*Siphonia*) and *Acyonium ficus* (*S. typum*), receives at length its true recognition.

1836. Sowerby. 'Trans. Geol. Soc.' ser. 2, vol. iv. pl. 2. p. 340, pl. xvia. fig. 169.

In this paper, which is an appendix to Dr. Fitton's memoir on the strata below the Chalk, Sowerby describes and figures specimens and sections of a species which he terms *Siphonia pyriformis*, Goldf., and which is found in the Greensand of Blackdown. He states that it exhibits as much variety in form as the fruit from which it derives its name. His figures are superb, and beautifully illustrate the general form and structure of the specimens described: they have in consequence been copied by many succeeding authors, too often, I regret to say, without due acknowledgment.

Sowerby's *S. pyriformis* is not spherical or obconical in shape, like Goldfuss's specimens, but more or less conical, and with a general resemblance to *S. ficus*, Goldf.; probably, however, in a type so variable these forms are but varieties of each other.

1839. Lee, J. E. 'Magazine of Natural History,' vol. iii. new ser. p. 10, figs. 2 to 6.

Lee describes two species, which he refers to *Siphonia*, as *S. clava* and *S. anguilla*, both forms from the Chalk of Bridlington, Yorksh. Neither, however, appears to agree in general characters with this genus; and as microscopic structure is not adduced, conclusive evidence as regards their affinities is wanting. A very interesting observation is made, to the effect that whilst the fibres of the roots of these sponges are often perfectly preserved in the Chalk, yet in no instance have they been found attached to a foreign body. This fact strikingly illustrates the similarity in habit between the old

Chalk sponges and those which live half-immersed and unattached in the Atlantic ooze of the present day.

1840-41. Römer, F. A. 'Die Versteinerungen des norddeutschen Kreidegebirges,' p. 4, tab. ii. figs. 1, 2, 3.

The genus is assigned, as in all works subsequent to Blainville, to the sponges; its characters are defined afresh; and eight species are described from Cretaceous strata, of which three, *S. cylindrica* (tab. ii. fig. 1), *ocellata* (ib. fig. 2), *oligostoma* (ib. fig. 3), are new, while a fourth, *S. Goldfussii*, is the *Manon pyriforme* of Goldfuss, renamed and transferred, I think rightly, to *Siphonia*.

S. oligostoma appears to be a Lithistid of some sort; but there is nothing to show that it possesses the essential structure of *Siphonia*; the two other new species exhibit no characters by which we can determine even their ordinal affinities.

A reference is made to *Choanites* as "*Scyphia (Choanites) Koenigii*," on page 8, where we find its right to generic independence strongly questioned, and its true place indicated as belonging to the *Scyphiae*.

LIST OF SPECIES.

<i>S. punctata</i> .*	Upper Chalk Marl	Sudmerberg, near Goslar.
	Lower " "	Ilsenburg and Coesfeld.
<i>S. ficus</i> .	Upper " "	Sudmerberg, near Goslar.
	Grey Chalk (Pläner)	Steckelnburg near Quedlinburg.
<i>S. Goldfussii</i> .	Lower Chalk Marl.	Near Coesfeld.
<i>S. cylindrica</i> .	Pläner.	Steckelnburg.
<i>S. ocellata</i> .		
<i>S. oligostoma</i> .	Chalk marl (Pläner)	Near Ilsenburg.
<i>S. multiformis</i> †.	Lower Chalk.	Near Peine.
	Greensand (glauconie).	Vouziers, Ardennes.
<i>S. cervicornis</i> .	Lower Chalk Marl.	Near Lemförde and Coesfeld.

1840-47. Michelin. 'Iconographie Zoophytologique.'

The additions to our knowledge of the genus made here consist chiefly in descriptions of a number of species, one of which, *S. arbuscula*, is a very interesting form, since it presents us with a composite *S. pyriformis*, characterized by a number of sponge-bodies borne on pedicels branching from the main stem.

Blainville's mistake in reference to *S. typum* is repeated, and my opinion in regard to its identity with *Alcyonium ficus*, Linn., confirmed by anticipation.

In the following list of species those which are printed with an asterisk either certainly do not belong here, or only doubtfully.

* This is considered identical with *S. incrustata*, Goldf.

† *S. pistillum* is supposed to belong to this species.

<i>S. acaulis</i>	Mich.	Cretaceous.	Cap la Hève.
„ <i>arbuscula</i> ...	„	„	Environs de Tours.
„ <i>ficoidea</i>	„	„	Poitiers.
„ <i>Pittoni</i>	„	„	Cognac, Loudun.
„ <i>incrassata</i> ...	Goldf.	„	Nogent le Rotrou, Tours, Rémalard, Guilbault, Coulonges.
„ <i>lagenaria</i> * ...	Mich.	Oolitic.	Caen.
„ <i>lycoperdoides</i> * ..	„	Cretaceous.	Luc, Ranville (Calvados)
„ <i>multioculata</i> ...	„	„	Tours.
„ <i>nuciformis</i> ...	„	„	Tours, Honfleur.
„ <i>pyriformis</i> ...	Goldf.	„	Rouen, Havre, Tours, Chateauxvieux, St. Aignan, Rémalard.
„ <i>ramosa</i> *	Mich.	„	Tours.
(<i>Hallirhoa</i>)			
<i>H. brevicosta</i>	„	„	Tours (<i>P. agariciformis</i> , Benett, Wilts).
„ <i>costata</i>	Lamx.	„	Vaches-noires, Nogent-le-Rotrou, Rémalard, Cap la Hève.
„ <i>Tessoni</i>	Mich.	„	Vaches-noires, Villers-sur-Mer.

1845-46. Reuss, A. E. 'Die Versteinerungen der böhmischen Kreideformation,' vol. ii. p. 72.

Mention is made of six species, of which four are described as new.

LIST OF SPECIES.

- S. ternata*, Rss., Lowest Chalk marl, S. foot of Borzen, near Bilin; Tripelberg, near Kutschlin. Pl. xvii. figs. 1 and 3.
S. pyriformis, Goldf., Upper Chalk marl, Kutschlin.
S. elongata, Rss., Upper Chalk marl, Kutschlin, Hundorf, Radowessitz. Pl. xliii. fig. 1.
S. heterostoma, Rss., Lowest hornstone-like conglomerate, S. Borgen, S. Hradist; Lowest Chalk marl, Schilling, near Bilin. Pl. xvii. figs. 4, 5.
S. biseriata, Rss., Conglomerate, southern foot, Borzen. Pl. xvii. fig. 6.
S. cervicornis, Goldf., Upper Chalk marl, Kutschlin, Hundorf; Lower Chalk marl, Bilin; 'Pyropensand' of Trzibletz.

S. ternata, the *Cnemidium ternatum*, Rss., of an earlier work (Geogn. Skizz. ii. p. 298), possesses the general structure of a *Siphonia*, and is in all probability a Lithistid, closely allied to, if not identical with our genus.

S. elongata. This appears also to be a Lithistid, and is very likely a *Siphonia* as well.

S. heterostoma and *biseriata*. These are both Hexactinellids, with no relations to *Siphonia*; on the other hand they closely resemble *Stauronema*, mihi, in the coarseness of their sexradiate fibre, and in the simplicity of its nodes: they are like this genus in general form also, and will therefore, I expect, on closer examination be found to be allied to it.

S. cervicornis is said to be exceedingly similar to the lower part of *Jerca arborescens*, Mich.

1850. D'Orbigny, A. 'Prodrome de Paléontologie,' vol. ii. pp. 186 and 285.

D'Orbigny includes *Hallirhoa* and *Choanites* with *Siphonia*, and

enumerates the following species from the "étage Cénomanién" (p. 186):—

1. *Siphonia costata*, which includes *Hallirhoa costata*, Lamx., and *H. Tessonis*, Mich.

2. *S. acaulis*, Mich.

3. *S. ficus*, Goldf., which includes Sowerby's *S. pyriformis*. From the "étage Sénonien" (p. 285):—

1. *S. lycoperdites*, D'Orb., in which are merged *S. pyriformis* and *S. incrassata*, Goldf.

2. *S. Königii*, *Choanites Königii*, Mantell, to which he adds, as belonging here, *Spongia terebrata*, Phil., and *Scyphia* (*Cnemidium*) *pertusum*, Reuss. Of course, without a knowledge of the intimate structure of these species, it is impossible to deny the justice of these identifications; but the figures of Phillips (Geol. Yorks. pl. i. fig. 10), and of Reuss (Böhm. Kreid. pl. xvi. figs. 7 to 12), exhibit a very marked difference from the *Choanites* of Mantell, since they possess only one set of canals, the longitudinal group being absent.

3. *S. tuberosa* equivalent to *Scyphia tuberosa*, Römer (Nordd. Kreid. pl. ii. fig. 9). Römer figures the minute structure of this sponge; it is a true Hexactinellid, and has nothing to do with *Siphonia*.

4. *S. dichotoma* is Michelin's *Scyphia dichotoma*; and the reference here is doubtful, to say the least, since the minute structure is not known.

5. *S. infundibulum*, D'Orb., is *Scyphia terebrata*, Mich.; another of those generic identifications which rest on no sufficient basis.

6 to 9. *S. arbuscula*, *ficoidea*, *Fittoni*, *brevicosta*, all Michelin's.

10. *S. elongata*, Reuss.

11. *S. ternata*, Reuss.

12. *S. multiformis*, Bronn.

1851. Bronn. 'Lethæa Geognostica,' Th. v. p. 73, t. xxvii. fig. 20.

Bronn considers that there is no essential difference between *Siphonia*, *Hallirhoa*, and *Jerea*; at the most they are subgenera. There can be no doubt that as regards the first two he is right; and with respect to the third the probabilities are in his favour; the *Siphonia* of the Folkestone Gault differs in no important particular from the *Jerea pyriformis* of Lamoureux and Michelin; but without an opportunity of examining more species of *Jerea* I do not feel able to pass an opinion upon the whole group. Bronn also describes and figures a new species, *Siphonia multiformis* (*Jerea pyriformis*, Defr. Dict. Sci. Nat., Atlas des Polyp. xlix. fig. 2); this does not possess the usual central cloaca of *Siphonia*, but otherwise strongly resembles it. The various other species of the genus, which he quotes and rearranges from other authors, will be found referred to him in the appended catalogue, pp. 825-833.

Choanites he maintains as a distinct genus, partly on account of its spiral canal; and his *C. Kœnigi* is made to include *Spongia terebrata*, Phill., and *Scyphia heteromorpha*, Gein.

1852. D'Orbigny. 'Cours élém. de Paléontologie et Géologie,' tom. ii. p. 212, fig. 336.

The sponges are here divided into two groups, those "à squelette corné" and those "à squelette testacé;" the latter, characterized by a stony calcareous skeleton, are wholly fossil and extinct, the former recent and never found in the fossil state. Our *Siphonia*, therefore, along with all other fossil sponges, belongs to the testaceous division, and, with six other genera, it constitutes the family "Siphonidæ."

The figure of *S. ficus* (fig. 336), so often quoted as D'Orbigny's is adopted without acknowledgment from Sowerby's beautiful drawings of *S. pyriformis*.

1853. Mantell, G. A. 'Medals of Creation,' p. 230.

A short account of the genus and some of its characteristic species is given, accompanied by woodcuts (lign. 73. figs. 1 to 5). A form very similar to *S. pyriformis* is said to occur somewhat abundantly in the Portland limestone; this confirms Goldfuss's observation on the range of this species.

A new species, *Siphonia Morrisiana* (lign. 69. fig. 3), is next described from slices commonly used at Brighton and in the Isle of Wight for mounting in brooches; but no evidence is produced to show whether this is a *Siphonia* or not.

Choanites Königi (lign. 75) is again described, and said to differ from *Siphonia* in the absence of a stem. The spiral tube which was detected by Mr. Cunningham winding round its central cavity, is stated to be inconstant.

1854. Morris, John. 'Catalogue of British Fossils,' p. 30.

The species of *Siphonia* recognized by Professor Morris as occurring in Britain are as follows:—*S. anguilla*, Lee; *cervicornis*?, Goldf.; *clava*, Lee; *costata*, Lamx.; *Morrisii* (*Morrisiana*, Mantell); *pyriformis*, Goldf.; *terebata* (*Spongia terebrata*, Phillips); *Websteri*, Sow.

1857. Pictet, F. G. 'Traité de Paléontologie,' tom. iv. p. 541, Atlas, pl. ex. figs. 15, *a*, *b*, *c*.

Follows D'Orbigny in his views of the structure and relations of *Siphonia*, adopting D'Orbigny's tribe of Siphonidæ, and placing this along with all other fossil sponges except Clionides, i. e. boring sponges, in his family PETROSPONGIDÆ, which corresponds with D'Orbigny's "sponges with testaceous skeletons," minus the Clionides before mentioned.

In addition to *Hallirhoa*, *Polypothecia* and *Choanites* are included as synonyms.

1859. Fromental. "Introduction à l'étude des Éponges fossiles;" extrait des Mém. Soc. Linn. de la Normandie, vol. xi. pl. i. f. 12 et 12 *a*.

The order "Spongitaires" of this author corresponds to Pictet's Petrospongidæ; and his suborder of *Spongitaria tubulosa* embraces the

three families Eudéens, Siphonocoliens, and Jéréens, the first two of which receive most of the genera of D'Orbigny's Siphonidæ, and are distinguished from the latter by the isolation of their tubules, which in the Jéréens are grouped together in fasciæ or in series. This difference the author is able to maintain in the case of *Siphonia*, apparently by never having examined actual specimens of the genus; at all events among his *réchauffées* figures of Sowerby's *S. pyriformis*, taken at second hand from D'Orbigny, there is one illustrating a section said to have been made longitudinally through the sponge, which does not exhibit the longitudinal tubules which are the most well-marked canals of all in Sowerby's faultless drawings, and in all specimens which have come under my own observation. Any thing more misleading than the section, fig. 12 *a*, pl. i., can scarcely be imagined.

Siphonia is distinguished from the other genera of this family by being borne on a stalk, and is divided into two distinct new genera, *Siphoneudea* and *Polysiphoneudea*, the latter founded on *Siphonia arbuscula*, Mich., and distinguished from the former by bearing several sponge-bodies on its raceme instead of a single one. The distinction is a trivial one, and scarcely of specific importance even.

The mistake made by earlier authors of regarding the specialized pore-areas on the exterior surface of the sponge as representing oscular openings is repeated here, and, I believe, by every one who has had occasion to mention them both before and since.

1861. Courtillier, A. "Éponges fossiles des sables du terrain Crétacé supérieur des environs de Saumur, étage Sénonien de D'Orbigny" (Extrait des Annales de la Société Linnéenne de Maine-et-Loire).

This author simply describes a number of species of *Siphonia*, the names of which will be found in the appendix. His specific distinctions are founded on slight variations of external form, so slight sometimes as to lead one to wonder whether he has not given a separate name to each individual specimen in his collection.

- 1864-66. Römer, F. A. "Die Spongitarien des norddeutschen Kreidegebirges," Palæontographica, vol. xiii. pp. 1-64.

Römer follows D'Orbigny and Fromentel in his classification, adopting, as Pomel remarks, the errors of both, which he modifies according to Etallon, or from his own inspiration, or Toulmin Smith.

The Siphonidæ are stated to possess "wurmförmig" (Lithistid) structure externally, sometimes combined with a "gitterförmig" (Hexactinellid) structure in the interior. This is as mythical a combination as the organism of the legendary "Griffin," and can only be explained on the supposition that a Lithistid sponge has grown over a Hexactinellid to the extent of enclosing it. In the forms I have examined certainly nothing of the kind is to be seen.

The genus *Siphonia* is defined according to Fromentel, whose genus *Polysiphonia* is accepted without comment; while the *Astylo-*

spongia * (*Siphonia excavata*, Goldf.), which occurs in the Silurian, is retained as a member of the family.

The species described are *S. ficus*, *Kœnigii*, *tuberosa* (*Scyphia tuberosa*, Römer, 1840), *ornata*, *astroides*; the last two of which are new, while *S. tuberosa* (as before mentioned p. 799) is a true Hexactinellid, and has no place with the *Siphonia*.

S. pyriformis and *S. punctata* are referred to *Jerea*; and many other species of previous authors find their place amidst new and strange relationships, going into various other genera and even different families. The new arrangements proposed by this reformer are indeed bewildering, and help to show what, unfortunately, is only too sufficiently obvious, the utter and distracting confusion in which the classification of the fossil sponges is involved, and which must continue without any prospect of order or finality till the ultimate structure of the forms described is made the basis of their arrangement, as in the case of recent sponges.

The multiplication of synonyms which has grown up in consequence of all absence of a guiding principle in the grouping of forms will be seen in the appended Tables (pp. 825-833), the value of which would be greater but for the fact that even the ordinal characters of a great number of the species which are therein named are unknown, and cannot be discovered from an examination either of the figures or the descriptions of their authors.

1866. D'Eichwald, E. 'Lethæa Rossica,' vol. i. p. 329; vol. ii. sec. 1, pp. 100-102.

In vol. i. p. 329, a new species, *Siphonia cylindrica* (Eichw. non Reuss), is described from the Orthoceratite bed of Zarskoje near St. Petersburg. There are no characters about this sufficiently marked for its reference to the sponges at all, and certainly none to show that it is a *Siphonia*. *Siphonia præmorsa* and *excavata*, Goldf., are given from the same horizon at Zarskoje, Poulkowa, and various other localities.

In vol. ii. p. 100, we find a description of the genus *Siphonia*, which is said, partly on the evidence of the species cited in vol. i., to range from the Palæozoic into the Mesozoic periods, attaining its maximum in the Cretaceous.

Two new species, *S. pirum* (pl. vi. fig. 8), a doubtful member of the genus, and *S. rivuligera* (pl. vi. fig. 7), a large and symmetrical form very similar to *S. pyriformis*, Sowerby, are described and figured from the Neocomian; and *S. radiata* of Fischer is mentioned as occurring in the Cretaceous of Bouschervoyé, near Moscow.

1868. Bowerbank, Dr. J. S. "A Monograph on the Siliceo-fibrous Sponges," pt. ii. (Proceedings of the Zoological Society, 1869, p. 342, pl. xxv. figs. 6 & 7).

Dr. Bowerbank gives the name "*Purisiphonia*" to a new genus of

* Zittel shows that this sponge is a true Hexactinellid (Abhandlungen der k. bayer. Akademie der Wiss. ii. Cl. xiii. Bd. i. Abth. pp. 35 & 44).

vitreo-hexactinellid sponges, apparently out of a vague impression that *Siphonia* and it are near relations. I merely make mention of the fact here in order to state definitely that *Siphonia* and *Purisiphonia* resemble each other in nothing except their names.

1872. Pomel, A. 'Paléontologie de la Province d'Oran,' p. 124.

This author makes a decided advance in regarding the differences in the skeletal tissue of sponges, whether vermiculate or lattice-like, as of fundamental importance; to the class characterized by the former tissue he refers the Siphonidæ; but he mars the value of this by assigning a calcareous composition to these sponges, a mistake probably due to his having had before him specimens which had undergone a mineral replacement.

Beyond the statement that the Siphonian skeleton is throughout vermiculate, this author, though he writes much, does not appear to add any thing new.

1872. Nicholson, H. A. 'A Manual of Palæontology,' p. 70.

After a brief description of the genus, Dr. Nicholson gives it as his opinion that the *Siphonice* present a very curious resemblance to the *Holtemice* (sarco-hexactinellid sponges) of the Atlantic ooze, and were probably, like them, inhabitants of a deep sea.

What resemblance there may be lies wholly on the surface and is not very remarkable even there. The ultimate structure of the two genera is as completely different as it can well be; and the "gisement" of most *Siphonice* is a greensand deposit, which was laid down, not in the depths of the Cretaceous ocean, but in the shallower waters not far from its shores. "*Choanites*," however, appears to be the deep-sea form of the genus.

1873. Thomson, C. Wyville. 'The Depths of the Sea,' p. 486.

After describing a new species of sponge, *Cœlosphæra tubifex**, "an aberrant group of the Esperiadæ" (Gray's?), Prof. Sir Wyville Thomson goes on to remark that *Choanites* may be some relation of this form, on grounds of resemblance which are given in the following paragraph:—"From points apparently irregularly placed on the surface of the sponge, tubes about 3 mm. in diameter run out in all directions; the walls of the tubes are thin and delicate, being more so towards the distant ends, where the tubes contract slightly to an open orifice. At the proximal end, at the junction between the tube and the sponge-body, there is also a contraction, and a slight pit-like involution of the surface of the sponge. There is something very characteristic in this peculiar form of junction which it is not easy to define, but which almost forces the conviction that there is the closest relation between these recent forms and tube-bearing fossil sponges such as *Choanites*."

The Professor, in his attempts to discover resemblances between

* *Histioderma appendiculata*, Carter, Ann. & Mag. Nat. Hist. ser. 4, vol. xiv. p. 4, pl. 18.

fossils of the Chalk and the living forms of the Atlantic, seems here to have been led astray: the tubes of *Cælosphæra* are external, and those of *Choanites* internal, to the sponge-body; and the peculiarity in the junction of these tubes with the body of the sponge in *Cælosphæra* is not alleged to have been observed in the case of *Choanites*. For my own part I certainly have never seen it. But it would be useless to argue the matter further on these grounds, since *Cælosphæra* is, in spiculation, closely allied to *Halichondria incrustans*, Johnst., while *Choanites*, on the other hand, possesses the genuine Lithistid skeleton, and belongs without doubt to the genus *Siphonia*.

3. DESCRIPTION.

General Form and Structure.—The outward form of *Siphonia* is exceedingly variable; and it is by not making due allowance for the extreme polymorphism of the genus that its species have been so extensively multiplied. Its principal part consists of a head or body, which is usually, but not always, supported on a distinct stem.

The stem, when present, is more or less cylindrical, straight near the head, but generally irregularly undulating lower down; it exhibits great variation both in length and breadth, sometimes becoming so short as to render the sponge-body almost sessile (*S. curta*, *cylindrica*, etc., Court.), at others attaining a length many times that of the sponge-body—*e. g.* in *S. Websteri*, Sow., which presents us with a slender stalk some four or five feet long; between these two extremes every intermediate gradation may occur. It is usually simple, but sometimes becomes branched (*S. arbuscula*).

At its proximal extremity it breaks up into a number of diverging irregular ramifications, by which it appears to be attached to the surface of some foreign body.

It rarely is found entire, having in most specimens been broken off at a greater or less distance from the head. When absent, as it sometimes is in *S. (Choanites) Königi*, it is replaced by a number of rooting fibres which ramify in all directions through the surrounding matrix of the fossil. With this substitution of anchoring filaments for a process of attachment may be correlated the fact that *S. Königi* is the chalk or deep-sea form of its genus, while the species provided with stalks are characteristic of greensand deposits, and consequently flourished in a somewhat shallow sea.

The same kind of adaptation is exemplified in the case of *Euplectella*, which is an anchoring sponge when it floats half immersed in the chalk-ooze of the Atlantic, but becomes fixed and adherent when it enters the shallower waters near the coast.

The sponge-body presents almost every possible variety of form. Commencing with *S. pyriformis*, Goldf. (tab. vi. f. 7 a), we have a head nearly spherical in shape; this by elongating vertically gives rise to a series of more or less prolate ellipsoids, *S. ovata*, Court., *nuciformis*, Mich., *pyriformis*, Sow. (*loc. cit.* f. 3 & 9); by becoming flattened at the extremities these assume a cylindrical shape, *S. cylindrica*, Court. On the other hand, a shortening of the globular

form along its vertical axis produces a series of oblate ellipsoids, *S. incrassata*, Goldf.; and again, if it enlarges at the base, conical forms result, *S. conica*, Court., *ficus*, Goldf., *Fittoni*, Mich., *pyriformis*, Sow.; or if at the summit the forms become obconic, *S. pyriformis*, Goldf., Mich., Court.; several heads of this form borne on a branching raceme constitute *S. arbuscula*, Mich. Finally, by unequal lateral growth, lobations more or less numerous and pronounced arise, and we have the different varieties of *S. costata*.

At the apex of the body is the opening of a central canal, which descends for a variable depth towards the base of the sponge, sometimes nearly reaching the stem, at others forming only a shallow saucer-shaped depression; while occasionally, as in *S. Websteri*, it may be altogether absent. In breadth it is equally variable: in some cases a large sponge is perforated by a long but very narrow canal; in others a much smaller specimen is widely excavated by a broad funnel-shaped cavity; and if *S. expansa* be, as I believe, a member of the genus, the widening and deepening may become so great as to convert the canal into a large cup-like hollow.

In a unique specimen lent me by Mr. Wm. Vicary, of Exeter, the sponge is incompletely divided by longitudinal fission into two parts, each of which possesses its apical opening and central canal.

The sides of the central canal or axial tube are perforated by a number of round or oval openings about $\frac{1}{20}$ to $\frac{1}{30}$ inch in diameter, situated at about equal distances from each other, but not exhibiting either a quaternary or quincuncial arrangement; they manifest, however, a tendency to succeed one another in tiers of circular rows.

These openings are seen in vertical sections to be the distal terminations of a number of canals which diverge from the axial tube and perforate the sponge; those which open into the basal part of the tube continue its axial direction downwards, and are prolonged into the interior of the stem below, while those which open into the sides spread out in descending curves. As the canals open nearer the summit of the central tube, so they lie nearer the exterior of the sponge; and as they approach the exterior, so they become more parallel with its contour.

In many specimens the most exterior of these canals are freely exposed on the surface, radiating away from the edge of the summit, opening as winding, bifurcating, and occasionally anastomosing furrows. From this we might infer that the more internal canals, which are not so clearly revealed, possess the same characters; and a tangential section made through one of the phosphatic specimens from Folkestone proves that such is really the case, the windings, branchings, and anastomosis being all well displayed.

We have now described the "excurrent" system of the sponge. The axial tube is the "cloaca;" and the openings in its walls are the "oscles" of the longitudinal or excurrent canals.

The exterior surface of the sponge-body is pitted by a number of irregularly dispersed more or less circular holes about $\frac{1}{12}$ inch diam., which are the openings of canals which radiate inwards, normal to the surface, towards the cloaca of the sponge, crossing the excurrent

canals on the way. These radiating canals are smaller than the excurrent ones, and also differ from them in not being continuous for any considerable distance, very few extending from the circumference to the centre. Following one of them as it leaves the exterior surface it is found to proceed for a shorter or longer distance inwards and then to terminate in one of the longitudinal or excurrent canals; but other radiating tubes start afresh from the vicinity of the place where it disappears, and, after proceeding further inwards and crossing several excurrent canals on the way, terminate like the one they have replaced; and so by easy stages the central cloaca is at length attained. Thus a succession of radiating canals maintains in connexion the exterior of the sponge and the various longitudinal canals. These radiating canals constitute the "incurrent" system; and their external openings are the functional mouths or specialized pore-areas of the sponge, and not "oscles," as is stated in works on palæontology.

The interior of the stem is occupied by longitudinal canals in direct continuation with those of the sponge-body. Radiating canals are not obviously present; but a number of small openings occur on the exterior, from which, in some cases, superficial branching canals radiately diverge and, after wandering for some distance over the surface, become gradually lost.

The interstices between the canals are occupied by an irregularly reticulate, originally siliceous skeleton, the examination of which must next engage our attention.

Minute Structure.—To investigate this the phosphatized specimens from the Folkestone Gault (Plate XXV. fig. 7) were in the first place employed. These specimens had become somewhat worn by the action of water before they were deposited in their latest "gisement," and, according to the extent of the attrition they have undergone, vary in colour from grey to black, just as may be observed in the case of the coprolites of the Cambridge Greensand. In outward form they are globular, ellipsoidal, spindle-shaped, and pyriform, varying in size from $\frac{3}{4}$ to $1\frac{1}{2}$ inch in length and breadth, with no constant ratio between the longitudinal and transverse diameters. At one end a round scar or broken stump remains to indicate the place of attachment of the pedicel now broken off; at the other extremity is a plain surface in the centre, from which, in some specimens, radiate for a greater or less distance down the sides a number of low smooth rounded ridges, about $\frac{1}{32}$ inch broad; these undulate somewhat in their course, and anastomose with each other laterally; between them the surface of the sponge is depressed and minutely pitted. The central plain area indicates the place where the interior excurrent canals originally opened on the surface, or, perhaps, in a few instances, according to Mr. F. G. H. Price, F.G.S., the summit of a cloaca now filled up with foreign matter. The radiating ridges are the phosphatic casts of the exterior excurrent canals, and the intervening depressions the skeletal interspaces, the pitting of which has been produced by the removal, in solution or otherwise, of the skeletal network exposed on the surface.

From these specimens, which I believe to be chiefly forms of *Siphonia Websteri*, Sow., slices were taken in the following directions:—1. Along the longitudinal axis of the sponge, *longitudinal* sections (Pl. XXV. fig. 7 *a*); 2. Transversely through its centre, *transverse* sections (Pl. XXV. fig. 7 *b*); 3. Parallel to the vertical axis, but at some distance from it nearer the exterior, *tangential* sections. In examining these sections we find the internal canals, owing to their having been partially filled in with chalk marl and other earthy material, are distinguished from the other parts by being more opaque and lighter in colour, so that with reflected light they are dull grey, and by transmitted light almost black in appearance; they are not, however, limited by definite walls, but shade into the surrounding substance, *i. e.* the phosphatic material which now occupies the place of the original sarcode of the sponge. This is more or less transparent, dark brown by reflected, and light amber or yellowish brown by transmitted light; it is everywhere traversed by the skeletal network, which is transparent and colourless, and always sharply defined from its matrix.

Skeletal Network.—The structure of this may be best examined with powers of from 60 to 140 diameters and by transmitted light.

Selecting a favourable portion (Pl. XXVI. fig. 1) of any one of the sections, we observe, well marked off from the surrounding brownish phosphate, a small circular colourless area (0.002 of an inch in diameter) (fig. 1 *a*), which is the cut end of a smooth cylindrical rod that has been traversed at right angles by the plane of the section; from this circle, then, *i. e.* from the end of the cylindrical rod, radiate three smooth cylindrical arms, 0.005 to 0.016 of an inch long and 0.002 of an inch broad, which terminate, either without or with previous bifurcation, by dividing into a number of rounded or hemispherical apophyses, between which are left corresponding rounded concavities, the whole termination roughly resembling a small bunch of grapes. The arms make various angles with each other, maintaining no constancy in this respect.

The structure thus described is that of a Lithistid spicule (Pl. XXVI. fig. 2), which, as it exists in recent sponges, likewise presents us with a principal cylindrical shaft, also dividing into three chief radiating arms, which terminate after one or, it may be, two bifurcations, by breaking up into a cluster of botryoidal processes.

The bunch of irregular knobs and sockets which ends one spicular ray fits into and interlocks with the similar cluster at the end of the ray of an adjoining spicule, the knobs of the one fitting into the sockets left between the knobs of the other.

This articulation affects all the spicules alike; the ends of none of them are free; and thus a skeletal network results which is as resistant and rigid as that of the Vitreohexactinellids, though it is arrived at in a totally different way; for in the latter sexradiate spicules are cemented into a glassy fibro-reticulate structure by a coating of silica which completely envelops them, while in the Lithistids no such cement is present, the junction of their trifold spi-

cules, which are thus naked, being effected solely by the interlocking of their extremities (Pl. XXVI. fig. 3).

In many instances the rounded apophyses can be distinctly seen in our phosphatized specimens, lying within but quite distinct from the containing sockets, while in others the effects of fossilization have gone so far as to obliterate the distinction between the two, and to fuse the articulated clusters into a more or less solid homogeneous mass.

In some parts of the sections (Pl. XXVI. fig. 1 *b*) simple circular areas occur, unconnected with the radiating arms; these are due to the section having passed through the shaft of a spicule at some distance above its point of trifurcation. In others, again, the arms are seen without a central circular area (fig. 1 *c*), owing to the section having passed through the plane of the arms beyond the end of the shaft, and thus separated the shaft with the upper half of the rays from the lower half, which remains imbedded in the slice.

In the spicules of recent Lithistids one may often observe, in the axis of the shaft, a central canal, which, at the point of radiation of the arms, gives off three branches, one for the axis of each arm; and in a section of a fossil sponge which was sent to Mr. Carter as taken from a *Polypothecia*, he has observed* not only all the details of Lithistid structure which we have described in *Siphonia*, but has also detected this very quadriradiate canal as well, occupying the axis of the spicular shaft and rays exactly as in the recent forms. In my specimens of phosphatized *Siphonia* I have carefully searched many times for these canals under a magnifying-power of from 140 to 500 diameters, but always without success; they have apparently disappeared during the mineral replacements to which the substance of the spicules has been subjected. Their absence, however, is of no consequence in our inquiry, since the characters which remain are in every detail so exactly those of a Lithistid spicule as to make the production of further evidence on this head unnecessary; and in so considering them I have the unreserved support of Mr. Carter.

Besides the Lithistid network the sections also exhibit a number of simple finely-pointed acerate spicules (Pl. XXVI. fig. 5 & 5 *a*) of variable size, but sometimes attaining very respectable dimensions, ranging in length from 0.02 to 0.045 of an inch, and in breadth from 0.0015 to 0.007 of an inch.

Arrangement of the Spicules.—The spicules of the skeletal network, though they do not exhibit a very regular arrangement in detail, are not, however, scattered without order through the sponge, but present on a large scale a definite and regular disposition.

Longitudinal Section (Pl. XXVI. fig. 1). Selecting a band of network lying between two radiating or incurrent canals, one finds it to consist of several series of spicules, the filigreed or botryoidal ends of which for each series lie along lines radiating from the exterior towards the centre of the sponge, *i. e.* in the same direction as the radiating canals; the smooth arms of the spicules are likewise ar-

* Ann. & Mag. Nat. Hist. ser. 4, vol. xii. p. 349, "On the Hexactinellidæ and Lithistidæ."

ranged in radiating series, those of each row lying approximately parallel with each other and concentric with the centre of the sponge, *i. e.* transverse to the direction of the radiating canals: thus we have bands of filigree and rows of smooth trabeculae radiating towards the centre of the sponge and regularly alternating with each other in a vertical succession. This results, as will be seen in fig. 1, Pl. XXVI., from the fact that the points of trifurcation of the spicules are confined more or less to certain radiating lines, and that two out of the three resulting rays, which diverge in a plane at right angles to the shaft, remain short and divide into their clustered apophyses at once, while the remaining ray is elongated in a concentric direction for a certain distance (the breadth of the series) before it breaks up into filigree; and, to keep the series uniform, it often happens that the points of trifurcation of the spicules are placed alternately on opposite sides of the series, so that one spicule divides into its three rays on the line where the long rays of the adjacent spicules terminate, and sends its long arm to divide into tubercles on the same line as that on which the trifurcation of its neighbours takes place.

Transverse Section (Pl. XXV. fig. 5). A similar arrangement is to be seen about the radiating canals here, while in both the transverse and longitudinal sections the circular ends of truncated shafts appear scattered, isolated amidst the network, or attached to rays which diverge from them. These show that the series of spicules exhibited in transverse section are connected by more or less vertical shafts with similar series above and below, and, similarly, that those series shown in longitudinal section are connected by horizontal shafts with similar series on each side—in other words, that the circles of the transverse section represent the shafts of the longitudinal one, and *vice versa*.

From this it follows that the skeletal walls of the incurrent tubes are composed of cylinders of a complex network consisting of parallel bands of the interlocked terminations alternating with parallel rows of the smooth rays of Lithistid spicules, the smooth rays lying concentric with the axis of the canals, but the series they form parallel with them. Thus a minute observer entering one of these canals would see around him, as it were, a number of ladders, the “rungs” represented by the smooth arms, and the side pieces by the clustered tubercles of the spicules; and he could walk from end to end on the same ladder without crossing from one to another, except where two ladders might merge into one.

The bands of network, although their direction is from the circumference towards the centre of the sponge, do not extend uninterruptedly the whole way, but they are exposed in the sections for a short distance only; this probably arises for the most part from the interference of the longitudinal canals with the course of the incurrent ones, by displacing or absorbing them, and, to a less extent, in the case of the transverse sections from the fact that while the incurrent canals follow approximately lines radiating towards the centre of the sponge, the sections, on the other hand, are taken simply at right angles to its axis, and consequently if they pass, as they are

sure to do, a little above or below its equator, will intersect the canals and their surrounding network obliquely.

The arrangement about the longitudinal canals differs from the preceding, though it appears partly to result from it. Walking up one of these canals, one would pass alternations of knotted ends, or of bands of knotted ends, and series of smooth trabeculae, resembling altogether a chain made of links of two alternating patterns; *i. e.* we should make our way from one spicular series to another.

It only remains to repeat that the arrangements just described are subject to very considerable modifications; but these, however great they may be, leave the general tendency always observable.

The simple acerate spicules (p. 808) also present us with a more or less obvious arrangement, generally lying in groups parallel with one another and with the direction of the adjacent longitudinal or radiating canals.

This exhausts, so far as my observation goes, the minute structure observable in the phosphatic specimens from the Gault; and it will now be worth while to determine how far similar characters are to be detected in species from other localities and in different states of fossilization.

Specimens from the Haldon Greensand near Exeter. *S. pyriformis*, Sow. (Pl. XXV. fig. 1), *S. cylindrica* (Pl. XXV. fig. 4) and *conica*, Court., *S. Fittoni*, Mich. (Pl. XXV. fig. 6).—These fossils are not much else than the deciduous skeletons of the sponges they represent, unaltered to any great extent by processes of fossilization. Scarcely any foreign material has entered to fill up the canals and interstices of the interior; and thus it happens that it is next to impossible to prepare transparent sections from them: the brittle siliceous network breaks away in the processes of cutting and grinding down, and none but thick, almost opaque, slices can be procured. Fortunately, however, this perfection of preservation has its own advantages; for, owing to it, we can dispense with section-cutting and preliminary preparation altogether; with no other apparatus than a low-power microscope, say of 60 diameters, and a common Haldon *Siphonia*, we can, by examining the latter under the former with reflected light, solve at once the characters and affinities of this long misunderstood genus. That the solution has not come before is due to the ignorance in which we have been left so long regarding the nature and existence of the Lithistina. Almost directly we have attained a knowledge of these we have also arrived at a solution of *Siphonia*.

On examining the natural surface of the Haldon specimens under a power of 60 diameters, one perceives that the spaces between the pore-areas are entirely occupied by a skeletal network (Pl. XXVI. fig. 4) possessing the true Lithistid structure. The quadriradiate spicules interlocked by their tubercular extremities are plainly visible throughout, and may be viewed here as solid objects of three dimensions, and not merely as linear figures drawn in the plane of a section; as regards outward appearance, many of these spicules are as whole and perfect, and clean and vitreous, as those of a recently dead sponge.

With regard to their arrangement, it will be observed that while previously (pp. 806–810) we described the cylinders of network about the radiate canals from upper, lower, and lateral longitudinal aspects, we are here viewing them transversely or end on; and thus no arrangement of spicules in series appears. What especially strikes one is:—first, the uniform length of the radiating arms, which here lie more or less parallel with the plane of the surface, while the spicular shafts pass inwards at right angles to the surface; and next the fact that the arms diverge from one another more frequently at angles of 120° than in the interior lateral views, so that they are generally equiangular.

Sections taken from these specimens may be examined as opaque objects. Observations so made simply confirm results previously obtained.

Specimens of S. costata from the Wiltshire Greensand.—Of this species I possess only one specimen (Pl. XXV. fig. 2); and it, in common with all others I have examined, has been infiltrated with silica to a much greater extent than the preceding specimens; and, as a consequence of this, the skeletal network is much better supported, so that Mr. Cuttall has been successful in obtaining a tolerably thin slice from it. In this section the structure has in many places been obliterated by mineral changes; but enough remains distinct to show that it possesses in all essential respects the same characters as the species we have already discussed.

Specimens of S. (Choanites) Königii from the Chalk of Sussex.—These have suffered greatly from mineral changes, the precise nature of which will be described in a subsequent paragraph (p. 817). Notwithstanding this, however, enough of the skeletal structure remains to determine its real character. The quadriradiate spicules, of the same form and size as in the other species, are united into a similar network; and there can be no doubt as to the Lithistid character of the sponge. The tubercular extremities are unfortunately not preserved so well; all one can say of them is that they were at all events confined to the ends of the spicular rays, and that what traces they have left behind accord best with an origin in tubercles of the same kind as those of other *Siphonia*. After a careful search through a beautiful series of *Choanites*, I have no hesitation at all in referring them to the genus with which they are here associated.

Structure of the Stem of Haldon Siphonia (Pl. XXVI. fig. 7).—The spicules which are exposed on the exterior of the stem of the Haldon specimens differ in an interesting way from those of the body, owing probably to physiological adaptation. The arms of these spicules are greatly elongated, and bent in a direction parallel with the long axis of the stem, and therefore with each other; or, at all events, those arms which do not take this direction remain short, whilst the produced ones always lie longitudinally. Again, all the spicular rays, whether bifurcated or not, appear, as far as one can see in unprepared specimens, to terminate in simple pointed extremities without forming clusters of botryoidal apophyses; hence

the elongation of the spicules seems to be at the expense of the material of their articular processes. The shafts of the spicules are not seen, and may be inferred to penetrate the stem at right angles to its surface. As, then, the long rays all lie in the same direction (that is, with the length of the stem), and as the terminations of the spicules overlap one another by passing above and below those alongside them, and as the shafts appear to penetrate amongst the spicules of the interior, we may consider that the arrangement we have here is of the nature of a "plait," serving to keep the spicules in place, and yet not binding them together with the same rigid union which we find in the network of the sponge-body. From this results flexibility combined with security, the value of which will be understood when we remember that the *Siphonice* lived in a somewhat shallow sea (75 to 375 fathoms), and were exposed to currents which a flexible stalk would be better able than a rigid one to sustain.

Longitudinal Section of the Stem.—This does not expose any very clearly defined structure; but what there is to be seen agrees completely with the foregoing description.

Development.—Amongst the specimens from Haldon is a very small one (Pl. XXV. fig. 3), which I believe to be a young form, and which agrees in every particular with similar ones figured by Sowerby as the young forms of his *S. pyriformis* from Blackdown, near Cullompton. The body is somewhat fusiform, $\frac{1}{8}$ of an inch long and nearly $\frac{3}{8}$ of an inch broad; it is supported on a straight slender stem, the proximal end of which is broken off. At the apex of the body is a small conical depression produced by the oscular openings of some four or five excurrent canals, and very insignificant in size when compared with the rest of the body.

From this youngest known form the adults arise by successive coatings on the exterior, the coatings on the body being thicker than those on the stem. Each coating possesses all the characters which belong to *Siphonia*; and thus we have produced successive groups of longitudinal canals opening in a series of tiers vertically over one another in the cloaca or central cavity left in the axis of the body of the sponge. Thus, also, the longitudinal canals are axial in direction below the cloaca, and become more parallel with the curve of the existing exterior surface as they lie nearer to it, the successive groups of canals indicating, indeed, the successive surfaces of the sponge. Thus also arise the concentric rings of skeletal network seen in transverse section around the cloaca; and by the opening in different places of fresh radial canals for every fresh exogenous layer, the discontinuity of the radial canals when traced for any distance results. Fig. 1b (Pl. XXV.) is a drawing of a section taken longitudinally from an adult *S. pyriformis*, Sow.: it is easy to understand how the series of changes just described would result in producing such a structure as this from the young form represented in fig. 3.

The differences presented in the surface of many fossil *Siphonice*, differences which have been held of specific importance by many

authors, may be explained by reference to this kind of growth ; for in cases where the last coating had grown so thick that a fresh set of excurrent canals was on the point of appearing in a new layer, but had not actually done so, it would require a considerable amount of attrition to reveal the outermost series of canals ; and the chances are that the exterior of the specimen would be smooth, *i. e.* not grooved by superficial canals. If, on the other hand, a new set of longitudinal canals had just been produced, then the mere dissolution of the dermal covering of the sponge would leave them exposed as well-marked grooves proceeding from the rim of the cloaca for a variable distance down the sides of the body, as already described (p. 805).

4. STATES OF MINERALIZATION.

1. *Phosphatic Specimens from the Gault*.—The infilling material of these fossils is a brown substance composed of calcic carbonate and phosphate, clear and transparent in thin sections, especially in those parts where it fills the intermeshes of the skeleton, since in the canals of the sponge it is rendered more or less opaque by included earthy material, consisting partly of Gault clay and partly of various small foreign bodies, such as glauconitic granules, minute Foraminifera, as well as contorted fibres of the same kind as those figured in the 'Geological Magazine,' Decade ii. vol. iii. pl. xiv. figs. 8, 9, 10, as resembling contort spicules, and which I hope to show in a subsequent paper to be algaoid growths, like that of *Saprolegnia*, that have infested the sponge subsequent to its death and during its decay.

The skeletal network in these specimens is generally transparent and colourless ; it dissolves with effervescence in hydrochloric acid, and behaves with a power of 60 diam., under polarized light, as pure calcite, of which mineral we may therefore conclude it is mainly composed. When examined, however, with polarized light under a higher power, say 140 diam., small portions of some of the spicules, but not of all, give here and there the colours of quartz ; and when such spicules are treated with hydrochloric acid an exceedingly small insoluble residue of a transparent mineral remains behind, which, when again examined with Nicol's prisms, turns out to be pure quartz. From this it is therefore evident that in some spicules a part, though a very insignificant part, possesses a siliceous composition, while on the other hand by far the larger portion of the skeletal network consists wholly of calcite. Now the skeleton of the Lithistidæ is siliceous ; *i. e.* it consists of organic matter and silica in intimate combination ; and since the skeleton of *Siphonia* is, as we have already shown on morphological grounds, that of a Lithistid sponge, it also must originally have been made up of organic silica, while its present calcareous state can only be due to a subsequent mineral replacement. In spite, however, of the fact that its original siliceous substance has been almost altogether exchanged for a crystalline calcareous one, and in some cases entirely so, it yet exhibits an

anatomical structure so well preserved that we can trace it in nearly all its details, even to distinguishing the peculiar apophyses which terminate the ramifications of its spicules. So completely, indeed, has the original form of the spicule been preserved, that the hemispherical pittings, which generally excavate the walls of these structures in recent sponges after death, are to be observed in some cases on the surface of these calcareous pseudomorphs. Thus the fact that anatomical structure, and not mineral composition, should guide us in our investigations into the characters of fossil sponges, is here enforced afresh, upon evidence scarcely less striking than that which presented itself in the case of *Stauronema Carteri**, a fossil sponge belonging to the order Hexactinellidæ. It will be noticed also that we have here another case of the conversion of colloidal silica into a crystalline state, so crystalline as to give colours with Nicol's prisms quite as brilliant as those of mineral quartz. Sometimes the spicules of the network are replaced by iron-pyrites, so that, seen by reflected light, they glitter like burnished brass.

Near the exterior of the fossil the spicules have sometimes wholly disappeared, and their places remain unoccupied as hollow casts; or more often these casts have become filled up with transparent "coprolite," which almost obliterates them, and is only prevented from quite doing so by the presence of a quantity of fine granular material along with it, which often collects into lines along the sides of the cast. Occasionally, also, an infiltration of glauconite accompanies the coprolitic infilling, so as to make it appear that the spicule has been replaced by that mineral, which, however, is not the case.

2. *Siliceous Specimens from Haldon*.—The internal canals in these remain to a great extent unoccupied, as mere hollow tubes, though here and there they have become partly filled in with crystalline silica; and very generally they contain a singular thread of silica, having very much the appearance of a thick bristle passed in to show the course of the canals; it lies in the axis of the canal containing it, and quite free from the walls, though sometimes it leaves this position and becomes attached to the side of the canal. The substance of the thread gives colours with polarized light; its exterior has a chalcedonic appearance; and it accommodates itself accurately to the course of its canal. From its irregular form, its position, and the entire absence of any such structure from the phosphatic specimens of the Gault, and in any known sponge, recent or fossil, I should say decidedly that it is not a spicule or any other structure proper to the sponge, but a subsequent formation produced during the mineralization of the particular specimens in which it occurs. Again, the position of the threads is sufficient to show that they cannot be of stalactitic formation; the running or dropping of water could never take place so as to form a thin axial thread extending throughout the length of a narrow, branching, and tortuous canal. On the other hand the connexion between the canals and their

* Ann. & Mag. Nat. Hist. ser. 4, vol. xix. p. 1.

fibres is too significant to be overlooked. - A comparison of the two shows a correspondence of a very exact kind: wherever the canal expands, there the fibre becomes thicker; when the canal branches, the fibre bifurcates with it, and both undulate together in common curves: the two structures agree together, in fact, just like a mould and a cast which has contracted after its first formation. The explanation which therefore commends itself to my mind, and which at least satisfies all the facts of the case, is, that the silica of these threads infiltrated the canals while in the colloidal state, and completely filled them up with a siliceous jelly; a subsequent and gradual loss of water of hydration caused this jelly to become dry and simultaneously to shrink till it attained its existing solidity and dimensions; finally, after a great lapse of time, the unstable colloid passed into the crystalline condition. The possibility of the latter transformation has been already proved by numerous observations on the existing crystalline condition of fossil siliceous spicules; and any one who has experimented with colloidal silica must have been struck with the wonderful amount of contraction which this substance experiences on desiccation, a contraction quite sufficient to account for the shrivelling of the silica in the canals of the Haldon *Siphonia*.

Network.—The interstices of the network are sometimes empty spaces, and sometimes occupied wholly or in part with crystalline silica. When empty, the spicules of the net retain their siliceous composition, but do not exhibit the central hollow canal, which frequently puts in an appearance in recent specimens of Lithistid spicules; they are solid throughout, and, since they give colours with polarized light, have evidently exchanged their originally colloidal state for the crystalline condition. In a single instance, to which I have not been able to recur, a spicule was observed in a section of one of these specimens with a smooth surface, and shining with a vitreous lustre, like the spicule of a sponge only just dead; but in all other cases the spicules are excavated all over with small hemispherical pittings, similar to those which Carter has described as affecting the deciduous spicules of recent sponges; they have a bluish opalescent appearance and a feeble resinous or gum-like lustre.

When the interstices are filled with silica, the spicules are represented by empty casts, the walls of which are coated interiorly with an opaque white substance, which appears black by transmitted light. Frequently the cast has entirely failed to preserve the original shape of the spicule, and the skeletal network presents the appearance of a number of fragments of moss irregularly scattered through a transparent ground of crystalline silica; these dendritic fragments, however, are, as we have already stated, not solid, as they appear to be by transmitted light, but merely hollow empty spaces.

The silica of the interstices presents a fibrous crystalline arrangement, the fibres generally radiating from the spicules, or what remains of them, in little tufts, each of which is defined at no great distance from the centre of crystallization by a curve concentric

with it and normal to the direction of the fibres themselves: sometimes this curve is made more apparent by the presence of a number of accompanying minute granules; and it appears to indicate a line of growth. The fibrous tufts, or hemispherical bosses, do not, however, nearly fill up the whole of the interstice, but always leave a larger or smaller space in the middle, which is also filled with crystalline silica, giving either a granular colour-pattern with polarized light, or a fibrous one—but usually the latter, in which case these crystalline fibres are bolder than those of the hemispherical bosses. Here, when the fibres from two adjacent centres of crystallization meet and oppose one another, they terminate abruptly in a sharply defined straight line of demarcation; and if the adjacent and opposing groups be more than two in number, the respective lines of demarcation intersect each other at angles of 60° , and hence they may be regarded as sections of the sides of incompletely formed crystals of quartz. The fact that we find solid siliceous spicules in the uninfiltrated network, and mere empty spicular casts when the interstices are filled with silica, seems to me very significant, and certainly suggests the idea that the spicules have to some extent furnished the silica with which the sponge has become mineralized, and thus, up to a certain stage at least, the sponge has fossilized itself.

3. *Specimen of S. costata from Wilts.*—This specimen is solid throughout, the canals are filled with quartz sand, glauconite grains, and other foreign bodies, cemented together by crystalline silica. The interstices of the skeleton are filled up by transparent and crystalline silica: and the spicules have become absorbed, leaving only hollow casts in their place. These casts are lined internally by white opaque material, and frequently contain certain curious black linear bodies or acerate spicula, which, on treatment with nitric acid, lose their dark colour, turn faintly yellowish, and become perfectly transparent, while the resulting acid solution yields a blue precipitate with potassium ferrocyanide: their composition would thus appear to be mainly siliceous, while their black colouring-matter consists of some salt of iron. It is just possible that these spicules may be the remains of some *Cliona*-like sponge, which entered the *Siphonia* some time after its death, and specially inhabited the enlarged axial canals in the spicules of its skeleton.

The exterior of the arms of the skeletal spicules is sometimes covered with a number of hemispherical bosses, very regular in shape, and with a sharply defined contour. If these were integral parts of the original spicules, they would remove *S. costata* from its alliance with *S. pyriformis* and the recent species *Discodermia polydiscus*, and place it in some other group of Lithistids. I have consequently given great attention to their examination, and find, first, that they are inconstant: in some cases a group of spicules does not exhibit a single one; in others the spicules are covered with them, and occasionally so thickly that the bosses appear piled one on another in thick clusters. Next, the walls of the spicular casts are subject to other, though related, peculiarities, sometimes be-

coming slightly irregular or sinuous in outline, and at others bulging out all round into a large protuberance of no very precise form: these are certainly subsequent formations; and since, in character and position, they resemble some of the tubercular bosses, it seems probable that the latter are subsequent also. Finally, the bosses are hollow within, like the rest of the spicule, and the silica of the interstices radiates away from them in fibrous tufts; and thus we have repeated a structure and arrangement which I have before described in a very different sponge, viz. *Stauronema*, one of the Hexactinellidæ, and in which certainly they are the result of changes which have taken place during fossilization. The same holds good with the tubercles of the specimen we are describing; they are not proper to the original spicule, but have been formed as products of its fossilization. In both sponges, in *Siphonia* and *Stauronema*, the cast of the spicule has eaten its way outwards from its original position into a number of hemispherical tubercles; and these have served as centres from which a radiating crystallization of silica has been set up; in *Siphonia*, however, the spicular casts have remained empty, but in *Stauronema* they have become filled up with a crystalline carbonate of lime.

4. *Specimens of S. Königii from the Chalk*.—These exist in a great variety of mineral states; but in all the chief fossilizing agent is silica. In examining a common flint nodule which has been split open and found to contain a Choanite, we observe on the fractured surface, most exteriorly, a ring of opaque milk-white silica, excavated by a perfect network of empty spaces, on which apparently its white colour, to a great extent, depends; succeeding this, next interiorly, is a zone of dark transparent flint; and next to this, occupying the central area of the broken surface, is a white network, having its canals and interspaces filled with dark transparent flint, like that of the previous or middle zone. The central network is not, however, uniformly white and opaque, but portions of it are considerably more transparent than the remainder, the whiter and less white parts differing in appearance just as a piece of ordinary white paper differs from the same paper when impregnated with oil or grease.

The central network alone represents the original Choanite, the outer and middle zones having accumulated round it during its silicification. The outer zone, however, sometimes contains isolated Lithistid spicules, or, rather, the empty casts of such spicules; and similar casts sometimes project from the interior of this zone into the clear flint of the succeeding middle zone, wherein they appear as white and solid spicules, the true nature of which is at once revealed, however, by examining their extremities where they are intersected by the plane of fracture. Indeed I may here go so far as to state that whenever one sees a very white and opaque, solid-looking spicule imbedded in clear transparent flint, one may at once expect to find it just the reverse, as regards solidity, of what it seems.

The middle zone contains numerous transparent spicules of various kinds of sponges, various Foraminifera, and other included bodies,

which all appear to have been derived from the chalk-silt in which the Choanite was originally imbedded.

The central network, or the true Choanite, is of a mixed nature, consisting partly of the skeletal rete of the sponge and partly of a mineral incrustation. Thus one observes in it true, well-defined Lithistid spicules, composed of very dark and clear transparent silica, with a thin axial thread of whiter silica occupying the position of the axial canal, and a coating of white fluffy-looking silica surrounding them exteriorly like a growth of some kind of mould. Sometimes this fluffy material is so dense and abundant as to exclude the darker flint from the intermeshes of the network; and the central area then becomes very white and opaque; sometimes it loses its opacity, becomes less dense and abundant, and fades away into a whitish blue haze, as though permeated by more transparent material; and this produces the more transparent parts of the central area. From the nature of these changes we might conclude that the whiteness of the "fluff" is partly owing to the presence of small empty spaces within it, and that it is rendered more transparent by becoming filled with clear flint, by which its internal cavities are obliterated and the internal reflection of light prevented. In addition to this spicular network we meet also with some isolated hollow casts of quadriradiate spicules, white and opaque in appearance, and excavated with hemispherical pits so extensively as to have become almost entirely eaten away. These casts have in some places been filled in with transparent silica; and then they lose their whiteness and opacity and are converted into nearly invisible granular films. In some specimens, again, the silica of the transparent spicules of the network has been replaced by granular iron-pyrites.

In rare instances the whole specimen of the Choanite, excepting the cloaca and canals, which are filled up with opaque white material, is composed of colourless and transparent silica, and the white network is wanting. The spicules then exist as mere traces only, consisting of scarcely any thing more than the axial canal, which has undergone a slight enlargement, and become filled in with silica, which is only distinguished from that exterior to it by the presence of a few dark-coloured granules. In such a case we notice in the surrounding silica hemispherical bosses, with their rounded surfaces turned away from the spicule, and serving as centres from which a fibrous crystallization of silica radiates towards the centre of the intermesh in which they occur. This arrangement resembles that in *Stauronema*, where, likewise, the spicule has in places altogether disappeared, leaving only its axial canal, where also bosses have proceeded outwards from the site of the vanished spicule, and a fibrous siliceous crystallization has filled up the interstices surrounding it. This also appears to be the final stage of the process which led to the production of tubercles on the spicules of *S. costata* from Wiltshire.

Finally, in some Choanites the skeletal network, having its fibres simply incrustated with silica, forms the nucleus of an otherwise hollow shell consisting of the outer and so much as is present of the

middle zone of flint which we described previously (p. 817). This appears to be a late stage of silicification in arrested development.

I have described the foregoing mineral changes in some detail and with great exactness, because I believe that the obscurity which prevails on nearly the whole subject of the mineralization of organic remains is, in great part, owing to our ignorance of the precise mineral replacements which have taken place, and consequently will not be dispelled till we have made ourselves masters of these. It is not part of my purpose now to theorize on the facts I have brought forward; that would require a paper to itself; and I shall content myself, therefore, with briefly summarizing in the following Table the various mineral changes which I consider I have demonstrated to have affected siliceous sponge-spicules in the course of their fossilization:—

Mineral changes of Sponge-spicules which were originally composed of Colloidal Silica in combination with Organic Matter.

1. Transformed into the crystalline state, with corresponding elevation of refractive index. Ex. *Stauronema*, *Siphonia*, &c.
2. Replaced by
 - a. Calcic carbonate (calcite). Ex. *Pharetrospongia*, *Siphonia*, *Stauronema*.
 - b. Ferric sulphide (iron-pyrites). Ex. *Siphonia*, certain spicules in Cambridge "coprolites."
 - c. Glauconite. Ex. *Ventriculites* and *Siphonia*, but merely as an accompaniment of a coprolitic replacement.
 - d. Phosphate and carbonate of lime (coprolite).
3. Dissolved, leaving empty casts. Ex. *Ventriculites*, *Siphonia*, *Eubrochus*, &c.

5. CLASSIFICATION.

The agreement in general and minute structure between the various species we have now described is so complete, that no one can doubt their generic identity. The genus to which they belong we have shown to possess a skeletal structure agreeing in all essential particulars with that of the Lithistidæ (O. Schmidt), or the Lithistina of Carter's Pachastrellidæ; and with this family group our *Siphonia* must consequently be associated.

We now proceed to a closer determination of the affinities of this genus. Amongst the various known Lithistids is one, *Discodermia polydiscus*, Bocage*, which is distinguished from the rest by the fact that the arms of its chief spicules remain short and round, whether bifurcated or not, till they break up into their terminal bunch of rounded apophyses, just as we described in the case of *Siphonia*. The two genera *Siphonia* and *Discodermia* thus show the same distinctive kind of spicule; and they so closely resemble one another in their other characteristics that a description of the

* Journ. des Sci. Math. Phys. et Nat. Lisbonne, No. iv. pl. xi. f. 1, 1869. This would belong to O. Schmidt's genus *Corallistes*, but differs from his *C. polydiscus*; Bowerbank erroneously includes it with *Dactylocalyx* as *D. polydiscus*, Bk. (Proc. Zool. Soc. Jan. 28, 1869).

one would apply very well to the other. Great interest attaches, therefore, to *Discodermia* as to the sole survivor of a once dominant race; and this seems sufficient to justify us in giving a short account of it. The figures 8 & 8a on Pl. XXVI., which have been kindly furnished to me by Mr. Carter, illustrate the inner and outer aspect of the single specimen of *D. polydiscus* preserved in the British Museum. It came from the island of St. Vincent. "All the *Lithistina*," Mr. Carter* remarks, "are short, sessile, or stipitate sponges which grow on rocks or attached to stones;" and this specimen is "in general form shallow, cup-like, with an equally short, stout, stipitate base. It is an inch in diameter and three quarters of an inch high." Thus its outward form is generally similar to that of some specimens of *Siphonia*; and we must also observe that its oscules are situate on the inside of the cup, just as they are in the interior of the cloaca of the fossil genus. As regards the arrangement of the canals in the recent specimen, we are without published descriptions; but Mr. Carter informs me that both they and the skeletal network are arranged in most Lithistids in very much the same fashion; we may therefore supply this gap by an account of what has been seen by Schmidt in a closely allied genus and species, viz. *Corallistes clavatella*, Schmidt†. This sponge is also stipitate; it is supported on a somewhat slender, not very short, pedicel, which enlarges above into an expanded head, on the flat superior surface of which the oscules are situated. Two sets of canals are observed, the longitudinal or excurrent and the radiating or incurrent ones, the latter reminding Schmidt of the canals and furrows of *Cnemidium*, a fossil genus which appears to me to be allied to *Siphonia*. Between the canals the spicules are arranged with the "coarser, smoothest, and short arms lying concentrically," and with their fligreed terminations lying in continuous bands parallel with the radiate canals, the whole forming just such a ladder-like arrangement as we have already found in *Siphonia* (Pl. XXVI. fig. 1).

This arrangement also, Mr. Carter informs me, is common to most Lithistids; and consequently our *Siphonia* resembles its existing allies not only in general form, but in the disposition of its canals and principal spicules as well.

To return to *D. polydiscus*. "Its structure internally consists of the fligreed spicules common to the Lithistidæ (but of a peculiar form, which will be mentioned directly), faced by a dermal layer of thin, smooth, subcircular disks, with more or less curvilinear or toothed margin, furnished respectively with a short, round, pointed shaft, which projects internally, and imbedded in a dermal sarcode densely charged with a minute, curved, acerate, microspined flesh-spicule. The peculiarity of the staple spicule of the interior is that it presents four smooth round arms, which, radiating irregularly from a central point, soon divide into two branches respectively that termi-

* Ann. & Mag. Nat. Hist. ser. 4, vol. xviii. pp. 460, 462.

† Grundzüge der Spongienfauna des atlantischen Gebietes, p. 23, Taf. iii. figs. 7, 7a & 6.

nate botryoidally, or in the form of a bunch of grapes, which unites or interlocks with that of the neighbouring branch, and thus the internal structure is formed, except at the surface, where the branches immediately under the dermal layer of disks &c. terminate respectively in flat filigreed or dendriform expansions, which do not intermingle with those of opposite branches."

Owing to the kindness of Mr. Carter, who has given me fragments of *D. polydiscus*, I am able to represent the "staple spicules" (Pl. XXVI. fig. 2) of the preceding paragraph side by side with those of *Siphonia*, so that any one who so wishes may judge of their resemblance for himself. In the same Plate (figs. 9 & 9a) will be observed some of the "disciform spicules" from the dermal skeleton of *Discodermia*, specimens of which, judging from all analogy, we ought to find in connexion with *Siphonia*, more especially as Mr. Carter has found such spicules entangled in the interior of rolled, dead fragments of *Discodermia* dredged up on board the 'Porcupine' near Cape St. Vincent (*l. c.* p. 463). No endeavour on my part, however, to discover these, either on the surface or in the interior of my specimens of *Siphonia*, has met with success, which may arise from the extreme thinness and thus perishable nature of the disk. The nearest approach is the form represented on Pl. XXVI. fig. 11, a single specimen of which was found imbedded among the staple spicules just on the edge of one of the excurrent canals of *S. costata*. This form, however, more nearly resembles the dermal spicules of other Lithistids, ex. gr. *C. clavatella* (O. S.), and is most likely a stray waif washed in. Still it is quite possible that spicules with entire (Pl. XXVI. fig. 10) and with divided (Pl. XXVI. fig. 11) margins may exist together in the dermal membrane of the same sponge; and I believe that an instance of this has already been found.

True disciform spicules (Pl. XXVI. fig. 10), both with simple and sinuated borders like those of *D. polydiscus*, have been met with by Mr. Carter* abundantly scattered loose in the spicule-bed of the Haldon Greensand, and have been named by him *Dactylocalycites Vicaryi*; and I have myself obtained them in great numbers associated with pieces of Lithistid network of the *Discodermia* type from the Upper Chalk of Trimmingham, in Norfolk.

The coating of disciform spicules forming the dermal skeleton of *Discodermia* is readily separable from the internal network which it covers and conceals; the connexion between the two is, indeed, of the very slightest kind; and hence, if *Siphonia* ever possessed a similar coating of disk-like spicules, it would in all probability lose it after death and during decay; and the disk-like spicules separating from the sponge and from each other would be buried in the surrounding silt or sand, to be discovered subsequently as isolated spicules like those which have occurred to Mr. Carter in the Haldon beds and to myself in the Chalk.

Here I must quote the last paragraph in Mr. Carter's description of *Discodermia polydiscus* (Annals, *t. c.* p. 464); for it is evident tha

* Ann. & Mag. Nat. Hist. ser. 4, vol. vii. p. 123, pl. vii. figs. 1, 2, & 6.
Q. J. G. S. No. 132.

another species has come to light from the Philippine Islands, vase-like in shape, similar to *Siphonia expansa* mentioned at p. 805, Mr. Carter says:—

“Schmidt's *Corallistes polydiscus* (Atlant. Spongiens. p. 24, Taf. iii. figs. 8 & 9) appears to me, from the form of its surface-spicules, to be a different species, according in this respect with a large vase-like specimen from the Philippine Islands that I have lately been examining, in which, however, there is, in addition to the acerate flesh-spicule, a small solid one of an elliptical form like that characterizing *Pachastrella abyssi*, while the acerate flesh-spicule in all is almost identical with that of *Macandrewia azorica*.”

Now, as further on (p. 464), the latter is considered equal to *Corallistes clavatella*, Sdt., the close alliance of this Lithistid to *Discodermia*, which I have before noticed, is thus corroborated; and, as this would give a discoid spicule with *more indented, tooth-like* margin, then the finding of the one in *S. costata* just mentioned might be accounted for.

The previous existence of a dermal skeleton of some kind about the exterior of *Siphonia* appears probable also from the exposure of the outermost excurrent canals as grooves radiating from the cloacal tube of many Haldon specimens; these grooves must once have been covered in by a membrane of some sort in order to form completed tubes.

Two other forms of spicules also occur in *Discodermia*:—one the flesh-spicule already alluded to, so minute that it has little or no chance of surviving the changes of fossilization, and, indeed, is found to have already disappeared in recent deciduous specimens of *Discodermia* before fossilization has set in; this consequently we do not and cannot expect to find in *Siphonia*; the other, not mentioned by any preceding writer, is a long, straight, or curved acerate spicule*, 0·072 long and 0·002 diam. (Pl. XXVI. figs. 6 & 6a), and tolerably abundant in my pieces of *Discodermia*, and a characteristic spicule of our *Siphonia* (p. 808, Pl. XXVI. figs. 5 & 5a).

From the preceding comparison it will be seen that the very closest resemblance exists between the recent *Discodermia* and the fossil *Siphonia*. Not only in fundamental structure, but also in general form, and in the arrangement of the canals and elements of the skeleton, the two are, in a broad sense, the same. Thus the two puzzles of the Cretaceous sponges are now cleared up, the Ventriculites survive in *Myliusia Grayi*†, and the *Siphonia* in *Discodermia polydiscus*.

* This spicule, Mr. Carter tells me, is equally common in the British-Museum specimen and in that from the Philippine Islands, also in the Lithistids *Theonella Swinhoei* and *Azorica Pfeifferæ*; it runs throughout the whole group of the Lithistina, and may, as Mr. Carter proposes, be conveniently termed the “beam spicule.” Bocage figures from *D. polydiscus* another large form of spicule (*l. c.* pl. xi. figs. 1d & 1e), which, however, differs from the beam spicule in being entirely superficial in position, and in having one end rounded off. Owing to its superficial position it would almost certainly be detached from the sponge before fossilization; and hence we cannot hope to find its representative in *Siphonia*.

† *Ann. & Mag. Nat. Hist.* ser. 4, vol. xix. p. 121, pl. ix. figs. 8–17.

The distribution of the Lithistid sponges is of interest as resembling and throwing light on that of the *Siphoniæ*: bathymetrically they range from 75 to 374 fathoms (*Carter*), or 152 to 270 (*Schmidt*); geographically they are found in the Atlantic, about the West Indies, Madeira, the Azores, and the coast of Portugal. The *Siphoniæ* similarly occur most abundantly in Greensand-beds, which were laid down not very far from the shore-line of the Cretaceous sea, and at not excessive depths from its surface. Here then is another link between the modern and the Cretaceous Atlantic. The specimen of *S. piriformis* described by Goldfuss, from the Jurassic, I must leave to Sir Wyville Thomson and his supporters.

Class SPONGIDA.

Order HOLORHAPHIDOTA.

Family PACHASTRELLIDÆ.

Group LITHISTINA.

Genus SIPHONIA.

Synonyms: *Caricoides*, Guettard; *Hallirhoa* et in parte *Jerea*, Lamx.; *Polypotheia*, pars, Benett; *Choanites*, Mantell.

Sponge. Consists of a head or body of variable shape supported on a longer or shorter stem, by which it is attached to some foreign body, or without a stem and anchored by a number of diverging rooting fibres which penetrate the silt in which it is imbedded.

Canals of two kinds, *excurrent* and *incurrent*, the former longitudinal, opening distally in oscules situated on the walls of a central cloaca, or upon a plane surface at the summit; the latter radiating, opening externally in pore-areas, and internally into the excurrent canals.

Skeleton siliceous; *spicules* (1) staple, quadrigonate with four diverging arms, all of which are smooth and round, bifurcating near their extremities, and terminating in a number of rounded apophyses with intervening concavities. Combined into a rigid network by the interlocking of their apophysial endings, and arranged in bands parallel to and chiefly about the radiating canals, the smooth arms lying concentrically, and their terminations forming a series of radiating bands of filigree. (2) Smooth acerate spicules, lying parallel with the series of staple spicules. (3) Flesh-spicules (?), (4) Dermal spicules (?), not found attached to the sponge, but occur in association in the Haldon Greensand.

Formation. Cretaceous and Jurassic.

Locality. England—Haldon, Blackdown, Wilts, Isle of Wight, Sussex, Yorkshire (?); Germany—Coesfeld, Quedlinburg, Borzen, Kutschlin; France—Cognac, Tours, Honfleur, Rouen, Havre, St. Aignan, Saumur; Russia—Bouchevoë (near Moscow).

Species. *S. pyriformis*, *costata*, *Websteri*, *Königii*, and *arbuscula*.

Note, October 1877.

It may not be out of place if I indicate here the kind of plan which I have set myself to follow in making a study of the fossil sponges. First, then, I wished to begin by publishing as exhaustive a description as I could of a number of single species of fossil sponges, each to illustrate a well-marked structural type, and having done this, to determine how far the various existing fossil species could be referred to these previously ascertained types.

The first part of my plan is now nearly accomplished; descriptions of *Stauronema*, *Pharetrospongia*, and *Siphonia* have appeared to illustrate the Vitreohexactinellidæ, Renieridæ, and Lithistidæ respectively; while we may expect to be furnished shortly with a good example of the Sarcotrichactinellidæ (*Acanthospongia*, *Hyalonema*) by other observers. The abundant material which has been placed at my disposal by the great kindness of Mr. Woodward at the British Museum, and by Mr. Moore of the Liverpool Free Museum, has now given me the opportunity of proceeding with the second part of my plan, *i.e.* with the classification of the various fossil species. Already I find that the Lithistidæ are well represented in the fossil state by very numerous species of great diversity in form and structure; Miss Benett's forms, for instance, more nearly related than I had previously imagined, belong all, or nearly all of them, to various Lithistid genera, some having affinities to *Discodermia*, some to *Macandrewia*, and others presenting us with a new generic type. No less abundant are the fossil Renieridæ, all the sponges with reticulate calcareous skeletons from Faringdon, such as *Manon macropora*, *Jerea mutabilis*, *Scyphia foraminosa*, and others, belonging to this group, or being closely allied to it. The Hexactinellidæ have already been dealt with in a very full and complete manner by Professor Zittel.

Hitherto the fossil sponges have furnished me with no type which does not find its close representative in existing seas. The existence of extinct calcareous sponges with reticulate skeletons finds no support from a study of either fossil or recent sponges; it is the merest myth; and the classification of D'Orbigny and his successors, based on an assumption, may now be regarded as finally and completely disposed of. I had the honour to receive a separate copy of Professor Zittel's Monograph on the fossil Hexactinellidæ on the day after this paper was read. Our independent observations agree in a manner no less remarkable than satisfactory, due doubtless to our having both followed the same modern methods of research. The points of difference between us are but few. Thus Professor Zittel speaks of the existence of fossil calcareous sponges with a reticulate fibrous skeleton; but I have reason to believe that since the publication of my paper on *Pharetrospongia* he has abandoned all belief in such forms, and thus made criticism on this matter needless. Professor Zittel also seems to consider that I regard the genus *Stromatopora* as belonging wholly to the Hexactinellidæ: this has at no time been my view; I regard the genus *Stromatopora* as a heterogeneous

mixture of very various forms, some of which belong to the Hydrozoa and are nearly allied to *Millepora* and *Hydractinia*, while some are true Hexactinellid sponges, as Mr. Carter himself now admits, and others finally fall into other groups, not yet determinable. All this, however, I hope soon to set forth in a paper devoted exclusively to this supposed genus.

In conclusion, I hope I may be allowed to congratulate Professor Zittel on what he has done by his valuable monographs to save palaeontologists from the reproach which the fossil sponges have for so long a time been to them.

A List of all described Species which have been rightly or wrongly assigned to the genus Siphonia.

Species.	Author.	Date.	Reference.		Page	Pl.	Fig.	Formation.	Locality and Remarks.
acaulis (1).....	Mich.	1840-7	Mich. Icon. Zooph.		139	38	2	Cretaceous	Cap le Hève. Doubtful <i>Siphonia</i> .
			D'Orb. Prodrome.		186			U. G. S.	Havre, Villers.
			Pictet, Traité.		544			"	
acaulis (2).....	Court.	1861	Court. Ep. foss. Saumur		15	25	3	Lower Chalk	Saumur.
acuta	"	"	"		15	22	2	"	"
agariciformis ..	Benett.	1831	Benett, Cat. Wilts foss.	(<i>Polypothecia</i>)	9	15	1, 2	U. G. S.	Wilts. True <i>Siphonia</i> .
ampullacea	Goldf.	1826	Goldf. Petref.		98	35	12	U. G. S.	Yorks.
anguilla.....	Lee.	1839	Lee, Mag. Nat. Hist.		12		5	Chalk	"
			Morris Catalogue		30			Upper Chalk	Saumur.
			Court. Ep. foss. Saumur		16	24	2	Lower "	Châteaueux, St. Aignan,
arborescens	Court.	1861	Mich. Icon. Zooph.	(<i>Jersea</i>)	136	42	2	Oret.	Tours. (Sussex, Berks, England.)
			"		139	33	2	"	Tours.
arbuscula	Mich.	1840-7	D'Orb. Prodrome		285			Lower Chalk	Saumur.
			Court. Ep. foss. Sau.		14		3 to 5	"	
			Fromentel, Introd.		30	1	10		
astroides	Römer.	1864	Römer, Falacont. xiii.	(<i>Polysiphonacea</i>)	28	10	6	Quader	Geröll, Ilsenburg.
biseriata	Reuss.	1845-6	Reuss, Verst. böhm. Kr. ii.		72	17	6	Conglomerate	Borzen, south foot of.
			" Geogn. Skizz. ii.		172				

A List of all described Species (continued).

Species.	Author.	Date.	Reference.		Page	Pl.	Fig.	Formation.	Locality and Remarks.
<i>brevicauda</i>	Mich.	1840-7	Mich. Icon. Zooph. D'Orb. Prodrome.	(<i>Hallirhoa</i>)	127 285	31	2	Lower Chalk	Tours.
<i>cervicornis</i>	Goldf.	1826	Goldf. Petref. Blainv. Man. d'Act. Morris, Catalogue. Reuss, Verst. böhm. K. ii. Römer, Verst. N. Kr. Römer, Palaeont. xiii. Court. l. c.		{ 18 98 536	6 35	11 11	Chalk Marl	Westphalia.
<i>caespitosa</i>	Court.	1861	"	(<i>Jerea</i>)	73			Low. Pläner Pyropensunde	England (?). Schillinge, near Bilin.
<i>ciconiformis</i>	"		"		5			Low. Chk. Ml.	Tržibetitz.
<i>clava</i>	Leo.	1839	" Mag. Nat. Hist. Morris, Catalogue.		34 16 15 12	23 21	2 4	Lower Chalk	Lenford, Coesfeld. Haldon. Saumur. (<i>Jerea</i> id., Mich.)
<i>clavata</i>	Court.	1861	"	(<i>Polypothecia</i>)	15	22	1	Upper Chalk	" Yorks.
<i>complexa</i>	Benett.	1831	Benett, Cat. Wilts. foss. Court. l. c.		9	6	1	Lower Chalk	" Saumur.
<i>compressa</i>	Court.	1861	"		14	20	1	U. G. S.	Wilts.
<i>conica</i>	"	"	"		{ 20 21	{ 3 1	{ 6 2	Lower Chalk	Saumur.
<i>coronata</i>	"	"	"		17	27	1	"	"
<i>costata</i>	Lamx.	1821	Lamx. Exp. Méth. Polyp.	(<i>Hallirhoa</i>)	72	78	1	"	"
			Benett, Cat. Wilts. foss.	(<i>Polypothecia</i>)	9	2 to 5	{ 1 to 3 1 to 2 1 to 2 1 to 3	Marne bleue	Vaches-noires.
			Bronn, Leth. Geogn. Th. v. D'Orb. Prodrome, ii.		74	27	19	U. G. S.	Wilts. This is Benett's <i>P. bi-</i> <i>to septem-loba.</i>
			Mich. Icon. Zooph. Morris, Catalogue. Pictet, Traité.	(<i>Hallirhoa</i>)	127 30 544	31	3	Cret. U. G. S.	This figure represents Mich.'s <i>H. brevicostata</i> . Villers, Honfleur, Réna- lard, Havre. D'Orb. in- cludes <i>H. Jessonis</i> , Mich., with this. Vaches-noires, Réna- lard. Warminster, Wilts.

AFFINITIES OF THE GENUS SIPHONIA.

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curta	Court.	1861	Court. <i>l. c.</i>	14	18	2	Lower Chalk	Saumur.
cylindrica (1) ...	Römer.	1840-1	Römer, Verst. N. Kr.	5	2	1	Chalk Marl, Planer	Steckelnburg, near Quedlinburg. Römer, Palæ. xiii. p. 49, refers this to the genus <i>Stellispongia</i> . Saumur. This appears to be a variety of <i>S. piriformis</i> .
" (2) ...	Court.	1861	Court. <i>l. c.</i>	14	18	1	Lower Chalk	
" (3) ...	Eichw.	1866	Eichwald, Lethæa Rossica, i.	329	22	12	Calcaire à Orthoceratites	Zarskoje, near St. Petersburg. Questionable whether this is a sponge at all.
decipiens	Court.	1861	Court. <i>l. c.</i>	13	16	1, 2	Lower Chalk	Saumur.
dichotoma	D'Orb.		D'Orb. Prodrome.	285	17	1 to 4	Lower Chalk	Tours. Non <i>P. dichotoma</i> , Benett.
difformis	Court.	1861	Mich. <i>l. c.</i>	142	28	5	Cret.	Tours.
elongata (1)	Reuss.	1845-6	Reuss, Böhm. Kr. ii.	16	22	5, 6	Lower Chalk	Saumur.
				72	43	1	Up. Pläner	Kutschlin, Hundorf, Radowissitz. This appears to be a true Lithistid, with the same difference between the spicules of the body and the stem which exists in <i>Siphonia</i> .
			Geogn. Skizz. ii.	171			Lower Chalk	Quedlinburg.
			D'Orb. <i>l. c.</i>	285			Lower Chalk	Hondfleur, Ste. Méneould, Monblainville.
			Mich. <i>l. c.</i>	134	34	4	Cretaceous	
			Römer, Palæ. xiii.	34			Quader	Ilme, near Hanover. Identifies this with <i>Spongia radiciiformis</i> , Phil. i. 9.
elongata (2)	Court.	1861	Court. <i>l. c.</i>	14	18	4	Lower Chalk	Saumur. A variety of <i>S. arbuscula</i> (Mich.).
emarginata	"	"	Pomel, Pal. d. P. d'Oran Court. <i>l. c.</i>	124	18	3	"	Saumur.
			Court. <i>l. c.</i>	14	18		"	"

A List of all described Species (continued).

Species.	Author.	Date.	Reference.		Pages.	Pl.	Fig.	Formation.	Locality and Remarks.
excavata	Goldf.	1826	Goldf. <i>l. c.</i>		17	6	8	?	?
			Blain. <i>l. c.</i>		536				
			Br. Leth. Geogn. Th. v. Th. ii.		75	27	21	Cretaceous: Firestone.	Maestricht.
			Eichw. <i>l. c.</i>		155			Orthoceratite limestone.	Zarskoje, Poulkowa, &c.
expansa	Benett.	1831	Milne-Edwards, in Lamk. vol. ii.		331				
			Mich. <i>l. c.</i>	(<i>Jera</i>)	614				
			Mich. <i>l. c.</i>	(<i>Polypothecia</i>)	135	33	3	} Cretaceous	{ Includes both <i>S. excavata</i> and <i>premorsa</i> , Goldf., in this species.
			Benett. <i>l. c.</i>		39	2	2		
ficus	Goldf.	1826	Goldf. <i>l. c.</i>		9	6		U. G. S.	Wills.
			Bronn. <i>l. c.</i> Th. v.		221	65	14	Quader	Quedlinburg.
			D'Orb. <i>l. c.</i>		72			Planer	Germany.
					186			U. G. S.	Blackdown and Quedlinburg. Includes <i>S. pyriformis</i> of Sowerby, not of Goldfuss.
ficioidea	Mich.	1840-7	Fromentel, Mén. Soc. Lin. Norm. vol. xi.	(<i>Siphonocleus</i>)	20	1	12 & 12a		" <i>Ficus</i> vel <i>pyriformis</i> (Sow.)".
			Pictet, <i>l. c.</i> , vol. ii.		544				
			Pomel, <i>l. c.</i>		124			Up. Chk. Ml. Planer	Sudnerberg, near Goslar. Near Quedlinburg.
			Roemer, Nordd. Kreid.		4				
Fittoni	Mich.	1840-7	Palae. xiii.		27	29	5	Cretaceous	Poitiers.
			Mich. <i>l. c.</i>		139			Lower Chalk	Cognac, Loudun. Syn.
			D'Orb. <i>l. c.</i>		285	29	6	Cretaceous	given by Mich. <i>S. ficus</i> , Gdf. pl. lxx. fig. 14. <i>S. pyriformis</i> , Sow.
			Mich. <i>l. c.</i>		140				Samur.
			Court. <i>l. c.</i>		15	21	3	Lower Chalk	Non <i>S. pyriformis</i> , Sow., nec <i>S. ficus</i> , Goldf.
			D'Orb. <i>l. c.</i>		285				

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<i>globosa</i>	Court.	1861	Court. <i>l. c.</i>	(<i>Manon pyri-</i> <i>forme</i>) (<i>Jerea</i>)	15 16 16 4	21 22 23	6 4 1	Lower Chalk " L. Chk. Ml.	Saumur. " Near Coesfeld, Syn. <i>Manon pyriforme</i> , Gdf.	(<i>Jerea</i> id., Mich.). "
<i>gracilis</i>	"	"	" <i>l. c.</i>					"		
<i>gregaria</i>	"	"	Römer, Nordd. Kreid.					L. Chk. Ml.	Coesfeld.	
<i>Goldfussii</i>	Roemer.	1840-1	Goldf. <i>l. c.</i>		220	65	10	Cretaceous	Coesfeld.	
			Römer, Palæ. xiii.		33			Chalk Quader	Coesfeld. Schwiechelt.	
<i>hastata</i>	Court.	1861	Court. <i>l. c.</i>		16	25	2	Lower Chalk	Saumur.	
<i>heterostoma</i>	Reuss.	1845-6	Reuss, Böhm, Kreid. ii.		72	17 4 to 5		Hornstein congl. and chalk marl.	S. Borzen, S. Hradist, Schellinge, near Bilin. A hexactinellid. Reuss states that it much re- sembles <i>Petopora crassa</i> , Mich.	
<i>hybrida</i>	Court.	1861	Court. <i>l. c.</i>		17	27	1	Lower Chalk	Saumur.	
<i>incrassata</i>	Goldf.	1826	Goldf. <i>l. c.</i>		17	34	5	U. G. S.	Coesfeld, <i>Caryocides aplati</i> of Guettard, Mém. Acad. iii. pl. i. fig. 3.	Westphalia.
			Blainv. <i>l. c.</i>		536			Lower Chalk	Includes in his " <i>S. lyco-</i> <i>perditæ</i> ."	
			D'Orb. <i>l. c.</i>		285			Cretaceous	Nogent le Rotrou, Tours, Rémalard, Coulonges.	
			Mich. <i>l. c.</i>		138	40	1	White Chalk	Coesfeld.	
			Pictet, <i>l. c.</i>		544			Chalk		
			Pomel, <i>l. c.</i>	(<i>Jerea</i>)	124			Lower Chalk	This is Michelin's <i>Seyphia terebrata</i> , not Phillips's <i>Spongia</i> id.	
<i>inequalis</i>	Pomel.	1872	Römer, Palæ. xiii.		32				Thinks may be identical with C. Königii, Mant.	
<i>infundibulum</i>	D'Orb.	1847	Pomel, <i>l. c.</i>		124					
			D'Orb. <i>l. c.</i>		285					
			Mich. <i>l. c.</i>	(<i>Seyphia tere-</i> <i>brata</i>)	141	29	4			
<i>intermedia</i>	Court.	1861	Court. <i>l. c.</i>		14	19	1, 2	Lower Chalk	Saumur.	

A List of all described Species (continued).

Species.	Author.	Date.	Reference.		Page	Pl.	Fig.	Formation.	Locality and Remarks.
Königii	Mantell.	1822	Mantell, Foss. South Downs Bronn. l. c.	(<i>Choanites</i>)	178 69	16 34	19-21 11	Upper Chalk	Lewes race-course (Sussex). Isenburgh. Gives as syn. <i>S. Konigii</i> , D'Orb., <i>S. terebrata</i> , Phill., <i>Sey. terebrata</i> , Mich., <i>Cn. pertusum</i> , Res., <i>Sey. heteromorpha</i> , Gein. Includes <i>Spongia terebrata</i> , Phill., and <i>Scyphia (Chenidium) pertusum</i> , Rss.
			D'Orb. l. c.		285			Lower Chalk	
			Mantell, Medals. Pictet, l. c. Römer, Nordd. Kreid. Römer, Palae. xiii.		234 544 8 27	75		Low. Chk. Ml.	Isenburgh. Bilin (Bohemia). Includes <i>Cn. pertusum</i> , Rss.
lagenaria	Mich.	1840-7	Mich. l. c.	{	114 250	26	4	Oolite Forest Marb. Bathonian	Caen.
lobata	Bennet.	1831	Fromentel, l. c. Bennet, l. c.	(<i>Discaudea</i>) (<i>Polypothecia</i>)	28 92 to 5		nume- rous		Luc. Ranville. Wills. This is <i>S. costata</i> .
lycoperdites	D'Orb.	1847	Mantell, Medals. D'Orb. l. c.	(<i>Siphonia</i>)	231 285	73	4	Lower Chalk	Tours, Havre, Nogent le Rotrou, etc. <i>Alcyonium</i> id., Deir., <i>S. pliciformis</i> and <i>incrassata</i> , Goldf., <i>S. pyriformis</i> , Mich.
lycoperdoides ...	Mich.	1840-7	Pictet, l. c. Mich. l. c. Lamx. l. c.	(<i>Hallirhoa</i>)	544 251 72	58 78	6 2	Forest Marb.	Ranville, &c. (Calvados).
minima	Court.	1861	Court. l. c.		15	21	7	Lower Chalk	Saumur.
Morrisiana	Mant.	1853	Mantell, Medals.		254	69	3	Upper Chalk	I. Wight and Brighton.

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Morrisi	Morris, <i>l. c.</i>	30	Upper Chalk	I. Wight, Brighton. Alters the name of "Morrisii," preceding to "Morrisii."
multiformis	Bronn. 1851-2 D'Orb. <i>l. c.</i> Mich. <i>l. c.</i>	73 285 133	20 4 4	"Glauconie" Lower Chalk Cret. Lower Chalk Near Peine. Vouziers.
multioculata ..	Römer, Nordd. Kreid. " Palæ. xiii. Mich. <i>l. c.</i>	5 33 138	6 33	Quader Cret. Tours. States that the species is still living!
nuciformis.....	Mich. " "	140	4	Honfleur, Tours.
ocellata	Römer. 1840-1	5	2	Iserburg. This is <i>Jerea clon-gata</i> , Mich., 134, 39, 4.
oligostoma	" Palæ. xiii. " Nordd. Kreid. " Palæ. xiii.	33 5	3	Ilsenburg.
ovalis	Court. 1861	33	5	Ilsenburg.
osculata.....	" Court. 1861	15	5	Saumur.
ornata	" Römer. 1864	13 17 27	5 5 5	" Sudmerberg.
parasitica	Court. 1861	13	8	Saumur.
pirum	Eichw. 1866	100	6	Morglakowo, nr. Kowask.
pistillum	Gödf. 1826	17	10	Courtagnon. Rethel, Vaches - noires, Courtagnon, Nögent-le-Rotrou, Coulouge, &c. Saumur.
polycephala	Court. 1861	15 17	3 9	Lower Chalk ?
preonorsa	Gödf. 1826	134 286 331	21	Orthoceratite Limestone
	Mich. <i>l. c.</i>	135	3	Zarskoje, Poulkowa, &c.
	Milne-Edw. in Lamk. ii. 1826	614	2	"

A List of all described Species (continued).

Species.	Author.	Date.	Reference.		Page	Pl.	Fig.	Formation.	Locality and Remarks.
præmorsa	Goldf.		Römer, F., Bronn's Jahr. 1848.	(<i>Astylospongia</i>)	684	1	1		
			Römer, F., Sil. fauna d. westl. F. ennesee.		8	2	6		
			Römer, F., Foss. fauna Sil. Dil.		10	26	1 to 4	Lower Chalk	Saumur.
prolifera	Court.	1861	Court. l. c.		17	25	4	"	"
pyramidalis	"		Goldf. l. c.		16	6	7	Cretaceous	Chaumont.
pyriformis	Goldf.	1826	"	(<i>Polypothecia</i>)	97	35	10	Jurassic	Streitberg.
			Bentt, l. c.		8	1	3	U. G. S.	Wils.
			Blainville, l. c.		536	14	6, 7	Lower Chalk	Saumur.
			Court. l. c.		14	18		Lower Chalk	Includes this species in his <i>S. lycoperdites</i> .
			D'Orb. l. c. (<i>piriformis</i>)		285				
			Mantell, Medals.		230	73	1 to 4	U. G. S.	Rouen, Havre, Tours, &c.
			Mich. l. c.		137	33	1	Cret.	Identifies Sowerby's with Goldfuss's <i>S. pyriformis</i> .
			Morris, l. c.	(<i>Chœanites</i>)	30			U. G. S.	Eure. This is a small <i>S.</i> <i>Königii</i> . Reuss, how- ever, adopts it as a dif- ferent species; he finds it in the Upper Planer
			Passy, l. c.					Upper Chalk	Kalk, Kutschlin (<i>loc.</i> <i>cit.</i>).
			Pictet.		544				Adopts D'Orbigny's <i>S. ly-</i> <i>coperdites</i> .
			Reuss, Böhm. Kreid. vol. i.		72			Up. Chalk. Ml.	Kutschlin.
			Römer, Palæ. xiii.	(<i>Polypterea</i>)	35			Quader	Kölherholz, nr. Ilson- burg.
			Sow. Trans. G. S. iv. ser. 2.		340	xva	1 to 9	U. G. S.	Blackdown.

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		1830-7	Fischer, Oryct. Mosc. Eichw. <i>l. c.</i> vol. ii.		178	48	3, 4	Upper Chalk Oret.	Bouchevoyé (Moscow). " " Ihme, nr. Hanover. Tours. Saumur. " " Mongelakowo, nr. Kowask. Saumur. Wilts.
<i>radiata</i>	Fischer.	1864-6	Römer. <i>l. c.</i> vol. ii.	(<i>Jeræa</i>)	102	28	6	"	"
<i>radiciformis</i>	Römer.	1840-7	Römer, Palæ. xiii.		33	24	1	Lower Chalk	"
<i>ramosa</i>	Mich.		Mich. <i>l. c.</i>		141	20	2	"	"
<i>varicosulata</i>	Court.	1861	Court. <i>l. c.</i>		16	6	7	Neocomian	"
<i>rivuligera</i>	Eichw.	1866	"		101	17	6	Lower Chalk	"
<i>sphærica</i>	Court.	1861	Court. <i>l. c.</i>	(<i>Polypothecia</i>)	13	9	2	U. G. S.	Saumur.
<i>sphaerocephalus</i>	Benett.	1831	Benett, <i>l. c.</i>	(<i>Choanites</i>)	9	16	1 to 4		Wilts.
<i>subrotundus</i>	"	"	"						
<i>ternata</i>	Reuss.	1845-6	Böhm. Kreid. ii.	(<i>Cnemidium</i>)	72	17	1 to 3	Lowest	Borzen, near Bilin; Tri- pelberg, nr. Kutschin.
<i>Tessonis</i>	Mich.	1840-7	Geogn. Skizz. ii. Römer, Palæ. xiii. Mich. <i>l. c.</i>	(<i>Tremospongia</i>)	298 40 128	34	1	Chalk Cret.	Bilin and Queßlinburg. Vaches-noires, Villers-sur- Mer.
<i>triloba</i>	Court.	1861	D'Orb. <i>l. c.</i>		186			U. G. S.	Includes in <i>Siphonia cos- tata</i> .
<i>tuberosa</i>	D'Orb.	1847	Court. <i>l. c.</i> D'Orb. <i>l. c.</i>		16 285	25	1	Lower Chalk "	Saumur. This is <i>Sey. tube- rosa</i> (Römer), a true Hexactinellid.
<i>typum</i>	Blainv.	1834	Römer, Palæ. xiii.		27				Goslar. Accepts here D'Orbigny's assignment of this species.
<i>undulata</i>	Benett.	1831	Blainv. <i>l. c.</i>		536	95	1	Living	Mediterranean (Sicily). This is a Renierid sponge.
<i>Websteri</i>	Sow.	1836	Benett, <i>l. c.</i> Sowerby.		9	7	1	U. G. S.	Wilts.
								U. G. S.	I. Wight.

EXPLANATION OF THE PLATES.

PLATE XXV.

- Fig. 1. Specimen of *S. pyriformis*, Sow., v. *S. ficus*, D'Orb., v. *S. conica*, Court., from the Haldon Greensand, lateral view. 1 a. Its apex, seen from above, showing the opening of its cloacal tube, and its exposed excurrent canals. 1 b. A longitudinal section of the same specimen, showing (a) its cloacal tube, (e) excurrent canals, and (i) incurrent canals. (All natural size.)
- Fig. 2. Specimen of *S. costata*, Lamx., from the Wiltshire Greensand. 2 a. Longitudinal section of the same specimen. (Nat. size.)
- Fig. 3. A young form of *S. pyriformis*, Sow. 3 a. Its apical end seen from above. (Nat. size.)
- Fig. 4. Specimen of *S. pyriformis*, Sow., var., *S. cylindrica*, Court.; lateral view. 4 a. Its summit as seen from above, showing cloacal aperture and exposed excurrent canals. (Nat. size.)
- Fig. 5. Part of a band of skeletal network of *S. Websteri*, Sow., from the longitudinal section fig. 7 a. ($\times 60$.)
- Fig. 6. Specimen of *S. pyriformis*, var. *Fittoni*, Mich., lateral view. (Nat. size.)
- Fig. 7. Specimen of *S. Websteri*, Sow., from the Gault of Folkestone. Lateral view. 7 a. Its longitudinal section. 7 b. A transverse section of the same species, but from another specimen. (Nat. size.)
- Fig. 8. Specimen of *S. pyriformis*, Sow., with divided summit. (Nat. size.)

PLATE XXVI.

- Fig. 1. Part of a band of skeletal network lying between two of the excurrent canals of the specimen of *S. Websteri*, shown in pl. i. fig. 7, as seen in its transverse section, fig. 7 b. a. Section of the shaft of one of its component quadriradiate spicules. b. Sections of shafts. c. Three arms of a quadriradiate spicule, separated from the shaft by the plane of the section. ($\times 60$.)
- Fig. 2. Single skeleton-spicule from the recent Lithistid sponge *Discodermia polydiscus*, Bocage. ($\times 60$.)
- Fig. 3. Union of the two spicular rays by the interlocking of their tubercular extremities, taken from the skeleton of *D. polydiscus*. ($\times 60$.)
- Fig. 4. A small part of the skeletal network of *S. pyriformis*, Sow., as exhibited on its surface by reflected light. ($\times 60$.)
- Figs. 5 and 5 a. "Beam" spicules from *Siphonia Websteri*, Sow. ($\times 60$.)
- Figs. 6 and 6 a. "Beam" spicules from the recent *Discodermia polydiscus*, Bocage. ($\times 60$.)
- Fig. 7. Skeletal network of the stem of the *Siphonia*, as exposed on the surface of the specimen shown in Pl. XXV. fig. 3. ($\times 60$.)
- Fig. 8. Specimen of the recent Lithistid sponge *Discodermia polydiscus*, Bocage, preserved in the British Museum. o. The oscules opening into the interior of the cup; internal view. 8 a. External aspect of the same specimen. (Nat. size.)
- [Figs. 8 and 8 a are from sketches furnished me by Mr. Carter.]
- Fig. 9. One of the "dermal" spicules of the preceding, seen in place, exhibiting the characteristic central triradiate canal. 9 a. Profile view of the preceding. ($\times 60$.)
- Fig. 10. Dermal spicule from the spicule-bed of the Haldon Greensand. ($\times 75$.) (After Carter, "Fossil Sponge-spicules of the Greensand compared with those of existing Species," Ann. & Mag. Nat. Hist. ser. 4, vol. vii. pl. vii. fig. 5.)
- Fig. 11. Dermal spicule from the network of *Siphonia costata*, Lamx. ($\times 60$.)

DISCUSSION.

Mr. CHARLESWORTH remarked that, if the consolidation of genera proposed by Mr. Sollas were satisfactorily established, it must be re-

garded as a great boon to palæontologists; but at the same time he thought there was some difficulty in ascertaining the structure, and in recognizing *Siphonia* by their structural characters. He inquired of the author what he regarded as the distinguishing characters of the genus *Siphonia*. He referred to the sponges of the chalk of Yorkshire, which he found to be siliceous by treating them with acid.

Mr. HULKE inquired of the author what was the nature of the triradiate cavity seen in the spicules with botryoidal branches.

Prof. JUDD referred to the discovery of Radiolarians in Carboniferous rocks near Chester, and stated that, on dissolving portions of the rock which clearly show the Radiolarian structure, the latter entirely disappears, but at the same time the rock itself furnishes small crystals of quartz. This seemed to be confirmatory of Mr. Sollas's statements.

Prof. TENNANT stated that the late Dr. Bowerbank's collection of fossil Sponges, including many microscopical sections, is now in the British Museum, and that a fine series of Greensand fossils, containing many Sponges, collected by the late Mr. Bensted, is in the Museum at Maidstone.

The PRESIDENT asked the author whether he knew of any other cases of replacement of silica by calcareous matter. He suggested that the supposed Radiolaria of the Carboniferous rocks of Cheshire might possibly belong to somewhat Radiolarian types in which the solid parts were calcareous instead of siliceous. So far as he knew, there were no instances of the replacement of silica by carbonate of lime in the Radiolaria of the Barbadoes earth.

The AUTHOR, in reply, said that the Yorkshire sponges mentioned by Mr. Charlesworth are often siliceous externally and calcareous within. The invention of their treatment with acid was rather an unfortunate one, as this treatment often removes delicate surface spicules, and thus modifies the external characters. The form of spicules which he had described as possessing three botryoidal arms were peculiar to the recent sponge *Discodermia* and to *Siphonia*, and would suffice to distinguish the genus. The triradiate cavity shown in the head of these spicules represents a triradiate canal. He stated that he had seen Radiolarian forms from the Carboniferous deposits of Scotland among the spicules which had been detected by Prof. Young. In *Stromatopora*, which he held to have been originally siliceous, the silica was converted into carbonate of lime, and similar crystals of silica to those already referred to were found here. The silica of the organism and that of quartz were in very different conditions as regards solubility; and the former contains organic matter. He thought that when remains were found presenting precisely the characters of living organisms we were bound palæontologically to regard them as of the same nature; and after referring to various instances cited, he said he thought the case of the substitution of siliceous by calcareous matter might be regarded as fully established.