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THE BRITISH STROMATOPOROIDS.

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A MONOGRAPH

OF THE

BRITISH STROMATOPOROIDS.

BY

H. ALLEYNE NICHOLSON, M.D., D.Sc., Ph.D., F.G.S.,
REGIUS PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF ABERDEEN.

LONDON:
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.
1886—1892.

PRINTED BY
ADLARD AND SON, BARTHOLOMEW CLOSE.

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PART I.—GENERAL INTRODUCTION.

Pages i—iii, 1—130. Plates I—XI.

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INTRODUCTORY REMARKS.

It may be doubted if there be any small group of fossil organisms which has given greater trouble to its investigators than that of the Stromatoporoids. Their study is, in fact, attended with quite peculiar and special difficulties, as will become abundantly evident in the course of the following Monograph. For my own part, I am very willing to admit that I have been led, by a prolonged and minute study of a very extensive series of these organisms, to modify or abandon various views which my earlier researches had induced me to accept as more or less probable. Nor, of course, do I claim anything approaching to finality for the present work, though I may be allowed to hope that the results herein set forth may afford a satisfactory basis for further and more extended inquiries.

Much of the difficulty attending the investigation of this group of fossils arises from the fact that so many specimens, though seemingly unaltered, have in reality been so far affected by mineralisation as to exhibit structural features which are only capable of proper interpretation in the light of the facts shown by other comparatively unaltered examples, or which, in the absence of such examples, become positively misleading. It sometimes happens, indeed, that almost all the specimens from some particular region are thus structurally affected by mineralisation, and that their study can only be satisfactorily carried out by means of examples obtained from the corresponding formation of some other region. Thus, I think it may fairly be asserted that the investigation of the Stromatoporoids of the Devonian Limestones of Devonshire, most of which are extensively altered by crystallisation or distorted by pressure, would prove an exceedingly difficult or well-nigh impossible task, except by the aid afforded by comparison with the similar but less altered forms which occur in the Devonian Rocks of Germany. Moreover, in the determination of these, perhaps to a greater extent than is the case with any other group of fossils, progress is absolutely impossible except by an unstinted application of the modern methods of microscopical inquiry—methods which involve considerable labour, and to which all observers are not equally willing or able to have recourse.

For the above-mentioned reasons, amongst others, it has come to pass that the Stromatoporoids have been, to a large extent and until comparatively recently, one of the *opprobria* of palæontology. It is true that excellent work has been done in reducing this chaotic group to something like order by von Rosen, Roemer, Steinmann, Bargatzky, Carter, and others, but most of this work has been necessarily fragmentary. That, in any case, much yet remains to be done is sufficiently evidenced by the fact that there are hardly any *species* of Stromatoporoids which are at this moment so clearly defined by illustration and description that their claims to specific distinctness would be at once and unhesitatingly admitted by palæontologists. Indeed, there are not wanting those who hold that, in spite of all apparent differences, the great majority of the described types of Stromatoporoids may be perhaps only variations of one or two forms, and therefore not entitled to specific distinction at all.

My own researches have led me to think that when sufficient material is available the distinctions between the different genera and species of the Stromatoporoids are just as well marked and just as readily recognisable as they are in the case of any other group of fossils in which the method of investigation by means of thin sections is likewise absolutely indispensable.

The present Monograph is based mainly upon my own collection of Stromatoporoids, embracing a very large series of examples which I have obtained from the Silurian and Devonian Rocks of Britain, as well as a series from the corresponding formations of North America, and a very extensive series from the Devonian strata of Germany. I have likewise recently visited Esthonia, and have made large collections of Stromatoporoids from the Silurian Rocks of that interesting region. I may also be permitted to add that in carrying out this investigation, as far as it has already gone, I have had occasion to personally prepare considerably over one thousand thin sections of Stromatoporoids, the labour involved in this being one which will be appreciated by all who have engaged in similar work.

Though my own collection has supplied most of the material with which I have worked, I am nevertheless very deeply indebted to many of my fellow-workers for the most cordial aid in the way of specimens or otherwise. I would more particularly express my gratitude to Mr. Champernowne, not only for the most generous assistance in the way of specimens from the Devonian Rocks of Devonshire, but also for much most valuable and suggestive advice. I owe a similar debt of gratitude to my friend, Dr. George J. Hinde. I am also under the greatest obligations to Mr. William Madeley and Mr. J. F. Whiteaves, both of whom have supplied me with material which would have been otherwise inaccessible to me, and the want of which would have rendered this work seriously imperfect. I have likewise received the most ungrudging help from Professor Schlüter, Dr. August Bargatzky—whose recent death will be deplored by all interested in the Stromatoporoids, Professor Ferd. Roemer, Monsieur E. Dupont, Professor J. W. Spencer,

Dr. Fr. Maurer, Mrs. Robert Gray, and Mr. R. Etheridge, junr. To Professor Schlüter, in particular, my best thanks are due for the help which he so freely accorded to me in studying the original types of Goldfuss and Bargatzky, and in collecting Stromatoporoids from the Devonian deposits of Germany. I am, further, deeply indebted to the kindness of my friend, Magister Friedrich Schmidt, who conducted me over the Silurian districts of Esthonia and Oesel, which his own researches have rendered classical ground, and who assisted me in examining in the University of Dorpat the originals of the Stromatoporoids described by Baron von Rosen in his well-known treatise on this group of organisms.

With regard to the general plan of the Monograph, it is sufficient to say that the first portion will be devoted to a general survey of the entire group of the Stromatoporoids, as far as such a survey seems to be at present possible; while the second and concluding portions will deal solely with the descriptions of the British species. I may add that I have made no attempt to deal in any way with any but the Palæozoic forms of the Stromatoporoids. There are certain Mesozoic and Kainozoic fossils which will, in all probability, ultimately find a place in this group, but no sufficient material has been available to me for the investigation of these.

The plates and wood engravings of this, the first instalment of the work, have been drawn from the specimens and slides by myself; and I take this opportunity of expressing my sense of the accuracy and beauty of Mr. Hollick's reproductions of my drawings upon the stone. In preparing the figures illustrative of microscopic structure, I have been in many cases greatly assisted by an excellent series of micro-photographs; and I am much indebted to Mr. George Gellie, of Aberdeen, for the care and intelligence with which these have been executed by him.

A MONOGRAPH

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BRITISH STROMATOPOROIDS.

I. HISTORICAL INTRODUCTION.

The singular extinct organisms of which the genus *Stromatopora*, Goldfuss, is the central type, and which we may conveniently speak of by the general name of the "Stromatoporoids," constitute a great group of fossil Invertebrates, which are specially characteristic of the Ordovician, Silurian, and Devonian formations, if not absolutely confined to strata belonging to these periods. Possessing a calcareous skeleton, and often attaining to very considerable dimensions, they enter very extensively into the formation of many of the older Palæozoic limestones. Abundant as they are in the Silurian and Devonian deposits of various regions, the investigation of their structure is attended with peculiar difficulties; and it is not therefore surprising to find that the most diverse views have been entertained as to their nature and zoological relationships. The groups to one or other of which they have been most commonly referred are the Sponges, the *Foraminifera*, the Corals, and the *Hydrozoa*. The results, however, of the most recent investigations, render it hardly a matter of doubt that they are truly referable to the *Hydrozoa*, and that they are more or less closely related to the Hydrocorallines on the one hand, and to the *Hydractiniidæ* on the other. The general progress of scientific research as regards the Stromatoporoids will, however, be best gathered from the following brief historical summary:

The genus *Stromatopora* was originally founded by Goldfuss ('Petrefacta Germaniæ,' Bd. i, p. 21, 1826), and was defined by him as including hemispherical Corals, with a calcareous skeleton composed of alternating dense and porous layers. He originally assigned to the genus a place between the Millepores and the Madrepores, but in a later portion of his great work he expressed the opinion that the genus could not properly be referred to the true Corals. The first species described by Goldfuss under the head of *Stromatopora*—and the species therefore which constitutes the type of the genus—is *S. concentrica*, a name which has obtained universal currency, and which has been employed by palæontologists for a large number of different Stromatoporoids from various parts of the Silurian and Devonian formations. As *S. concentrica* is the type of the genus *Stromatopora*, it becomes a matter of the greatest importance to ascertain precisely its characters and its minute structure, and with this end in view I have made a careful examination of the original specimens of this, and of the other species of Stromatoporoids described by Goldfuss, all of which are preserved in the Museum of the University of Bonn. My friend, Prof. Schlüter, has also had the kindness to have prepared for me thin sections of the original specimen of *S. concentrica*, Goldf., and of some others of the Goldfussian types, such sections not having been previously in existence. It may be as well therefore that I should indicate here the general results that I have arrived at as to the characters and structure of the different forms of the Stromatoporoids which Goldfuss has described and figured in the 'Petrefacta.'

(1) *Stromatopora concentrica*, Goldf.—The type-specimen of this form, as figured by Goldfuss ('Petref. Germ.,' Taf. vi, fig. 5), is preserved in the Bonn Museum, and has the form of a large mass, composed of numerous thick concentric strata, separated by narrow interspaces which are more or less largely filled with oxide of iron. The concentric strata ("latilaminæ") are from $1\frac{1}{2}$ to 3 mm. in thickness, and are more or less undulated. The general texture of the fossil is so dense that no clear idea can be obtained as to the minute structure of the skeleton by the use of a hand-lens. Besides the figured specimen, the Bonn Museum possesses another example of *S. concentrica* of precisely the same general aspect, the two having very probably originally formed part of one fossil.[1] A microscopic examination of thin sections of *S. concentrica*, Goldf., shows that the skeleton is essentially a complex network of anastomosing calcareous fibres, so disposed as to enclose correspondingly complex anastomosing canals. In the main, two sets of fibres may be distinguished, though the two are so united as to form a continuous reticulation. The fibres of one series are vertical, and each of the successive concentric strata ("latilaminæ") of which the skeleton is composed is traversed by such fibres running continuously from the under to the upper surface. The fibres of the other series are tangential to the surface, or at right angles to the vertical fibres, and are very irregular. There are, also, two corresponding series

[1] I may mention that at one locality near Gerolstein, in the Eifel, I have collected a number of specimens which in general characters, and in their mode of preservation, are absolutely undistinguishable from the above-mentioned originals of Goldfuss, and I have little doubt that Goldfuss collected his specimens from the same locality.

of canals. Thus each concentric stratum, or "latilamina," is traversed by irregular vertical canals, which are sometimes crossed by delicate cross-partitions or "tabulæ," and there are also numerous irregular and tortuous horizontal channels by which the vertical tubes are placed in communication with one another.

Though the skeletal elements are thus theoretically divisible into two series, the two are really fused with one another into a continuous reticulation. The general tissue of the skeleton is, therefore, exceedingly similar to that of the recent genus *Millepora*, Lam., the principal difference between the skeleton of *Stromatopora concentrica*, Goldf., and that of *Millepora*, being that the zoöidal tubes of the former are not divisible, as they are in the latter, into a series of large "gastropores" and a series of smaller "dactylopores."

I shall more fully describe and figure the minute structure of the skeleton in *S. concentrica*, Goldf., at a later period. It will be evident from the above, however, that the genus *Stromatopora*, Goldf., as typified by the first-described species, viz. *S. concentrica*, Goldf., comprises fossils of an entirely different structure to those which palæontologists have hitherto usually included under this generic name. I shall be able to show that *S. concentrica*, Goldf., is really only one of a very extensive series of forms, abounding in the Silurian and Devonian Rocks, and constituting a well-marked group, for which the name of *Stromatoporidæ* may be employed.

On the other hand, the various fossils which have been placed by palæontologists generally under the head of *Stromatopora*—when this name has been used in a restricted sense—are really of a very different structure, and must be placed under new generic titles. The most characteristic of these, namely the forms understood formerly by Bargatzky, Carter, and others who have specially investigated the subject, as *Stromatoporæ*, may be included under the new genus *Actinostroma*, which will form the type of the group of the *Actinostromidæ*. It follows, further, that whenever in the present work *Stromatopora concentrica*, Goldf., is mentioned, the type understood under this name is the original of Goldfuss, as above described, and is therefore neither generically referable to what has been previously understood as *Stromatopora*, nor specifically identical with the forms which have usually been regarded as constituting *S. concentrica*, Goldf.

Before leaving the subject of the nature of the original specimens of *Stromatopora concentrica*, Goldf., I may mention that the Bonn Museum contains a third specimen, which is believed to have been in Goldfuss's view when he described this species. Being unfigured, this specimen has, of course, no authority as compared with the figured specimen above described, which we must take as the real type of *S. concentrica*, Goldf. It is worth noting, however, that the specimen here alluded to, though in its general aspect and superficial characters very like the true *S. concentrica*, is in reality of a totally different structure. It has the form of a hemispherical mass, composed of concentrically disposed strata of considerable thickness ("latilaminæ"), its texture being so dense as to exhibit the minute structure but imperfectly under the lens.[1] Examined microscopically, the skeleton is seen not to be composed of a continuously reticulated fibre, but to be built up of definite "radial pillars," which are united at regular intervals by radiating horizontal connecting-processes or "arms," thus constituting a series of "concentric laminæ." It has, therefore, the so-called "hexactinellid structure," which is characteristic of all those Stromatoporoids which were formerly referred to the genus *Stromatopora*, and for which I shall now propose the generic title of *Actinostroma*. Specifically, it is identical with, or very closely allied to, the form which Bargatzky has erroneously identified ('Stromatoporen des rheinischen Devons,' p. 56) with *Stromatopora astroites*, Rosen.

(2) *Tragos capitatum*, Goldf. ('Petref. Germ.,' p. 13, Taf. v, fig. 6). This was originally described by Goldfuss as a distinct species, but was subsequently (in a later portion of the 'Petrefacta') referred by him to his *Stromatopora polymorpha.* The original specimen shows that this form possesses the continuously reticulated skeleton and the minutely porous skeleton-fibre which characterise the group of the *Stromatoporidæ* proper; and it must be referred either to *Stromatopora*, Goldf., itself or to some allied genus. Thin sections of the original specimen do not exist, but I have collected from the Devonian Limestones of the Paffrath district a number of examples of apparently the same species, and a minute examination of these has led me to think that the species should probably be referred to the genus *Idiostroma*, Winchell. In any case the species is one quite distinct from the true *Stromatopora concentrica*, Goldf.

(3) *Ceriopora verrucosa*, Goldf. ('Petref. Germ.,' p. 33, Taf. x, fig. 6). In the later portion of his work Goldfuss referred this form also to *Stromatopora polymorpha.* A superficial examination of the original specimen shows that this type is really referable to what I shall now term *Actinostroma* (*i. e.* to what has previously been regarded as *Stromatopora* proper), the skeleton being made up of "radial pillars" and horizontal connecting-processes. It is a good species, and is common at certain localities in the Rhenish Devonians (*e. g.* at Büchel). It will stand as *Actinostroma verrucosum*, Goldf. sp.

(4) *Stromatopora polymorpha*, Goldf. Under this name Goldfuss included a number of quite distinct forms which are at present only partially known. The forms in question are as follows:

(*a*) A group of encrusting forms ('Petref. Germ.,' Taf. lxiv, figs. 8 *a*, 8 *c*, 8 *d*), which seem to be referable to what I shall subsequently define as *Stromatoporella.* They are common in the Devonian Limestone at Büchel, and we may follow

[1] Precisely similar specimens are abundant at Gerolstein in association with the true *S. concentrica*, Goldf., the latter being, however, much less common.

Bargatzky in retaining for them the specific name of "*curiosa*," which Goldfuss gave to them as a variety of *S. polymorpha*.

(*b*) A massive form having the surface covered with perforated nipple-shaped eminences ('Petref. Germ.,' Taf. lxiv, fig. 8, *f*), subsequently distinguished by Bargatzky as *S. polyostiolata*. This form is only imperfectly known, and it is not at present possible to state definitely what are its complete characters. Through the kindness of Professor Schlüter I have been able to examine a thin section of the original specimen, and I am able to say that it belongs to one of the groups of the Stromatoporoids in which the skeleton is completely reticulated and the skeleton-fibre is minutely porous. I have little doubt that the species (as based on the original specimen) is really referable to *Stachyodes*, Barg., with which it agrees entirely in the minute structure of the skeleton-fibre. In any case it is entirely distinct from the other forms included by Goldfuss under the name of *S. polymorpha*.

(*c*) The form for which Goldfuss used the varietal name of "*ostiolata*" ('Petref. Germ.,' Taf. lxiv, fig. 8, *e*), and which Bargatzky subsequently raised to the rank of a distinct species under the name of *S. monostiolata*. The single original specimen has never been sectioned, and it is therefore impossible to come to any positive conclusion as to its internal structure or its real affinities.

It would appear from the above that Goldfuss included probably three distinct forms under the name of *S. polymorpha*. If one were disposed to retain the specific title of "*polymorpha*" at all, it would be probably best to do so for the forms which Bargatzky has called *S. curiosa*, but it would appear to be best to drop the name altogether. An additional reason for following this course is that Goldfuss himself, in the 'Petrefacta,' ultimately referred his *Tragos capitatum* to *S. polymorpha*, the former thus becoming the first described example of *S. polymorpha*, and therefore the type of the species. Goldfuss also ultimately referred his *Ceriopora verrucosa* to *S. polymorpha*. Upon the whole, therefore, any attempt to retain the species would be sure to lead to confusion.

Prof. Ferd. Roemer has expressed the opinion ('Rhein. Uebergangsgebirge,' p. 57, 1844) that *Stromatopora concentrica*, Goldf., and *S. polymorpha*, Goldf., are identical. I have examined in the Bonn Museum the specimen upon which Roemer relied in making this statement, and it seems certainly (so far as can be judged without thin sections) to belong to the true *S. concentrica*, Goldf. As, however, the specimen in question is not one of the originals upon which Goldfuss founded his *S. polymorpha*, and as it does not agree in any of its obvious characters with any of these originals, it cannot be accepted as throwing any light upon the validity of this species.

Having now dealt at some length, as the importance of the subject demanded, with the species of Stromatoporoids described and figured by Goldfuss, I may more briefly summarise the history of the group since the appearance of the 'Petrefacta Germaniæ' in 1826.

In the year 1833, de Blainville referred *Stromatopora*, with some doubt, to the Corals ('Manuel d'Actinologie,' p. 413).

In 1834, Steininger ('Mém. de la Soc. Géol. de France,' tom. i) described some species of Stromatoporoids from the Eifel Limestone. One of these, which he termed *Alcyonium echinatum*, has been generally identified with *Actinostroma* (*Stromatopora*) *verrucosum*, Goldf. The genus *Stromatopora* was referred by Steininger to the Sponges.

In the 'Silurian System' (1839), Mr. Lonsdale gave a list, accompanied by figures, of the Silurian Corals, and among these he described two species of Stromatoporoids under the names *S. concentrica*, Goldf., and *S. nummulitisimilis*, Lonsd. The former of these cannot be certainly identified from the description and figure given ('Sil. Syst.,' p. 680, pl. xv, fig. 31), there being at least two species in the Wenlock Limestone of Britain, which might have served as Lonsdale's type. An examination, however, of Lonsdale's original specimen, now preserved in the British Museum, shows it to be really one of the most beautiful and characteristic of the Wenlock Stromatoporoids, and properly referable to the genus *Clathrodictyon*. As d'Orbigny subsequently named Lonsdale's species *Stromatopora striatella*, this form will now stand as *Clathrodictyon striatellum*, d'Orb. sp. The second form described by Lonsdale, viz. *S. nummulitisimilis*, is not organic, but was founded upon specimens of the pisolitic limestone which forms part of the series of the Wenlock Limestone at Colwell, near Ledbury.

In addition to the above, Lonsdale described and figured a third Stromatoporoid from the Wenlock Limestone, under the name of *Porites discoidea* ('Sil. Syst.,' p. 688, pl. xvi, fig. 1). The true nature of the fossil so named certainly could not have been recognised from the description or figure given of it; and it is not surprising that in the later editions of 'Siluria' it should have been doubtfully placed under *Heliolites*. The original specimen of *Porites discoidea*, Lonsd., now in the British Museum, can, however, be at once shown to be, as long since surmised by Lindström, a genuine Stromatoporoid. The internal structure of the figured specimen has been, unfortunately, so far destroyed by secondary crystallisation that thin sections yield no conclusive evidence as to its true nature and affinities. Judging, however, from its external characters, there can be little hesitation in identifying the species with the form described by von Rosen under the name of *Stromatopora elegans*. This is a true *Stromatopora*, Goldf. (in the sense previously defined), and the species will therefore stand as *Stromatopora discoidea*, Lonsd. sp.

In 1840, Mr. Lonsdale published some further observations on the Stromatoporoids ('Trans. Geol. Soc. Lond.,' ser. 2, vol. v). He placed the genus *Stromato-*

pora (as understood by him) among the Corals; and he described and figured, under the name of *Coscinopora placenta*, the singular fossil subsequently and better known as *Caunopora placenta*.

Michelin ('Iconographie Zoöphytologique,' p. 190, pl. 49, fig. 4, 1840—47) described and figured a Stromatoporoid under the name of *Stromatopora concentrica*, Goldf. The figure given would answer fairly for this species, but without an examination of the original specimen it would be of little use to hazard a conjecture as to the precise form which he had before him.

In 1841, Professor Phillips described and figured certain Stromatoporoids from the Devonian formation of Devonshire ('Palæozoic Fossils of Cornwall,' &c., p. 18). The two forms identified respectively as *Stromatopora concentrica*, Goldf., and *S. polymorpha*, Goldf., are certainly not identical with the forms described by Goldfuss under these two names. What they really are could only be determined positively by an examination of the specimens which Phillips had under investigation. The extraordinary fossil described by Lonsdale under the name of *Coscinopora placenta* is here referred to a new genus, viz. *Caunopora*. Under the name of *Caunopora ramosa* Phillips also describes and figures the remarkable form which now constitutes the type of the genus *Amphipora* of Schulz.

In 1843, Fr. Ad. Römer referred certain fossils to the Stromatoporoids, and placed the genus *Stromatopora* itself among the Corals ('Versteinerungen des Harzgebirges'). Judging from his figures, however, the forms to which he assigns the names of *S. concentrica* and *S. polymorpha* are not really referable to the Stromatoporoids at all.

In the same year, Count von Keyserling ('Reise in das Petschora-Land') expressed the opinion that the genus *Stromatopora* is referable to the Corals, and that it is nearly related to *Alveolites*, Lam.

In 1844, Prof. Ferdinand Roemer first brought forward the highly important conjecture that the genus *Caunopora*, Phill., is really based upon specimens of *Syringopora* growing parasitically along with *Stromatopora*; or, to use his own words, that *Caunopora* is "nichts anderes als *Stromatopora polymorpha* von Syringoporen durchwachsen"—('Das rheinische Uebergangsgebirge'). At the same time he expressed the opinion, as previously noted, that *Stromatopora concentrica*, Goldf., is only a form of *S. polymorpha*, Goldf.; and he arrived at the conclusion that almost all the species of Stromatoporoids described by former observers might be regarded as variations of a single type.

In 1844, Prof. M'Coy ('Synopsis Carb. Limestone Foss. of Ireland') described briefly some more or less obscure fossils from the Carboniferous Limestone of Ireland, to which he gives the names of *Caunopora placenta*, Phill., *Stromatopora concentrica*, Lonsd., *S. polymorpha*, Goldf., and *S. subtilis*, M'Coy. The true structure and nature of these must remain at present doubtful.

In 1847, Hall ('Pal. New York,' vol. i, p. 48, pl. xii) founded the genus *Stromatocerium* for a Stromatoporoid from the Trenton Limestone of North America, the structural characters of the genus, however, being left undefined. In the same work (vol. ii, p. 135, 1852) Prof. Hall states that, according to his observations, the skeleton of *Stromatopora* is "composed of minute cylindrical tubes with considerable space between, and that the laminated structure arises from thin layers of calcareous matter deposited and filling the spaces between, and enclosing the tubes." He considers the genus to be referable to the Corals, and to be "more nearly related to *Tubipora* than to any other genus."

In the 'Prodrome de Paléontologie' (1850), d'Orbigny places the genus *Stromatopora* among the Sponges, and names a number of new species, all of which, however, are founded upon forms previously described by other writers. For the Wenlock Stromatoporoid which Lonsdale had erroneously referred to *S. concentrica*, Goldf., he proposed the name of *S. striatella;* and *Tragos capitatum*, Goldf., is removed to *Stromatopora* as *S. capitata.* On the other hand, *S. polymorpha*, Goldf., appears under the guise of no less than five new species, distributed partially under *Stromatopora* and partially under the new genus *Sparsispongia* (viz. *Stromatopora Goldfussii*, *S. sulcata*, *Sparsispongia polymorpha*, *S. radiosa*, and *S. ramosa*). Lastly, *Actinostroma* (*Stromatopora*) *verrucosum*, Goldf., is taken as the genuine *Stromatopora polymorpha* of Goldfuss.

In the subsequently published 'Cours Élémentaire de Paléontologie' (1851), d'Orbigny again expressed the opinion that the Stromatoporoids are referable to the Sponges.

In 1851, Prof. M'Coy expressed the opinion ('Brit. Pal. Foss.,' p. 12) that *Stromatopora* is a true Coral allied to *Fistulipora* and *Heliolites* (*Palæopora*). His definition of the genus is: "Corallum calcareous, forming large amorphous masses composed of very thin superficial layers of minute vesicular tissue of the thickness of one cell each, occasionally marked on the upper surface with extremely obscure, distant, quincuncially-arranged small pits."

In a later portion of the same work (p. 65) M'Coy described, unfortunately only partially with figures, several species of British Stromatoporoids. The forms which he identified as *Stromatopora concentrica*, Goldf., and *S. polymorpha*, Goldf., cannot now be certainly determined without an examination of the original specimens. The former would seem from the description given to be an *Actinostroma*, and the latter is apparently a true *Stromatopora.* The genus *Caunopora* of Phillips is regarded as a subgenus of *Stromatopora*, Goldf., and three species are referred to it, viz. *C. placenta*, Lonsd., *C. ramosa*, Phill. (Brass. MS.), and *C. verticillata*, M'Coy. The last of these three is a remarkable Devonian fossil, which seems to be really identical with the *Stachyodes ramosa* of Bargatzky, from the Devonian Limestones of the Paffrath district.

In 1853, Steininger ('Geognostische Beschreibung der Eifel') described a Stromatoporoid from the Devonian Limestones of the Eifel under the name of *Stromatopora foliata*, referring the genus to the Sponges.

Two species of *Stromatopora* were also described by Fr. Ad. Römer in the 'Palæontographica' (Bd. iii, 1852, and Bd. v, 1855) under the names of *S. patella* and *S. polymorpha*, var. *stellifera*. The true nature of these forms is, however, uncertain.

The two Sandbergers ('Die Versteinerungen des rheinischen Schichtensystems in Nassau,' p. 380, 1850—56) express the opinion that the genus *Stromatopora* should be referred to the *Polyzoa*, but they base this view upon the untenable supposition that the "radial pillars" served for the lodgment of zoöids.

The same view as to the affinities of *Stromatopora* is expressed by Prof. Ferd. Roemer ('Lethæa Geognostica,' 3rd ed., vol. i, p. 166, 1851—56), who compares the genus with the recent *Cellepora*. In a note, however, Roemer adds that he has since examined specimens of *S. polymorpha* from the Eifel in which he can detect both prismatic tubes and tabulæ, and that it will be therefore necessary to remove the genus *Stromatopora* to the Tabulate Corals, and to place it in the vicinity of *Chætetes* and *Favosites*. This last conclusion was really based (as subsequently pointed out by Roemer himself, 'Lethæa Palæozoica,' p. 460, 1883) upon certain singular corals (*Chætetes stromatoporoides*, Roemer), which commonly have their surface covered by an encrusting Stromatoporoid.

In 1857, Mr. Billings founded the genus *Beatricea* for the reception of certain extraordinary fossils from the Ordovician and Silurian Rocks of North America ('Geological Survey of Canada; Rep. of Progress for 1856,' p. 343, 1857, and 'Canadian Naturalist,' new ser., vol. ii, 1857). Mr. Billings at first held the opinion that *Beatricea* was probably referable to the vegetable kingdom. It will be shown subsequently, however, that the affinities of this remarkable genus are probably with the Stromatoporoids, though the structure of the skeleton is highly anomalous.

In 1858, Magister Friedrich Schmidt described two species of Stromatoporoids from the Silurian Rocks of Esthonia ('Silurische Formation von Ehstland, Nord-Livland und Oesel,' p. 232). One of these he identified with *Stromatopora striatella*, d'Orb., and the other he described as *S. mammillata*, n. sp. The latter is really the previously described *Clathrodictyon striatellum*, d'Orb.

In 1860, Eichwald ('Lethæa Rossica,' vol. i, p. 345) defined *Stromatopora* as a spongy mass, composed of closely approximated lamellæ, and enveloping other organic bodies; its surface being covered with minute rounded pores arranged without order over the whole surface of the skeleton. He seems to have been the first to promulgate the view, afterwards supported by von Rosen, that the skeleton of the Stromatoporoids consisted of a network of *horny* fibres, which had been replaced by carbonate of lime in the process of fossilisation. He describes *S. polymorpha*, Goldf., var. *constellata*, which he regards as identical with *Stromatopora verrucosa*, Goldf.

In 1862, Mr. Billings described a Stromatoporoid from the Black-River Limestone, under the name of *Stromatopora compacta* ('Palæozoic Fossils,' p. 55). He at first referred the Stromatoporoids to the *Amorphozoa;* but in a later portion of the same work he expressed the opinion that they are Corals, and are allied to *Fistulipora.*

In 1865, Professor Hyatt expressed the opinion ('Amer. Journ. Sci. and Arts') that the singular genus *Beatricea*, Bill., should be placed among the *Cephalopoda*, of which it should be regarded as the type of a special family.

In 1866, Professor Winchell published an important paper on the structure and affinities of the Stromatoporoids ('Proc. Amer. Assoc. for the Advancement of Science,' 1866, p. 91). In this memoir, the author not only discusses the minute structure and systematic position of the Stromatoporoids, but also gives descriptions of four species from the Devonian Rocks (Hamilton group) of Michigan and Ohio.[1] The species described are named *S. pustulifera*, *S. monticulifera*, *S. nux*, and *S. cæspitosa;* but they are, unfortunately, not figured. The two former are stated to be of the general type of *S. polymorpha*, Goldf.; and it is interesting to note the statement of the author that, having examined "ship-loads" of specimens, he has "never detected evidence that they were in any sense encrusting." *Stromatopora nux* is said to be of the same type as *S. concentrica*, Goldf.; and *S. cæspitosa* is a wholly aberrant form, for which a new genus (*Idiostroma*) is proposed. As regards the general affinities of the Stromatoporoids, Professor Winchell comes to the conclusion that they constitute a peculiar group of the true Corals, with relationships to the *Cystiphyllidæ* and *Cyathophyllidæ.* The following is the arrangement of the Stromatoporoids and their subdivisions as proposed by Winchell.

"Family, *Stromatoporidæ.*—Polyps isolated or confluent; exserted, never forming a cup; secreting a corallum which consists of a series of concentric layers (or diaphragms) of vesicular tissue, separated and perforated by vermicular ramifying passages, which are either radially or confusedly disposed. Mural system wanting; lamellar structure distinctly present only in the higher forms.

"Genus, *Idiostroma* (n. gen.).—Polypi completely isolated, forming branching masses; lamellar system represented by a radial structure.

"Species: *I. cæspitosum*, *I. gordiaceum.*

"Genus, *Cænostroma* (n. gen.).—Polypi confluent, but individualised, forming elongated or spheroidal compound masses; diaphragms common and continuous

[1] These species were originally described by Prof. Winchell in his 'Report on the Grand Traverse Region,' a work to which I have unfortunately not had access.

throughout; lamellar system indicated by the radiate arrangement of the vermicular passages, which commonly diverge from the summits of little eminences raised in the concentric laminæ.

"Species: *C. pustulosum*, *C. monticuliferum*, *C. granuliferum*, *C. polymorphum*, *C. radiosum*, *C. ramosum*.

"Genus, *Caunopora* (Phillips).—'Corallum polymorphous, composed of minute, irregular, vermicular, cellulose tissue, disposed in obscure concentric layers, traversed by a few long, larger, variously disposed, vermiform, cylindrical channels' (M'Coy, 'Brit. Pal. Foss.,' p. 66).

"Species: *C. placenta*, *C. ramosa*, *C. verticillata*.

"Genus *Stromatopora* (Goldf.).—Polypi confluent, with individualities sensibly obliterated. Corallum consisting essentially of confluent diaphragms, or concentric layers, which generally inclose a foreign body—being secreted on all sides of it, and forming a spheroidal mass.

"Species: *S. concentrica*, *S. striatella*, *S. nux*, *S. rugosa*, *S. compacta*, *S. nummulitisimilis*."

With regard to the two new genera proposed by Professor Winchell in the above-quoted synopsis, *Idiostroma* is an exceedingly abnormal form, and the absence of figures illustrative of the minute structure may sufficiently explain why the type has not been recognised by subsequent observers. The type of the genus, viz. *I. cæspitosum*, Winch., is described as resembling a large cæspitosely-branched Cyathophylloid Coral, forming masses three or four feet in diameter, composed of stems which vary from one fifth to one third of an inch in diameter, and which may be either apart or in contact with another. The exterior is "longitudinally vermicular-striate." The transverse section "exhibits a radiating structure, as in the *Cyathophyllidæ;* but there is no outer wall or definite limitation to the structure, and the interior is completely filled with concentric circles of coralline substance except a small perforation in the centre." In the absence of a more detailed account of the minute structure, it would, as above remarked, be difficult to decide positively as to the true relationships of this singular type. I have, however, collected a number of specimens from the Devonian Limestone of Hebborn, in the Paffrath district, which seem to be unquestionably congeneric with *Idiostroma cæspitosum*, Winch.; and I shall subsequently give a description of the characters of the genus as elucidated by these examples.

The genus *Cœnostroma*, Winchell, on the other hand, comprises Stromatoporoids of the normal type, and the only really distinctive feature in the diagnosis of the genus, as given by its founder, is the presence of "astrorhizæ," or radiately disposed canal-systems (the "polypi" of Winchell's definition). As will be subsequently seen, however, such stellate canals are developed in a large number of Stromatoporoids, in which the minute structure is otherwise exceedingly different;

and the mere presence of such canal-systems does not, therefore, afford a sufficient ground for generic distinction. Indeed, it occasionally happens that certain individuals of a given species exhibit such "astrorhizæ," while in other individuals of the same species these structures are wanting, or are, at any rate, not conspicuous. I am, therefore, of opinion that the genus *Cœnostroma,* Winch., cannot be retained with advantage.

One of the most important contributions to the study of the Stromatoporoids is that published by Baron von Rosen in 1867, under the title 'Ueber die Natur der Stromatoporen, und über die Erhaltung der Hornfaser der Spongien im fossilen Zustande.' In this work, the author recounts the results of an investigation into the structure of the Stromatoporoids by means of thin sections prepared for the microscope; and the value of his memoir is further enhanced by a number of excellent plates, dealing principally with the minute structure of the skeleton. The material upon which von Rosen based his work was derived from the Upper-Silurian Rocks of the north of Europe, from which he describes several new species.

Having recently had the opportunity of examining in Dorpat the original specimens and slides upon which von Rosen founded his species, and having myself collected a large series of the same forms, I shall be able later to discuss more fully the characters and affinities of these species. In the meanwhile the following brief remarks may be made as regards some of them.

Stromatopora typica, Rosen (op. cit., Taf. I, fig. 1), is a species common in the Wenlock Limestone of Britain, and is a true *Stromatopora* (in the sense previously defined). The type-specimen of *Stromatopora astroites*, Rosen, has its internal structure almost destroyed, as the result of crystallisation; but other specimens included by Rosen under this name are apparently identical with *S. typica*, and the specific name of *astroites* must therefore be abandoned in favour of *typica. Stromatopora elegans*, Rosen, though much crystallised, appears to be identical with *S. discoidea*, Lonsd., the latter name having the priority. *Stromatopora Schmidtii*, Rosen, is a very peculiar type of the genus *Actinostroma.* The *Stromatopora variolaris* of Rosen is a species of *Clathrodictyon*, and is of common occurrence in the Wenlock Limestone of Britain. *Stromatopora regularis*, Rosen, is also a species of *Clathrodictyon;* and is also found, though rarely, in the Wenlock Limestone of Britain and of Gotland. The remarkable type described under the name of *Stromatopora dentata* appears to be properly referable to a new genus allied to *Labechia*, E. and H., which I shall name *Rosenella.* To this genus also belongs the species described as *Stromatopora Ungeri.* It may be added that von Rosen devotes a section to the discussion of the characters of *S. polymorpha*, Goldf., and, rightly, concludes that Goldfuss had included several types under this specific name.

As regards general results, the main conclusion reached by Von Rosen is that the skeleton of the Stromatoporoids is composed of horny fibres arranged in bundles, and that these organisms are referable to the group of the Keratose Sponges, or allied to these. The minute openings on the surface of many Stromatoporoids he regards as "pores," and the larger openings, which are occasionally present, as "oscula." In this latter view, he has been preceded by D'Orbigny and others, and has been followed by many later investigators. In his opinion that the skeleton of the Stromatoporoids was in reality of a horny nature, Von Rosen was preceded by Eichwald; but there can be no hesitation, in the light of all known facts, in unequivocally rejecting this view. In spite of the above erroneous conclusion as to the composition of the skeleton of the Stromatoporoids, Von Rosen's work will continue, justly, to retain its position as a classical treatise upon a most difficult group of organisms.

In 1870, Dr. Gustav Lindström published a valuable paper on the *Anthozoa perforata* of Gotland ('Kongl. Svenska Vetenskaps-Akad. Handlingar,' Bd. ix), in which he describes and figures the *Porites discoidea* of Lonsdale as a Stromatoporoid, under the name of *Cœnostroma discoideum*. An examination of the original specimen, now preserved in the British Museum, has shown that Dr. Lindström is perfectly correct in the belief that *Porites discoidea*, Lonsd., was really founded upon a Stromatoporoid. I should be disposed, however, to think that in his description of this species, Dr. Lindström has included more of the Wenlock Stromatoporoids than Lonsdale's species, and, for reasons above given, I am unable to retain the genus *Cœnostroma*, Winch. In Lindström's opinion, *Cœnostroma* is a true Coral, and is allied to the *Montiporinæ*. On the other hand, he regards the genus *Stromatopora*, Goldf., as distinguished from *Cœnostroma*, Winch., as having quite different affinities, and as being probably related to the *Foraminifera*.

In a memoir on the affinities of the *Anthozoa tabulata* ('Œfversigt af Kongl. Vetenskaps-Akad. Förhandl.,' 1873, translated in the 'Annals of Natural History,' 1876), Dr. Lindström expresses the opinion that *Cœnostroma*, Winchell, presents certain points of likeness to *Labechia*, E. and H. He further makes the very important suggestion that the genus *Labechia* is of Hydrozoal affinities, and is related to the recent genus *Hydractinia*. To Dr. Lindström, therefore, belongs, so far as I am aware, the credit of having first publicly pointed out the direction in which the true relationships of the Stromatoporoids might be looked for.

In the 'Twenty-third Annual Report on the State Cabinet,' dated 1873, Prof. Hall and Mr. Whitfield describe as new species five Stromatoporoids from the Devonian Rocks (Chemung group) of North America. These are named *Stromatopora erratica*, *S. expansa*, *S.* (*Cœnostroma*) *incrustans*, *S.* (*Cœnostroma*) *solidula*, and *Caunopora planulata*. It would not appear that the last of these is really of the same nature as the fossils referred properly to *Caunopora*, Phill, as it seemingly does not possess the *walled* tubes which are characteristic of the latter.

In 1873, Mr. Salter expressed the opinion that *Stromatopora* is "a very solid calcareous Sponge" ('Cat. Sil. Foss.,' p. 99).

In the same year, the present writer described ('Ann. and Mag. Nat. Hist.,' ser. 4, vol. xii) several Stromatoporoids from the Silurian and Devonian Rocks of Canada. In one of these, viz. *Clathrodictyon* (*Stromatopora*) *ostiolatum*, Nich., the presence of regularly-disposed round apertures of large size was pointed out, and it was suggested that these corresponded with the "oscula" of Sponges.

In 1874, the present writer further discussed ('Ann. and Mag. Nat. Hist.,' ser. 4, vol. xiii) the affinities of the Stromatoporoids, referring them to the *Calcispongiæ*, and indicating the presence in various species of large openings, which might be regarded as of an "oscular" nature. The skeleton was regarded as "composed of an amalgamated system of horizontal spicules, separated by interspaces, and kept apart by a vertical system of delicate calcareous rods, giving rise to a system of more or less quadrangular tubes." In the 'Report on the Palæontology of the Province of Ontario' (1874) the same opinion is repeated. In the 'Palæontology of the State of Ohio' (vol. ii, 1875) the writer described several species of Stromatoporoids from the Devonian Rocks of Ohio, and proposed two new genera under the names *Syringostroma* and *Dictyostroma*. The type of *Syringostroma* is the singular *S. densum*, which possesses the reticulated skeleton characteristic of *Stromatopora*, Goldf., but which has certain peculiarities of its own. I shall later on discuss the value of these peculiarities. Besides *S. densum*, Nich., another remarkable form was placed under *Syringostroma*, under the name of *S. columnare*, Nich. This latter, however, is really quite distinct in its structure, and forms the type of the genus *Stylodictyon*, Nich. and Mur. The genus *Dictyostroma* was proposed for a remarkable Stromatoporoid from the Silurian Rocks of Kentucky; but as the minute structure of the skeleton is still unknown, it is doubtful whether this genus can be retained.

In the 'Dawn of Life' (1875), Principal Dawson incidentally gives the result of his observations on the structure of *Stromatopora* and its allies, regarding them as connected on the one hand with the *Foraminifera* and on the other hand with the Sponges. He compares the astrorhizal tubes of certain Stromatoporoids with the "canal-system" of *Eozoön*.

In a memoir upon the genus *Stauronema*, Prof. Sollas ('Ann. and Mag. Nat. Hist.,' ser. 4, vol. xix, 1877) places *Stromatopora* among the Vitreo-hexactinellid Sponges. In a subsequent paper ('Quart. Journ. Geol. Soc.,' 1877), the same author expresses the opinion that under the head of *Stromatopora* are included organisms of very different affinities, some being Siliceous Sponges, some related to *Millepora* and *Hydractinia*, and some with relationships as yet undetermined.

In 1877, Mr. Carter expressed the opinion ('Ann. and Mag. Nat. Hist.,' ser. 4, vol. xix) that the Stromatoporoids are closely related to the living *Hydractinia*, and that the extinct genus *Parkeria*, described by Dr. W. B. Carpenter as a Foraminifer, is also truly Hydrozoal and related to *Hydractinia*. This memoir is the first of a long and important series of papers in which Mr. Carter deals with the recent *Hydractiniæ* and their extinct allies, and the result of which has been the gradual conversion of palæontologists to the view that the Stromatoporoids are properly referable to the *Hydrozoa*. Leaving *Parkeria* out of the question, as not concerning us here, Mr. Carter in the memoir alluded to describes various recent and fossil species of *Hydractinia*, and gives an excellent account of the structure, and also of the development, of the skeleton of *Hydractinia echinata*, Flem. He maintains the opinion that the Stromatoporoids are extinct allies of *Hydractinia*, and that they have nothing in common with the Sponges, to which they have been referred by so many previous writers. The stellate canals ("astrorhizæ") which constitute such a conspicuous feature in many Stromatoporoids, and which superficially exhibit such a sponge-like appearance, are parallelled by Mr. Carter with the shallow, radiating, cœnosarcal grooves which furrow the surface of the crust in the recent *Hydractiniæ*.

In a supplementary note to the English translation ('Ann. and Mag. Nat. Hist.,' ser. 4, vol. xix, 1877) of his masterly memoir, entitled "Beiträge zur Systematik der fossilen Spongien" ('Neues Jahrbuch für Mineralogie,' &c., 1877), Professor Zittel gives his adhesion to Mr. Carter's view that the Stromatoporoids are really to be regarded as allies of *Hydractinia*, and as belonging therefore to the *Hydrozoa*.

In an interesting and valuable memoir published in 1878 ('Palæontographica,' 3 Folge, Bd. i, 3 Lief., p. 101), Dr. Steinmann also expresses the opinion that the Stromatoporoids should be placed in the neighbourhood of the *Hydractiniidæ*. The author founds the genus *Sphæractinia* for certain concentrically-laminated fossils from the Upper-Jurassic Rocks, which in internal structure present considerable resemblance to certain of the Stromatoporoids. The genus *Labechia*, E. and H., is regarded as constituting a connecting link between the Tabulate Corals and the *Hydractiniidæ*. The author also deals with *Parkeria*, Carp., *Loftusia*, Brady, and the three new genera *Porosphæra*, *Cylindrohyphasma*, and *Ellipsactinia*, all of which he considers as being related to the *Hydractiniidæ*, and as having, therefore, more or less close relationships with the Stromatoporoids.

In the same year Mr. Carter published a second paper, "On New Species of Hydractiniidæ, recent and fossil, and on the Identity in Structure of *Millepora alcicornis* and *Stromatopora*" ('Ann. and Mag. Nat. Hist.,' ser. 5, vol. i, pp. 298—311). In this memoir the author compares the Stromatoporoids with *Millepora*, and comes to the conclusion that there exists between them a substantial agreement in structure. The stellate canal-systems ("astrorhizæ") of many Stromatoporoids are compared with the irregular cœnosarcal canals which ramify through the skeleton of *Millepora*, and are regarded as being essentially of the same nature.

In a succeeding number of the same publication ('Ann. and Mag. Nat. Hist.,' ser. 5, vol. i, p. 412), Mr. Carter has a short note on "Calcareous Hexactinellid Structure in the Devonian Limestone," in which he describes specimens from the Devonshire Limestones as showing a structure apparently similar to that of the Hexactinellid Sponges, but calcareous in composition. The specimens in question belonged, doubtless, to Stromatoporoids appertaining to the genus *Actinostroma*, some of these, when examined in certain aspects, presenting an appearance very similar to that of some of the *Hexactinellidæ*.[1]

In a still later number of the same publication ('Ann. and Mag. Nat. Hist.,' ser. 5, vol. ii, p. 28), Principal Dawson opposes the views expressed by Mr. Carter as to the relationships which the latter sought to establish between the Stromatoporoids and *Millepora*.

Later again ('Ann. and Mag. Nat. Hist.,' ser. 5, vol. ii, p. 304, 1878), Mr. Carter returns to the same subject in a paper entitled "On the probable Nature of the Animal which produced the *Stromatoporidæ*, traced through *Hydractinia*, *Millepora alcicornis*, and *Caunopora* to *Stromatopora*." Much of this memoir is, in the main, a repetition of points which had been brought forward by the author in previous communications. Mr. Carter explains that in former papers he had spoken of *Caunopora*, Phill., under the name of *Stromatopora*, and he has now come to the conclusion that *Caunopora* is really intermediate in its characters between *Millepora*, Lam., and *Stromatopora*, Goldf. The tubes of *Caunopora* he regards as being inhabited by polypites, and as being comparable with the "gastropores" of *Millepora*.

Also in the year 1878, but prior to the appearance of most of the memoirs just noted, a paper on "The Minute Structure of the Skeleton of *Stromatopora* and its Allies," was published by Dr. Murie and the present writer ('Journ. Linn. Soc.,' vol. xiv, 1878). In this memoir, after a historical summary, the authors treat of the general structure of the Stromatoporoids, and bring forward evidence to show that the skeleton of these organisms was certainly originally calcareous. Being at that time unacquainted with the minute structure of the skeleton of the original specimen of *Stromatopora concentrica*, Goldf., the authors followed all previous writers in considering the genus *Stromatopora*, Goldfuss, as comprising those types which possess definite "radial pillars" united by periodically-developed horizontal connecting processes. The genus *Clathrodictyon* was proposed for certain Stromatoporoids with short and irregular "radial pillars," and two species of the

[1] It may be noted that, in certain states of preservation, the singular Coral described by Roemer under the name of *Chætetes stromatoporoides*, also exhibits appearances curiously like those shown by certain Hexactinellid Sponges. This Coral occurs in the Devonian of both Devonshire and Germany.

same, viz. *C. vesiculosum* and *C. cellulosum*, were briefly defined. The genus *Stylodictyon* was founded for the singular *S. columnare*, Nich., and a second species was included in the genus under the name of *S. retiforme*, Nich. and Mur. The latter, however, is really a member of the genus *Actinostroma*, and is closely related to the *A. verrucosum*, Goldf., of the European Devonian Rocks. The genus *Pachystroma* was proposed for certain curious Stromatoporoids of which the new species *P. antiquum*, from the Niagara Limestone of North America, was taken as the type. A recent examination, however, of thin sections of the original specimens of *Stromatopora concentrica*, Goldf., has shown that the genus *Pachystroma*, Nich. and Mur., is nothing more than the veritable *Stromatopora*, Goldf. (non *Stromatopora*, auct.), and the name *Pachystroma* must, therefore, be abandoned. An attempt was made to revive the genus *Stromatocerium*, Hall, upon the basis of a new species (*S. canadense*, Nich. and Mur.) from the Trenton Limestone of Canada. Further and more extended observations have shown, however, that this type is really a *Labechia* in a peculiar condition of preservation. Lastly, the authors accepted the genus *Caunopora*, Phill., as comprising independent organisms. With regard, finally, to the question of the systematic relationships of the Stromatoporoids, the authors came to the conclusion that, in the absence of any demonstration of the existence in any of the Stromatoporoids of definite zoöidal tubes, the reference of these organisms to the *Hydrozoa* cannot be unconditionally accepted. They concluded, therefore, that with the evidence at that time available, the Stromatoporoids may be best regarded as a separate section of the Calcareous Sponges, for which they proposed the name of *Stromatoporoidea.*

In his 'Petrefaktenkunde Deutschlands' (Schwämme, Pls. 141, 142, 1878), Professor Quenstedt treats of the Stromatoporoids among the Sponges. He describes and figures a number of species, mostly from North America; but it is in most cases difficult to identify the species which he had in view. The species which he names *Stromatopora verruculosa* seems, as conjectured by Bargatzky, to be really one of the forms included by Goldfuss under the head of *S. polymorpha*, and the form which he terms *S. striatella*, D'Orb., seems to be really the *S. discoidea* of Lonsd. (= *S. elegans* Rosen) The form described as *S. Wortheni*, Rom., is unquestionably identical with that which I described from the Corniferous Limestone of Ohio, under the name of *Stylodictyon* (*Syringostroma*) *columnare*.[1] The form named *Stromatopora cæspitosa* is the *Idiostroma cæspitosum* of Winchell, and should be placed in *Idiostroma*. The other forms described are *Stromatopora textilis*, Rom., *S. minuta*, Winch., *S. pustulifera*, Winch., and *S. consors*, Quenst., all from the Silurian and Devonian Rocks of North America.

[1] I have not been able to discover that any description of this species has been published by Rominger.

In the year 1879 appeared several memoirs dealing with the Stromatoporoids. One of these was a memoir by Principal Dawson on "The Microscopic Structure of the Stromatoporidæ" ('Quart. Journ. Geol. Soc.,' vol. xxxv, pp. 48—66), in which he maintained his previously-expressed opinion as to the Rhizopodal affinities of these organisms. He altogether rejects the asserted relationship between the Stromatoporoids and the *Hydractiniidæ*, as supported by Carter and Steinmann. Two new species are described under the names of *Caunopora hudsonica* and *Cœnostroma galtense;* and the *Stromatopora compacta* of Billings is stated to be apparently a true Coral. The author considers that the Stromatoporoids "have apparently always been calcareous when recent." Lastly, the author has some remarks upon some of the genera of the Stromatoporoids, in which he adopts *Cœnostroma*, Winch., in much the same sense as that of its original founder, but includes under *Caunopora*, Phill., forms which have not usually been placed in that problematical genus.

In the same publication ('Quart. Journ. Geol. Soc.,' vol. xxxv, p. 67) Mr. Champernowne has a "Note on some Devonian Stromatoporidæ from Dartington, near Totnes." This note deals chiefly with the mode of occurrence of Stromatoporoids in the dolomitic limestone of Dartington; but the author makes the interesting observation that in certain specimens of *Caunopora* he has seen the tubes not to be open, but to be lamelliferous, and to present "some appearance of a columella." With regard to the affinities of the Stromatoporoids, the author concludes that "it is difficult to regard them as forming a compact group of *Calcispongiæ*," and adds—what later observations have fully borne out—that they "clearly seem to embrace structures similar to that of the *Milleporidæ*."

In the 'Annals and Magazine of Natural History' (ser. 5, vol. iv, p. 101, 1879) Mr. Carter published a paper on "The Mode of Growth of Stromatopora, including the Commensalism of Caunopora." In this paper he maintains that *Stromatopora* is essentially an encrusting organism, "not only entering into and filling up the open interstices of other calcareous organisms during their growth, but enveloping their detritus." This view is, however, based upon a study of Stromatoporoids of particular species, or growing under particular conditions. There is, of course, no doubt that Stromatoporoids very commonly do enclose and envelop other organisms of all sorts in the course of their growth, and they also occasionally form thin crusts parasitically attached to foreign bodies. A very large number of the Stromatoporoids, however, have an epithecate base, with a single narrow peduncle of attachment, and are no more given to surround other organisms than are the species of *Alveolites* or *Favosites*, which occur in the same strata. Mr. Carter also now expresses his conviction that the genus *Caunopora*, Phill., is (as long previously maintained by Ferdinand Roemer) really founded upon specimens of some Coral or other organism enveloped in a Stromatoporoid, the "tubes" of *Caunopora* being thus adventitious structures.

In a further communication ('Ann. and Mag. Nat. Hist.,' ser. 5, vol. iv, p. 253, 1879) Mr. Carter returns to the subject of the structure of the skeleton in the Stromatoporoids. He follows Von Rosen in distinguishing two principal types of structure in the skeleton, viz. a "curvilinear structure" and a "rectilinear structure." Mr. Carter also here modifies his previously-expressed view—a view in which at that time most observers concurred—that the "radial pillars" of the Stromatoporoids were solid; and he comes to the conclusion that they were traversed by an axial canal (as in *Labechia*, E. and H.), but closed superficially. The genus *Labechia*, E. and H., is placed by Mr. Carter close to *Hydractinia*, one ground for this collocation being the supposed encrusting habit of *Labechia*. It may be certainly stated, however, that *Labechia* very rarely assumes an encrusting form, the great majority of specimens being in the form of laminar expansions, with a basal epitheca, and a small point of attachment. Lastly, Mr. Carter notices a peculiarity in the appearance of thin sections of certain specimens of *Stromatopora dartingtonensis*, Cart. (erroneously identified with *S. elegans*, Rosen)—namely, that the stellate canals appear to terminate in the fibre of the cœnenchyma itself; but he gives no satisfactory explanation of this phenomenon. The real reason of this appearance, as will be subsequently more fully shown, is that in this form, as in various others, certain specimens are so preserved that the entire system of canals and internal cavities has been filled with more or less opaque, calcareous or argillaceous sediment, the real skeleton having then been dissolved out, and the spaces thus formed finally filled up with calcite. Hence, in such "reversed" specimens, the canal-system and tubes of the organism have the appearance of being parts of the solid skeleton, while the latter is represented only by transparent calcite, and thus looks as if it had been originally hollow, or as if it represented the original cœnenchymal canals and cells.

In his admirable 'Handbuch der Palæontologie' (Bd. i, Lief. ii, p. 284, 1879), Professor Zittel treats of the Stromatoporoids under the Hydrocorallines. He includes the genera *Labechia*, E. and H., and *Ellipsactinia*, Steinm., in the group of the *Stromatoporoidea*.

Lastly, in 1879 the present writer gave a description, accompanied by figures, of the minute structure of the skeleton of the genus *Labechia*, E. and H. ('Palæozoic Tabulate Corals,' p. 330, Pl. XV, figs. 4, 4*a*). In this description it was pointed out that the "pillars" of *Labechia conferta*, Lonsd., are "primitively tubular, but that the median tube is finally largely or entirely obliterated." With regard to the affinities of *Labechia*, the genus was regarded as doubtfully belonging to the Corals, and was considered as in some respects related to the genus *Fistulipora*, M'Coy.

In 1880, an important memoir was published by Prof. Ferd. Roemer on the genus *Caunopora*, Phill. ('Geological Magazine,' dec. ii, vol. vii, p. 343). As previously mentioned, this veteran palæontologist, as long ago as 1844, expressed the opinion that *Caunopora placenta*, Phill., was founded upon specimens of *Stromatopora concentrica*, which had "surrounded and overgrown the stems of *Syringopora*." In the present memoir, Roemer states that the tubes of *Caunopora* are not, strictly speaking, referable to *Syringopora*, but rather belong to *Aulopora*, especially to *A. repens*. He regards *Caunopora placenta*, Lonsd. sp., as being, therefore, the result of the combined growth of a colony of *Stromatopora* with one of *Aulopora;* the latter extending its tubes upwards, as the former adds new layers to its surface, and thus preventing itself from being entirely covered up and killed. The occurrence of thick masses of *Caunopora* is accounted for on the hypothesis that "the vertical tubes do not necessarily all belong to the same individual of *Aulopora*, but different colonies of these little creeping Corals attached themselves repeatedly to the surface of succeeding concentric layers of *Stromatopora*, and were covered by the succeeding one." He adds further that "in fact, on vertical sections of *Caunopora* the same vertical tubes can never be followed up through the whole mass, but they are mostly only a few lines in length." On this point, however, I am unable to agree with Prof. Roemer. Even in very thick specimens of *Caunopora*, the same tubes may often be traced continuously for long distances, and in laminar specimens, an inch or more in thickness, most, if not all, of the tubes pass directly from the top to the bottom. Roemer, moreover, states that a Silurian Stromatoporoid (which he considers to be *S. striatella*) also occasionally exhibits the structure of *Caunopora*, the tubes in this case also being produced by a species of *Aulopora*. Specimens of this nature, in the author's view, had been previously described from the Drift of Groningen, in Holland, being named *Syringopora filiformis* by Goldfuss ('Petref. Germ.' Taf. xxxviii, fig. 15), and referred by Roemer himself to *Heliolites interstincta* ('Diluvial Geschiebe von Sadewitz,' t. iv, fig. 2 *e*). As regards, finally, the perforated tubercles or eminences which are found on the surface of various Stromatoporoids, Prof. Roemer brings forward an ingenious explanation; namely, he discovered that underneath such openings were sometimes to be found the tubes of species of *Spirorbis*, and he therefore suggests that "the hole on the top of the tubercle is the opening of the canal by which that little animal kept up its communication with the surrounding water, and the tubercle was formed by the bending upwards of the successive layers of *Stromatopora* round the canal." That buried specimens of *Spirorbis* may thus give rise to superficial openings, simulating "oscula," is a point which I can myself confirm, from observations upon various of the Silurian Stromatoporoids. Moreover, successive generations of *Spirorbes* may in this way become embedded in the skeleton of a Stromatoporoid, and they often assume a rough grouping in vertical lines.

On the other hand, as I shall point out more fully later on, this explanation by no means applies to such openings as are observable in *Stromatopora ? polyostiolata*, Barg., *Stromatoporella granulata*, Nich., and various other types, in which rounded apertures are seen to be regularly disposed over the surface, and often to be supported upon prominent "mamelons." In these cases, the superficial openings belong in the strictest sense to the structure of the Stromatoporoids themselves, as can conclusively be shown by the fact that thin vertical sections demonstrate them to be the mouths of approximately vertical, wall-less tubes, which form the axes of successively superimposed groups of "astrorhizæ."

In 1880, Mr. Carter published a paper ('Ann. and Mag. Nat. Hist.,' ser. 5, vol. vi, p. 339) in which he criticised the memoir just mentioned. Contrary to the views of Roemer, he expressed the opinion that the tubes of *Caunopora* can not be ascribed to *Aulopora repens*, as an invariable rule at any rate, as they sometimes possess infundibuliform tabulæ, resembling the tabulæ of *Syringopora*. Much stress, however, cannot really be laid upon this argument, as undoubted species of *Aulopora* can be shown to sometimes possess funnel-shaped tabulæ. In the same paper, Mr. Carter proposes the convenient name of "astrorhizæ," for the stellate cœnosarcal canals of certain of the Stromatoporoids; and he describes a Stromatoporoid from Devonshire, under the name of *Stromatopora dartingtonensis*, in which he has detected transverse plates, resembling "tabulæ," in the branches of the astrorhizæ. As to the occurrence of these transverse calcareous partitions in the branches of the astrorhizæ, no doubt whatever is possible. I am, however, unable to accept Mr. Carter's conclusion that these structures are in any way comparable with the "tabulæ" in the tubes of the "gastrozoöids" of *Millepora*, a view which he further maintains in the present memoir. For one thing, many Stromatoporoids (such as the *Stromatoporidæ* generally) really do possess other structures comparable with the "tabulæ" of *Millepora*. Moreover, to accept this view would, as it seems to me, entirely upset the much more reasonable comparison of the "astrorhizæ" of the Stromatoporoids to the branched cœnosarcal grooves of *Hydractinia* and to the irregularly-divided canal-system of the general skeleton of *Millepora*—a comparison which has been ably supported by Mr. Carter himself.

In the 'Neues Jahrbuch für Mineralogie,' &c. (Jahrg. 1880, Bd. ii, p. 403), Dr. Steinmann reviews Mr. Carter's previously noted paper on *Caunopora*. He expresses the opinion that Ferd. Roemer and Carter are correct in their conclusion that the genus *Caunopora* is founded upon specimens in which a Stromatoporoid and a Coral are associated as commensals.

The principal work dealing with the Stromatoporoids, which appeared in the year 1881, is the elaborate memoir by Dr. August Bargatzky on the Stromatoporoids of the Rhenish Devonian formation ('Die Stromatoporen des rheinischen Devons,' Bonn, 1881). I shall have occasion to frequently refer to this memoir, which is, unfortunately, insufficiently illustrated, but which is otherwise a very valuable and important contribution to the subject; so I need here only indicate its general scope. Commencing with a historical summary, the author next gives a detailed account of the general structure of the skeleton in the Stromatoporoids. He describes this structure as consisting of a series of horizontal and vertical, or concentric and radial, elements; and expresses the view that *Caunopora*, Phill., is the only type of the Stromatoporoids in which the skeletal elements are disposed indifferently, so as to give rise to a "curvilinear" or round-meshed structure. The "radial pillars" he regards as invariably solid, and he states that he has never observed them to open by apertures on the surface. The pores in the concentric laminæ are regarded as having served for the exit of polypites; and Carter's views as to the homology between the astrorhizæ and the cœnosarcal canals of *Hydractinia* are accepted. The existence in some forms of vertical wall-less tubes, which give off the astrorhizæ of successively superimposed interlaminar spaces, is noted; and it is rightly pointed out that these have nothing to do with the walled tubes of *Caunopora*. The absence of such a central vertical tube in the astrorhizæ of various Stromatoporoids is further shown to be due to the fact that in these forms the astrorhizæ of successive interlaminar spaces do not lie above one another, or correspond in position. With regard to *Caunopora*, Phill., Bargatzky considers that two distinct groups have been included under this name. In one of these groups, the general skeleton has a "curvilinear" structure, and to such forms he would restrict the name *Caunopora*. In the other group, the skeleton has a "rectilinear" structure (really only partially so), and for forms of this type he proposes the new genus *Diapora*. As regards both *Caunopora* and *Diapora*, Bargatzky concludes that the walled tubes are *not* foreign to the organism in which they occur; and he gives various detailed reasons for this view. The genus *Parallelopora*, the characters of which I shall discuss subsequently, is founded by Bargatzky for some Stromatoporoids from the Devonian Rocks of the Paffrath district. The next section of Dr. Bargatzky's memoir is occupied with descriptions of the species of Stromatoporoids which occur in the Devonian Rocks of the Rhenish region. Owing to the fact that he had not examined thin sections of the original specimens of Goldfuss, Bargatzky has fallen into the same error as all who had preceded him with regard to *Stromatopora concentrica*, Goldf. He selects, namely, for this classical species the common Devonian Stromatoporoid with the "rectilinear" or "hexactinellid" structure, that is to say, with continuous "radial pillars" and with periodically-developed horizontal connecting-processes. I have examined his named specimens in the Bonn Museum, and he has also been so good as to show me the specimens in his own collection, so that I can speak positively on this point. As a matter of fact, however, as previously pointed out, the true *Stromatopora concentrica* of Goldfuss has a reticulated skeleton, with the typical "curvilinear" structure, and belongs, therefore, to an entirely different group of the Stromatoporoids to that which includes the forms with a "rectilinear" structure (*i. e.* the *Actinostromidæ*). It follows, therefore, that *Stromatopora concentrica*, Barg., has no relationship with *Stromatopora concentrica*, Goldf. Of the other forms placed by Bargatzky under the genus *Stromatopora*, *S. verrucosa*, Goldf., is likewise a typical *Actinostroma*, with continuous "radial pillars" and a well-marked hexactinellid structure; and this is also the case with the forms named by Bargatzky *S. papillosa*, n. sp., and *S. astroites*, Rosen. The latter of these has really nothing to do with the form described by Rosen as *S. astroites*, but it is a well-marked and perfectly distinct species of the genus *Actinostroma*, of which the former is probably only a variety. On the other hand, the form described as *S. Beuthii*, Barg., is a genuine *Stromatopora*, as above defined, and appears to be a good species. The forms included by Goldfuss under the head of *S. polymorpha* are broken up by Bargatzky into the three species *S. curiosa*, *S. monostiolata*, and *S. polyostiolata*. The two forms included by Bargatzky under the names of *Caunopora placenta*, Phill., and *C. Hüpschii*, Barg., appear to me to be undoubtedly the same; and as I shall subsequently give reasons for not retaining the name of "*placenta*," Phill., the species should stand as *Stromatopora Hüpschii*, Barg., sp. The specimen in the Bonn Museum labelled *Caunopora büchelensis*, Barg., appears to me also to be identical with the preceding. As, however, Dr. Bargatzky sent me authentic specimens of his *Caunopora büchelensis*, which are quite different from his *C. Hüpschii*, and as these specimens belong to a form of common occurrence in the Devonian Rocks of Germany and of Britain, I shall retain this specific name, placing the species under *Stromatopora*. Of the species referred to *Parallelopora*, Barg., *P. ostiolata* is a remarkable form, which I shall notice later on; but *P. stellaris*, and *P. Goldfussi* are not so clearly distinct, and the latter may be only the *Stromatopora capitata* of Goldfuss. *P. eifeliensis*, Barg., appears to be a *Fistulipora*. Finally, as regards the systematic position of the Stromatoporoids, Bargatzky agrees with Steinmann and Carter in placing these organisms in the neighbourhood of the *Hydractiniidæ*.

In a second paper ('Zeitschr. der deutscher geol. Gesellschaft,' Jahrg., 1881), Dr. Bargatzky describes a singular Stromatoporoid from the Devonian Limestone of Hebborn, near Paffrath, under the name of *Stachyodes ramosa*. The characters of the new genus *Stachyodes* I shall consider in detail later on. The species is identical with the *Stromatopora verticillata* of M'Coy.

In the 'Eleventh Report on the Geology of Indiana,' 1881, p. 400, Prof. James Hall figures a Stromatoporoid under the name of *Stromatopora pustulifera*?, Winchell, and quotes a previously published description of the same by Winchell.

In the 'Twelfth Report on the Geology of Indiana,' 1882, p. 263, Prof. Hall figures a Stromatoporoid, which he considers as probably identical with *Syringostroma densum,* Nich.

In 1881, 1882, and 1883, Monsieur E. Dupont published three successive papers on the structure of the Devonian and Carboniferous Limestones of Belgium, viz. (1) "Sur l'Origine des Calcaires Devoniens de la Belgique," 1881; (2) "Les Iles Coralliennes de Roly et de Philippeville," 'Bull. du Musée Royal d'Hist. Nat., t. i, 1882;' and (3) "Sur les Origines du Calcaire Carbonifère de la Belgique," 1883. In these papers the author draws attention to the very important part played by the Stromatoporoids in the formation of the Devonian Limestones of Belgium, and concludes that these organisms commonly constituted reefs of a similar nature to the coral reefs of the present day. M. Dupont is also of opinion that certain of the Carboniferous Limestones of Belgium (*e. g.* the Limestone of Waulsort) are composed of organisms related to the Stromatoporoids. For these organisms, or for certain of them, the author proposes the generic names of *Stromatactis*, *Stromatocus*, and *Ptylostroma;* but the distinguishing characters of these genera are not given. M. Dupont has been so good as to furnish me with specimens of *Stromatactis*, but I have not been able to recognise in these any characters which would lead me to suppose that they could be placed in the group of the Stromatoporoids.

In 1882, Mr. S. A. Miller described a Stromatoporoid from the Cincinnati group under the name of *Stromatocerium richmondense* ('Journ. Cincinnati Soc. Nat. Hist.,' vol. v). This paper I have not seen.

In 1883, Prof. Ferdinand Roemer published the second part of the text of his great work, the 'Lethæa Palæozoica,' the plates for this having appeared in 1876. In this work the Stromatoporoids are placed among the Hydrozoa, and an account of their general characters and structure is given. The author maintains most of the distinctive views which he had previously published with regard to these organisms. He regards the surface as invariably destitute of larger apertures of every kind, which is certainly not the case in various species in which "astrorhizæ" are well developed, many such having well-marked openings in the centre of the astrorhizæ. The composition of the horizontal "laminæ," out of horizontal anastomosing processes, which leave minute openings between them, is also not recognised by the author, though readily capable of demonstration in well-preserved examples. The "radial pillars" are looked upon as being invariably solid—a view which has been generally held, but which is certainly by no means always correct. The lower surface is rightly stated to be usually covered by a thin, concentrically-wrinkled epitheeal membrane, and not to be cemented down to some foreign body. The "astrorhizæ" are regarded, erroneously, as having no value as a specific character, and the absence of central vertical canals is asserted, though in certain forms such structures are commonly developed. The author's well-known views upon the nature of *Caunopora*, Phill., are here repeated, and the conclusion is expressed that "die angebliche Gattung begreift Stromatoporen die von röhrenförmigen, gewöhnlich zur Gattung *Aulopora* gehörenden, fremdartigen Körpern durchwachsen sind." The genus *Labechia*, E. and H., is placed among the Stromatoporoids, where it properly belongs; and the *Stromatopora dentata* of von Rosen, from the Silurian Rocks of Oesel, is referred to this genus. Lastly, with regard to the species of *Stromatopora* described by Prof. Roemer, it will be better to defer any points which may need discussion till a later period.

In 1883, Herr Eugen Schulz published a very interesting and valuable memoir on the Devonian Limestones of Hillesheim in the Eifel ("Die Eifelkalkmulde von Hillesheim, nebst einem palæontologischen Anhang," 'Jahrg. d. königl. preuss. geol. Landesanstalt für 1882;' Berlin, 1883). The author draws attention to the existence of a well-marked horizon in the Eifel Limestone of the Hillesheim basin, which is characterised by the presence of vast quantities of the singular organisms which Phillips described from the Devonian formation of Devonshire under the name of *Caunopora ramosa.* Herr Schulz points out that the structure of this fossil, of which he figures thin sections, is quite different to that of *Caunopora*, whether we regard the latter as a veritable organism or not. He therefore proposes the new genus *Amphipora* for the reception of this peculiar form.

In 1884, Mr. Carter published a paper under the title 'Note on the Assumed Relationship of *Parkeria* to *Stromatopora*, and on a microscopic section of *Stromatopora mammillata*, Fr. Schmidt" (Ann. and Mag. Nat. Hist., ser. 5, vol. xviii, p. 353). In this paper the author supports his previously expressed view that *Parkeria* is a Hydroid, "indirectly connected through *Hydractinia* with *Stromatopora*." He also confirms, from an examination of a thin section of *Stromatopora mammillata*, Fr. Schmidt, the statement of Murie and myself that the skeleton of the Stromatoporoids is "composed of non-spicular, granular, calcareous matter."

Dr. Carl Riemann has recently published some observations on some Stromatoporoids from the Devonian Limestones of Taubenstein, near Wetzlar ("Die Kalke des Taubensteins bei Wetzlar und ihre Fauna;" 'Neues Jahrb. für Min. Geol. und Palæontologie,' Beilage Band, iii, pp. 142—169, Taf. I, 1884). The limestones in question correspond in a general way with the "Stringocephalen-Kalk" of the Eifel, or with the "Brachiopoden-Kalk" of Schulz; and the author notes the occurrence in them of *Stromatopora concentrica*, Goldf., and *Diapora laminata*, Barg. With regard to the latter, Dr. Riemann supports the views of Bargatzky, and rejects the theory of commensalism put forward by Roemer. The grounds which have led him to take this view are briefly as follows.

(1) *Aulopora* does not appear to occur at Taubenstein, although *Diapora* is present.

(2) The tubes of *Diapora laminata* are much smaller in their diameter than are the tubes of *Aulopora repens*, the common Devonian species of *Aulopora*.

(3) It is very unlikely that any organism should be able to stretch its power of accommodating itself to changes of environment to the extent demanded by Roemer's theory of the commensalism of *Caunopora*. It is known from various observations, including those of Roemer himself ('Leth. Pal.,' p. 519), that each corallite of *Aulopora* ceases to grow so soon as it has begun to throw out buds, remaining thereafter completely stationary, and no longer extending itself vertically. In the case of *Caunopora*, if we admit the correctness of Roemer's views, we should have to suppose that, long after the corallites of *Aulopora* have thrown out buds and had therefore become stationary, they are capable of beginning an entirely new process of growth, as a consequence of entirely changed conditions of life. It would be difficult, however, to point to an analogy to this among recent organisms. So far as we can judge from what we observe at present, the power of accommodation to changes of environment is only possessed by organisms, to any marked extent at any rate, while they are in a state of active growth. On the other hand, when the organism has reached its full limits of growth and has become stationary, its power of accommodation is greatly restricted, and it rapidly perishes if subjected to conditions unsuitable for its life.

Still more recently, Prof. J. W. Spencer has described some Stromatoporoids from the Niagara formation of North America ('Bulletin of the Museum of the University of the State of Missouri,' vol. i, No. 1, pp. 43—52, 1884). The following are described as new species, *Caunopora Walkeri*, *C. mirabilis*, *Cœnostroma ristigouchense*, *C. botryoideun*, and *Dictyostroma reticulatum*.

Lastly, some Stromatoporoids have been described by Dr. Friedrich Maurer in an extensive and valuable memoir on the fossils of the Devonian rocks of the neighbourhood of Giessen ("Die Fauna der Kalke von Waldgirmes bei Giessen," 'Abhandl. der Grossh. Hess. geolog. Landesanstalt zu Darmstadt,' 1885). Dr. Maurer has had the great kindness to send me specimens of most of the forms which he has described, of which I have prepared thin sections; but all the specimens are in an unsatisfactory state of preservation, some being dolomitised, while others are highly crystallised or distorted by pressure. The form which Maurer has described and figured as *Stromatopora concentrica,* Goldf., is (like the form so named by most previous writers) an *Actinostroma*, and appears to be referable to *A. verrucosum*, Goldf., sp. The form identified as *Stromatopora Beuthii,* Barg., is the *S.* (*Caunopora*) *Hüpschii*, Barg., in its normal condition, *i.e. without* any "Caunopora-tubes." On the other hand, *S. indubia,* Maur., is the *S.* (*Caunopora*) *Hüpschii*, Barg., *with* numerous "Caunopora-tubes," and greatly distorted and altered by intense pressure. The species described by Maurer under the name of *S. turgicolumnata* is identical with the form which I understand (from the specimens sent to me by Bargatzky) to be *Stromatopora Beuthii*, Barg. I should also be disposed to think that the form named *Caunopora placenta*, Phill., is really identical with *S. Beuthii*, Barg., but the fragment sent me by Dr. Maurer is much crystallised and altered, and I should not like to be positive on this point. *Stromatopora maculosa*, Maur., is seemingly a true *Stromatopora*, and is related to *S. Beuthii*, Barg., or to *S. Hüpschii*, Barg., standing apparently very near to the latter; but in this case also the state of preservation is very bad. *S. hainensis*, Maur., I have not seen, and I am not able, therefore, to give any personal opinion as to its relationships; but it may perhaps be compared with the form which I have named *Stromatoporella eifeliensis*. Lastly, it may be mentioned that Dr. Maurer excludes from *Caunopora* all those examples in which there exist imbedded tubes with definite walls, and having horizontal connecting-tubes. Of all such examples he takes Roemer's view, namely that they are the result of the commensalism of a Coral with a Stromatoporoid. He therefore understands by *Caunopora* something quite different to what has been usually understood by this name.

II. GENERAL STRUCTURE OF THE SKELETON OF THE STROMATOPOROIDS.

1. General Form and Mode of Growth.

As regards their general form, the Stromatoporoids present themselves under the most varied aspects, while the mode of growth, though less variable, is also not absolutely constant even among the individuals of a single species. As a general rule, however, each species has a more or less highly characteristic form and mode of growth, from which it only departs when subjected to changes in its conditions of existence. The *typical* form of the skeleton of the Stromatoporoids is that of a hemispherical mass or a flattened expansion, attached by a narrow peduncle, or directly, to some foreign body, but having the under surface covered by a concentrically wrinkled imperforate epitheca, while the apertures for the emission of the polypites are carried upon the upper surface. In form and mode of growth, therefore, the majority of the Stromatoporoids may be, with complete accuracy, compared with the massive or laminated species of *Favosites*, *Pachypora*, *Alveolites*, or *Michelinia*. In a large number of species (such as *Labechia conferta*, E. and H., *Stromatoporella granulata*, Nich., *Clathrodictyon striatellum*, D'Orb., *C. fastigiatum*, Nich., *Stromatopora discoidea*, Lonsd., &c.), the form of the cœnosteum is almost always that of a thicker or thinner laminar expansion (Pl. III, fig. 7), often of large size, epithecate below, and attached by a narrow basal peduncle. In many other forms (such as *Stromatopora concentrica*, Goldf., *S. typica*, Rosen, and *Actinostroma clathratum*, Nich.) the skeleton is generally of a more massive character, mostly hemispherical or subspherical, the epithecate basal region being reduced in size as compared with the bulk of the organism. Not uncommonly in these more massive species the base is deeply concave, even in very large specimens, and it is sometimes difficult to imagine that the fossil could have been otherwise than quite free.

All the above-mentioned types of Stromatoporoids are occasionally liable to have their surface of attachment extended laterally, so as to suit the particular foreign body to which they may have been originally attached. Hence specimens may be met with in which the colony has been fixed by the greater part, or even the whole, of the lower surface. All of them also are liable to envelope other organisms which may happen to have attached themselves to their surface or to have grown up alongside of them. Hence it is common to meet with specimens which have grown round, or more or less completely enveloped, colonies of *Favosites*, *Alveolites*, *Syringoporæ*, various Rugose Corals, Orthoceratites, Lamellibranchs, or Gasteropods. It is also common to find that specimens of the Stromatoporoids support upon their surface colonies of *Aulopora*, *Favosites*, *Alveolites*, *Thecia*, &c.; these latter, in turn, occasionally supporting a second colony of the same or of some other species of Stromatoporoid. It is, finally, a common thing to find that in some particular locality the Stromatoporoids are particularly liable to grow round and envelope foreign organisms in the way above mentioned, whereas in other localities the same species may be found to manifest very little of this tendency. Thus, in the quarries in the Devonian Limestone of the Schlade-Thal, near Paffrath, the Stromatoporoids seem to have grown round and encrusted almost all the other fossils which occur in the rock; whereas in the Devonian Limestones in the Eifel the same species (such as *Actinostroma clathratum*, Nich.) are almost always massive and independent. This difference in different localities doubtless depends upon the fact that the local conditions, as to depth of water and the like, were not the same in the two areas, and that these organisms accommodated themselves to the particular environment in which they lived.

It is also to be borne in mind that the peculiarities above noted with regard to the mode of growth of the Stromatoporoids are by no means special to these organisms. Thus it is quite a common thing for the massive or laminar species of *Favosites* or *Alveolites* to attach themselves to foreign bodies, or to surround such extraneous organisms, or to have parasitic colonies growing upon their surface. In neither case do the observed phenomena lend any support to the view that the

Stromatoporoid or the Coral was an habitually "encrusting" organism, such as we see in the recent *Hydractinia.*

While the majority of the Stromatoporoids have the under surface largely free and covered by an epitheca, there are, however, other forms which have normally a different mode of growth. Thus certain forms are ordinarily ramose or dendroid, resembling in this respect the ramose species of *Pachypora* or *Alveolites.* This is the case, for example, with *Amphipora ramosa*, Phill., and *Stachyodes verticillata*, M'Coy (Plate VIII, fig. 9).

Lastly, there are species of Stromatoporoids in which the mode of growth is *habitually* an "encrusting" one. Thus, there occurs in the Eifler-Kalk of Gerolstein a Stromatoporoid with remarkably large astrorhizæ, which usually forms thin crusts, attached by their entire lower surface to the summit of expanded specimens of *Heliolites porosa*, Goldf., *Alveolites suborbicularis*, Lam., and *Chætetes stromatoporoides*, Roemer.[1] This species, however, though usually encrusting, is not invariably so, for I have collected examples of considerable thickness in which the under surface has been furnished with an epitheca. Some of the forms which were included by Goldfuss under the name of *Stromatopora polymorpha* (*e.g.* *S. curiosa*, Barg.) appear also to usually form crusts attached to the exterior of corals. This is, further, the case with the form which I described from the Devonian Rocks of North America under the name of *Stromatopora nulliporoides* ('Second Rep. on the Palæontology of the Province of Ontario,' p. 78).

Upon the whole, however, it may be unhesitatingly asserted that an "encrusting" mode of growth, such as we see in the recent *Hydractinia*, is very unusual among the Stromatoporoids, but that they mostly grow after a fashion very similar to what is seen in the majority of the species of *Favosites* and *Alveolites.*

2. Chemical Composition and Mode of Preservation.

The Stromatoporoids occur for the most part in limestones, but they are occasionally found in argillaceous sediments. They may be regarded, in fact, as having played quite as important a part in the formation of the older Palæozoic Limestones as even the Corals themselves, whole beds of Silurian and Devonian Limestone being often essentially made up of the remains of these organisms.

The majority of specimens of the Stromatoporoids are composed of carbonate of lime, but it is not unusual, in certain beds, to find specimens in which the skeleton is siliceous. This fact has led some observers to conjecture that the

[1] This curious Stromatoporoid (Pl. IV, fig. 2) is very abundant at the Auberg, near Gerolstein. It has been wrongly identified by Roemer with *Stromatopora concentrica*, Goldf. ('Lethæa Palæozoica,' p. 460). It is really a species of *Stromatoporella*, and may be provisionally termed *S. eifeliensis*.

Stromatoporoids possessed a primitively siliceous skeleton, and that all calcareous specimens owe their present constitution to the fact that the original silica of the skeleton has been replaced by carbonate of lime. This conjecture has been fully discussed by Dr. Murie and myself (' Journ. Linn. Soc.,' vol. xiv, p. 197), and the evidence against its correctness is so overwhelming that it is unnecessary to enter again into the question here. It is sufficient to point out that adequate proof of the fact that the skeleton of the Stromatoporoids was primitively calcareous in its constitution is to be obtained from the following considerations: Firstly, in all those Silurian and Devonian Limestones in which the Corals, Brachiopods, and other fossils are normally calcareous or non-silicified, the Stromatoporoids are also calcareous. Secondly, in all those deposits in which we meet commonly with Stromatoporoids having a siliceous skeleton, we find the Corals, Brachiopods, and associated fossils to be mostly or wholly silicified. Thirdly, the skeleton of the Stromatoporoids is composed, normally, of *granular* carbonate of lime, whereas if it had been originally composed of silica and had been replaced by carbonate of lime at some period subsequent to fossilisation, it ought to consist of *crystalline* carbonate of lime.

As I shall point out immediately, there *are* cases among the Stromatoporoids where the original skeleton has been replaced by calcite; but these lend no support to the view that the skeleton was primitively siliceous, and seem really to point to the fact that the skeleton was composed of *arragonite*, rather than of ordinary carbonate of lime.

There are, in fact, three principal modes of preservation under which specimens of the Stromatoporoids present themselves. In the first group of specimens, comprising by far the larger number of ordinary examples, the actual skeleton has been preserved more or less unchanged, and all the cavities of the skeleton have been infiltrated with transparent calcite. In such specimens (Plate I, fig. 1) the skeleton is readily distinguished from the calcareous infilling of the chambers, in thin sections, by its brown colour and granular or cloudy, non-crystalline texture. In certain cases, however, the skeleton has undergone a partial secondary crystallisation, and is then only distinguishable from the calcite-matrix by its darker colour and less complete crystallisation. Specimens of this kind occur more commonly in dolomitic limestones than in ordinary limestones, though sometimes seen in the latter.

In a second group of specimens, more or less complete silicification has taken place. In some examples, the actual skeleton has remained more or less completely calcareous, while the cavities of the skeleton have been filled in with silica. In other cases, not only is the infilling of the chambers siliceous, but the skeleton itself has been replaced by silica. In other cases, again, the porous skeleton of the Stromatoporoid has, to begin with, been infiltrated with water holding mineral substances in solution, the result being the formation of a thin layer of crystals of carbonate of lime or of silica in the interior of the chambers; and then at a later stage all the remaining cavities have been filled up with transparent silica (Plate I, fig. 2).

In a third group of specimens, of comparatively rare occurrence, a still more remarkable series of changes has taken place. The specimens in question are preserved in limestones or in argillaceous deposits, and the first change to which they were subjected consisted in the complete infiltration of the porous skeleton, not with transparent calcite as in the first group of cases, but with fine calcareous mud or minutely levigated argillaceous sediment. When in this condition, we must suppose that the calcareous skeleton was more readily soluble in percolating water than the calcareous or argillaceous mud filling the interstices of the fossil—this greater solubility being due either to the fact that the skeleton consisted of arragonite, or perhaps merely to its being impregnated with organic matter. The next step in the process, therefore, consisted in the gradual dissolution of the skeleton and its replacement by *crystalline carbonate of lime*, the infilling of the chambers remaining in the meanwhile unaltered. Hence, thin sections of such specimens show a precisely reversed condition of matters to what we observe in ordinary non-silicified examples. Instead of seeing the dark-coloured skeletal framework filled in with transparent calcite, we now see the entire skeleton represented by clear calcite, while the chambers, pores, and canal-system of the fossil are represented by comparatively opaque calcareous mud or fine argillaceous sediment.

It is only comparatively recently that I have been led to recognise this very peculiar mode of preservation as occurring among the Stromatoporoids, and that I have been able to interpret the very puzzling phenomena to which it gives rise. It occurs, among British specimens, most commonly in certain of the Stromatoporoids of the Devonian Limestones of Devonshire, and especially in a form (*S. dartingtonensis*, Carter) with exceedingly large astrorhizæ.[1] I have figured (Plate IV, fig. 1) a portion of a tangential section of this form, in this state of preservation, showing the appearances which it presents when the canal-system and chambers are in this way filled up with comparatively opaque calcareous mud. For comparison with this, I have also figured the same section, as it would appear supposing it to have been preserved in the ordinary manner, viz. with the skeleton comparatively opaque and the canal-system and chambers filled in with transparent calcite (see Plate IV, fig. 1, *a*).

A still more easily recognisable case of the same mode of preservation is presented by a specimen (in my collection) of an apparently undescribed species of *Labechia* from the Cincinnati group of Ohio, which I may provisionally term *L.*

[1] The form in question has been spoken of by Mr. Carter as *Stromatopora elegans*, Rosen, but it is really only a peculiar condition of *S. Dartingtonensis*, Carter, and is quite distinct from Rosen's species.

ohioensis[1]. In this specimen all the interspaces of the fossil have been filled in with a fine-grained greenish calcareous mud, the skeleton having been subsequently dissolved out and then replaced, more or less completely, with transparent calcite (Pl. II, figs. 1 and 2). Another case of the same mode of preservation is presented by the curious fossil described by Dr. Murie and myself from the Trenton Limestone of Canada, under the name of *Stromatocerium canadense* ('Journ. Linn. Soc.,' p. 223, Pl. iii, figs. 9 and 10). At the time we described this fossil, we had not observed any cases of the mode of preservation now in question, and we therefore naturally regarded the portions of the fossil which were composed of calcite as being the canals and chambers of the organism, and the dense and opaque portions as being the skeleton. In reality, however, the chambers have been filled with dense calcareous mud, and the skeleton has been replaced by calcite (Pl. II, figs. 3—5). *Stromatocerium canadense*, Nich. and Murie, when viewed in this light, is therefore no longer the anomalous form that it appeared to be, but is readily recognised as a species of *Labechia*, which, being apparently distinct from previously described forms, must stand as *L. canadensis*, Nich. and Murie.

3. Minute Structure of the Stromatoporoids.

All palæontologists probably will readily admit that the study of the Stromatoporoids can only be prosecuted, with any certainty, by means of properly prepared thin sections, which can be examined under the microscope by means of transmitted light. In mode of growth, in their general form, and in their merely superficial characteristics, many Stromatoporoids present a remarkable similarity; and hence many observers have been led to regard the majority of these organisms as being nothing more than variations of a common type, their differences being supposed to be due to local conditions, or to the adaptations rendered necessary in different individuals by differences in their environment. Thus, even at the present day, so distinguished and acute an investigator as Professor Ferd. Roemer is inclined to regard the greater number of the Devonian Stromatoporoids of Germany as mere variations of the *Stromatopora concentrica* of Goldfuss, and a considerable number of the Upper-Silurian forms as variations of *S. striatella*, D'Orb.

My own experience, based on a study of many hundreds of microscopic slides, has led me to the conclusion that the minute internal structure of the skeleton of the Stromatoporoids shows very remarkable and constant differences, even in types which in external aspect are not very dissimilar; that in properly prepared sections

[1] So far as I am aware, no species of *Labechia* has been hitherto recorded from the Silurian Rocks of North America. *Labechia ohioensis* differs from *L. conferta*, Lonsd., in the greater delicacy of the radial pillars, these structures often appearing to be angulated rather than round, while the vesicles of the interstitial tissue are much more minute than in the latter species.

these differences can be recognised with absolute certainty, provided the internal structure has not been destroyed in the process of fossilisation; and that both in consistency and in amount they are perfectly adequate for the discrimination of the different species, or for the establishment of generic distinctions. Moreover, when once the peculiarities of the microscopic structure have been fully recognised, it is usually quite easy to correlate these with small and otherwise hardly recognisable external characteristics, so that it becomes, in general, a comparatively light matter to determine the position of a given specimen by a mere macroscopic examination. I do not mean to assert that the generic divisions of the Stromatoporoids are all rigidly marked off by their minute structure, for there are types, of an inosculant character, which it is difficult to place definitely in one genus rather than in another. Nor do I mean to assert that one does not meet with specimens which can only with difficulty and uncertainty be determined even with the help of microscopic sections. I do mean to assert, however, that the minute microscopic structure of the skeleton of the Stromatoporoids may be relied upon in the determination of species or genera, to just the same extent, with just as much certainty, and under precisely the same limitations, as in the case of the Corals or the Polyzoa.

There is, however, a special and exceptional difficulty in the case of the Stromatoporoids in the preparation of thin sections, which should not be passed over wholly without remark. As will be seen immediately, the skeleton of the Stromatoporoids consists essentially of two sets of elements, one radial and the other tangential, as regards the whole specimen, and therefore in the main intersecting each other at right angles. Hence, two sets of sections must in all cases be prepared, viz. one section parallel with the radial (or vertical) elements of the skeleton, and one at right angles to this, parallel with the tangential (or horizontal) elements of the skeleton. If the two component elements of the skeleton were rectilinear, and cut each other accurately at right angles, it would be an easy matter to prepare such sections. As a matter of fact, however, the vertical or radial elements of the skeleton are usually flexuous, and the tangential or concentric elements are invariably more or less curved; so that it is a matter of more or less difficulty to prepare slides which shall be accurately parallel to either of these sets of elements. It is, however, absolutely necessary to secure approximate parallelism to the constituent elements of the skeleton, if the sections are to yield reliable information. A very slight obliquity—especially in vertical sections—causes a distortion of the structure, which may be recognised and allowed for by the experienced observer, but which is exceedingly likely to mislead anyone who has not examined a large series of specimens. For the same reason, the beautiful polished sections prepared by lapidaries are in many cases of comparatively little value for working purposes, as they are cut at all angles of obliquity to the component parts of the skeleton, and thus yield results which may be easily misleading.

Moreover, under certain circumstances, which are not easy to explain, the skeleton of the Stromatoporoids is liable to undergo a more or less complete secondary crystallisation, by which the internal structure is greatly obscured or, it may be, completely obliterated. This is seen in many of the specimens from the Devonian Limestones of Devonshire, and particularly in many of those found in the rolled limestone pebbles of the Triassic conglomerates of South Devon. In these cases, it would seem probable that the crystallisation is largely connected with mechanical causes, as it is almost always accompanied with a greater or smaller amount of distortion of the skeletal framework. In other cases, however, the crystallisation is the result of an internal rearrangement of the particles of which the skeleton is composed, the general form of the skeleton remaining unchanged, while the surface and the epitheca may be beautifully preserved. This is commonly seen in the Stromatoporoids of the Wenlock Limestone of Gotland and of Esthonia, and, more rarely, in specimens from the Wenlock Limestone of Britain.

In the following general account of the structure of the skeleton of the Stromatoporoids, it will not be possible to take any one single type as illustrative of the main facts to be considered, as there exist very wide variations within the limits of the group, as here understood. We shall find, however, that these variations may, on the whole, be reduced to one or other of two leading types of structure. In one series of forms, of which the true *Stromatopora concentrica* of Goldfuss is the type, the skeleton is of what may be called the "Milleporoid" type, having what Mr. Carter has designated as a "curvilinear" structure. In the other great series of forms, typified by *Actinostroma clathratum*, Nich.,[1] the skeleton is of what may be termed the "Hydractinioid" type, having what Mr. Carter has called the "rectilinear" structure.

The bond of union by which these two groups of forms are linked together, is found in the fact that the calcareous cœnosteum in both groups can be shown to be made up of two sets of elements, one vertical to the surface, and the other parallel with the surface. In the "Milleporoid" series, typified by *Stromatopora*, Goldf., the vertical or "radial" elements are so combined with the horizontal or "concentric" elements as to give rise to a continuously reticulated skeleton, in which the elementary constituents are with difficulty recognisable as distinct structures. On the other hand, in the "Hydractinioid" series, typified by *Actinostroma*, Nich., the "radial" and "concentric" elements of the skeleton remain more or less clearly recognisable as distinct structures, and the skeleton never has the form of a continuous vermiculate reticulation.

[1] It is to be borne in mind, as previously explained, that the form here called *Actinostroma clathratum* is what has hitherto been regarded as being *Stromatapora concentrica*, Goldf., a microscopic examination of the original of the latter having shown that its structure is quite unlike what it was supposed to be.

The one feature which, perhaps more conspicuously than any other, characterises the entire group of the Stromatoporoids, is the constitution of the skeleton, more or less obviously, of superimposed concentric layers. Sometimes, as in *Stromatopora concentrica*, Goldf., the skeleton is composed of concentric strata ("latilaminæ) of considerable thickness (Plate V, figs. 8 and 9). In such cases, the intervals between two of the "latilaminæ" merely mark periodic pauses in the growth of the skeleton, and it is difficult or impossible to recognise any composition of the individual strata out of secondary layers or "laminæ." Each stratum, or "latilamina," is made up of a series of parallel vertical rods ("radial pillars"), which run from the top to the bottom of the stratum, and are united at irregular intervals by oblique or horizontal processes (Plate V, figs. 10 and 15; Plate XI, fig. 18). The intervals between these vertical rods are the tortuous tubular canals in which the zoöids of the colony were lodged, and they are often "tabulate." In other forms the entire skeleton is made up of closely approximated concentric layers, or "laminæ," which may or may not be arranged in thick strata, or "latilaminæ" (Plate I, figs. 9 and 12). The "laminæ" are not in absolute contact, but are separated by narrower or wider interspaces ("interlaminar spaces"). These interspaces are intersected by numerous vertical columns ("radial pillars"), which connect together the laminæ bounding the interspace on both sides, and may run continuously through several interspaces and laminæ. Reduced to its simplest expression, the above may be taken as giving the essential structure of a typical Stromatoporoid; but it will be necessary to discuss the different elements of the skeleton separately and in greater detail, and to consider the more important variations which they exhibit in different types of the group.

(*a*) *The Skeletal Tissue.*—The investigation of the ultimate structure of the skeletal tissue of the Stromatoporoids is a matter of great difficulty, owing to the fact that in many specimens the skeleton has undergone considerable secondary alteration, while probably none retain their original constitution unchanged. There is, in fact, considerable reason for concluding that the skeleton was originally composed of arragonite, and that in almost all, or perhaps all, specimens which have not been silicified, the arragonite has become more or less extensively replaced by calcite. In the case of the Stromatoporoids from the pebbles of Devonian limestone contained in the Triassic conglomerates of Devonshire, the skeleton usually consists, like the matrix, of crystals of calcite, and is chiefly distinguishable from the matrix by its darker colour. Hence, in these specimens little or no advantage can be gained by the preparation of very thin sections, as the reduction of the slide to extreme tenuity renders the skeleton more or less inconspicuous, or even undistinguishable from the surrounding matrix. In specimens which have undergone less alteration during the process of fossilisation, as in most of the examples from the Wenlock Limestone of Britain, the skeleton of certain types (*e. g. Actinostroma* and *Clathrodictyon*) seems to be composed of exceedingly minute granules of carbonate of lime. In thin sections of such types (Plate I, fig. 1) the skeleton-fibre appears generally to be of a much darker colour than the matrix, and often presents a tolerably uniform cloudy or granular aspect, mostly darkest in the centre, and shading off to a blurred and ill-defined margin. Under high magnifying powers, and in sufficiently thin sections, innumerable minute irregular dark specks, sometimes with a clear centre, may be seen to be disseminated through the fibre. The form of these specks is very irregular, and it is their presence which gives to the fibre its cloudy aspect when examined under low magnifying powers. I am inclined to think that these specks are certainly of the nature of minute vacuities in the fibre, more or less completely filled up with opaque matter, and that they represent the system of minute pores or tubuli which characterise the skeleton-fibre of certain other types. These minute specks are exceedingly well shown in very thin sections of *Labechia conferta*, in which I shall be able to show that the radial pillars have an unquestionable cribriform structure.

In no case has any observer succeeded in detecting anything of the nature of definite *spicules* in the skeleton-fibre of the Stromatoporoids; and this has always been one of the strongest arguments against the reference of these organisms to the Sponges.

There are, however, many Stromatoporoids in which the skeletal tissue has an obviously complex character, the nature of which can not be always fully determined. Thus, in all the species of the genus *Stromatopora*, Goldf., thin sections, taken either tangentially or vertically, exhibit a characteristic dotted or porous structure, the skeleton-fibre being marked with innumerable oval or rounded, clear spaces, surrounded by dark granular tissue (Plate I, figs. 6 and 7). In some cases, as in *S. Carteri*, n. sp., *S. Beuthii*, Barg. (Plate V, figs. 12 and 13), *S. Hüpschii*, Barg. (Fig. 6), and others, this vesicular structure of the fibre is upon such a large scale as to be recognisable with the use of a hand-lens and in merely polished slabs. In most cases thin sections are necessary for its demonstration. In other cases, the structure, though essentially the same as in the forms above mentioned, is more minute. Thus in the common *S. typica*, Rosen, of the Wenlock Limestone, the skeleton-fibre, as seen in thin sections, has a minutely dotted aspect (Plate I, fig. 3), the clear spaces in the fibre being very small, and often replaced by opaque dots. That in all these cases the clear spaces in the fibre are really of the nature of vacuities, filled with transparent calcite, can hardly be doubted; and that these vacuities are of the nature of *vesicles* rather than of *tubes*, would seem certain from the fact that there is no sensible difference in their shape as displayed either in tangential or in vertical sections.

In the species of the genus *Stromatoporella*, Nich., not only is the skeleton-fibre similarly vacuolated, but the cavities in the fibre often assume the character of a system of minute branching tubuli. Thus, in *Stromatoporella granulata*, Nich., from the Hamilton formation of Canada, in which the skeleton has undergone little change, tangential sections (Plate I, fig. 4) show that the skeleton-fibre is traversed by numerous minute vesicular cavities and elongated or flexuous canaliculi, separated by the ordinary granular tissue of the skeleton. Vertical sections (Plate I, fig. 5) exhibit the same condition of things, the minute channels of the fibre being mostly directed vertically, and leaving a comparatively clear central line in the centre of the fibre. The same structure is still better shown in other species of *Stromatoporella*. Thus in *S. eifeliensis*, Nich. (Plate XI, figs. 1 and 2), both the horizontal laminæ and the radial pillars are seen in really well-preserved examples to be traversed by a central clear space, connected on both sides with a complex system of ramifying canaliculi, which branch out in the substance of the fibre. There seems no reason to doubt that the clear central line above spoken of is really a tube, and that the entire system is one of minute intra-skeletal tubuli filled during life with living matter, similar to what is found in the skeleton of the living *Distichopora* (Plate IV, fig. 4, and Plate IX, fig. 5). A system of precisely similar tubuli is found in an allied species of *Stromatoporella* from the Eifel (Plate XI, figs. 3 and 4). On the other hand, in *S.* (*Diapora*) *laminata*, Barg., the skeleton-fibre has more of a coarsely porous than of a tubulated structure (Plate XI, fig. 10), tangential sections of this species often showing here and there comparatively large-sized clear circular spaces, which seemingly represent the axial canals of the radial pillars.

The cases just considered are alike in the fact that the skeleton-fibre, as seen in thin sections, is opaque and granular, while the pores or tubuli appear as clear spaces in the substance of the fibre. There are cases, however, in which this state of things is reversed. This is seen on a large scale in the genus *Hermatostroma*, in which the skeleton-fibre is composed of clear and transparent carbonate of lime, exhibiting in its interior conspicuous opaque dots and lines. In vertical sections (Plate III, fig. 2) each radial pillar exhibits a dark central axis, while similar but more slender lines run in the interior of the horizontal laminæ. In tangential sections (Plate III, fig. 1) each transversely-divided radial pillar exhibits a central dark dot, from which often radiate delicate dark lines. It is hardly possible that we can here have anything else to deal with than a more or less complicated canal-system in the interior of the skeleton-fibre, the larger divisions of which are now injected with some opaque material, such as oxide of iron.

The same phenomenon on a more minute scale, and in a completely convincing form, is shown by specimens of *Stachyodes verticillata*, M'Coy, sp. In some examples, namely, of this species the skeleton-fibre is traversed by delicate tubuli, which appear in cross sections as transparent dots (Plate XI, fig. 6), and in longitudinal sections as clear lines. In other specimens of the same species no tubuli are visible, but the skeleton-fibre exhibits in tangential sections numerous dark dots (Plate XI, fig. 5), and in long sections corresponding delicate dark lines. It cannot be doubted that the different appearances presented by different examples of this species depend upon the nature of the material which has served as the infilling of the canal-system of the fibre, the tubuli being in the one case filled with transparent calcite, and in the other with opaque oxide of iron.

There are, however, still other cases in which the appearances presented by the skeleton-fibre are more puzzling, though the phenomena just recounted would seem to afford a key to their true nature. One of the cases in question is that of *Parallelopora ostiolata*, Barg., of which, through the kindness of Professor Schlüter, I have investigated the original specimen. In tangential sections of this singular type (Plate II, fig. 6) the skeleton-fibre is seen to be thick and reticulated, and to be composed of nearly transparent carbonate of lime. Scattered through the transparent fibre, and particularly abundant on its edges, are numerous conspicuous dark dots, of oval, circular, or elongated shape, and of variable size. Some of the dots show a minute ill-defined light centre, but they are mostly quite opaque. In vertical sections of the same these dark dots are seen to be the cut ends of minute rod-like bodies, which are prolonged vertically downwards, running parallel with one another in the substance of the skeleton-fibre (Plate II, fig. 7) in the intervals between the tabulate zoöidal tubes. These rods are dark and opaque, and are connected together at tolerably regular intervals by dark horizontal lines, which constitute a series of horizontal or concentric laminæ. It seems to me that the most probable explanation of the appearances just mentioned is that the dark rod-like bodies in the substance of the skeleton-fibre are really of the nature of delicate tubuli filled up by some opaque material, and that the dark cross lines by which they are connected together represent a system of horizontal tubuli similarly injected. The phenomena previously alluded to as seen in thin sections of *Stachyodes verticillata*, M'Coy, and *Hermatostroma Schlüteri*, Nich., would entirely bear out this view of the subject. Moreover, this explanation is further supported by an examination of one of the other species of *Parallelopora*, viz. *P. Goldfussi*, Barg., of which I have also been able to examine the original specimens. In this form the thick reticulated skeleton-fibre is seen in thin sections to be traversed by numerous comparatively large vacuities or clear spaces (Plate XI, fig. 9), which are bounded by dark tissue. These were regarded by Bargatzky ('Die Stromatoporen des rheinischen Devons,' figs. 10 and 11) as being so many vertical "cœnenchymal tubes." In one sense this view is correct, since these tubes were doubtless filled with organic matter during life; but the "cœnenchymal canals" of this and other similar forms are, strictly speaking, the much larger canals which place the different zoöids in communication. The tubuli of *P. Goldfussi*, Barg., do not, however, differ essentially from the still more minute vesicles and tubuli which are found in the skeleton-fibre of *Stromatopora*, *Stromatoporella*, and *Stachyodes*, and they are not so regular nor so continuous as they are shown to be in Bargatzky's figures, while they have much thicker walls. Moreover, if we examine thin sections of other specimens of what I believe to be the same species (which is very probably the same as the *Stromatopora capitata* of Goldfuss) we find that the skeleton-fibre exhibits in thin tangential sections numerous large, dark, rounded dots, which in longitudinal sections are seen to be really the cut ends of dark rod-like bodies, the fibre itself being clear and transparent (Plate XI, figs. 7 and 8). I take it, therefore, that in this case also we have really to deal with a system of vertical canals, which run in the skeleton-fibre, and are connected at intervals by cross branches, and that the different appearances presented by different specimens result from the infiltration of these canals in the one set of examples with calcite, and in the other set with oxide of iron.

(*b*) *The Radial Pillars and Concentric Laminæ.*—If such a Stromatoporoid as *Actinostroma clathratum* be examined, the skeleton is seen to consist of two principal sets of structures, one "radial" or vertical, the other "concentric" or horizontal. These may be termed respectively the "radial pillars" and the "concentric laminæ" or "horizontal laminæ" (Plate I, figs. 9 and 12). These may be exceedingly distinct, or they may be so far blended together as to be hardly or not at all recognisable as separate structures, so that it is almost a matter of necessity to deal with these two constituents of the skeleton in conjunction.

In most Stromatoporoids the "concentric laminæ" are the most conspicuous structures, as giving rise to the characteristic foliated structure of most of the fossils of this group. The skeleton, in fact, will in most cases split more or less readily in a direction parallel with these laminæ, and therefore tangential to the general surface; whereas it has little or no natural tendency to fracture in directions at right angles to the surface, *i.e.* parallel to the radial pillars. The laminæ are never strictly "horizontal," but are more or less undulated or curved, the entire skeleton being thus more or less obviously formed of concentrically disposed layers. In certain forms, moreover, (*e.g. Actinostroma verrucosum*, Goldf.) the laminæ are only partially concentric as regards the general surface, but are concentrically arranged with regard to a number of points or lines of growth.

Successive laminæ are separated by interspaces which are usually much wider than the laminæ themselves, and which are termed the "interlaminar spaces." These spaces are most conspicuous in forms such as *Actinostroma* and *Clathrodictyon* (Plate I, figs. 9 and 1). Even in these cases the interlaminar spaces are not absolutely continuous, but are intersected at right angles by the "radial pillars," which spring from the lamina which bounds the interspace inferiorly and extend upwards, sometimes falling short of the upper bounding lamina, sometimes reaching it and sometimes being continued onwards through many successive laminæ and interlaminar spaces. On the other hand, in the genus *Stromatopora*, Goldf., itself, and in some other forms, the interlaminar spaces become reduced to rows of irregular chamberlets, or may even be almost obsolete (Plate V, fig. 15, and Plate VII, fig. 2).

Growth of the skeleton in the Stromatoporoids is effected by the upward extension of the radial pillars, and the production of successive concentric laminæ from their apices. In many Stromatoporoids there occurred, in addition, periodic pauses in the upward growth of the pillars and in the production of new laminæ, giving rise to a sort of major stratification of the skeleton. That is to say, the skeleton is now not only composed of successive "concentric laminæ," but these in turn are arranged in concentric strata of comparatively considerable thickness. Successive strata may be in contact, or may be separated by incomplete intervals, which are sometimes partially filled up with the matrix (Plate V, figs. 8 and 9). In any case, the fossil splits more easily along the lines of division between successive strata than elsewhere. I shall apply the term of "latilaminæ" to these thick strata, which result from an intermittent method of growth. They are very conspicuous in some types of *Actinostroma* (*e.g.* *A. clathratum*, Nich.); but they are exhibited in perfection in many species of the genus *Stromatopora*, Goldf., and particularly in the type-species *S. concentrica*, Goldf. (Plate XI, fig. 15). There, is, moreover, this difference between the "latilaminæ" in the cases just mentioned. In *Actinostroma*, namely, each "latilamina" is made up of a series of subordinate "concentric laminæ;" whereas in the true *Stromatoporæ* the proper "concentric laminæ" can not be said to have any recognisable existence, or are, at any rate, imperfectly developed; so that the "latilaminæ" have no tendency to split along a subordinate series of concentric layers.

As regards the *general* arrangement of the "radial pillars" and "concentric laminæ," the genera *Stromatopora*, Goldf., and *Actinostroma*, Nich., may be taken respectively as types of the two principal sections of the Stromatoporoids, namely, the Milleporoid and the Hydractinioid sections. In the genus *Stromatopora*, Goldf., the radial pillars and concentric laminæ are completely amalgamated with one another, and are hardly recognisable, as a rule, as distinct structures. Hence, in tangential sections of such forms (Plate V, figs. 14 and 15, and Plate XI, fig. 16) the skeleton is seen to be a continuous reticulation, resembling that of *Millepora*. In vertical sections of the same, the radial pillars can usually be recognised to be present, but they are thick, irregular, and flexuous, and the "concentric laminæ" are only represented by irregular lateral outgrowths, which spring from the pillars and unite them into a continuous framework (Plate V, figs. 15 and 17, and Plate XI, fig. 18). In certain of the *Stromatoporæ*, however, though the skeleton has the completely reticulate structure which characterises the genus, the "radial pillars," nevertheless, persist as distinct structures. Thus, in tangential sections of *S. Bouthii*, Barg., the cut ends of the radial pillars can be recognised in the interior of the general reticulation (Plate V, fig. 12), and their existence can also be made out in vertical sections (Plate V, fig. 13). This fact—and there are other similar ones in other species—show that the striking dissimilarity between the true *Stromatoporæ* and the *Actinostromata* is more apparent than real, and that similar structural elements are really present in both.

On the other hand, in the "Hydractinioid" section of the Stromatoporoids, represented by forms such as *Actinostroma clathratum*, Nich. (the *Stromatopora concentrica* of authors), the radial pillars and concentric laminæ are present as distinct, though closely connected structures. Thus, in vertical sections of *A. clathratum* (Plate I, figs. 9 and 12) we observe a series of longer or shorter parallel vertical rods, placed at tolerably equal distances, and connected at regular intervals by a series of parallel horizontal laminæ. The vertical rods, or "radial pillars," appear to vary much in length, but this is really due to the fact that the section never passes along the plane of any one rod for more than a very limited distance. In reality, the radial pillars are in this species continuous for very considerable distances, running persistently through twenty or thirty, or more, successive laminæ and interlaminar spaces. Indeed, as this species is one which grows with "latilaminæ," it is probable that most of the radial pillars run continuously from the lower surface of a latilamina to the upper surface of the same. If the section under examination be at all oblique, or inclined to the axes of the radial pillars, then the pillars appear to run only from one lamina to the next, instead of showing their true "continuous" character.

If we next look at a tangential, or horizontal, section of *Actinostroma clathratum* (Plate I, figs. 8 and 11), we necessarily see the transversely-divided ends of the radial pillars, in the form of either rounded or stellate dots, placed at tolerably regular intervals. The precise form in which the cut ends of the radial pillars present themselves depends upon the precise level at which they happen to have been divided in the section examined. The radial pillars, in fact, give out at regular intervals verticils of horizontal connecting-processes or "arms," which join with one another to form a more or less complete network, as they are given out at successive corresponding levels by all the pillars. Each successive "concentric lamina" is thus formed by the fusion of the ends of the connecting-processes or "arms" of the radial pillars at a given level. Hence, if the line of the section passes along the plane of one of the concentric laminæ, then the cut ends of the radial pillars have a stellate form (Plate I, fig. 10); the "arms" forming by their union an angular meshwork not unlike the skeletal framework of a "hexactinellid" sponge. If, on the other hand, the line of the section should correspond with one of the interlaminar spaces, then the cut ends of the radial pillars appear to be simply rounded or oval (Plate I, fig. 13). Owing to the undulating form of the fossil, all obtainable tangential sections, as a matter of fact, run partly through the horizontal laminæ, and partly through the interlaminar spaces.

As regards the "concentric laminæ" of *Actinostroma clathratum*, Nich., and of similar forms, very different appearances are presented by tangential and vertical sections respectively. The former show us, as above pointed out, that the concentric laminæ are really formed by the inosculation and fusion of the radiating processes, or "arms," thrown out by the radial pillars at definite and corresponding intervals. It follows from this that the concentric laminæ are not, strictly speaking, "laminæ" at all, but that they are really only a closer or looser reticulation of calcareous fibres, penetrated by more or less numerous pores of various sizes and shapes (Fig. 1, A). Hence, if we examine the surface of any concentric lamina in *Actinostroma clathratum*, either by looking at the actual surface or by studying the plane of a concentric fracture, or if we take a properly prepared tangential section, we can observe numerous minute pores passing through the lamina, and placing the interlaminar space below the lamina in direct communication with the interlaminar space above the same. These pores are most readily recognised as being truly "pores," if we have under observation such forms as any of the true *Stromatoporæ*, in which the general skeleton is reticulated and continuous, but we cannot refuse this name to the wider, more open, and more irregular meshes formed by the union of the horizontal "arms" in the typical *Actinostromata* (Plate I, figs. 8 and 10).

FIG. 1.

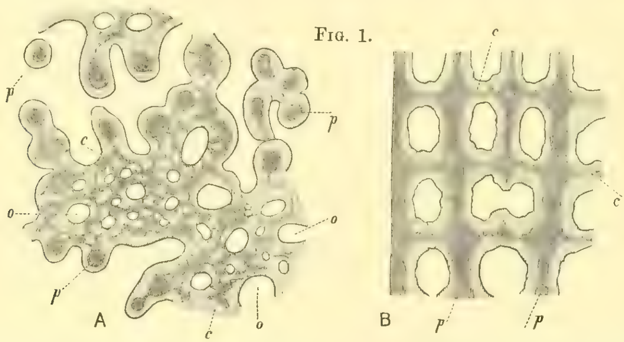

FIG. 1.—Thin sections of *Hermatostroma Schlüteri*, Nich. A. Tangential section. B. Vertical section. Enlarged twenty-four times. The tangential section passes along the plane of one of the concentric laminæ, and shows the cut ends of the radial pillars with their axial canals (*p p*), the extension of the canals into the laminæ (*c c*), and the pores formed by the inosculation of the horizontal processes or "arms" (*o o*). The vertical section shows the axial canals of the pillars (*p p*) and the extensions of these canals horizontally into the concentric laminæ (*c c*). Devonian, Herborn, near Paffrath.[1]

[1] I take this opportunity of expressing my sense of the very admirable manner in which Mr. Charles Ferrier, F.L.S., has engraved on the wood such highly trying subjects as the thin sections figured in this work.

Most Stromatoporoids show, in one form or another, similar openings in the concentric laminæ, and we can hardly doubt that they served for the passage of stolons of the cœnosarc, and, in the last formed lamina, for the emission of zoöids.

In spite of the fact that the concentric laminæ are thus porous, they necessarily present themselves in thin *vertical* sections as continuous horizontal lines, since the interlacing "arms," out of which they are formed, are placed at corresponding levels (Plate I figs. 9 and 12).

(*c*) *Variations in the Structure of the Radial Pillars and Concentric Laminæ.*—The above is, in brief, the general structure of the skeleton in the two great sections of Stromatoporoids represented respectively by *Stromatopora*, Goldf., and *Actinostroma*, Nich. There are, however, numerous more or less striking deviations from this type which require consideration. Most of these will be best discussed in connection with the descriptions of the genera and species. It will be sufficient, therefore, here merely to deal briefly with certain points of special structural importance.

FIG. 2.

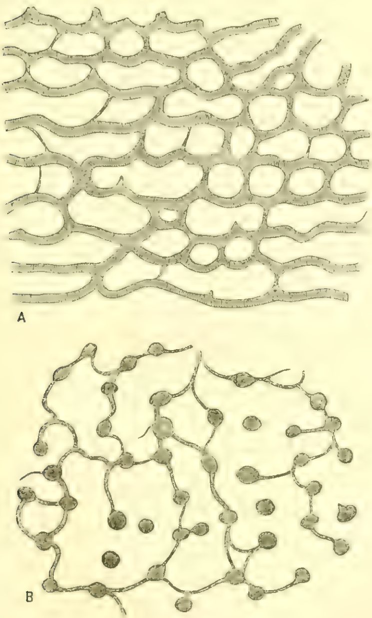

FIG. 3.

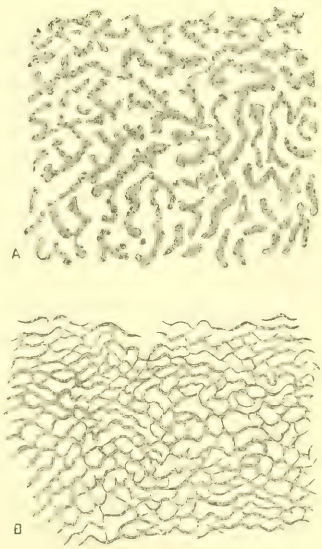

FIG. 2.—A. Vertical section of *Clathrodictyon cellulosum*, Nich. and Mur., enlarged twelve times. B. Tangential section of the same, similarly enlarged. Corniferous Limestone, Wainfleet, Ontario.

FIG. 3.—A. Tangential section of *Clathrodictyon fastigiatum*, n. sp., enlarged twelve times. B. Vertical section of the same, similarly enlarged. Wenlock Limestone, Dormington.

As regards the "radial pillars," the following are the chief variations to be noted:—In the genus *Clathrodictyon*, Nich. and Mur., the radial pillars are incomplete, or even almost obsolete as distinct structures. In some forms of the group, such as *C. regulare*, Rosen, the radial pillars are confined to their respective interlaminar spaces, running from their lamina of origin to the lamina next above, but not being continued through more than one interlaminar space (Plate V, fig. 1). In *C. striatellum*, D'Orb., a nearly allied Silurian species, the pillars are not only confined to their respective interlaminar spaces, but many of them are imperfect, and fall short of the lamina next above that from which they arise (Plate V, fig. 3). In the more typical species of *Clathrodictyon*, such as *C. cellulosum*, Nich. and Murie, *C. vesiculosum*, Nich. and Mur., *C. variolare*, Rosen, and *C. fastigiatum*, n. sp., the concentric laminæ are crumpled into numerous minute undulations, which become continuous with the radial pillars. In these cases, therefore, the radial pillars become largely confounded with the concentric laminæ, the appearance exhibited by vertical sections (Fig. 2, A, and Fig. 3, B, and Plate V, figs. 5 and 6) being that of vesicular tissue composed of larger or smaller cells arranged in rows. The radial pillars in these cases have, however, nevertheless, a real existence, as shown by the fact that their cut ends can generally be recognised clearly in tangential sections (Fig. 2, B, and Fig. 3, A).

In the genus *Labechia*, E. and H., the radial pillars reach their maximum of development, being exceedingly stout, pointed at their free ends, and, as a rule, continuous from the epitheca to the upper surface (Fig. 5). In this genus, also, as to a less extent in some species of *Clathrodictyon*, adjoining pillars may become closely united by their sides, thus giving rise to short flexuous rows, or sometimes (as in *L. alveolaris*, n. sp., from the Wenlock Limestone) to a reticulated tissue not very unlike that of such "Tabulate Corals" as *Alveolites*.

As regards the genus *Actinostroma* in particular, and, indeed, as regards the Stromatoporoids generally, much question has arisen among different observers as to whether the radial pillars are hollow or solid. The earlier observers generally believed them to be the former; later observers, working mostly with thin sections, have generally maintained the latter view. For my own part, I have previously regarded the radial pillars as being solid; but more extended observations have shown me that this is certainly not invariably the case. In some forms (*e. g.* in certain species of *Actinostroma* and *Clathrodictyon*) no traces of any central aperture can be detected in cross-sections of the radial pillars. In other cases there is clear evidence of the existence of an axial tube in the pillars. At the same time, there is no ground for supposing, as was thought by many of the earlier observers, that the radial pillars were inhabited by zoöids, or that they are in any way comparable with the zoöidal tubes of *Millepora*. On the contrary, it is still uncertain if they were ever really open at their free extremities, even where, as in *Labechia*,

E. and H., there is clear evidence that they were hollow internally. Even where the surface carries perforated tubercles (as in *Stromatoporella laminata*, Barg., Pl. X, fig. 4), it remains to be shown that these tubercles are the upper ends of the radial pillars.

In various types of *Actinostroma*, such as *A. clathratum* (Plate I, figs. 10 and 13), tangential sections show that the exterior of the pillars is of a denser structure than the interior. The cut ends of the radial pillars thus show a dark external ring and an internal lighter space, or, in some cases, a dark outer ring and a minute central clear spot surrounded by a dark ring. This appearance, which is very distinct in some specimens, though not recognisable in others, would seem to show clearly that the radial pillars were primitively furnished with a minute central canal, which probably became largely or entirely filled up in the process of growth. There is no reason to think, however, that this axial canal opened on the surface, as the pillars in *Actinostroma clathratum* and its allies appear to end superficially in blunt imperforate tubercles (Plate II, fig. 11).

In *Labechia*, E. and H., similar appearances have been long since recognised as existing in a still more marked form (Steinmann "Ueber fossile Hydrozoen," 'Palæontographica,' 1878, Plate XII, figs. 10 and 11; and Nicholson, "Pal. Tabulate Corals," Plate XIV, fig. 4). Thus in tangential sections of *Labechia conferta*, Lonsd. (Fig. 5) one can almost always detect in the cut ends of the radial pillars a minute central dark or light spot, surrounded by a well-marked concentrically-laminated ring; and there is no reason to doubt that this central spot marks the position of a small central canal. That the same phenomenon is much less frequently recognisable in *vertical* sections, is easily explained by the fact that it is necessarily only an occasional thing for the section to cut a radial pillar precisely in the median plane. There is, however, evidence, as will be subsequently shown, that the radial pillars of *Labechia conferta* have really a cribriform structure. The central canals of the pillars are, in any case, of small size, and it is doubtful if they are continued to the summits of the pillars. The pillars, in fact, terminate superficially in blunt tubercles, which as a rule show no evident signs of a perforation at their summits (Plate III, fig. 12). In other specimens, however, there does appear to be an opening at the summits of some of the pillars (Plate III, fig. 14), though whether this appearance may not be the result of weathering is difficult to decide.

In a beautiful species of *Labechia* which I have found in the Devonian Limestones of South Devon, and which I shall name *L. serotina*, a much larger and more conspicuous axial canal is developed in the radial pillars (Fig. 4). Tangential sections of this species show that each of the radial pillars is traversed by a large central tube, which is seen in long sections to be crossed by numerous thick, curved, transverse partitions, to a large extent obliterating its cavity. I do not know the upper surface of this form, and cannot positively assert that the axial canals of the pillars may not sometimes be open above; but in those pillars which terminate in the sections examined, the free end of the pillar is pointed, and the canal apparently ceases before the extremity is reached.

Still more remarkable phenomena are presented by a singular Stromatoporoid, of which I collected examples from the Devonian Limestones of Herborn, near Paffrath, and which I shall term provisionally *Hermatostroma Schlüteri*, as I am unable to refer it to any recorded genus or species. In this aberrant type (Fig. 1, p. 42, and Plate III, figs. 1 and 2) the general structure of the skeleton is like that of the normal Stromatoporoids, consisting of radial pillars and concentric laminæ; but the pillars are of unusual size, and are furnished with large axial canals. These canals are rendered exceedingly conspicuous by being filled with dark-coloured oxide of iron, and they are seen not only to occupy the axes of the pillars, but to send off branches which run along the radiating processes or arms

Fig. 4.

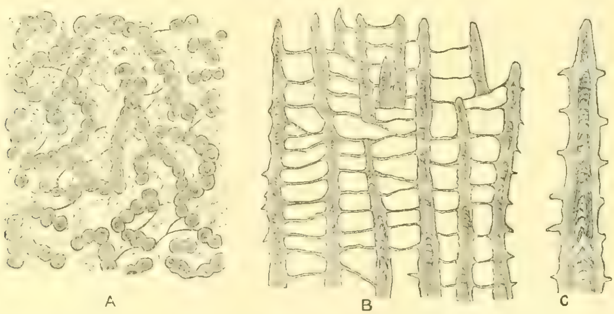

Fig. 4.—*Labechia serotina*, n. sp. Devonian, Teignmouth. A. Tangential section, enlarged twelve times, showing the arrangement of the pillars in short interlacing rows, and their large axial canals. B. Vertical section, similarly enlarged, showing the partitioning of the axial canals of the pillars by transverse plates, and the connection of the pillars by numerous horizontal "arms." C. A single radial pillar further enlarged, showing its pointed extremity.

which make up the concentric laminæ. In this case, therefore, not only are the radial pillars furnished with wide axial canals, but these canals are placed in direct communication with one another through the medium of the horizontal processes of the laminæ. None of my specimens show the upper surface, so that it is not possible to decide positively whether or not the axial canals opened on the surface. It would seem, however, probable that they did so, as they terminate in open orifices on the upper surfaces of the laminæ as exposed by concentric fractures.

The only point about the concentric laminæ which demands a moment's notice here is the question as to whether they are double or single in their constitution. Many observers have held that the concentric laminæ are composed each of two lamellæ, firmly united with one another in the mesial plane. The general fact that the result of rough fracture of specimens of the Stromatoporoids is invariably that of laying bare the *surface* of the concentric laminæ, and never that of splitting them into two halves, would go to prove that the laminæ are not composed of two definite strata. The way in which they are developed, by the fusion of the horizontal connecting-processes or "arms" given out by the pillars, would still further confirm this view. At the same time, the concentric laminæ, when examined in thin vertical sections, often show phenomena which it is not easy to fully explain. In various types, the concentric laminæ exhibit a central darker band, with comparatively lighter-coloured calcareous tissue above and below (Plate I, fig. 1). In other cases, there seems to be a definite thin line dividing the lamina into an upper and lower half (Plate II, fig. 8). In various other types, such as *Stromatoporella granulata*, Nich. (Plate I, fig. 5), or *Stromatoporella eifeliensis*, n. sp. (Plate XI, fig. 1), the central plane of the lamina is marked by a distinct, clear, broad line with darker tissue on both sides, in which minute tubuli are seen. The case of those forms in which there is only a thin dark line in the centre of the lamina might perhaps be explained by supposing that the laminæ are at first very thin, and that they gradually become thickened by the deposition of fresh calcareous tissue both on their under and upper sides. In this case the dark central line would represent the original lamina. It seems to me, however, to be more probable that the inosculating fibres, out of which the laminæ are composed, are really hollow, each having an axial canal. This supposition is rendered exceedingly probable by the existence of forms, such as *Hermatostroma Schlüteri*, in which the axial canals in the radial pillars certainly send prolongations into the horizontal fibres out of which the concentric laminæ are made. On this view, the dark or light colour of the mesial line observable in the concentric laminæ of many Stromatoporoids would depend on whether these supposed canals were filled with calcite or with some opaque material.

(*d*) *The Interlaminar Spaces.*—The spaces between each successive pair of laminæ may be spoken of by the general name of the "interlaminar spaces." In theory, these spaces are continuous, but in reality they are minutely subdivided, and the subdivisions are to a varying extent in free communication with one another; while in certain forms they cease to have any existence as separate structures.

In such forms as *Actinostroma clathratum*, the interlaminar spaces are practically continuous, as they are simply broken up by the passage through them of the innumerable radial pillars which connect together successive laminæ, as also by such imperfect pillars as merely project into the interlaminar spaces from below. In such cases, also, the interlaminar spaces are all placed in direct communication with one another by means of the innumerable pores with which the concentric laminæ are perforated. In such forms, therefore, we may suppose that the whole system of the interlaminar spaces was filled with the cœnosarc and that the zoöids were given off at the surface of the last formed lamina.

On the other hand, in the genus *Stromatopora*, Goldf., where the cœnosteum is generally developed in "latilaminæ," and where the radial pillars are so conjoined with their horizontal arms as to give rise to a continuously reticulated skeleton, the interlaminar spaces, as such, can hardly be said to exist. They are, in fact, represented only by the irregular branches of communication between adjoining zoöidal tubes (Plate V figs. 11, 15 and 17). Hence, in these forms the vitality of the colony must at any given moment have been confined to the last formed latilamina.

In the *Labechiidæ*, again, it is difficult to arrive at any certain conclusions as to the true condition of the interlaminar spaces. If we regard the horizontal processes or "arms" given out by the radial pillars of *Labechia conferta*, Lonsd., as being actual *plates*, then there are no true interlaminar spaces. In place of interlaminar spaces, we should have a series of oblong or lenticular cells, occupying all the intervals between the pillars, and resembling the intertubular tissue of *Plasmopora* or the vesicular tissue of *Cystiphyllum*. If, on the other hand, we consider the horizontal connecting-processes of the radial pillars of *Labechia* (Fig. 5,

Fig. 5.

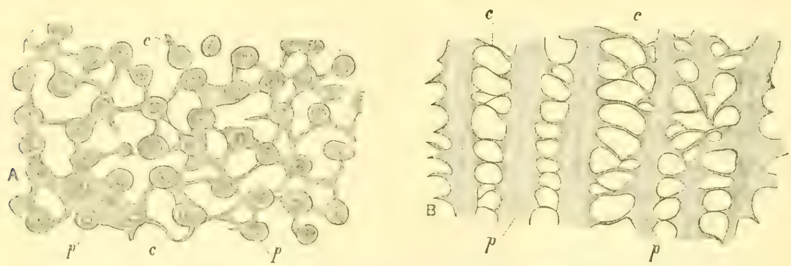

Fig. 5.—Sections of *Labechia conferta*, Lonsd., enlarged twelve times. Wenlock Limestone, Benthall. A. Tangential section. B. Vertical section. *p p*. Radial pillars. *c c*. Connecting-processes.

c c) to be mere calcareous filaments, such as we see in *Actinostroma clathratum*, Nich., then the interlaminar spaces of *L. conferta*, Lonsd., are represented by a loose network of irregular, intercommunicating cellular cavities. Thin sections, unfortunately, are not conclusive on this point. The balance of evidence at present, derived both from thin sections and also from observations of the true surface or of fractured surfaces of *Labechia*, would seem to me to be in favour of the view that the connecting-processes in this genus are really in the form of tabular plates. If this view be correct, then there are no interlaminar spaces, strictly so-called, in *Labechia*, the condition of parts being very much what we find to exist in various "tabulate" Corals, such as *Fistulipora* or *Plasmopora*, except that the large tubes of the latter types are represented in *Labechia* by the "radial pillars." If this view be correct, it would follow further that only the very last formed layer of the skeleton in *Labechia* could be truly alive, the cœnosarcal sheet and its zoöids being superior to the last-formed series of "tabulæ." Observations made upon such species of *Labechia* as *L. alveolaris*, n. sp., of the Wenlock Limestone, and *L. serotina*, n. sp., of the Devonian (Fig. 4), would strongly confirm the view here taken as to the tabular nature of the connecting-processes in the genus *Labechia*. It is quite certain, at any rate, that no differences whatever can be detected in thin sections between the connecting-processes in the species of *Labechia* just mentioned, and the "tabulæ" of such Corals as *Favosites* and *Alveolites*.

(*e*) *Zoöidal Tubes.*—The great difficulty which many observers have felt in the way of accepting the reference of the Stromatoporoids to the *Cœlenterata* is that no clear demonstration had been made of the existence in the skeleton of any tubes which might have lodged the zoöids of a Hydrozoan or Actinozoan colony. It was this difficulty which induced me previously to adhere to the reference of the group to the *Rhizopoda.* The first steps in the removal of this difficulty were taken by Carter in his researches on *Hydractinia*; but, after all, the thin crust of *Hydractinia* is in many respects very different to the huge masses of the larger Stromatoporoids, and it seemed only reasonable to expect that the latter, if Cœlenterate, ought to show in their skeleton traces of tubes, such as might have been inhabited by separate zoöids. Many observers have regarded the radial pillars as hollow, and as being such zoöidal tubes; but it is, I think, quite certain that this view is untenable. Even when hollow, the radial pillars seem to be mostly closed superficially; and where it may be surmised that they did open on the surface (as, perhaps, in *Hermatostroma Schlüteri*, Nich.), it still seems certain that they did not lodge zoöids, the cavities for which can, indeed, be shown to exist elsewhere. Such cases can, in fact, be parallelled by what we see in *Hydractinia circumvestiens*, Wood (Plate VI, figs. 8 and 9), in which definite zoöidal tubes coexist with large perforated pillars.

The most complete demonstration of the existence of definite zoöidal tubes is obtained from the examination of the skeleton of the genus *Stromatopora*,[1] Goldf., and of those allied types which make up the "Milleporoid" section of the Stromatoporoids. In these forms the skeleton is essentially composed of vermiculate and reticulated calcareous fibres, forming a more or less continuous framework, which is only roughly and imperfectly divisible into radial and concentric elements. The skeleton has in fact a close general resemblance to that of the recent *Millepora*, except that the tubes which traverse it are, as a rule at any rate, not divisible into two distinct series, differing from one another in point of size. The skeleton in these forms is, however, penetrated by numerous minute, flexuous, but essentially parallel, vertical tubes (Plate V, figs. 10,13 and 15), which are not bounded by definite walls but are

[1] It must not be forgotten that the forms understood here under the name of *Stromatopora* are those of the type of the true *Stromatopora concentrica*, Goldf., and are therefore wholly distinct from those which have usually been grouped under *Stromatopora*.

simply enclosed by the vermiculate fibres of the cœnosteum, precisely as are the zoöidal tubes in *Millepora*. There is, it need hardly be pointed out, no relationship between the tubes here in question and the occasionally present axial tubes of the radial pillars; nor have these tubes anything in common with the comparatively large *walled* tubes of the so-called "*Caunoporæ*," whatever view we may take as to the nature of these latter structures. There can not, in fact, be the smallest question but that the minute vertical tubes of *Stromatopora* belong to the cœnosteum proper; nor does there appear to be any reasonable ground for doubting that they served for the lodgment of the zoöids of the colony. This conclusion is, in my opinion, rendered absolutely certain by the fact that in all the typical species

Fig. 6.

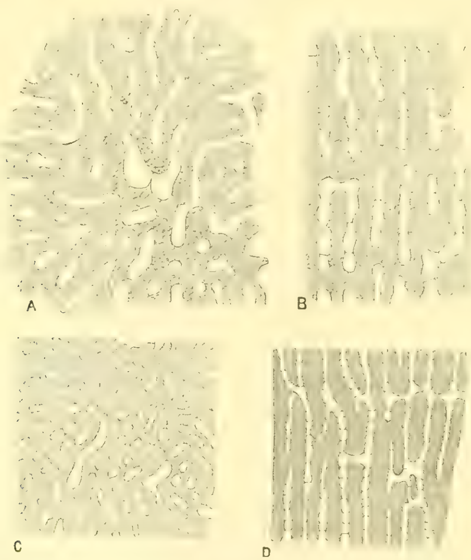

Fig. 6.—A. Tangential section of *Stromatopora Hüpschii*, Barg., sp., enlarged twelve times, showing the reticulate skeleton and the porous structure of the skeleton-fibre. B. Vertical section of the same, similarly enlarged, showing the tabulate zoöidal tubes. C. Tangential section of *Stromatopora bücheliensis*, Barg., sp., enlarged twelve times. D. Vertical section of the same, similarly enlarged. From the Devonian Limestone of Büchel (Paffrath district). Both these forms commonly occur in the "*Caunopora*" state, and were referred by Bargatzky to *Caunopora*, Phill.

of the genus *Stromatopora* (such as *S. concentrica*, Goldf., *S. Hüpschii*, Barg., *S. bücheliensis*, Barg., *S. antiqua*, Nich. and Mur., *S. discoidea*, Lonsd., *S. typica*, Rosen, *S. Beuthii*, Barg., *S. Carteri*, Nich., &c.), these vertical tubes are crossed by more or less numerous, complete, transverse, calcareous plates, which in all respects agree precisely with the "tabulæ" of the Hydrocoralline genus *Millepora* and of the so-called "tabulate" Corals. I give here sketches of two characteristic species of

Stromatopora (viz. *S. Hüpschii*, Barg., and *S. bücheliensis*, Barg.), which occur in the Devonian formation of both Britain and Germany, and in which these partitions in the zoöidal tubes are very well shown (Fig. 6). Nor do I see, for my own part, any reason for doubting that these transverse partitions in the zoöidal tubes agreed in function, as they undoubtedly do in structure and position, with the "tabulæ" in the tubes of *Millepora*. If this be admitted, we have in the genus *Stromatopora*, Goldf.—and I am not aware that this fact has been previously clearly demonstrated —a group of Stromatoporoids in which *the skeleton was provided with distinct tabulate tubes in which the individual zoöids were contained.*

Moreover, with the recognition of this fact it becomes comparatively easy to demonstrate the existence of similar zoöidal tubes in other Stromatoporoids, in which they occur in a more imperfect and less completely developed form. Thus, in *Stromatoporella granulata*, Nich., as in the closely allied *Stromatoporella eifeliensis*, n. sp., thin sections show the existence of short, irregularly distributed, vertical tubes, which rarely extend through more than two or three interlaminar spaces, and which are here and there crossed by irregular tabulæ. The existence of these tubes can be recognised in both tangential and vertical sections (Plate I, fig. 15, and Plate II, figs. 9 and 10); and they appear to open on the surface by elevated tubercles perforated by round apertures (Plate I, fig. 14, and Plate IV, fig. 6.) It can hardly be doubted that we have here an imperfect form of the tabulate zoöidal tubes of the typical *Stromatoporæ*.

Well-developed tabulate zoöidal tubes, in all respects essentially similar to those of *Stromatopora*, Goldf., may also be recognised, in a more or less complete form, in such genera as *Idiostroma*, Winch., and *Stachyodes*, Barg.

The forms in which definite zoöidal tubes are least developed and least easily recognised as existing at all are those which have usually been regarded as the typical *Stromatoporæ*, namely, those which I shall place under the genus *Actinostroma*, together with such types as *Clathrodictyon*, Nich. and Mur. If, for example, we take such a type as *Actinostroma clathratum* (the *Stromatopora concentrica* of most authors) and compare the skeleton with that of *Hydractinia echinata*, Flem., we have little difficulty in recognising the cavities in which the zoöids were contained, though definite zoöidal tubes such as those of *Stromatopora* proper are not developed. We recognise, in fact, that anything of the nature of actual *tubes* is not required by the necessities of the case. In the early condition of the cœnosteum in *Hydractinia echinata*, the outer surface of the horny crust is covered by the cœnosarc, as a thin layer from which the zoöids are given off. Similarly, in the earliest condition of the skeleton in the genus *Labechia*, E. and H., there do not seem to have been any superficial apertures; but the zoöids must have been given off from the layer of cœnosarc covering the first-formed layer of the skeleton. This is well shown in the example figured in Plate III, figs. 9 and 10, which may be either a very young specimen of *L. conferta*, Lonsd., or perhaps a new species. In this specimen the cœnosteum is a thin discoid expansion, covered below by a delicate striated epitheca, which bears superiorly a single layer of blunt imperforate tubercles; there being no traces of superficial apertures, nor any room for the existence of vertical tubes. In the adult *Labechia conferta*, Lonsd., it seems probable that the zoöids were likewise given off from the surface-layer of the cœnosarc; the principal change effected in the course of growth being, that as the radial pillars grew upwards the spaces between them became divided into cellular compartments by the development of curved calcareous plates. In the adult *Hydractinia echinata*, on the other hand, the successively formed layers of the cœnosteum are not absolutely imperforate but are traversed by numerous minute pores, by which the entire cœnosarc is kept in organic connection, and from the last series of which the zoöids are emitted.

In *Actinostroma clathratum*, Nich., and its immediate allies, the concentric laminæ are, as has been already pointed out, minutely porous (Plate I, figs. 8 and 11). They are composed of calcareous filaments so interlaced as to leave between them innumerable minute apertures, which pass through the laminæ and place successive interlaminar spaces in direct communication. The existence of such pores can generally be made out by a simple examination of the surface with a hand lens, and always by means of properly prepared thin sections taken parallel to the laminæ. In *Actinostroma clathratum* itself these pores are simply the wide angular meshes formed by the inosculation of the horizontal arms which are thrown out from the pillars; and it seems certain that their function must have been that of transmitting stolons by which the cœnosarc in successive interlaminar spaces was bound together. We may also reasonably suppose that in the last formed and most superficial concentric lamina the pores would correspond with the points at which the separate zoöids were budded off, and that these openings therefore represent zoöidal tubes.

As to whether or not *dimorphism* of the colony occurs in any of the Stromatoporoids, it is not easy to speak with certainty. Mr. Champernowne has been good enough to furnish me with examples of a species of *Stromatopora*—apparently an undescribed form—in which scattered among the ordinary tubes are tolerably regularly placed tubes of larger size, both sets of tubes being tabulate. This can hardly be interpreted as other than a case of dimorphism; but it appears to be an exceptional case, and I have not been able in the other species of *Stromatopora* to recognise any marked or constant differences between different zoöidal tubes. When we consider, however, how slight, comparatively speaking, are the differences between the gastropores and the dactylopores of the cœnosteum of *Millepora*, it may be conjectured that dimorphism may well have existed generally in the genus *Stromatopora*, without our being able to demonstrate this from the hard parts alone.

It is also almost certain that the large tabulate axial tubes of such genera as *Idiostroma*, Winch., *Stachyodes*, Barg., and *Amphipora*, Schulz, with their lateral branches, served for the lodgment of a special series of zoöids; but we have at present no absolutely final evidence on this point. If, moreover, it were possible to show that the large, thick-walled, tabulate tubes which characterise the so-called genera *Caunopora*, Phill., and *Diapora*, Barg., really formed a constituent portion of the Stromatoporoids in which they are found, we should have had in these an admirable example of dimorphism. Indeed, the comparisons which have been made by earlier observers between the Stromatoporoids and the recent *Millepora* have usually been based upon specimens of "*Caunopora*." The real nature of the tubes in question in *Caunopora* and *Diapora* is, however, a subject involved in such difficulty, that I shall consider it in a separate section.

(*f*) *The Astrorhizæ.*—One of the most prominent features in many Stromatoporoids is the presence on the surface, and also at all deeper levels in the skeleton, of numerous shallow grooves arranged in definite stellate systems upon the surfaces of the concentric laminæ (Plate IV, figs. 2 and 6). For these stellate canal-systems Mr. Carter's apt name of "astrorhizæ" may be employed with advantage. There is, also, no reason to doubt that Mr. Carter has decided correctly in his determination of these structures as the homologues of the branching cœnosarcal grooves on the surface of the skeleton of many *Hydractiniæ* (Plate VI, figs 3 and 9). They may also be compared with the branching and inosculating cœnosarcal canals of the cœnosteum of *Millepora* (Plate IV, fig. 5). The correctness of this view seems to be sufficiently proved by a consideration of various other facts which are now known as to the structure of the skeleton in various Stromatoporoids, and especially by the fact that many of them can be proved to have possessed tabulate zoöidal tubes. At the same time, it should be remembered that, in the absence of this confirmatory evidence, earlier observers were not without justification in comparing the astrorhizæ of the Stromatoporoids, as many have done, with the dermal canals of certain of the Sponges.

The size of the astrorhizæ is very variable in different types of Stromatoporoids, but, when present at all, they are always visible to the eye, and they are often extremely conspicuous objects (Plate IV, fig. 2). Whatever their size may be, their general form is tolerably constant, each astrorhiza consisting of a stellate group of comparatively large-sized shallow gutters, which spring from a central point and branch as they radiate outwards, diminishing at the same time in diameter, and giving off more or less numerous lateral branches. These branchlets communicate freely, and they finally inosculate with the terminal twigs of adjoining astrorhizæ (Plate III, fig. 3). The entire series of astrorhizæ thus forms a system of shallow, open, anastomosing grooves on the surface of the cœnosteum, and doubtless served for the lodgment of corresponding cœnosarcal stolons.

As the astrorhizæ are mere grooves on the surface of the last-formed layer of the skeleton, in their typical condition at any rate, it follows that they are not only present on the free surface of the colony, but also on the surface of successive concentric laminæ; since each lamina in turn constituted for a time the actual surface. As, however, each successive lamina is produced, the astrorhizal grooves on the surface of the lamina below necessarily become roofed over by the new layer, and are thus converted, in all the parts of the skeleton below the surface-lamina, from open *grooves* into *canals*. Hence, in vertical sections of such Stromatoporoids as possess astrorhizæ, the cut ends of the astrorhizal canals appear in the section at various points as larger or smaller round apertures (Plate V, fig. 6, and Plate XI, figs. 12 and 14). They are, however, necessarily *without any proper walls*, their lower margin being formed by the lamina to which they belong, their upper margin by the lamina next above, and their sides by the irregular radial pillars which connect these two laminæ.

There is one Stromatoporoid, viz. *Stromatopora discoidea*, Lonsd. (= *S. elegans*, Rosen), from the Wenlock Limestone of Sweden, Esthonia, and Britain, in which the astrorhizal canals seem to depart in important respects from their ordinary form. The elucidation of the true structure of this singular type is attended with unusual difficulties, as, for some reason difficult to explain, most specimens have undergone a more or less complete secondary crystallisation of their skeleton, even when the surface-characters are retained in admirable preservation. Superficially regarded, *S. discoidea*, Lonsd., is remarkable for the generally large size of the astrorhizæ, for the minute subdivision of the main channels, and for the extremely perfect inosculation established between the entire system of astrorhizæ (Plate III, fig. 3). Thin sections show, however, that the astrorhizal canals are not, as usual, mere shallow grooves on the surfaces of the successive laminæ, but that the laminæ are obsolete, and the astrorhizal canals are converted into comparatively deep channels, with perpendicular sides which extend downwards through the thickness of each successive "latilamina." In other words, beginning as open grooves on the surface of the primitive crust, the sides of the astrorhizal canals grew upwards to form so many deep narrow channels with vertical walls, these channels extending through the whole of the first "latilamina." When the second "latilamina" is formed, new astrorhizal grooves are produced, which pass through the same process of development; and so on through the entire system of "latilaminæ" of which the skeleton is made up. Moreover, the tabulate zoöidal tubes open into the sides of these deep channels, and are, in fact, confluent with them. Perhaps, therefore, the most correct way of regarding the astrorhizal grooves of *S. discoidea*, Lonsd., would be to consider them as really formed by the serial junction of the zoöidal tubes in sinuous lines, much as we see in the serially-united polypes of *Diploria* and other types of Corals. Be this as it may, the result of the peculiar constitution of the astrorhizal system in *Stromatopora discoidea*, Lonsd., is that we get very different appearances in thin sections to those presented by the normal *Stromatoporæ*. Thus, in tangential sections (Plate VII, fig. 1) the grooves representing the astrorhizal canals are seen to be constant in form and position at whatever level in the "latilamina" the section may have been taken. In vertical sections, further, we do not see the round apertures representing the cut ends of the radiating astrorhizal canals, but in place of these we observe (Plate VII, fig. 2) deep vertical fissures, which are in many places crossed by transverse "tabulæ," and which clearly represent, in large part at any rate, the zoöidal tubes.

In those Stromatoporoids which possess astrorhizæ, there arises an important distinction according as the astrorhizæ of successive laminæ are produced irregularly, or are developed one above the other in a system of vertically superposed groups. In the latter case, the astrorhizæ of each vertical series are connected together by an approximately vertical central tube, which opens on the surface of the cœnosteum by a distinct aperture, from which the grooves of the last-formed astrorhiza radiate (Plate III, figs. 4 and 6, and Plate IV, fig. 6). The opening of this central canal is often placed on a more or less conspicuous "monticule," and Bargatzky conjectures that the existence of such monticules or "warts" may be taken as a general indication of the presence of vertically superimposed astrorhizæ. Prof. Ferd. Roemer has doubted the existence of such vertical central canals to the astrorhizal groups, and has explained the phenomena presented by these as being really produced, in a manner formerly alluded to, by the inclusion of the tubes of *Spirorbis* in the tissues of the growing Stromatoporoid. An examination of thin sections, however, shows this supposition to be baseless, though such imbedded *Spirorbes* do occur not infrequently. Thin sections, in fact, entirely confirm the conclusion which one would naturally draw from the regular distribution of these prominent apertures on the surface of many Stromatoporoids (see Plate III, figs. 4 and 6)—the conclusion, namely, that they are the apertures of canals belonging to the cœnosteum itself. These axial canals of the astrorhizæ are wholly devoid of proper *walls*, as is also the case with the radiating canals of the astrorhizæ, and they cannot, therefore, be confounded with the wholly different *walled* tubes of the so-called *Caunoporæ*. As regards their function, we may suppose that these axial astrorhizal canals lodged primary stolons of the cœnosarc, from which were given off the radiating and inosculating stolons occupying the grooves of the astrorhizæ. There does not seem, certainly, to be any ground for regarding these canals as having served for the lodgment of zoöids.

Certain types of Stromatoporoids are apparently wholly destitute of astrorhizæ. I have, for example, failed to detect any definite representatives of these structures in any species of *Labechia*. Other types, again, appear to constantly possess these structures. They are, in fact, present in so many Stromatoporoids, of the most diverse affinities, that they cannot, in my opinion, be employed with any advantage as constituting by their presence a *generic* character. Hence I have not thought it expedient to retain Winchell's genus *Cœnostroma*, in the definition of which the presence of astrorhizæ is taken as the essential character. On the other hand, I cannot agree with Prof. Ferd. Roemer ('Leth. Pal.,' p. 532) in thinking that they are of quite variable occurrence, and that they have not even a *specific* value. My experience is that the astrorhizæ are, in general, quite constant in their absence or presence, and also in their characters when present, in types which can be otherwise shown to belong to the same species; and that they can, therefore, be used as marks of specific distinction. It must be admitted, however, that there are Stromatoporoids which are otherwise very similar to one another in general structure, but which in some cases possess astrorhizæ, whereas at other times they appear to be without these structures. In such cases, all that can at present be said, is that a careful and extended series of microscopic observations will be needed, before we can assert positively that such types are not distinguishable by any other characters than the presence or absence of astrorhizal canals.

(*g*) *Astrorhizal Tabulæ.*—In *Stromatopora? dartingtonensis*, Cart., Mr. Carter has described transverse calcareous partitions as developed in the astrorhizal canals, which in this particular type are usually of large size ('Annals and Mag. Nat.

Fig. 7.

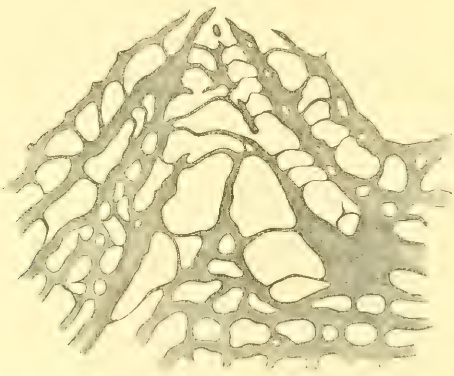

Fig. 7.—Vertical section through the centre of one of the astrorhizæ of *Stromatoporella eifeliensis*, Nich., enlarged twelve times, showing the central canal of the astrorhiza and the numerous "astrorhizal tabulæ" in the larger radiating canals. Middle Devonian; Gerolstein, Eifel.

Hist.,' ser. 5, vol. vi, p. 339). The same observer has also compared these transverse partitions with the "tabulæ" in the zoöidal tubes of *Millepora*. As the astrorhizal canals appear to me to be in no way homologous with the zoöidal tubes of *Millepora*, and as many Stromatoporoids have truly tabulate zoöidal tubes, I shall speak of the structures now in question as "astrorhizal tabulæ." So far as I have seen, these structures can almost always be recognised in thin sections of *Stromatopora? dartingtonensis*, Cart.; but they are by no means peculiar to this species. Similar structures in an equally well-developed form, occur in *Stromatoporella eifeliensis*, n. sp., and they are present more or less commonly in various other types. Even in those forms in which they may be said to be of constant occurrence, they have, however, a very variable development, and they likewise vary much in form. In most cases they have the form of complete calcareous plates, which are placed at irregular intervals across both the larger and smaller astrorhizal canals, but principally in the former (Fig. 7). They may be straight or curved, or even funnel-shaped or vesicular, as, for example, they sometimes are in *Stromatoporella laminata*, Barg. They doubtless indicate the periodically produced lines of demarcation between the superficial and still active portions of the colony and the deeper dead portions of the mass; but it is difficult to assign to them, with our present knowledge, any further function.

(*h*) *Axial Tubes.*—In certain anomalous types of Stromatoporoids there occur tubes which may be distinguished by their position and other characters from the astrorhizal canals or the ordinary zoöidal tubes. The tubes in question are of large size; they have a definite relation to the entire organism; they are definitely circumscribed by the general tissue of the cœnosteum; and they are usually, if not always, intersected by distinct calcareous plates or "tabulæ." Except in the presence of a thickened *proper wall*, the well-known tubes of the so-called "*Caunoporæ*" have very similar characters, and it might therefore have been natural to consider the distinctive tubes of the forms included under the head of *Caunopora*, Phill., and *Diapora*, Barg., in this place also. Many reasons have, however, induced me to devote a special section to the consideration of these latter fossils. The tubes to which I now specially refer, and which I shall distinguish by the name of "axial tubes," are found, in their most marked form at any rate, only in certain aberrant genera of Stromatoporoids, namely *Idiostroma*, Winch., *Amphipora*, Schulz, *Stachyodes*, Barg., and *Beatricea*, Bill. The axial tube of the last of these is, however, in many respects peculiar, and I need here only speak of the three first-named genera. All these form, typically, cylindrical colonies, sometimes branched or multiple, sometimes simple, rooted basally, and having a general resemblance to the dendroid species of *Favosites* or *Pachypora*. In the above three genera, the cylindrical cœnosteum is traversed by a large axial canal, which may be single, or which may be accompanied by a small but variable number of lesser but otherwise similar canals, running parallel with the main tube and at a little distance around it. Both the axial tube and the smaller tubes (when the latter are present) are definitely circumscribed, and have their internal cavities intersected by transverse calcareous plates or "tabulæ." These tabulæ may run directly across the axial tube, as generally in *Stachyodes* (Plate VIII, fig. 10), or they may be curved, or even regularly funnel-shaped. They often have the form last mentioned in the genus *Idiostroma*, Winch., and they then show a curious resemblance to the tabulæ in the genus *Syringopora*. As a rule, the axial tube gives off smaller lateral branches, which ascend in the substance of the cœnosteum, dividing as they proceed. These are also furnished with tabulæ, and appear to be directly connected with the general interspaces of the skeleton. Whether the axial tube and its ascending lateral branches open finally upon the surface is a point on which it is difficult to obtain conclusive evidence; but there are strong reasons for thinking that they certainly do so.

Now, it is certain that these tubes, whatever may be their function and nature, are veritable constituents of the organisms in which they are found. Whatever may be the nature of the "tubes" in "*Caunopora*," it is not admissible to regard the tubes above alluded to as being parasitic structures, or as otherwise foreign to the Stromatoporoid in which they occur. They hold a definite position in relation to the rest of the organism, they communicate with the cavities of the general skeleton by apertures in their walls, they often give off branching lateral canals, and they are invariably present in the genera which they characterise. These considerations render it certain that these tubes are truly portions of the organisms in which they occur.

With regard, however, to the *function* of these axial tabulate tubes in *Idiostroma*, *Amphipora*, and *Stachyodes*, there is not at present sufficient evidence to warrant any very definite hypothesis. Perhaps the most probable theory that we can in the meanwhile form as to their nature is that the main axial tube lodged a stolon or axis of the cœnosarc, and that the lateral branched tubes in connection with this were occupied by a special series of zoöids. There are, also, some considerations which would render it not wholly unlikely that these tubes were connected with the process of reproduction, and lodged the generative zoöids. Apart, however, from all theories as to their nature, it may be pointed out that the existence of such tubes as a constituent portion of the cœnosteum of certain Stromatoporoids, deprives the hypothesis that the walled tubes of "*Caunopora*" also belong to the organism, of part of the inherent improbability that would otherwise attach to it.

(*i*) *The Epitheca.*—In a very large number of Stromatoporoids the under surface of the cœnosteum is covered by a thin, imperforate, concentrically striated, calcareous membrane (Plate III, figs. 7, 8, and 9), which has all the characters of the "epitheca" of many composite Corals, and to which the same name may be applied. In microscopic structure it appears to be merely composed of granular calcareous matter. Very many of the Stromatoporoids appear to constantly possess an epitheca, which in general arrangement and appearance is precisely similar to the epitheeal membrane in the massive species of *Favosites*, *Alveolites*, *Heliolites*, *&c.* When such forms are attached to foreign objects, the attachment usually takes place by means of a narrow peduncle; and if we sometimes find such types to be attached by a wide base, this is only what we also see occasionally in such corals as *Favosites gotlandica*, Lam., *Heliolites interstincta*, Wahl., and other similar types. Still, such forms are in no way "encrusting" types; and we sometimes meet with even large specimens in which the entire under surface is covered by the epitheca, and is at the same time deeply concave; so that the primitive condition of attachment to some foreign body appears to have been merely temporary.

In other forms, such as *Actinostroma clathratum*, Nich., an epitheca may be developed; but more commonly this structure is wanting, and the organism has simply grown in a succession of superimposed strata, applied first to some foreign body and then to one another. In a third group of forms, the organism seems to have been mainly or exclusively "encrusting" in its habit, the entire lower surface being applied to some foreign body, and no epitheca being developed. This is the case, for example, with certain of the so-called *Stromatopora polymorpha* group of forms (*e.g. S. curiosa*, Barg.), and is also common, though not universal, in *Stromatoporella eifeliensis*, Nich. Lastly, in the dendroid types, such as *Amphipora ramosa*, Phill. sp., and *Stachyodes verticillata*, M'Coy, sp., the colony resembled that of the ordinary dendroid Corals in being fixed at its base and in having no epitheca.

(*j*) *The Surface.*—The condition of the external surface in the Stromatoporoids can be studied only in specimens in a condition of very good preservation. In some essential respects the surface of any concentric lamina, at *any* depth, doubtless represents the condition of the exterior; since each lamina in turn formed for a time the free surface. We are, however, hardly justified in assuming that this is entirely or invariably the case. The most remarkable phenomenon in this connection is the occasional development, in certain specimens, over a part or the whole of the surface, of a thin, apparently structureless, calcareous membrane, largely or wholly imperforate. A somewhat similar phenomenon, though probably one of a totally different significance, is occasionally observed in certain of the *Favositidæ* (*e.g. F. tuberosa*, Rom.). Various Stromatoporoids show this curious phenomenon. Thus it occurs commonly in various encrusting types from the Devonian Rocks (Plate II, fig. 14), such as some of those which Goldfuss included under the name of *Stromatopora polymorpha* ('Petref. Germ.,' Pl. LXIV, fig. 8, *d*). It is seen in the *Stromatoporella* (?) *nulliporoides*, Nich., of the Devonian of North America, and apparently also in the similar or identical "*Cœnostroma*" *incrustans*, Hall and Whitfield (Plate III, fig. 6). The same thing is seen in *Stromatoporella granulata*, Nich., from the Devonian of Canada, well-preserved specimens of which often show over parts of the surface a thin calcareous membrane, pierced at intervals by minute elevated openings (Plate IV, fig. 6). Similar phenomena are observable, not uncommonly, in specimens of *Idiostroma* and of *Stachyodes verticillata*, M'Coy (Plate VIII, fig. 12). The form, however, which displays this membrane most completely is the singular *Amphipora ramosa*, Phill. (Plate IX, fig. 1), in which many examples have the surface entirely covered with an apparently imperforate calcareous envelope. In this case, however, it can be shown, that underneath this membrane, between it and the true surface, are developed numerous comparatively large-sized lenticular vesicles. I am disposed to regard these marginal vesicles as corresponding to the "ampullæ" which have been shown by Professor Moseley to contain the gonophores in the recent Stylasterids. If this view be accepted, it seems probable that the development of the calcareous pellicle above alluded to, in all those Stromatoporoids in which it occurs, is connected with the formation of the reproductive zoöids. I shall, however, have occasion to refer to this point again.

In all the species of *Actinostroma*, such as *A. clathratum*, the surface (Plate II, fig. 11) is studded, in well-preserved examples, with numerous minute projecting tubercles, which are simply the upper ends of the radial pillars, and represent the small spines in *Hydractinia*. I have never succeeded in detecting any apertures in these tubercles, but it is possible that such exist.

In the nearly allied genus *Clathrodictyon*, Nich. and Mur., either the surface is covered with tubercles similar to those of *Actinostroma* (Plate II, fig. 12), or the tubercles have coalesced with one another to form vermiculate ridges (Plate II, fig. 13).

In the genus *Labechia*, E. and H., the upper ends of the radial pillars project above the surface as prominent tubercles (Plate III, fig. 12), much in the same way as in *Actinostroma*, except that, owing to the stoutness of the pillars, the tubercles are much more pronounced. The tubercles may be quite separate, or they may be partially confluent, so as to form sinuous rows (Plate III, fig. 13), these variations occurring in individuals of the same species (e. g. *L. conferta*, Lonsd.). In some species, however, as in *L. serotina*, n. sp. (Fig. 4), and *L. alveolaris*, n. sp., the tubercles coalesce so as to form a sort of labyrinthine pattern, after the fashion of the corallites in the genus *Halysites*. Whether the tubercles in *Labechia* are perforated or solid, is a point very difficult to determine positively. In some forms, such as *L. serotina*, they certainly would seem to be solid. In others, such as *L. conferta*, Lonsd., they sometimes have all the appearance of being solid, while at other times they show distinct round pits at their summits (Plate III, fig. 14); but it is quite possible that this latter phenomenon may be simply the result of weathering.

In a large number of Stromatoporoids the surface normally shows larger or smaller conical eminences, which may be distinguished from the granules and tubercles formed by the upper ends of the radial pillars under the name of "mamelons" or "monticules" (the "Warzen" and "Höcker" of German writers).

These are well seen in such types as *Stromatopora concentrica*, Gold., var. *colliculata*, Nich. (Plate III, fig. 5), and *Actinostroma verrucosum*, Goldf., sp.; but they occur in various types of diverse affinities. Sometimes these monticules are small and pointed, sometimes they are large and blunt, and sometimes they coalesce into ridges. In some cases they do not appear to be perforated at their summits, and they seem to have no special connection with the astrorhizæ. In many cases, however, each monticule corresponds with the centre of an astrorhizal system; and in such cases each is perforated at its summit by one or more comparatively large apertures (Plate III, figs. 4 and 6). These apertures at the summits of the monticules are what have been regarded as "oscula" by those who, like myself at one time, have upheld the reference of the Stromatoporoids to the Sponges. The possession of perforated monticules is a phenomenon which is specially characteristic of such Stromatoporoids as have astrorhizæ in regularly superposed groups; each vertical series having a central canal, from which the astrorhizæ of successive laminæ spring, and which ultimately opens on the surface (Fig. 7). Prof. Ferd. Roemer, as formerly pointed out, has endeavoured to explain away the existence of any such openings, as being merely formed by the inclusion in the growing Stromatoporoid of the tubes of *Spirorbis*; but I have often seen surface-openings produced in this way, and they are entirely different to those now in question. The latter can be shown conclusively, by means of thin sections, to belong to the Stromatoporoid in which they are found, and to be formed in the way I have above described; this conclusion being the one which we should have been otherwise led to draw from the great regularity with which these monticules and their openings are disposed in many types. There are, in fact, certain species in which the skeleton may be said to be built up of a series of cylinders, each terminating on the surface by a perforated prominence, and being traversed longitudinally by a median canal from which the astrorhizæ are given off. It is, however, to be noted that there are, on the other hand, certain types having well developed astrorhizæ arranged in more or less regular vertical rows, but not having the surface covered with monticules corresponding with the centres of the astrorhizæ. This condition of things occurs, for example, in *Stromatopora typica*, Rosen.

In a great many Stromatoporoids it is not possible to recognise with any distinctness any definite superficial apertures which might have served for the emission of zoöids. In a large number of cases this is probably only due to the fact that when these openings are filled with the matrix it becomes difficult or impossible, owing to their minute size, to detect their presence at all, except in specimens preserved in quite exceptional perfection. In other cases, as in young examples of *Labechia conferta*, Lonsd. (Plate III, fig. 10), the apparent absence of surface-perforations seems to be due to a real want of any apertures, the zoöids having been given off from the surface-investment of the cœnosarc. In weathered examples of the genus *Actinostroma* (such as *A. clathratum*), it is often possible to recognise the angular meshes formed by the inosculating horizontal " arms " given out by the radial pillars, and we have seen that these meshes in all probability represent the zoöidal apertures.

On the other hand, in all the typical species of the genus *Stromatopora*, Goldf., well-preserved examples exhibit the rounded, oval, or vermiculate apertures of the zoöidal tubes. In many of such forms, therefore, the general aspect of the surface is exceedingly like that of an *Alveolites* or *Pachypora*, except that the zoöidal openings are mostly smaller than they are in the Corals just alluded to. Precisely similar apertures are seen on the surface of the species of *Idiostroma* (Pl. IX, fig. 9), *Stachyodes*, Barg. (Pl. VIII, fig. 12), and certain examples of *Amphipora ramosa*, Phill., sp. In the genus *Stromatoporella*, the surface in well-preserved examples exhibits rounded tubercles, which are perforated at their summits by round apertures which can hardly be anything else than the openings of the zoöidal tubes. These are well seen in specimens of *Stromatoporella granulata*, Nich. (Pl. I, fig. 14), and *S.* (*Diapora*) *laminata*, Barg. (Pl. X, fig. 4).

The conspicuous round apertures which are seen on the surface of specimens of *Caunopora*, Phill., cannot be considered apart from the question of the walled tubes to which they belong—a question which will be fully dealt with at a later period.

Lastly, the surface of many Stromatoporoids exhibits the astrorhizæ and their canals. These, when present, vary much in size, but it is unnecessary to say more about their characters here. As has been already seen, they are often apparently entirely absent in certain species, even when present in closely allied types. This, however, cannot be considered as surprising, when it is remembered that the corresponding cœnosarcal canals of *Hydractinia*, though so characteristic of many species, are said to be wanting in certain forms of the genus.

(*k*) *The Reproductive Organs.*—As regards most of the Stromatoporoids, the process of reproduction is wholly unknown. Accepting, however, the relationship of the Stromatoporoids to the *Hydrocorallinæ*, it would be naturally expected that the reproductive zoöids should have been lodged in special cavities within the skeleton, such as have been described by Professor Moseley in the case of the *Stylasteridæ*, under the name of "ampullæ." As a matter of fact, structures which do appear to be of the nature of "ampullæ," are to be recognised in certain of the Stromatoporoids. Thus, as has already been alluded to, many examples of *Amphipora ramosa*, Phill., possess a series of large-sized lenticular vesicles, which form a sort of marginal zone to the cylindrical cœnosteum, and which are covered over by a thin calcareous membrane (Pl. IX, figs. 2 and 3). Many examples of this species are, however, wholly destitute of these "marginal vesicles" and of the membrane which encloses these (Pl. IX, fig. 4). From their form and position, as well as from their only occasional development, it seems a not unreasonable conjecture that these "marginal vesicles" gave lodgment to the reproductive zoöids, and that they are, therefore, of the nature of "ampullæ."

In the Devonian Rocks of Devonshire, and also, more abundantly, in the same deposits in the Paffrath district, I have found a Stromatoporoid, which I think to be probably identical with the *Stromatopora* (*Tragos*) *capitata* of Goldfuss. As the cœnosteum of this form is traversed by irregular tabulate tubes of a much larger size than the ordinary zoöidal tubes, it should probably be referred to the genus *Idiostroma*, Winch., and should stand as *I. capitatum*, Goldf., sp. Scattered through the tissues in this species, in a large number of specimens, are vesicles

Fig. 8.

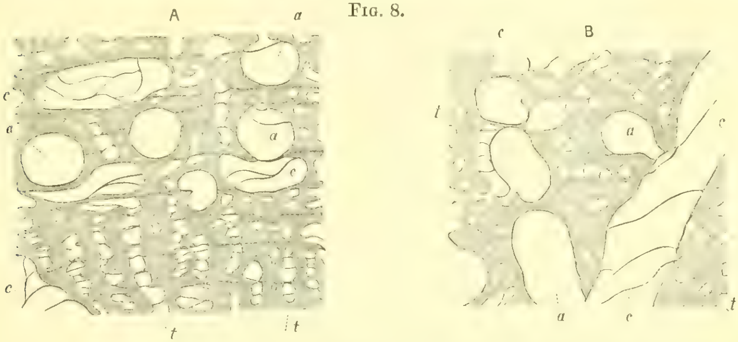

Fig. 8.—A. Vertical section of *Idiostroma capitatum*, Goldf. (?), from the Devonian Rocks of Hebborn (Paffrath district), enlarged twelve times; B. Tangential section, similarly enlarged; *a a*. Supposed "ampullæ;" *c c*. Large tabulate tubes; *t t*. The ordinary zoöidal tubes.

(Fig. 8) of a lenticular, oval, spherical, or elongated shape, which are bounded principally by the general skeletal tissue, and commonly have no proper wall of their own. These are mostly about 1 mm. in diameter, less or more; and they are occasionally crossed by one or more calcareous partitions or tabulæ. Sometimes they appear to be appended to the sides of the large tabulate canals which traverse the skeleton in this type; but at other times they seem to have no connection with these. They occur, as might be expected, at all depths below the surface, since the species is one which grows by the formation of successively superimposed laminæ, and each successive layer constitutes therefore in its turn the actual surface.

I have not recognised these curious structures with any certainty, or in any conspicuous form, in any other Stromatoporoid except the one just mentioned; but it is quite possible that they will be found in others if carefully looked for. In the particular type above alluded to, thin sections prove conclusively that these vesicles are really parts of the organism in which they are found, and are not adventitious or imbedded structures of any kind. It is necessarily impossible to speak with certainty as to their nature; but the most probable hypothesis seems to be that which would regard them as having lodged the reproductive zoöids, and as corresponding with the "ampullæ" of the *Stylasteridæ* and of *Millepora Murrayi*, Quelch. It may, further, be conjectured, with some probability, that the axial tubes of the cylindrical types of *Idiostroma* (Pl. IX, figs. 6, 7, 8), as also of *Stachyodes* (Pl. VIII, fig. 10), with their lateral tabulate offshoots, were connected with the development of the reproductive zoöids.

III. SYSTEMATIC POSITION AND AFFINITIES.

The Stromatoporoids have been referred by different naturalists to very different groups in the animal kingdom, but most generally to one or other of the four divisions of the Sponges, to the *Foraminifera*, the Corals, or the *Hydrozoa*. We may, therefore, speaking roughly, say that they have been generally regarded either as Rhizopods or Cœlenterates. The former view is the one which, with some reservations, I have myself held, being influenced in so doing principally by the fact that no observer had succeeded in demonstrating in any Stromatoporoid (excluding the problematical forms grouped under *Caunopora*, Phill.) the existence of any tubes or cells which might have been supposed to have served for the lodgment of the zoöids of a Cœlenterate colony. My own researches, however, have now led me to recognise the presence of such unquestionable zoöidal tubes (as previously described) in various typical Stromatoporoids, and I am therefore, now able to frankly accept the views of Carter, Lindström, Steinmann, Zittel, Bargatzky, and other well-known observers, as to their Cœlenterate affinities. I am also quite satisfied that the Stromatoporoids belong to the *Hydrozoa* and not to the *Actinozoa*, and that they have relationships with both *Hydractinia* on the one hand and *Millepora* on the other hand, though I regard them as quite distinct from either of these genera, and as forming a special group of the *Hydrozoa*, for which the name of *Stromatoporoidea*, originally proposed by Dr. Murie and myself, may be retained.

In the presence of the large body of evidence which we now have as to the minute structure of the Stromatoporoids, it does not appear to me to be necessary here to discuss in detail the reasons which induced different investigators to refer the Stromatoporoids to the *Foraminifera*,[1] the Sponges, or the Corals. I shall,

[1] From one point of view, the system of minute tubuli which I have been able to show to exist within the skeletal tissue of many Stromatoporoids might, no doubt, be accepted as evidence of Foraminiferal affinities. The value of such evidence is, however, destroyed by the still closer resemblance of the tubuli in question to the minute canaliculi of the skeleton in various of the Hydrocorallines (*e.g.* *Distichopora* and *Allopora*).

therefore, merely deal briefly with the evidence bearing upon their reference to the *Hydrozoa*, and upon the position in that class which ought to be assigned to them.

The first observer who seems to have suspected the relationship between the Stromatoporoids and the *Hydrozoa* was Dr. Lindström, who pointed out that *Labechia*, E. and H., previously regarded as a "Tabulate" Coral, possessed a skeleton in many respects very similar to that of *Hydractinia*, Van Beneden ('Öfvers. af Kongl. Vetenskaps-Akad. Förh.,' No. 4, 1873, and 'Ann. and Mag. Nat. Hist.,' July, 1876). The next observer who took up this subject was Mr. Carter, who published a series of most valuable papers on the structure of the skeleton of the *Hydractiniidæ* ('Ann. and Mag. Nat. Hist.,' 1877 and 1878), and who maintained that the Stromatoporoids were *Hydrozoa* and related to *Hydractinia* and also to *Millepora*. In 1878 also, Dr. Steinmann published his admirable memoir 'Ueber fossile Hydrozoen' ('Palaeontographica,' n. F., v. 3 (xxv), p. 101), in which he not only referred *Stromatopora* itself to the *Hydrozoa*, but greatly increased our knowledge of various related types. The views advocated by the observers just mentioned have been since adopted by Zittel ('Handbuch der Palaeontologie'), Roemer ('Lethæa Palæozoica'), Bargatzky ('Die Stromatoporen des rheinischen Devons'), and other competent authorities, and may be regarded as now almost universally accepted. This general acceptance of the reference of the Stromatoporoids to the *Hydrozoa* is, perhaps, the more remarkable, when it is considered, as before pointed out, that no demonstration had been effected of proper zoöidal tubes in any of the normal Stromatoporoids. At the present time, therefore, when such tubes can be shown to exist in many forms, there can be little hesitation in admitting the Stromatoporoids to a place in the class of the *Hydrozoa*, though there may be some difference of opinion as to the precise position in this class which they ought to occupy.

In order to determine this last point, if only approximately, it will be necessary to consider more particularly the structure of the skeleton in the two recent genera of *Hydrozoa* which are most nearly related to the Stromatoporoids, viz. *Hydractinia* and *Millepora*.

Hydractinia echinata, Flem., the most readily obtainable type of the genus *Hydractinia*, forms thin horny crusts, which grow upon the exterior of various Gasteropodous shells, but apparently only upon those which are tenanted by Hermit Crabs. In its earliest condition, the skeleton consists of a delicate chitinous pellicle, growing upon some shell, by the maceration of which in weak acid it can be readily obtained for examination. In this stage it consists of numerous nodal points, the so-called "horn-cells" of Carter, united by radiating horizontal processes, or fibres, which coalesce to form an irregular cribriform membrane, for which we may employ Mr. Carter's name of the "basal lamina" (Plate VI, fig. 2). According to Mr. Carter's researches, the "horn-cells" appear first in the substance of the shell as separate cells, which generate round themselves concentric layers of chitine. In their nature the horn-cells are the primitive "radial pillars," into which they become ultimately converted in old colonies, while the horizontal clathrate fibres represent the first concentric lamina. The interstices of the creeping network are occupied by the cœnosarc, from which the polymorphic zoöids are given forth. Superiorly, the "horn-cells" project upwards as short tubercles, interspersed at intervals with larger serrated spines. Moreover, the primitive lamina may show shallow branching grooves or gutters, the "astrorhizal grooves," which lodged corresponding stolons of the cœnosarc.

If the colony continues to grow, the "horn-cells," or "radial pillars," grow upwards, and when they attain a certain height, throw out irregular horizontal processes or "arms," by the union of which a second cribriform horizontal "lamina" is produced. By a repetition of this process, the colony may at last assume a considerable thickness; but, as a rule, it is only in the neighbourhood of the mouth of the invested shell, where the polypites are most abundantly supplied with food, that more than two or three successive laminæ are produced. In the immediate vicinity of the mouth of the invested shell the colony may grow to a thickness of one line or more, partly by the addition of fresh concentric laminæ, and partly by a simultaneously effected absorbtion of the shell on which it grows. This gradual absorbtion of the invested shell goes on over the whole surface, but much more actively near the mouth of the shell than elsewhere; and hence in old colonies of *Hydractinia echinata* one often finds the calcareous substance of the shell largely, or in parts wholly, replaced by the horny fibres of the investing crust, the shell being also lined internally by a smooth horny layer.

It is to be remembered that this kind of transformation of the shell of a Gasteropodous Mollusc, though commonly the result of the growth of a colony of *Hydractinia,* is also well known to be occasionally produced by investing parasites of quite a different nature. Thus, a similar change is not uncommonly effected by *Suberites domuncula*, Nardo; the Sponge in this case further resembling the colony of *Hydractinia* in the fact that it invariably, so far as I have seen, grows upon a shell which is tenanted by a Hermit-Crab. The same phenomenon is also sometimes the result of the growth of certain of the *Polyzoa.* Thus, colonies of *Cellepora edax,* Busk, one of the Crag *Polyzoa*, produce a similar transformation of the Gasteropodous shell upon which they grow.

I may note, in passing, that, though I have often specially investigated the point, I have never observed any case in which there are indications of a similar transformation of an invested shell or coral as produced by colonies of *Labechia* or of any other Stromatoporoid. On the contrary, the invested body seems always —as shown by thin sections—to retain its original form and its original surface unchanged, the investing Stromatoporoid simply growing upon its exterior.

In order to satisfactorily compare the skeleton of *Hydractinia echinata* with that of a Stromatoporoid, it is best to take the thickened portion of an old colony of *Hydractinia*, where it surrounds the mouth of the invested shell. In this region the shell itself has usually been absorbed, so that decalcification is not needful, and it is easy to make thin sections, both in a vertical and a tangential direction. On looking at the *surface* (Pl. VI, figs. 3, 3, *a*) we see that it is studded with numerous small projecting tubercles, which represent the free upper ends of the "radial pillars." Intermixed with these are numerous larger serrated "spines" (Pl. VI, fig. 6), which are apparently formed by the upward growth of a number of the radial pillars, and by the coalescence of the free ends of these into a loose reticulation. Between the bases of the tubercles and spines may be seen minute circular apertures, which either give exit to polypites, or which serve for the passage of stolons which place the superficial layer of the cœnosarc in connection with the deeper layers of the same. The surface also exhibits the shallow, irregular astrorhizal grooves. The surface-lamina is, therefore, in the main, only a repetition of the "basal lamina," as also of all the laminæ intervening between the first and the last-formed layer. The principal difference is only that the "astrorhizal" grooves have the form of shallow open gutters on the surface of the last-formed lamina, whereas they are necessarily in all the other laminæ more or less completely roofed over, and converted into canals by the growth of each new layer in turn.

Vertical sections of the thickened colony (Pl. VI, fig. 5) show that it is composed of numerous parallel chitinous rods, which are perpendicular to the surface and to the invested base, and which are united at intervals by horizontal horny fibres. The vertical rods are the "radial pillars," produced by the upward growth of the primitive horn-cells; the connecting fibres are the horizontal "arms," which the pillars give out at intervals; and the spaces between these are filled with the cœnosarc, and represent "interlaminar spaces." In *tangential* sections (Pl. VI, fig. 1) we see the cut ends of the transversely-divided radial pillars, in the form of round horny nodes, which are united by the irregular radiating arms which they give out at intervals. Many of the radial pillars run continuously from the basal lamina to the surface, where their free ends project as tubercles or spines; but others do not seem to be continued through more than two or three successive laminæ. Moreover, each lamina, in turn, may give rise to short ascending tubercles or spines, which simply project into the interlaminar space, but do not reach the next lamina above.

Upon the whole, it must be admitted that there is a remarkable similarity between the minute structure of the chitinous skeleton of *Hydractinia echinata* and that of the large calcareous cœnosteum of certain of the Stromatoporoids, more particularly of the genera *Actinostroma*, Nich., and *Labechia*, E. and H.

A similar resemblance, though not so striking, may be found if we take one of those *Hydractiniæ* which produce a calcareous cœnosteum. The only one of these which I have been able to examine by means of thin sections is the *Hydractinia circumvestiens*[1] of the Red Crag and Coralline Crag of Suffolk. In this interesting species the skeleton is calcareous, and forms crusts of considerable thickness growing upon species of *Trophon* or other Gasteropodous shells. Viewed in thin sections by transmitted light, the skeleton appears to be composed of irregular calcareous grains closely fitted together (Plate VI, fig. 13); but I am not able to say whether or not this is the result of secondary alteration. A rough vertical fracture (Plate VI, fig. 7) shows that the skeleton is traversed by numerous irregular vermiculate tubules, which are approximately vertical, and run parallel to one another at little distances. These vertical tubules are interrupted at intervals by irregular chamberlets, placed in roughly horizontal lines, so as to give rise to imperfect "interlaminar spaces," and to confer upon the skeleton an indistinct lamination. The vertical tubules appear to have lodged the polypites, or to have given passage to stolons of the cœnosarc, and they either terminate in the chamberlets above mentioned (which at one time formed successively the surface of the colony), or they terminate above in minute round apertures on the free surface (Plate VI, figs. 8, 9, and 10). Thin vertical sections (Plate VI, fig, 11) show much the same phenomena as rough fractures; but the skeleton is now seen to be traversed at intervals by a series of vertical "radial pillars" of comparatively large size, and of a more or less open and cribriform texture in their central axes. These large pillars are also recognisable in tangential sections (Plate VI, fig. 12), and they terminate on the surface in prominent round tubercles, which, in some instances at any rate, seem to be furnished with distinct central perforations (Plate VI, figs. 9 and 10). In addition to these large and seemingly hollow pillars, the surface shows numerous small imperforate tubercles, together with well-developed branching astrorhizal grooves (Plate VI, figs. 9 and 10).

From the above sketch of the structure of the skeleton in *Hydractinia echinata*, Flem., and *H. circumvestiens*, Wood, it will be seen that these types exhibit marked points of likeness to certain forms of the Stromatoporoids, with, at the same time, equally marked points of dissimilarity. It will also be seen that so far as *H. echinata*, Flem., is concerned, it is only with a particular section of the Stromatoporoids that the likeness is at all very conspicuous. The section to which I refer is that comprising the genera *Actinostroma* and *Clathrodictyon*, and their allies—what may be called the section of the "Hydractinioid" Stromatopo-

[1] *Hydractinia circumvestiens* was described by Searles Wood under the name of *Alcyonidium circumvestiens* ("Catalogue of Zoophytes from the Crag," 'Ann. and Mag. Nat. Hist.,' ser. i, vol. xiii, 1844). I should be disposed to think that it is really identical with the form described at a later date by Dr. Allman, under the name of *H. pliocæna* ('Geol. Mag.,' 1872, p. 337); but I have not had the opportunity of examining the latter.

roids. The structure of the skeleton of these, with its "radial pillars" and their interlacing "arms," is certainly very similar to that of *Hydractinia*. On the other hand, these types differ from *Hydractinia* in the constantly calcareous constitution of the skeleton, in its massive construction, and in the fact that the organism was certainly for the most part not of an "encrusting" habit of growth. The resemblance between the *Labechiidæ* and *Hydractinia echinata* does not appear to me to be nearly so close as it is in the case of the *Actinostromidæ*. At the same time, it must be admitted that the general structure of *Labechia* and its allies is of the "Hydractinioid" type.

So far as *Hydractinia circumvestiens* is concerned, there are the special peculiarities that well-marked zoöidal tubes are present; that the interlaminar spaces are reduced to rows of irregular chamberlets, and that certain of the radial pillars appear to open upon summit-apertures. Upon the whole, therefore, the Stromatoporoids which most nearly resemble *H. circumvestiens* are the true *Stromatoporæ*, and not the *Actinostromata*.

The genus *Stromatopora*, Goldfuss, and the forms allied to this are, however, more nearly related to *Millepora*, Lam., than to the *Hydractiniæ*. This will be evident from the following brief account of the minute structure of the skeleton in *Millepora*, though on this point I need say little, as the cœnosteum of this genus has been fully described by Professor Moseley ('Report on the Scientific Results of the Voyage of H.M.S. "Challenger," vol. ii, 1881). In connection with the present inquiry I have prepared a tolerably large number of thin sections of various species of *Millepora* for comparison with corresponding sections of the Stromatoporoids, but I have nothing of importance to add to Professor Moseley's description. The skeleton of *Millepora*, as regards its main mass, is essentially composed of a complex network of anastomosing calcareous fibres, so disposed as to give rise to a correspondingly complex network of anastomosing and tortuous canals (Fig. 9, *c c*). In the living condition, this canal-system (Plate IV, fig. 5) is filled with anastomosing stolons of the cœnosarc. According to Professor Moseley, "the canals form regular branching systems, with main trunks which give off numerous branches, from which arise secondary branches, and from these again smaller ramifications. The whole canal-system is connected together by a freely anastomosing meshwork of smaller vessels, and communicates freely by numerous offsets with the cavities of the pores."

The general spongy skeleton, constituted as above described, is traversed at intervals by the vertical tubes in which the zoöids were contained. These are in two series, differing slightly in size according as they contained "gastrozoöids" or "dactylozoöids." The "gastropores" and "dactylopores" may be irregularly distributed, or the dactylopores may be arranged in more or less definite systems round the gastropores. Whatever may be the nature of the zoöids contained in them, the tubes are intersected by distinct tabulæ (Fig. 9, B), and the skeleton itself shows a more or less conspicuous composition out of thin concentric laminæ, only the thin surface-layer being at any given moment actually alive. Lastly, Mr. Quelch has recently described the reproductive organs of a new species of *Mille-*

Fig. 9.

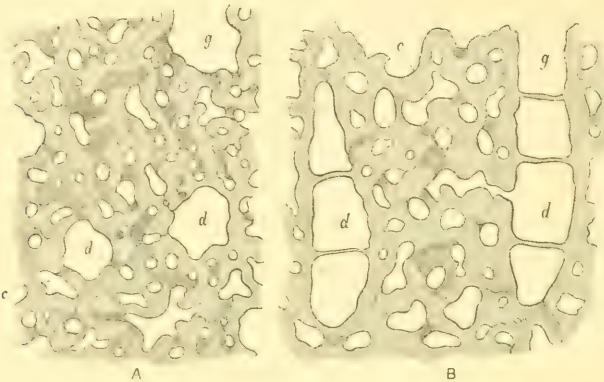

Fig. 9.—Thin sections of *Millepora*, sp., enlarged about thirty-five times. A. Tangential section. B. Vertical section. *g g.* Gastropores; *d d.* Dactylopores; *c c.* Cœnosarcal canals.

pora (*M. Murrayi*), as having the form of circular cavities or "ampullæ," contained within the reticulated spongy skeleton, and covered superficially by a thin porous layer which is often broken away ('Nature,' October 2nd, 1884). In the other species of *Millepora* the reproductive organs have not hitherto been detected; but the above discovery is sufficient to confirm the relationship between the *Milleporidæ* and the *Stylasteridæ*, which had been previously established by the researches of Professor Moseley.

It will be seen from the above brief description of the structure of the skeleton in *Millepora*, that there is a considerable resemblance between it and the skeleton of certain of the Stromatoporoids. This is most conspicuously exhibited when we compare with *Millepora* the forms which constitute the genus *Stromatopora*, Goldfuss. Thus, in the typical *Stromatoporæ*, such as *S. concentrica*, Goldf. (Plate XI, figs. 16 and 18), or *S. typica*, Rosen. (Plate V, figs. 14 and 15), or *S. Hüpschii*, Barg., sp. (Fig. 6), the skeleton is composed of a trabecular calcareous network, traversed by vertical zoöidal tubes, which are placed in communication by means of numerous ramifying cœnosarcal canals. Moreover, the zoöidal tubes are provided with transverse "tabulæ" as they are in *Millepora*. The principal distinctions, in fact, between the skeleton of such types and that of *Millepora* are that the zoöidal tubes of the former are not, as a rule at any rate, divided into two distinct series ("gastropores" and "dactylopores"), while their skeleton-fibre has a peculiar minutely porous structure. Moreover, in various forms of *Stromatopora* we can demonstrate, more or less clearly, the existence of the "radial pillars," which are such characteristic structures in the Stromatoporoids generally.

If, lastly, we turn to the group of the *Stylasteridæ*, as exemplified by such a type as *Distichopora*, Lam., we find, again, certain likenesses to the Stromatoporoids as well as certain marked differences. In *Distichopora* the zoöidal tubes are divisible, as they are in *Millepora*, into two distinct series ("gastropores" and "dactylopores") which occupy definite tracts of the cœnosteum. The general skeleton is composed of dense calcareous tissue, excavated in every direction by branched and anastomosing, microscopic cœnosarcal canals (Plate IV, fig. 4, and Plate IX, fig. 5). Lastly, in the species I have examined, I find that the pore-tubes are traversed by sparsely-developed, complete, transverse partitions or "tabulæ," which seem, however, to be confined to the deeper portions of the zoöidal tubes, and to disappear as the surface is approached.

There are, unquestionably, strong points of resemblance between such a Stylasterid as *Distichopora* and such Stromatoporoids as *Stachyodes*, Barg. In this latter genus (Plate VIII, figs. 9—14), the cœnosteum is dendroid; there are zoöidal tubes, which open by definite apertures upon the surface (though only doubtfully divisible into two distinct series); and the general tissue of the skeleton is traversed by innumerable microscopic tubuli. The genus *Stachyodes*, however, is an aberrant type, and with regard to the more normal Stromatoporoids we may in the meanwhile leave the Stylasterids comparatively out of view, as apparently further removed from these ancient *Hydrozoa* than either the *Hydractiniæ* or the *Milleporæ*.

Upon the whole, therefore, it would appear that certain of the Stromatoporoids (such as *Actinostroma*, Nich., and *Labechia*, E. and H.) have a skeleton in many respects resembling that of the *Hydractiniidæ;* while others (such as *Stromatopora*, Goldf.) possess hard structures which are more closely comparable with the cœnosteum of *Millepora*. As, however, these two groups of Stromatoporoids are linked together by various intermediate forms (*Clathrodictyon*, *Stromatoporella*, &c.), and as the natural series thus constituted possesses an aggregate of characters distinct from those of either the *Hydractiniidæ* or the *Milleporidæ*, it would not accord with the principles of sound classification to merge the former in either of the last-named divisions of the *Hydrozoa*. I shall, therefore, retain the name of *Stromatoporoidea* for the whole group of organisms now under consideration, regarding them as a peculiar division of the *Hydrozoa*, with affinities to the *Hydractiniidæ* on the one side and to the *Hydrocorallinæ* on the other side. The propriety of thus keeping the Stromatoporoids as a separate group is the more evident when it is remembered that our knowledge of these singular organisms is necessarily derived from an examination of their hard parts alone. Could we examine them in the living condition, it is not impossible that we should find that the differences which separate them from either *Hydractinia* or *Millepora* are greater than those which separate the animal of the former of these recent genera from that of the latter.

IV. SKETCH-CLASSIFICATION.

In the present state of our knowledge it is probably impossible to give any classification of the Stromatoporoids which can claim to have a more than provisional value. Many forms are still imperfectly known; while others have been described from their external characters only, and cannot, therefore, be at present placed in any system of classification based upon the minute structure of the skeleton. Considering, however, that we can never have any positive knowledge as to the nature of the soft parts in the Stromatoporoids, it is clear that the foundation of any sound classification must be sought for in the construction of the skeleton, and all modern observers will admit that a satisfactory acquaintance with this can only be acquired by the help of the microscope and through the medium of properly prepared thin sections. When we have obtained a definite knowledge of the minute structure of the skeleton, we can usually correlate this with certain external characters, and it thus becomes possible to recognise many species of Stromatoporoids by superficial peculiarities alone. Under the best of circumstances, however, there are always many specimens so badly preserved as regards their superficial characters, that even a practised observer would fail to identify them without the help of microscopic slides. Moreover, as has been already pointed out, there are many specimens in which even the microscope ceases to be of much service in their determination, owing to the fact that the internal structure of the skeleton has been more or less altered during the process of fossilisation. Many of the Stromatoporoids from the Wenlock Limestone of Gotland are in this condition, and this is occasionally the case with the specimens from the Wenlock Limestone of Britain. I find a similar change to have affected most of the Stromatoporoids which have been collected by Mrs. Robert Gray from the Silurian Rocks of the Girvan area, and which she has been good enough to confide to me for examination. In other cases, again, a long series of specimens may be examined, and perhaps not more than one or two examples will be found in which the internal structure is satisfactorily preserved.

In view of the above-mentioned difficulties which attend the study of the Stromatoporoids, and bearing in mind that there are yet various described types which have still to be examined by modern methods, the following classification must be regarded as largely tentative, though I think it will be found to indicate the lines upon which any future classification must be based. Students of recent forms may be inclined to consider the number of families proposed as out of all proportion to the number of genera. It should be remembered in this connection, however, that many more generic types almost certainly remain to be yet discovered, and that the forms at present known are in all probability only the widely separated links of a great series of extinct *Hydrozoa*, of which our knowledge is at present very imperfect. I shall subsequently discuss the characters of the families and genera at some length; but it may be as well, at the risk of some repetition, to subjoin here a brief tabular view of the classification which I have ventured to suggest.

ORDER—STROMATOPOROIDEA, *Nich. and Mur.*

Hydroid Zoophytes producing a calcareous cœnosteum, which may be encrusting or dendroid; but which is most commonly laminar or massive, with a basal epitheca, and a comparatively small peduncle of attachment. Cœnosteum composed essentially of two sets of elements, viz.: (1) hollow or solid calcareous rods, or pillars, which are "radial" in position, or are vertical to the general surface; and (2) hollow or solid calcareous fibres or plates, which are in the main rectangular to the preceding, or "tangential" to the general surface, and which are developed at more or less definite intervals, thus giving rise to a series of horizontal "laminæ." The radial pillars may be much modified, or even partially suppressed as definite structures. Very generally the horizontal fibres are more or less closely united with one another and with the radial pillars, and thus give rise to a reticulated skeleton.

The skeleton-fibre may be apparently solid, but in other cases is minutely porous or tubulated.

Definite zoöidal tubes may be present or absent. When present, they are usually "tabulate," and appear in general to be approximately similar to one another in size and internal structure.

"Astrorhizal canals" may be present, or absent. [No account is taken of the so-called "*Caunoporæ*" in the above definition, as the nature of the fossils so named will be dealt with separately.]

SECTION A ("Hydractinioid" Group).

Fam. 1. ACTINOSTROMIDÆ, *Nich.*

Skeleton composed of distinct radial pillars which give off horizontal processes, these latter having a radiating arrangement, and inosculating with one another in such a manner as to give rise to a "rectilinear" meshwork. Radial pillars confined to the separate interlaminar spaces, or passing continuously through many successive laminæ. Definite zoöidal tubes are wanting, or are very imperfectly developed.

Genera.—Actinostroma, Nich.; *Clathrodictyon*, Nich. and Mur.; *Stylodictyon*, Nich. and Mur. (?).

Fam. 2. LABECHIIDÆ, *Nich.*

Cœnosteum usually laminar or massive, with a basal epitheca; sometimes cylindrical. Skeleton composed of curved or horizontal calcareous plates, arranged so as to constitute a stratified vesicular tissue, but not giving rise to concentric "laminæ." Radial pillars sometimes well developed and "continuous," at other times rudimentary. Definite zoöidal tubes not developed.

Genera.—Labechia, E. and H.; *Rosenella*, Nich.; *Beatricea*, Bill. (?); *Dictyostroma*, Nich. (?).

SECTION B ("Milleporoid" Group).

Fam. 3. STROMATOPORIDÆ, *Nich.*

Cœnosteum having the radial and horizontal elements so combined with one another as to give rise to a more or less continuously reticulated skeleton. Skeleton-fibre minutely porous or tubulated. Definite zoöidal tubes furnished with "tabulæ" are developed.

Genera.—Stromatopora, Goldf.; *Stromatoporella*, Nich.; *Parallelopora*, Barg. (sub-genus?); *Syringostroma*, Nich. (sub-genus?).

Fam. 4. IDIOSTROMIDÆ, *Nich.*

Cœnosteum usually cylindrical, often branched and dendroid, with a principal "axial tube," which is intersected by tabulæ and gives off lateral tabulate branches. Definite zoöidal tubes are present. The general tissue of the skeleton is continuously reticulated, and the skeleton-fibre is mostly porous or tubulated.

Genera.—Idiostroma, Winch.; *Hermatostroma*, Nich. *Amphipora*, Schulz; *Stachyodes*, Barg.

V. FAMILIES AND GENERA OF THE STROMATOPOROIDS.

Fam. 1. Actinostromidæ, *Nich.*

Skeleton composed of distinct "radial pillars," which give rise to concentrically disposed "laminæ," by the production at successive levels of horizontal processes or "arms," which inosculate to form a "rectilinear" meshwork.

In this family I include those Stromatoporoids in which the cœnosteum is clearly composed of radial pillars and concentric laminæ, the latter formed by the anastomosis of radiating calcareous fibres, in such a manner as to give rise to a loose network, the meshes of which are typically angular. The skeleton is not a continuously reticulated one, and therefore in this family, unlike what occurs in the *Stromatoporidæ*, the radial pillars are always recognisable in tangential sections as distinct from the horizontal processes to which they give rise. The skeleton-fibre is not minutely porous, and the radial pillars are often hollow internally. Definite zoöidal tubes, as distinct from the angular meshes formed by the inosculating horizontal processes, are not present. The surface is granulated or tuberculated by the projecting upper ends of the radial pillars. Astrorhizæ may be present or absent. The form of the cœnosteum is exceedingly variable, an epitheca being sometimes present, sometimes absent.

Genus Actinostroma, *Gen. nov.*

(= *Stromatopora*, auctt.).

Radial pillars "continuous," *i.e.* passing continuously through a number of laminæ and interlaminar spaces. When the laminæ are grouped into "latilaminæ," as is not uncommonly the case, the radial pillars are continued from the under surface of each latilamina to the upper surface. The horizontal processes or "arms" are delicate, solid or hollow fibres, which are given off from the radial pillars in whorls, at corresponding levels, and which unite to form an angular meshwork. Astrorhizæ may be present or absent.

Owing to the discovery that the original specimen of *Stromatopora concentrica*, Goldf., possesses a continuously reticulate skeleton of the "Milleporoid" type, I have been compelled to propose the new generic name of *Actinostroma* for those widely-spread Stromatoporoids which had up till now been generally regarded as referable to the genus *Stromatopora*, Goldf. The species, which has been generally identified as *Stromatopora concentrica*, Goldf., I shall name *A. clathratum*. It is an abundant form in the Devonian formation of both Britain and Germany, but I have not recognised its existence hitherto in the Devonian of North America. In the Devonian formation there occur several other types, more or less closely related

FIG. 10.

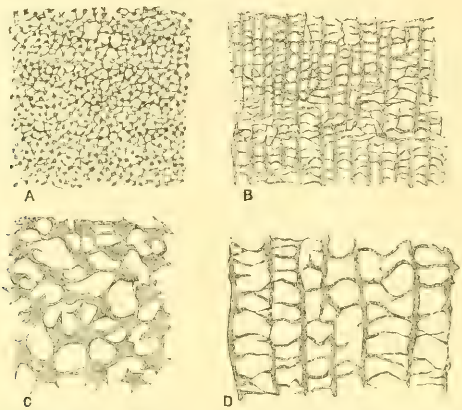

FIG. 10.—Minute structure of *Actinostroma intertextum*, n. sp., from the Wenlock Limestone, Benthall Edge. A and B. Tangential and vertical sections, enlarged twelve times. C and D. Parts of the same, enlarged twenty-four times.

to *A. clathratum*. One of these is the form to which Goldfuss gave the name of *Ceriopora verrucosa*, and which will now stand, therefore, as *Actinostroma verrucosum*. Another is the common Devonian species which Bargatzky described under the name of *Stromatopora astroïtes*, Rosen; the latter being really a true *Stromatopora*. I shall describe this later as *Actinostroma stellulatum*. A third form, which, like the preceding, is found in the Devonian deposits of both Britain and Germany, is remarkable for the possession of two distinct series of radial pillars, one of large size and the other small; and I shall name this *Actinostroma bifarium*. The only Silurian species of the genus with which I am at present acquainted are the singular *A.* (*Stromatopora*) *Schmidtii*, Rosen, and a new form (*A. intertextum*, Fig. 10) from the Wenlock Limestone of Britain.

The essential character which distinguishes *Actinostroma* from the genus *Clathrodictyon* is the continuity of the radial pillars in the former. As no vertical section can possibly be prepared, which shall run precisely along the axis of any single radial pillar, or of any set of pillars, throughout its entire length, it is not possible to ascertain precisely the extent to which this continuity of the radial pillars is carried. A single radial pillar may often be followed through ten, fifteen, twenty, or more laminæ and successive interlaminar spaces; and I am of opinion that they really run continuously for considerably greater distances. In *A. clathratum*, in which the cœnosteum commonly grows in "latilaminæ," the pillars seem certainly to extend in general through the entire thickness of a latilamina. The radial pillars are mostly, perhaps always, hollow, each being traversed by a minute and apparently often nearly obliterated axial canal (Pl. I, figs. 10 and 13). This phenomenon can only be recognised in tangential sections, and only in well-preserved specimens. On the free surface of the cœnosteum, the pillars terminate in blunt and apparently imperforate tubercles (Pl. II, fig. 11).

Tangential sections (Pl. I, figs. 8, 10, 11) show the cut ends of the radial pillars and the angular meshwork formed by the inosculation of the horizontal connecting-processes; the structure being of what has been called the "hexactinellid type," from its superficial resemblance to the spicular network of some of the Hexactinellid Sponges.

So far as my observations have extended, astrorhizæ are present in the majority of species belonging to the genus *Actinostroma*, including the type-species *A. clathratum* (= *S. concentrica*, Barg.) in which their existence has been denied. They vary, however, greatly in their development, and they are apparently occasionally wanting. In at least one species of the genus (namely, that which Bargatzky has erroneously identified with *Stromatopora astroites*, Rosen) they are largely developed, and are arranged in successive superposed groups, connected by vertical wall-less canals (Pl. IV, fig. 3, *a*).

The form of the cœnosteum in the genus *Actinostroma* is usually massive or laminar, and in the latter case an epitheca is almost always developed basally. In the massive forms, however, the colony often grows in successive layers, of which the first is attached to some foreign body.

Genus Clathrodictyon, *Nich. and Mur.*

('Journ. Linn. Soc.,' vol. xiv, p. 220, 1878.)

Cœnosteum often of large size, usually expanded or laminar, with a concentrically-wrinkled basal epitheca and a small base of attachment; occasionally massive. The general structure of the skeleton is like that of *Actinostroma*, but the radial pillars are incomplete, and are never "continuous." Astrorhizæ are present. The surface is minutely granular or vermiculate, without marked prominences or "mamelons."

In certain of the types which may be placed under *Clathrodictyon*, such as *C. regulare*, Rosen, the general structure of the skeleton is precisely that of *Actinostroma*, except that the radial pillars are confined strictly to the interlaminar spaces in which they take their origin, and never pass continuously through successive laminæ and interlaminar spaces. The result of this is to give to vertical sections (Pl. II, fig. 8, and Pl. V, fig. 1) a singularly regular aspect, as formed of rectangular spaces arranged in successive tiers one above the other. Tangential sections (Pl. V, fig. 2) show the cut ends of the short radial pillars, and in the centre of these one may sometimes observe traces of the existence of a minute central cavity. The last-formed pillars terminate superficially in minute, apparently imperforate tubercles (Pl. II, fig. 12).

In the more characteristic species of *Clathrodictyon*, including the type-species, *C. vesiculosum*, Nich. and Mur., not only are the radial pillars incomplete, in the sense that many of them simply project for a short distance into the interlaminar space in which they are developed, but in many cases they cease to a greater or less extent to exist as independent structures. Not only do the radial pillars become very irregular, but the horizontal processes which form the concentric laminæ are equally irregular; and the two sets of structures are so united together as to give rise to a tissue of larger or smaller lenticular vesicles. Hence in vertical

FIG. 11.

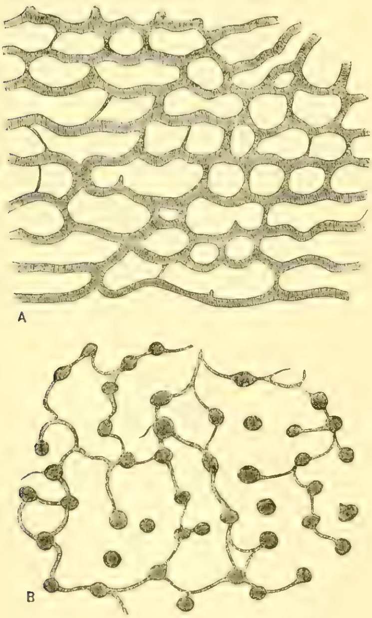

FIG. 11.—*Clathrodictyon cellulosum*, Nich. and Mur., Corniferous Limestone, Ontario. A. Vertical section. B. Tangential section, enlarged twelve times.

FIG. 12.

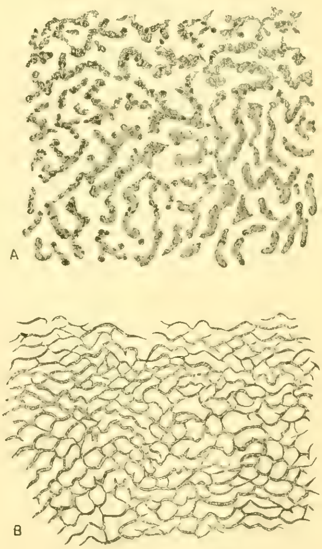

FIG. 12.—*Clathrodictyon fastigiatum*, Nich., Wenlock Limestone, Dormington. A. Tangential section. B. Vertical section, enlarged twelve times.

sections (Figs. 11 and 12, and Plate V, figs. 1, 3, 5, 6) the general aspect of the structure resembles that of the vesicular tissue of a *Cystiphyllum* or the so-called "cœnenchymal" tissue of such corals as *Plasmopora* or *Fistulipora*. Tangential sections (Plate V, figs. 2, 4, 7) show a somewhat similar reticular structure, sometimes vermiculate, and generally more or less clearly exhibiting the cut ends of a number of the radial pillars.

Astrorhizæ are generally present. The surface is either minutely granular, or is covered with vermiculate ridges (Plate II, figs. 12 and 13); but there are no conical elevations or "mamelons."

With the exception of *C. cellulosum*, Nich. and Mur., from the Corniferous Limestone of Canada (Fig. 11), and of an undescribed form from the Devonian Limestones of South Devon (from the collection of Mr. Champernowne), I am not acquainted with any Devonian species of *Clathrodictyon*. On the other hand, the genus is largely represented in the Upper Silurian rocks. The type-species is the *C. vesiculosum*, Nich. and Mur., of the Clinton and Niagara formation of North America (Plate V, fig. 5). A very nearly allied type is the *C. variolare*, Rosen, sp. (Plate V, fig. 6), of the Wenlock Limestone of Esthonia and of Britain. Another very beautiful species is *C. striatellum*, D'Orb. sp. (Plate V, figs. 3 and 4), which is characteristic of the Wenlock Limestone of Britain, but occurs also in the Ordovician Rocks of Esthonia, whence it was described by Friedrich Schmidt under the name of *Stromatopora mammillata*. Other Wenlock species of the genus are *C. regulare*, Rosen, sp. (Plate V, figs 1 and 2), and *C. fastigiatum*, n. sp. (Fig. 12).

Genus Stylodictyon, *Nich. and Mur.*

('Journ. Linn. Soc.,' vol. xiv, p. 221, 1878).

Cœnosteum massive, traversed by numerous closely-set circular vertical columns of large size, which are formed by the upward bending of the concentric laminæ, and which terminate on the surface in small pointed eminences (Plate VII, figs. 7, 8, 9). Each of these vertical columns is composed of a dense central axis surrounded by a zone of thickened reticulated tissue. The intercolumnar spaces (Plate VII, figs. 10 and 11) are occupied by the general tissue of the skeleton, composed of concentric laminæ and radial pillars, and much resembling the skeletal tissue in the genus *Clathrodictyon*. The radial pillars are imperfectly developed, not being "continuous," and commonly falling short of the lamina next above that from which they take their origin. The concentric laminæ are well developed, being curved in each intercolumnar space, with their convexities downwards, and bent upwards sharply as they join the "columns" on both sides. The laminæ have further a kind of alternate arrangement in groups, those of one group being very close together, with few or no radial pillars in the interlaminar spaces; while those of the next group are further apart, and have their interlaminar spaces crossed by short irregular pillars. Extremely well-developed astrorhizæ are present.

This genus was founded by Dr. Murie and myself (*loc. cit.*) for the singular *S. columnare* (=*Stromatopora Wortheni*, Quenst.), first described by me from the Devonian Rocks of North America ('Pal. of Ohio,' vol. ii, p. 253, Plate XXIV, fig. 1). We included in the genus another form (viz. *S. retiforme*, Nich. and Mur.), but this is in reality a species of *Actinostroma*, and is nearly related to *A. verrucosum*, Goldf., sp. On the other hand, *Stylodictyon columnare*, Nich., is a very peculiar type, and in the present state of our knowledge can hardly be referred to any other genus. I am not, however, clear as to the position which the genus *Stylodictyon* ought properly to occupy, as the characters of the type-species are in many respects such as would give it an intermediate place between the *Actinostromidæ* and the *Stromatoporidæ*. In vertical sections, the structure of the skeleton—apart from the characteristic columns—conforms to that of the *Actinostromidæ*, the concentric laminæ being very well developed, and the radial pillars not being obliterated. On the other hand, tangential sections (Plate VII, fig. 10) do not show the cut ends of the pillars, but rather show a reticulated tissue, similar to that of the *Stromatoporidæ*.

Various Stromatoporoids show an approach to the structure of *Stylodictyon columnare* as regards the peculiar vertical columns which intersect the entire cœnosteum. *Stromatopora consors*, Quenst., is an example in point. Much more extended researches are, however, necessary before it can be asserted that the structure of the forms in question is really the same as in the present genus, or before we can deal more precisely with the type-species, *S. columnare*.

The columns of *Stylodictyon* may, perhaps, be compared with the large spines of *Hydractinia circumvestiens*, S. V. Wood (Plate VI, figs. 11 and 12); but they appear to be rendered quite solid centrally, by the complete obliteration of the interlaminar spaces, and they do not, therefore, open by apertures on the surface.

Fam. 2, LABECHIIDÆ, *Nich.*

The cœnosteum in this family is composed of large-sized calcareous vesicles, which are usually lenticular in shape, but may be rectangular, and which are arranged in superposed strata as regards either a basal plane or an axial tube. The vesicles are traversed at intervals by " radial pillars " directed at right angles to the plane of their strata; or they carry the same structures in a rudimentary form upon their upper convex surfaces. The external surface usually exhibits larger or smaller tubercles, representing the upper ends of the radial pillars. No astrorhizæ are present. A basal epitheca is often present. No definitely circumscribed zoöidal tubes appear to exist. The skeletal tissue is mostly apparently compact or granular; but its minute structure has at present been imperfectly investigated. [The radial pillars of *Labechia conferta* appear to have a peculiar cribriform structure, apart from their possession of axial canals.]

It would be easy to give a satisfactory definition of this family, if we were to include in it only the various species of *Labechia*, E. and H. It is, however, impossible in the present state of our knowledge to frame a sufficient diagnosis of the family, if we include in it, as we seemingly must do, not only the singular *Rosenella dentata*, Rosen, sp., and its allies, but also the still more aberrant types included by Billings under the name of *Beatricea*. As a merely provisional arrangement, we may also place in this family the very incompletely known genus *Dictyostroma*, Nich.

Genus Labechia, *Edwards and Haime.*

('Polyp. Foss. des Terr. Paléoz.,' p. 279, 1851.)

The skeleton in this genus is laminar or massive, usually furnished with a concentrically wrinkled basal epitheca (Plate III, fig. 7), and attached by a small peduncle, and not genuinely encrusting, though often involving foreign bodies in its growth. Very young examples (Plate III, figs. 9—11) consist of a flattened circular basal epitheca supporting a single layer of blunt tubercles on the upper surface. Adult examples have these tubercles developed into stout radial pillars, which are continued through the thickness of the cœnosteum without a break, and terminate on the upper surface in blunt and apparently imperforate tubercles. The radial pillars contain a distinct axial canal, but they would seem to be solid at their apices. They run parallel to one another, and are united by curved or straight calcareous plates which form a series of large-sized vesicles, filling up all the interspaces between the pillars. Owing to the entirely irregular development of these vesicles, the cœnosteum shows no tendency to split concentrically, as is observed in the normal Stromatoporoids, and there are no definite " concentric laminæ."

The skeleton in the genus *Labechia*, E. and H., has in the main a resemblance to that of *Actinostroma*, Nich., but it differs from this in the great size of the radial pillars, and in the fact that the horizontal processes which are developed from these appear to have the form of convex or flat plates, instead of mere fibres, while they are produced with such irregularity as not to give rise to distinct " laminæ." The radial pillars are undoubtedly hollow, and contain an axial canal

(Fig. 13), which may in some cases be even transversely partitioned (e.g. in *L. serotina*, n. sp. Fig. 4). The axial canals are surrounded by denser tissue arranged in

Fig. 13.

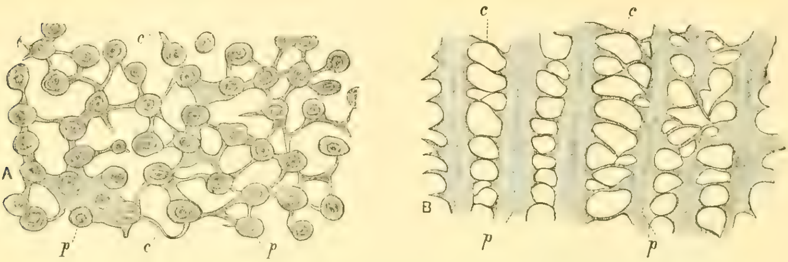

Fig. 13.—Sections of *Labechia conferta*, Lonsd., enlarged twelve times. Wenlock Limestone, Benthall. A. Tangential section. B. Vertical section. *p p*. Radial pillars. *c c*. Tabular connecting-processes.

concentric layers, but exhibiting distinct vacuities, and thus not strictly solid. The superficial terminations of the pillars are for the most part apparently solid. If, however, the tissue of the pillars be really cribriform, as there seems reason to believe, then this apparent solidity may be only due to the fact that any superficial pores are filled with the matrix. Sometimes the surface tubercles clearly show at their summits a minute pit, representing the upper end of an axial canal (Plate III, fig. 14), but no traces of such openings can be detected in other examples (Plate III, fig. 15), and it is not impossible that the appearance of perforations may be really the result of weathering.

Dr. Gustav Lindström and Professor Ferdinand Roemer have given descriptions of the structure of *Labechia*, which differ in important respects from that given above. The former of these distinguished observers has described the cœnosteum of *Labechia* as consisting in its earliest stages of growth "of a very thin circular disc, with concentric lines of growth beneath, and having the superior surface studded with blunt spines, which radiate from the centre, and also coalesce and form continuous ridges. . . . . During the course of growth the primitive disc of *Labechia* is increased in thickness by the addition of successive thin strata, which closely conform to the subjacent fundamental crust, being elevated where the spines are situated. As these successive layers leave a small space between them and are in themselves very thin, they give rise to a false appearance of tabulæ" ('Ann. and Mag. Nat. Hist.,' ser. 4, vol. xviii, p. 4, 1876). Prof. Ferd. Roemer ('Lethæa Palæozoica,' p. 543, 1883) describes the skeleton of *Labechia* as consisting wholly of very thin horizontal lamellæ, which are superimposed one above the other in a continuous series, all being in practically direct contact with one another, and being bent into a system of close-set conical elevations, which in the last-formed layer give rise to the surface-tubercles. According to this view there are in *Labechia no* radial pillars, *no* interlaminar spaces, and, of necessity, none of the vesicular tissue which I have described as filling all the spaces between the radial pillars.

It is, however, quite beyond question that the skeleton of the English examples of *Labechia conferta* consists essentially of radial pillars and intervening vesicular tissue, as above described. Some specimens of the same species which Dr. Lindström was good enough to send me from the Wenlock Limestone of Gotland, exhibited this structure quite as clearly as our British examples, and I was, therefore, at first much puzzled with the discrepancy between the phenomena observed in these and the descriptions given by Lindström and Roemer. Professor Roemer was, however, so kind as to send me a specimen and slide of the form which had served as the basis of his description of the structure of *Labechia conferta*, Lonsd., and which, as coming from Gotland, may be supposed to agree with those that had been under observation by Dr. Lindström; and an examination of this explained the discrepancy in question. The specimen, namely, apparently belonged to *Labechia conferta*, Lonsd., and, indeed, exhibited a very well-preserved surface; but the internal structure had been almost wholly destroyed by a process of secondary crystallisation—a phenomenon which is not uncommonly observable in other Stromatoporoids. Hence the radial pillars and intervening lenticular vesicles, which are quite well preserved in certain of the Gotland specimens, had been wholly obliterated, and the observable structure was simply that of a series of undulated and closely superimposed layers, as described by Dr. Lindström and by Professor Roemer. Recently, moreover, I have collected a number of examples of *Labechia* from the Upper Oesel Group (Ludlow formation) of Esthonia, which are in a precisely similar condition of internal crystallisation, and show precisely similar phenomena. Whether these examples are *specifically* identical with *L. conferta*, Lonsd., or belong to a distinct species, is a matter for further investigation.

The type-species of the genus *Labechia* is the well-known *L. conferta*, Lonsd., of the Wenlock Limestone. Another very interesting type, which I shall subsequently describe under the name of *L. alveolaris*, occurs in the Wenlock Limestone of Britain. In the Devonian Limestone of Devonshire occurs another highly remarkable form, which will be described as *L. serotina* (Fig. 4). The genus has not hitherto been detected in the Ordovician (Lower Silurian) Rocks of either Britain or Europe. At least two species, however, occur in rocks of this age in North America, viz. *L. Canadensis*, Nich. and Mur., of the Trenton Limestone (Plate II, fig. 3), and *L. Ohioensis*, n. sp., from the Cincinnati group of Ohio (Plate II, figs. 1 and 2). The former of these types was taken by Dr. Murie and myself as probably representing the ill-defined genus *Stromatocerium*, Hall ('Pal. N. Y.,' vol. i, p. 48), and we based upon a microscopic investigation of its structure an amended definition of this genus ('Journ. Linn. Soc.,' vol. xiv, p. 222). Further investigation has, however, shown, as previously pointed out, that the specimens which we had under examination were "reversed," the skeleton being replaced by calcite. When viewed from this aspect, it becomes at once evident that *Stromatocerium canadense*, Nich. and Mur., is really a *Labechia*. The genus *Stromatocerium*, Hall, must therefore be in the meanwhile kept *in retentis*, until a sufficient investigation shall have been made into the minute structure of the original specimens which Professor Hall had under his observation.

Genus ROSENELLA, *gen. nov.*

Cœnosteum laminar or massive, with a basal epitheca. Skeleton composed of slightly curved or undulated calcareous plates, which are so combined as to give rise to a series of comparatively large, elongated, lenticular vesicles, upon the convex upper surfaces of which are carried numerous short and rudimentary radial pillars. The radial pillars mostly fall short of the under surface of the lamina next above that from which they spring, and therefore appear merely as conical tubercles on the upper surfaces of the vesicular plates. Definite zoöidal tubes are not developed; but the laminæ are porous; and when the laminæ are very thick (as they sometimes are) the pores become converted into vertical tubes, which doubtless lodged zoöids. Surface flat or undulated, covered with tubercles. Astrorhizæ not developed.

As the type of this genus we may take a singular Stromatoporoid (*R. macrocystis*, n. sp.) from the Wenlock Limestone of Gotland, of which, through the kindness of my friend Dr. George J. Hinde, I have been enabled to examine specimens. A nearly allied type is the *R.* (*Stromatopora*) *dentata*, Rosen, of the Silurian Rocks of Oesel; and the form which the same author has described under the name of *Stromatopora Ungerni* ("Die Natur der Stromatoporen," Taf. ix, figs. 5 and 6), should also be placed here. I am, further, acquainted with two or three undescribed forms of the genus. One of these is a large form from the Ordovician deposits of Ayrshire, which Mrs. Robert Gray has been good enough to submit to me from her unrivalled collection of the fossils of the Palæozoic Rocks of Ayrshire, and which, though in bad preservation, seems to be properly referable to this genus.

The genus *Rosenella* is nearly related to *Labechia*, E. and H., on the one hand, while it has certain striking relationships with *Clathrodictyon*, Nich. and Mur., on the other hand. With his usual acumen, Prof. Ferd. Roemer had recognised the relationships of *Stromatopora dentata*, Rosen, with *Labechia*, to which genus he had, indeed, transferred the species ('Leth. Pal.,' p. 543). As based upon the type-form, *R. macrocystis*, n. sp., the genus *Rosenella* differs, however, from

Labechia in the very rudimentary condition of the radial pillars, and also in the correspondingly increased development of the vesicular laminæ. In *Labechia* (Fig. 5), the cœnosteum consists of strong, "continuous" radial pillars, separated and united by curved vesicular plates which carry no tubercles. In *Rosenella*, on the other hand, the cœnosteum (Plate VII, fig. 12) consists wholly of curved vesicular plates, which are not traversed by continuous radial pillars, but have the whole of their upper surfaces covered with rudimentary pillars in the form of conical tubercles. Tangential sections (Plate VII, fig. 13) show sometimes the cut edges of the curved vesicular plates, sometimes the transversely divided tubercles which spring from these plates, and sometimes the porous tissue of the plates themselves. The type-species of the genus is remarkable for the large size of the elongated cells which form the cœnosteum, single vesicles being sometimes an inch or more in length; but in other species (*e.g. R. dentata*, Rosen) the vesicles are much smaller. There are certain forms of the genus which show a singular transition between this and *Clathrodictyon;* but I shall be able to speak more definitely on this point later on.

Genus DICTYOSTROMA, *Nich.*

('Palæontology of Ohio,' vol. ii, p. 254, pl. xxiv, fig. 6, 1875.)

This genus was founded by me for the reception of a singular Stromatoporoid (*Dictyostroma undulatum*) from the Niagara Limestone of North America. As I unfortunately prepared at the time no thin sections of this form, and now possess no examples of it, the genus cannot be regarded as being adequately defined or satisfactorily established. The merely macroscopic characters of *D. undulatum*, so far as they can be used as a guide, would seem to show that *Dictyostroma*, if on further investigation it should prove to be a valid genus, is closely allied to *Rosenella*. Possibly, if its minute structure were known, it might be found to embrace the types which I have here referred to *Rosenella*, but on this point nothing certain can be said at present.

The cœnosteum in *Dictyostroma* consists of very thick, undulating, concentrically-disposed calcareous laminæ, which are separated from one another by intervals of about their own width (about two thirds of a millimetre), and which give off from their upper surface strong, remote, pointed radial pillars, which appear to reach the under surface of the lamina next above that from which they spring, but do not become amalgamated with it. The broken edges of the laminæ, when seen in vertical fractures, exhibit minute rounded apertures, but the precise nature of these could only be determined by means of thin sections.

Genus Beatricea, *Billings.*

(' Geol. Survey of Canada, Report of Progress for 1856,' p. 343, 1857.)

Cœnosteum in the form of cylindrical or angulated stems, which are nearly straight, are unbranched, and may attain a great size. (Billings states that specimens are sometimes over ten feet in length and more than a foot in diameter.) In the centre of the cœnosteum, running along its whole length, is a large axial tube, crossed by strongly curved calcareous partitions, or tabulæ, the remainder of the skeleton being composed principally of lenticular calcareous vesicles, arranged in concentric layers round the axial canal (Plate VIII, figs. 2 and 3). Well-preserved specimens exhibit radial pillars, resembling those of the Stromatoporoids generally, which intersect the vesicular tissue of the skeleton, and are directed outwards in a radiating manner from the axial tube towards the surface. No zoöidal tubes are certainly known to exist. The surface is ridged, or covered with elevated and usually elongated projections or mamelons (Plate VIII, fig. 1). The surface may be apparently imperforate, or may show minute rounded apertures of different sizes (Plate VIII, fig, 8). There is no external calcareous membrane, such as would correspond with the "epitheca" of a Rugose Coral.

The fossils for which Mr. Billings proposed the name of *Beatricea* are of a most anomalous character, and have been assigned to very different positions in the animal kingdom by different observers. Most generally they have been regarded as aberrant types of the Rugose Corals, and have been placed in the neighbourhood of the genus *Cystiphyllum*, a view which is borne out by the broad features of their skeletal structure, but which is rendered untenable by a study of the microscopic characters of the same. They have been referred by Professor Winchell to the Stromatoporoids; but I have not succeeded in finding any published account of this view, or of the grounds upon which it was based. The most recent opinion upon the subject of the affinities of *Beatricea* is that of Professor Hyatt, who formerly referred the genus to the *Cephalopoda,* but who has been led to the conclusion that it is properly to be placed among the *Foraminifera* (' Amer. Assoc. for the Adv. of Sci.,' 1884).

My own studies upon *Beatricea* have been based in part upon specimens from the Cincinnati Group of Kentucky, and partly upon a number of very interesting examples which my friend Mr. Whiteaves, the accomplished palæontologist to the Geological Survey of Canada, was good enough to send me. These latter were obtained from the Hudson-River formation of Anticosti and of Rabbit Island, Lake Huron. The two species originally described by Mr. Billings, viz. *B. nodulosa* and *B. undulata,* were both represented in the material which I have examined.

One of the great difficulties connected with the study of *Beatricea* arises from its apparently uniformly poor state of preservation. The skeletal tissue seems to have been very delicate and apparently very readily dissolved; hence the central portions of the cœnosteum are very commonly more or less largely replaced by calcite, while larger or smaller tracts throughout the skeleton are either similarly replaced, or are completely broken up. Moreover, even where the actual structure of the skeleton has been retained, it seems to have undergone some secondary change which has rendered its interpretation exceedingly difficult, certain parts of all the sections which I have prepared always showing a cloudy and granular aspect by which the minute details are hopelessly obscured.

The two conspicuous features in the skeleton of *Beatricea*, as displayed by transverse or longitudinal sections of the cylindical cœnosteum (Pl. VIII, figs. 2 and 3), are the axial tube and the peripheral vesicular tissue. The axial tube is a longitudinal canal, generally 5—6 mm. in diameter, running the entire length of the cylindrical cœnosteum. It has no definite walls, but is formed by the superposition of a series of deeply convex vesicles of large size, the convexities of which are all turned in one direction (Pl. VIII, fig. 3). Whether the convexities of these curved tabulæ point to the distal or to the proximal end of the cœnosteum I am unable to say, but I incline to think that they point to the former.

The remainder of the skeleton is formed by a thick sheath of vesicular tissue, formed of lenticular calcareous cells, arranged in successive concentric zones round the axial canal, and having a general long diameter of from 1 to 3 mm., their convexities being uniformly turned towards the exterior of the cylinder. The general character of the vesicles, superficially at any rate, is very similar to that of the cellular tissue of *Cystiphyllum;* and, if we take the axial canal as representing a central tabulate area, there would be considerable ground for regarding *Beatricea* as an ally of the Cystiphylloid Corals.

The structure of the vesicles is, however, not so simple as might at first sight appear. In all thin sections, in whatever direction they may be taken, the interior of the vesicles is more or less extensively occupied by ill-defined granular calcareous matter, which, beyond doubt, belongs to the skeleton of the fossil. Sometimes the entire cavity of the vesicle is filled with this granular tissue, but more often the vesicle is only lined with it, the lining being often confined to the convex margin of the vesicle, the rest of the space being filled up with calcite. That this granular tissue is properly part of the cœnosteum, and not a mere product of mineralisation, is shown by two facts. In the first place, in certain specimens, towards the exterior of the cylinder, the walls of the vesicles disappear to a larger or smaller extent, and then the granular matter which lined them forms a series of concentric laminæ, resembling the "laminæ" of an ordinary Stromatoporoid. In the second place, most specimens have this granular material in the interior of the vesicles so arranged as to leave a larger or smaller number of clear lines which radiate from the convex outer margins of the vesicles towards their shorter inner sides (Plate VIII, fig. 5). This is one of the points concerning which one is unfortunately left in the dark owing to the imperfect preservation of the specimens; for out of a large series of sections, taken tangentially, transversely, and longitudinally, I fail to find one in which this structure is so clearly shown as to allow of a definite interpretation of its nature, though all show it more or less. All that I can say is that it reminds one, to some extent, of the arrangement of the rudimentary radial pillars on the surface of the vesicles of *Rosenella macrocystis* (Plate VII, fig. 12).[1]

The most characteristic structures of the Stromatoporoids, however, are the "radial pillars," and I am now able to show that apparently similar structures exist in *Beatricea* in a well-marked form. Here, again, we have the disappointing fact that these structures, owing to the state of preservation of the specimens, are not uniformly to be recognised. Even in specimens in which they are well shown they are only to be found in portions of the cœnosteum, having apparently disappeared elsewhere; or if they are present, the ordinary vesicular tissue is apt to be wanting. In certain specimens, however, the vesicles and the radial pillars are preserved in the same section (Plate VIII, fig. 4), in which case the pillars are seen as strong, apparently hollow rods, which are directed outwards in a radiating manner from the axial canal towards the circumference, and which are united to one another by the vesicular tissue. In this case, therefore, the structure is essentially the same as is observed in the genus *Labechia*, E. and H.

In another, very large specimen, for which I am indebted to Mr. Whiteaves, the inner layers of vesicular tissue, in the vicinity of the axial canal, show no traces of the radial pillars; but these latter structures are very well preserved in the peripheral zone of the cœnosteum. Transverse or longitudinal sections of this region of the skeleton show a general structure quite similar to what we might expect in any Stromatoporoid. Such sections (Plate VIII, fig. 6) show a series of strong radial pillars radiating from the central portion of the skeleton towards the circumference, and united by well-marked concentric "laminæ," which undulate in conformity with the surface-elevations. Both the pillars and the laminæ are composed of granular matter, showing well-marked dark points. The ordinary vesicles are present here and there among the pillars, and run parallel to the laminæ; but they are mostly wanting, in which case the concentric laminæ seem to be formed out of the granular lining which is seen in all the vesicles. Tangential sections, taken close to the circumference (Plate VIII, fig. 7), also show

[1] In one section of *Beatricea nodulosa*, Bill., I have noticed perpendicular calcareous septa crossing the vesicles, but whether or not this has anything to do with the appearances described above I am unable to say.

appearances very similar to that of corresponding sections in an ordinary Stromatoporoid, such as any species of *Clathrodictyon*. We see, namely, a number of close-set, rounded or oval, granular masses, which represent the ends of the transversely-divided radial pillars. These are also highly granular, and they are sometimes unquestionably hollow, though at other times they appear to be solid. The section further shows curved tracts of dark granular matter, formed by the close apposition of the cut ends of the pillars, and representing the points where the plane of the section corresponds with the plane of one of the undulating concentric laminæ.

Lastly, the surface of this remarkable specimen (Plate VIII, fig. 8) exhibits innumerable small rounded apertures, of which some are larger than the others, and are arranged in irregular longitudinal lines, which have seemingly a tendency to assume a spiral direction. The larger openings are, almost certainly, the apertures of the hollow radial pillars, and possibly all are of this nature. I cannot be sure, however, that these openings are not the result of the removal of the outermost layer of the skeleton. No traces of similar openings can be detected on the surface of most specimens of the same species (*B. nodulosa*, Bill.), though their absence may only be due to their bad state of preservation.

It need only be added that though the other species of *Beatricea* described by Billings, viz. *B. undulata*, is distinguished from *B. nodulosa* by its external form, its general structure is precisely the same. I have not, however, succeeded in recognising definite radial pillars in *B. undulata*, though I do not doubt they would be found were a sufficiently large series of specimens examined by means of thin sections.

Upon the whole, the balance of evidence seems to me to be in favour of regarding the genus *Beatricea* as an abnormal type of the Stromatoporoids. I do not recognise any Foraminiferal affinities in it; and there are various points in its structure, as above described, which seem quite incompatible with its being a Cystiphylloid Coral. On the other hand, it presents many of the features of the Stromatoporoids. This is especially the case as regards its possession of "radial pillars," and when these structures are combined with vesicles, the appearances presented are hardly distinguishable from what is observable in sections of *Labechia*. Moreover, one of its most abnormal features, namely, the possession of an axial tabulate tube, finds a parallel in the genera *Idiostroma*, *Stachyodes*, and *Amphipora*. I was, indeed, at first disposed to place it in the family *Idiostromidæ*, on the ground of this peculiarity alone; but the general structure of its tissues is such that, if it be regarded as one of the Stromatoporoids, it would seem to find its most natural place in the neighbourhood of the genera *Labechia* and *Rosenella*. The genus *Beatricea*, in fact, occupies with regard to *Labechia* the same place that the genus *Idiostroma* does to *Stromatopora*. It may, however, be a question, whether, in view of its numerous peculiarities, it would not be expedient to regard *Beatricea* as the type of a special family.

Fam. 3. STROMATOPORIDÆ, *Nich.*

Cœnosteum massive, laminar, dendroid, or encrusting, often with a basal epitheca. Radial pillars usually more or less extensively combined with their horizontal connecting-processes, so as to give rise to a continuously reticulated skeleton. The skeleton-fibre is thick, and is minutely porous or tubulated. Definite zoöidal tubes, crossed by well-developed "tabulæ" are present; but the cœnosteum is not traversed by a tabulate axial tube.

I include in this family the two principal genera *Stromatopora*, Goldf., as here emended, and *Stromatoporella*, gen. nov. The forms which have been referred by Bargatzky to *Parallelopora* and by myself to *Syringostroma* also belong to the family, but it is questionable if these names can be regarded as of more than subgeneric value. Moreover, most of the forms which have been referred to the genera *Caunopora*, Phill., and *Diapora*, Barg., are essentially referable to this family, but as the true nature of these so-called genera is a matter of great intricacy, I shall discuss it separately later on.

In the typical members of this family, namely in the species of *Stromatopora* itself, the skeleton is a completely reticulated one, and the radial pillars can hardly be said, as a rule, to have any existence as distinct structural elements. In the vermiculate structure of the skeleton, and in the presence of definite tabulate zoöidal tubes, the typical *Stromatoporæ* make a decided approach to the recent genus *Millepora*, Lam. In fact, the most striking points in which they differ from the latter are that they do not appear usually to have possessed more than a single series of zoöidal tubes, while the general skeleton-fibre has a peculiar and characteristic microscopic structure (Plate I, figs. 3—7, and Plate XI, figs. 1—4). There are, however, good reasons, apart from mere general likenesses in form and mode of growth, for not removing the *Stromatoporidæ* far from the *Actinostromidæ*. Thus, though there are wide differences between a typical *Stromatopora* and a typical *Actinostroma*, nevertheless the groups which these respectively represent are closely linked together by various transitional forms. In the vesicular cœnosteum of *Clathrodictyon* we have an approximation to the reticulate skeleton of the *Stromatoporidæ*; while in the genus *Stromatoporella* the radial pillars are so far distinct that vertical sections have a general resemblance to those of *Actinostroma* itself. Again, in *Stromatopora Beuthii*, Barg. (Plate V, figs. 12 and 13), the radial pillars, which are so characteristic of the *Actinostromidæ*, are more or less obviously persistent in the interior of the reticulate skeleton-fibre. Many Stromatoporoids, moreover, possess exceedingly well-developed astrorhizal canals, the structure of which is entirely similar to that of the same structures in the Actinostromids.

Genus Stromatopora, *Goldf.* (emend.)

('Petrefacta Germaniæ,' Bd. i, p. 21, 1826.)

Cœnosteum usually massive or laminar, and generally furnished with an epitheca. The skeleton is completely reticulate, the radial pillars and their connecting-processes being so far fused together as to give rise to a trabecular or vermiculate tissue, traversed by irregular zoöidal tubes. Concentric laminæ are usually very imperfectly developed. The growth is very commonly by "latilaminæ," the radial pillars being continued from the top to the bottom of each latilamina; but it is rare for the pillars to have any distinct existence as separate structures. The zoöidal tubes appear to be in general of one kind only, and they are traversed by a larger or smaller number of transverse partitions or "tabulæ." Astrorhizæ are usually largely developed.

As previously explained, the genus *Stromatopora*, Goldf., has hitherto been generally taken as including the forms which have been here placed in the genus *Actinostroma*. I have, however, examined the original type-specimen of *S. concentrica*, Goldf. ('Petref. Germ.,' Taf. VI, fig. 5), of which Prof. Schlüter was so good as to have thin sections prepared. I have also made a minute examination of a number of examples which I collected in the Eifel myself, and which in all respects agreed precisely with the type-specimen of *S. concentrica*, the type-species of the genus *Stromatopora*, Goldf. The result of this has been to render it certain that the genus *Stromatopora*, Goldf., comprises forms entirely distinct from those which have usually been placed under this head. The genus is, in fact, the representative of a large and very natural series of Stromatoporoids which abound in the Silurian (Upper-Silurian) and Devonian formations. One well-marked example of this genus was described by Dr. Murie and myself from the Niagara Limestone of North America under the name of *Pachystroma antiquum* ('Journ. Linn. Soc.,' vol. xiv, p. 223, 1878), and we made this the type of the new genus *Pachystroma*. This genus must, however, be now regarded as a synonym of *Stromatopora*, Goldf. Other types of the genus *Stromatopora* have been described by different authors as belonging to the so-called "*Caunopora*" of Phillips; but I shall subsequently show that whatever conclusion we may form as to the nature of "*Caunopora*," it cannot be regarded as a *genus* of Stromatoporoids.

The general texture of the skeleton in the genus *Stromatopora*, Goldf., is often extremely dense, and the formation of the cœnosteum out of successive "latilaminæ," each of which marks a periodic cessation of growth, is also often a conspicuous feature. Vertical sections (Plate V, figs. 10, 13, 15, 17, and Plate XI, fig. 18) show indistinct parallel radial pillars, more or less wavy and united at intervals by irregular horizontal processes, or by partial confluence with one another. Between the irregular pillars are the vertical but similarly irregular zoöidal tubes, usually crossed by very well-developed "tabulæ."

Tangential sections (Plate V, figs. 11, 13, 14, 16, and Plate XI, fig. 16) exhibit a vermiculate and continuously reticulate framework, traversed by the irregular apertures of the zoöidal tubes, and thus, but for the absence of "gastropores," in many respects resembling corresponding sections of *Millepora*. Such sections also, as a rule, exhibit extremely well-developed stellate cœnosarcal canals or "astrorhizæ." As a rule, tangential sections exhibit no traces of the cut ends of the radial pillars, as distinct structures, but such may occasionally be detected. Thus, in well-preserved examples of *S. Beuthii*, Barg., from the Devonian Rocks of Germany and Britain, the transversely divided ends of the radial pillars can usually be recognised in tangential sections as opaque round masses immersed in the general reticulate tissue of the skeleton (Plate V, fig. 12). The same phenomenon is seen, but less clearly, in some other types.

The genus *Stromatopora*, Goldf., attains its maximum in the Devonian Rocks, but several Silurian species are known. One of the most abundant of the Silurian types is *Stromatopora typica*, Rosen, which is apparently not separable from the *S. astroites* of the same author, and which occurs in vast abundance in the Wenlock Limestone of Britain and in the Upper-Oesel beds of Esthonia. An allied type is *S. Carteri*, n. sp., from the Wenlock Limestone of Britain; and a third interesting form is the *Stromatopora discoidea*, Lonsd. sp. (= *S. elegans*, Rosen), which is found in the Upper-Silurian series of Britain, Gotland, and Esthonia. In the Devonian Rocks of Britain and Germany the type-species, *S. concentrica*, Goldf., is of decidedly rare occurrence; but *S. Hüpschii*, Barg., sp., *S. Beuthii*, Barg., and *S. bücheliensis*, Barg., sp., are all abundant and characteristic types, while other less completely known forms are also present.

Genus Stromatoporella, *gen. nov.*

Cœnosteum usually expanded, mostly laminar, and furnished with a basal epitheca; sometimes thin and encrusting. Skeleton imperfectly reticulate, not growing in "latilaminæ," or exhibiting such a structure in but an imperfect form. Both the concentric laminæ and the radial pillars are comparatively well developed, and are only partially fused to form a reticulate framework. Zoöidal tubes are present, but they are irregular, short, comparatively few in number, and in general but sparingly furnished with tabulæ. Astrorhizæ are, as a rule, largely developed, and are commonly intersected by internal partitions or "astrorhizal tabulæ;" while they are often superposed in successive interlaminar spaces, in which case the members of each series are connected by one or more vertical canals. Skeleton-fibre minutely porous, or traversed by irregular microscopic tubuli (Plate I, figs. 4 and 5; Plate XI, figs. 1—4).

It is difficult to rigidly define the present genus, as in many of its characters it occupies an intermediate position between *Stromatopora*, Goldf., and *Actinostroma*, Nich. It agrees with *Stromatopora* in the minutely porous structure of the skeleton-fibre, in the fact that the skeletal elements are in part fused with one another, so as to form an imperfectly continuous framework, and in the possession of distinct tabulate zoöidal tubes. On the other hand, owing to the incomplete fusion of the horizontal and radial elements of the skeleton, there is a considerable resemblance between *Stromatoporella* and *Actinostroma*. Thus, in vertical sections (Plate VII, figs. 4 and 6) the concentric laminæ and the radial pillars are usually perfectly recognisable, and are often quite distinct. In tangential sections also (Plate VII, figs. 3 and 5), though we have in part the vermiculate network so characteristic of the Stromatoporids, we likewise observe the detached ends of the transversely-divided pillars, which form so conspicuous a feature in tangential sections of *Actinostroma* or *Clathrodictyon*.

Of the peculiar characters of the genus *Stromatoporella*, one of the most important is the nature of the zoöidal tubes. In the type-species of the genus (*S. granulata*, Nich.), the zoöidal tubes have the form of short irregular tubes, which often only lead from one interlaminar space to the next, or, at most, to the next space but one, and which are crossed by but few tabulæ (Plate II, fig. 10, and Plate VII, fig. 6). In tangential sections (Plate I, fig. 15, and Plate VII, fig. 5) are seen numerous complete or incomplete rings, which represent these irregular zoöidal tubes transversely divided. Moreover, the surface (Plate I, fig. 14, and Plate IV, fig. 6) exhibits numerous large-sized tubercles, the centres of which are perforated by round apertures, which we may suppose to have served for the emission of zoöids. In *Stromatoporella* (*Diapora*) *laminata*, Barg., the zoöidal tubes are more numerous, are longer, and are more richly furnished with tabulæ, but the general structure is the same as in *S. granulata*, Nich. In this species also the surface, in well-preserved examples, exhibits numerous perforated tubercles (Plate X, fig. 4) which probably gave exit to the zoöids of the colony.

Astrorhizal canals are also very extensively developed in most of the *Stromatoporellæ*, and are sometimes of very large size (Plate IV, fig. 2). In this genus, the astrorhizal canals are very commonly intersected by irregular partitions, or "astrorhizal tabulæ" (Fig. 7, and Plate VII, fig. 3). In some cases, these partitions are simply transverse, but in other cases they may be vesicular, or almost funnel-shaped. Very probably connected with these astrorhizal tabulæ are the curved, oblique, or irregular partitions which are seen crossing the interlaminar spaces in almost all the species of *Stromatoporella* (Plate VII, fig. 4).

Many of the types which exhibit the above general characters are encrusting, but they are by no means always so, and *S. granulata*, Nich., the type-species, appears to be always a free laminar expansion, with a basal epitheca. Not only are they very variable as to their mode of growth and general form, but they also vary much as to certain details in their actual structure.

Much more labour, therefore, will be required before it will be possible to speak positively as to the number and limits of the species which belong here. All the forms of this genus which have come under my observation belong to the Devonian formation. The type-species is *S. granulata*, Nich. ('Ann. and Mag. Nat. Hist.,' 1873), which is abundant in the Hamilton and Corniferous formations of Western Canada. Closely allied to this is a beautiful species which occurs commonly in the Devonian Limestones of the Eifel, and which I shall provisionally name *S. eifeliensis*. The microscopic structure of these two forms (Plate VII, figs. 3 and 4, and figs. 5 and 6) is very much the same; but *S. eifeliensis* possesses remarkably well-developed astrorhizæ, and has certain other structural peculiarities which will probably entitle it to specific distinction. In various features, the form described by Mr. Carter as *Stromatopora dartingtonensis* makes a close approach to the above-mentioned forms; but it seems to possess some special characters of its own, and will require further investigation. Related to the preceding also is the singular Stromatoporoid of the Devonian Limestones of the Paffrath district, which Bargatzky described as *Diapora laminata*, and on which he founded the genus *Diapora*. This being the case, it might have been proper, in accordance with the strict laws of priority, to retain the name of *Diapora* for the present genus. Bargatzky, however, made the essential character of his genus *Diapora* to consist in the possession of thick-walled "Caunopora" tubes, the genus being only separated from the so-called "*Caunopora*" of Phillips by the character of the tissue surrounding these tubes. As, however, I am able to show that the said thick-walled tubes—whatever their nature may be—are merely of occasional occurrence, and that they only constitute a particular phase in the history of certain kinds of Stromatoporoids, it seems clear that it would be highly unadvisable to retain the names *Caunopora*, Phill., and *Diapora*, Barg., as the titles of *generic* divisions. It could, in fact, only lead to confusion to retain these names for forms in which the characteristic thick-walled tubes, upon the existence of which these genera were established, are commonly wholly wanting. For this reason, therefore, I have thought it best to give the new name of *Stromatoporella* to the group of forms at present in question.

In addition to the forms above alluded to there are several other imperfectly known Stromatoporoids which probably belong to this genus. It is tolerably certain, namely, that some of the forms included by Goldfuss under the name of *Stromatopora polymorpha* (*e.g.* *S. curiosa*, Barg.) are really referable to *Stromatoporella.* The *Stromatopora nulliporoides*, Nich., of the Devonian of North America, and the allied, or identical, *Cœnostroma incrustans*, Hall and Whitf. (Plate III, fig. 6), from the same formation, are likewise probably referable here.

Genus Parallelopora, *Bargatzky.*

('Die Stromatoporen des rheinischen Devons,' p. 63, 1881.)

The general structure of the skeleton in the forms which Bargatzky placed under *Parallelopora* resembles that of the typical *Stromatoporæ*, the radial and horizontal elements of the skeleton being so amalgamated as to give rise to a continuously reticulated framework, traversed by vertical tabulate zoöidal tubes. The coarse, reticulated skeleton-fibre is traversed by irregular vertical tubuli, or by minute dark-coloured vertical rods, which are united at intervals by horizontal bars. Astrorhizæ are present.

It seems doubtful if *Parallelopora*, Barg., can be regarded as having the rank of a genus. The general structure of such forms as I have seen (including Bargatzky's original specimens) would appear to be very much the same as that of *Stromatopora*, Goldf., or of *Idiostroma*, Winch., some of the described species being more like the former genus, and others more like the latter. The peculiarities in the structure of the forms in question are, in fact, chiefly concerned with the existence in the skeleton-fibre of minute vertical tubules, in many respects similar to the tubuli seen in *Stachyodes*, Barg. In one form, viz. *P. Goldfussi*, Barg., of which I have examined the original specimen, the skeleton-fibre is coarsely tubulated (Plate XI, fig. 9); but the general structure is not otherwise peculiar. I am disposed to think this species to be really identical with *Idiostroma ?* (*Stromatopora*) *capitatum*, Goldf.

More remarkable appearances are presented by *P. ostiolata*, Barg., from the original of which, through the kindness of Prof. Schlüter, I have also prepared thin sections. In tangential sections of this type, as previously mentioned, the skeleton is seen to be densely reticulated, and to be traversed by numerous rounded zoöidal tubes (Plate II, fig. 6). The skeleton-fibre is very thick and very transparent, so that it is in places difficult to distinguish it from the surrounding calcitic matrix. It is, however, distinctly marked out by a vast number of rounded or oval black dots, which are scattered through the thickness of the fibre, but are most abundant round the margins of the zoöidal apertures. These dots have every appearance of being solid, the use of a quarter-inch objective showing them to be granular in texture and to have no distinct lumen. In *vertical* sections (Plate II, fig. 7) the thick radial pillars are seen to separate vertical zoöidal tubes, which are crossed by well-developed transverse partitions or tabulæ. The radial pillars are further traversed by minute dark-coloured vertical rods, which run parallel to one another and to the zoöidal tubes, and which are connected at short intervals by similar transverse rods, giving rise to a sort of ladder-like tissue. These rod-like bodies appear to be solid, and the dark dots in the tangential section are their transversely divided ends.

Dr. Bargatzky (*loc. cit.*) considers these rod-like bodies to be the walls of interstitial tubes occupying all the spaces between the larger tubes, and he regards the transverse rods which connect these as being the "tabulæ" of these interstitial tubes. On this view the structure would be very much the same as that of such Corals as *Heliolites* or *Callopora*. Tangential sections, however, show conclusively that the dark vertical lines which run in the spaces between the ordinary zoöidal tubes, are not the *walls of tubes*, but that they are *rods*, and that they are contained *in the interior of a reticulated skeleton-fibre.* I am therefore unable to accept Dr. Bargatzky's views upon this point, though it is not possible to give an absolutely satisfactory explanation of the nature of these curious structures. Two conjectures might, in fact, be hazarded as to their nature. They have a general resemblance, especially in vertical sections, to the radial pillars and their horizontal connecting-processes as seen in the typical *Actinostromæ*. We might therefore regard these rods as being the radial pillars and "arms" of an *Actinostroma* persisting in the general reticulate skeleton-fibre, a phenomenon which can be observed to a certain extent in such forms as *Stromatopora Beuthii*, Barg. On the other hand, a much more probable hypothesis—and one supported by the observed phenomena in other cases—is that these rod-like bodies are really of the nature of minute canals in the skeleton-fibre, which have been injected with some dark-coloured and opaque material. This conjecture is not absolutely incompatible with the former hypothesis, since such canals might represent the axial tubes of a system of radial pillars and their horizontal connecting-processes. On this view the structure of the skeleton in *Parallelopora ostiolata*, Barg., would become comparable with that of *Hermatostroma*. Or we might suppose the canal-system to be of the same type as the remarkable tubulation of the skeleton-fibre in the genus *Stachyodes*, Barg., in which the tubuli are sometimes filled with transparent calcite, or at other times are occupied by opaque oxide of iron. It seems, however, hardly possible to arrive at final conclusions as to the structure of *Parallelopora* until a more abundant material shall have been collected and examined.

Genus Syringostroma, *Nich.*

('Palæontology of Ohio,' vol. ii, p. 251, 1875.)

Cœnosteum massive, formed of successive "latilaminæ." Skeleton-fibre minutely porous. The skeletal tissue is, on the whole, of the reticulated type characteristic of the *Stromatoporidæ*, but the radial pillars are distinctly recognisable and some of them may be of large size. Astrorhizæ are largely developed.

I originally founded this genus for a singular Stromatoporoid (*S. densum*) from the Devonian Rocks of Ohio. My material is unfortunately very limited, but I have recently succeeded in preparing good thin sections, and can therefore speak more confidently as to the real structure of this type. In the minutely porous character of the skeleton-fibre, as also in the essentially reticulate structure of the skeletal tissue (Plate XI, fig. 13), *S. densum* quite resembles the species of *Stromatopora*, Goldf. It has, however, the peculiarity that the cœnosteum is traversed at intervals by large-sized radial pillars which are recognisable in both tangential and vertical sections (Plate XI, figs. 13 and 14). I should not have been disposed to regard this feature as of generic value, except that I have recently had the opportunity, through the kindness of Professor J. W. Spencer, of examining an apparently related form which certainly seems worthy of generic distinction. The form in question was described by Professor Spencer from the Upper Silurian formation of New Brunswick ('Bulletin of the Mus. of the Univ. of the State of Missouri,' p. 49, 1884), under the name of *Cœnostroma ristigouchense*. Tangential and vertical sections of this beautiful type (Plate XI, figs. 11 and 12) show a curious combination of the characters of *Stromatopora*, Goldf., and *Actinostroma*, Nich. Thus, the skeleton-fibre has to a marked extent the minutely porous structure which is so characteristic of *Stromatopora*, properly so called; while the radial pillars and their connecting-processes are as distinctly and clearly developed as in the type-forms of *Actinostroma*. The radial pillars, in fact, are exceedingly large, and give off whorls of delicate "arms" or connecting-processes, which are emitted at corresponding levels in a radiating manner, and which circumscribe rounded pores representing the zoöidal tubes. The astrorhizal canals are largely developed, and we therefore see in vertical sections (Plate XI, fig. 12), as in similar sections of *S. densum*, the large rounded apertures which represent the cut ends of these tubes, and upon which the genus *Syringostroma* was originally based. This latter character is, of course, one of no generic importance, as, indeed, present in all Stromatoporoids with large astrorhizal canals. There can, however, be little hesitation in regarding this type as really distinct from both *Stromatopora* and

Actinostroma; and it appears to have various structural relationships with the form which I described as *Syringostroma densum.* Pending fuller investigation, I shall therefore place it under the head of *Syringostroma.* The validity of this, however, either as a genus or sub-genus, will, of course, depend upon further and more exhaustive researches into the minute structure of the type-species, *S. densum*, Nich.

Fam. 4. IDIOSTROMIDÆ, *Nich.*

The cœnosteum in this family is dimorphic, and the general skeletal tissue is in the main reticulated, but the radial pillars and concentric laminæ are usually developed as clearly distinct structures. The skeleton-fibre may be porous, or tubulated, or apparently compact (*Amphipora*). Definite zoöidal tubes, often extensively tabulate, are generally present. There are also present larger tubes, likewise tabulate, and sometimes furnished with distinct walls. These may be distributed irregularly through the cœnosteum; but they more usually form a single or multiple "axial tube," which gives off lateral tabulate branches. The typical form of the cœnosteum is that of a cylinder, sometimes simple, sometimes branched, sometimes fasciculate, but in other cases the skeleton may be massive or spheroidal. Astrorhizæ do not appear to be developed.

I propose to provisionally group together under the above head the four genera, *Idiostroma*, Winch., *Hermatostroma*, Nich., *Stachyodes*, Barg., and *Amphipora*, Schulz. It must be admitted that this arrangement is in important points not a natural one, and it is very probable that further researches may render its modification necessary. If we were to take the typical cylindrical or dendroid examples of *Idiostroma*, *Stachyodes*, and *Amphipora*, we should have a compact group of forms, distinguished by the shape of the colony, and by the possession of a main axial tube furnished with tabulæ, and connected with smaller tabulate offshoots. Both *Idiostroma* and *Stachyodes*, however, occur in massive or sub-massive forms, and in these there is no principal axial tabulate tube, but there are a number of such tubes irregularly distributed through the colony. This, in fact, is the only character of importance which would separate the massive examples of the former of these two genera from *Stromatopora*, Goldf. Then, again, the relationship between the massive forms of *Idiostroma* and the type which I have named *Hermatostroma*, is too close to allow of their separation to any distance from one another; though in the latter the characteristic large tabulate tubes of *Idiostroma* are either apparently wanting or are present only in a modified form. The type which Bargatzky named *Stachyodes* is in its general features very similar to the cylindrical forms of

Idiostroma, but can be readily distinguished from all the other members of this group by the peculiar minute tubulation of the skeleton-fibre. Lastly, *Amphipora*, Schulz, in the complete reticulation of its skeletal tissue, and in the apparently compact character of its skeleton-fibre, stands quite alone; though it agrees with the cylindrical forms of *Idiostroma* and *Stachyodes* in the shape of the cœnosteum, and in the very striking character that it possesses a principal axial tabulate tube. I should, however, be inclined to think that *Amphipora* might perhaps be regarded as the type of a separate group.

Genus Idiostroma, *Winchell.*

('Proc. Amer. Assoc. Adv. of Science,' p. 99, 1867.)

The cœnosteum is typically cylindrical, sometimes fasciculate, sometimes massive or sub-massive. The general skeletal tissue is reticulated, but the radial pillars and concentric laminæ remain largely distinct from one another. The skeleton-fibre is coarsely porous. Definite zoöidal tubes, furnished with numerous tabulæ, and opening on the surface by rounded apertures, are present. In addition to the ordinary zoöidal tubes there are present larger tabulate tubes. In typical examples of the genus each cylinder of the skeleton has a single tabulate axial tube, which gives off secondary lateral tubes, also intersected by tabulæ. In the massive and sub-massive examples the large tubes are irregularly distributed through the mass. These tubes may be only bounded by the general tissue of the skeleton, or they may be enclosed by definite walls, which may be thickened towards their mouths. In any case the tubes communicate more or less extensively with the interlaminar spaces. The surface shows prominent pointed tubercles, often arranged in vermiculate ridges, which may radiate from prominent conical "mamelons," so as to form imperfect astrorhizæ. The openings of the small zoöidal tubes are placed in the grooves separating these vermiculate ridges. The conical "mamelons" may or may not have large apertures at their summits.

The genus *Idiostroma* was founded by Winchell for the reception of two species (*I. cæspitosum* and *I. gordiaceum*) from the Devonian Rocks of North America. *I. cæspitosum* has subsequently been described and figured, presumably from American specimens, by Quenstedt, under the name of *Stromatopora cæspitosa* ('Die Schwämme,' pl. 142, fig. 14, 1878). My own knowledge of the genus is based upon a large series of specimens belonging to three different species, of which two are common to the Devonian Rocks of Germany and of Devonshire, while the third seems, so far, not to have been detected in Britain. One of the forms in question I am disposed to regard as probably the *Stromatopora* (*Tragos*) *capitata* of Goldfuss, which, again, not improbably, may be identical with the *Parallelopora Goldfussi* of Bargatzky. The other two forms have the typical cylindrical or fasciculate cœnosteum of the genus, and I shall speak of them by the provisional names of *I. Roemeri* and *I. oculatum;* since the descriptions of Winchell and Quenstedt are not sufficient to allow of any comparison of these with the two described American species.

Taking *Idiostroma Roemeri* (Pl. IX, fig. 6), of the Rhenish Devonian, as a typical example of the genus, the cœnosteum has the form of a generally branched cylindrical stem, rooted basally to some foreign object, which it may partially encrust. The stems vary from one to three centimetres in diameter, and they are sometimes so far confluent as to give rise to a sub-massive skeleton, in which the component cylinders are, however, still clearly recognisable. Both transverse and longitudinal sections (Pl. IX, figs. 7 and 8) show that each stem is traversed by a main axial tube, which is intersected by numerous transverse, vesicular, or funnel-shaped "tabulæ." This axial tube gives off lateral branches, which are also tabulate, and which ascend towards the surface, giving off secondary branches in their course. Sometimes there is more than one longitudinal tube, in which case the central one is the largest, and the subordinate tubes run parallel with it at a little distance. Whether the lateral branches given off from the main tube open on the surface by definite apertures, or whether the latter has an opening at the end of the stem, is in this species difficult to decide positively. Some of my specimens do not show any openings, except the minute apertures of the ordinary zoöidal tubes; but others exhibit here and there much larger perforations, which can hardly be anything else than the apertures of the lateral branches of the axial tube. These large apertures are often placed upon prominent elevations or "mamelons." There is no reason, so far I can see, for doubting that the large tubes above mentioned must have had definite surface-apertures, though these may not be visible in all specimens.

The surface of *Idiostroma Roemeri* is highly characteristic, and is covered with vermiculate ridges, formed by the confluence of rows of pointed tubercles, and separated by deep winding grooves (Plate IX, fig. 9). Often these ridges radiate from the apices of conical "mamelons," and in the intervals between them are seen the circular openings of the ordinary zoöidal tubes. Thin sections show that the cœnosteum is built up of numerous concentrically-disposed layers, which grow as a series of deeply convex caps round the free end of the stem, where each layer is thicker than elsewhere. The skeletal tissue is in the main reticulate, but the confluence of the radial pillars and their horizontal connecting-processes is not nearly so complete as in the *Stromatoporidæ*. Hence, not only are the radial pillars thoroughly recognisable as distinct structures, but the concentric laminæ are conspicuous in both transverse and longitudinal sections of the stem. Transverse sections of the stems also show very clearly, as also longitudinal ones do less perfectly, that the entire cœnosteum is traversed by innumerable distinct zoöidal tubes, which radiate outwards from the axis of the stems to open on the surface by distinct apertures, and which are crossed by numerous curved or straight tabulæ (Plate IX, fig. 8). Lastly, thin sections show that the skeleton-fibre has the minutely porous character which is such a marked feature in the case of the species of *Stromatopora*, Goldf.

A second still more remarkable species of *Idiostroma* occurs in the Devonian Rocks of Britain and Germany, which may be provisionally distinguished by the name of *I. oculatum*. I was under the impression that this would prove to be identical with the fossil described and figured by Kayser from the Devonian Rocks of the Eifel under the name of *Trachypora circulipora* ('Zeitschr. der deutschen Geol. Gesell.,' 1879, p. 304, Taf. v, figs 2—4), with which it agrees closely in aspect and general appearance. Professor Schlüter, however, having examined the original specimens of *Trachypora circulipora*, Kays., informs me that though the fossil so named may be in part of the nature of a Stromatoporoid, it is not the same as the singular dendroid *Idiostroma* here in question. I have therefore thought it best to distinguish the latter by the above-mentioned title.

The cœnosteum in *Idiostroma oculatum* (Fig. 14) consists of slender cylindrical stems, from three to five mm. in diameter, which branch and inosculate freely, so

FIG. 14.

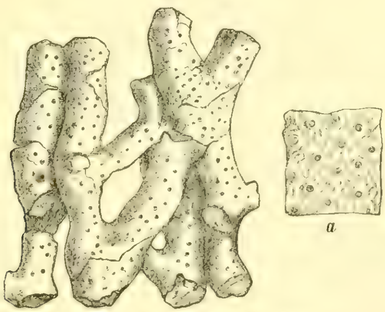

FIG. 14.—A fragment of the cœnosteum of *Idiostroma oculatum*, n. sp., of the natural size. Devonian, Büchel. *a*. A small portion of the surface enlarged

as to give rise to large fasciculate masses. The general structure of the skeleton is essentially the same as in the previously described *I. Roemeri*. Each cylindrical stem is traversed by a large axial canal, which is intersected by transverse, curved, or vesicular tabulæ, and which gives off diverging lateral canals which are also tabulate. The general skeletal tissue is built up in concentric layers round the main axial tube (Fig. 15), the concentric laminæ and interlaminar spaces being thus very conspicuous. On the other hand, the radial pillars are proportionately much less developed than in *I. Roemeri*, while the small zoöidal tubes are tortuous and

FIG. 15.

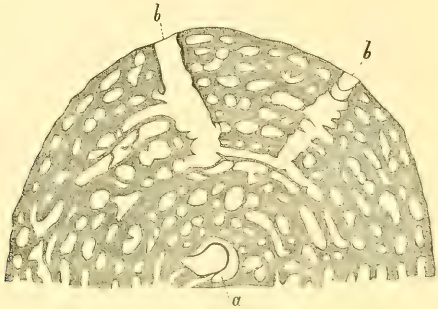

FIG. 15.—Transverse section of half of a stem of *Idiostroma oculatum*, n. sp., enlarged twelve times. *a*. The axial canal, transversely divided. *b b*. The large radial tubes, longitudinally divided, opening inferiorly into the interlaminar spaces, but acquiring thickened walls, and being intersected by tabulæ where they approach the surface.

irregular. Some specimens show no further character which would demand notice here, the surface being simply covered with small tubercles, often arranged in winding rows, and exhibiting here and there the minute openings of the ordinary zoöidal tubes. The majority of specimens, however, exhibit additional features of great interest and importance. In most specimens, namely, the surface everywhere exhibits a considerable number of round apertures, which are placed at tolerably regular intervals, are of much larger size than the openings of the ordinary zoöidal tubes, and are surrounded by thickened and elevated rims (Fig. 14, *a*). Longitudinal and transverse sections show that these apertures are the openings of large tubes, which are at first directed inwards, and then curve downwards as they approach the axis of the stems. These tubes (Fig. 15, *b b*) are intersected by curved or vesicular tabulæ, and they appear to be provided near their mouths with thickened *proper walls*. As they approach the axis of the stems, however, the thickened wall disappears, and they seem to be only bounded by the general tissue of the skeleton; while they finally *terminate by opening into the interlaminar spaces of the cœnosteum*. Whether or not they have have any direct connection with the axial tube which traverses each stem is a point very difficult to determine positively. The phenomena presented by longitudinal sections would, however, seem to show that such a connection certainly exists, in at any rate some instances.

I shall subsequently illustrate and describe the singular structures just alluded to more fully, but there are one or two general considerations which may be noticed here. It will be evident, namely, from the above description, that the tubes in question are in most respects identical with the tubes which occur in those Stromatoporoids which have been referred to the so-called genera "*Caunopora*," Phill., and "*Diapora*," Barg. In fact, the specimens would, in an ordinary way, be certainly regarded as belonging to a species of *Caunopora*. The tubes of *Idiostroma oculatum* resemble the embedded tubes of "*Caunopora*" and "*Diapora*" in opening on the surface by large prominent apertures, in having thickened walls, and in being intersected internally by tabulæ. They differ, however, from the tubes of "*Caunopora*" in the fact that the thickened wall seems to be confined to the outer portion of each tube, where it begins to approach the surface, and also in the important feature that the tubes to all appearance communicate freely internally with the interlaminar spaces of the skeleton—a communication which has not been proved to take place in the case of the tubes of "*Caunopora*," and which probably does not take place in the latter. Leaving the nature of "*Caunopora*" and "*Diapora*" for future consideration, it may be well to point out here the grounds for thinking that the embedded tubes of *Idiostroma oculatum* are certainly parts of the organism in which they are found; and there are two principal reasons for coming to this conclusion. In the first place, these tubes can hardly belong to any organism foreign to the Stromatoporoid in which they occur, seeing that they appear to be to a large extent bounded only by the proper skeletal tissue of the latter, while they seem clearly to open internally into the general cavities of the cœnosteum in which they are embedded. In the second place it is apparently inconceivable that the tubes of any Coral, such as *Aulopora* or *Syringopora*, could be embedded, parasitically or commensally, throughout the numerous slender and branching stems of *Idiostroma oculatum* in such a way that the mouths of the tubes, and the mouths only, should appear at the surface. If, indeed, we could remove the enveloping skeletal tissue of *Idiostroma oculatum*, and could inspect the embedded tubes alone, we should find a structure entirely unlike any known species of Auloporoid or Syringoporoid Corals. Moreover, the main axial tabulate tube of *I. oculatum* is, beyond all question, a part of the Stromatoporoid, and it is only close to the surface that the radial tubes exhibit any feature which would distinguish them from the axial tube, since it is only in this region that they appear to develop proper walls.

If we accept the conclusion that the radial tubes of *I. oculatum* belong to the organism in which they are found, it still remains to consider what these tubes *are*, and what functions we may suppose them to have discharged. As regards this point, it is to be observed, in the first place, that some specimens of *Idiostroma oculatum*, though possessing the axial tubes in the stems, show no traces of the above-described radial tubes, while other specimens have every branch full of them. It is obvious, therefore, that the presence or absence of these radial tubes cannot be used as a generic, or even a specific character. It is an *individual* peculiarity with which we have to deal; and the tubes in question can therefore only be structures which are occasionally developed. The only structures, however, in an ordinary Hydroid colony which are present in some individuals of a species and not in others are the reproductive zoöids. Thus, if we accept the conclusion that the embedded radial tubes of *I. oculatum* belong to the organism in which they occur, we are apparently shut up to the further conclusion that they must have served for the lodgment of the reproductive zoöids. On this view, those specimens of *I. oculatum* which are destitute of these radial tubes represent the sterile colonies, while the more numerous "Caunoporoid" examples are the fertile individuals of the species. Upon the whole, therefore, while fully admitting the difficulty of anything like definite proof on the point, it seems to me that the most probable hypothesis as to the embedded tubes of *Idiostroma oculatum* is to regard them as connected with the function of reproduction, and as corresponding with the differently constructed "ampullæ" of the recent Stylasterids.

The only other species of *Idiostroma* with which I am personally acquainted is the form, previously alluded to, which I have dubiously identified with the *Tragos capitatum* of Goldfuss, and which I think is probably the *Parallelopora Goldfussi* of Bargatzky. This type occurs commonly in the Paffrath district, and is also not rare in the Devonian Limestones of Devonshire. It differs from *I. Roemeri* and *I. oculatum* in not being cylindrical or fasciculate in form, but in being massive or sub-massive, generally more or less spherical. Moreover, in place of a principal axial canal, giving off lateral tabulate branches, we find in this species numerous large tabulate tubes distributed irregularly through the cœnosteum, and quite distinct from the normal but also tabulate zoöidal tubes. In this species, we find, as I have formerly described, numerous lenticular or oval vesicles of comparatively large size, scattered through the general skeletal tissue (Fig. 8), and it may be conjectured that these are also of a reproductive nature, and correspond with the "ampullæ" of the Stylasterids. These vesicles are generally from one to three mm. in diameter, and are often crossed by internal partitions or tabulæ. They are often only bounded by the general skeletal tissue of the cœnosteum; but at other times they appear to have a thin proper wall of their own. Other specimens of this species exhibit somewhat similar cavities which are surrounded by greatly thickened walls; but I have not been able to make out whether these are a still further modification of the supposed "ampullæ" just spoken of, or whether they are not rather embedded adventitious structures.

Genus HERMATOSTROMA, *gen. nov.*

Cœnosteum massive, laminated, the surface of the concentric laminæ covered with low rounded elevations. The skeletal framework is incompletely reticulated, the radial pillars and their horizontal connecting-processes being largely distinct from one another. The radial pillars are "continuous," are very stout, and are traversed by very large axial canals. The horizontal "arms" or connecting-processes, out of which the concentric laminæ are composed, are also very stout, and the axial canals of the pillars are prolonged into these also. These processes give rise to well-marked and regularly disposed concentric laminæ, but they do not form by their anastomosis an *angular* meshwork, such as characterises the genus *Actinostroma*. On the contrary, they produce a network of rounded apertures (Fig. 1), which served for the emission of zoöids. Astrorhizæ are apparently wanting. Embedded in the tissues at tolerably regular intervals are short flexuous tubes of considerable size, bounded by thin proper walls, and crossed by occasional tabulæ. These tubes open on the surfaces of the concentric laminæ, often at the summits of the low prominences above spoken of, by large rounded apertures.

The above description is based upon a remarkable type which I collected from the Devonian Limestones of the Paffrath district, and which I have named *H. Schlüteri*, in honour of the distinguished palæontologist, Professor Schlüter, of Bonn, to whose kindness I have been greatly indebted in working out the Stromatoporoids of the Rhenish Devonian formation. An apparently allied form occurs in the Devonian Limestones of Devonshire, but I have not yet completely investigated its structure.

All the specimens of *Hermatostroma Schlüteri* which I have seen, have the canal-system of the radial pillars and concentric laminæ largely injected with some opaque material, apparently oxide of iron, the tubes in question being thus rendered extremely conspicuous in thin sections. Vertical sections (Fig. 16, B, and Plate III, fig. 2) show the large hollow pillars running continuously across the concentric laminæ for considerable distances, and forming with these a marked quadrangular meshwork. The canals of the radial pillars are filled with oxide of iron, and can thus be traced continuously into the concentric laminæ, being dilated at the crossing-nodes of these two sets of structures. Tangential sections (Fig. 1, and Plate III, fig. 1) vary in the appearances which they present, according as the line of section intersects the interlaminar spaces, or coincides with the concentric laminæ themselves. In the former case they show the round or oval ends of the transversely-divided radial pillars (Fig. 16, A), with their large axial tubes. In the latter case (Fig. 1, A), they show the rounded and variously-sized pores formed by the inosculation of the horizontal connecting-processes given off by the radial pillars. These pores doubtless represent the sections of imperfect zoöidal tubes. In fact, vertical sections sometimes show such tubes, crossed by delicate transverse tabulæ, to be present; but they are always very irregularly and feebly developed. Both tangential and vertical sections show that the main canals of the radial pillars and concentric laminæ give off secondary tubuli, which inosculate to form a system of canaliculi traversing the substance of the skeleton-fibre. These secondary tubuli are best seen in sections traversing the concentric laminæ (Fig. 1, A).

FIG. 16.

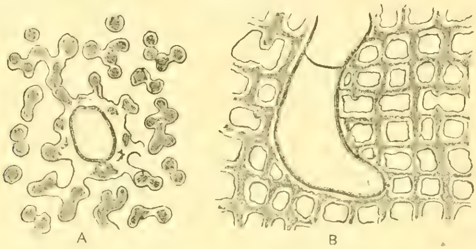

FIG. 16.—A. Tangential section of *Hermatostroma Schlüteri*, n. sp., enlarged twelve times. B. Vertical section of the same, similarly enlarged. Both sections intersect one of the large thin-walled tubes which are found at intervals in this species.

One of the most singular features in *Hermatostroma Schlüteri* is to be found in the fact that each successive stratum of the massive cœnosteum is traversed by a series of short, wide, flexuous tubes, directed vertically to the concentric laminæ, and apparently terminating inferiorly by closed ends, while they open above on the surfaces of the laminæ by large rounded apertures. Thin sections (Fig. 16) show that these tubes have thin proper walls of their own, and have occasional internal tabulæ; and they might therefore be supposed to be adventitious structures. That they belong, however, to the Stromatoporoid in which they are found seems to be sufficiently shown by their comparatively regular development, by their being uniformly present in all parts of the mass and at all levels, and by their opening on the surface by definite apertures, often placed on rounded "mamelons." By the fact that they have no connection with one another, it is rendered certain that they cannot belong to embedded colonies of either *Aulopora* or *Syringopora*. It is difficult to see what these tubes can be, if they did not serve for the lodgment of the reproductive zoöids.

There is in many respects a close relationship between *Hermatostroma* and *Idiostroma*, the general arrangement of the skeletal tissue being very similar in the two genera. The system of tubuli in the skeleton-fibre is, however, greatly more developed in the former than in the latter. Moreover, the tabulate zoöidal tubes of *Idiostroma* have only a very feeble representation in *Hermatostroma*, while the axial tabulate tube of the typical forms of *Idiostroma*, with its lateral tabulate offshoots, is a feature apparently unknown in the present genus.

Genus STACHYODES, *Bargatzky.*

('Zeitschr. der deutschen Geol. Ges.,' Jahrg., 1881, p. 688.)

Cœnosteum having typically the form of branched cylindrical stems, which are rooted basally, and terminate distally in rounded ends. The skeletal tissue is of the reticulated type, neither the radial pillars nor the concentric laminæ being developed as distinct structures. The skeleton-fibre is minutely tubulated, the tubuli running parallel with the zoöidal tubes. Definite zoöidal tubes, which are sparingly tabulate, are present and open on the surface by rounded apertures. In the centre of the stems is a large axial tube, which is crossed by numerous curved or straight tabulæ, and which gives off diverging lateral branches, which are also tabulate. No astrorhizæ appear to be present.

It seems probable that one of the forms which Goldfuss included under the name of *Stromatopora polymorpha*, namely, the form which Bargatzky named *S. polyostiolata*, is really a *Stachyodes*, as shown by the minute structure of the skeleton of the original specimen. The above definition, however, is based upon the singular type which Bargatzky (loc. cit. *supra*) has described under the name of *Stachyodes ramosa*. Having examined a large series of specimens of this, which I have obtained from the Devonian Rocks of Devonshire and of Germany, I see no reason to doubt that it is really the previously described *Stromatopora* (*Caunopora*) *verticillata*, M'Coy ('Brit. Pal. Foss.,' p. 66,) under which specific title it will therefore have to remain. The cœnosteum in this form consists of cylindrical stems, generally about a centimetre in diameter, which commonly branch, and which terminate in rounded ends (Plate VIII, fig. 9). In its general aspect the fossil closely resembles the dendroid species of *Pachypora*, Lindst., a resemblance which is increased by the fact that the surface is extensively covered with the rounded apertures of the zoöidal tubes. Parts of the surface, however, very commonly do not exhibit these apertures, but, on the contrary, are occupied by a thin investing calcareous membrane (Plate VIII, fig. 12). Judging from the analogy of *Amphipora ramosa*, it is not improbable that the development of this membrane is connected with the production of reproductive zoöids in "ampullæ." Though the dendroid form is the commonest, I have seen examples which form irregular masses. In the centre of the stem runs a principal axial tube (Plate VIII, figs.

10, 11) which is crossed by more or less numerous curved tabulæ, and which gives off lateral tabulate branches. Judging from the few examples which I have seen in which the ends of the branches are perfectly preserved, it would appear that the main axial tube terminates at the end of each branch in one, two, or more large-sized apertures. The lateral divisions of the main axial tube, however, subdivide and give off numerous small zoöidal tubes, which are continued to the surface, and which seem to be only sparsely furnished with tabulæ. Growth of the cœnosteum is effected by the formation of successively formed convex layers, which are much thicker over the growing ends of the branches than elsewhere (Plate VIII, fig. 10), and which give rise in thin sections to a series of curved concentric lines, the convexities of which are turned towards the distal end of the colony. There are, however, no true concentric laminæ, nor can any definite radial pillars be recognised. The skeleton is continuously reticulated, and the sclerenchyma is everywhere traversed by innumerable delicate tubuli, which run parallel to the zoöidal tubes (Plate VIII, fig. 14). In tangential sections (Plate VIII, fig. 13), the cut ends of these tubuli are seen, sometimes as minute rounded apertures, sometimes as dark dots (Plate XI, figs. 5 and 6), according as the tubuli are empty or are infiltrated with oxide of iron. Though in the main running parallel with the zoöidal tubes, the tubuli frequently branch and anastomose with one another.

Stachyodes verticillata shows some curious points of resemblance to certain of the *Stylasteridæ*. Thus, longitudinal sections of *Distichopora*, taken in the median plane of the cœnosteum and dividing the pore-tubes lengthways, show phenomena in many ways resembling those presented by *Stachyodes* (Plate IX, fig. 5). This resemblance is particularly marked as regards the microscopic tubuli of the skeleton-fibre of both these types. If *Stachyodes* stood quite alone there might be some ground for regarding it as an ancient type of the *Stylasteridæ*. It has, however, strongly marked relationships to *Idiostroma*, Winch., and through this with the whole group of the *Stromatoporidæ* proper. It agrees entirely with the cylindrical types of *Idiostroma* as regards the possession in the interior of the stems of a tabulate axial tube, from which spring secondary lateral tubes, which are also tabulate. In fact, the essential point by which it is separated from *Idiostroma* is only the characteristic tubulation of the skeleton-fibre.

Genus Amphipora, *Schulz.*

('Die Eifelkalkmulde von Hillesheim,' p. 89, 1883. Reprinted from the 'Jahrb. der königl. preuss. geol. Landesanstalt' for 1882.)

The cœnosteum in this genus is in the form of slender cylindrical stems, which may or may not branch in a dichotomous manner. In the centre of the cœnosteum and running its entire length is a wide axial tube, which is intersected by transverse or funnel-shaped tabulæ. The general skeletal tissue is continuously reticulated, of the type of that of the *Stromatoporidæ,* but apparently compact instead of being minutely porous. Distinct but irregular zoöidal tubes radiate outwards from the axial tube to open on the surface by definite apertures. The surface sometimes shows the apertures of the zoöidal tubes, surrounded by vermiculate or tuberculated margins, but at other times the cylindrical cœnosteum is surrounded by a zone of large-sized lenticular vesicles, which are enveloped by a delicate, apparently imperforate calcareous membrane.

So far as known, the genus *Amphipora* is represented by one species only, viz. the form described by Phillips under the name of *Caunopora ramosa* ('Fig. and Descript. Pal. Foss.,' p. 19). This remarkable species occurs in vast numbers in the Devonian Rocks of Germany and Devonshire, apparently occupying in the former region, as probably in the latter also, a definite horizon in the upper portion of the Middle Devonian series (the "Ramosa-Bänke" of Schulz). In its dendroid cœnosteum (Plate IX, fig. 1), *Amphipora ramosa*, Phill., resembles *Stachyodes verticillata,* and this resemblance is further increased by the fact that in both these types the skeleton is traversed by a principal axial tabulate tube (Plate IX, figs. 2 and 4). The skeleton-fibre of *Amphipora ramosa* exhibits, however, no traces of the microscopic tubulation which is so characteristic of even the smallest fragment of the skeleton of *Stachyodes.* In fact, the skeleton-fibre of *Amphipora* appears to be quite compact, though there are grounds for thinking that this is perhaps only the result of mineralisation and that the fibre may be to some extent porous. The most remarkable peculiarities of *A. ramosa* are, however, connected with the condition of its surface. In examining a large series of specimens, one is at once struck by the fact that many individuals have the surface covered with the rounded apertures of the zoöidal tubes, which are bounded by tuberculate margins and which give to the fossil very much the appearance of a small species of *Pachypora.* On the other hand, many other individuals (Plate IX, fig. 1) have the surface entirely covered by a thin, imperforate, calcareous membrane, which gives them very much the aspect of the stems of such Corals as *Lithostrotion junceum* or

Diphyphyllum stramineum, Bill. Very commonly a portion of a single stem will be covered in this way by a smooth calcareous envelope, while other portions, from natural or artificial deficiency of the membrane in question will exhibit the apertures of the zoöidal tubes. In transverse sections of such specimens as possess this membranous covering we find that it is not applied directly to the poriferous surface below, but that between the two are developed numerous large-sized lenticular vesicles, the general appearance of which is not unlike the vesicles of such Corals as the *Cystiphylla* (Plate IX, fig. 3). To begin with, I was under the impression that these "marginal vesicles" were structures of constant occurrence and that their non-existence in certain specimens was only due to the fact that the peripheral vesicles had been decorticated prior to fossilisation. I am, however, now satisfied that this is not the case, but that there exist under *Amphipora ramosa* two distinct groups of specimens, those of the one group, seemingly the most numerous, exhibiting a poriferous and vermiculate surface; while those of the other group have their original surface surrounded by a zone of vesicles which are in turn enveloped by a thin calcareous pellicle. The only conjecture which I can offer as to the nature of these "marginal vesicles" is that they are reproductive in function, and that they correspond with the "ampullæ" of the *Stylasteridæ*. This view would not only explain the fact that these vesicles were not universal in their occurrence in *A. ramosa*, but would also throw some light upon the otherwise inexplicable phenomenon that various Stromatoporoids have so commonly portions of the surface covered by a kind of calcareous pellicle.

VI. THE NATURE OF "CAUNOPORA."

The singular fossils for which the generic names of "*Caunopora*," Phill., and "*Diapora*," Barg., have been proposed are known, to their cost, by all students of the Stromatoporoids. They have proved a fertile source of differences of opinion; and these differences are important, since the conclusions which are to be formed as to the structure and relations of the whole group of the Stromatoporoids necessarily depend largely upon the views which may be held as to the nature of the so-called "*Caunoporæ*" and "*Diaporæ*." As is well known, the fossils to which these names have been given, resemble in all essential respects the ordinary Stromatoporoids, except that the cœnosteum is traversed by numerous *thick-walled* tubes, which are directed at right angles to the concentric laminæ of the fossil, and which open by definite rounded apertures upon its surface. Sometimes these tubes—which may in the meanwhile be conveniently called "Caunopora-tubes"—have simply a thin, but quite definite proper wall, either alone or with but a very thin secondary lining. More commonly, the proper wall is strengthened by a dense secondary deposit of light-coloured sclerenchyma, which may nearly obliterate its internal cavity (Plate X, fig. 2). The tubes are attached inferiorly to irregular horizontal stolons, which sometimes clearly have a proper wall, but which at other times seem to be bounded only by the general tissue of the Stromatoporoid. The tubes further give out lateral horizontal tubes, which may simply open into adjoining tubes, or which may ultimately bend upwards and give origin to new vertical tubes. Superficially, the "Caunopora-tubes" terminate in rounded thickened apertures, which are flush with the general surface, or project very slightly above it. In the few specimens in which the tubes appear to be prolonged above the surface at all, it is probable that the fossil has been partially decorticated; but the horizontal connecting-processes certainly seem to occasionally lie above the last-formed layer of the Stromatoporoid (Plate X, fig. 3). As to whether or not there exists any communication between the "Caunopora-tubes" and the interlaminar spaces and zoöidal tubes of the enveloping Stromatoporoid, it seems impossible to arrive at present at any absolutely positive conclusion. In most cases there certainly seems to be no such communication. On the other hand, thin sections occasionally show phenomena which would lead to the belief that the horizontal connecting-tubes *may* open into the adjoining zoöidal tubes, or that the main "Caunopora-tubes" themselves sometimes open inferiorly into the interlaminar spaces of the Stromatoporoid; but it is probable that the phenomena in question are delusive.

As regards their internal structure, the "Caunopora-tubes" are probably always *tabulate*. It is true that in a number of specimens "tabulæ" cannot be detected, but this is probably the result of mineralisation, as I have rarely failed to detect these structures in well-preserved examples of all the forms of "*Caunopora*." The tabulæ may be simply horizontal, or curved, but they are more commonly partially funnel-shaped, a number of vesicular tabulæ being placed on one side or on both sides of the tube. Hence cross-sections of the tubes present appearances almost exactly similar to those seen in corresponding sections of the corallites of *Syringopora*, and sometimes in similar sections of *Aulopora*. Very often, the same "Caunopora-tube" is partially furnished with flat tabulæ, and partially with funnel-shaped tabulæ. As a general rule I have failed to detect the existence of *septal spines* in the "Caunopora-tubes;" and I am not aware that these structures have been clearly recognised as occurring in any instance by previous observers. I have never found any satisfactory indications of septa in any of the "*Caunoporæ*" of the British Devonian Rocks, but it may well be that this is the result of the extent to which most of the Devonshire specimens have been altered by fossilisation. I have also not succeeded in detecting such structures in a large number of specimens from the Devonian Rocks of Germany, where the minute structure is very well preserved. It is therefore extremely probable that the tubes of many of the "*Caunoporæ*" and "*Diaporæ*" are really destitute of anything of the nature of septa. On the other hand, I have recently found a number of "*Caunoporæ*" in the Devonian Rocks of the Eifel, in which the "tubes" are furnished with well-preserved and quite unmistakeable septal spines. In such cases the septal spines are arranged in vertical rows in the interior of the tubes, eight of such rows being apparently the general number. The spines are altogether of the type of these structures, as seen in many species of *Favosites* or in *Syringopora*. They have the form of blunt calcareous spines (Fig. 17), which fall short of the centre of the tubes, and

FIG. 17.

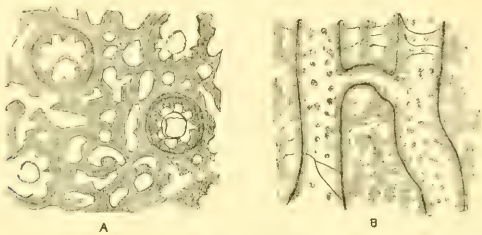

FIG. 17.—Sections of a species of *Stromatopora*, from the Devonian Limestone of Gerolstein, enlarged twelve times, showing "Caunopora-tubes" with septal spines. A. Tangential section. B. Vertical section

are often quite marginal. They are most easily recognised, as a rule, in longitudinal sections, in which they are transversely divided near their bases, and appear in the interior of the tubes as rows of dark round spots (Fig. 17, B). I may add that in a specimen of "*Caunopora*" from the Corniferous Limestone of Ontario, which Dr. Hinde was so good as to submit to me, I have found similar but even more largely developed septal spines.

Another point in which great variations exist among the so-called "*Caunoporæ*" is as to the mode of growth of the tubes. In some specimens, which, however, are by no means typical ones, the "Caunopora-tubes" are very irregular in their growth, being often far apart, and not extending their vertical growth to any great distance from the horizontal stolons to which they are attached. In such specimens, the "Caunopora-tubes," if divested of the enveloping Stromatoporoid, might fairly enough represent an ordinary *Aulopora* colony, in which the tubes had grown to a much greater height than is usual in the genus *Aulopora*, and had also become here and there connected by an occasional cross-tube. This is the condition of things, for example, in the specimen from the Corniferous Limestone just alluded to. In the great majority of the "*Caunoporæ*," however, the tubes are placed close together, and usually at tolerably regular intervals, and they grow straight upwards for very considerable distances. Owing to the fact that it is not possible to make any vertical sections which shall intersect any given tube along its entire length, it is not possible to assert positively that the individual tubes of the "*Caunoporæ*" are continued through the entire thickness of the larger examples without interruption. In laminar specimens of "*Caunopora*" it seems almost certain that the majority of the tubes are continued straight from the base of the organism to the surface, without any interruption, merely giving off horizontal connecting-processes to adjoining tubes at intervals. In such specimens I have often traced a single tube, without a break, through a vertical thickness of an inch or more. In the more massive specimens, which often reach several inches in thickness, I have little doubt that the tubes also run for very long distances without interruption, though I am not able to say that they are continued from the base to the surface. [I have traced a single tube for over two inches.] In such specimens, therefore, the "Caunopora-tubes," if divested of the surrounding tissue, would more nearly resemble a colony ot *Syringopora* than one of *Aulopora*. They would, however, differ from any ordinary *Syringopora* in the regularity with which they are spaced, and, still more, in their often very minute size.

In other specimens, again, parts of the organism may be charged with "Caunopora-tubes," while they may be wanting, or very sparsely developed, in other parts of the same. In other cases, again, the "*Caunopora*" assumes a cylindrical shape, and then the tubes radiate outwards in all directions to open on the surface of the specimen. A modification of this is seen in some specimens where the organism consists of a series of parallel cylinders united by a larger or smaller amount of interstitial tissue. In such cases, each cylinder is generally traversed by its own set of "Caunopora-tubes," radiating outwards from its central line.

Another important consideration in the case of the "*Caunoporæ*" and "*Diaporæ*" is that of the nature of the Stromatoporoid in which the "Caunopora-tubes" are enveloped. I have examined many hundreds of these fossils, but it has not been in more than perhaps a dozen instances that I have met with anything that could be properly called a "*Caunopora*" or "*Diapora*" unless the enveloping Stromatoporoid has belonged to the "Milleporoid" section of the Stromatoporoids, *i. e.* to that section in which the skeleton is of the more or less completely reticulated type. In fact, almost all the "*Caunoporæ*" and "*Diaporæ*" belong, as regards the tissue of the enveloping Stromatoporoid, to the genera *Stromatopora*, Goldf., and *Stromatoporella*, Nich., and it was upon the difference in the structure of the skeleton in these two genera that Bargatzky founded his genus *Diapora*, as distinct from *Caunopora*, Phill. Until recently, I should have said that *all* specimens of "*Caunopora*" and "*Diapora*" belonged, as regards the enveloping Stromatoporoid, to the genera *Stromatopora* and *Stromatoporella*. Dr. Hinde has, however, shown me a specimen of a "*Caunopora*" from the Corniferous Limestone of Canada, in which the enveloping Stromatoporoid is referable to the genus *Clathrodictyon*.

Mr. Champernowne has, further, shown me a specimen of *Actinostroma*, from the Devonian Rocks of Devonshire, in which "Caunopora-tubes" are developed. Lastly, I have myself recently collected a number of specimens of "*Caunoporæ*" from the Silurian Rocks of Oesel, in which the enveloping Stromatoporoid belongs to a peculiar group of forms intermediate between *Clathrodictyon* and *Rosenella*.

It should be borne in mind, however, that there occasionally occur specimens which are penetrated by isolated or quite irregular tubes which have internally much the same structure as "Caunopora-tubes," from which, indeed, they could not be morphologically distinguished, but which should not be considered as being true "*Caunoporæ*" or "*Diaporæ*." In such cases, the tubes are generally of large size, are entirely irregular in their growth and distribution, run usually more or less horizontally or obliquely, and sometimes are exposed over parts of the surface. It seems safe to set down all such specimens as cases in which some Stromatoporoid has more or less completely enveloped in its growth some Syringoporoid or Auloporoid Coral. I do not mean by this to imply that the *true* "*Caunoporæ*" may not also be due to the combined growth of a Stromatoporoid with some Syringoporoid or Auloporoid Coral; only in that case, as will be shown later on, it is necessary to suppose that the enveloped Coral has undergone certain striking changes in its normal mode of growth, whereas in the specimens just alluded to the embedded Coral exhibits nothing distinctive or peculiar.

One other important general point about the "*Caunoporæ*" and "*Diaporæ*" remains to be noticed, and it is of the highest significance. I have found, namely, that all those Stromatoporoids, which are known to me as *habitually* giving rise to "*Caunoporæ*" and "*Diaporæ*," occur both with and without the embedded "Caunopora-tubes." That is to say, while, as a general rule, only certain particular species of Stromatoporoids occur in the condition of "*Caunoporæ*" or "*Diaporæ*," the same species can always be shown to exist *without* the embedded tubes which characterise these two so-called genera. I shall deal more fully with this point later on. All that it is in the meanwhile necessary to insist upon is that this discovery would seem to render it certain that the "Caunopora-tubes"—whatever the true nature may be—are not structures characteristic of particular *species* of Stromatoporoids. On the contrary, they occur only in certain individuals of those species in which they are found at all, and they are wanting in other individuals of the same species. It follows from this, *a fortiori*, that the presence of "Caunopora-tubes" cannot be employed as a character distinctive of certain *genera* of the Stromatoporoids. We must therefore abandon the names *Caunopora*, Phill., and *Diapora*, Barg., as the titles of genera.

The main details of the history of opinion as to *Caunopora* may be told in a few sentences. The genus *Caunopora* was originally founded by Phillips ('Pal. Foss. of Cornwall, &c.,' p. 18, 1841) for two different forms, viz. *C. placenta*, Lonsd., and *C. ramosa,* Phill. The latter of these has been seen not to be a "*Caunopora*" at all, but to be the type of the genus *Amphipora*, Schulz. The former is the *Coscinopora placenta* of Lonsdale, and it would be difficult or impossible, from the figures and descriptions of both Lonsdale and Phillips, to identify it precisely with any particular one of the three or four commoner kinds of "*Caunoporæ*" which occur in the Devonian Rocks of Devonshire. It would, at any rate, in my opinion, be inexpedient to attempt to retain the name of "*placenta*" as a *specific* title, unless *Caunopora* were also to be retained as a *genus*. My reason for this conclusion is that the presence of "Caunopora-tubes" in the fossil was, of course, the essential feature selected by Lonsdale and Phillips as characterising their *Caunopora placenta* as a *species*, whereas these tubes occur in all the so-called *Caunoporæ*, and their presence cannot, therefore, be employed to characterise a species.

As early as 1844, Professor Ferdinand Roemer expressed the opinion ('Das rheinische Uebergangsgebirge') that *Caunopora*, Phill., was merely based upon examples of Stromatoporoids, which in the course of growth had enveloped colonies of *Syringopora*, and that the genus consequently must fall to the ground. To this view Roemer has always adhered, so far as concerns the belief that "Caunopora" has no existence as a single organism ; but he has so far modified his original view ('Geol. Mag.,' New Ser., Dec. ii, vol. vii, p. 343, 1880) that he now regards *Aulopora* rather than *Syringopora* as the Coral which is associated with Stromatoporoids in the production of "*Caunopora*" colonies.

In the series of valuable papers which he has published on the Stromatoporoids Mr. Carter was at first disposed to accept "Caunopora" as an independent organism ; but he subsequently abandoned this view, and expressed the opinion that, as previously asserted by Roemer, the *Caunoporæ* were the result of the commensalism of a Stromatoporoid and a Coral ('Ann. and Mag. Nat. Hist.,' Ser. 5, vol. iv, p. 101, 1879). At a still later date, while retaining this view as to the commensalism of *Caunopora*, Mr. Carter expressed the opinion that the Coral which was thus associated with Stromatoporoids was rather to be regarded as *Syringopora* than as *Aulopora*, since infundibuliform tabulæ could be occasionally recognised in the tubes ('Ann. and Mag. Nat. Hist.,' Ser. 5, vol. vi, p. 339, 1880.)

Mr. Champernowne, whose opinion upon any subject connected with the Devonian Stromatoporoids is of the greatest value, also arrived at the conclusion that the "commensal theory" was probably the true one, and has consistently opposed the view that "*Caunopora*" and "*Diapora*" are *genera* of Stromatoporoids.

On the other hand, many observers have at various times maintained views as to the nature of *Caunopora* opposed to the preceding. It has, namely, been held by many authorities that the thick-walled tubes of "*Caunopora*" are not foreign to the Stromatoporoid in which they are found, but truly belong to it, and that the genus is therefore a valid one. To mention only the most recent writers on this subject, this view has been maintained by Dr. August Bargatzky ('Die Stromatoporen des rheinischen Devons,' 1881), and by Dr. Carl Riemann ("Die Kalke des Taubensteins bei Wetzlar und ihre Fauna," 'Neues Jahrb. für Min. Geol. und Pal.,' 1884). Dr. Bargatzky, indeed, not only supports the validity of the genus *Caunopora*, Phill., but founds the new genus *Diapora* for certain "Caunopora" colonies in which the "ground-mass" exhibits radial pillars and concentric laminæ, instead of being simply reticulate, as it is in the true "*Caunopora*" of Phillips, as understood by Bargatzky.

For my own part, I must frankly admit that my views have always been in favour of the validity of "*Caunopora*," as comprising independent organisms. In pursuit of the present inquiry, however, I have had to make a microscopic examination of a very extensive series of specimens of "*Caunopora*" and "*Diapora*" from the Devonian Rocks of Devonshire, Germany, France, and North America, and I have been driven to the conclusion that these names do not correspond with generic divisions, but that the fossils so called are in reality occasional *conditions* of certain particular species of Stromatoporoids. This does not, however, necessarily involve the acceptance of the "commensal theory" of "*Caunopora*," of which Roemer is the originator, and in which he has been followed by Carter and Champernowne—the theory, namely, that the fossils upon which "*Caunopora*" is based are really the result of the commensalism of certain types of Stromatoporoids with certain types of Corals. The problem as to the precise nature of the tubes of "*Caunopora*" has, indeed, proved to be one of such extreme difficulty that it will be best to give here a kind of summary of the arguments for and against the different views which might be taken as to this subject, without committing myself finally to any one theory as opposed to the others. In so doing there are three principal theories which I shall pass in review, viz.:—(1) The view that "*Caunopora*" and "*Diapora*" are *genera* of Stromatoporoids; (2) the theory of Roemer that "*Caunopora*" and "*Diapora*" are the result of the commensalism of certain Stromaporoids with certain Corals; and (3) the theory that the "tubes" of "*Caunopora*" and "*Diapora*" belong to the organism in which they are found, but that they represent structures which are only developed in certain colonies or in certain individuals, and that these names, therefore, merely indicate a *state* of certain Stromatoporoids.

I. *Caunopora and Diapora as Genera.*

The theory that *Caunopora*, Phill., and *Diapora*, Barg., are *genera* of Stromatoporoids may, in the light of presently known facts, be dismissed with comparative brevity. So long as it remained unknown with what particular types of Stromatoporoids "Caunopora-tubes" were associated, it was a not unreasonable conclusion that the forms possessing these singular structures were really distinct genera. Bargatzky was the first observer who directed his attention specially to the minute structure of the tissue enveloping the tubes; and he showed, quite rightly, that this tissue is sometimes of the completely reticulated type, while at other times the reticulation is incomplete. On this difference—which is really the difference between *Stromatopora*, Goldf., and *Stromatoporella*, Nich.—he based his separation of *Diapora*, Barg., from *Caunopora*, Phill. As already pointed out, it would appear that there are only certain particular types of the Stromatoporoids which habitually form "Caunoporoid" colonies, and that other common and well-known types rarely or never do so. For example, the species of *Actinostroma*, which occur in such vast numbers in the Devonian Rocks of Britain and Germany, seem hardly ever to form "*Caunoporæ*." They very commonly envelop Corals of different kinds in the course of their growth; but with the exception of a single specimen in the collection of Mr. Champernowne, I have never met with an example of the genus associated with the regular "Caunopora-tubes." No *Labechia* has ever been recorded as giving rise to "*Caunopora*" colonies, though the cœnosteum in this genus also quite commonly grows round and envelops Corals or other foreign organisms. Similarly, the species of *Clathrodictyon* are almost never observed with associated "Caunopora-tubes." With very few exceptions, all the "*Caunoporæ*" and "*Diaporæ*" which I have examined belong, as regards the investing Stromatoporoid, to the family of the *Stromatoporidæ*, and to one or other of the two genera *Stromatopora*, Goldf., and *Stromatoporella*, Nich. Moreover, all the species of these two genera which are of common occurrence as "*Caunoporæ*" and "*Diaporæ*," occur also *without the embedded tubes*, the two "states" of each species being often found side by side in the same locality. The species of *Stromatopora* and *Stromatoporella* which are most commonly concerned in the production, respectively, of "*Caunoporæ*" and "*Diaporæ*" are the following:

(*a*) *Stromatopora concentrica*, Goldf. (Plate XI, figs. 16 and 17, respectively with and without "Caunopora-tubes").

(*b*) *Stromatopora Hüpschii*, Barg., sp. (Plate X, figs. 8—12, with the "Caunopora-tubes;" woodcut, Fig. 6, without the tubes).

(*c*) *Stromatopora bücheliensis*, Barg., sp. (Plate X, figs. 6 and 7, with the "Caunopora-tubes;" woodcut, Fig. 6, without the tubes).

(*d*) *Stromatopora Beuthii*, Barg., sp.

(*e*) *Stromatoporella laminata*, Barg., sp. (Plate X, figs. 1—4).

(*f*) *Stromatoporella eifeliensis*, Nich.

The species of *Stromatoporella* have not yet been worked out, and I do not know whether there are any species of this genus which never form "*Diapora*" colonies. I have not, however, so far, found the type-species of this genus, viz. *S. granulata*, Nich., to be associated with "Caunopora-tubes." On the other hand, there are various species of the genus *Stromatopora* which, so far as our present knowledge goes, never give rise to "*Caunopora*" colonies. Thus, I have never seen any examples of "*Caunopora*" colonies in the case of the Silurian *Stromatoporæ*, such as *S. typica*,[1] Rosen, *S. Carteri*, n. sp., and *S. discoidea*, Lonsd., though the first of these is the commonest of all the Silurian Stromatoporoids in this country. So far as I know, indeed, the Silurian Rocks of Britain have as yet yielded no "*Caunoporæ*." It has, however, been pointed out by Professor Ferdinand Roemer ('Geol. Mag.,' 1880, p. 345) that the Silurian pebbles of the Drift of Holland and North Germany sometimes yield specimens of "*Caunoporæ*." Of this nature is the fossil described by Goldfuss ('Petref. Germ.,' vol. i, p. 113, Taf. 38, fig. 13) as *Syringopora filiformis* and subsequently described by Roemer himself as *Heliolites interstincta* ('Diluvial Geschiebe von Sadewitz,' p. 24, Taf. 4, fig. 2 *c*). I have also recently collected in the Silurian Rocks (Upper Oesel Group) of Oesel a number of remarkable specimens of "*Caunoporæ*." These present, however, certain special peculiarities of their own, one of the most important of these being that the enveloping Stromatoporoids appear to be related to the genus *Clathrodictyon*, the associated species of *Stromatopora* being seemingly free from "Caunopora-tubes."

Upon the whole, considering that the embedded tubes constitute the essential feature upon which *Caunopora*, Phill., and *Diapora*, Barg., were founded, the facts above recounted would seem to render it absolutely certain that these names cannot be retained as names of *genera*. To retain these names would lead us into the position of having a series of forms of *Stromatopora* and *Stromatoporella* which could only be separated from a parallel series of forms of *Caunopora* and *Diapora* by the fact that the latter possessed embedded tubes, the structure of these tubes being in all these species essentially the same. As this position appears to me to be a quite untenable one, I shall abandon *Caunopora*, Phill., and *Diapora*, Barg., as genera of the Stromatoporoids ; since the attempt to reconstruct these genera by the omission of the "tubes" from the list of their distinctive characters could only lead to confusion.

[1] I have recently collected in the Silurian Limestones of Hoheneichen, in Oesel, a remarkable specimen of *Stromatopora typica*, Rosen, which has the general aspect of a "*Caunopora*," with unusually large tubes. In this specimen, however, the embedded tubes differ entirely in their structure from those of all the ordinary "*Caunoporæ*." Not only do they unquestionably belong to an organism foreign to the Stromatoporoid in which they are enveloped, but they belong to a very peculiar type of Rugose Corals with which I am not otherwise acquainted.

II. *The Theory of the Commensalism of Caunopora and Diapora.*

In discussing Prof. Roemer's theory of the "commensalism" of "*Caunopora*" and "*Diapora*," I shall, in the first place, review generally the arguments against the theory and those in favour of it. In the second place, it will be necessary to discuss the question whether, if the theory of commensalism be accepted, the "Caunopora-tubes" are referable to *Syringopora*, or whether they belong to *Aulopora*.

(A) *General Arguments against Commensalism.*—The following, stated briefly and in a summary form, are the principal facts and considerations which tell against any theory of the commensalism of "*Caunopora.*" It should be premised that all those cases where Stromatoporoids demonstrably envelop different kinds of Corals are here left out of sight. All we have to deal with here are the *typical* "*Caunoporæ*" and "*Diaporæ*," in which we cannot at present *demonstrate* commensalism. With regard to all such specimens—and they are very numerous—it may be taken for granted, with our present knowledge, that if the organism be the result of the commensalism of a Coral and Stromatoporoid, the former must belong to *Syringopora* or *Aulopora*, or to some closely allied type. We are not, at any rate, acquainted with any Palæozoic Corals, except the species of these two genera or of closely related types, the internal structure of which is such as to permit of our supposing that the "Caunopora-tubes" might belong to them.

1. In the first place, colonies of *Aulopora* are often found associated in different ways with Stromatoporoids, and yet not giving rise to "*Caunoporæ*" or "*Diaporæ*." Thus, in the Wenlock Limestone of Britain nothing is commoner than to find *Aulopora* colonies spreading over the upper or under surfaces of Stromatoporoids, and even sometimes in part enveloped in these; but in an examination of two or three hundred of such specimens I have not detected a single one in which the Stromatoporoid had completely enclosed the Coral, or in which the latter had been induced to lengthen its tubes or to alter in any way its normal mode of growth. On the other hand, in the Devonian Strata I have often noticed tubes apparently belonging to *Auloporæ*, or to some of the types which have been placed under *Syringopora*, completely immersed in Stromatoporoids, and nevertheless not giving rise to "Caunoporæ;" the growth of the embedded Coral being altogether irregular and showing none of the peculiar characters of the latter.

2. Again, there are extensive groups of rocks in which all the conditions required, on the theory of commensalism, for the production of "Caunoporæ" are present, and yet the fossils so called are unknown, or are extremely rare. Thus, as just noted, the Wenlock Limestone of Britain contains a vast abundance of Stromatoporoids (including three species of the genus *Stromatopora* itself) along with

numerous examples of both *Aulopora* and *Syringopora;* and yet I have never found a single example of either "*Caunopora*" or "*Diapora*" in it, nor do I know that one has ever been found.[1] Another but not so striking case is that of the Corniferous Limestone of North America, in which we find a remarkable profusion of species of *Syringopora*, and to a less extent of *Aulopora*, existing with great numbers of Stromatoporoids; and yet "*Caunoporæ*" and "*Diaporæ*" are exceedingly rare.

3. The converse of this also holds good. That is to say, there are strata in which "*Caunoporæ*" and "*Diaporæ*" are very abundant, and in which *Aulopora* and *Syringopora* may be very rare. This is most marked in the case of the Devonian Limestones of Devonshire, in which "*Caunoporæ*" are extraordinarily abundant, whereas species of *Aulopora* or of *Syringopora* (unless they are supposed to be nearly all "commensals") are hardly known, and are certainly very rare. A partial explanation of this may doubtless be found in the difficulties which attend the collection of fossils from these strata otherwise than in polished slabs; but this explanation would not apply to cases like the Devonian Limestones of Gerolstein, in the Eifel, where "*Caunoporæ*" and "*Diaporæ*" are very common, whilst *Auloporæ* are not particularly abundant, and *Syringoporæ*, if they occur at all, are extraordinarily rare.

4. If we accept the theory of the commensalism of "*Caunopora*" and "*Diapora*," we must suppose that the production of the fossils so named involves something very much more than mere *envelopment*. Perhaps all the forms of the Stromatoporoids—save such abnormal types as *Amphipora* and *Beatricea*—occur *occasionally* encrusting or enveloping foreign organisms. We should therefore expect that *any* type of the Stromatoporoids might sometimes be found in the "Caunopora-state." On the contrary, it is only the Stromatoporoids of one particular group which seem habitually to give rise to "*Caunoporæ*" and "*Diaporæ*;" and it is only certain species in this group which appear to do so. Moreover, the forms which *do* produce such colonies are mostly non-encrusting types, furnished with a basal epitheca.

5. Moreover, supposing that "*Caunoporæ*" and "*Diaporæ*" are the result of the associated growth of a Stromatoporoid and a Coral, there are no Palæozoic Corals which have even a general correspondence as regards their internal structure with the "tubes" of these fossils, except the Auloporoid and Syringoporoid Corals.

[1] As before mentioned, I have recently found a number of specimens of "*Caunopora*" in the Upper Silurian Limestones of Oesel, these being the only Silurian "*Caunoporæ*" that I have ever seen. At one locality (Kattri-pank) these "*Caunoporæ*" are associated with numerous examples of *Syringopora bifurcata*, Lonsd. (= *S. reticulata*, His.); and I thought at first that the former might easily prove to be merely colonies of the latter living commensally with Stromatoporoid colonies. A microscopic examination of both, however, has satisfied me that in this particular instance the embedded tubes of the "*Caunoporæ*" are certainly *not* referable to this particular species of *Syringopora*, as they differ from the latter both in size and in their internal structure.

But there are no known species of either *Aulopora* or *Syringopora*, the colonies of which, in their normal habit and mode of growth, would correspond in any *precise* way with the aggregate of tubes of a "*Caunopora*" or "*Diapora*," as these latter would be seen when divested of the Stromatoporoid in which they are enveloped. I shall enter into this subject at greater length in discussing the special claims of either *Aulopora* or *Syringopora* to be regarded as concerned in the production of "*Caunoporæ*." In the meanwhile it is enough to point out, that whether we select *Aulopora* or *Syringopora* as the Coral associated with a Stromatoporoid to form "*Caunopora*" colonies, or whether we allow both to play this part, we are alike compelled to suppose that the Coral, when living under these conditions of life, entirely modifies its normal habits and mode of growth. This seems to me to be the only way of accounting satisfactorily for the peculiarities of the tubes of a "*Caunopora*" colony, if we suppose these tubes to belong to any known species of *Aulopora* or *Syringopora*.

6. Lastly, if the theory of the commensalism of "*Caunopora*" be accepted, we must admit not only that several species of Stromatoporoids are liable to form such colonies, but also that at least two or three species of Corals are concerned in the process. For "*Caunoporæ*" differ from one another, not only as to the structure of the "ground-mass" of the fossil, but also as to the size and other characters of the embedded tubes.

(B) *General Arguments in favour of Commensalism.*—The above are the principal difficulties which have to be confronted, if we accept the theory of the commensalism of "*Caunopora*;" and they are so numerous and so weighty as to form, in my opinion, an ample justification for those who have hitherto hesitated to admit the correctness of the theory. On the other hand, the following are the principal arguments, of a merely *general* nature, which support the theory of commensalism :

1. The general aspect of the tubes of "*Caunopora*" and "*Diapora*" is extremely like that of the tubes of the Auloporoid and Syringoporoid Corals; sometimes resembling *Auloporæ*; at other times making a close approach to the *Syringoporæ*.

2. The tubes have definite thickened *walls* of their own, quite distinct as a rule from the tissue of the investing Stromatoporoid (Plate X, figs. 1, 2, 6, 7, 8, 9). In all cases, the tubes are uniformly and universally covered throughout with a thin layer of the tissue of the Stromatoporoid, so that it is never possible in thin sections to find any portions of the walls of the "Caunopora-tubes" which are not covered externally by the ordinary tissue of the Stromatoporoid. The proper wall of the tubes may be quite thin, and may be merely represented by a dark line; but usually the wall is further thickened by an extensive deposit of light-coloured sclerenchyma by which the internal cavity of the tube is much contracted (Plate X, fig. 11). In some thin sections I have been unable to make out any proper wall

to the "Caunopora-tubes," the walls of which appear to be composed only of the ordinary tissue of the Stromatoporoid-colony. Little stress, however, can be laid upon this observation, as it might merely be a case in which the original walls of the "Caunopora-tubes" had been gradually absorbed and "replaced" by the Stromatoporoid, after the fashion so well known in the recent *Hydractinia*.

3. It has hitherto proved impossible to demonstrate in a satisfactory way the existence of any communication between the cavities of the "Caunopora-tubes" and the interlaminar spaces or zoöidal tubes of the investing Stromatoporoid. Some thin sections appear to show the occasional existence of such a communication; others show no traces of anything of the kind. In the absence of any clear and positive proof of the existence of such a communication we are precluded from any comparison between the "tubes" of "*Caunopora*" and the gastropores of the *Milleporidæ* and *Stylasteridæ*. The absence, therefore, of a proved cœnosarcal connection between the "Caunopora-tubes" and the investing Stromatoporoid is in my opinion the strongest of all arguments in favour of the theory of commensalism—in spite of the great difficulties which this theory has to overcome. Indeed, till such a connection can be shown to exist—and I am not prepared to assert positively that it may not yet be shown to exist—it does not seem to me possible to definitely accept *any* theory which would regard the "Caunopora-tubes" as constitutent parts of the organisms in which they are found.

4. Most well-preserved specimens of "*Caunopora*" and "*Diapora*," when examined in thin sections, can be shown to have their tubes intersected by a larger or smaller number of "*tabulæ*," which are sometimes flat or simply curved, sometimes vesicular, and often infundibuliform. Very commonly the same tube will be provided in part with flat tabulæ, and in part with vesicular or funnel-shaped tabulæ (Plate X, figs. 1 and 2). I entertain little doubt but that the tubes of "*Caunopora*" and "*Diapora*" really always possess these tabulæ; though owing to imperfect preservation (as, for example, in most of the Devonshire specimens) their presence may be difficult to demonstrate or they cannot be shown to exist at all. Owing to the presence of these tabulæ, longitudinal and transverse sections of the tubes of "*Caunopora*" and "*Diapora*" possess a striking resemblance to corresponding sections of the corallum of *Syringopora*, or, to a less degree, of *Aulopora*. It appears to me, however, that it is easy to give a far more than due weight to this resemblance, since precisely similar "tabulæ," exhibiting precisely similar variations in their form and arrangement, can be shown to exist in the astrorhizal canals of certain *Stromatoporellæ* and in the axial canals of *Idiostroma*, *Stachyodes*, and *Amphipora;* and it cannot be doubted that *these* tubes belong to the Stromatoporoid in which they are found.

5. A much more weighty argument in favour of the theory of commensalism may be based upon the discovery, which I have recently made, that the "tubes"

of certain "*Caunoporæ*" and "*Diaporæ*" are provided with *septal spines.* I have already described and figured these structures (Fig. 17), and need only repeat here that in their structure and general arrangement they show nothing which would distinguish them from the corresponding septal spines of a *Syringopora* or a *Favosites*. The only existing *Hydrozoa* which have any structures which could be confounded with the "septa" of the *Actinozoa* are the Stylasterids, in some of which the dactylopores of each cyclo-system are separated by thin radiating partitions or "pseudo-septa" (Moseley). These structures, however, have no resemblance to the rows of septal spinules just alluded to as occurring in the interior of the tubes of certain of the "*Caunoporæ*" and "*Diaporæ*." It appears, therefore, to be quite certain that in all those "*Caunoporæ*" and "*Diaporæ*" in which the tubes possess septal spines, the tubes must be foreign to the Stromatoporoid in which they are found, and must belong to some *Actinozoön*. Moreover, as those "*Caunoporæ*" and "*Diaporæ*" in which the tubes have septal spines are in no other respect distinguishable from those in which the tubes appear to be without such spines, it seems hardly possible to evade the conclusion that in the latter also the "tubes" are foreign structures.

(c) *Syringopora as the Commensal of Caunopora.*—Admitting that the so-called "*Caunoporæ*" and "*Diaporæ*" are the result of the commensalism of some Coral and some Stromatoporoid, the nature of the Corals concerned in the process still remains for determination. The settlement of this point has proved a matter of extreme difficulty, since the choice seems in most cases to lie between *Syringopora* and *Aulopora*, and neither of these genera fulfils all the requirements of the case.

If we take the larger and more massive examples of "*Caunopora*," and imagine the investing Stromatoporoid to be removed, there is no doubt but that the aggregate of the embedded tubes would show a close *general* resemblance to the corallum of *Syringopora*. In such examples the "Caunopora-tubes" are very long, run parallel with one another, and are connected by cross-branches which sometimes give origin to new vertical tubes instead of opening into an adjoining tube. In their internal structure, also, the tubes would answer very well for *Syringopora*-tubes. The tabulæ of *Syringopora*, though usually funnel-shaped, are sometimes simply flat or curved (*e. g.* in *S. geniculata*, Phill.), and sections of the "Caunopora-tubes" show all the phenomena which are seen in similar sections of *Syringopora*, as regards the "tabulæ." The septal spines of the "Caunopora-tubes" are likewise—when present—quite like those of *Syringopora*, except that there appear to be only eight rows of these structures in each tube, whereas there are generally from twelve to twenty of such rows in *Syringopora*.

There are, however, in spite of these resemblances, great difficulties in the way of supposing that the "Caunopora-tubes" are really referable to *Syringopora*. In the first place, very many "*Caunoporæ*" and most "*Diaporæ*" are not massive, but form thin, laminar expansions, often of great size, the thickness of which varies from 4—6 mm. up to perhaps 2—4 cm. In such cases, the embedded tubes, if set free from their investment, would be quite unlike any known *Syringopora*, and would much more closely approach the general characters of an *Aulopora*-colony. In the second place, there are no known species of *Syringopora* which possess such exceedingly delicate tubes as those of many "*Caunoporæ*" and "*Diaporæ*." In many examples of the latter I find the tubes to be not more than perhaps $\frac{1}{3}$ mm. in diameter, and they are sometimes even smaller than this (Plate XI, fig. 17). As regards the Devonian species of *Syringopora*, Schlüter ('Sitzungsberichte der niederrhein. Gesell.,' 1885) states that his *S. tenuis* has the smallest tubes of any species of *Syringopora* known to occur in the Middle Devonian of the Rhenish region, in which "*Caunoporæ*" are very abundant. The diameter of the corallites in this species are stated not to exceed 1 mm.; and in the *Syringopora moravica* of Ferd. Roemer ('Leth. Pal.,' p. 495), from the Devonian of Olmütz, the corallites are said to be only $\frac{2}{3}$ mm. in diameter. In both of these, however, the diameter of the corallites much exceeds that of the tubes of many "*Caunoporæ*," and the tubes in most species of *Syringopora* are much larger than in these two.

In the third place, the massive examples of "*Caunopora*," which otherwise most resemble *Syringoporæ*, have the tubes much more regularly spaced, and much more uniformly parallel, than we see them to be in any known species of the genus *Syringopora*. In many specimens in which the entire colony may be some inches in thickness, the mass is traversed throughout by straight parallel tubes which may be from $\frac{1}{3}$ to $\frac{1}{2}$ mm. in diameter, and which on an average are placed at about a millimetre apart. On the other hand, in all the known *Syringoporæ* the tubes are not only thicker, but much more irregular in their growth, being invariably more or less flexuous, and thus more or less intertwined with one another.

Again, we have not at present any right to assume that septal spines are always present in the tubes of "*Caunopora*." The discovery of these structures in certain "*Caunoporæ*" and "*Diaporæ*" has certainly greatly lessened the difficulty of accepting *Syringopora* as the "commensal" of these fossils, but many excellently preserved specimens show no traces of these structures, and they do not seem therefore to have been uniformly present. On the other hand, all the *Syringoporæ* appear to possess septal spines in the corallites.

Lastly, there are formations or localities in which "*Caunoporæ*" and "*Diaporæ*" are very abundant, but in which no examples of *Syringopora* have ever been detected. Thus at Büchel in the Paffrath district, we find an enormous number of "*Caunoporæ*" and "*Diaporæ*," but no single example of a *Syringopora* has ever been found, though *Aulopora*-colonies are sufficiently abundant. This is true also, so far as I am aware, of another well-known German locality, viz. Gerolstein in the Eifel. It is also true, in a general way at any rate, of the Devonian Limestones of Devonshire, in which "*Caunoporæ*" are extremely abundant, while *Syringoporæ* are nearly unknown. Of course, in such cases it might be said that the reason of the absence or scarcity of *Syringoporæ* is merely that these Corals have wholly or mostly become commensals with Stromatoporoids, and have thus become "*Caunoporæ*;" but till it is proved that the "*Caunopora*-tubes" belong to *Syringopora,* this seems to me to be to some extent begging the question at issue.

It seems, at any rate, certain that if we accept *Syringopora* as the Coral which is concerned in the production of "*Caunoporæ*" and "*Diaporæ*" we must at the same time make two admissions which are attended with more or less of doubt and difficulty. In the first place, we must admit that the *Syringoporæ*, when growing commensally with Stromatoporoids, to some extent alter their normal mode of growth, in so far as to grow with much greater regularity and uniformity than they do in their free state. This admission is not of much importance, because we must make the same, on a considerably larger scale, if we suppose *Aulopora* to be the Coral concerned in the production of "*Caunoporæ*" and "*Diaporæ.*" A much more important admission is that we are compelled to suppose that many of the *Syringoporæ* which give rise to "*Caunoporæ*" belong to species which are unknown in their free state, and which never occur except when thus living commensally with some Stromatoporoid; since no known species of this genus of Corals has tubes nearly so minute as those of certain "*Caunoporæ.*" The difficulties connected with this admission are so great that at present I do not see how it is possible to accept *Syringopora* as being the genus of Corals *usually* concerned in the production of "*Caunopora*"-colonies.

(D) *Aulopora as the Commensal of Caunopora.*—As previously stated, Roemer ultimately came to the conclusion that *Aulopora*, and not *Syringopora*, was the Coral concerned in the production of "*Caunoporæ.*" If we take the thin laminar expansions of the "*Diaporæ*" and of some "*Caunoporæ*" then there is no doubt that the embedded tubes, if divested of the enveloping Stromatoporoid, would much more nearly resemble an *Aulopora*-colony than a *Syringopora.* In some very thin specimens, the embedded tubes consist of nothing except an irregular series of horizontal stolons, sending out short erect branches, which do not seem to be connected by cross-tubes. In most specimens, however, the tubes grow vertically upwards to the full thickness of the cœnosteum, and are connected by cross-tubes at varying heights, thus losing their general resemblance to *Auloporæ.* Even in the thicker examples of the laminar "*Caunoporæ*" and "*Diaporæ,*" it is, however, not unusual to find that horizontal stolons are developed at more than one level in the fossil, showing that different sets of the "*Caunopora*-tubes" succeeded each other vertically at intervals of time. As a general rule, however, the tubes are continuous in the particular types here alluded to.

The tabulæ of the "*Caunopora*-tubes," though more like those of *Syringopora* than those usual in *Aulopora*, would nevertheless answer sufficiently well to the tabulæ seen in species of the latter genus. Many *Auloporæ*, in fact, have a mixture of curved or straight tabulæ with vesicular or funnel-shaped tabulæ, such as occur so commonly in "*Caunopora*-tubes."

Moreover, when we meet, in a single locality, with examples of "*Caunopora*" and "*Diapora*," which differ from one another in the sizes of the embedded tubes, irrespective of the nature of the "ground-mass," then it is not unusual to find *free* colonies of different species of *Aulopora*, differing from one another in having differently-sized tubes, in the same locality.

One great argument, however, against accepting *Aulopora* as the commensal of "*Caunopora*" and "*Diapora*" is that though *Auloporæ* with differently-sized tubes occur in strata where the latter fossils also have tubes of different sizes, there are no known species of *Aulopora* in the Devonian Rocks which have tubes so small as those of certain *Caunoporæ* (viz. about $\frac{1}{3}$ mm. in diameter). In the case of such types, therefore, we have the same difficulty in taking *Aulopora* as the commensal of "*Caunopora*" that I have shown to exist in the case of *Syringopora*. We should have, namely, to suppose that certain of the *Auloporæ* concerned in the production of "*Caunoporæ*" and "*Diaporæ*" are types not known to exist in the free condition.

The corallites of *Aulopora* are also not known to possess any septal spines, whereas certain "*Caunopora*-tubes" undoubtedly possess these structures. Again, free colonies of *Aulopora* (*i. e.* colonies merely attached by their lower surface) do not send up straight vertical tubes such as are seen in "*Caunopora*" and "*Diapora*;" nor do the tubes, once produced, become connected by horizontal tubes or cross-branches. Lastly, colonies of *Aulopora* are very abundant in both Silurian and Devonian strata, growing on the upper or under surface of Stromatoporoids, but *not* giving rise to "*Caunoporæ*" or "*Diaporæ*."

The difficulties which attend the hypothesis that the "tubes" of even the laminar forms of "*Caunopora*" and "*Diapora*" are referable to *Aulopora*, are well exemplified by such a type as *Stromatoporella* (*Diapora*) *laminata*, Barg., which occurs in great numbers and in wonderful preservation (showing both its upper and lower surfaces in perfection) in the quarry of Büchel, in the Devonian Limestones of the Paffrath district. This interesting type forms laminar expansions, often of great size, and completely covered below with a striated epitheca, being only very rarely incrusting. The cœnosteum varies in thickness from 2—3 mm. up to 2—3 cm., according to the age of the colony. Whatever the thickness may be, the under surface shows no signs of the tubes, whereas the upper surface shows the circular apertures of the tubes distributed uniformly and at tolerably regular intervals, and having their margins just level with the last-formed layer of the Stromatoporoid (Plate X, fig. 3). Vertical sections further would show that, whether the cœnosteum be thin or thick, the tubes arise from a level a little above the epitheca, and are continued in an essentially vertical course through the whole thickness of the Stromatoporoid to terminate above in the rounded apertures on the surface. Now, it is quite clear that in this case the epitheca and the first layer of the Stromatoporoid must have existed before the "*Diapora*" tubes were produced. On the theory of commensalism, therefore, we must imagine that the Stromatoporoid after forming its original epitheca, and one or more of its first laminæ, became covered by an *Aulopora*-colony. This latter must have covered the greater part, at any rate, of the upper surface of the Stromatoporoid, and must have produced its first set of tubes with great regularity. Then, as the Stromatoporoid continued its growth by the upward extension of its pillars and by the formation of fresh laminæ, the *Aulopora* must have lengthened its tubes to a corresponding extent, the tubes growing up in a vertical direction, and always keeping pace with the Stromatoporoid, in such a way that the mouths of the tubes were always just flush with the last-formed layer of the Stromatoporoid. Moreover, every now and then horizontal stolons would be thrown out from the lips of the tubes and would become connected with the lips of neighbouring tubes. If, therefore, we removed the enveloping Stromatoporoid, and could examine the embedded tubes alone, we should find a creeping and very regularly-developed network of horizontal tubes, which at tolerably regular intervals would throw up straight vertical tubes, which would be tolerably equal in length and would be joined at different levels by a variable number of horizontal connecting-tubes. The appearances just described differ, however, to a serious extent, from anything that we know of in any species of *Aulopora* when having its normal mode of growth, and when it is attached parasitically to the exterior of any foreign organism such as a Stromatoporoid or a Coral. Under ordinary conditions, namely, an *Aulopora*-colony has a very irregular mode of growth, generally forming loose straggling networks, which throw up tubes at irregular intervals. Furthermore, the calices in such a colony are reclined; they do not show any tendency to grow up vertically; and though they may throw out creeping stolons which in turn become calices, they do not become united with one another by a system of horizontal connecting-processes.

The above-mentioned differences between an ordinary *Aulopora*-colony and the aggregate of tubes of a "*Caunopora*" or "*Diapora*" are so striking that we cannot apparently accept of *Aulopora* as being the Coral which gives rise to these latter fossils, except upon the hypothesis that when living as a commensal with certain types of Stromatoporoids, the *Aulopora* is forced to completely alter its normal mode of growth. The change in its environment caused by the commensalism must be supposed to induce the *Aulopora* to enter upon a more active and vigorous as well as a much modified mode of increase. It must be supposed to throw out tubes at much more regular and less distant intervals than it would normally do; and at the same time to abandon its natural *creeping* habit, and to send up vertical tubes which continue their growth upwards to an apparently almost indefinite extent. Moreover, instead of producing horizontal stolons at a single level only, namely, in the plane of the general creeping expansion, it must be supposed to go on producing horizontal processes or connecting-tubes at successive levels in the mass. It is, in fact, not uncommon in some types, such as *Stromatoporella* (*Diapora*) *laminata*, Barg., to find such horizontal stolons developed on the upper surface of the last-formed layer of the Stromatoporoid (Pl. X, fig. 3), in which cases the appearances produced often closely resemble those presented by an ordinary *Aulopora*-colony. Professor Ferdinand Roemer has explained the apparent continued growth upwards of the "*Caunopora*-tubes" as being perhaps due to the fact that a single "*Caunopora*" may be the result of the combined growth of one Stromatoporoid with many successive colonies of *Aulopora*. I am, however, satisfied that, in the case of most laminar examples of "*Caunopora*" at any rate, only *one Aulopora*-colony is concerned, and that the tubes which arise from the basal reticulation are continued upwards through the mass to the upper surface. I believe that this is also commonly the case in the massive examples of "*Caunopora*," though in the case of these it is difficult to prove this positively.

There are, no doubt, great difficulties in the way of accepting the view that *Auloporæ* when living commensally with Stromatoporoids so fundamentally change their natural mode of growth, as they must be supposed to do if we are to regard them as giving rise to "*Caunoporæ*" and "*Diaporæ*." Upon the whole, however, I think the difficulties in the way of this hypothesis are not so great as those are which confront us if we select *Syringopora* as the commensal of "*Caunopora*." Possibly some of these difficulties might be evaded by supposing that in some "*Caunoporæ*" and "*Diaporæ*" the tubes belong to *Aulopora*, while in others they belong to *Syringopora*. If we retain the theory of the commensalism of "*Caunopora*," but do not accept either *Aulopora* or *Syringopora* as the source of the "tubes," we are driven to the exceedingly improbable hypothesis that these structures belong to a genus of Corals, the species of which are totally unknown, save when living as commensals with certain Stromatoporoids.

I may just add here that I have found a single example of a "*Diapora*" from the Devonian Rocks of Devonshire in which the tubes resemble neither *Syringopora* nor *Aulopora*, but are more like those of the Auloporoid genus *Romingeria*, Nich. In this singular specimen, the tubes are aggregated into cylindrical bundles, which would closely resemble the stems of a slender *Pachypora*, except that they give out at intervals *detached* tubes which radiate outwards to a considerable distance from the central bundle of tubes. I shall describe and figure this specimen later on, and need not say more about it at this moment.

III. *Caunopora and Diapora as " states " of Stromatopora and Stromatoporella.*

The only other hypothesis which seems worth a moment's consideration as an alternative to the theory of commensalism, is that the ordinary " *Caunoporæ* " and " *Diaporæ* " are *states* of certain species of *Stromatopora* and *Stromatoporella.* The fact that the " *Caunopora*-tubes " are, as a rule, only found in particular species, belonging to particular genera, affords *primâ facie* ground for supposing that they belong to the species in which they are found. We have seen, however, that all the species which exhibit these tubes also exist without the tubes. It is therefore clear that if the " *Caunopora*-tubes " belong to the organism with which they are associated, they can only represent structures which are developed in certain individuals and not in others. It would therefore be a not unnatural hypothesis to suppose that the " tubes " of " *Caunopora* " and " *Diapora* " represent the cavities in which the reproductive zoöids were lodged. I was at one time strongly tempted to take this view, and there are certain facts which would go a considerable way in its support. Thus, there is an undoubted resemblance between the " *Caunopora*-tubes " and the tabulate axial tubes of *Idiostroma*, *Stachyodes*, and *Amphipora*, these structures belonging unquestionably to the organism in which they are found. Again, there is a still more striking resemblance between the tubes of " *Caunopora* " and " *Diapora* " on the one hand and the large round-mouthed tubes of *Idiostroma oculatum*, Nich., on the other hand. These resemblances do not, however, go far enough. Thus, the tabulate axial tubes of *Idiostroma* and its allies have no proper walls, and communicate freely with the cœnosarcal canals of the general skeleton. In *Idiostroma oculatum*, also, the large round-mouthed and tabulate tubes, though furnished with proper walls near their mouths, appear to lose these walls internally, and also seem to communicate freely at their bases with the interlaminar spaces of the general skeleton. Until, however, we obtain something like positive proof of the existence of a free communication between the cavities of the tubes of " *Caunopora* " and " *Diapora* " on the one hand and the cœnosarcal canals of the surrounding Stromatoporoid on the other hand, it seems impossible to accept any hypothesis which would treat these tubes as being constituent parts of the Stromatoporoid in which they are found. Moreover, it is now certain that " *Caunoporæ* " and " *Diaporæ* " are not *exclusively* referable, as regards the tissue of the enveloping Stromatoporoid, to the two genera *Stromatopora* and *Stromatoporella.* Had this held good, there would have been strong ground for regarding the embedded " *Caunopora*-tubes " as belonging to the investing Stromatoporoid. We now know, however, that species of other genera than the two first mentioned occur occasionally as " *Caunoporæ.*" Upon the whole, therefore, I think we must at present conclude that the fossils ordinarily called "*Caunoporæ*" and "*Diaporæ*" are the result of the combined growth of some Stromatoporoid with some Coral, the former usually being a species of *Stromatopora* or *Stromatoporella*, and the latter generally belonging either to *Syringopora* or to *Aulopora*. We must also conclude, however, that there are other fossils, in general aspect exceedingly similar to the ordinary "*Caunoporæ*," in which the embedded tubes really do belong to the organism in which they are found; as we have seen to be the case in *Idiostroma oculatum*. In practice, therefore, each individual specimen must, with our present knowledge, be judged on its own merits, apart from all preconceived theories. Moreover, as the "*Caunoporæ*" and "*Diaporæ*" show many points of interest which are quite independent of any hypothesis as to their actual nature, I shall, where needful, describe and figure any noticeable features in connection with the "Caunopora-state" of certain Stromatoporoids, irrespective of all theoretical views as to the precise nature of this "state."

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A MONOGRAPH

OF THE

BRITISH STROMATOPOROIDS.

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PART II.—DESCRIPTION OF SPECIES.

Pages 131—158. Plates XII—XIX.

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FAMILY—ACTINOSTROMIDÆ.

Genus 1.—ACTINOSTROMA, *Nicholson*, 1886.

(Introduction, p. 75.)

1. ACTINOSTROMA CLATHRATUM, *Nich.* Pl. I, figs. 8—13, and Pl. XII, figs. 1—5.

STROMATOPORA CONCENTRICA, *M'Coy* (?). Brit. Pal. Foss., p. 65, 1851.
— — *Bargatzky.* Die Stromatoporen des rheinischen Devons, p. 54, 1881.
— — *Frech.* Zeitschr. der deutsch. geol. Gesell., Jahrg. 1885, p. 116.
ACTINOSTROMA CLATHRATUM, *Nich.* Monogr. Brit. Strom., General Introduction, p. 76, pl. 1, figs. 8—13, 1886.
— — *Nich.* Ann. Nat. Hist., ser. 5, vol. xvii, p. 226, pl. vi, figs. 1—3, 1886.

Cœnosteum massive, usually spheroidal or globular, but very irregular in form, and sometimes attaining a large size (Plate XII, fig. 1). The base of attachment is small and the under surface is not epithecate, as a general rule. In many cases the process of growth was intermittent, and the skeleton thus comes to consist of more or less conspicuous concentric strata or "latilaminæ." The concentric laminæ are simply curved or are but slightly undulated, and the surface is, therefore, smooth and free from pointed eminences or "mamelons." In well-preserved examples the surface exhibits numerous rounded tubercles—the upper ends of the radial pillars—connected by radiating "arms," which enclose angular or rounded meshes—the apertures of the zoöidal pores. Less well-preserved specimens (Plate II, fig. 11) show simply the rounded tubercles.

Astrorhizæ may be present, in which case they are mostly quite inconspicuous, and are hardly recognisable except in thin tangential sections. In one variety astrorhizæ are comparatively numerous, and in some cases they appear to be wholly wanting.

As regards internal structure the radial pillars are "continuous," each pillar passing without interruption through several successive laminæ (Plate XII, figs. 3 and 4). On an average there are from three to four radial pillars, and the same number of interlaminar spaces in the space of 1 mm. The pillars and concentric laminæ are thus about $\frac{1}{6}$ mm. more or less apart. The radial pillars are connected by horizontal processes or "arms," which are given off with great regularity in radiating whorls, the result being the formation of an angular meshwork, which in tangential sections (Plate XII, fig. 2, and Plate XIII, fig. 1) has a close resemblance to the structure of a hexactinellid sponge. The angular pores formed in this way served for the emission of the zoöids, and definite tabulate zoöidal tubes are not present.

Obs.—Actinostroma clathratum, Nich., is of very variable outward form, and has also a wide range as regards size. Small specimens are usually globular, subglobular, or pyriform; large examples are mostly hemispherical or irregular in shape. The under surface is generally, if not always, non-epithecate, and the upper surface is destitute of "mamelons." Very generally the cœnosteum is composed of successive thick, concentric strata ("latilaminæ"); but in some instances this structure is not observable. In the former case the radial pillars are continuous from the bottom to the top of each latilamina at least. In the latter case the pillars run continuously for apparently indefinite distances.

In some specimens "astrorhizæ" cannot be detected at all, but they are by no means universally wanting in this species, as stated by Bargatzky. I have now found them to exist in many of the German specimens, and they seem to be always, or almost always, present in British specimens. In the Dartington specimens they are even numerous. Their individual development is, however, an imperfect and irregular one, and they do not appear to be usually superposed in vertical series in successive interlaminar spaces. Hence the cœnosteum is not traversed by conspicuous vertical astrorhizal canals, and, for the same reason, the surface is free from "mamelons."

The surface, in well-preserved examples, is studded with minute rounded tubercles, representing the free ends of the radial pillars (Plate II, fig. 11), and sometimes exhibits also the radiating connecting-processes between them and the intervening zoöidal pores. In some dolomitised specimens the skeletal network becomes dissolved out of the matrix towards the surface of the mass, leaving stellate or rounded pores which represent the pillars and their radiating "arms" (Plate I, fig. 5).

In spite of the great variability in external form, the *general type* of internal structure is in this species very constant. The radial pillars are stout, usually rounded, but in some forms subangular. Cross sections of the pillars usually show a minute axial canal (Plate I, figs. 10 and 13), but this cannot always be made out. The horizontal "arms" are very regularly produced, and give rise by their union to a regular "hexactinellid" network, the zoöidal pores being more or less angular in form (Plate XII, fig. 2).

On an average there are generally about three radial pillars and as many concentric laminæ in the space of a millimètre. It must be borne in mind, however, that precise measurements of this kind possess but a limited and general value, even individual specimens commonly showing more or less variability as regards the closeness of the pillars and laminæ. Moreover, specimens collected from distant localities very generally show slight but apparently constant differences in this respect.

A. clathratum is liable to considerable variation, and among the forms which I am disposed to include under this title are three recognisable types, two of which are so far distinct from one another that some palæontologists would probably consider them to be separate species.

In the first of these varietal forms—which I regard as the type of the species—the radial pillars are very regularly developed, the distances between them being approximately uniform in a given specimen (generally about $\frac{1}{5}$ or $\frac{1}{6}$ mm.). The pillars are, further, remarkably parallel to one another, making due allowance for the intercalation of new ones as the surface is approached, and in cross-sections they usually have a well-marked round shape (Plate I, figs. 11—13). Astrorhizæ may be wholly wanting, but there are usually small astrorhizæ to be detected in tangential sections, though the development of these is always feeble. This form of *A. clathratum* is the one which occurs commonly in the Middle Devonian of Germany (Gerolstein, Hebborn, &c.), and it likewise occurs in Devonshire, though it is not the most abundant form in the latter region.

In the second of the varietal forms in question, the radial pillars are comparatively irregular in their development, and vary considerably, even in the same specimen, as regards their distances apart, while they are often variously bent or sloped; and they show a want of general parallelism to each other (Plate XII, fig. 3). In transverse sections (Plate XII, fig. 2), the pillars are often more or less angular, rather than strictly round. Upon the whole, also, the pillars are mostly farther apart than in the preceding variety, being usually separated by interspaces of about $\frac{1}{3}$ or $\frac{1}{4}$ mm. Lastly, astrorhizæ are comparatively well developed, and are not only numerous but comparatively large. This form occurs commonly in the Devonian Rocks of Devonshire, being particularly abundant at Dartington. If it should be thought necessary to distinguish this variety by a special name, I should propose to call it *A. irregulare.*

Finally, there exists a third varietal form which is intermediate in its characters between the two previously described. The form in question agrees with the normal form of the species in having stout round pillars (Plate XIII, fig. 1), but it resembles the last-named variety in having the pillars irregularly developed, and incompletely parallel (Plate XIII, fig. 2). This variety occurs comparatively rarely in the Devonian Limestones of Devonshire.

As compared with the other species of the genus, *Actinostroma clathratum*, Nich., is most nearly related to *A. verrucosum*, Goldf., with which it closely agrees as regards minute structure. It is, however, readily separated by the fact that the laminæ are not flexuous, and that it is devoid of the astrorhizal cylinders and corresponding conical "mamelons," which are so characteristic of the latter species. From its next nearest ally, viz. *A. hebbornense*, Nich. (*Stromatopora astroites*, Barg.), the present species is distinguished by its much stouter pillars and generally coarser structure, and also by the fact that the latter possesses very well-developed astrorhizæ arranged in vertical groups. From *A. bifarium*, Nich., again, it is separated by the fact that the pillars are approximately uniform in size, and are not divisible into two distinct sets, as they are in the latter. None of the other species of *Actinostroma* are sufficiently near to *A. clathratum* in structure to require special mention in this connection.

It is probable that this abundant species has been often described, as *Stromatopora concentrica*, or under some other title, by previous observers. In this case, however, as in the case of many other species, it is difficult to give an extensive synonymy, as most of the older descriptions and figures of Stromatoporoids are insufficient to allow of confident identification. Even in the case of the *Stromatopora concentrica* of M'Coy, which I have placed, with some doubt, in the list of synonyms of this species, it would not be possible to arrive at complete certainty without an examination of the actual specimens which this observer had before him.

Distribution.—*Actinostroma clathratum*, so far as known to me, is exclusively confined to the Middle and Upper Devonian Rocks. In Devonshire it occurs abundantly (Dartington, Teignmouth, Plymouth). In the German Devonians it is very abundant in the Eifel (Gerolstein, Sötenich, &c.). It is also very common in the Paffrath district in certain localities (Hebborn), but is rare at others (Büchel). I have not hitherto recognised this species as occurring in the Devonian deposits of North America.

2. Actinostroma verrucosum, *Goldfuss* sp. Pl. XVI, figs, 1—8,

Ceriopora verrucosa, *Goldfuss.* Petref. Germ., p. 33, Taf. x, fig. 6, 1826.

? Alcyonium echinatum, *Steininger.* Mém. de la Soc. Géol. de France, tom. i, pl. xx, fig. 11, 1834

Stromatopora polymorpha, *D'Orbigny* (*pars*). Prodr. de Paléont., tom. i, p. 109, 1850.

— verrucosa, *Quenstedt.* Petrefaktenkunde Deutschlands, Bd. v, p. 560, Taf. cxli, fig. 10, 1878.

— — *Bargatzky.* Die Strom. des. rheinischen Devons, p. 55, 1881.

Actinostroma verrucosum, *Nich.* Ann. Nat. Hist., ser. 5, vol. xvii, p. 228, 1886.

The cœnosteum in this species is massive, spheroidal, or hemispherical, often attaining a considerable size, and having a broad base of attachment, the under surface being seemingly non-epithecate. The cœnosteum is composed of undulated and flexuous concentric laminæ, which are bent round a largely-developed series of "astrorhizal cylinders," and fill up the interspaces between these (Plate XVI, fig. 1). Each astrorhizal system consists of a vertical, wall-less, axial canal, enclosed in a sheath formed by a variable number (three to five or more) of concentrically disposed laminæ, the innermost of these being often loosely reticulate (Plate XVI, fig. 5). To the structure thus formed, the name of "astrorhizal cylinder" may be given. In its course through the cœnosteum, the axial canal of the astrorhizal cylinder gives off irregular and feebly developed radiating canals at different heights, and it ultimately terminates by an aperture on the surface, which is placed at the summit of a prominent conical "mamelon" (Plate XVI, fig. 8).

The astrorhizal cylinders radiate outwards from the base of the cœnosteum, and the surface therefore exhibits a number of pointed conical eminences (Plate XVI, fig. 4), which may be 5 to 10 mm. in width at their base, and are often 4 or 5 mm. in height. Each of these eminences or "mamelons" represents the free upper end of an astrorhizal cylinder. Tangential sections of the cœnosteum (Plate XVI, fig. 1) exhibit the transversely divided cylinders, and the flexuous concentric laminæ of the general skeleton filling up the interspaces between these. The cylinders are generally from 5 to 10 mm. in diameter, and are mostly placed about their own width apart. In well-preserved specimens, the whole surface further exhibits numerous minute rounded tubercles (Plate XVI, fig. 8), which represent the upper ends of the radial pillars.

As regards the minute structure of the cœnosteum, this species does not essentially differ from *A. clathratum*, the skeletal tissue consisting of stout radial pillars of the "continuous" type, crossed by strong concentric laminæ (Plate XVI, figs. 3 and 6). As there are no "latilaminæ," the pillars appear to run without a break for indefinite distances. There are usually about four pillars and five concentric laminæ in the space of 1 mm. The pillars are approximately equal in size, and often show a minute axial canal (Plate XVI, fig. 7). As seen in cross-sections the pillars are connected by numerous radiating "arms" (Plate XVI, figs. 2 and 5), which give rise to a hexactinellid network, and enclose angular zoöidal pores.

Obs.—It is unnecessary to enter into any discussion as to the differential characters of *A. verrucosum*, Goldf.; since, so far as I am aware, it is the only species of the genus *Actinostroma* in which the cœnosteum is built up of astrorhizal cylinders filled in by undulated, concentrically laminated tissue. A precisely similar general structure is shown by at least one species of *Clathrodictyon* (viz. *C. retiforme*, Nich. and Mur.), but in this case the skeletal tissue is of a different generic type. *A. verru-*

cosum, as regards its *minute* structure, is not separable from the normal form of *A. clathratum*. Specimens of the former are, however, readily distinguished from those of the latter by the prominent "mamelons" on the surface, while weathered or fractured surfaces at once reveal the presence of astrorhizal cylinders. The general features of *A. verrucosum* are singularly constant; but some specimens have comparatively small "mamelons."

Distribution.—*A. verrucosum* appears to be exclusively confined to the horizon of the Middle Devonian. In the Devonian Limestones of Devonshire it is a decidedly rare species, and I am only acquainted with it as occurring in the pebbles from the Triassic conglomerates of Teignmouth. In the Middle Devonian of Germany the species is comparatively abundant, occurring commonly in the Paffrath area (Büchel, Bosbach, &c.), and being less frequent at Gerolstein and Sötenich.

3. Actinostroma bifarium, *Nich.* Pl. XIII, figs. 3—7.

Actinostroma bifarium, *Nich.* Ann. Nat. Hist., ser. 5, vol. xvi, p. 231, pl. iv, figs. 4 and 5, 1886.

The cœnosteum in this species is massive, spheroidal or hemispherical in shape, and of considerable size. The base has not been observed, and the surface is also unknown. Irregular astrorhizæ are sometimes present, but they are not extensively developed and are sometimes not to be recognised at all.

As regards internal structure the radial pillars are of two sizes, large and small. The large pillars are very stout, and are much fewer in number than the small pillars, their development being irregular, so that they may be from $\frac{1}{2}$ mm. or less to more than 1 mm. apart. The small pillars are very numerous, and are set more closely together, and both sets are connected by numerous radiating "arms" (Plate XIII, fig. 6), which enclose angular zoöidal pores. The concentric laminæ are well developed, and there are from four to six interlaminar spaces in the space of one millimètre.

This well-marked species is distinguished at once from all the other recorded forms of *Actinostroma* by the possession of a series of specially large radial pillars interspersed among the ordinary pillars of the cœnosteum. As growth does not take place by well-marked "latilaminæ," the pillars are apparently continued for indefinite distances, and their development is always more or less irregular. The shape of the zoöidal pores depends upon the state of preservation of the specimen, or is really liable to variation in different individuals. Thus the zoöidal pores are usually distinctly angular, but in some cases the "arms" connecting the pillars appear to be thickened, and the intervening pores then assume a roundish shape. German specimens, so far as I have seen, always have the concentric laminæ placed at a greater distance apart than is the case with English examples (compare figs. 7 and 5 in Plate XIII), but there is no other marked difference to be noted.

Distribution.—*Actinostroma bifarium* is only known as occurring in the Middle Devonian. The species is not rare in the pebbles of Devonian Limestone in the Triassic conglomerates of Devonshire (Teignmouth, &c.). In Germany it has not hitherto been found except in the Paffrath area, occurring not very rarely at Büchel. I have figured the minute structure of the German examples, as all the British specimens which I have examined are more or less extensively affected by crystallisation, and usually somewhat distorted by pressure.

4. ACTINOSTROMA HEBBORNENSE, *Nich.* Pl. XVI, figs. 9—16.

STROMATOPORA ASTROITES, *Bargatzky.* Die Stromatoporen des rheinischen Devons, p. 56, 1881. (Non *Stromatopora astroites*, Rosen.)

ACTINOSTROMA HEBBORNENSE, *Nich.* Ann. Nat. Hist., ser. 5, vol. xvii, p. 228, pl. vii, figs. 7 and 8, 1886.

The cœnosteum in this species is massive, often of large size, and apparently non-epithecate. The skeleton is very regularly laminated, and the surfaces of the laminæ are smooth and devoid of "mamelons." The astrorhizal system is extensively developed, the laminæ showing numerous large branching astrorhizæ (Plate XVI, fig. 9), the centres of which are usually from 6 to 8 mm. apart, and which may or may not be arranged in vertical groups.

As regards the internal structure of the skeleton, the radial pillars are very slender and are straight; and as definite "latilaminæ" are not developed, they run for indefinite distances. Usually about five radial pillars occupy the space of a millimètre, but in some examples they are closer than this. The concentric laminæ are well marked, and there are generally about four (sometimes five) interlaminar spaces in one millimètre. The radial pillars give out radiating "arms" in very regular whorls, each whorl generally consisting of four or five spokes, and the union of these gives rise to a very regular angular meshwork (Plate XVI, figs. 10 and 11).

Obs.—*Actinostroma hebbornense* was identified by Bargatzky with *Actinostroma* (*Stromatopora*) *astroites*, Rosen sp.; but I have examined the original specimens of both species, and find them to be quite distinct. In its general structure *A. hebbornense* is closely related to *A. clathratum*, Nich., with which it agrees in intimate structure and also in its mode of growth. It is, however, clearly distinguished from *A. clathratum* by the much greater delicacy of its general skeletal tissue. The radial pillars are not only straight, and for the most part parallel with one another, but they are very slender. Considerable variations exist, however, in the closeness of the pillars in the specimens which I am disposed to place in this species. The connecting processes or "arms" of the pillars are also exceptionally regular in this species. The specially distinctive feature of *A. hebbornense*, however, is the unusually complete development of the astrorhizæ, as compared with the species of *Actinostroma* in general. In this respect, the species agrees with *A. astroites*, Rosen sp., from which, however, it is at once separated by its much coarser skeletal tissue, as well as by other minor characters. The only other species of *Actinostroma* with which it is necessary to compare the present species is *A. intertextum*, Nich., but the latter is readily separated by the fact that its skeletal tissue is still more delicate than in *A. hebbornense*, while the concentric laminæ are irregular and sub-vesicular, and the astrorhizæ are still more highly developed, and the general form and mode of growth are quite different.

Distribution.—So far as known, *A. hebbornense* is almost exclusively confined to the Middle Devonian, but it seems to be exceedingly local in its distribution. It occurs in great abundance in the Middle Devonian of Hebborn (Bargatzky's original locality), but I have not found it elsewhere in the Paffrath district, and I have also not clearly identified it from the Eifel. In the Middle Devonian of Devonshire it seems to be of rare occurrence, and I am only acquainted with it from the pebbles of the Triassic conglomerates of Teignmouth. The few Devonshire specimens which I have examined are all highly crystallized, and more or less distorted by pressure (Plate XVI, figs. 13—16). I have therefore figured the minute structure of unaltered German examples (Plate XVI, figs. 10—12). By the kindness of Dr. Daniel Œhlert I have been enabled to examine a specimen apparently belonging to this species from the Inferior Devonian of La Baconnière, Mayenne.

5. Actinostroma intertextum, *Nich.* Pl. XIII, figs. 8—11.

Actinostroma intertextum, *Nich.* Monogr. Brit. Stromatoporoids, p. 76, fig. 10, 1886 (figured but not described).
— — *Nich.* Ann. Nat. Hist., ser. 5, vol. xvii, p. 233, pl. vii, figs. 3—6, 1886.

The cœnosteum has the form of a laminar, more or less circular expansion (Pl. XIII, fig. 8), which may reach half a foot or more in diameter, and an inch or more in thickness, and which is covered inferiorly by a concentrically wrinkled basal epitheca. The surface is smooth or gently undulated, without "mamelons," but exhibiting fairly developed astrorhizæ, the centres of which are a centimètre or less apart. The astrorhizæ do not appear to be arranged in vertical groups, and the cœnosteum is, therefore, not traversed by vertical astrorhizal canals. The general surface is covered with exceedingly minute, close-set tubercles, representing the upper ends of the radial pillars.

As regards the internal structure of the cœnosteum, the "continuous" radial pillars are very delicate (Pl. XIII, fig. 11), and, as growth is not effected by means of "latilaminæ," they run apparently indefinite distances. About five pillars occupy the space of 1 mm. The concentric laminæ are placed about as far apart as the pillars, but instead of forming continuous lines, as seen in vertical sections, they are incomplete, and give rise to a species of loose vesicular reticulation, which is highly characteristic of the species. The connecting-processes, or "arms," given out by the pillars, are numerous, slender, and very regularly developed, and they give rise, by their union, to a close "hexactinellid" network, the meshes of which are mostly more or less triangular (Pl. XIII, fig. 10).

Obs.—*Actinostroma intertextum*, Nich., is distinguished from most of the species of *Actinostroma* by the general characters of its delicate radial pillars, the loosely reticulate structure of the concentric laminæ, and the fact that the cœnosteum has the form of a thin laminar expansion, with a basal epitheca. The species with which it is most nearly related is the *Actinostroma Schmidtii*, Rosen sp., of the Silurian Rocks of Oesel. As I have elsewhere pointed out, however ('Ann. Nat. Hist.,' ser. 5, vol. xvii, p. 233), this latter species is distinguished by the fact that its astrorhizæ are of large size, with wide and very slightly subdivided branches, and are arranged in vertical groups, each group being connected with a wide vertical or axial canal. The network formed by the union of the "arms," as seen in tangential sections, is formed of oblong or irregular, rather than angular meshes; and some of the radial pillars appear to be of decidedly larger size than the others. Lastly, the cœnosteum appears to have been massive, though the mode of growth is not perfectly known.

The ordinary British examples of *A. intertextum*, Nich., show no particular variations from the general type. Examples from the Silurian Rocks of Esthonia have the radial pillars decidedly more closely set, while the concentric laminæ are more completely developed, and are not of such a reticulate or vesicular character. They also do not exhibit the same regular "hexactinellid" network in tangential sections; though this latter feature may be only the result of imperfect preservation. I have therefore proposed (loc. cit. supra, p. 234) to indicate these differences by giving to the Russian examples the special name of *A. intertextum* var. *suevicum*.

In the Silurian and Ordovician Rocks of Britain there occur specimens of what I am inclined to regard as examples of this species in a peculiar state of preservation. The specimens in question are exceedingly ill-preserved, and thin sections have more the aspect of the genus *Clathrodictyon* than of *Actinostroma*. The radial pillars are imperfectly or not at all recognisable in vertical sections, and the hexactinellid network of well-preserved tangential sections is replaced by irregular dark dots, only visible here and there, and partially connected with one another by radiating "arms." My reasons for thinking that these may be only badly preserved examples of the present species are: firstly, that even in well-preserved specimens the radial pillars are not clearly recognisable in vertical sections if these should be at all oblique; and secondly, that unquestionable examples of this species sometimes fail to show the hexactinellid network in tangential sections in any parts of the mass which are imperfectly preserved, but show instead a granular or dotted aspect. The specimens to which I refer must, however, be studied in a more complete series than I possess before it will be possible to assert positively that they are referable to the present species.

Distribution.—All the unquestionable examples of this species which I have seen are from the Wenlock Limestone, occurring not very rarely at Ironbridge, Much Wenlock, and Dudley. The Russian variety is from the Silurian Limestones (zone of *Pentamerus esthonus*) of Kattentack, Esthonia. The doubtful specimens above alluded to occur sometimes in the Wenlock Limestone; but other similar examples have been collected by Mrs. Robert Gray in the Ordovician Rocks ("Balcletchie Conglomerate") of Balcletchie, Girvan.

6. Actinostroma stellulatum, *Nich.* Pl. XIV, figs. 1—8, and Pl. XV.

Stromatopora concentrica, *Maurer.* Die Fauna der Kalke von Waldgirmes bei Giessen, p. 108, pl. ii, figs. 12 and 13. (Non *Stromatopora concentrica*, Goldf.)

Actinostroma stellulatum, *Nich.* Ann. Nat. Hist., ser. 5, vol. xvii, p. 231, pl. vi, figs. 8 and 9.

The cœnosteum in this species is sometimes laminar, with a basal epitheca, sometimes massive. Massive specimens may be more or less spheroidal, and composed simply of concentrically disposed strata; or they may be irregular in form, and may be made up of a series of large-sized cylinders, each of which is composed of concentrically arranged layers. The surfaces of successive strata are sometimes smooth or gently undulated, but are at other times covered with low, rounded, closely-approximated prominences or "mamelons." In well-preserved specimens the free surface of the cœnosteum exhibits the radiating astrorhizal grooves, and the spaces between these are occupied by innumerable minute, rounded, or elongated granules, representing the upper ends of the radial pillars. These granules are either isolated, or may be more or less connected into sinuous groups by means of delicate connecting processes.

Astrorhizæ are invariably present, and are arranged in superposed systems, each system having a common vertical axial canal (Plate XIV, fig. 2), which may or may not open at the surface on a special eminence. In any case, the "mamelons," when present, are comparatively low and flat, and are not prominent and conical (Plate XV). The astrorhizæ are always delicate, with slender, radiating branches, which are sometimes few and comparatively simple, and sometimes numerous and much branched. In the former case the astrorhizæ are small, and their centres are placed at a distance of about 5 or 6 mm. In the latter case, they are comparatively large and their centres are from 6 to 10 mm. apart.

As regards the internal structure of the cœnosteum, the radial pillars are slender, and about six or seven occupy the space of 1 mm. The radial pillars seem to be really continued through an indefinite number of interlaminar spaces. Owing, however, to the fact that no individual pillar lies for more than a short distance in the plane of a vertical section (Plate XIV, figs. 4 and 6), it happens that the pillars only appear to run through a few interlaminar spaces before they seem to terminate. If the plane of the section happens at some point to coincide accurately with the plane of the pillars, then a single pillar may be readily traced through ten or twenty successive interlaminar spaces. If, on the other hand, the section be slightly oblique to the pillars, then these structures may appear to run only through two or three successive interlaminar spaces, or even to be confined to a single space, thus producing a likeness to the genus *Clathrodictyon*.

The concentric laminæ are well marked, about from six to eight occupying the space of 1 mm. Tangential sections (Plate XIV, figs. 3 and 5) show the radiating astrorhizal canals and the cut ends of the radial pillars. In some cases the radial pillars are connected with one another, more or less extensively, by means of numerous delicate and hair-like connecting-processes or "arms" (Plate XIV, fig. 5). In most cases, however, these connecting-processes are not visible at all in tangential sections (Plate XIV, fig. 3), or they can only be very partially detected. Hence such sections do not show the typical "hexactinellid" network characteristic of the genus *Actinostroma*, but usually closely resemble corresponding sections of the genus *Clathrodictyon*.

Obs.—*Actinostroma stellulatum*, Nich., is a very well-marked and widely distributed species. It is most nearly related to *A. hebbornense*, Nich. (=*Stromatopora astroites*, Barg.). It is, however, distinguished from this, as from all the other species of *Actinostroma*, by the fact that tangential sections do not usually show the characteristic "hexactinellid" meshwork of the genus. On the contrary, such sections resemble corresponding sections of *Clathrodictyon* in showing the detached ends of the transversely divided radial pillars, either quite separate or partially confluent into vermiculate rows. There do, however, occur specimens in which the typical "hexactinellid" structure can be detected, in parts at any rate, in tangential slices. In these cases (Plate XIV, fig. 5) the "arms" given out by the radial pillars are numerous, and almost thread-like or capillary in point of size. The general skeletal framework in the present species is decidedly closer and more dense than in *A. hebbornense* or *A. clathratum*; and a very well-marked and characteristic feature in vertical sections (Plate XIV, figs. 4 and 6) is the presence of large rounded apertures caused by the cutting across of the radiating astrorhizal tubes. These apertures are commonly distributed in irregular vertical lines which correspond with the separate astrorhizal systems. Vertical sections, also, often show the vertical wall-less canals from which spring the astrorhizæ of successive interlaminar spaces and round which the concentric laminæ are usually bent upwards (Plate XIV, fig. 2).

As regards its form and mode of growth *A. stellulatum* is very variable, but its variations may be reduced to the following three chief types:

1. The first type includes forms in which the cœnosteum grows as a larger or smaller laminar expansion of comparatively small thickness, and having a concentrically wrinkled basal epitheca. Growth by "latilaminæ" is not marked, and the surface is destitute of "mamelons." The concentric laminæ are nearly plane or only gently wavy, and are never sharply undulated. Lastly, the astrorhizæ are comparatively large, with numerous long, slender, radiating branches, and have their centres from 6 to 8 mm. or more apart. This laminar variety is common at Gees and at other localities near Gerolstein, but it is of doubtful occurrence in Devonshire.

2. The second type comprises massive forms, often of large size, more or less spheroidal or irregular in shape, and without a basal epitheca. Very commonly the cœnosteum is markedly composed of successive "latilaminæ," and the concentric laminæ are often more or less undulated. The surface is sometimes nearly smooth or gently wavy, but it is very generally covered with low, rounded "mamelons," which average 5—6 mm. apart, and mostly correspond with the axial canals of the astrorhizæ. The astrorhizæ are mostly of small size with few radiating branches, and these comparatively short. The forms of this group are extremely abundant at Gerolstein in the Eifel, and they are not very rare in Devonshire. I have figured (Plate XV) a beautiful pyriform specimen from Devonshire which Mr. Vicary was so kind as to place in my hands for examination.

3. A third well-marked group of forms comprises examples in which the cœnosteum appears in transverse sections (Plate XIV, fig. 1) as if made up of parallel cylinders, the interspaces between which are filled up by undulated laminæ. The cylinders vary from 1—6 cm. in diameter, and longitudinal sections

(Plate XIV, fig. 2) show that they are formed of laminæ which are strongly bent upwards or towards the surface, and which are somewhat wider apart than usual. On the other hand, the intervals between the cylinders are occupied by laminæ, which are sharply bent in the reverse direction, and are closer together than elsewhere. The centres of the cylinders commonly correspond with the axial canals of the astrorhizal systems, and the surface (which I have not seen) would doubtless exhibit prominent "mamelons" corresponding with these. The astrorhizæ are small, with few radiating branches, and have their centres placed 5—6 mm. apart. Intermediate forms between these and the preceding group exist, in which the undulations of the laminæ are sufficiently sharp to produce a system of parallel cylinders, but these are small and close together. The forms of this group are the commonest examples of the species in Devonshire, but I have not yet seen any from the Eifel.

As regards the synonymy of the species I am unable to identify it with certainty with any of the forms described by Bargatzky, or, indeed, with any previously described species except the one which Dr. Maurer (loc. cit. supra) regarded as being *Stromatopora concentrica*, Goldf. Dr. Maurer was good enough to send me a fragment of the type-specimen of this, and from a macroscopic examination of this I came to the conclusion that it was probably referable to *Actinostroma verrucosum*, Goldf. sp. ("Introduction," p. 26). I have, however, prepared thin sections and I now find it to belong really to the present species.

Distribution.—Actinostroma stellulatum appears to be confined to the Devonian formation and is at present only known as occurring in the Middle Devonian. In Devonshire it is by no means a rare species, occurring abundantly at Dartington and Lummaton, and more rarely in the pebbles from the Triassic conglomerates of Teignmouth. In the Eifel it is exceedingly common in the neighbourhood of Gerolstein, and it occurs also at Sötenich, but I have not hitherto recognised it in the Paffrath district.

7. Actinostroma astroites, *Rosen* sp. Pl. XVII, figs. 1—7.

Stromatopora astroites, *Rosen*. Ueber die Natur der Stromatoporen, p. 62, pl. ii, figs. 6 and 7, 1867. (Non *Stromatopora astroites*, Barg.)

Actinostroma ? astroites, *Nich*. Ann. Nat. Hist., ser. 5, vol. xvii, p. 229, pl. vi, figs. 6—7 *a*, 1886.

The cœnosteum in this species is massive, or in the form of a thick laminar expansion, and grows in successive strata, or "latilaminæ," of varying thickness.

Small specimens are often spheroidal or pyriform, and in some cases a wrinkled basal epitheca is recognisable. The concentric laminæ are sometimes nearly horizontal, sometimes simply curved to a greater or less extent, or sometimes gently undulated.

The surfaces of all the strata are covered with well-marked branching astrorhizæ (Plate XVII, fig. 1), the centres of which are placed about 10 or 12 mm. apart. The astrorhizæ do not appear to be arranged in superposed groups or systems, and the cœnosteum is therefore not traversed by wall-less vertical canals corresponding with the axes of such systems. For the same reason, the surface does not exhibit definite "mamelons," though small rounded eminences are sometimes irregularly developed.

As regards internal structure, the cœnosteum is composed of exceedingly delicate and close-set radial pillars, of which from twelve to fifteen may occupy the space of 1 mm. The radial pillars are "continuous," and they are not interrupted in their course by the concentric lines of growth which intersect the skeleton. The radial pillars (Plate XVII, fig. 4) give out exceedingly delicate horizontal connecting processes or "arms," which give rise, as seen in tangential sections (Plate XVII, figs. 2 and 5), to a correspondingly delicate "hexactinellid" structure. About twenty interlaminar spaces occupy the space of 1 mm., but the proper concentric laminæ are irregular and often more or less broken or reticulate (as they are in *A. intertextum*, Nich.).

A constant and exceedingly characteristic feature of vertical sections (Plate XVII, figs. 3, 4, and 7) is that the entire cœnosteum is divided by well-marked and quite definite concentric lines, which have nothing to do with the ordinary concentric laminæ nor with latilaminæ. These concentric "lines of growth," as they may be termed, are placed at distances of from $\frac{1}{10}$th mm. to 1 or 2 mm. apart; and they are usually arranged in groups of close-set lines separated by wider bands in which these lines are few or wanting.

Obs.—When I first fully described this remarkable species ('Ann. Nat. Hist.,' ser. 5, vol. xvii, p. 229, 1886), I was not absolutely clear as to its being truly referable to the genus *Actinostroma*. This uncertainty arose from the fact that von Rosen's original specimens, as also the majority of all specimens hitherto examined, are in such a highly crystalline condition that their minute internal structure is hardly to be deciphered. I have, however, now examined specimens, from the Silurian Rocks of Britain, in which the internal structure is very fairly preserved, and these leave no doubt as to the fact that the species, as I conjectured, is properly referable to the genus *Actinostroma*. The species of this genus, with which *A. astroites* is most nearly related in general structure, is unquestionably *A. intertextum*, Nich. The present species is, however, distinguished from this, as from all the other known forms of *Actinostroma*, by the extraordinary delicacy of its skeletal tissue, the radial pillars and concentric laminæ being so fine, and so close together, as to render their clear recognition with a hand-lens, even in well-preserved specimens, impossible. A still more characteristic feature, which separates the present form from all the other known species of the genus, is the presence of the singular concentric lines of growth above spoken of. These structures can be almost always clearly recognised in fractured surfaces or in thin vertical sections, even in the worst preserved specimens of the species, and they may be taken as diagnostic. The astrorhizæ, though sufficiently well marked on fractured surfaces, can with difficulty be recognised at all in their tangential sections, even where the state of preservation is fairly good.

I have examined a very large number of examples of this species from the Silurian Rocks of Esthonia, Gotland, and Britain, and find the majority of specimens to have undergone a kind of cystalline change, which has more or less extensively obliterated their internal structure. Tangential sections of such examples generally exhibit nothing more than a finely granular aspect, while vertical sections show a finely reticulate structure (Plate XVII, fig. 7). Vertical sections also show the concentric lines of growth, sometimes as dark lines, sometimes as light lines, and the closeness of these differs greatly in different examples. A common phenomenon in this species, though it is one by no means peculiar to it, is that the cœnosteum contains numerous embedded *Spirorbes*, usually arranged in vertical rows (Plate XVII, fig. 7).

In a few specimens the cœnosteum is traversed by minute vertical tubes, which resemble ordinary " Caunopora-tubes " in having definite walls (Plate XVII, figs. 5 and 6). These tubes differ from the structures known generally as " Caunopora-tubes " in not being connected together, so far as I have seen, by horizontal tubes. They are also peculiar in the fact that they are very variable in point of size—in the same specimen, that is to say—and they exhibit at intervals dark transverse lines, which *may* be of the nature of " tabulæ," though I do not feel clear on this point.

Another noticeable feature about *A. astroites*, Rosen sp., is that its vertical sections, especially when in poor preservation, present a singular resemblance to similar sections of certain specimens of *Stromatopora typica*, Rosen. Some examples of this latter species exhibit a peculiar structure of the skeleton-fibre—probably a sort of decomposition—in consequence of which the thick and reticulated skeleton-fibre becomes broken up into innumerable minute, dark-coloured, vertical and horizontal lines. This remarkable alteration of the skeleton-fibre from its normal porous condition is well figured by von Rosen ('Ueber die Nat. der Strom.,' pl. i, fig. 2) in a vertical section of *S. typica*. So close is the resemblance thus produced between vertical sections of *A. astroites* and corresponding sections of certain specimens of *S. typica*, that I was at first

("Introduction," p. 12) led to think that *A. astroites* would turn out to be only a highly altered condition of *S. typica*. The examination, however, of well-preserved specimens of *A. astroites* has shown that this conjecture is quite unfounded.

The Devonian Stromatoporoid described by Bargatzky as *Stromatopora astroites*, Rosen, I have previously shown to be a distinct species of *Actinostroma*, to which I have given the name of *A. hebbornense*.

Distribution.—*Actinostroma astroites* is only known as occurring in the Silurian Rocks. Von Rosen's original specimens are from Kaugatoma Pank in the Island of Oesel, and I have collected precisely similar specimens in the same formation (Upper Oesel Group) at the same locality, and also at Hoheneichen. The species also occurs at Kattentack in Esthonia, in the zone of *Pentamerus esthonus*. In the Wenlock Limestone of Wisby, in Gotland, the species seems to be not uncommon, but all the examples I have seen are highly altered. In Britain, *A. astroites* is only known as occurring in the Wenlock Limestone, and I have collected examples of it at Ironbridge and at Much Wenlock. In the latter locality it is not rare, and is often in a state of excellent preservation.

8. Actinostroma fenestratum, n. sp. Pl. XVII, figs. 8 and 9.

The cœnosteum in this species is apparently massive, but the mode of growth, general form, and superficial characters are entirely unknown. Well developed astrorhizæ are sometimes present, but in other examples do not appear to be developed, or, at any rate, are not conspicuous.

As regards internal structure, the cœnosteum is composed of remarkably stout and strong radial pillars, which appear to run without a break for indefinite distances. About three pillars occupy the space of 1 mm. Not only are the pillars exceptionally thick, but they generally show large axial canals traversing their substance, these canals appearing as dark dots (Plate XVII, fig. 8) or as clear spaces, in tangential sections. The concentric laminæ are thick, and somewhat irregularly developed, about four interlaminar spaces occupying the space of 1 mm. The connecting-processes or "arms" given out by the pillars are stout and few in number, and the "hexactinellid" network shown by tangential sections (Plate XVII, fig. 8) is, therefore, coarse and irregular.

Obs.—The few examples of this species which I have examined are all from the pebbles of Devonian Limestone in the Triassic conglomerates of South Devon, and are all comparatively small. I am, therefore, unable to give any particulars as to the general form and mode of growth of the species. Moreover, they have all undergone extensive crystallisation and distortion by pressure, so that their internal structure cannot be satisfactorily studied in thin sections. In spite of these drawbacks, I think there is no reason to doubt that the present form is a perfectly distinct species. In its general structure it does not differ essentially from *A. clathratum*, Nich., but it is at once separated from this, as from all other recorded species of the genus *Actinostroma*, by the remarkable thickness of the radial pillars and the general coarseness of the skeletal framework. Its general aspect is exceedingly similar to that of the form described by Dr. Maurer from the Devonian Rocks of Giessen, under the name of *Stromatopora turgidecolumnata* ('Fauna der Kalke von Waldgirmes,' p. 112, Taf. iii, fig. 4). Dr. Maurer was, however, good enough to send me a minute fragment of this species, and so far as I can judge from this— which is unfortunately in a very bad state of preservation —I am disposed to think it is a true *Stromatopora*, with a porous skeleton-fibre, allied to, or identical with, *Stromatopora Beuthii*, Barg. In the meanwhile, therefore, I have thought it safest to describe the present species—which is unquestionably referable to the genus *Actinostroma*—as distinct.

Distribution.—Rare in the pebbles of Devonian Limestone in the Triassic Conglomerates of Teignmouth.

Genus 2.—Clathrodictyon, *Nicholson* and *Murie*, 1878.

(Introduction, p. 77.)

9. Clathrodictyon vesiculosum, *Nich.* and *Mur.* Pl. XVII, figs. 10—13, and Pl. XVIII, fig. 12.

? Stromatopora striatella, *M'Coy.* Brit. Pal. Foss., p. 12, 1851. (Non *Stromatopora striatella*, D'Orb.)
Clathrodictyon vesiculosum, *Nich.* and *Mur.* Journ. Linn. Soc. Zool., vol. xiv, p. 220, pl. ii, figs. 11—13, 1878.
— — *Nich.* and *R. Eth., jun.* Mon. Sil. Foss. Girvan, p. 238, pl. xix, fig. 2, 1880.
Stromatopora minuta, *Rominger.* Proc. Acad. Nat. Sci. Phil., p. 49, 1886.
Clathrodictyon vesiculosum, *Nich.* Ann. Nat. Hist., ser. 5, vol. xix, p. 1, pl. i, figs. 1—3, 1887.

The cœnosteum in this species is in the form of a laminar expansion, having the lower surface covered with a concentrically striated or wrinkled epitheca (Plate XVIII, fig. 12), and attached at one point to some foreign body. Adult specimens grow to a size of half a foot or more in diameter, with a thickness in the centre of an inch or more. The upper surface is irregularly undulating, without "mamelons," and exfoliating concentrically round the elevated points. Small, but well-developed astrorhizæ, the centres of which are from 3 to 5 mm. apart, are present; but the central canals of these do not open on the surface by prominent apertures.

As regards internal structure, the cœnosteum is made up of closely concentric laminæ, which are only slightly or not at all undulated, and of which from nine to eleven in general occupy the space of 1 mm. The laminæ are minutely crumpled, so as to give rise to more or less perfect radial pillars; but these structures are invariably confined to their respective interlaminar spaces, and are, therefore, not "continuous." In this way the interlaminar spaces become broken up into minute, often imperfect, lenticular cells (Plate XVII, figs. 10 and 12), which are formed by the curved inflections of the concentric laminæ conjoined with the more or less incomplete radial pillars. In general from eight to ten interlaminar spaces occupy the space of 1 mm. The cells formed by the radial pillars or by the bendings of the laminæ are very variable in size, but are mostly from $\frac{1}{8}$ to $\frac{1}{10}$ mm. in length.

Obs.—C. vesiculosum is the type-species of the genus *Clathrodictyon*, Nich. and Mur. As in all the species of the genus, therefore, the radial elements of the skeleton are incompletely developed, and never extend from one interlaminar space into adjoining ones. While the radial pillars are thus imperfect, the concentric laminæ of the cœnosteum are minutely undulated, and the interlaminar spaces thus become broken up and subdivided into vesicles, the size and shape of which are exceedingly variable. Hence vertical sections of *C. vesiculosum* (Plate XVII, figs. 10 and 12) show a minutely vesicular structure, the cœnosteum appearing to be made up of exceedingly small lenticular cells, arranged in horizontal or slightly curved rows. On the other hand, tangential sections (Plate XVII, figs. 11 and 13) show the cut ends of the isolated and imperfect radial pillars, together with the irregularly divided edges of the concentric laminæ. The radial pillars, as seen in tangential sections, show no traces of radiating "arms" or connecting-processes, but they may sometimes become conjoined in short vermiculate rows. Small astrorhizæ are seen in tangential sections, and these usually are arranged in vertical groups, and have wall-less axial canals, but the openings of the latter on the surface are not prominently elevated.

C. vesiculosum, Nich. and Mur., belongs to a series of forms, the specific determination of which is exceptionally difficult. The forms in question, viz. *C. vesiculosum*, Nich. and Mur., *C. variolare*, Rosen sp., *C. Linnarssoni*, Nich., and *C. crassum*, Nich., are all easily recognised as distinct when typical examples are selected for examination. It is, therefore, expedient to distinguish them by separate specific names. At the same time, there are close relationships between all these forms, and examples are not uncommon which show intermediate or transitional characters, and which, therefore, it is difficult to refer definitely to any one of the four. In a less striking form, a passage may also be traced between this group of types and *C. fastigiatum*, Nich.

From all of the allied forms above mentioned *C. vesiculosum* is best distinguished by the extreme closeness with which the concentric laminæ are set, and the resulting minuteness of the cells which compose the cœnosteum. Not only are the laminæ exceedingly close, but the interlaminar spaces are nearly equal in width, and the cellular tissue of the skeleton is thus approximately uniform. On the other hand, in typical examples of *C. variolare*, Rosen sp., the interlaminar spaces are unequal in size—wide spaces alternating tolerably regularly with spaces which are much narrower than the average, and which are usually arranged in groups (Plate XVIII, fig. 1). Trivial as this difference is, it is one which gives a very different aspect to vertical sections of these two forms. In other examples of *C. variolare*, in which this alternation of wide and narrow interlaminar spaces is not so marked, all the interlaminar spaces are wider and the cellular structure is coarser than in the present species. In *C. Linnarssoni*, Nich., again, the concentric laminæ are much less crumpled and the cells of the interlaminar spaces are, therefore, much more nearly quadrangular than is the case in *C. vesiculosum*. The form which I have named *C. crassum* is sufficiently distinguished from the present species—when characteristic examples of the two are compared with one another—by the comparatively small number of concentric laminæ in a given space, and by the much thicker and coarser structure of the skeleton-fibre. Lastly, *C. fastigiatum*, Nich., is in general readily separated from *C. vesiculosum* by the much greater width of the interlaminar spaces and the chevron-like foldings of the concentric laminæ.

Distribution.—*Clathrodictyon vesiculosum*, so far as known, is exclusively confined to the Silurian Rocks, and is especially characteristic of the lower portion of the Silurian (May Hill and Wenlock zones). In strata of this age the species has, in fact, an extraordinarily wide range. In England *C. vesiculosum* is of comparatively common occurrence in the Wenlock Limestone, and I have collected examples of it at Much Wenlock, Dudley, Ironbridge, and Dormington. In Scotland it has been collected by Mrs. Robert Gray in the Silurian Rocks (Woodland-beds) of Woodland Point, near Girvan. In North America the species seems to be abundant in the Clinton and Niagara formations, and I have personally collected examples in the Clinton-beds of Yellowsprings, Ohio, and the Niagara Limestone of Canada (Thorold). By the kindness of Mr. Whiteaves I have also recently had submitted to me examples of this species collected by the Geological Survey of Canada in the Clinton formation of Anticosti (Junction Cliff and west side of Gamache Bay). I have, further, collected examples of this species in the

Silurian Limestones of Esthonia, in the "*Zone of Pentamerus esthonus*" at Kattentack, and in the "Raiküll-beds" at Raiküll. The prevailing species of *Clathrodictyon* in the Silurian Rocks of Esthonia is, however, not the present form, but *C. variolare*, Rosen, and I have not seen any examples of this species from Gotland though I entertain no doubt of its occurrence there.

10. Clathrodictyon variolare, *Rosen* sp. Pl. XVIII, figs. 1—5, and Pl. XVII, fig. 14.

Stromatopora variolaris, *von Rosen*. Ueber die Natur der Stromatoporen, p. 61, pl. ii, figs. 2—5, 1867.
Clathrodictyon variolare, *Nicholson*. Ann. Nat. Hist., ser. 5, vol. xix, p. 4, pl. i, figs. 4—6, 1887.

The cœnosteum in this species is laminar, hemispherical or massive, with a concentrically wrinkled basal epitheca, and often attaining a large size. The surface may be smooth, or may exhibit numerous "mamelons," which are sometimes small and pointed, or, more commonly, low and rounded (Plate. XVII, fig. 14). There are numerous astrorhizæ, but these are small in point of size, and do not appear to correspond in any special way with the surface-eminences or "mamelons," when these latter structures are present. Generally, the astrorhizæ are arranged in vertical groups or systems, each group having a wall-less axial canal, but this arrangement does not appear to be constant.

The internal structure of *C. variolare* is very similar to that of *C. vesiculosum*, the skeleton being composed of close-set concentric laminæ, which are horizontal, or, more usually, gently undulated, and are minutely crumpled, so as to give rise, along with the incomplete radial pillars, to a fine vesicular tissue. From eight to ten laminæ occupy the space of 1 mm.; but the interlaminar spaces are of unequal size, rows of large vesicles alternating with rows of much smaller cells (Plate XVIII, figs. 1 and 3). As a rule, rows of large vesicles are separated by from one to three rows of much more minute vesicles; but there may be only a single row of the latter or they may even be wanting in places. Tangential sections (Plate XVIII, figs. 2 and 5) show the cut ends of the irregular radial pillars and the divided edges of the crumpled laminæ, but show no characteristic features. The radial pillars, especially in the rows of large cells, are very commonly imperfect, thus allowing contiguous cells to communicate freely with one another.

Obs.—*Clathrodictyon variolare*, Rosen sp., is very closely allied to *C. vesiculosum*, Nich. and Mur., on the one hand, and to *C. crassum*, Nich., on the other; and it is connected with both of these species by transitional forms. The character which most decisively separates it from *C. vesiculosum* is the alternation of rows of large cells with wider or narrower zones of exceedingly minute vesicles. In other respects the two forms stand very close to one another. Some of the British specimens are absolutely typical, and differ in no respect from the ordinary Russian examples of the species. Other British specimens which I regard as referable to this species show a marked diminution in the rows of small vesicles which normally separate the rows of large cells. In such cases (Plate XVIII, fig. 4) the vertical section of the cœnosteum shows only rows of comparatively large-sized cells with few or no rows of small vesicles. Such examples show an approximation to the type of *C. crassum*, Nich., this being further accentuated by the fact that the skeleton-fibre is decidedly coarser in these cases than it is in thoroughly typical specimens of *C. variolare*. The only other species of the genus with which the present form could well be confounded is *C. Linnarssoni*, Nich. In this latter species, however, the concentric laminæ are not crumpled, and as a result of this the interlaminar vesicles are quadrangular rather than lenticular in form, while the interlaminar spaces are approximately uniform in width.

Distribution.—*C. variolare* has not hitherto been detected out of the Silurian Rocks in Britain; but it occurs in the Ordovician (Borckholm'sche Schichten) at Borckholm and Worms in Esthonia. With this exception its vertical range seems to be much the same as that of the preceding species. I have not, however, met with any examples of it in the Clinton and Niagara formations of North America, where *C. vesiculosum* is very abundant. Von Rosen's type-specimen of *C. variolare* (which I have examined) is from Errinal in Esthonia. I have also collected the species abundantly in the "zone of *Pentamerus esthonus*" at Kattentack in Esthonia, and elsewhere in the same region. In Britain the species is by no means uncommon in the Wenlock Limestone, and I have collected examples of it at Ironbridge, Dormington, and Much Wenlock.

11. Clathrodictyon crassum, *Nich.* Pl. XVIII, figs. 6 and 7.

Clathrodictyon crassum, *Nicholson.* Ann. Nat. Hist., ser. 5, vol. xix, p. 8, pl ii, figs. 1 and 2, 1887.

The cœnosteum in this species is in the form of a thin laminar expansion (about a centimètre or thereabouts in thickness) and of small size. The under side is covered with a concentrically wrinkled epitheca. The upper surface is studded with vermiculate tubercles, and exhibits well-marked branching astrorhizal canals.

No "mamelons" are present, though the astrorhizæ are often superposed in vertical systems.

As regards internal structure, the cœnosteum is seen in vertical sections (Plate XVIII, fig. 6) to be composed of nearly horizontal or gently bent concentric laminæ, of which five or six occupy the space of 1 mm. The laminæ are minutely inflected and become blended with the thick radial pillars, by which the interlaminar spaces are divided into irregularly-sized, oval, or rounded cells. In tangential sections (Plate XVIII, fig. 6) the divided edges of the interlaminar cells and the cut ends of the radial pillars form a coarse and loose reticulation in which the ends of the pillars are seen as dark dots or granules. Such sections also show numerous large-sized branching astrorhizal canals. The skeleton-fibre is of unusual thickness, and the width of the interlaminar spaces is therefore proportionately reduced as compared with the width of the concentric laminæ.

Obs.—Clathrodictyon crassum is most nearly related to *C. variolare*, Rosen, and, as before mentioned, some examples of the latter make a decided approach to the present species. Typical examples of these two species cannot, however, possibly be confounded with one another. As regards its general characters *C. crassum*, Nich., is sufficiently distinguished by its constantly small size and the fact that it grows in thin laminæ. The coarse tuberculation of the surface and the comparatively large development of the astrorhizæ are also good distinctive characters. The characteristic features of the internal structure are the excessive thickness of the skeleton-fibre, the complete reticulation of the laminæ and radial pillars, and the peculiar coarse granular reticulation presented by tangential sections. The largest specimen I have seen had a long diameter of about 8 cm., and a thickness in the centre of rather more than 1 cm.

Description.—C. crassum is only known as occurring in the Wenlock Limestone of Britain, in which it is a rare form. I have collected examples at Ironbridge and Dormington, and Mr. William Madeley, to whom I am indebted for much friendly assistance, has been good enough to give me a specimen from Dudley.

12. Clathrodictyon fastigiatum, *Nich.* Pl. XIX, figs. 1—5.

Clathrodictyon fastigiatum, *Nicholson.* Introduction, p. 43, fig. 3 (figure only), 1886.

— — *Nicholson.* Ann. Nat. Hist., ser. 5, vol. xix, p. 8, pl. ii, figs. 3 and 4, 1887.

The cœnosteum in this species is laminar and cake-like, of variable size, but of small thickness, full-grown examples having a diameter of 15 cm. or more, with a thickness in the centre of from 2 to 3 cm. The under surface (Plate XIX, fig. 2) is covered with a concentrically-wrinkled epitheca. The superior side of the cœnosteum is flat, or slightly undulated (Plate XIX, fig. 1), but is quite free from "mamelons." The surface exhibits, when well preserved, numerous vermiculate and inosculating ridges formed by rows of elongated tubercles (Plate XIX, fig. 3). Small and remote astrorhizæ may sometimes be recognised in thin sections; but their development is imperfect, and I have not detected their presence on the free surface.

As regards its internal structure, the cœnosteum is composed of bent and crumpled concentric laminæ, of which about five (or four interlaminar spaces) usually occupy the space of 1 mm. As shown by vertical sections (Plate XIX, fig. 5) the laminæ are bent in two ways. In the first place they are bent into numerous chevron-like foldings, no traces of which appear on the surface of the cœnosteum. In the second place each lamina is minutely crumpled or inflected in such a way that the interlaminar spaces are constricted into rows of very imperfect and more or less open vesicles. The radial pillars are developed from the point of inflection of the laminæ, but are thin and largely imperfect. Hence, in vertical sections, the bent and crumpled laminæ are far more conspicuous than the radial pillars. Tangential sections (Plate XIX, fig. 4) exhibit the irregularly sinuous and vermiculate edges of the transversely-divided and folded laminæ, the cut ends of the radial pillars appearing in these as dark rounded dots. Occasionally we may also recognise in tangential sections scattered points round which rows of dots are disposed in a radiating manner. Such points represent the centres of small astrorhizæ.

Obs.—*C. fastigiatum* has certain relationships with *C. variolare*, Rosen sp., and specimens occasionally occur which present a mixture of the characters of the two forms. In typical examples, however, the present beautiful species cannot readily be confounded with any other known member of the genus *Clathrodictyon*. It is distinguished from its nearest allies (viz. *C. variolare*, Rosen, and *C. vesiculosum*, Nich. and Mur.) by the greater remoteness of the concentric laminæ, and by the peculiar and constant chevron-like and angular folds into which the laminæ are thrown. The appearances presented by tangential sections are also exceedingly characteristic, and quite unlike those seen in any other species of *Clathrodictyon* with which I am acquainted. The very imperfect development of the astrorhizæ is also a point in which the present species is separated from the forms above alluded to. Lastly, as far as I have seen, the cœnosteum of *C. fastigiatum* always has the form of a thin, cake-like expansion, with a concentrically wrinkled epitheca below.

Distribution.—*C. fastigiatum* occurs abundantly in the Wenlock Limestone of Britain, and I have specimens of it from Ironbridge, Dudley, Much Wenlock, and

Dormington. I have also collected examples of this species in the Silurian ("zone of *Pentamerus esthonus*") of Kattentack, Esthonia. By the kindness of Mr. Whiteaves, I have also been enabled to examine specimens of this species belonging to the collection of the Geological Survey of Canada. The specimens in question are from Glenelg Township, near Durham, Ontario, and occur in a Magnesian Limestone belonging to the Guelph formation.

13. Clathrodictyon confertum, n. sp. Pl. XVIII, figs. 13 and 14.

Cœnosteum massive; the base, surface, and mode of growth unknown. The growth is by means of "latilaminæ," each of which is composed of excessively close-set concentric laminæ, which are so inflected as to form with the radial pillars an exceedingly fine vesicular tissue (Plate XVIII, fig. 13). The concentric laminæ seem to be incompletely developed, and tangential sections show simply a minute reticulation, interspersed with minute dark dots and lines (Plate XVIII, fig. 14). Astrorhizæ appear to be wanting.

I have hesitated greatly in founding a distinct species for this form, as I have only a single incomplete example of it, which I owe to the kindness of my friend the late Mr. Champernowne, and its state of preservation is exceedingly poor. In spite of this, there seems to be no reason to doubt that we have to deal with a species of *Clathrodictyon*, of the type of *C. vesiculosum* and *C. variolare*; and a special interest thus attaches to the specimen, as no other example of a *Clathrodictyon*[1] of this type has hitherto been detected in the Devonian Rocks in Britain. In its general aspect this form approaches in fact very closely to *C. vesiculosum*, but its skeletal tissue is even finer than in the latter. Vertical sections, indeed, show simply a congeries of excessively small cells arranged obscurely in lines, and disposed in successive strata or "latilaminæ" of a millimètre in thickness, or thereabouts (Plate XVIII, fig. 13). Owing partly to its fineness, and partly to its very poor state of preservation, I have found it impossible to make reliable measurements of the number of interlaminar spaces in a given space. Moreover, the concentric laminæ do not seem to be so well developed as in *C. vesiculosum*, and the general structure is therefore more thoroughly vesicular than is the case in the latter species. The same feature is observable in tangential sections. Another character which distinguishes it from *C. vesiculosum* is the apparent absence of

[1] Among some fossils submitted to me for examination from the Devonian Rocks of France by Dr. Daniel Œhlert, I find more than one form of *Clathrodictyon*. One of these approaches very close to *C. vesiculosum*, Nich. and Mur., which is so characteristic a type in the Silurian Rocks. The specimen in question is found in the Devonian deposits of St. Jean, Laval, Mayenne.

astrorhizæ. Lastly, though the fragmentary nature of my material precludes my forming a clear notion as to the mode of growth of the species, the cœnosteum may be stated with certainty to be massive and not laminar.

Distribution.—The only known example of this form was collected by Mr. Champernowne in the Middle Devonian Limestones of Pit Park Quarry, Dartington, South Devon.

14. Clathrodictyon regulare, *Rosen* sp. Pl. XVIII, figs. 8—11*a*.

Stromatopora regularis, *von Rosen*. Ueber die Natur der Stromatoporen, p. 74, pl. ix, figs. 1—4, 1887.
Clathrodictyon regulare, *Nicholson*. Ann. Nat. Hist., ser. 5, vol. xix, p. 10, pl. ii, figs. 5 and 6, 1887.

The cœnosteum in this species is of small size; sometimes laminar and discoidal, with a basal epitheca, sometimes encrusting foreign bodies. The largest specimen examined is less than 5 cm. in diameter, with a maximum thickness of little more than a centimètre. As the concentric laminæ are nearly horizontal, or only slightly undulated, the surface is smooth, and "mamelons" are absent. The surface, however, often exhibits the edges of the exfoliated laminæ (Plate XVIII, fig. 8); and in well-preserved examples (fig. 9) it is seen to be studded with small rounded tubercles representing the free ends of the radial pillars, which often send out radiating horizontal prolongations, enclosing minute interstitial pores.

As regards internal structure, the skeleton is made up of horizontal or slightly flexuous concentric laminæ, of which about six (or five interlaminar spaces) occupy the space of 1 mm. The laminæ (Plate XVIII, figs. 10 and 10 *a*) are thick, often traversed horizontally by a median dark line and slightly crumpled. At each point of inflection the lamina sends down from its under surface a stout radial pillar, which may only project a short way downwards into the interlaminar space, but more commonly becomes connected with the lamina next below. The interlaminar spaces thus become broken up into rows of regular oblong cells, which are upon the whole slightly convex on their superior aspect, and which, though very variable in this respect, are mostly about one-third of a millimètre in length. Tangential sections (Plate XVIII, figs. 11, 11 *a*) exhibit large dark rounded dots, representing the cut ends of the radial pillars. These are often connected together by distinct radiating "arms," thus showing an imperfect form of the "hexactinellid" structure so characteristic of the species of the genus *Actinostroma*. Astrorhizæ do not appear to be developed at all.

Obs.—*Clathrodictyon regulare*, Rosen sp., is readily recognised by its slightly inflected, thick laminæ, its stout radial pillars, the oblong, superiorly convex form of the very regularly disposed interlaminar cells (as seen in vertical sections), and the presence of a limited number of radiating "arms" connecting the radial pillars. In its general characters, both external and internal, it most nearly resembles *C. striatellum*, D'Orb, sp., with which alone it could possibly be confounded. It is, however, an altogether smaller form; its skeletal tissue is much finer, and the form of the radial pillars and interlaminar cells is quite different.

Distribution.—This species is of rare occurrence in the Wenlock Limestone of Britain, and I have not seen any specimens from any locality except Dudley. It occurs also in the Wenlock Limestone of Wisby, Gotland. Von Rosen's original specimen (which I have examined) is from the Silurian ("zone of *Pentamerus esthonus*") of Kleine-Ruhde, Esthonia.

15. Clathrodictyon striatellum, *D'Orb.* sp. Pl. I, fig. 1; Pl. V, fig. 3, and Pl. XIX, figs. 6—12.

Stromatopora concentrica, *Lonsdale.* Silurian System, p. 680, pl. xv, fig. 31, 1839.
— striatella, *D'Orbigny.* Prodrome de Paléontologie, t. i, p. 51, 1850.
— mammillata, *Fr. Schmidt.* Sil. Form. von Ehstland, p. 232, 1858.
— — *von Rosen.* Ueber die Natur der Stromatoporen, p. 71, pl. viii, figs. 1—5, 1867.
— — *Ferd. Roemer.* Lethæa Palæozoica, part 1, p. 531, fig. 125, 1883.
Clathrodictyon striatellum, *Nicholson.* Ann. Nat. Hist., ser. 5, vol. xix, p. 6, pl. i, figs. 9 and 10, 1887.

The cœnosteum in this species is mostly laminar or hemispherical, with a concentrically wrinkled epitheca. The surface is more or less undulated, but without definite eminences or "mamelons," the concentric laminæ usually exfoliating concentrically round elevated points (Plate XIX, fig. 6). In well-preserved examples, the surface shows innumerable minute rounded tubercles, between which are small circular or oval pores (Plate XIX, fig. 7). Astrorhizæ are apparently wanting.

As regards internal structure, vertical sections (Plate XIX, fig. 8) show that the concentric laminæ are comparatively remote, about four interlaminar spaces, and therefore five laminæ, occupying the space of 1 mm.; but the interlaminar spaces are wider over the convexities of the undulated laminæ. The concentric laminæ are thrown into successive undulations, which are more pronounced in some specimens than in others, but are always gentle and regularly curved. The laminæ are also regularly crumpled in the same manner as in *C. vesiculosum*, but less completely, so that there is no appearance in vertical sections of rows of lenticular vesicles, such as are so characteristic of the latter species. Each infolding of the lamina is, however, prolonged *downwards*[1] into the interlaminar space below in the form of a more or less complete radial pillar. Some of the radial pillars are quite short, others project about half-way into the interlaminar space; others cross the space and become connected with the lamina below; finally, a few spring from the *upper* sides of the laminæ. A further very characteristic point about the radial pillars is that they are very commonly double at their bases, where they spring from their producing lamina.

Tangential sections (Plate XIX, fig. 9) of this species are much more characteristic than is usual in the genus *Clathrodictyon*. Where such a section traverses an interlaminar space, the cut ends of the radial pillars are seen in the form of dark granular masses, of considerable size, and usually of a more or less elongated or oval shape. Where the section more or less closely coincides with a concentric lamina, the cut ends of the radial pillars are more closely set and larger in size, and often form a sort of mosaic pavement, or at other times a loose reticulation. Tangential sections are also unlike similar sections of most species of this genus in the apparent absence of astrorhizal canals.

Obs.—In its general features *Clathrodictyon striatellum* can hardly be confounded with any other member of the genus. In external and superficial characters it makes a close approach to *C. regulare*, Rosen but its size is usually much greater, its general texture is coarser, and its internal structure is quite different. Its most distinctive characters are the gentle and regular undulation of the concentric laminæ, and the peculiar form of the radial pillars which spring, very commonly by a double base, from the under sides of the laminæ, and often fall short of the upper surface of the lamina next below. The exposed surfaces of the concentric laminæ in well-preserved examples show, much more clearly than is usual in the genus, the presence of innumerable zoöidal pores. The radial pillars produce no connecting-processes or "arms;" whereas these structures are occasionally developed in *C. regulare*. Lastly, the present form shows a more complete absence of the astrorhizal system—so far as my observation goes—than is the case in any related form of *Clathrodictyon*.

My identification of this form as the one which D'Orbigny had in view in establishing his *Stromatopora striatella* is based upon an examination of Lonsdale's original specimen, which served as the type of the species to the French palæonto-

[1] In the illustrations which I formerly gave of vertical sections of this species (Pl. I, fig. 1, and Pl. V, fig. 3), the figures were inadvertently reversed in position, so that the radial pillars are represented as growing from the *upper* sides of the laminæ, instead of from the lower as is really the case.

logist, and which is now in the British Museum. My identification of *Stromatopora mammillata*, Fr. Schmidt, with D'Orbigny's species, is based upon specimens of the former kindly given me by Magister Schmidt himself. I have figured a portion of the surface, and also tangential and vertical sections of one of these specimens (Plate XIX, figs. 10—12). These will show that there exists no substantial difference between the Russian and the British specimens, which I have here included in the present species. Any apparent differences which are present may probably be accounted for by the fact that the Esthonian specimens are silicified, and have therefore undergone considerable alteration.

Distribution.—*Clathrodictyon striatellum*, D'Orb., occurs in the Ordovician Rocks of Esthonia (in the "Borkholm'sche Schichten"); but elsewhere it is only known as a Silurian species. It is common in the Wenlock Limestone of Britain (Dudley, Ironbridge, Dormington, &c.), and it is also found in the Wenlock Limestone of Wisby, Gotland.

Family—LABECHIIDÆ.

Genus 1.—Labechia, *Edwards and Haime*, 1851.

(Introduction, p. 81.)

1. Labechia conferta, *Lonsd.* sp. Pl. III, figs. 7—15, and Pl. XX, figs. 1 and 2.

Monticularia conferta, *Lonsdale.* In Murchison, Silurian System, p. 688, pl. xvi, fig. 5, 1839.
Labechia — *Milne-Edwards* and *Haime.* Polypiers foss. des Terr. Pal., p. 280, 1851.
— — — Brit. Foss. Corals, p. 269, pl. lxii, figs. 6, 6 *c*, 1855.
— — *Nicholson.* Ann. and Mag. Nat. Hist., ser. 5, vol. xviii, p. 11, 1886.

Cœnosteum usually in the form of a laminar expansion of variable thickness, attached by a basal peduncle, and having the rest of the lower surface covered by a concentrically wrinkled epitheca (Plate III, figs. 7 and 8). Upper surface without monticules, covered with prominent, rounded or elongated, often conical tubercles, the apices of which may be imperforate, or which exhibit a minute circular summit-aperture. Often the tubercles become coalescent to a greater or less extent, and give rise to vermiculate ridges (Plate III, fig. 13). The surface between the tubercles is smooth, and no astrorhizal grooves are developed.

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A MONOGRAPH

OF THE

BRITISH STROMATOPOROIDS.

BY

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PART III.—DESCRIPTION OF SPECIES.

Pages 159—202; Plates XX—XXV.

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In internal structure the cœnosteum consists of stout, circular or oval, radial pillars, which have a diameter of $\frac{1}{4}$ to $\frac{1}{3}$ mm., and terminate upwards in pointed extremities, each being traversed by a central canal. The pillars give rise to radiating "arms" or plates, which unite with one another in such a manner that the entire space between the pillars becomes filled with a tissue of calcareous vesicles, the convexities of which are directed upwards.

Obs.—This well-known species occurs typically in the form of laminar expansions, with an epithecate base and peduncle of attachment; but in some instances an encrusting habit of growth is observable. Young examples (Plate III, figs. 9 and 10) may be only 2 or 3 cm. in diameter and 1 mm. in thickness; but old specimens may be of greater size, perhaps a foot in diameter, and may reach a thickness of 2—3 cm. A single specimen often consists of two or more superposed colonies. The surface differs from that of many Stromatoporoids in the complete absence of "mamelons" and of any indications of an astrorhizal system, though studded throughout with prominent tubercles, which may be about $\frac{1}{3}$ mm. in height, and about the same diameter at their base. The tubercles may be placed about $\frac{1}{3}$ to $\frac{1}{4}$ mm. apart, or may be in contact, often coalescing in sinuous rows. The apices of the tubercles may be simply rounded or pointed, and may be apparently imperforate. In other cases a distinct circular aperture may be detected at the apex of a pillar, though it is not clear that this is not the result of weathering.

Vertical sections (Plate XX, fig. 1; and Fig. 18, B) show that the cœnosteum

Fig. 18.

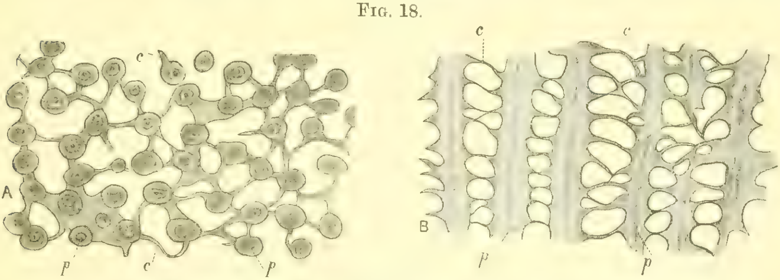


Fig. 18.—Sections of *Labechia conferta,* Lonsd. sp., enlarged twelve times. Wenlock Limestone, Ironbridge. A. Tangential section. B. Vertical section. *p p.* Radial pillars. *c c.* Connecting-processes or "arms."

is essentially composed of very stout radial pillars which spring from the basal epitheca and are continued to the upper surface, where they terminate in the prominent tubercles above spoken of. The interspaces between the pillars are occupied by a vesicular tissue formed by the coalescence of connecting-processes or "arms," given out from the pillars, the convexities of the vesicles being turned towards the upper surface.

Tangential sections (Plate XX, fig. 2; and Fig. 18, A) show that the radial pillars are hollow, each being traversed by a well-marked axial canal. The tissue forming the periphery of the pillars (Plate XX, fig. 3) is composed of very delicate laminæ, which surround the axial canal concentrically, and which often show a minute cribriform structure. The connecting-processes spring from this tissue, and can commonly be followed in vertical sections for a considerable distance into the substance of the pillars. Tangential sections further exhibit irregular dark lines connecting the transversely divided radial pillars; these lines are the cut edges of the vesicular plates or processes which fill the intervals between the pillars.

There is, apparently, a complete absence of definite zoöidal tubes or surface-apertures, and the "concentric laminæ" of the ordinary Stromatoporoids are represented solely by the vesicular tissue which unites the pillars together.

L. conferta differs from the *L. ohioensis*, Nich., of the Ordovician Rocks of North America in the fact that the radial pillars are of larger size, the surface-tubercles being correspondingly bigger, while the interstitial vesicular tissue is of a coarser type and is present in smaller amount. In its general external appearance *L. conferta* nearly resembles the *Lophiostroma* (*Labechia?*) *Schmidtii*[1] of the Silurian Rocks of the Island of Oesel; but the surface-tubercles of the latter are much larger, while the internal structure appears to be wholly different.

Distribution.—Labechia conferta appears to be wholly confined to the Silurian Rocks (Upper Silurian of Murchison). It is a common species in the Wenlock Limestone of Britain, occurring at Ironbridge, Dudley, Dormington, Longhope, &c. I have also specimens from the Wenlock Limestone of Gotland (collected by Prof. Lindström); but the species has not been recognised as occurring in the Silurian Rocks of Esthonia or Oesel.

2. Labechia scabiosa, n. sp. Pl. XX, figs. 4—6.

Cœnosteum forming a small discoid expansion, with a concentrically striated basal epitheca (Plate XX, fig. 5). The upper surface is flat, and is covered with irregular tubercles, which are usually multiple and are mostly placed from $\frac{1}{2}$ to

[1] *Labechia? Schmidtii* was described by me at some length in the 'Annals and Magazine of Natural History,' ser. 5, vol. xviii, 1886. Judging from its apparent structure it cannot be referred to the genus *Labechia*, and I propose for it the generic name of *Lophiostroma*. The genus is characterised by the possession of a laminar cœnosteum, composed throughout of sharply undulated, closely approximated, and exceedingly thin calcareous lamellæ. The upward bendings of these lamellæ give rise to a series of spurious pillars, the superior extremities of which appear on the surface as prominent tubercles, while the downward bendings correspond with the interspaces between these. The under surface is covered with a concentrically-striated epitheca.

1 mm. apart, their size and height being variable (Plate XX, fig. 4). The only known specimen is about $2\frac{1}{2}$ cm. in length by 2 cm. in width.

I have felt much hesitation in giving a name to this form, as I have only a single small specimen of it, and have therefore been unable to examine its internal structure by means of thin sections. It is clear, however, that we have to deal here with a species of *Labechia* which is distinct from *L. conferta*. The young form of the latter (Plate III, figs. 9 and 10) is an exceedingly thin, coin-shaped plate, epithecate below and tuberculate above. On the other hand, the specimen here described as *L. scabiosa* is not coin-shaped, and it is uncertain whether it is a young example or is fully grown. Moreover, the character of the tuberculation of the upper surface is very distinct from that shown in young examples of *L. conferta*, the tubercles being larger and more remote, while their distribution is irregular and does not show any radial tendency, and they are commonly multiple in structure.

Distribution.—Wenlock Limestone, Dudley.

3. Labechia stylophora, n. sp. Pl. XX, figs. 7 and 8.

The cœnosteum in this species is of unknown form, but is probably laminar. It consists of irregularly undulated laminæ, traversed by strong radial pillars, and so disposed as to give rise to the formation of a number of cylinders, which run at right angles to the general mass (Plate XX, fig. 7). The cylinders are about 8 or 9 mm. in diameter, and are placed about 5 mm. apart; and the radial pillars within them are so arranged as to be parallel with the axis of the cylinders in the middle line, while they are directed more or less transversely to the cylinder towards the circumference of the latter (Plate XX, fig. 8). The radial pillars are rounded or somewhat quadrangular in form, about two occupying the space of 1 mm.; and the interstitial vesicular tissue is exceedingly delicate, four or five vesicles occupying the space of a millimètre measured vertically.

Owing to the peculiar state of preservation of all the specimens of *L. stylophora* which I have seen, thin sections fail to yield any information further than that afforded by polished slabs. The species is, however, clearly distinguished from all other known forms of the genus by its unique mode of growth, its characteristic cylinders reminding one closely of the similar structures seen in the cœnosteum of *Actinostroma verrucosum*, Goldf. sp.

Distribution.—Not very uncommon in the Middle Devonian Limestones of Shaldon, South Devon.

4. Labechia serotina, *Nich.* Fig. 19.

Labechia serotina, *Nicholson.* Introduction, p. 45, 1885.
— — — Ann. and Mag. Nat. Hist., ser. 5, vol. xviii, p. 15, 1886.

General form and surface of the cœnosteum unknown. In internal structure the skeleton is composed of cylindrical radial pillars, which have a diameter of about $\frac{1}{6}$ mm., and which are traversed by large axial canals. The canals of the pillars are provided with curved internal partitions, which run transversely to the canal, and have their convexities turned upwards. The pillars are very rarely isolated, but are mostly in contact laterally in such a way that they give rise to sinuous rows, forming a network of much the same pattern as that produced by the corallites of *Halysites escharoides*, Lamk. sp. The interspaces between the winding rows of pillars are crossed by delicate calcareous fibres or plates, which connect the pillars together, and which are only rarely and partially vesicular. These connecting plates are usually straight, and are only occasionally curved; hence they give to vertical sections the aspect of a tabulate coral.

Fig. 19.

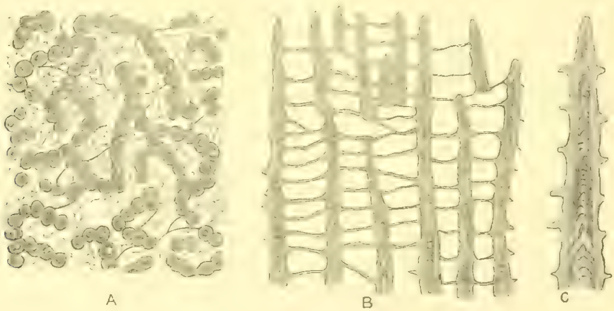


Fig. 19.—*Labechia serotina*, Nich. Devonian, Teignmouth. A. Tangential section, enlarged twelve times, showing the arrangement of the pillars in short interlacing rows, and their large axial canals. B. Vertical section, similarly enlarged, showing the partitioning of the axial canals of the pillars by transverse plates, and their connection by numerous horizontal "arms." C. A single radial pillar further enlarged, showing its pointed extremity.

The only example which I possess of this remarkable Stromatoporoid is a small polished fragment from a Devonian Limestone of Devonshire, which I purchased from Mr. Sclater, of Teignmouth. The structure of the skeleton differs so widely from that of the ordinary species of *Labechia* that it is unnecessary to compare it minutely with these. The characteristic features of *L. serotina* are the confluence of the radial pillars into a reticulation of sinuous rows, the large size of the axial canals, the presence of curved transverse partitions in the interior of the axial canals of the pillars, and the fact that the interstitial tissue is composed of straight horizontal plates, which but rarely become vesicular, and then only to a very limited extent.

Distribution.—Middle Devonian of Devonshire. The only known specimen is in a red limestone, and is probably from the neighbourhood of Torquay.

5. Labechia canadensis, *Nich. and Mur.* sp (?). Pl. XX, fig. 9.

Stromatocerium canadense, *Nicholson* and *Murie*. Journn. Linn. Soc. Zool., vol. xiv, p. 223, pl. iii, figs. 9, 10 (1878).
Labechia canadensis. *Nicholson*. Mon. Brit. Stromatoporoids, pl. ii, figs. 3—5, 1886.
— — — Ann. and Mag. Nat. Hist., ser. 5, vol. xviii, p. 14, pl. ii, fig. 5, 1886.

Typical American examples of this species have a generally massive cœnosteum, the upper surface of which is not fully known. The skeletal tissue (Plate II, figs. 4 and 5) consists of large, comparatively remote, and irregularly developed radial pillars, which are united by a very irregularly developed vesicular interstitial tissue, the cells of which are usually of large size and irregular form, though occasionally of moderate dimensions. The vesicles have their convexities turned upwards, and the radial pillars terminate upwards in pointed extremities.

This species is distinguished from all the other forms of the genus by its irregular and often remote radial pillars, and by the large size and irregular form of the interstitial cells. The only British specimen which I should feel disposed to identify with *L. canadensis* is a massive Stromatoporoid collected by Mrs. Robert Gray in the Ordovician limestones of the neighbourhood of Girvan. Unfortunately this specimen, as, indeed, is usual in all examples of the species which I have examined, is in a highly mineralised condition, and its characters cannot therefore be determined with absolute certainty. Vertical sections (Plate XX, fig. 9) show longitudinal rows of large-sized lenticular vesicles, of very irregular dimensions, and thus closely resemble corresponding sections of typical examples of *L. canadensis*. The vesicles vary from less than a millimètre to about 3 mm. in their long diameter. On the other hand, though the vesicular tissue is sufficiently well marked, there are only obscure indications of the presence of the radial pillars, which must have existed if the species is rightly identified. Upon the whole, however, I have little doubt but that this specimen is really referable to *L. canadensis*, since the radial pillars are commonly more or less entirely destroyed in undoubted examples of this species. If we were to suppose that radial pillars were really wanting, the specimen would have to be referred to the genus *Rosenella*, Nich.; but this reference is negatived by the fact that the upper surfaces of the vesicles, as seen in vertical sections, are quite smooth, and are completely destitute of the tubercles which are present in this situation in all species of the genus *Rosenella*.

Distribution.—A single large specimen was collected by Mrs. Robert Gray in the Aldons Limestone (Ordovician) at Aldons, near Girvan. The typical forms of the species are found in the Trenton Limestone of Peterborough and Lake Couchiching in Ontario. The species also occurs in the Ordovician Rocks ("Wassalem Beds") of Saak in Esthonia.

Family—STROMATOPORIDÆ.

Genus 1.—Stromatopora, *Goldfuss* (emend.), 1826.

(Introduction, p. 91.)

1. Stromatopora concentrica, *Goldfuss*. Pl. III, fig. 5; Pl. XI, figs. 15—18; Pl. XX, fig. 10; Pl. XXI, figs. 1—3; and Pl. XXIV, figs. 9 and 10.

Stromatopora concentrica, *Goldfuss*. Petref. Germ., p. 22, pl. viii, fig. 5, 1826.

? — — *Michelin*. Iconographie Zoöphytologique, p. 190, pl. xlix, fig. 4, 1840—47.

— — *Nicholson*. Monogr. Brit. Strom., Introduction, p. 2, pl. xi, figs. 15—18, 1886.

— — *Waagen* and *Wentzel*. "Salt Range Fossils," Palæontologia Indica, No. 7, pl. cxx, figs. 4 and 5, and pl. cxxi, 1 *a*—1 *c*, 1887 (figured, from European specimens, but not described).

— — *Wentzel*. Ueber fossile Hydrocorallinen, "Lotos," Neue Folge, Bd. ix, Taf. ii, figs. 4 and 5, and Taf. iii, figs. 1 and 2 (figures only), 1889.

The cœnosteum in this species is massive, spheroidal, cylindrical or bluntly conical, or irregular in form, often attaining a very large size. The base of attachment seems to have been small, and an epithecal membrane does not appear to have been developed. The skeleton always consists of successive "latilaminæ," or concentric strata, which are generally 2 to 3 mm. in thickness, and mark periodic intermissions in the process of growth (Plate XX, fig. 10, and Plate

XXI, fig. 1). Each latilamina is made up of a number of trabecular concentric laminæ, which are simply curved or are usually but slightly undulated, the surface being, therefore, usually free from prominences. Pointed eminences or "mamelons" are, however, present in one variety of the species (*S. concentrica*, var. *colliculata*, Nich.).

Astrorhizæ are usually fairly numerous and are generally of small size (Plate XXI, fig. 3). In one form (var. *colliculata*) the astrorhizæ are disposed in vertical systems, and are often surrounded by concentrically disposed laminæ, thus giving rise to "astrorhizal cylinders;" and in another form, which may be provisionally referred here (var. *astrigera*, Nich.), the astrorhizæ are large and spreading. The surface of the cœnosteum, when well-preserved, exhibits vermiculate and inosculating ridges corresponding with the reticulated skeleton (Plate XXI, fig. 3).

As regards its internal structure, the cœnosteum is of the strictly "reticulate" type, the radial pillars and horizontal connecting-processes being fused with one another to form a continuous and complex network traversed by correspondingly complex anastomosing canals (Plate XI, figs. 16—18). Distinct zoöidal tubes, of a somewhat irregular and tortuous form, are developed, and are crossed by a moderate number of transverse partitions or "tabulæ." The skeleton-fibre itself is minutely porous in structure, and is from $\frac{1}{5}$ to $\frac{1}{6}$ mm. in diameter, the reticulated tissue which it forms being thus very dense.

Obs.—The typical examples of *Stromatopora concentrica*, Goldf., are usually spheroidal or subcylindrical in shape, and vary from about an inch up to over a foot in diameter. The latilaminæ are concentric with the general surface, and are either simply curved or are thrown into wide undulations (Plate XX, fig. 10). In the form which I have named, *S. concentrica*, var. *colliculata*, the cœnosteum is cylindrical or cylindro-conical in shape, and the latilaminæ are rolled concentrically round an imaginary central axis. Though the latilaminæ form such a conspicuous feature in this species (Plate XXI, fig. 1), it can hardly be said that this feature is developed to a greater extent in *S. concentrica*, Goldf., than it is in *S. Carteri*, Nich., or *S. typica*, Rosen, or in some other Stromatoporoids of entirely different affinities (as, for example, in certain forms of *Actinostroma stellulatum*, Nich.).

As regards its internal structure, *S. concentrica* presents the completely reticulate skeleton of all the species of *Stromatopora* proper; but the blending of the radial and horizontal elements of the cœnosteum is not so complete as to prevent the ready recognition of the radial pillars in properly prepared vertical sections. Owing to the comparative distinctness of the radial pillars (Plate XI, fig. 18) the zoöidal tubes are clearly marked out as irregular, often sinuous, vertical tubes, the internal cavities of which are crossed by remote transverse "tabulæ." Tangential sections (Plate XI, figs. 16, 17) are, in general, readily distinguished from corresponding sections of allied species of the genus by the comparative density and closeness of the reticulation, due in part to the coarse nature of the skeleton-fibre, and in part to the proportionately small size and the irregular distribution of the canals which traverse the cœnosteum. The skeleton-fibre is minutely porous (Plate XXI, fig. 2), but in very many cases, where the skeleton has not been perfectly preserved, the pores are represented by dark or cloudy dots only.

Two principal groups of forms of *S. concentrica* may be distinguished, to which a third, of a more doubtful nature, may be provisionally added.

The first group comprises what may be considered the normal form of the species, in which the cœnosteum is spheroidal or irregular in shape, the latilaminæ are simply curved or undulated, and the surface is smooth and without "mamelons." The astrorhizæ (Plate XXI, fig. 3) are small, their centres being from 7 to 10 mm. apart, and are not surrounded by sheaths of concentrically disposed laminæ ("astrorhizal cylinders").

The forms of the second group may be included under the varietal name of *S. concentrica*, var. *colliculata*, Nich. In this variety the cœnosteum usually has the form of a thick cylinder, with a bluntly conical apex (Plate III, fig. 5), composed essentially of laminæ rolled concentrically round a vertical line. The astrorhizæ are comparatively small, but are developed in superimposed groups, and are commonly the centres of more or less definite "astrorhizal cylinders," the spaces between which are filled up by undulated and flexuous laminæ. Owing to this disposition of the astrorhizæ, the surface exhibits numerous eminences or "mamelons," which may be rounded or sometimes acuminate, or at other times more or less drawn out in the direction of the long axis of the fossil (Plate III, fig. 5). The minute structure of the skeleton in this variety does not differ in any recognisable respect from that of normal examples of the species.

To the above I may add, under the provisional name of *S. concentrica*, var. *astrigera*, Nich., a third group of forms distinguished essentially by the large size of the astrorhizæ, the centres of which may be 2 or 3 cm. apart, while their branches are comparatively few, and divide dichotomously at wide intervals (Plate XXIV, fig. 10). The only examples of this form with which I am acquainted occur in the Devonian Limestones of Devonshire, and their state of preservation is, unfortunately, such that I can say nothing as to the general form of the cœnosteum, or the condition of the surface. The best-preserved examples of this form which have come under my notice exhibit a microscopic structure of the skeleton which, except as regards the astrorhizæ, appears to agree in all essential respects with that of typical examples of *S. concentrica*. In the worse-preserved examples the skeleton has been more or less extensively replaced by calcite and its canal-system filled up with calcareous mud, thin sections thus appearing under the microscope in a "reversed" condition (Plate XXIV, fig. 9). In thin slices of such examples the astrorhizal canals often show a singular structure, oval or circular clear spaces separated by dark intervals marking out the lines of the principal tubes (Plate XXIV, fig. 9). This curious phenomenon is easily recognised in polished sections of this form, even by the naked eye, or with a lens, but I cannot give any satisfactory explanation of it. The skeleton in this form grows in "latilaminæ," as in the ordinary examples of the present species. The large size and characteristic form of the astrorhizæ in this type might, however, perhaps justify us in considering it as a distinct *species* of *Stromatopora* rather than as a mere variety of *S. concentrica*, Goldf.

Specimens of all the three forms of *S. concentrica* above distinguished commonly occur in the "Caunopora-state." In such specimens the "Caunopora-tubes" are generally of very small size, usually about $\frac{1}{4}$ mm. in diameter, but sometimes reaching a diameter of $\frac{2}{3}$ mm. The tubes are connected with one another by horizontal stolons, as is the case with "Caunopora-tubes" generally, but I have not recognised in them any structures of the nature of "tabulæ," nor do they appear to be provided with septal spines.

S. concentrica, Goldf., is more or less nearly related to *S. Carteri*, Nich., and *S. discoidea*, Lonsd., and, in a less degree, to *S. Hüpschii*, Barg., in all of which the skeleton-fibre is thick and coarse. From *S. Hüpschii* the present species is readily distinguished by the much less open reticulation of the skeletal framework, while the radial pillars and zoöidal tubes are not so regular nor so well developed. The skeleton-fibre of *S. Hüpschii* is, moreover, even more coarse than that of *S. concentrica*, while its cœnosteum does not grow in latilaminæ. *S. discoidea*, Lond., also has a thicker skeleton-fibre than that of *S. concentrica* ($\frac{1}{4}$ to $\frac{1}{5}$ mm. in diameter as compared with $\frac{1}{5}$ to $\frac{1}{6}$ mm. in the latter); and is at once distinguished from the present species by its extraordinarily developed astrorhizal system. *S. Carteri*, Nich., again, grows in latilaminæ, but the skeleton-fibre is of a finer character than that of *S. concentrica* (about $\frac{1}{6}$ or $\frac{1}{7}$ mm. in diameter) and the general reticulation of the skeleton is much more lax and open. Moreover, the skeleton-fibre of *S. Carteri* is more coarsely porous than that of *S. concentrica*. Lastly, *S. typica*, Rosen, has a skeleton-fibre of about $\frac{1}{7}$ mm. in diameter, and the general cœnosteal tissue is much less dense than that of *S. concentrica*, while the radial pillars and tabulate zoöidal tubes are much better developed than in the latter species.

I have found it impossible to draw up a satisfactory synonymy of this species, owing to the great difficulty of determining the real nature of many of the forms described under this name by older writers. The *S. concentrica* of Michelin ('Iconographie Zoöphytologique,' p. 190, pl. xlix, fig. 4, 1840—47) is quoted from both Devonian and Silurian localities, and thus clearly cannot be relied upon; and though his figure might answer very well for that of a fragment of *S. concentrica*, Goldf., it would stand even better for one of *Actinostroma stellulatum*, Nich. The species described by Lonsdale ('Sil. Syst.,' p. 680, pl. xv, fig. 31, 1839) as *S. concentrica* is really *Clathrodictyon striatellum*, D'Orb. sp. The form described under this name by Phillips ('Pal. Foss. of Cornwall, &c.,' p. 18, pl. x, fig. 28, 1841) appears to be an example of a hitherto undescribed Stromatoporoid which occurs commonly in the Devonian Limestones of Devonshire, and which will, I think, prove to be referable to the genus *Hermatostroma*. At any rate, the *S. concentrica* of Phillips is certainly quite distinct from the form which rightly bears this name. The fossil noted by M'Coy from the Carboniferous Limestone of Ireland ('Synopsis of the Carb. Foss. of Ireland,' p. 193, 1844), under the name of *S. concentrica*, Lonsd., is described with extreme brevity and is not figured, so that its true nature is wholly doubtful, though it may be taken for certain that it is not the present species. On the other hand, the fossil described by M'Coy from the Devonian Limestones of Devonshire as *S. concentrica*, Goldf. ('Brit. Pal. Foss,' p. 65, 1851), is clearly an *Actinostroma*, and is probably identical with *A. clathratum*, Nich. The *S. concentrica* of Bargatzky ('Die Stromatoporen des rheinischen Devons, p. 54, 1881) is unquestionably the form which I have described under the name of *Actinostroma clathratum*, and has no relationship with the *S. concentrica* of Goldfuss. Under the name of *S. concentrica*, Goldf., Prof. Ferd. Roemer ('Leth. Pal.,' p. 538, 1883) includes a number of distinct species of Stromatoporoids of Devonian age, and it is not possible to determine how far his descriptive remarks really apply to the true *S. concentrica* of Goldfuss. The figures which accompany his description (loc. cit., Atlas, Taf. xxvi, figs. 3*a*, 3*b*) would seem to be probably referable to *Actinostroma stellulatum*, Nich. The form identified as *S. concentrica*, Goldf., by Dr. Maurer ('Die Fauna der Kalke von Waldgirmes,' p. 108, Taf. ii, figs. 12, 13, 1885) is referable in reality to *Actinostroma stellulatum*, Nich., but is very badly preserved. Lastly, the form described as *S. concentrica*, Goldf., by Frech ("Die Korallenfauna des Oberdevons," 'Zeitschr. d. deutschen geol. Gesellschaft,' p. 116, Jahrg., 1885) is also an *Actinostroma*, and is apparently partly referable to *A. clathratum*, Nich., and partly based on *A. verrucosum*, Goldf. sp.

Distribution.—*Stromatopora concentrica*, Goldf., so far as at present known, is a purely European species, and is entirely confined to the Devonian Rocks. The normal form of the species occurs, not uncommonly, in the Middle Devonian Limestones in the neighbourhood of Gerolstein, and occurs also at Sötenich, but seems to be absent from the limestones of the Paffrath area. In Britain, the typical form of the species occurs in the Middle Devonian Limestones of Lummaton, in Devonshire, in strictly characteristic examples. It is also found in the Devonian pebbles of the Triassic conglomerates at Teignmouth; but it is always a rare form. The form which I have called *S. concentrica*, var. *colliculata*, is common at Gerolstein, commoner, in fact, than the normal form of the species, and it likewise occurs at Sötenich. Examples of this variety also occur in the Devonian pebbles of Teignmouth. Lastly, the type which I have provisionally designated *S. concentrica*, var. *astrigera*, appears to be confined to the Devonian Limestones of Devonshire, occurring in the Teignmouth conglomerates, and in the limestone of Chinkenwell Quarry, near Marychurch.

2. Stromatopora typica, *von Rosen.* Pl. I, fig. 3; Pl. V, figs. 14 and 15; Pl. XXI, figs. 4—11; and Pl. XXII, figs. 1 and 2.

Stromatopora typica, *von Rosen.* Ueber die Natur der Stromatoporen, p. 58, Taf. i, figs. 1—3, and Taf. ii, fig. 1, 1867.

— — *Nicholson.* Monogr. Brit. Stromatoporoids, General Introduction, pl. i, fig. 3, and pl. v, figs. 14 and 15, 1886 (figured but not described).

The cœnosteum in this species is typically hemispherical or discoid, more rarely laminar, with a flattened or concave base which is covered by a concentrically wrinkled epithecal membrane (Plate XXI, figs. 4 and 5), the organism being usually attached to foreign bodies by a limited portion of its lower surface. The size of the cœnosteum varies from less than two centimètres up to a foot or more at its base.

The mode of growth is always by distinct "latilaminæ," which are not made up of recognisable finer concentric laminæ, and which are always gently curved or bent, the exterior being thus destitute of conspicuous eminences or "mamelons." The surface, in well-preserved examples, shows a minutely vermiculate network (Plate XXI, fig. 7), pierced by innumerable small and close-set circular apertures, representing the mouths of the zoöidal tubes. Astrorhizæ are always developed in great numbers, but are slightly branched, and are of small size, their centres averaging about 6 mm. apart. They may be superimposed in vertical systems, with a common axial canal to each system; but this arrangement is rarely distinct, each astrorhiza usually showing two or more small apertures at its centre where it terminates on the surface.

As regards its internal structure, the skeleton is completely "reticulate," the horizontal elements of the cœnosteum ("connecting-arms") being indistinctly developed as separate from the radial pillars. The skeleton-fibre is about $\frac{1}{7}$ mm. in diameter, and is minutely porous (Plate XXI, figs. 9 and 10), the network formed by its inosculations being of a close and fine character. Vertical sections (Plate XXII, fig. 2) show that the radial pillars are quite distinct, and are separated by well-developed, approximately vertical zoöidal tubes, the cavities of which are intersected by numerous transverse partitions or "tabulæ." From six to eight zoöidal tubes, with their intervening radial pillars, occupy a space of 2 mm. measured at right angles to their length. Tangential sections (Plate XXII, fig. 1) show the finely reticulated skeletal network, pierced by the generally round openings of the transversely divided zoöidal tubes and traversed by the branching astrorhizal canals. The latilaminar structure of the skeleton is also well exhibited by vertical sections.

Obs.—The form of the cœnosteum in *S. typica* is essentially discoidal, with a basal epitheca, the smallest example seen being $1\frac{1}{2}$ cm. in diameter. Young specimens (Plate XXI, figs. 4—6) are thin, approximately circular discs, fixed basally to foreign objects by a small peduncle of attachment, or, at other times, by a large portion of the under surface. In some cases the discoidal or laminar form is more or less completely retained throughout life, few latilaminæ being produced, and these being widely extended laterally. More usually, the successively produced latilaminæ not only extend beyond the margins of the previously formed disc, the cœnosteum thus increasing in diameter; but each stratum is thicker in the middle than at the periphery, so that the colony assumes a hemispherical shape, with a flat or concave base (Plate XXI, fig. 8). Large specimens may exceed a foot in diameter, but the hemispherical form is usually more or less closely retained.

Latilaminar growth is almost as marked a feature as in *S. concentrica*, Goldf., each latilamina consisting of a single layer of zoöidal tubes. The latilaminæ are always in gentle curves or slight undulations, conforming with the surface of the hemispherical cœnosteum. The astrorhizæ of *S. typica* are characteristic in their great numbers, small size, and few straggling branches (Plate XXI, fig. 7). Usually their centres are 5 or 6 mm. apart, but they may be more widely spaced than this. An arrangement of the astrorhizæ into vertically superimposed systems, each with a common axial canal, can often be made out; but this is not a conspicuous feature, and "astrorhizal cylinders" are never developed, the surface of each successive latilamina being thus devoid of eminences or "mamelons" corresponding with the astrorhizal centres.

The skeleton-fibre (Plate I, fig. 3, and Plate XXI, figs. 9 and 10) is minutely porous, and this structure is more or less clearly recognisable in all well-preserved examples. In some examples, however, the skeleton-fibre appears to have undergone a sort of change, in virtue of which it appears in vertical sections as if traversed by innumerable perpendicular and horizontal dark striæ. This appearance has been figured by Baron von Rosen ('Ueber die Nat. der Strom.,' Taf. i, fig. 2), and is not uncommonly seen in specimens from Gotland or Esthonia, but only in examples which can be otherwise shown to have undergone more or less alteration. As has been previously pointed out (p. 145), vertical sections of specimens in which the skeleton-fibre has been altered in the way just described show a singular resemblance to corresponding sections of *Actinostroma astroites*, von Rosen, sp.

Owing to the imperfect development of the horizontal elements of the skeleton as distinct structures, "concentric laminæ," in the strict sense of the term, can hardly be said to exist, the skeletal tissue being thoroughly reticulate. Tangential sections (Plate XXII, fig. 1) exhibit a close calcareous network, traversed horizontally or more or less obliquely by the branching astrorhizal canals, and pierced by close-set oval or circular pores, representing transverse sections of the zoöidal tubes. On the other hand, vertical sections (Plate XXII, fig. 2) show that each latilamina consists of a series of closely arranged slightly flexuous radial pillars, which probably run from the bottom to the top of the latilamina without a break, though they are necessarily so cut in sections as to appear to be more or less discontinuous. The radial pillars are connected at intervals by irregularly developed horizontal processes, but their individuality is not thereby destroyed. Vertical sections, also, always show very distinctly developed and freely tabulate zoöidal tubes, which, like the radial pillars, are probably really continuous from the bottom to the top of each latilamina.

I have never seen a British example of *S. typica* in the "Caunopora-state." Prof. Ferdinand Roemer has, however, presented to me an example of this species from the Drift of Northern Germany, in which the skeleton is traversed by numerous minute "Caunopora-tubes." I have given a figure of a portion of the surface of this specimen (Plate XXI, fig. 11), from which it will be seen that, in this case, the "Caunopora-tubes" probably belong to a species of *Aulopora*. Professor Lindström, moreover, has recently shown ('Bihang till k. Svenska Vet. Akad. Handlingar,' Bd. xv, Afd. iv, No. 9, 1889) that the curious fossil described by Kunth under the name of *Prisciturben* is really a kind of "Caunopora," in which the imbedded tubes belong to a Cyathophylloid coral. The original specimen of *Prisciturben* was derived from the Wenlock Limestone of Sweden (apparently from Gotland), and was supposed by Kunth to be a peculiar type of Coral ("Beiträge zur Kenntniss fossiler Korallen," 'Zeitschr. d. deutsch. geol. Gesell.,' 1870, p. 82). Lindström, however, has shown that the supposed "cœnenchyma" of *Prisciturben* is really a mass of *Stromatopora typica*, v. Rosen, imbedded in which, as in a matrix, are the cylindrical tubes of a Cyathophylloid coral. I have carefully examined a specimen of *Prisciturben* which I collected in the Wenlock Limestone of Oesel, and I am able to entirely corroborate Professor Lindström's observations on this subject.

The characters of *S. typica*, throughout its entire range, remain remarkably uniform; and I am not acquainted with any definite varietal forms of the species, unless the *Caunopora Hudsonica* of Dawson—to be spoken of immediately—should be regarded as one.

From *S. concentrica*, Goldf., the present species is distinguished by its much finer skeleton-fibre and the greater delicacy of the cœnosteal tissue resulting from this. The cœnosteum is, further, distinguished by its hemispherical or discoidal form, and the presence of a basal epitheca; while the zoöidal tubes are closer, more regular, and more abundantly furnished with tabulæ than is the case with the former. From both *S. Hüpschii*, Barg., and *S. discoidea*, Lonsd., the present species is distinguished, among other characters, by the comparative fineness of the skeleton-fibre and the greater delicacy of the reticulated skeleton. In *S. discoidea*, moreover, the astrorhizal system is extraordinarily developed. From *S. Carteri*, Nich., lastly, the present species is separated by its more delicate skeleton-fibre and the much less lax and open character of the skeletal network; while the former is destitute of astrorhizæ, or has these structures developed in the feeblest manner.

Stromatopora typica, Rosen, though a very abundant and very widely distributed form, seems to have been commonly overlooked by palæontologists, and I have therefore little to say as to its synonyms. I have examined von Rosen's original specimens in Dorpat, and I have collected many similar ones in the Silurian Rocks of Esthonia; so that I have no doubt as to the precise species this observer had in view, even if his excellent figures had not placed this beyond doubt. My friend Mr. J. F. Whiteaves has been good enough to send me a fragment of the original specimen of the "*Cannopora*" *Hudsonica*, described by Sir J. W. Dawson ('Quart. Journ. Geol. Soc.,' vol. xxxv, p. 52, pl. iv, fig. 9, and pl. v, fig. 10, 1879) from the Silurian Rocks of Hudson's Bay, together with another and much better preserved fragment of the same species from the Silurian of Cape Churchill. The microscopic examination of these fragments has shown that this form is a true *Stromatopora*, with very close relationships to *S. typica*, Rosen. The general character of the skeletal network is precisely similar to that of *S. typica*, except, perhaps, that it is a shade coarser than is usual in the latter species; while the minute structure of the skeleton-fibre is identical in the two. There are, in fact, only two apparent points of distinction between *S. Hudsonica*, Daws. sp., and *S. typica*, Rosen, to which any importance could be attached. One of these is that in the former the astrorhizæ are always regularly superimposed in vertical rows, each system being connected with a wall-less axial canal of comparatively large size. Each astrorhiza, therefore, opens on the surface of the latilamina to which it belongs by a comparatively large circular aperture, corresponding with the axial canal, this aperture being placed at the summit of a minute pointed eminence. The surface thus shows numerous small, regularly placed "mamelons," corresponding each with the centre of an astrorhizal system. In this character, as pointed out by Dawson, *S. Hudsonica* resembles the form described by Hall and Whitfield ('Twenty-third Ann. Rep. on the State Cabinet,' pl. ix, fig. 3,

1873) as *Cœnostroma incrustans* (Plate III, fig. 6); but it is by no means probable that these species are identical. The other point which seems to distinguish *S. Hudsonica* from *S. typica* is that the zoöidal tubes of the former seem to be provided with very few tabulæ; but much stress cannot be laid upon this, as my specimens are in a state of poor preservation. Upon the whole, it may at present be concluded that *S. Hudsonica*, Dawson sp., is specifically distinct from *S. typica*, Rosen, though certainly nearly related to it.

Mr. Whiteaves has also supplied me with a fragment of the original specimen described from the Guelph Limestones (Niagara Group) of Canada by Sir J. W. Dawson under the name of *Cœnostroma galtense* ('Life's Dawn on Earth,' p. 160, 1875, and 'Quart. Journ. Geol. Soc.,' vol. xxxv, p. 52, 1879). The minute structure of this specimen is practically destroyed by dolomitisation, but all its general characters would lead to the belief that it is very closely related to *S. typica*, Rosen, and is probably absolutely identical with it.

Prof. J. W. Spencer has kindly supplied me with a fragment of the species which he described from the Niagara Limestone of North America under the name of *Cœnostroma constellatum* ('Niagara Fossils,' p. 48, pl. vi, fig. 11, 1884). The minute structure of this is also almost wholly destroyed by dolomitisation; but it does not appear to be in any way distinguishable as regards its general characters from *Cœnostroma galtense*, Dawson, and I am strongly disposed to think that it is really identical with *S. typica*, Rosen.

If the above view should prove to be correct, then *Cœnostroma galtense*, Dawson, and *C. constellatum*, Spencer, must be considered as synonyms of *S. typica*, Rosen. Prof. Spencer, however, identifies his species with the previously described *Stromatopora constellata* of Hall ('Pal. N. Y.,' vol. ii, p. 324, pl. lxxii, fig. 2 *a*, *b*, 1852). If the identity of this last with *S. typica*, Rosen, should also be proved, then Hall's name should, strictly speaking, have precedence over that of Rosen. The real nature of Hall's *Stromatopora constellata* could, however, be established only by an investigation of the original specimen, if even then; since the brief description, with its accompanying figures, is not sufficient to establish clearly so much as the generic position of the fossil. Under these circumstances it would appear unreasonable to abandon the name of *S. typica* for that of *S. constellata*, even were the identity of the two to be ultimately proved; since Rosen based his species upon well-preserved specimens, and illustrated its characters by admirable and thoroughly recognisable figures.

Distribution.—*Stromatopora typica*, Rosen, appears to be wholly confined to the Silurian (Upper Silurian) Rocks, of which it is by far the commonest and most characteristic Stromatoporoid. No Ordovician or Devonian examples of the species are known. The species is, in fact, an essentially Wenlock type, and has an extremely wide distribution in space. In the Wenlock Limestone of Britain the species is extremely abundant, occurring in numerous localities, as, for example, at Ironbridge, Dudley, Dormington, Longhope, and Much Wenlock. It is also a common form in the Wenlock Limestone of Gotland, though most of the specimens I have seen from this region are more or less altered by crystallisation. In Esthonia, in the Upper Oesel formation, it occurs plentifully, specimens being abundant at Lode (near Arensburg), Kaugatoma-pank, Kattri-pank, or Hoheneichen, all in Oesel. It also occurs in the Drift in Northern Germany. If I am right in regarding *Cœnostroma galtense*, Dawson, and *S. constellatum*, Spencer, as identical with *S. typica*, Rosen, then the species occurs in the Silurian Rocks of North America as well as in Europe.

3. Stromatopora Carteri, n. sp. Pl. I, figs. 6 and 7; and Pl. XXIII, figs. 1—3.

The cœnosteum in this species is of considerable size, massive, irregular in shape, and composed of gently undulated or curved latilaminæ (Plate XXIII, fig. 1), which vary from 2 to 4 or 5 mm. in thickness in their central portion. The under surface and mode of attachment are not known, but the upper surface is without distinct eminences or "mamelons," and shows simply an irregular vermiculate tuberculation. Astrorhizæ are not developed in any recognisable form.

As regards internal structure, the skeleton-fibre is about $\frac{1}{6}$ mm. in diameter, and is coarsely porous (Plate I, figs. 6 and 7). Vertical sections (Plate XXIII, fig. 2) show that each latilamina is composed of very distinctly developed radial pillars, which are separated from one another by equally distinct zoöidal tubes, and which really run continuously from the bottom to the top of each latilamina; though they appear to be more or less broken up, if—as in the example figured—the plane of the section is slightly oblique. About seven radial pillars, with their intervening zoöidal tubes, occupy a space of 2 mm., measured transversely. The zoöidal tubes are furnished with a moderate number of well-developed transverse partitions or "tabulæ." The radial pillars are connected at varying intervals by irregular horizontal or oblique processes, but these do not give rise to distinct "concentric laminæ," and the skeleton thus forms a loose and open reticulation, in which the vertical elements are far more conspicuous than the horizontal. As a result of this, tangential sections (Plate XXIII, fig. 3) show the cut ends of the radial pillars, either as separate structures, or, more usually, as united by the irregular horizontal processes above spoken of in such a way as to give rise to vermiculate and sinuous rows, which inosculate with one another and form a lax network.

Obs.—The specimens upon which I have founded this species, though moderately numerous, are all more or less imperfect, none of them showing the base or mode of attachment. The species grows to a large size, and the cœnosteum is of the massive as distinguished from the laminar or discoidal type, the under surface having very possibly been devoid of an epithecal membrane. Latilaminar growth is a very marked feature, and each latilamina, as is the case in *S. typica*, Rosen, consists essentially of a single stratum of radial pillars which extend continuously from its lower to its upper surface, and are united by irregular horizontal or oblique connecting processes, these latter not being sufficiently regular to give rise in vertical sections to the appearance of definite "concentric laminæ." The skeleton-fibre in *S. Carteri* is of medium thickness, being finer than that of *S. concentrica*, Goldf., *S. Hüpschii*, Barg., or *S. discoidea*, Lonsd., but is remarkable for its coarsely porous structure, as seen in thin sections (Plate I, figs. 6 and 7). A characteristic feature is the peculiarly loose and open nature of the reticulated cœnosteal tissue (Plate XXIII, figs. 2 and 3). Another characteristic feature is the total or almost total absence of the branched and radiating astrorhizal canals, which are so conspicuous in most species of *Stromatopora*. In most examples of the present form no traces whatever of these structures can be detected, and in none are these more than the merest indications of their existence. The surface, therefore, is simply smooth or gently undulated, and is entirely without "mamelons."

I am not acquainted with any undoubted varietal forms of this species, nor have I ever seen a specimen of it in the "Caunopora-state."

S. Carteri cannot easily be confounded with any other species of the genus *Stromatopora*. It agrees with *S. typica*, Rosen, and with *S. concentrica*, Goldf., in its conspicuously latilaminar mode of growth; but it is distinguished from both these forms by the peculiar character of the skeletal reticulation, as also by the absence of astrorhizæ. By this last feature it is equally distinguished from *S. Hüpschii*, Barg., *S. Beuthii*, Barg., and *S. discoidea*, Lonsd., while it is further separated from these by the composition of its skeleton out of regular latilaminæ. The only species of *Stromatopora* with which *S. Carteri*, Nich., is really closely allied is a form from the Silurian Rocks (Upper-Oesel group) of Oesel, which I may provisionally name *S. borealis*. The general structure of the skeleton-fibre and of the cœnosteal tissue is the same in these two types, a distinct relationship, or, perhaps, an actual identity, being thus indicated. *S. borealis*, Nich., is, however, distinguished from *S. Carteri* by the fact that the cœnosteum of the former has the shape of a thin extended lamina, with a basal epitheca, while it is not composed of successively superimposed latilaminæ. The astrorhizal system of *S. borealis* is, moreover, very well developed. A further point of distinction is found in the fact that the zoöidal tubes of *S. borealis* are more abundantly furnished with tabulæ than is the case in *S. Carteri*, while these structures are often placed at the same level in adjoining tubes, thus giving rise to the appearance of successive continuous concentric lines.

Distribution.—*S. Carteri*, so far as known, is entirely confined to the Wenlock Limestone of Britain; and my specimens have been principally obtained from the single locality of Ironbridge, in Shropshire, where the species is not altogether uncommon, though vastly more rare than is *S. typica*, Rosen. The species has not hitherto been certainly recognised in the Silurian Rocks of Gotland or Esthonia. Mr. Whiteaves has submitted to me for examination a fragment of a species of *Stromatopora*, obtained from a loose boulder on the banks of the Hayes River, in Hudson's Bay Territory, which very closely approaches in its characters to *S. Carteri*, though my material is not sufficient to justify me in asserting that it is absolutely identical with the latter.

4. Stromatopora Hüpschii, *Bargatzky* sp. Pl. X, figs. 8 and 9; Pl. XXII, figs. 3—7.

? Stromatopora polymorpha, *Phillips*. Palæozoic Fossils of Cornwall, &c., p. 18, pl. x, fig. 27, 1841. (Non *Stromatopora polymorpha*, Goldfuss.)
?? Caunopora placenta, *Phillips*. Ibid., p. 18, pl. x, fig. 29.
— — *Bargatzky*. Die Stromatoporen des rheinischen Devons, p. 61, 1881.
— Hüpschii, *Bargatzky*. Ibid., p. 62, 1881.
Stromatopora Beuthii, *Maurer*. Die Fauna der Kalke von Waldgirmes bei Giessen, p. 113, Taf. iii, fig. 5, 1885. (Non *Stromatopora Beuthii*, Bargatzky.)
— indubia, *Maurer*. Ibid., p. 111, Taf. iii, figs. 1—3.
? — maculosa, *Maurer*. Ibid., p. 114, Taf. iii, figs. 6 and 7.
— Hüpschii, *Nicholson*. Monogr. Brit. Strom., General Introduction, fig. 6, a, b, and pl. x, figs. 8 and 9 (figured but not described).

The cœnosteum in this species is generally laminar, with a basal epitheca, but it is sometimes massive or irregular in form. Laminar examples vary in thickness from half a centimètre (young forms) to four or five centimètres, and when fully grown are often more or less cake-like in shape.

Latilaminæ are not at all, or very imperfectly, developed, though, as in most Stromatoporoids, traces of periodic intermissions of growth can be recognised. The "concentric laminæ," so far as such can be said to exist, are approximately straight, or are gently curved; and the surface is, therefore, devoid of "mamelons," at any rate in the typical form of the species. When well preserved, the surface (Plate XXII, fig. 6) exhibits coarse vermiculate ridges, which inosculate with one another so as to form a network corresponding with the reticulated skeleton, while the elongated or rounded meshes correspond with the apertures of the zöoidal tubes. The surface also shows numerous astrorhizæ of a characteristic ramified type, which vary in size and distance, but usually have their centres about a centimètre apart.

As regards internal structure, the skeleton-fibre (Fig. 20, A and B) is coarsely porous, and is unusually stout (about $\frac{1}{4}$ mm. in diameter, or rather more). The cœnosteal tissue is of the completely "reticulate" type, the radial pillars and the trabeculæ of the "concentric laminæ" being fused into a continuous network. Vertical sections (Plate XXII, fig. 3), however, show that the radial pillars exist as distinct structures, united at irregular intervals by horizontal or oblique connecting-processes, and separated from one another by very well-developed zoöidal

FIG. 20.

FIG. 20.—A. Tangential section of *Stromatopora Hüpschii,* enlarged twelve times, showing the reticulate skeleton and the porous skeleton-fibre. B. Vertical section of the same, similarly enlarged, showing the tabulate zoöidal tubes. C and D. Tangential and vertical sections of *Stromatopora Bücheliensis,* similarly enlarged. Middle Devonian.

tubes (Fig. 20, B), which are intersected by occasional remote tabulæ. About five radial pillars, with their intervening zoöidal tubes, occupy the space of two millimètres measured transversely. Tangential sections (Plate XXII, fig. 4, and woodcut, Fig. 20, A) show the loosely-woven and coarse network of the reticulated skeleton, in which no traces of the radial pillars (as distinct structures) are recognisable. The apertures in this network correspond with the zoöidal tubes, and some of these are simply circular, while others are confluent, and thus give rise to elongated and sinuous meshes.

Obs.—The general form of the cœnosteum in this species is that of a thick lamina or cake, with an inferior epithecal membrane. Some examples, however, are massive in growth and irregular in form, and may not have possessed an epitheca. The upper surface is devoid of elevations, though it is probable that pointed prominences or "mamelons" corresponding with the astrorhizæ were present in the variety of the species which I shall term *S. Hüpschii*, var. *seposita*. Latilaminar growth is not clearly recognisable, as a rule, and the general skeletal structure is very characteristic. The skeleton-fibre (Fig. 20, A) is coarsely porous, and is unusually thick, the general cœnosteal reticulation being loose, with usually elongated and sinuous meshes. The zoöidal tubes, as seen in vertical sections (Fig. 20, B), are very clearly developed, but they show comparatively few tabulæ, or they may be even devoid of these structures.

Astrorhizæ (Plate XXII, fig. 5) are very abundantly developed, but are usually of small size, while they melt away rapidly at their circumference into the general reticulated tissue of the skeleton. In that form of the species which I propose to call *S. Hüpschii*, var. *seposita*, the astrorhizæ are superimposed in regular vertical systems, which are surrounded by concentrically disposed laminæ, penetrated more or less transversely by the radial pillars, thus giving rise to regular "astrorhizal cylinders." The spaces between these cylinders may be simply filled by loose reticulated tissue of the type ordinarily characteristic of this species, or may be occupied by undulated laminæ in a manner similar to what occurs in *Actinostroma verrucosum*, Goldf. sp. (figured in Plate XVI, fig. 1). It is probable that in this variety of *S. Hüpschii* each astrorhizal cylinder would project above the upper surface of the cœnosteum as a pointed "mamelon;" but none of my examples exhibit the general form or exterior. In its minute structure *S. Hüpschii*, var. *seposita* shows nothing to distinguish it from the normal form of the species.

Stromatopora Hüpschii very commonly occurs in the "Caunopora-state." It is, indeed, comparatively rare to meet with an example of this species which is *not* penetrated by "Caunopora-tubes." Such tubes vary considerably in size in different examples, but they can be commonly shown to possess funnel-shaped tabulæ in their interior (Plate X, fig. 9), and they sometimes possess radiating septal spines in addition. In some specimens, the "Caunopora-tubes" are short, and give off numerous lateral stolons, reminding one of an *Aulopora*-colony. In other cases, the tubes are straight, regularly parallel, and continuous throughout considerable vertical distances, thus reminding one rather of a *Syringopora*-colony.

I have figured a characteristic example of this latter type from the Devonian Limestone of Dartington, in which the tubes are exposed to view as the result of weathering (Plate XXII, fig. 7).

The species with which *S. Hüpschii* is most nearly allied is undoubtedly *S. Beuthii*, Barg., with which it agrees in the coarsely porous, stout skeleton-fibre, as also in the general type of reticulation of the cœnosteal tissue. *Well-preserved* examples of *S. Beuthii* are readily distinguished from *S. Hüpschii* by the fact that the radial pillars are so far persistent as to be quite recognisable as distinct structures; whereas in the latter the radial pillars have lost their axial canals, and are thus irrecognisably incorporated with the general skeletal reticulation. Hence, in tangential sections of *S. Beuthii* (Plate XXIII, figs. 10 and 12) the cut ends of the radial pillars are seen within the general cœnosteal network as distinct, circular, dark or light spaces, usually with a central dot representing the axial canal of the pillar; and even in vertical sections the axes of the pillars may be more or less clearly recognisable; whereas no such phenomena are observable in sections of *S. Hüpschii*. It must be admitted, however, that this distinction cannot always be made out in practice, since in badly-preserved specimens of *S. Beuthii* all traces of the persistent axes of the radial pillars may apparently be lost. Under such circumstances, examples of *S. Beuthii* can be distinguished from those of *S. Hüpschii* only by the comparatively uncertain tests that the general reticulation of the skeleton in the former is not so lax as in the latter; the radial elements of the cœnosteum are of stouter build than in *S. Hüpschii*, and are more clearly separated from the horizontal elements; while the zoöidal tubes are more abundantly tabulate, and the astrorhizæ are much less developed than is the case in the latter species.

From *S. concentrica*, Goldf., the present species is distinguished by its somewhat coarser skeleton-fibre, the much looser and more open character of the reticulated skeleton, the less perfect circumscription of the astrorhizæ, and the fact that growth of the cœnosteum is not effected by distinct latilaminæ.

As regards the *synonymy* of the present species, it seems very probable, judging from the figures given, that the fossils described by Phillips from the Devonian Limestones of Dartington and Chudleigh as *Stromatopora polymorpha*, Goldf. (loc. cit. supra) are really referable to *S. Hüpschii*, Barg.; but this cannot be asserted positively without an examination of the original specimens. In any case, the point is one of comparatively small interest, since I have shown (p. 4) that *Stromatopora polymorpha*, Goldf., probably covered three distinct forms, and that this specific name is therefore not worthy of retention. It also seems by no means improbable that the *Caunopora placenta* of Phillips (loc. cit. supra) was based upon a specimen of *Stromatopora Hüpschii* in the "Caunopora-state." This is a point of considerable importance, since if this could be established with certainty, the specific name given by Phillips would, strictly speaking, have a claim to be retained, and the species would stand as *Stromatopora placenta*, Phill. sp. Upon full consideration, however, I have decided to retain Bargatzky's name for this species upon two grounds—viz. in the first place, that the description and figures given by Phillips of his *Caunopora placenta* are entirely insufficient to determine clearly the form which he had under consideration, and, in the second place, that the "Caunopora-tubes" are made an essential part of the diagnosis of the species. If the original specimen of Phillips were examined, it is very possible that it might prove to be referable to what is here understood as *Stromatopora Hüpschii*, Barg. It might, however, prove to be a "Caunoporised" example of *S. Benthii*, Barg., or *S. Büchelensis*, Barg., and, indeed, I am rather disposed to think that it is to the last-named of these that it really belongs. At any rate, the original figures and descriptions would fit the one hypothesis quite as well as the other; and under these circumstances it seems to me best to allow the name of *Caunopora placenta*, Phill., to fall altogether.

On the other hand, the *Caunopora placenta* of Bargatzky himself—as I have established by an examination of the original specimens—is really identical with the *Caunopora Hüpschii* of the same author; and in order to avoid confusion with the fossil described by Phillips as *C. placenta*, the second of Bargatzky's specific titles must be retained. As I have shown previously, however, Bargatzky was led into a misconception of the true nature of the genus *Stromatopora* by reason of his ignorance of the minute structure of *S. concentrica*, Goldf., the type-species of this genus. The *Stromatopora* of Bargatzky is thus really what I have named *Actinostroma*, and the *Caunopora* of this author is really *Stromatopora*. The present species, therefore, under the circumstances just recounted, may best stand as *Stromatopora Hüpschii*, Barg. sp.

The *Stromatopora Benthii* of Maurer (loc. cit. supra) appears to be founded upon a specimen of *S. Hüpschii*, Barg., *without* "Caunopora-tubes," while the *S. indubia* of the same author seems to be *S. Hüpschii with* "Caunopora-tubes." The *S. maculosa* of Maurer may also be referable to *S. Hüpschii*, but its preservation is bad, and its true affinities are doubtful.

Distribution.—*S. Hüpschii*, Barg., appears to be entirely confined to the Devonian Rocks, occurring with great frequency in the Middle Devonian Limestones of both Britain and Germany. In the latter region it occurs abundantly at Büchel, in the Paffrath District, but appears to be wanting at Hebborn (where *S. Benthii*, Barg., is common), while it is a rare species at Gerolstein. In the Devonian Limestones of Devonshire it is the commonest of all the forms of *Stromatopora*, occurring usually in the "Caunopora-state." Large and perfect examples are found at Dartington (Pit-Park Quarry), while others are found at Bishopsteignton, and the species is exceedingly abundant in the pebbles of

Devonian Limestone in the Triassic conglomerates of Teignmouth. *S. Hüpschii*, var. *seposita*, Nich., occurs not very uncommonly at Teignmouth.

5. Stromatopora inæqualis, n. sp. Pl. XXIV, figs. 11 and 12.

The form, size, and surface-characters of this species are unknown, as also is the mode of attachment of the organism. The mode of growth is continuous, and not by latilaminæ. The skeleton-fibre is thick and coarsely porous, and is woven into a loose reticulation, the meshes of which are elongated and sinuous, the general characters of the cœnosteal tissue agreeing in all essential respects with those distinctive of *S. Hüpschii*, Barg. Vertical sections show that the radial pillars are well developed, while numerous distinct zoöidal tubes, intersected by a moderately large number of transverse partitions or "tabulæ," are present. The astrorhizæ are exceedingly well developed, and exhibit a distinct division into two series, a larger and smaller, which are regularly intermingled with one another (Plate XXIV, figs. 11 and 12). The larger astrorhizæ have a few slightly divided branches, their centres being placed from 6 to 12 mm. apart. The smaller astrorhizæ consist of numerous short, hardly divided, radiating canals, and occupy the interspaces between the larger ones.

Obs.—This species is only known to me by polished specimens obtained from the Devonian pebbles in the Triassic conglomerates of Teignmouth, and these show nothing as to the general form or mode of attachment of the cœnosteum. Moreover, almost all the specimens I have examined are in the "reversed" condition, the actual skeleton being more or less extensively replaced by calcite, while the astrorhizal canals and zoöidal tubes are more or less completely infiltrated with opaque calcareous mud. I have only obtained one specimen in which the state of preservation of the skeleton is normal. This specimen shows that, as regards general internal structure, there is nothing that would clearly distinguish *S. inæqualis*, Nich., from *S. Hüpschii*, Barg., and it is possible that the former is only a well-marked variety of the latter. The apparently constant division of the astrorhizæ in *S. inæqualis* into two series of different sizes and shapes is, however, so marked a feature (Plate XXIV, figs. 11 and 12), that it seems to me advisable to consider this form as a distinct species. If the character in question be admitted as of specific value, then there is no other species of the genus *Stromatopora* with which the present form could be confounded.

Distribution.—*S. inæqualis* is of rare occurrence in the pebbles of Devonian Limestone in the Triassic conglomerates of Teignmouth.

6. STROMATOPORA FLORIGERA, n. sp. Pl. XXII, figs. 8—10.

The form, size, and mode of growth of the cœnosteum in this species are unknown. The cœnosteal tissue is not developed in latilaminæ, and is completely reticulated (Plate XXII, fig. 9), the skeleton-fibre being coarsely porous in structure, and having an average diameter of from $\frac{1}{5}$ to $\frac{1}{6}$ mm. The astrorhizæ are exceedingly numerous and are of small size, their centres being in general about 4 mm. apart (Plate XXII, fig. 8). The astrorhizæ are developed in vertically superimposed rows, each system being traversed by an axial wall-less canal; but proper "astrorhizal cylinders" are not usually developed. From the condition of the astrorhizæ it may be inferred that the surface exhibited close-set conical "mamelons" corresponding with the centres of the astrorhizal systems. Tangential sections (Plate XXII, fig. 9) show the completely reticulate character of the general skeleton, into which the minute astrorhizæ melt insensibly at their edges. Vertical sections (Plate XXII, fig. 10) show that the radial pillars are clearly recognisable, and that well-developed zoöidal tubes, traversed by numerous transverse partitions or "tabulæ" are present. Such sections also commonly exhibit the axial canals of the astrorhizal systems. About six zoöidal tubes, with their intervening pillars, occupy a space of 2 mm. measured transversely.

Obs.—This species is of the same general type as *S. Hüpschii*, Barg., from which it is chiefly distinguished by the more delicate character of the skeleton-fibre, the much smaller size and greater proportionate number of the astrorhizæ, and the fact that these structures are developed in regular vertical systems. From *S. Hüpschii*, var. *seposita*, Nich., in which the astrorhizæ are also developed in vertical systems, *S. florigera* is separated by its more delicate texture, the much more closely-set astrorhizæ, and the fact that astrorhizal cylinders are usually wanting. The zoöidal tubes of *S. florigera* are also furnished with more numerous tabulæ than is the case with those of *S. Hupschii*, Barg. There is no other species of the genus *Stromatopora* with which the present form could well be confounded. My material of *S. florigera* is, unfortunately, very limited, and I am unable to give any information as to the general form of the cœnosteum or the condition of its surface. I have seen no specimens in the "Caunopora-state," but examples occasionally occur in the "reversed" condition.

Distribution.—This species is only known to me as occurring rarely in the pebbles of Devonian Limestone in the Triassic conglomerates of Teignmouth.

7. STROMATOPORA BEUTHII, *Bargatzky*. Pl. V, figs. 12, 13; Pl. XXIII, figs. 8—13; and Pl. XXIV, fig. 1.

STROMATOPORA BEUTHII, *Bargatzky*. Die Stromatoporen des rheinischen Devons, p. 56, 1881.

? — TURGIDECOLUMNATA, *Maurer*. Die Fauna der Kalke von Waldgirmes, p. 112, Taf. iii, fig. 4, 1885.

— BEUTHII, *Nicholson*. Monogr. Brit. Strom., General Introduction, pl. v, figs. 12 and 13, 1886 (figured but not described).

The cœnosteum of this species is massive, and often attains a considerable size, an imperfectly developed latilaminar structure being in some instances recognisable. The cœnosteum is apparently fixed by a small portion of the inferior surface, a basal epitheca being absent. The concentric laminæ are simply curved, and the surface is therefore free from "mamelons," and merely exhibits a coarse vermicular reticulation corresponding with the skeletal framework, and pierced by rounded or sinuous apertures representing the mouths of the zoöidal tubes. Astrorhizæ are absent, or are irregularly and imperfectly developed.

The skeleton-fibre is about $\frac{1}{4}$ mm. in diameter, and has a coarsely porous structure (Fig. 21, A—C). The general skeletal tissue is of the reticulated type (Plate XXIII, figs. 10 to 12), but the radial pillars retain their individual distinctness to an extent not seen in any other species of *Stromatopora*. As a rule, the axial canals of the radial pillars are persistent, and the cut ends of these structures can be recognised in thin tangential sections (Plate V, fig. 12; and Plate XXIII, figs. 10 and 12) as rounded dark or light spaces, sometimes with a dark central dot, immersed in the substance of the general cœnosteal mesh. Vertical sections (Plate V, fig. 13; and Plate XXIII, fig. 11) also exhibit very distinct radial pillars, the axial canals of which are likewise occasionally recognisable in well-preserved examples (Plate V, fig. 13). The zoöidal tubes are very well developed, and are intersected by numerous thick and complete horizontal partitions or "tabulæ" (Plate V, fig. 13; and Plate XXIII, fig. 11). Three or four zoöidal tubes, with their intervening pillars, occupy a space of 2 mm. measured transversely.

Obs.—The cœnosteum of *S. Beuthii*, Barg., is usually hemispherical or spheroidal in shape, and is often of large size. The characteristic surface-features of the species are the coarse superficial reticulation, the want of "mamelons," and the more or less complete absence of astrorhizæ. A few examples apparently referable to this species do, however, exhibit astrorhizæ; but these are few in number and are irregularly developed. In its coarsely porous and very stout skeleton-fibre (Fig. 21), as also in the general character of the cœnosteal network, *S. Beuthii* closely approaches *S. Hüpschii*, Barg.; but the skeletal mesh is of a closer and less lax type, while the latter species has also a largely developed astrorhizal system. The essentially distinctive feature of *S. Beuthii*, however, is to be found in the condition of the radial pillars, these structures being, in good specimens, readily recognisable as separate from the general cœnosteal tissue in which they are immersed. As a result of this, polished horizontal or vertical slices of *S. Beuthii* (Plate XXIII, figs. 8 and 9) have a close general resemblance to corresponding slices of such a species of *Actinostroma* as *A. fenestratum*, Nich. Vertical slices, in particular, very nearly resemble similar sections of an *Actinostroma*, the radial pillars in such sections constituting an extremely

Fig. 21.

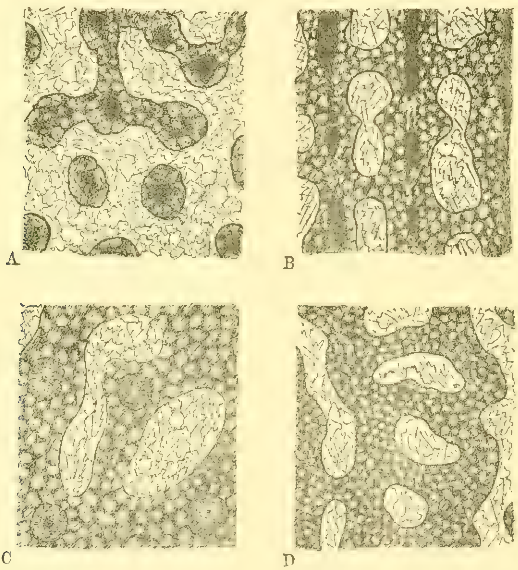


Fig. 21.—A. Tangential section of a specimen of *Stromatopora Beuthii*, Barg., from the Middle Devonian of Büchel, showing the axes of the persistent radial pillars as dark spaces in the general network. B. Vertical section of the same specimen. C. Tangential section of another specimen of *S. Beuthii*, from the Middle Devonian of Hebborn, showing clearly defined cross-sections of the radial pillars immersed in the general reticulation. D. Tangential section of a specimen of *S. Hüpschii*, Barg., from the Middle Devonian of Büchel, showing the complete disappearance of the radial pillars as separate structures. All the figures are enlarged about 30 times.

marked feature. On the other hand, thin sections (Fig. 21) show that the radial pillars, though apparently so distinct, are really buried in the interior of the general reticulation, the latter having all the characters observable in the other species of *Stromatopora*. In thin tangential sections (Plate V, fig. 12; Plate XXIII, figs. 10 and 12; and woodcut, Fig. 21, A and C) the cut ends of the radial pillars appear as more or less distinct rounded areas in the general cœnosteal network, from which they are usually distinguished by their greater density and darker colour. In some instances, as in Plate XXIII, fig. 12, they appear as light spaces, with a dark central dot representing the axial canals of the pillars. In parts of thin tangential sections—corresponding probably with places where the plane of the section traverses an interlaminar space—it is also not unusual to find that the reticulated character of the skeleton is lost, and we simply see the isolated rounded or oval ends of the transversely divided radial pillars. In such cases, as shown in Fig. 21, A (in the lower part of the figure), the radial pillars are seen to consist of an external sheath of porous tissue surrounding a central more compact core. On the other hand, the horizontal or oblique connecting-processes which join the radial pillars with one another, and which constitute the "concentric laminæ," are wholly composed of porous tissue, and have no central core. In thin vertical sections (Plate XXIII, fig. 11) the radial pillars are at once recognisable, but their central axes are usually but indistinctly seen. In some cases, however, as in Fig. 21, B, the dark central axes of the pillars can be clearly made out.

S. Beuthii, Barg., commonly occurs in the "Caunopora-state" (Plate XXIII, fig. 13; and Plate XXIV, fig. 1), in which condition it is with difficulty separable from *S. Hüpschii*, the distinctive character of the persistent radial pillars being much obscured or wholly lost.

I am not acquainted with any well-marked varietal forms of *S. Beuthii*. The species with which *S. Beuthii* is most nearly allied is *S. Hüpschii*, Barg., and the chief points of distinction between the two have been already pointed out in speaking of the latter form. In a general way, and in well-preserved examples, *S. Beuthii* is distinguished from *S. Hüpschii* by the more clear separation of the radial pillars from the general cœnosteal reticulation, and the less loose and open character of this latter; while the astrorhizæ are incompletely developed or may be absent, and the zoöidal tubes are more closely tabulate. Badly preserved specimens, or "Caunoporised" examples of *S. Beuthii* are, however, hardly to be distinguished with certainty from those of *S. Hüpschii*. There is no species of *Stromatopora*, except the above, with which *S. Beuthii* could be easily confounded.

Distribution.—*S. Beuthii* appears to be wholly confined to the Middle Devonian Rocks, occurring in deposits of this age both in Britain and on the Continent of Europe. In Devonshire it is commonly found in the limestones of Pit-Park Quarry, Dartington, and of Bishopsteignton, most examples being "Caunoporised." It also occurs with moderate frequency in the Devonian pebbles of the

Triassic conglomerates of Teignmouth. In Germany the species is tolerably abundant in the Middle Devonian Limestones of Hebborn and Büchel in the Paffrath district. A single poorly preserved example, which I collected at Gerolstein, differs from the ordinary form of the species in having a laminar cœnosteum.

8. Stromatopora Bücheliensis, *Bargatzky* sp. Pl. X, figs. 5—7, and Pl. XXIII, figs. 4—7.

Caunopora bücheliensis, *Bargatzky*. Die Stromatoporen des rheinischen Devons, p. 62, 1881.

Stromatopora bücheliensis, *Nicholson*. Monogr. Brit. Strom., General Introduction, p. 23, pl. x, figs. 5—7, 1886 (figured but not described).

The cœnosteum in this species is very variable in form, being mostly either massive or lobate, but being sometimes composed of slender cylinders united in bundles, or being in rare cases laminar in shape. A basal epitheca is present in the laminar examples, as, probably, in the massive specimens also.

Most specimens show a more or less distinct zonal mode of growth, the successive zones or strata of the cœnosteum hardly assuming the character of proper "latilaminæ," since they are directly continuous with one another, and thus mark but incomplete intermissions of growth.

Whatever may be the form of the cœnosteum, the concentric laminæ are simply curved, and "astrorhizal cylinders" are not developed, the surface being thus free from "mamelons." The surface shows a minute reticulation, the rounded or oval pores of which represent the apertures of the zoöidal tubes. Astrorhizæ are numerous, but are of small size, with few branches, their centres being usually placed at distances of 10 mm. or more apart.

The skeleton-fibre is minutely porous, and has a diameter of $\frac{1}{8}$ or $\frac{1}{9}$ mm. The cœnosteal tissue is of the reticulate type (Plate XXIII, fig. 7; and woodcut, Fig. 20, c), the radial pillars being united into a continuous network by horizontal or oblique bars of the same thickness as themselves. As seen in cross-sections, the cœnosteal mesh is close, with narrow and often sinuous interspaces representing the transversely divided zoöidal tubes. Vertical sections (Plate XXIII, fig. 6; and woodcut, Fig. 20, d) show that the radial pillars are distinctly recognisable, and that the cœnosteum is traversed by numerous narrow zoöidal tubes which are abundantly furnished with cross-partitions or "tabulæ." About seven zoöidal tubes, with their intervening pillars, occupy a space of 2 mm. measured transversely.

Obs.—The cœnosteum of *S. Bücheliensis*, Barg., is mostly of a lobate or sublobate form (Plate X, fig. 5), and of comparatively small size. Massive specimens, however, are not uncommon, and these may attain a diameter of several inches. The laminar form of cœnosteum is very rare, but is not absolutely unknown. Many specimens, again, consist of elongated, finger-like cylinders (Plate XXIII, fig. 4), which may be more or less isolated and separate, or which may be partially or wholly enwrapped and bound together by a common sheath of cœnosteal tissue (Plate XXIII, fig. 5). Each cylinder has the zoöidal tubes vertical in the centre, but bent outwards marginally so as ultimately to open on the surface more or less nearly at right angles to the axis of the growth. Individual cylinders vary in diameter from 1 to 2 cm. Examples with the peculiar mode of growth just described are so characteristic that they may be distinguished by a special title as *S. Bücheliensis*, var. *digitata*, Nich.

The surface of *S. Bücheliensis* is without eminences or "mamelons," and the astrorhizæ are characteristically small and remote. These structures are not placed in vertically superimposed systems, nor are astrorhizal cylinders, even in the digitated variety of the species, ever developed. As regards its internal structure, the present species has the porous skeleton-fibre and the completely reticulate cœnosteal tissue of all the species of *Stromatopora*. The skeleton-fibre is comparatively slender, and the skeletal network is of a close character, the zoöidal pores being mostly oval or elongated; the zoöidal tubes are very numerous and well developed, and are generally furnished with numerous transverse tabulæ (woodcut, Fig. 20, D).

S. Bücheliensis occurs very commonly in the "Caunopora-state." The "Caunopora-tubes" are usually very small, perhaps from $\frac{3}{10}$ to $\frac{4}{10}$ mm. in diameter; but in some specimens the tubes may be as much as from $\frac{1}{2}$ to $\frac{3}{4}$ mm. in diameter. Very generally the Caunopora-tubes show distinct funnel-shaped tabulæ, and in some cases they also possess short septal spines.

S. Bücheliensis is more nearly related to *S. Hüpschii*, Barg., than to any other species of the genus *Stromatopora*. It is, however, readily distinguished from the latter by its much finer skeleton-fibre and the correspondingly closer texture of the skeletal tissue; while the astrorhizæ are more remote and are more definitely circumscribed than is the case in *S. Hüpschii*. From *S. typica*, Rosen, the present species is likewise distinguished by its more delicate skeleton-fibre and the much more limited development of the astrorhizæ. From *S. florigera*, Nich., the species is readily separated by the remoteness of the astrorhizæ, as well as by the fact that these structures are not placed in regular vertical systems, while the skeletal network is also finer and closer.

Distribution.—*S. Bücheliensis*, Barg., appears to be wholly confined to rocks of Middle Devonian age, and is a common species both in Britain and the Continent of Europe. Both the ordinary lobate or massive forms of the species and the digitated variety occur commonly in the Middle Devonian Limestones of Dartington (Pit-Park Quarry), and are found abundantly in the Devonian pebbles of the Triassic conglomerates at Teignmouth. In Germany the species is not uncommon in the Middle Devonian Limestone of Büchel, in the Paffrath district, most examples from this locality being lobate in form. The species does not seem to occur at Hebborn, in the same district, and is of rare occurrence at Gerolstein, in the Eifel.

9. STROMATOPORA DISCOIDEA, *Lonsd.* sp. Pl. III, fig. 3; Pl. VII, figs. 1 and 2; and Pl. XXIV, figs. 2—8.

PORITES DISCOIDEA, *Lonsdale.* Silurian System, p. 688, pl. xvi, fig. 1, 1839.
HELIOLITES? DISCOIDEUS, *Salter.* In Murchison's Siluria, 3rd ed., pl. xxxix, fig. 1, 1859.
STROMATOPORA ELEGANS, *von Rosen.* Ueber die Natur der Stromatoporen, p. 63, Taf. ii, fig. 8, and Taf. iii, figs. 1 and 2, 1867. (Non *Stromatopora elegans*, Carter, Ann. and Mag. Nat. Hist., ser. 5, vol. iv, 1879.)
CŒNOSTROMA DISCOIDEUM, *Lindström.* Kongl. Svenska Vetenskaps-Akad. Handlingar, Bd. ix, Taf. i, figs. 6 and 7, 1870.
STROMATOPORA DISCOIDEA, *Nicholson.* Monogr. Brit. Strom., General Introduction, pl. iii, fig. 3, and pl. vii, figs. 1 and 2, 1886 (figured but not described).

The cœnosteum of this species is essentially of the laminar or expanded type, and usually has the form of a thinner or thicker disc, attached by a portion of the base to some foreign body, and having the rest of the under surface covered with a concentrically wrinkled or striated epithecal membrane. In some cases, while the same general form is retained, the cœnosteum is so thickened as to assume a hemispherical shape, the base remaining flat or concave. In the thinner examples growth of the skeleton is continuous, but in the thicker examples more or less regular "latilaminæ" are observable, indicating periodic pauses in the process of growth.

The concentric laminæ are simply undulated, and the surface is therefore free from eminences or "mamelons." Astrorhizæ are extraordinarily developed, being not only very numerous, but being of an excessively ramified or arborescent type (Plate III, fig. 3; and Plate XXIV, fig. 2). The astrorhizæ vary in size in different individuals, their centres being usually from 5 to 7 mm. apart; but in all cases they become more or less completely confluent with one another by the inosculation of their terminal twigs with those of adjoining systems. As a result of this, the entire surface (Plate XXIV, figs. 3 and 4) becomes mapped out into innumerable small and irregular polygonal areas, bounded on all sides by the interlacing astrorhizal canals. These areas, as seen in well-preserved examples, are studded with minute rounded pores, which represent the openings of the zoöidal tubes. The astrorhizæ are not arranged in vertically superimposed systems.

As regards the internal structure of the cœnosteum, the skeleton-fibre (Plate XXIV, fig. 5) is minutely porous, and has a diameter of from $\frac{1}{5}$ to $\frac{1}{4}$ mm. Tangential sections (Plate XXIV, fig. 6) show that the skeletal tissue is completely reticulate, while the meshwork—owing to the thickness of the skeleton-fibre and the small size of the zoöidal tubes—is exceptionally dense. Such sections show the repeatedly branched astrorhizal canals—often intersected by transverse calcareous partitions ("astrorhizal tabulæ")—and also the minute rounded openings of the transversely divided zoöidal tubes. Vertical sections (Plate XXIV, fig. 7) show numerous thick and irregular radial pillars, which are separated by the zoöidal tubes, and are united at short intervals by stout and irregular horizontal or oblique connecting-processes. The zoöidal tubes are intersected by numerous straight or curved transverse partitions or tabulæ. About five zoöidal tubes, with their intervening pillars, occupy a space of 2 mm. measured transversely.

Obs.—The form of the cœnosteum in this species is remarkably constant, being always that of a thicker or thinner disc-like expansion, with a basal epitheca. Average examples vary from 6 or 8 cm. to 10 or 12 cm. in diameter, with a thickness in the centre of from 1 to 5 cm., but hemispherical examples may be considerably thicker than this.

The surface-features in *S. discoidea* are essentially conditioned by the form of the astrorhizæ, and are exceedingly characteristic. The astrorhizæ are excessively branched, and also anastomose with their neighbours round their entire periphery, there being thus no definite boundary between one astrorhiza and those next it. Hence the surface is wholly cut up by the astrorhizal grooves into irregularly shaped islands of cœnosteal tissue (Plate XXIV, figs. 3 and 4), which are pierced by the minute rounded openings of the zoöidal tubes. Even where the surface has been much weathered it is generally possible to recognise under a lens the peculiar lobulated structure thus produced. Though developed on the surface of each successive lamina of the colony, the astrorhizæ do not form regular vertical systems springing from axial wall-less canals, and there are therefore no superficial eminences or "mamelons."

The skeleton-fibre is minutely porous, but the pores are usually infiltrated with some dark material, and appear therefore in thin sections as so many opaque dots (Plate XXIV, fig. 5). This phenomenon is commonly seen in all the species of *Stromatopora*, and it is not an unusual thing to find that part of a thin section may have the pores simply filled with clear calcite, and therefore appearing as rounded vacuities, while another portion of the same has the pores infiltrated with opaque material, and appearing as dark spots. The skeleton-fibre of *S. discoidea* is, however, particularly prone to undergo change by mineralisation, and thin sections of altered specimens often show puzzling appearances. In Plate VII, figs. 1 and 2, I have figured thin sections of one of these partially decomposed specimens, in which the skeleton-fibre has assumed a minutely dotted appearance, but in which the characteristic features of the cœnosteum are still clearly recognisable. In more extreme cases, however, the minute structure of the skeleton becomes more or less extensively obliterated, and the diagnostic features of the species can with difficulty be recognised in thin sections, or may be wholly lost; and it is a curious fact that this highly mineralised condition of the cœnosteum is often found in specimens in which the preservation of the surface-characters may be exceedingly good. It is also to be noted that the most highly mineralised examples of *S. discoidea* yield thin sections which might readily be confounded with corresponding sections of altered examples of *Actinostroma astroites*, Rosen sp.

On the other hand, well-preserved specimens of *S. discoidea* yield thin sections which are quite characteristic. Tangential sections (Plate XXIV, fig. 6) show appearances closely conforming with those of the surface, the skeletal network having the form of numerous irregular islands of dense cœnosteal tissue, perforated by the minute openings of the transversely divided zoöidal tubes, and separated by branches of the astrorhizæ. Vertical sections (Plate XXIV, fig. 7) are characterised by the thick radial pillars, and by the presence of well-defined and abundantly tabulate zoöidal tubes.

S. discoidea often encrusts or envelops corals or other foreign bodies in the course of its growth, but I have never seen a specimen in the "Caunopora-state." Very commonly the cœnosteum contains embedded *Spirorbes*, which are often arranged in vertical rows, as they become successively immersed in the tissue of the growing Stromatoporoid.

From *S. typica*, Rosen—its nearest ally—as from all other recorded forms of *Stromatopora*, the present species is readily distinguished by the remarkable development of the astrorhizal system and the resulting characters of the surface, as also by the density and closeness of the cœnosteal network.

Having examined the original specimen of *S. elegans*, Rosen, as well as thin sections of the same, I am satisfied that this name is synonymous with *S. discoidea*, Lonsd. Von Rosen's specimen of *S. elegans* is, in fact, an example of *S. discoidea*, Lonsd., in which the skeleton has been largely altered by mineralisation, as shown in the tangential section which I have figured (Plate XXIV, fig. 8).

Distribution.—*S. discoidea*, Lonsd. sp., is entirely confined to the Silurian Rocks, and has hitherto been recognised only in the Wenlock Limestone of Britain, and in corresponding deposits in Northern Europe. In the Wenlock Limestone of England the species is moderately common, occurring at Ironbridge, Much Wenlock, and Dudley; but really well-preserved examples are rare. In the Wenlock Limestone of Wisby (Gotland) *S. discoidea* appears to be a common species, the specimens from this region being usually highly mineralised, but commonly having the surface well preserved. In Esthonia the species has hitherto been recognised only at the single locality of Kleine Ruhde, occurring in limestones belonging to the zone of *Pentamerus ehstonus*.

Genus 2.—PARALLELOPORA, *Bargatzky*, 1881.

(Introduction, p. 95.)

1. PARALLELOPORA GOLDFUSSII, *Bargatzky*. Pl. XI, figs. 7—9; and Pl. XXV, figs. 4—9. Woodcuts, figs. 22, 24, and 25.

PARALLELOPORA GOLDFUSSII, *Bargatzky*. Die Stromatoporen des rheinischen Devons, p. 63, 1881.

Cœnosteum irregularly spheroidal or clavate, from 2 to 7 cm. in diameter, with a limited basal attachment, and apparently devoid of an epitheca. The mode of growth is not distinctively latilaminar, and the concentric laminæ are simply curved, the surface being free from "mamelons." Where observed, the surface shows a moderately coarse reticulation, with oval, rounded, or vermiculate pores representing the mouths of the zoöidal tubes; or it may be partially covered by an apparently imperforate calcareous membrane.

Astrorhizæ are present, but are variably developed, being sometimes small and inconspicuous, and at other times composed of large, few-branched canals. In the latter case the astrorhizæ are exceedingly irregular in their distribution, being abundant in some specimens and nearly absent in others. The horizontal canals of the astrorhizæ are often furnished with oblique or transverse calcareous partitions ("astrorhizal tabulæ"); and are sometimes connected with comparatively large, rounded or oval internal cavities, which are scattered through the cœnosteum, and are also furnished with calcareous partitions or tabulæ. These cavities are not always present, and may possibly be connected with reproduction, thus representing the "ampullæ" of the Hydrocorallines.

As regards its internal structure, the skeleton-fibre of *Parallelopora Goldfussii* is from $\frac{1}{6}$ to $\frac{1}{5}$ mm. in diameter, and has a peculiar porous or tubulated structure, which will be more fully described hereafter, but the most characteristic feature of which is the appearance, in thin sections, of isolated clear spaces of comparatively considerable size within the substance of the fibre (Plate XXV, figs. 4—7). The skeleton-fibre thus constituted is woven into an irregular network enclosing the vertical, straight or flexuous zoöidal tubes. In tangential sections (Plate XXV, fig. 4) this irregular reticulation is seen to be traversed by the scattered and commonly tabulate branches of the astrorhizæ, and pierced by the variably shaped apertures of the transversely divided zoöidal tubes. Vertical sections (Plate XXV, figs. 5 and 9) show that the cœnosteal tissue is composed of thick and irregular radial pillars united at intervals by thick horizontal or oblique connecting-processes, the network thus formed enclosing numerous zoöidal tubes, which are furnished with well-developed transverse tabulæ. About six zoöidal tubes, with their intervening pillars, occupy a space of 2 mm. measured transversely.

Obs.—The cœnosteum of *P. Goldfussii*, Barg., is typically spheroidal, pyriform, or clavate in shape (woodcut, Fig. 22), and is usually of small size. The

FIG. 22.

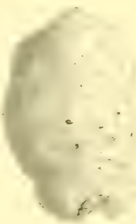


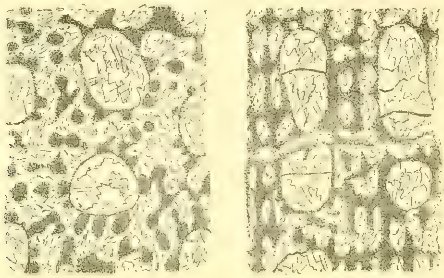
FIG. 22.—A small specimen of *Parallelopora Goldfussii*, Barg., from the Middle Devonian of Hebborn, viewed sideways; of the natural size.

specimens from the Middle Devonian Rocks of Hebborn (Paffrath district) are mostly stunted, being usually about 2 to 3 cm. in diameter; whereas those from Steinbreche near Refrath, in the same area, are of considerably larger size. There is no trace of an epitheca in such specimens as I have seen; and the cœnosteum often envelops corals and other foreign bodies. The specimens from Devonshire, being mostly derived from the Devonian pebbles in the Triassic breccias of that region, have no recognisable form as a rule; but a badly preserved example from Dartington, apparently referable to this species, has a massive cœnosteum of considerable size, with much-undulated laminæ.

The astrorhizal system is remarkably variable in its development in this species. Some examples show only very small and scattered astrorhizæ; but the typical state of things is to find irregularly distributed astrorhizæ consisting of a few slightly branched canals of large size, the internal cavities of these being generally intersected by calcareous partitions or "astrorhizal tabulæ" (Plate XXV, fig. 4). In vertical sections the cut ends of these large astrorhizal canals (when these structures are present) appear as round or oval apertures of considerable size. Apart from these, however, some specimens show numerous irregular, oval or rounded cavities of considerable proportionate dimensions, which appear to be generally in connection with the astrorhizal canals, though this cannot always be demonstrated. Such cavities are commonly crossed by calcareous partitions, and are entirely wanting in some specimens. They are more largely developed in the allied *P. capitata*, Goldf. sp., than in the present form, and may perhaps be compared with the "ampullæ" of the existing Hydrocorallines. Leaving out of sight the minute structure of the skeleton-fibre itself, the cœnosteal tissue of *Parallelopora Goldfussii* is built upon the same general plan as that of *Stromatopora* proper. The skeleton-fibre presents, however, very remarkable microscopic characters, and it may be as well here to treat of these in some detail, as regards not only the present species but also its immediate allies, since upon this alone depends any distinction which can be drawn between *Parallelopora*, Barg., and *Stromatopora*, Goldf.

The type-species of Bargatzky's genus *Parallelopora* is *P. ostiolata*, Barg., of the Middle Devonian of Germany, a form which has not hitherto been recognised in Britain, and which does not, therefore, fall to be described here. Only a single imperfect specimen of this remarkable type is at present known, and, by the kindness of Prof. Schlüter, I have been enabled to examine this both macroscopically and by means of thin sections. As previously pointed out (Introduction, p. 95), the cœnosteal tissue of *P. ostiolata*, Barg., is completely reticulate, and is traversed by numerous tabulate zoöidal tubes (Plate II, figs. 6 and 7), the general structure thus entirely agreeing with that of *Stromatopora* proper. The skeleton-fibre is, however, peculiar in being traversed by numerous dark, rod-like bodies of very minute size, which have a general direction parallel to the radial pillars, or, in other words, at right angles to the surface. As seen in tangential sections (Plate II, fig. 6; and woodcut, Fig. 23, A), these rods appear as rounded or oval black dots, scattered throughout the fibre, but most abundant round the margins of the zoöidal tubes. In vertical sections (Plate II, fig. 7; and woodcut, Fig. 23, B) the rods in question are seen as dark-coloured vertical lines, connected at intervals by similarly dark-coloured transverse beams, thus giving to the fibre the appearance of a trellis-like tissue. Bargatzky (op. cit. supra, p. 51, figs. 10 and 11) interpreted the appearance just described as indicating that the cœnosteum of *P. ostiolata* was composed of numerous interstitial tabulate tubes of minute size, surrounding and isolating a series of larger tabulate tubes, the structure being thus comparable with that seen in some Monticuliporoids (as in *Callopora*), or in *Heliolites*. Bargatzky's figures, however, are ideal, and no traces of the supposed minute cœnenchymal tubes of *P. ostiolata* can be detected in properly prepared thin sections. On the contrary, it is quite certain that the large tabulate zoöidal tubes of *P. ostiolata* are simply enclosed in a reticulated skeleton, the fibre

Fig. 23.



A B

Fig. 23.—A. Part of a tangential section of *Parallelopora ostiolata*, Barg., from the Middle Devonian Rocks of Büchel (Paffrath district), enlarged 80 times. B. Part of a vertical section of the same, similarly enlarged.

of which is traversed by dark and seemingly solid rods. It is quite probable that these apparent rods are really the result of the infiltration with opaque matter of a system of minute tubuli running in the interior of the reticulated skeleton-fibre; but it may be taken as altogether certain that such tubuli are part of the fibre itself, and are in no way comparable with the interstitial tubes ("mesopores") of the Monticuliporoids or the "siphonopores" of the *Heliolitidæ*.

In *Parallelopora Goldfussii*, Barg., the appearances presented by the skeleton-fibre, as seen in thin sections, differ considerably from those shown by corresponding sections of *P. ostiolata*, though the differences observed may be largely the result of differences in the mode of preservation, and in the extent to which mineralisation has been carried. In a tangential section of a well-preserved specimen of *P. Goldfussii* (Plate XXV, fig. 4; and woodcut, Fig. 24) the skeleton-fibre is seen to be thick, and to be completely reticulated, while it exhibits in its substance numerous small round or oval spaces, which are filled with clear calcite, and thus look like the apertures of transversely divided tubuli. As the result of this, tangential sections acquire a characteristic perforate or cribriform appearance (Plate XXV, figs. 4 and 8), which differs from the uniformly porous aspect presented by corresponding sections of any species of *Stromatopora* proper in so far that the apparent pores in the fibre are few in number and comparatively large in size. *Vertical* sections of a well-preserved specimen of *P. Goldfussii* do not, however, show the presence in the fibre of regular vertical tubules, such as would be inferred to exist from the phenomena exhibited by tangential sections. On the contrary, such sections (Plate XXV, figs. 5 and 7; and woodcut, Fig. 25) show that the skeleton-fibre is penetrated by clear round spaces or pores similar to those seen in tangential sections, while irregular branching canaliculi appear to be also present. The information

FIG. 24.

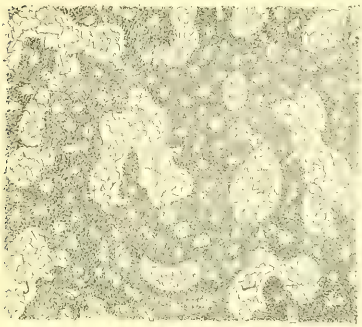


FIG. 24.—Part of a tangential section of a specimen of *Parallelopora Goldfussii*, Barg., from the Middle Devonian of Steinbreche (Paffrath district), enlarged 50 times.

FIG. 25.

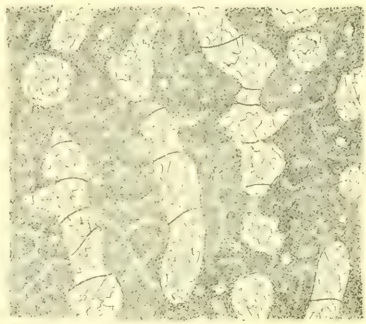


FIG. 25.—Part of a vertical section of the preceding specimen of *Parallelopora Goldfussii*, similarly enlarged.

derivable from both sets of sections would thus lead to the belief that the skeleton-fibre of *P. Goldfussii* is traversed by minute and irregular canals, together with moderately numerous vesicular cavities of comparatively large size. If this view be correct, then the structure of the skeleton-fibre in *Parallelopora Goldfussii* differs from that seen in *Stromatopora* or *Stromatoporella* in degree rather than in kind.

In certain states of preservation, however, the skeleton-fibre of *P. Goldfussii* presents appearances differing considerably from those described above. The skeleton-fibre, namely, often appears in tangential sections as if it were composed of nearly transparent calcite, in which are developed dark granular tracts which inosculate with one another to form an irregular open network or a close reticulation (Plate XI, fig. 7,[1] and Plate XXV, fig. 6). In vertical sections (Plate XXV, fig. 7) the fibre may show appearances very similar to those seen in tangential sections; or the dark tracts in the fibre may assume more or less of a ladder-like or trellis-like arrangement (Plate XI, fig. 8). In *Parallelopora capitata*, Goldf. sp., the appearances presented by the skeleton-fibre in thin sections are very similar to those shown by *P. Goldfussii*, Barg.; and in *P. dartingtonensis*, Cart. sp., there are indications that the fibre is similarly constituted, though none of my

[1] This figure (as also fig. 8 of the same plate) is doubtfully referred in the explanation of the plate to *Parallelopora* (*Idiostroma?*) *capitata*, Goldf., but it really belongs to the species here under consideration.

specimens are in a state of preservation suitable for the exhibition of the characters in question.

Upon the whole, it would appear that the genus *Parallelopora* is nearly allied to *Stromatopora*, but that it may be fairly separated from this by the structure of the skeleton-fibre. In *Stromatopora*, Goldf., the skeleton-fibre is minutely porous, being traversed throughout by innumerable small vacuities, which are closely contiguous. In *Parallelopora*, Barg., on the other hand, the thick fibre is penetrated by irregular canaliculi, and also contains a moderate number of comparatively large vacuities or pores, which are scattered through the fibre at intervals. As a result of this, tangential sections show a markedly perforate or cribriform character of the fibre, which can commonly be recognised in polished specimens even with a hand-lens, while vertical sections show a similarly perforate aspect, or may exhibit a lattice-like structure.

Putting aside the peculiar structure of the skeleton-fibre, thin sections of *Parallelopora Goldfussii*, Barg., nearly resemble in general type those of various species of *Stromatopora*. The zoöidal tubes are excavated in the reticulated cœnosteal tissue, and appear in cross-sections (Pl. XXV, fig. 4) as rounded or oval or sinuous perforations, while they are seen in long sections (Plate XXV, fig. 5) to be provided with numerous tabulæ. The radial pillars are wavy, but are approximately parallel, and are connected at irregular intervals by thick cross-bars.

In some instances (Plate XXV, figs. 8 and 9) *P. Goldfussii*, Barg., occurs in the "Caunopora-state," the "Caunopora-tubes" being furnished with funnel-shaped tabulæ.

From *P. capitata*, Goldf. sp., which it nearly resembles in general form, the present species is sufficiently distinguished by the much finer texture of the skeletal tissue and the smaller and more closely set zoöidal tubes. From *P. dartingtonensis*, Cart. sp., on the other hand, the present species is separated by its thicker skeleton-fibre, and particularly by the fact that the radial pillars are comparatively stout and irregular, whereas in the former these structures are narrow, close-set, and straight. Moreover, the cœnosteum in *P. Goldfussii* is comparatively small and is typically spheroidal in shape, while it is massive or laminar in *P. dartingtonensis*, and may attain a considerable size.

Distribution.—*Parallelopora Goldfussii*, Barg., is not uncommon in the Middle Devonian Limestones of the Paffrath district, occurring at Hebborn, Hand, and Steinbreche (near Refrath), the last locality in particular yielding excellent examples. In the Devonian Rocks of Devonshire the species occurs rarely in the pebbles of the Triassic conglomerates, and I have a single doubtful example from Dartington.

2. Parallelopora capitata, *Goldfuss* sp. Pl. XXV, figs. 10—13. Woodcuts, Figs. 26 and 27.

Tragos capitatum, *Goldfuss.* Petrefacta Germaniæ, p. 13, Taf. v, fig. 6, 1826.
Stromatopora capitata, *D'Orbigny.* Prodr. de Paléontologie, p. 51, 1850.
— concentrica, *Bargatzky* (pars). Die Stromatoporen des rheinischen Devons, p. 54, 1881.
Idiostroma capitatum? *Nicholson.* Monogr. Brit. Strom., General Introduction, p. 63, fig. 8, and p. 104, 1886.

The cœnosteum in this species is of the massive type, and is usually spheroidal or pyriform in shape (woodcut, Fig. 26), being attached by a small portion of its

Fig. 26.

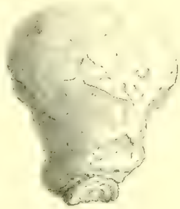


Fig. 26.—Side view of a small specimen of *Parallelopora capitata*, Goldf. sp., from the Middle Devonian of Hebborn (Paffrath district), of the natural size.

under surface, and not having a basal epitheca. The cœnosteum did not attain a great size, most examples being from 2 to 6 cm. in diameter. Growth is not distinctly latilaminar, and the concentric laminæ are generally simply curved or undulated, the surface being thus approximately smooth or simply nodulated. When well preserved, the surface shows a coarse vermiculate reticulation, corresponding with the form of the skeletal network, along with large and irregularly distributed astrorhizal canals (woodcut, Fig. 26), but parts of the surface may be concealed beneath an apparently imperforate calcareous membrane.

Astrorhizæ are developed in an irregular manner, their tubes (woodcut, Fig. 27, *c c*) being of very large size, and furnished internally with numerous transverse calcareous partitions ("astrorhizal tabulæ"), which sometimes assume a subvesicular character (Plate XXV, fig. 10).

Sometimes connected with the astrorhizal tubes, or at other times independently scattered throughout the cœnosteal tissue, are large, lenticular, oval, or spherical vesicles, which are apparently destitute of proper walls, and are about a millimètre in average diameter. These vesicles are occasionally crossed by one or more calcareous partitions, and may possibly be connected with reproduction, and may correspond with the ampullæ of the recent Stylasterids.

Fig. 27.

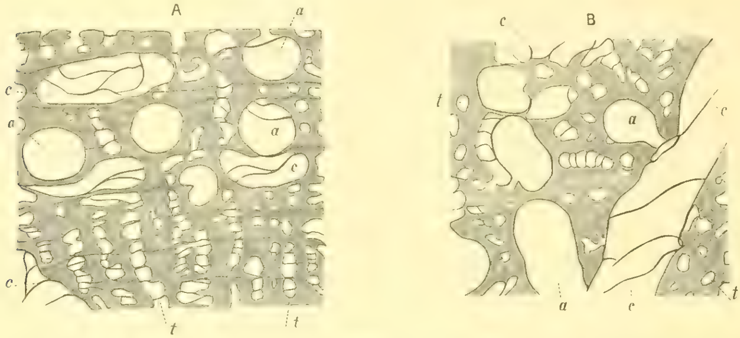


Fig. 27.—A. Vertical section of *Parallelopora capitata*, Goldf. sp., from the Devonian Rocks of Hebborn (Paffrath district), enlarged 12 times. B. Tangential section, similarly enlarged. *a a.* Supposed "ampullæ." *c c.* Large tabulate tubes belonging to the astrorhizæ. *t t.* The ordinary zoöidal tubes.

The skeleton-fibre is stout, and possesses a tubulated or perforate structure (Plate XXV, fig. 13), similar to that previously described in *P. Goldfussii*, Barg., though, owing to the imperfect state of preservation of the majority of specimens, this can only be clearly made out in an occasional example. The cœnosteal tissue, as seen in tangential sections (Plate XXV, figs. 10 and 11; and woodcut, Fig. 27, B), is irregularly reticulated, and is traversed by the irregularly distributed, tabulate astrorhizal canals, and by the apertures representing the transversely divided zoöidal tubes. As seen in vertical sections (Plate XXV, fig. 12; and woodcut, Fig. 27, A) the skeleton is composed of stout, approximately parallel radial pillars, which are connected at short intervals by thinner or thicker cross-bars, tolerably regular and close-set "concentric laminæ" being in this way sometimes developed. The radial pillars are separated by well-developed zoöidal tubes, which are intersected by numerous straight or curved "tabulæ." About four zoöidal tubes, with their intervening radial pillars, occupy the space of 2 mm. measured transversely. Vertical sections also show the large rounded apertures of the transversely divided astrorhizal tubes as well as the supposed "ampullæ" above spoken of, these structures communicating to such sections (Plate XXV, fig. 12; and woodcut, Fig. 27, A) a very characteristic aspect.

Obs.—I do not feel at all certain as to the identification of this species with the *Tragos capitatum* of Goldfuss; since no thin sections of the original of the latter are in existence, and the preparation of such might very possibly show that the form which Goldfuss had in view was really the subsequently described *P. Goldfussii* of Bargatzky. Owing to the very close general resemblance between the form now under consideration and that described by Bargatzky as *P. Goldfussii*, I was formerly disposed to think (General Introduction, p. 104) that we had to deal with a single species only, for which the specific name given by Goldfuss should be retained; but I am now satisfied that the two are really distinct. This being the case, it will be best to retain Bargatzky's name for the species to which he originally gave it, and to apply provisionally to the present species the title given by Goldfuss. I was also formerly disposed to think (loc. cit.) that this species might be referred to the genus *Idiostroma*, Winch.; but a further and more complete investigation has shown that the large and irregular tabulate tubes by which the cœnosteum is traversed are really of the nature of astrorhizal canals, and that the proper place of the species is in the genus *Parallelopora*.

In the general form of the cœnosteum, the characters of the surface, the general structure of the skeletal tissue, the irregular development of the astrorhizæ, and the common presence of scattered lenticular or globular vesicles (ampullæ?) of large size, the present species very closely resembles *P. Goldfussii*, Barg. It is, however, distinguished from the latter by the very much coarser nature of the cœnosteal tissue; so that even with the aid of a pocket lens only it is usually easy to separate examples belonging to these two types. All the specimens of *P. capitata* which I have investigated are more or less highly mineralised; and in most cases the minute structure of the skeleton-fibre has been largely or wholly destroyed. It is, therefore, rarely possible to fully determine the characters of the skeleton-fibre; but so far as these can be made out they agree essentially with those distinctive of *P. Goldfussii*. From *P. dartingtonensis*, Cart. sp., the present form is at once distinguished by its greatly more robust fibre and the irregular development of the astrorhizæ.

Distribution.—*P. capitata*, Goldf. sp., occurs commonly in the Middle Devonian Limestone of Hebborn (Paffrath district), in association with *P. Goldfussii*, Barg.; but it appears to be wholly absent at Steinbreche (Refrath), where the latter species is very abundant. The species also occurs, though by no means plentifully, in the Devonian pebbles in the Triassic breccias of South Devon.

3. Parallelopora dartingtonensis, *Carter* sp. Pl. IV, fig. 1; Pl. XXIV, figs. 13—15; and Pl. XXV, figs. 1—3.

Stromatopora elegans, *Carter*. Ann. and Mag. Nat. Hist., ser. 5, vol. iv, p. 263, 1879 (non *Stromatopora elegans*, Rosen).

— dartingtonensis, *Carter*. Ibid., vol. vi, p. 346, pl. xviii, figs. 1—5, 1880 (fig. 1 of the plate is doubtfully referable to this species, and perhaps belongs to *Stromatoporella eifeliensis*, Nich.).

The cœnosteum in *P. dartingtonensis*, Cart. sp., is massive or laminar in form, and often attains a considerable size; the mode of attachment and condition of the under surface is not thoroughly known. The mode of growth is often more or less clearly latilaminar, though in many specimens this feature is not conspicuous. The concentric laminæ are generally simply curved or slightly undulated. The astrorhizæ (Plate XXIV, figs. 13 and 14) are extensively but variably developed, consisting usually of large stellate branching canals, the cavities of which are crossed by more or fewer internal partitions ("astrorhizal tabulæ"). Commonly the astrorhizæ are arranged in vertically superimposed systems, each system being connected with an axial wall-less canal; but this disposition of parts is not always recognisable. Owing to the curvature of the concentric laminæ, the astrorhizal canals commonly exhibit a more or less truncated or irregular disposition in straight tangential sections (Plate XXIV, fig. 13), while their cut ends appear at intervals in vertical sections as large rounded or oval apertures. The centres of the astrorhizæ are usually from 1 to 2 cm. apart. The condition of the surface is imperfectly known, but it is probable that there were more or less pronounced eminences or "mamelons," corresponding with the centres of the astrorhizal systems.

As regards the minute structure of the skeleton, an examination of the surface of polished specimens with a pocket lens clearly shows the skeleton-fibre to possess the perforate or cribriform character which distinguishes the species of *Parallelopora*. Owing, however, to the bad state of preservation of most specimens, this feature is often more or less completely lost in thin sections; though indications of it may be observed in most examples, and in a few cases the structure in question can be clearly observed (Plate XXV, fig. 2).

When examined in thin tangential sections (Plate XXIV, fig. 15; and Plate XXV, fig. 2) the cœnosteal tissue is seen to be essentially of the reticulate type, though the reticulation is not so complete as in the species of *Stromatopora* proper. Such sections also commonly show the transversely partitioned astrorhizal canals. Vertical sections (Plate XXV, figs. 1 and 3) show the cœnosteum to be made up of delicate, close-set, and very distinct radial pillars, which are united at short and regular intervals by comparatively thin horizontal cross-bars, these latter giving rise to the appearance of regular and closely arranged "concentric laminæ." About nine or ten pillars occupy a space of 2 mm. measured transversely, and about the same number of "concentric laminæ" occupy this space measured vertically. The spaces between the radial pillars represent the zoöidal tubes, and these, in well-preserved specimens, exhibit a moderate number of straight or curved tabulæ.

Obs.—As regards its larger characters, so far as these are known, *Parallelopora dartingtonensis* is chiefly distinguished from the allied *P. Goldfussii*, Barg., by its massive or laminar mode of growth, and the extensive development and comparatively great size of the astrorhizæ, as well as by the common arrangement of these structures in vertical systems. It is, however, essentially by the minute structure of the skeleton that the present species is separated from its congeners, as well as from the species of *Stromatopora* and *Stromatoporella*. The principal characteristic features in the internal structure are the distinctness of the narrow radial pillars, and the regularity and slender form of the connecting processes by which these are united. These characters give to vertical sections (Plate XXV, figs. 1 and 3) the aspect of corresponding sections of an *Actinostroma* rather than of one of the *Stromatoporidæ* proper. On the other hand, the connecting processes of the pillars are not developed in whorls, as they are in the species of *Actinostroma;* and tangential sections show nothing, therefore, of the "hexactinellid" structure so characteristic of the genus *Actinostroma*. On the contrary, tangential sections (Plate XXIV, fig. 15, and Plate XXV, fig. 2) show that the skeleton is, in the main, a reticulated one, as it is in the *Stromatoporidæ* generally. At the same time, owing to the distinctness of the radial pillars, and also to the fact that their connecting processes are developed at regular levels, the reticulation of the skeleton, as seen in tangential sections, is not so complete as in the species of *Stromatopora* proper. Indeed, where the plane of such a section happens to coincide with an interlaminar space (*i.e.* a space between two contiguous sets of connecting processes) the reticulated character of the skeleton is lost, and we see only the detached rounded or oval ends of the transversely divided pillars. It was this phenomenon which induced me in the earlier portion of this work to take the view that the present species might possibly find a place in the genus *Stromatoporella*. Upon the whole, however, the characters of the skeleton-fibre, so far as these have been ascertained, would show that the species is properly referable to *Parallelopora*, with which genus it also agrees in the possession of large "tabulate" astrorhizal tubes.

The form with which the present species seems to be most nearly allied is *P. Goldfussii*, Barg., and this alliance is particularly shown in a variety of the species which I may term *P. dartingtonensis*, var. *filitexta*. This variety is distinguished from the normal form of the species by its more delicate skeleton-fibre (Plate XXV, fig. 2), and by the less regular development of the radial pillars (Plate XXV, fig. 3), tangential and vertical sections having thus a markedly distinctive character communicated to them. In this variety also the peculiar perforate character of the skeleton-fibre is more marked, or, at any rate, is more conspicuous, than it is in the ordinary form of the species.

Specimens of *P. dartingtonensis* often occur in a "reversed" condition, when they are known to the Devonshire lapidaries as "stag-horn" specimens. In this condition (Plate IV, fig. 1) the astrorhizal canals, as well as the other internal cavities of the cœnosteum, have been filled, as previously explained (p. 31), with a more or less opaque calcareous mud, while the real skeleton has been more or less extensively converted into transparent calcite. A "reversed" state of preservation is, however, by no means peculiar to the present species, and I have noticed it in *Stromatopora florigera*, Nich., *S. inæqualis*, Nich., and occasionally in *S. concentrica*, Goldf.

I have never seen an example of *S. dartingtonensis* in the "Caunopora-state," though there is no reason to doubt that it occurs occasionally in this condition.

Distribution.—*Parallelopora dartingtonensis*, Cart. sp., has hitherto been recognised only in the Middle Devonian Limestones of Devonshire. The ordinary form of the species is not uncommon at Pit-Park Quarry, Dartington (the original locality for the species). Both the normal form of the species and the variety *filitexta* occur not uncommonly in the Devonian pebbles of the Triassic conglomerates of South Devon.

Genus 3.—Stromatoporella, *Nicholson*, 1886.

(General Introduction, p. 92.)

1. Stromatoporella granulata, *Nich.* Pl. I, figs. 4 and 5 and 14 and 15; Pl. IV, fig. 6; Pl. VII, figs. 5 and 6; and Pl. XXVI, fig. 1.

Stromatopora granulata, *Nicholson*. Ann. and Mag. Nat. Hist., ser. 4, vol. xii, p. 94, pl. iv, figs. 3, 3 *a*, 1873.
— — — Ibid., ser. 5, vol. xviii, p. 10, 1886.

The cœnosteum in this species forms laminar expansions of considerable size, which are not incrusting, but are attached basally by a peduncle, and have the rest of the lower surface covered by a concentrically wrinkled and striated epitheca. The thickness of the cœnosteum varies from less than 2 mm. up to 2 or 3 cm. The surface (Plate XXVI, fig. 1, and Plate IV, fig. 6) shows a variable number of low rounded or conical eminences or "mamelons," the apices of which are usually perforated, each showing in general a single circular opening representing the axial canal of one of the astrorhizal systems. From the apices of the mamelons radiate more or less conspicuous astrorhizal gutters, and the general surface is covered with close-set tubercles of various sizes, the smaller of these being imperforate, while the larger ones are pierced at their apices by distinct circular apertures (Plate I, fig. 14). In places the surface-tubercles coalesce into

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A MONOGRAPH

OF THE

BRITISH STROMATOPOROIDS.

BY

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PART IV.

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Pages 203—234; Plates XXVI—XXIX.

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vermiculate ridges. Parts of the surface may be covered by a thin calcareous membrane, which is perforated by scattered circular apertures (Plate IV, fig. 6).

As regards its internal structure, the skeleton-fibre is minutely porous, or is penetrated by delicate canaliculi (Plate I, figs. 4 and 5); while the general cœnosteal tissue is of the incompletely reticulated type. Vertical sections (Plate I, fig. 5, and Plate VII, fig. 6) show well-developed "concentric laminæ," each of which commonly exhibits a median clear line. The apparent "laminæ" of vertical sections (Plate XXVI, fig. 1 *b*) represent the regularly developed connecting processes of the radial pillars; the latter structures being short and usually discontinuous, being commonly confined to the interlaminar space in which they originate. From eight to ten concentric laminæ occupy the space of 2 mm. measured vertically. Imperfect zoöidal tubes, with remote tabulæ, are sometimes recognisable, but, in general, vertical sections do not clearly exhibit the presence of such structures in a definite form. In tangential sections (Plate I, fig. 15; Plate XXVI, fig. 1 *a*) the perforated tubercles of the successive laminæ are abundantly seen, each in the form of a more or less complete ring, enclosing a central space. Occasionally the intervals between the cut ends of the radial pillars are crossed by delicate partitions, indicating the presence of astrorhizal tabulæ or "interlaminar septa."

Obs.—Having now fully examined my available material, I have come to the conclusion that the Devonian rocks of North America contain two allied but nevertheless really distinct species of *Stromatoporella*, which up till now I have included under the single name of *S. granulata*. One of these—the true *S. granulata*—occurs in the Hamilton formation, and I have supplemented the figures of its microscopic structure with a drawing of an actual specimen (Plate XXVI, fig. 1). The other form in question occurs in the Corniferous Limestone of Canada; and I shall briefly describe it under the name of *S. Selwynii*, Nich. Neither of these forms can be positively asserted to occur in the Devonian rocks of either Britain or Germany, though from both of these regions I have examples of closely related if not identical types.

As regards its general characters, *S. granulata*, Nich., as here restricted, is distinguished by its laminar cœnosteum, its non-parasitic habit, and its epithecate under surface. The upper surface always exhibits well-marked astrorhizal prominences or "mamelons" (Plate XXVI, fig. 1), and is always studded with numerous tubercles, of which the larger have apertures at their apices.[1]

[1] In the heading to this description of *S. granulata*, fig. 14 of Plate I is inadvertently quoted as illustrating the surface-characters of the species. In the explanation to Plate I this same illustration is likewise ascribed to *S. granulata*. This figure, however, really belongs to the form which I now name *S. Selwynii*, which in surface-characters closely resembles *S. granulata*. Fig. 6 of Plate IV is illustrative of the surface of the true *S. granulata*.

As regards its microscopic structure, the most marked feature in *S. granulata* is the presence in tangential sections (Plate I, fig. 15, and Plate XXVI, fig. 1 *a*) of more or less numerous, complete or incomplete, rings, enclosing each a central space. These represent the perforated tubercles of the successive laminæ, as seen when transversely divided. The same feature characterises corresponding sections of *S. Selwynii*, Nich., also; but the latter species is sufficiently separated from the present form by its comparatively coarse structure.

From *S. eifeliensis*, Nich., the present species is distinguished by its non-parasitic habit of growth, by the much more limited development of the astrorhizæ, by the presence of "mamelons" or astrorhizal prominences, and by the possession of the perforated tubercles alluded to above.

The form which I shall here describe under the name of *S. solitaria* is nearly related to *S. granulata*, as shown by its similar mode of growth, its possession of "mamelons," and the general likeness of the minute structure of the skeleton in the two. It also exhibits in tangential sections (Plate XXVII, fig. 6) appearances very similar to those which are above referred to as characterising corresponding sections of *S. granulata*. At the same time *S. solitaria* is sufficiently proved to be distinct from *S. granulata* by its decidedly coarser structure, and also by the much more complete development of "astrorhizal cylinders," while its skeleton resembles that of *S. eifeliensis* in being tubulated rather than simply porous.

From *S. socialis*, Nich., the most abundant of the British species of *Stromatoporella*, the present species is distinguished by its generally thicker skeleton-fibre, and more lax structure, as well as by the characteristic perforated tubercles previously referred to. Lastly, *S. damnoniensis*, Nich., is adequately separated from *S. granulata* by its much coarser skeleton-fibre, as well as by the limited development of its astrorhizal system.

I have not so far met with any example of *Stromatoporella granulata* in the "Caunopora-state." Indeed, one of the difficulties in arriving at absolutely clear and satisfactory conclusions as to the so-called "Caunoporæ" is that "Caunopora tubes" are so commonly present in certain Stromatoporoids, while there are a few forms—apparently of very similar structure and habit—in which such tubes are seemingly never present.

Distribution.—Not uncommon in the Devonian rocks (Hamilton formation) of Ontario. As above stated, no undoubted British or German examples of this species have been recognised as yet; but the microscopic structure of some of the *Stromatoporellæ* which abound in the pebbles of Devonian Limestone in the Triassic conglomerates of South Devon strongly reminds us of this species.

2. STROMATOPORELLA SELWYNII, n. sp. Pl. I, fig. 14, and Pl. XXVI, figs. 2—4.

The cœnosteum in this species is massive or laminar, and apparently attains a considerable size. The mode of attachment, in the only case observed, is by the greater portion of the under surface. The laminæ are gently undulated, but there are no distinct astrorhizal eminences or "mamelons," nor are "astrorhizal cylinders" developed. The surface is studded with numerous, tubercles, of different sizes, the smaller ones being imperforate, while the larger ones are blunt, and have their apices pierced by round apertures (Plate XXVI, fig. 2). Astrorhizæ are apparently wanting, or may be incompletely developed; but they do not constitute a marked feature in the specimens examined.

As regards microscopic structure the skeleton-fibre is thick, and is seen in sections to be minutely porous. Tangential sections (Plate XXVI, fig. 3) show the cut ends of the radial pillars, together with a larger or smaller number of complete or incomplete rings, the latter representing sections of the hollow tubercles which are developed on each successive lamina. Vertical sections (Plate XXVI, fig. 4) show very well-defined concentric laminæ, of which about six occupy the space of 2 mm. measured vertically. The radial pillars are well developed, but are, as a rule, confined each to its own interlaminar space. Imperfect zoöidal tubes are occasionally recognisable, but are never conspicuous.

Obs.—This form, as shown by the characters of the skeleton, is closely related to *S. granulata*, Nich., and I had previously regarded it as merely a variety of the latter. I am, however, now satisfied that it may be fairly considered as a good species, and I have much pleasure in naming it after the distinguished Director of the Geological Survey of Canada.

Stromatoporella Selwynii is separated from *S. granulata* by the fact that the laminæ of the cœnosteum are simply undulated, and the astrorhizæ are imperfectly developed, the surface therefore never exhibiting the characteristic rounded or conical "mamelons" of the latter species. As regards internal characters, *S. Selwynii* is further separated from *S. granulata* by its markedly coarser structure, as will be at once seen from a comparison of corresponding sections of the two forms in question drawn to the same scale (compare figs. 1 *a* and 1 *b* of Plate XXVI with figs. 3 and 4 of the same plate). From other related species of the genus *Stromatoporella*, *S. Selwynii* is separated by characters essentially the same as those distinctive of *S. granulata*, as pointed out in the observations made with regard to the latter form.

Distribution.—Not uncommon in the Corniferous Limestone of Port Colborne, Ontario. *S. Selwynii* has not yet been certainly recognised in Britain, though some specimens from the Devonian pebbles in the Triassic conglomerates of Devonshire yield sections in some respects resembling those of the present species.

3. Stromatoporella socialis, n. sp. Pl. XXVI, figs. 5—7.

This species is only known to me from the pebbles of Devonian Limestone in the Triassic conglomerates of South Devon, and the characters of its surface and its mode of growth are therefore imperfectly or not at all known. It appears, however, to have been in general either laminar or massive in form, and it certainly was not of an encrusting habit. The laminæ of the cœnosteum are always more or less extensively undulated, and sections show conclusively that "astrorhizal cylinders" were usually more or less largely developed. The astrorhizæ, namely, are not only well marked and of large size, but they are superimposed in vertical rows in successive laminæ, each series having a wall-less axial canal round which the laminæ are concentrically wrapped (Plate XXVI, fig. 5). The interspaces between the astrorhizal cylinders are occupied by undulating laminæ, in the same manner as in *Actinostroma verrucosum*, Goldf. We may, therefore, assume that the surface, when observed, will be found to be more or less extensively covered with prominent conical eminences or "mamelons," at the apex of each of which the central canal of a series of astrorhizæ will open.

The skeleton-fibre was doubtless porous, but in all the specimens examined the intimate structure of the fibre has been so obscured by secondary crystallisation that this point cannot be definitely ascertained.

Tangential sections (Plate XXVI, figs. 5 and 6) show the cut ends of the radial pillars united into a reticulation, which, though imperfect, is more complete than is usual in the genus *Stromatoporella*. Where such sections traverse an astrorhizal cylinder (as in Plate XXVI, fig. 5), then, of course, the laminæ are seen as cut vertically or obliquely. Tangential sections do not exhibit the incomplete or complete rings so characteristic of corresponding sections of *Stromatoporella granulata* or *S. Selwynii*, and we may therefore conclude that the surface did not possess the perforated tubercles of the species just mentioned.

Vertical sections (Plate XXVI, fig. 7) show well-defined concentric laminæ and short radial pillars, the latter confined to their respective interlaminar spaces, or not even extending completely across these. Definite zoöidal tubes cannot be detected. Nine or ten laminæ occupy the space of 2 mm. measured vertically.

Obs.—This is by far the commonest species of *Stromatoporella* in the Devonian rocks of Britain; and its microscopic characters enable us to separate it definitely from the other species of the genus. From *S. granulata*, Nich., it is distinguished by its total want of perforated tubercles, and the more complete development of astrorhizal cylinders, pointing to a more massive habit of growth. From *S. Selwynii*, Nich., it is separated not only by the characters just mentioned, but also by the much finer structure of the skeleton. In the general structure of the skeleton, and more especially in the possession of astrorhizal cylinders, *S. socialis* more nearly resembles *S. solitaria*, Nich., than it does either of the species just alluded to; but its skeletal tissue is much finer and closer, while the latter has perforated tubercles. From *S. damnoniensis*, Nich., lastly, the present species is at once distinguished by the much greater delicacy of its skeleton. There are no other species of the genus known to me with which *S. socialis* could well be confounded.

The great majority of the specimens of *Stromatoporella socialis* occur in the "Caunopora-state" (Plate XXVI, fig. 6), the "Caunopora-tubes" showing well marked infundibuliform tabulæ and, occasionally, radiating spines or "septa." A few specimens appear to be free from "Caunopora-tubes" (Plate XXVI, fig. 5).

Distribution.—Very abundant in the pebbles of Devonian Limestone in the Triassic conglomerates of South Devon. It occurs also in the Devonian Limestone of Dartington and at Bishopsteignton. An apparently identical form, with a laminar cœnosteum, occurs in the Middle Devonian of the Eifel.

4. Stromatoporella damnoniensis, *Nicholson.* Pl. XXVII, figs. 8 and 9.

Stromatoporella damnoniensis, *Nicholson.* Ann. and Mag. Nat. Hist., ser. 5, vol. xvii, p. 237, pl. viii, figs. 3 and 4, 1886.

The external characters of this species are imperfectly known; but the cœnosteum appears to be in general massive, and more or less hemispherical in shape, with an epithecate under surface. The upper surface is not known completely, but seems to have been generally gently undulated.

The concentric laminæ of the cœnosteum are gently undulated, and the astrorhizæ are arranged in vertical systems, each of which is built up round a wall-less axial canal; so that "mamelons" were almost certainly present. At the same time the astrorhizæ are comparatively small and remote. "Astrorhizal tabulæ" are present in the horizontal astrorhizal canals.

The skeleton-fibre is exceedingly thick, and is minutely tubulated. About six laminæ and five interlaminar spaces occupy the space of 2 mm. measured vertically, the laminæ and intervening spaces being of about equal width as seen in vertical sections (Plate XXVII, fig. 9). The radial pillars are confined to their respective interlaminar spaces. Irregular tabulate zoöidal tubes, usually extending from one interlaminar space to the next above only, may be present. Tangential sections (Plate XXVII, fig. 8) show an irregular and imperfect reticulation, the more complete tracts of which (where the section is most completely coincident with the plane of a concentric lamina) exhibit the rounded apertures of the irregularly divided zoöidal tubes.

Obs.—This species is most nearly related to *S. solitaria*, Nich., from which it is distinguished more particularly by the markedly greater thickness of the skeleton-fibre, and the greater density of the cœnosteal network thence resulting. The astrorhizal system is also not so highly developed in *S. damnoniensis* as it is in *S. solitaria*. From *S. eifeliensis*, Nich., the present species is distinguished by its wholly different mode of growth, by the much more rudimentary condition of the astrorhizal system, and by the more solid character of the skeleton-fibre. There are no other species of the genus *Stromatoporella*, as yet described, with which *S. damnoniensis* could well be confounded.

The external characters of *S. damnoniensis* are imperfectly known, as all the British examples hitherto recognised have been derived from the Triassic conglomerates of Devonshire, and the few German specimens which I have collected are in a state of poor preservation.

Distribution.—Rare in the pebbles of Devonian Limestone in the Triassic conglomerates of Teignmouth. Also in the Middle Devonian Limestones of Sötenich, in the Eifel.

5. Stromatoporella eifeliensis, *Nicholson*. Pl. IV, fig. 2; Pl. VII, fig. 3 (*non* fig. 4); Pl. XI, figs. 1 and 2; Pl. XXVII, figs. 1—3.

Stromatoporella eifeliensis, *Nicholson*. Mon. Brit. Strom., part 1, 1886 (named and figured, but not described).

— — — (pars). Ann. and Mag. Nat. Hist., ser. 5, vol. xvii, p. 235, pl. viii, fig. 5 (*non* figs. 6 and 7), 1866.

The cœnosteum in this species is encrusting and parasitic, and is attached by the whole of the lower surface to some foreign body, the thickness of the crust varying from one millimètre up to $1\frac{1}{2}$ centimètres. The laminæ are straight or gently curved, and the surface is therefore smooth and destitute of "mamelons." The astrorhizæ are exceedingly well developed, greatly ramified (Plate XXVII, fig. 1, and Plate IV, fig. 2), and often of remarkably large size, their centres being commonly 2 to 3 centimètres apart. The astrorhizal canals are often furnished with transverse partitions or "astrorhizal tabulæ;" but the astrorhizal systems are not superimposed in vertical groups.

As regards its minute structure, the skeleton-fibre is thick, and is seen in well-preserved examples to be traversed by minute inosculating microscopic tubuli (Plate XI, figs. 1 and 2, and Plate XXVII, figs. 2 and 3). Vertical sections (Plate XXVII, fig. 3) show thick and very distinct concentric laminæ, of which about six occupy the space of 2 mm. measured vertically. Owing to the thickness of the laminæ, the interlaminar spaces are comparatively narrow, and the correspondingly thick radial pillars usually run from lamina to lamina, but do not extend beyond the interlaminar space within which each originates. Definite zoöidal tubes are not recognisable. The interlaminar spaces are occasionally traversed by a few irregular, curved, calcareous partitions ("interlaminar septa"), but these are never numerous, and may be wanting. Tangential sections (Plate XXVII, fig. 2) show that the skeleton is more completely reticulate than is usual in the genus *Stromatoporella*. The cut ends of the radial pillars are so far confluent as to give rise to a coarse network, which is traversed by the branches of the astrorhizal canals, and is perforated by rounded or oval apertures representing sections of short zoöidal tubes.

S. eifeliensis, as above defined, has not as yet been recognised in the "Caunopora-state."

Obs.—A careful examination of a very large series of specimens has now satisfied me that in my former description of the species ('Ann. Nat. Hist.,' ser. 5, vol. xvii, p. 235) I embraced two distinct though related types, which differ from one other both in habit and in minute structure.

One of these forms, to which I shall restrict the name of *S. eifeliensis*, is invariably parasitic, and forms thin crusts attached by the whole of the lower surface to foreign organisms, such as *Heliolites porosa*, Goldf., or, still more commonly, *Rhaphidopora stromatoporoides*, Roem. The other form, which I shall describe immediately under the name of *S. solitaria*, possesses a laminar cœnosteum with an epithecate under surface, and is non-parasitic, being attached by a limited point only.

The surface of *S. eifeliensis* is smooth, and is destitute of "mamelons" (Plate XXVII, fig. 1); while it is characterised by the extraordinary development of the astrorhizal gutters, which are typically so extremely branched as to permit of the free inosculation of adjoining systems. The general aspect of the surface in well-preserved specimens thus closely reminds us of that of *Stromatopora discoidea*, Lonsd. The astrorhizæ (Plate IV, fig. 2) are, moreover, usually of large size, and their centres are widely remote. On the other hand, in *S. solitaria* the astrorhizæ are circumscribed and comparatively small, while they are arranged in vertically superimposed systems. Each of these systems, further, becomes surrounded in *S. solitaria* by an "astrorhizal cylinder," similar to what is seen in *Actinostroma verrucosum*, Goldf. Hence the surface exhibits conspicuous conical prominences or "mamelons" (Plate XXVII, fig. 4).

Again, as regards the minute structure of the cœnosteum, though the concentric laminæ have much about the same closeness in the two species, these structures are much more delicate in *S. solitaria* than they are in *S. eifeliensis*, the interlaminar spaces of the former thus becoming comparatively much wider and more open (compare figs. 3 and 7, Plate XXVII).

Lastly, the skeletal tissue is much less completely reticulated in *S. solitaria* than it is in *S. eifeliensis*, while there exist perforated tubercles of the same character as those seen in *S. granulata*, Nich.

As above restricted, *S. eifeliensis* becomes an exceedingly natural and well-defined species of *Stromatoporella*; and the only other form of the genus with which it could be confounded is *S. arachnoidea*, Nich., which occurs associated with it. This latter species ('Ann. Nat. Hist.,' ser. 5, vol. xvii, p. 237, pl. viii, figs. 1 and 2) is, however, distinguished from *S. eifeliensis* not only by its non-parasitic habit, but also by the extraordinary development of the "interlaminar septa," which give to both tangential and vertical sections of the cœnosteum an altogether unique and characteristic appearance.

Distribution.—*S. eifeliensis* occurs abundantly in the Middle Devonian of Gerolstein, in the Eifel. I have not certainly identified the species as occurring in the corresponding rocks in Britain, the form which I doubtfully referred to this species ('Mon. Brit. Strom.,' pl. ii, figs. 9 and 10) being rather referable to the type which I now call *S. solitaria*.

6. Stromatoporella solitaria, n. sp. Pl. VII, fig. 4, and Pl. XXVII, figs. 4—7; (?) also Pl. II, figs. 9 and 10.

Stromatoporella eifeliensis, *Nicholson*. Mon. Brit. Strom., pt. 1, pl. vii, fig. 4 (figure only); and woodcut, fig. 7, 1886.

— — — (pars). Ann. Nat. Hist., ser. 5, vol. xvii, pl. viii, figs. 5 and 7 (not fig. 6), 1886.

The cœnosteum in this species is of considerable size, laminar in form, with a basal epitheca, attached at one point only, not parasitic. The thickness of the cœnosteum is from two to nearly three centimètres. The surface (Plate XXVII, fig. 4) exhibits prominent conical eminences or "mamelons," the centres of which are from one to one and a half centimètres apart; and is covered with small but well-marked tubercles, some of which appear to be perforated at their apices. The "mamelons" are formed by the upward bending of the skeletal laminæ in such a way as to form "astrorhizal cylinders," each of which encloses a vertical wall-less canal forming the axis of a series of superimposed astrorhizæ (woodcut, fig. 28). The opening of this axial canal is placed at the summit of a mamelon, and the radiating canals diverge from this. The astrorhizæ are, however, small and circumscribed, and they do not become confluent by the anastomosis of the terminal twigs of adjoining systems.

FIG. 28.

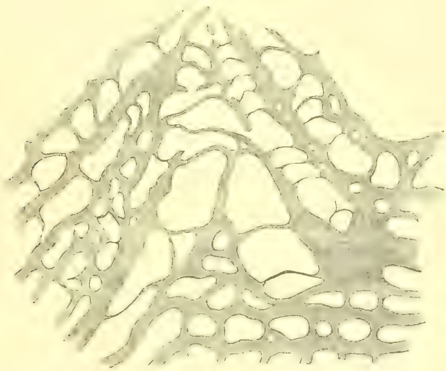


FIG. 28.—Vertical section through part of an astrorhizal cylinder of *Stromatoporella solitaria*, Nich., enlarged twelve times. Middle Devonian, Gerolstein, Eifel. (This is fig. 7, p. 56, where it is figured as belonging to *S. eifeliensis*, Nich.)

As regards internal structure, the skeleton-fibre is moderately thick, and is minutely porous, or even delicately canaliculated, though it does not exhibit the marked tubulated structure of typical examples of *S. eifeliensis*. Tangential sections exhibit different appearances according as the section traverses an interspace between two mamelons, or cuts across one of these eminences. In the first case (Plate XXVII, fig. 6) the cut ends of the radial pillars are seen, separate or more or less confluent, and often showing central clear spots which correspond with those seen in similar sections in *S. granulata*, Nich., and *S. Selwynii*, Nich., and which indicate the presence of perforated surface-tubercles. On the other hand, if the section traverses a mamelon (Plate XXVII, fig. 5), we see in the centre the aperture of a transversely divided axial astrorhizal canal, surrounded by concentrically disposed laminæ with their uniting pillars.

Vertical sections (Plate XXVII, fig. 7) show well-marked concentric laminæ, of which about six occupy the space of 2 mm. measured vertically. The radial pillars are stout, and are confined to the interlaminar spaces in which each originates. "Interlaminar septa" are often present in fairly large numbers, and have the form of delicate curved calcareous partitions intersecting the interlaminar spaces obliquely. If a vertical section traverses a mamelon (woodcut, fig. 28), the axial and radial canals of the astrorhizal system belonging thereto are seen to be crossed by irregular calcareous partitions or "astrorhizal tabulæ."

Specimens of *S. solitaria* are commonly found in the "Caunopora-state," but show no phenomena of special interest.

Obs.—As previously pointed out, I am now satisfied that I formerly included two distinct types under the name of *Stromatoporella eifeliensis;* and I now propose the name of *S. solitaria* for those specimens which agree with the specific description above given. In various respects, and particularly as regards minute structure, *S. solitaria* agrees with *S. eifeliensis;* while the difficulty of separating the one from the other is enhanced by the fact that specimens of the two are very commonly associated with one another. Nevertheless, both as regards microscopic structure and macroscopic characters, there are sufficient distinctive features to warrant the separation of the two forms as distinct species.

Thus while the cœnosteum of *S. eifeliensis* has the form of a crust parasitically attached to foreign bodies by the whole of the lower surface, that of *S. solitaria* is laminar, is furnished with an inferior epithecal membrane, and is attached by one point only. The astrorhizæ of *S. eifeliensis* are extraordinarily developed, and anastomose freely with one another, but they are not arranged in superimposed systems, and neither "astrorhizal cylinders" nor surface-eminences are developed. On the other hand, the astrorhizæ of *S. solitaria* are comparatively small, and are circumscribed; but they are vertically superimposed, and usually form the centres of well-defined "astrorhizal cylinders," while they open on prominent surface-projections or "mamelons" (Plate XXVII, fig. 4).

As regards minute structure, again, the skeleton-fibre of *S. solitaria* is not so finely tubulated as it is in *S. eifeliensis*, and is at the same time much more delicate. The result of this latter character is that the cœnosteal network of *S. solitaria* becomes conspicuously more lax and open than is the case in *S. eifeliensis* (compare figs. 2 and 3 with figs. 6 and 7 of Plate XXVII). Lastly, *S. solitaria* shows in tangential sections the same perforated tubercles as are characteristic of corresponding sections of *S. granulata* or *S. Selwynii.*

Leaving *S. eifeliensis* out of consideration, the species which *S. solitaria* most nearly resembles is *S. Selwynii*, Nich. From this form, however, the present species is separated by the comparatively greater delicacy of the skeletal framework, the much more extensive development of the astrorhizal system, and the presence of "mamelons." There is no other species of *Stromatoporella* which *S. solitaria* resembles with such closeness in internal structure as to demand a detailed comparison.

Distribution.—*S. solitaria* is not uncommon in the Middle Devonian Limestones of the Auberg, at Gerolstein in the Eifel. It is very difficult to identify this form among the species of *Stromatoporella* which occur in the pebbles of Devonian Limestone in the Triassic conglomerates of Devonshire, since such derived specimens necessarily exhibit no surface-characters. I am disposed, however, to think that the sections figured by me in Plate II, figs. 9 and 10, and doubtfully referred to *S. eifeliensis*, really belong to the present species.

7. Stromatoporella curiosa, *Barg.* sp. Pl. XXVIII, figs. 1—3.

Stromatopora polymorpha, *Goldfuss.* Petref. Germ., pl. lxiv, figs. 8 *a*, 8 *c*, and 8 *d* (cæt. excl.), 1826.
— curiosa, *Bargatzky.* Die Stromatoporen des Rheinischen Devons, p. 55, 1881.
Stromatoporella curiosa, *Nicholson.* Ann. and Mag. Nat. Hist., ser. v, vol. xviii, p. 8, pl. i, figs. 1—3, 1886.

Cœnosteum incrusting, thin, attached by the whole of the inferior surface to some foreign body, and usually developing externally numerous irregular pointed eminences, at the extremities of which the astrorhizæ open. Surface usually covered with minute rounded tubercles, the apices of which may be perforated, and also exhibiting branched astrorhizal canals; in other cases part or the whole of the surface may be covered by a thin calcareous membrane, which exhibits few or no apertures of any kind. As regards internal structure, the skeleton-fibre is minutely porous, and the skeletal tissue is of the imperfectly reticulate type. The concentric laminæ are thick and well marked, often with a median clear line in each (as seen in vertical section), and they are placed from $\frac{1}{4}$ to $\frac{1}{3}$ millimètre apart. The transversely divided ends of the radial pillars can be more or less extensively recognised as distinct structures in tangential sections. The astrorhizæ are furnished with vertical axial canals, and astrorhizal tabulæ may be sparingly present. Definite zoöidal tubes are not recognisable.

Obs.—This is a typical example of an incrusting and parasitic Stromatoporoid. It envelops Rugose Corals or other organisms, and forms crusts varying in thickness from less than a millimètre up to 5 or 6 millimètres One of its most characteristic and conspicuous external features is the fact that the exterior is more or less extensively covered with pointed conical eminences (Plate XXVIII, fig. 1), which may be imperforate, or which may terminate in an aperture corresponding with the centre of one of the astrorhizal systems. These eminences or "mamelons" may be comparatively large, sometimes more than a centimètre in height, in which case they are comparatively few in number. More usually they are smaller, perhaps 2 or 3 millimètres in height, and in this case they are numerous. When well developed, each of these pointed eminences consists of concentrically laminated tissue traversed centrally by the axial canal of an astrorhizal system, and having the external opening of the same at its apex, while the astrorhizal twigs run down its sides externally.

The surface presents curious and very puzzling variations in different examples, or in different regions of the same specimen. Sometimes the whole, or a part only, of the surface is covered with minute rounded or elongated tubercles, which sometimes coalesce into vermiculate ridges, and which may have their apices perforated with minute circular apertures. This seems to be the normal condition of the surface. In many specimens, however, this granulated surface is extensively or completely concealed from view by the development of a delicate smooth calcareous pellicle or membrane. This external membrane may pass unbrokenly over the mamelons as well as over the general surface; but commonly the apices of the mamelons show a few small apertures or the single larger opening of an astrorhizal canal. In this latter case the appearances presented remind one of the general surface of *Distichopora* at points where ampullæ are developed.

As regards internal structure, the general appearances presented by tangential and vertical sections (Plate XXVIII, figs. 2 and 3) are very similar to those of corresponding sections of *Stromatoporella eifeliensis*, Nich., and need not be more minutely discussed here. The present species is distinguished from *S. eifeliensis*, as from the other related species of *Stromatoporella*, by its uniformly incrusting habit, the development of pointed mamelons, and the characters of its surface. On the other hand, there is a close general resemblance between *Stromatoporella curiosa*, Barg., and the form which Hall and Whitfield described from the Devonian rocks of Iowa under the name of *Cœnostroma incrustans* ('Twenty-third Ann. Rep. of the State Cabinet,' p. 227, pl. ix, fig. 3, 1873). This latter, as I have shown elsewhere ('Ann. Nat. Hist.,' ser. 6, vol. vii, p. 310, 1891) is really identical with the fossil which I described from the Hamilton rocks of Ontario under the name of *Stromatopora nulliporoides* ('Second Report on the Palæontology of Ontario,' p. 78, 1875), this title thus falling to be abandoned. I have now examined an authentic example of *Cœnostroma incrustans*, H. and W., and find it to be a species of *Stromatoporella*, very nearly related to *S. curiosa*, Barg., in general characters and in minute structure. Upon the whole, however, the American and Canadian type may fairly rank as a distinct species, since it not only shows the superficial distinction that its mamelons are closer set, more regular, and more pointed than they are in *S. curiosa* (see Plate III, fig. 6), but the general skeletal tissue, as shown in thin sections, is decidedly more close and dense.

Distribution.—This species is of common occurrence in the Middle Devonian Limestones of Büchel (in the Paffrath district), and occurs also in the Eifel. As regards Britain, I possess two examples of an incrusting Stromatoporoid, collected by the late Mr. Champernowne in the Middle Devonian Limestones of Pit Park Quarry, Dartington, which show all the general characters of the present species. Unfortunately the internal structure of these specimens is imperfectly preserved, and though I have no reason to doubt the correctness of my determination, I have preferred to take the description of the species from specimens collected in Germany, and the specimens figured are also German.

Genus 4.—HERMATOSTROMA, *Nicholson*, 1886.

(General Introduction, p. 105.)

1. HERMATOSTROMA SCHLÜTERI, *Nicholson*. Pl. III, figs. 1 and 2; Pl. XXVIII, figs. 12 and 13; and woodcuts, figs. 1, 16, 29, 30, 31, and 32.

HERMATOSTROMA SCHLÜTERI, *Nicholson*. Mon. Brit. Strom., General Introduction, p. 105, 1886 (figured but not described).

The cœnosteum in this species is massive, and readily splits into thick concentric strata of the nature of "latilaminæ." The true surface is not known, but the supposed upper surfaces of the laminæ are covered with broad and comparatively low, rounded elevations of variable size, which are formed by gentle bendings of the concentric layers (Plate XXVIII, fig. 12). These elevations are about 3—4 mm. in diameter, two of them usually occupying a space of about 1 cm., and they do not constitute proper "mamelons," since they do not carry the apertures of the astrorhizæ at their summits. Astrorhizæ, in fact, appear to be wanting.

As regards its minute structure, the skeleton-fibre is very thick, and is furnished with an axial canal, which may give off secondary prolongations, but it is not minutely porous. Vertical sections (Plate III, fig. 2) show exceedingly strong "continuous" radial pillars, which traverse many successive interlaminar spaces without a break, and are connected at definite intervals by short and stout connecting processes, which give rise to very regular "concentric laminæ." As the connecting processes are rectangular to the pillars, vertical sections show a characteristic trellis-like appearance, the interlaminar spaces being broken up into rectangular meshes. The radial pillars are traversed by very large axial canals, and prolongations of these canals extend into the horizontal connecting processes. Six or fewer pillars, and a like number of concentric laminæ, occupy a space of 2 mm., measured respectively in the transverse or vertical direction.

Tangential sections (Plate III, fig. 1) show the broad round or oval ends of the transversely divided radial pillars, with the dark infilling of the cut axial canals of the pillars. Where the section corresponds with the plane of a concentric lamina, the cut ends of the pillars are seen to be united into a loose network, with rounded or oval meshes representing sections of zoöidal tubes.

Tangential sections also commonly show large oval or rounded apertures (woodcut, fig. 16 *a*), which are bounded by thin but definite walls, and are placed at distances of from 3 to 12 or 15 mm. apart. The apertures in question are cross-sections of short, wide, flexuous tubes, which pierce the skeletal network at right angles to the surface, are bounded by thin proper walls, and are crossed by occasional horizontal "tabulæ" (woodcut, fig. 16 *b*). Tubes of this kind seem to be very generally developed in variable numbers, and they open sometimes on the convex, but more usually on the concave surfaces of the laminæ (woodcut, fig. 29). The nature of these tubes is quite problematical, and it is not clear that they are

Fig. 29.

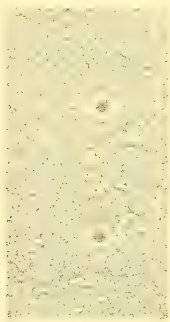


Fig. 29.—Under (?) surface of part of a lamina of *Hermatostroma Schlüteri*, Nich., enlarged, showing the apertures of two of the large thin-walled tubes which traverse the cœnosteum of this species at irregular intervals.

not adventitious structures. If they really belong to the Stromatoporoid in which they are found, they may perhaps be connected with the function of reproduction.

Obs.—All the examples of this species which I possess are fragments of a single very large specimen, the complete form of which was, unfortunately, not accurately noted before it was broken up. All the fragments are made up of gently curved concentric layers, and are, therefore, more or less convex on one side and concave on the other. If we are to judge from analogy, the *convex* sides of such fragments ought to represent the *upper* surfaces of the mass, and this view is supported by the fact that these sides (Plate XXVIII, fig. 12) are covered with rounded eminences resembling the "mamelons" of the Stromatoporoids generally. It is, however, possible that the mass was really basin-shaped, and that the *concave* sides are really the successive upper surfaces. This view is supported by the fact that the wide, scattered, and thin-walled tubes above spoken of as perforating the cœnosteum—whatever their true nature may be—generally open by prominent apertures on the *concave* sides of the laminæ.

In the possession of definite and "continuous" radial pillars *Hermatostroma Schlüteri* entirely resembles a true *Actinostroma*, but differs from the species of this genus in the fact that the connecting processes of the pillars do not give rise to an angular or "hexactinellid" network. On the contrary, the cœnosteal meshes are oval or round; and the aspect of tangential sections, so far as this point is concerned, resembles that of similar sections of *Stromatopora* or *Stromatoporella*. From these latter genera the present form is distinguished not only by the complete development of the radial pillars as distinct structures, but also by the fact that the skeleton-fibre is apparently not of the minutely "porous" type. The other two general features distinctive of *Hermatostroma Schlüteri* are the apparent absence of astrorhizæ, and the imperfect development of zoöidal tubes as recognisable structures. The zoöidal tubes are, in fact, in general represented by nothing more than the pores which pierce the successive "laminæ" of the skeleton.

The most remarkable features in the skeleton of *Hermatostroma Schlüteri* are connected with the tubulated condition of the skeleton-fibre. Vertical sections (woodcut, fig. 30) show that each radial pillar is traversed by a wide axial canal, which sends out horizontal prolongations into the successive laminæ formed by the connecting processes. The entire canal-system is more or less completely injected with some opaque material, apparently an iron oxide, and the extensions of the radial canals into the laminæ can thus easily be followed, the crossing nodes of the two sets of canals being generally more or less dilated. The laminar canals also send off irregular secondary tubes, but it is uncertain whether or not these open directly into the interlaminar spaces. On the other hand, an examination of the surfaces of the concentric laminæ, as exposed by fractures, renders it certain that the axial canals of the radial pillars open by circular apertures both superiorly and inferiorly (Plate XXVIII, fig. 13). Tangential sections (woodcut, fig. 31) show that the large dark masses representing the infiltrated axial canals of the radial pillars are connected with one another by more delicate dark threads representing the canals of the connecting processes. Moreover the main axial canals are commonly seen to give off subordinate and irregular prolongations, which may form a loose network in the substance of the fibre, and which seem in some cases to actually reach the surface of the fibre itself, so as to open into the interlaminar spaces.

Fig. 30.

Fig. 30.—Part of a vertical section of *Hermatostroma Schlüteri*, Nich., enlarged about 24 times.

Fig. 31.

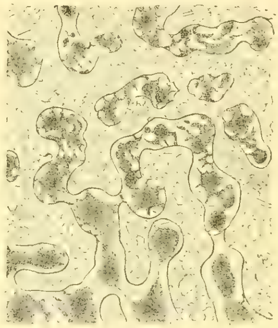


Fig. 31.—Part of a tangential section of the same, similarly enlarged.

It follows from what has been above said that, though the skeleton-fibre of *Hermatostroma Schlüteri* is not "porous," in the sense in which this term is used in connection with the cœnosteal fibre of *Stromatopora*, it is nevertheless traversed by tubes which, in point of fact, are chiefly remarkable for their exceptional size and regular distribution. It has further to be borne in mind that the only known example of this species has undergone considerable change in fossilisation, and that the apparent absence of minute pores in the skeleton-fibre may be simply the result of mineralisation. This view is rendered the more probable since the *Hermatostroma episcopale* of the British Devonians—to be described immediately—has, if rightly placed in this genus, a skeleton-fibre which is both porous and tubulated.

The generic diagnosis of *Hermatostroma* given in the earlier portion of this work (p. 105) must be, therefore, so far amended as to admit that the skeleton-fibre is, in some cases at any rate, porous as well as canaliculated. A further amendment has been necessitated by the examination of *H. episcopale*, since this species possesses well-marked astrorhizæ.

I had formerly placed the genus *Hermatostroma* in the immediate neighbourhood of *Idiostroma* chiefly on account of its possession of a skeleton which is essentially reticulate, but which at the same time possesses exceedingly well-developed radial pillars. Upon the whole, however, I am now rather disposed to consider *Hermatostroma* as really one of the same series of generic types as *Stromatopora*, *Stromatoporella*, and *Parallelopora*. The essential distinctions between the members of this series, on the view here expressed, may be summarised as follows:

1. *Stromatopora.*—Skeleton-fibre minutely porous; radial pillars and their connecting processes more or less indistinguishably fused to form a reticulate skeleton.

2. *Stromatoporella.*—The skeleton-fibre minutely porous; the skeleton network incompletely reticulate, and the radial pillars more or less clearly recognisable as distinct structures.

3. *Parallelopora.* — Skeleton-fibre porous and minutely canaliculated; the skeleton incompletely reticulate, and the radial pillars more or less clearly recognisable, but never traversed by large axial canals.

4. *Hermatostroma.*—Skeleton-fibre with large and conspicuous canaliculi, and sometimes also minutely porous; the skeleton reticulate, but showing exceedingly well developed, "continuous" radial pillars, which are traversed by large axial canals.

From *Hermatostroma episcopale*, Nich., the only other species of the genus at present known to me, the present form is at once distinguished by the greater coarseness of the skeleton-fibre, the absence of astrorhizæ, and the extraordinary development of the canal-system of the radial pillars.

Distribution.—Rare in the Middle Devonian Limestones of Hebborn in the Paffrath district. The species has not been recognised in Britain.

2. Hermatostroma episcopale, n. sp. Pl. XXVIII, figs. 4—11.

? Stromatopora concentrica, *Phillips.* Pal. Foss. of Cornwall, &c., p. 18, pl. x, figs. 28 *a*, 28 *b*, 1841.

The cœnosteum in this species is massive, not composed of definite latilaminæ, and apparently attached at one point only; but its mode of growth is not perfectly known. It may, however, be inferred from the structure of the skeleton that the surface was elevated into prominent astrorhizal eminences—"mamelons," and at the same time covered with well-defined tubercles, the latter being probably perforated at their apices.

The laminæ are undulated, and well-defined "astrorhizal cylinders" are developed round the astrorhizal systems (Plate XXVIII, fig. 4). The astrorhizæ, though of small size, are usually well developed, their centres being from 7 to 10 mm. apart. They are arranged in vertically superimposed systems, each system having an axial wall-less canal, which doubtless opened on the surface at the apex of a mamelon.

As regards the internal structure, the skeleton-fibre is of moderate thickness, and is minutely porous, the pores being often unrecognisable, or being infiltrated with some foreign material, and appearing therefore as so many dark dots (Plate XXVIII, fig. 10). Tangential sections (Plate XXVIII, figs. 5, 7, and 8) show the cut ends of the radial pillars, sometimes more or less distinct, sometimes completely confluent, according as the plane of the section corresponds with an interlaminar space or intersects a concentric lamina. Definite zoöidal tubes cannot be clearly distinguished, and are represented essentially by mere perforations in the concentric laminæ. Tangential sections further show the transversely divided astrorhizal cylinders (Plate XXVIII, figs. 4 and 5).

Vertical sections (Plate XXVIII, figs. 6, 9, and 11) show well-marked, often undulated, concentric laminæ, and very distinct radial pillars of the "continuous type"—*i. e.* pillars which are continued for longer or shorter distances across successive interlaminar spaces. About six concentric laminæ occupy a space of 2 mm. measured vertically, and about six or seven radial pillars occupy the same space measured transversely.

In well-preserved examples both vertical and tangential sections show that the radial pillars are occupied by large axial canals, which send off delicate prolongations into the periodically produced horizontal connecting processes, which unite adjoining pillars at corresponding levels, and thus give origin to the "concentric laminæ." Both the vertical and the horizontal canals are usually infiltrated with some dark and opaque material, and in this condition they are readily recognised in both vertical and tangential sections (Plate XXVIII, figs. 6, 8, and 11). In badly preserved specimens the canals of the skeleton-fibre may be imperfectly infiltrated, and may therefore be recognisable with difficulty (Plate XXVIII, figs. 7 and 9). In some cases the canals cannot be clearly made out at all.

Vertical sections, lastly, often show that the interlaminar spaces are traversed by a larger or smaller number of curved or straight calcareous partitions, or "interlaminar septa," which are commonly more or less horizontal in direction, and thus run parallel with the concentric laminæ (Plate XXVIII, fig. 9).

Specimens occasionally, but not very commonly, present themselves in the "Caunopora-state."

Obs.—*Hermatostroma episcopale* is a common Stromatoporoid in parts of the Devonian rocks of Britain, and the reference of the species to *Hermatostroma*, rather than to *Stromatopora* or *Stromatoporella*, appears to be justified by its minute structure. It agrees, namely, with the first of these genera, and differs from the two latter in its possession of "continuous" radial pillars, and also in the fact that these structures are furnished with well-marked axial canals. The specimens known to me are, however, as a rule, so imperfectly preserved, that, though it is possible to determine their generic affinities, they do not throw any additional light upon the structure of the genus *Hermatostroma*.

Hermatostroma episcopale differs from *H. Schlüteri*, the only other recorded species of the genus, in the following characters:

(*a*) The astrorhizal system of *H. episcopale* is very well developed, and astrorhizal cylinders are present; on the other hand, in *H. Schlüteri* astrorhizæ are apparently not developed in any recognisable form.

(*b*) The skeletal tissue of *H. episcopale* is not so coarse as that of *H. Schlüteri*, and the axial canals of the radial pillars are proportionately less developed.

(*c*) The skeleton-fibre of *H. episcopale*, apart from the presence of the axial canals above spoken of, is minutely porous; whereas in *H. Schlüteri* the skeleton-fibre, but for the above-mentioned canals, appears to be solid. It is to be remembered, however, that the porous character of the skeleton-fibre can be recognised in *H. episcopale* in certain specimens only, and it is therefore quite possible that the apparently solid nature of the skeleton-fibre in the only known example of *H. Schlüteri* may be simply the result of imperfect preservation.

(*d*) The interlaminar spaces of *H. episcopale* are usually intersected by more or less numerous "interlaminar septa," which generally have a direction more or less conforming to that of the concentric laminæ themselves. Similar structures do not occur in any marked form in *H. Schlüteri*.

Distribution.—*Hermatostroma episcopale* is not uncommon in the Devonian of Shaldon and Bishopsteignton, and occurs more rarely in the pebbles of the Triassic conglomerates at Teignmouth.

Family—IDIOSTROMIDÆ.

Genus 1.—Stachyodes, *Bargatzky*, 1881.

(Introduction, p. 107.)

1. Stachyodes verticillata, *M'Coy* sp. Pl. VIII. figs. 9—14; Pl. XI, fig. 5; and Pl. XXIX, figs. 1 and 2.

Stromatopora (Caunopora) verticillata, *M'Coy*. Brit. Pal. Foss., p. 66, woodcuts *a* and *b*, 1851.

Stachyodes ramosa, *Bargatzky*. Zeitschr. der deutschen Geol. Ges., Jahrg., 1881, p. 688.

— verticillata, *Nicholson*. Mon. Brit. Strom., General Introduction, p. 107, pl. viii, figs. 9—14; and pl. xi, fig. 5, 1886.

The cœnosteum in this type consists of rounded cylindrical stems (Plate VIII, fig. 9), rooted basally, and terminating distally in rounded ends, the diameter varying from $\frac{1}{2}$ cm. up to as much as $1\frac{1}{2}$ cm.

The surface is generally more or less extensively covered with the rounded or polygonal apertures of the zoöidal tubes (Plate VIII, fig. 9), thus giving the fossil the aspect of a dendroid Monticuliporoid, or of a species of *Pachypora* with small corallites. In many specimens, however, the surface is not uniformly occupied by the zoöidal apertures, but larger or smaller areas may be covered by a thin imperforate calcareous membrane (Plate VIII, fig. 12). The surface does not exhibit " mamelons," nor are astrorhizæ developed.

As regards the internal structure of the cœnosteum, the centre of each stem is occupied by a main axial tube, from $\frac{1}{2}$ to $\frac{2}{3}$ mm. in diameter, which is crossed by more or less numerous curved or straight tabulæ, and which gives off smaller lateral branches, which are directed upwards and outwards. These lateral branches subdivide, and may also be more or less extensively furnished with tabulæ. The principal axial tube seems to terminate at the end of the stem in one, two, or more apertures, but the extremities of the branches are commonly in a state of bad preservation, and may not exhibit any openings.

Longitudinal sections (Plate VIII, figs. 10 and 14) show that the lateral divisions of the main axial tube become connected, as they pass outwards, with numerous small zoöidal tubes, which are continued to the surface, and which have few tabulæ or none. Long sections further show, in an exceedingly marked and characteristic manner, the mode of growth of the cœnosteum. Such sections, namely, always exhibit a series of delicate, curved, concentric lines, the convexities of which are directed towards the distal ends of the branches (Plate VIII, fig. 10). These lines are due to the formation of successive conical layers of cœnosteal tissue, which are much thicker over the growing ends of the branches than elsewhere. Hence, as viewed in long sections, these lines are seen to be comparatively wide apart in the centre of the branches, but to approximate gradually to one another as they approach the surface, with which they ultimately become nearly parallel.

Transverse sections of the cœnosteum (Plate VIII, fig. 11) show the cross-sections of the main axial tube and its lateral offshoots. Moreover, owing to the fact that the zoöidal tubes in proceeding to the surface bend outwards till they become nearly rectangular to the axis of the stem, the peripheral portion of a transverse section shows the zoöidal tubes in *longitudinal* section.

The skeletal tissue of *Stachyodes verticillata* is of the reticulate type, neither radial pillars nor concentric laminæ being recognisable as distinct structures. Sections of the skeleton, taken in any direction, show that the sclerenchyma is traversed by a series of exceedingly delicate and close-set tubuli, which in the main run parallel with the zoöidal tubes, but frequently branch and anastomose with one another. The precise appearance presented by these tubuli in thin sections varies according as they are infiltrated with calcite or with oxide of iron. In the latter condition—which is the one of most frequent occurrence—the tubuli appear in long sections of the skeletal fibre as delicate and closely approximated dark lines (Plate VIII, fig. 14), whereas in cross-sections of the fibre they appear as minute dark and well-defined dots (Plate XI, fig. 5).

Obs.—As there is only one known species of *Stachyodes*, and as its peculiarities are exceedingly well marked and distinctive, it is unnecessary to add anything to the above description. The only Stromatoporoid with which it would be possible, even on a superficial examination, to confound *S. verticillata* is *Idiostroma oculatum*, Nich.; but, apart from grosser differences between the two, a thin section of *Stachyodes verticillata* would be at once recognised by the highly characteristic minute tubulation of the skeleton-fibre.

Having examined a very large series of both German and British specimens (the former collected by myself from Bargatzky's typical locality), I do not see any reason to doubt the identity of *Stachyodes ramosa*, Barg., with the previously described *Stromatopora verticillata* of M'Coy. It is true that M'Coy has described his species from very small examples, and he states that the diameter of the stems is from " one to two lines," but this is clearly a matter of little importance. The stems in the British examples which I have examined never fall below a tenth of an inch in diameter, and their average diameter is about three tenths of an inch, but I cannot think that this is a matter of specific value.

I have never seen an example of *Stachyodes verticillata* in the " Caunopora-state."

Distribution.—*Stachyodes verticillata*, McCoy, is a not uncommon form in the Devonian Limestone of Shaldon and Teignmouth (pebbles in the Triassic conglomerates). In the German Devonians I am only acquainted with it as occurring in the limestones of Hebborn, in the Paffrath district, where it is by no means uncommon.

Genus 2.—Amphipora, *Schulz*, 1882.

(Introduction, p. 109.)

1. Amphipora ramosa, *Phill.* sp. Pl. IX, figs. 1—4, and Pl. XXIX, figs. 3—7.

Caunopora ramosa, *Phillips.* Palæozoic Foss. of Cornwall, &c., p. 19, pl. viii, fig. 22, 1841.

Stromatopora (Caunopora) ramosa, *M'Coy.* Brit. Pal. Foss., p. 67, 1851.

AMPHIPORA RAMOSA, *Schulz*. Die Eifelkalkmulde von Hillesheim, p. 90, pl. xxii, figs. 5 and 6, and pl. xxiii, fig. 1, 1882 (Jahrg. d. königl. preuss. geol. Landesanstalt für 1882).
— — *Nicholson*. Mon. Brit. Strom., Introduction, p. 109, pl. ix, figs. 1—4, 1886.

The cœnosteum in *Amphipora ramosa* is in the form of slender cylindrical stems, from 2 to 7 mm. in diameter, which may be simple, or may branch in a dichotomous manner. The surface of the cœnosteum is smooth, exhibiting neither "mamelons" nor astrorhizæ, and presenting itself under two different aspects (Plate IX, fig. 1). In one series of specimens the surface shows numerous irregularly rounded or vermiculate zoöidal apertures, with prominent tuberculate margins, giving to the fossil the aspect of a small dendroid *Alveolites*. In another series of specimens the surface is covered with a thin imperforate calcareous membrane, and the fossil looks like a stem of some such coral as *Lithostrotion junceum*. Partly decorticated specimens may show zoöidal apertures over part of the surface, while other portions are covered with a calcareous membrane; but there is reason to think that the two conditions of the surface are not simply due to the state of preservation, but indicate differences in the state of the organism in different examples (see p. 110).

As regards the internal structure of the skeleton, the cylindrical cœnosteum is traversed by a wide axial tube, which is intersected by transverse or funnel-shaped tabulæ (Plate IX, figs. 2 and 4, and Plate XXIX, fig. 4). The general cœnosteal tissue is completely reticulate, of the type of that of the *Stromatoporidæ*, neither radial pillars nor concentric laminæ being recognisable as distinct structures. The skeleton-fibre (Plate XXIX, fig. 6 *a*) is apparently solid, without pores or tubuli, each lamina being traversed by a median, dense, and dark-coloured primordial layer, thickened on both sides by lighter-coloured, fibro-crystalline, secondary sclerenchyma, and thus resembling the structure seen in many corals.

Irregular zoöidal tubes radiate outwards from the axial tube, to open on the surface by definite apertures; but the development of the zoöidal tubes is very variable, and they are generally short and sinuous, and are apparently for the most part destitute of tabulæ.

Many examples of *Amphipora ramosa* have the cylindrical cœnosteum surrounded by a sheath of large-sized lenticular vesicles, which are in turn surrounded by the delicate imperforate calcareous cuticle above spoken of (Plate IX, figs. 2 and 3, and Plate XXIX, fig. 5). Other specimens either show no traces of marginal vesicles and a bounding membrane (Plate IX, fig. 4), or they may have the marginal vesicles imperfectly developed and of small size (Plate XXIX, figs. 6 and 7). The significance of the above variations of structure cannot be at present fully estimated; but it is possible that the marginal vesicles are connected with reproduction, and that they correspond with the "ampullæ" of the Stylasterids and of *Millepora.*

Obs.—*Amphipora ramosa*, Phill. sp., being the only known species of the genus *Amphipora*, I have nothing special to add to the above description of its general characters. In an examination of a large number of transverse and longitudinal sections of the species one is at once struck with the fact that certain specimens (Plate IX, fig. 3, and Plate XXIX, fig. 5) are composed of a comparatively dense central core of reticulated tissue, which is traversed by a large axial canal, and is enclosed in a sheath of large peripheral vesicles bounded externally by a delicate calcareous membrane. Other specimens, on the contrary, have a generally more loosely reticulate structure, and have comparatively small marginal vesicles, while an axial canal may apparently be wanting or imperfectly developed (Plate IX, fig. 4, and Plate XXIX, figs. 6 and 7). Other examples, lastly, appear to be completely devoid both of the marginal zone of vesicles and of the external calcareous cuticle (Plate IX, fig. 4), though a well-marked axial tube may be present. It seems most probable that these different forms are really different conditions of a single type, though it must be admitted that at present we have no decisive evidence in support of this view.

I have never seen any example of *Amphipora ramosa* in which "Caunopora-tubes" are developed.

Distribution.—*Amphipora ramosa* occurs in great numbers in the Devonian rocks of both Germany and Britain, marking a distinct horizon, which the German geologists have determined as being in the upper portion of the Middle Devonian rocks (the "Ramosa-bänke" of Schultz). The *Amphipora-ramosa*-beds of the German Devonians are admirably seen at Hebborn (Paffrath district) and at Hillesheim (in the Eifel). In Britain the species occurs abundantly in the Devonian Limestones of Devonshire, at Shaldon, Newton Abbot, Teignmouth, &c.

Genus 3.—Idiostroma, *Winchell*, 1867.

(Introduction, p. 99.)

1. Idiostroma oculatum, *Nicholson.* Pl. XXIX, figs. 8—11; woodcuts, figs. 32, 33.

Idiostroma oculatum, *Nicholson.* Mon. Brit. Strom., Introduction, p. 101, figs. 14 and 15, 1886.

The cœnosteum in this form consists of slender cylindrical stems, from 3 to 10 mm. in diameter, which branch and inosculate freely, so as to give rise to fasciculate masses of considerable size (woodcut, fig. 32). The surface is devoid of "mamelons" or astrorhizæ, and is partly covered with the irregularly rounded

FIG. 32.

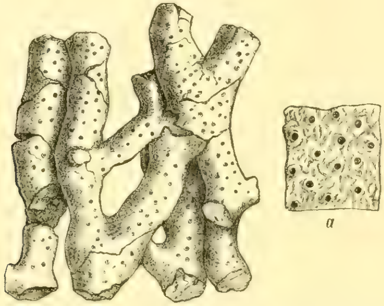


FIG. 32.—A fragment of the cœnosteum of *Idiostroma oculatum*, Nich., of the natural size. Devonian, Büchel. *a*. A small portion of the surface of the same enlarged.

or vermiculate apertures of the zoöidal tubes, while other portions are covered with a smooth calcareous membrane.

As regards internal structure, the general cœnosteal tissue is more or less reticulate; but stout radial pillars are usually clearly recognisable in transverse sections of the stems (Plate XXIX, fig. 9). Such sections also generally show with extreme clearness that the skeleton is built up of definite concentric layers surrounding a central core of loose reticulate tissue. The skeleton-fibre is almost certainly porous (as it is in *I. Rœmeri*, Nich.); but owing to the extent to which all the specimens examined are mineralised, this point cannot be certainly ascertained.

Each stem typically exhibits in longitudinal section (Plate XXIX, fig. 11) a well-developed axial tube, which is provided with transverse or infundibuliform tabulæ. This central tube gives off lateral branches, which are also tabulate, and which ascend obliquely towards the surface, giving off secondary branches in their course. Hence in transverse sections (Plate XXIX, fig. 9) we may see not only the central opening representing the section of the main axial canal, but also a variable number of apertures external to this, representing sections of the secondary tubes above spoken of. Tangential sections (Plate XXIX, fig. 10) likewise often show these secondary tubes as seen when obliquely divided. None of the specimens examined show the final terminations of the axial tubes, so that it is unknown whether or not they open on the surface.

Zoöidal tubes are sometimes well exhibited in the peripheral portions of transverse sections of the stems; but in longitudinal sections they are usually badly shown, apparently owing to their tortuous character.

Many specimens of *Idiostroma oculatum* exhibit embedded tubes which have the general character of "Caunopora-tubes," since they open on the surface by

FIG. 33.

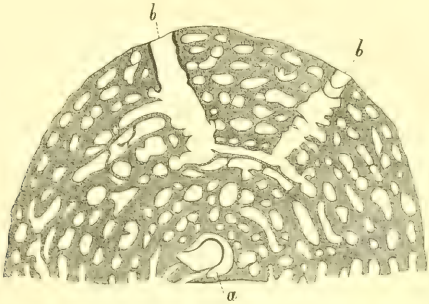


FIG. 33.—Transverse section of half of a stem of *Idiostroma oculatum*, Nich., enlarged about 12 times. *a.* The axial canal transversely divided. *b b.* Large radially directed tubes embedded in the cœnosteum, opening inferiorly into the interlaminar spaces, but acquiring thickened walls, and becoming intersected by tabulæ where they approach the surface.

rounded apertures with thickened margins, and are provided with proper walls (woodcuts, figs. 32 *a* and 33). Other examples show no traces of these embedded tubes (Plate XXIX, fig. 8). Sections of the stems (Plate XXIX, fig. 11, and woodcut, fig. 33) show that these supposed "Caunopora-tubes" possess a thickened proper wall in the outer part of their course, but apparently lose this as they are traced internally, till they appear in some cases to open directly into the interlaminar spaces of the cœnosteum. Doubt is thus thrown upon the true nature of these embedded tubes; and if they were *constantly* present there would be good ground for thinking that they really belong to the organism with which they are associated. This conclusion is, however, rendered doubtful by the fact that some specimens do not show any traces of the presence of these tubes; and, in spite of a laborious investigation, I must still confess myself as unable to come to any positive conclusion as to whether or not these embedded tubes are adventitious. In view, however, of the extent to which the calcareous tissue of a shell enclosed in a crust of the recent *Hydractinia echinata* may be eaten away or absorbed by the parasite, I feel inclined to doubt if any stress can be laid upon the apparent absence of a proper wall to the embedded tubes of *Idiostroma oculatum* in the more deeply buried part of their course.

Obs.—The only other species of the genus *Idiostroma* with which I have any personal acquaintance is *Idiostroma Roemeri*, Nich., of the Devonian rocks of Germany (Introduction, p. 100, Plate IX, figs. 6—10). From this latter species the present form is at once distinguished by its slender stems, its fasciculate mode of growth, the characters of its surface, and the much less complete development of the zoöidal tubes.

Distribution.—Not uncommon in the Devonian Limestones of Büchel, in the Paffrath district. It is also of not very rare occurrence in the Devonian Limestones of South Devon (Teignmouth, Shaldon, &c.).

SUPPLEMENT TO THE HISTORICAL INTRODUCTION.

In what follows I have given a brief notice of all the memoirs or works dealing with the Stromatoporoids which are known to me as having been published subsequent to the autumn of 1885, at which time the first part of the present Monograph was in print.

In the later part of 1885 Herr Fritz Frech described some Stromatoporoids from the Upper Devonian rocks of Germany in a paper entitled "Die Korallenfauna des Oberdevons in Deutschland" ('Zeitschr. d. deutschen Geol. Ges., Jahrg.,' 1885). Following Bargatzky and Maurer, the author selected a species of *Actinostroma* as being the form described by Goldfuss as *Stromatopora concentrica*. In an appendix, however, the author states that he is now satisfied that this identification is incorrect, though he still regards an *Actinostroma* as being the true *Stromatopora concentrica*, Goldf. A Stromatoporoid (apparently a *Stromatoporella*) is identified with the *Stromatopora stellifera* of A. Römer; and a new species, of uncertain affinities, is described under the name of *Stromatopora philoclymenia*. In 1886, in his work entitled "Die Cyathophylliden und Zaphrentiden des deutschen Mitteldevon" ('Palaeontologische Abhandlungen,' Berlin), Herr Frech discusses the nature of "*Caunopora*," and concludes that the fossils included under this name are the result of the commensal growth of a Stromatoporoid with an *Aulopora* or a *Syringopora*.

In 1886, Mdlle. Eugenia Solomko published a work on the Stromatoporoids of the Devonian rocks of Russia (pp. 48, with two plates, St. Petersburg, 1886). As it is written in Russian I have, unfortunately, been unable to read this memoir, but an analysis of its contents is given by Waagen and Wentzel in the 'Palæontologia Indica,' "Salt Range Fossils," ser. 13, vol. vii, 1887. Mdlle. Solomko deals principally with points connected with the general structure of the Stromatoporoids, and proposes a classification based upon the structure of the skeleton-fibre. The Stromatoporoids are regarded as belonging to the Sponges (*Pharetrones*). No new species are described.

In 1886, Mr. E. O. Ulrich described and figured a species of *Labechia* from the Cincinnati group of Ohio under the name of *L. montifera* ('Contributions to North American Palæontology,' vol. i, p. 33, woodcut and pl. ii, figs. 9 and 9 *a*).

Mr. Ulrich has been so good as to supply me with a specimen of this form, and I think it is certainly identical with that previously described by me under the name of *L. ohioensis.*

In 1886, Dr. C. Rominger published a paper on the "Minute Structure of *Stromatopora* and its Allies" ('Proc. Acad. Nat. Sci. Philadelphia,' pp. 39—56, 1886). This paper is principally occupied with a criticism of the memoir on the structure of the skeleton of the Stromatoporoids published in 1878 by Dr. Murie and the present writer; but as Dr. Rominger wrote without having previously made himself acquainted with the General Introduction to the present work, it is unnecessary to discuss his views in detail. Dr. Rominger further resuscitates a number of manuscript names of Stromatoporoids which he had employed in a paper which had been laid before the Academy of Sciences in Philadelphia in 1871, but which had never been published. The names in question cannot, however, be now allowed to have any validity, since the forms to which they were applied by Dr. Rominger have been described, prior to 1886, under other titles in various published memoirs by other investigators.

In 1886, the present writer published two parts of a paper entitled "On some New or Imperfectly described Species of Stromatoporoids" ('Ann. and Mag. Nat. Hist.,' ser. 5, vol. xvii, pp. 225—239, pls. vi—viii; and vol. xviii, pp. 8—22, pls. i and ii). The species dealt with are fully described, and in all cases figures of the microscopic structure of the skeleton are given. The following forms are described and figured :—*Actinostroma clathratum*, Nich.; *A. verrucosum*, Goldf.; *A. hebbornense*, Nich.; *A. astroites*, Rosen sp.; *A. bifarium*, Nich.; *A. stellulatum*, Nich.; *A. Schmidtii*, Rosen sp.; *A. intertextum*, Nich.; *Stromatoporella laminata*, Barg. sp.; *S. eifeliensis*, Nich.; *S. damnoniensis*, Nich.; *S. arachnoidea*, Nich.; *S. curiosa*, Barg. sp.; *S. granulata*, Nich.; *Labechia conferta*, Lonsd. sp.; *L. ohioensis*, Nich.; *L. canadensis*, Nich. and Mur.; *L. serotina*, Nich.; *Lophiostroma* (*Labechia?*) *Schmidtii*, Nich.; *Rosenella dentata*, Rosen sp.; *R. macrocystis*, Nich.; and *R. pachyphylla*, Nich.

In 1887, the third part of the preceding memoir was published ('Ann. and Mag. Nat. Hist.,' ser. 5, vol. xix, pp. 1—17, pls. i—iii). The following species are described and figured :—*Clathrodictyon vesiculosum*, Nich. and Mur.; *C. variolare*, Rosen sp.; *C. Linnarssoni*, Nich.; *C. striatellum*, D'Orb. sp.; *C. crassum*, Nich.; *C. fastigiatum*, Nich.; *C. regulare*, Rosen sp.; *C. cellulosum*, Nich. and Mur.; *C. ostiolatum*, Nich.; *C. laxum*, Nich.; *C. retiforme*, Nich. and Mur.; and *C.* (*?*) *tuberculatum*, Nich.

In 1887, Waagen and Wentzel published the volume of the "Salt Range Fossils" dealing with the Stromatoporoids and some of the Corals ('Palæontologia Indica,' ser. 13, vol. vii, pp. 925—962, pls. cxvii—cxxi). The earlier portion of this work is occupied with a discussion of the general structure and zoological affinities of the Stromatoporoids, which the authors divide into two families, and refer to the Hydrocorallines. It would, however, be unprofitable to discuss at length the views on the above subjects propounded in the work now under consideration; since it may be reasonably assumed that the authors would have materially modified many of their statements had they been acquainted with the previously published "General Introduction" to the present Monograph, of the existence of which they appear to have been in ignorance. The authors retain the genus *Cœnostroma*, Winch., as the type of their family *Cœnostromidæ*, upon the ground that it possesses astrorhizæ; whereas they assert these structures to be wanting in *Stromatopora concentrica*, Goldf., the type of the genus *Stromatopora*. As a matter of fact, however, astrorhizæ are always more or less largely developed in *Stromatopora concentrica*, Goldf., so that the alleged distinction between *Cœnostroma* and *Stromatopora* cannot be maintained. The authors further propose five new genera of Stromatoporoids under the titles of *Carterina*, *Circopora*, *Disjectopora*, *Irregulatopora*, and *Rosenia*. Having had no opportunity of examining specimens of the first four of these genera, I do not feel myself competent to discuss their relationships. The last-mentioned genus, however, is proposed for the fossil described by von Rosen under the name of *Stromatopora astroites*, and I have shown that this is really a species of *Actinostroma*. The most interesting and important point established by the researches of Waagen and Wentzel is that forms of the Hydrozoa related to *Stromatopora* proper occur in the "Productus Limestone" of the Salt Range of India, the age of which is regarded as Permo-Carboniferous. We may, therefore, look forward with confidence to the future discovery of Stromatoporoids in the Carboniferous rocks of Europe and America.

In 1889 Herr Joseph Wentzel published a memoir entitled "Ueber fossile Hydrocorallinen (Stromatopora und ihre Verwandten) nebst einem Anhange" ('Lotos,' Neue Folge, Bd. ix, pp. 1—24, pls. i—iii); but this is essentially a kind of abstract of the earlier portion of the work just spoken of, and, for reasons given above, does not require detailed discussion.

In 1889 Professor Lindström published a memoir with the title "Ueber die Gattung Prisciturben, Kunth" ('Bihang till K. Svenska Vet.-Akad. Handlingar,' Bd. xv, Afd. 4, No. 9, p. 10, pl. i). In this memoir Lindström shows that the genus *Prisciturben*, Kunth, is not referable to a Perforate Coral, but that it is founded upon a mixed organism resulting from the commensalism of a Stromatoporoid and a Cyathophylloid coral.

In 1889 appeared the second part of the present Monograph, in which *Actinostroma fenestratum* and *Clathrodictyon conjertum* are described for the first time.

In 1890 the present writer recorded the occurrence in Devonian deposits in

Western Australia of two European Stromatoporoids, viz. *Actinostroma clathratum*, Nich., and *Stromatoporella eifeliensis*, Nich. ("Notes on the Palæontology of Western Australia," 'Geol. Mag.,' dec. 3, vol. vii, p. 193, pl. viii).

In 1891 appeared the third part of the present Monograph. The species described in this for the first time are *Labechia scabiosa*, *L. stylophora, Stromatopora Carteri*, *S. inæqualis*, and *S. florigera.*

Lastly, in 1891 was published part iv of the memoir by the present writer, "On some New or imperfectly Known Stromatoporoids" ('Ann. and Mag. Nat. Hist.,' ser. 6, vol. vii, pp. 309—328, pls. viii—x, and two engravings). The forms described are principally American, and include the following:—*Stromatopora antiqua*, Nich. and Mur.; *S.* (*Caunopora*) *Hudsonica*, Daws.; *S. Carteri*, Nich.; *S. borealis,* Nich.; *Actinostroma expansum*, Hall and Whitf. sp.; *A. Tyrrellii*, Nich.; *A. Whitearesii*, Nich.; *A. matutinum*, Nich.; *A. fenestratum*, Nich.; *Syringostroma ristigouchense*, Spencer sp.; *S.* (*Stromatopora*) *nodulatum,* Nich.; and *S. densum*, Nich. The species described for the first time are *Stromatopora borealis*, *Actinostroma Tyrrellii*, *A. Whitearesii*, and *A. matutinum*. It is further pointed out that the form described by the author from the Hamilton formation of Ontario under the name of *Stromatopora nulliporoides* ('Report on the Palæontology of Ontario,' 1875, p. 78) is identical with the previously described *Cœnostroma incrustans* of Hall and Whitfield from the Devonian rocks of Iowa, and that the latter is properly referable to the genus *Stromatoporella*.

APPENDIX.

By the kindness of Professor Edward Orton, of the State University of Ohio, I have been permitted to re-examine the fossil which I originally described as a Stromatoporoid under the name of *Dictyostroma undulatum*, and which I regarded as the type of the genus *Dictyostroma* ('Palæontology of Ohio,' vol. ii, p. 254, pl. xxiv, fig. 6, 1875). In the Introduction to the present work (p. 85) I pointed out that the genus *Dictyostroma*, for want of knowledge of its microscopic structure, could not be regarded as being "adequately defined or satisfactorily established." Having now made a careful examination of the original example of *Dictyostroma undulatum*, Nich., by means of thin sections, I am able to state that the fossil so named is certainly not referable to the Stromatoporoids. Its precise affinities are not absolutely clear, but it is sufficient for my present purpose to point out that the genus *Dictyostroma*, Nich., must no longer be regarded as a member of the great series of the *Stromatoporoidea.*

INDEX

TO THE

FAMILIES, GENERA, AND SPECIES OF STROMATOPOROIDS DESCRIBED IN THIS MONOGRAPH.

[Names of genera or species which are regarded as synonyms, or invalid, are printed in italics.]

PLATE I.

[*Unless otherwise stated, all the specimens figured are in the collection of the Author.*]

Fig. 1.—*Clathrodictyon striatellum*, d'Orb.; vertical section, enlarged 24 times, showing the granular aspect of the skeleton-fibre, with indications of a median dark line in the horizontal laminæ. Wenlock Limestone, Ironbridge.

Fig. 2.—*Clathrodictyon cellulosum*, Nich. and Mur.; vertical section, enlarged 24 times. The specimen is silicified, and the cavities of the skeleton have first been lined with a layer of minute crystals, and subsequently filled with transparent silica, often containing orbicular masses. The skeleton-fibre is traversed by minute transverse lines of a lighter colour than the rest of the fibre, probably representing minute canals. Corniferous Limestone, Ontario.

Fig. 3.—*Stromatopora typica*, Rosen; tangential section, enlarged 24 times, showing the minutely porous character of the skeleton-fibre. Wenlock Limestone, Ironbridge.

Fig. 4.—*Stromatoporella granulata*, Nich.; tangential section, enlarged 48 times, showing the minute pores and channels in the skeleton-fibre. Hamilton Formation, Arkona, Ontario.

Fig. 5.—Vertical section of the same, similarly enlarged, showing the minute tubular spaces and the clear median line in the skeleton-fibre.

Fig. 6.—*Stromatopora Carteri*, n. sp.; tangential section, enlarged 48 times, showing the porous skeleton-fibre. Wenlock Limestone, Ironbridge.

Fig. 7.—Vertical section of the same, similarly enlarged. *t t*, zoöidal tubes.

Fig. 8.—*Actinostroma clathratum*, Nich.; tangential section, enlarged 12 times, showing the cut ends of the radial pillars. The section passes for the most part along the plane of a horizontal lamina. Devonian, Dartington, South Devon.

Fig. 9.—Vertical section of the same, similarly enlarged, showing the "continuous" radial pillars.

Fig. 10.—Part of tangential section of the same, enlarged 48 times, showing the presence of an axial canal in some of the radial pillars.

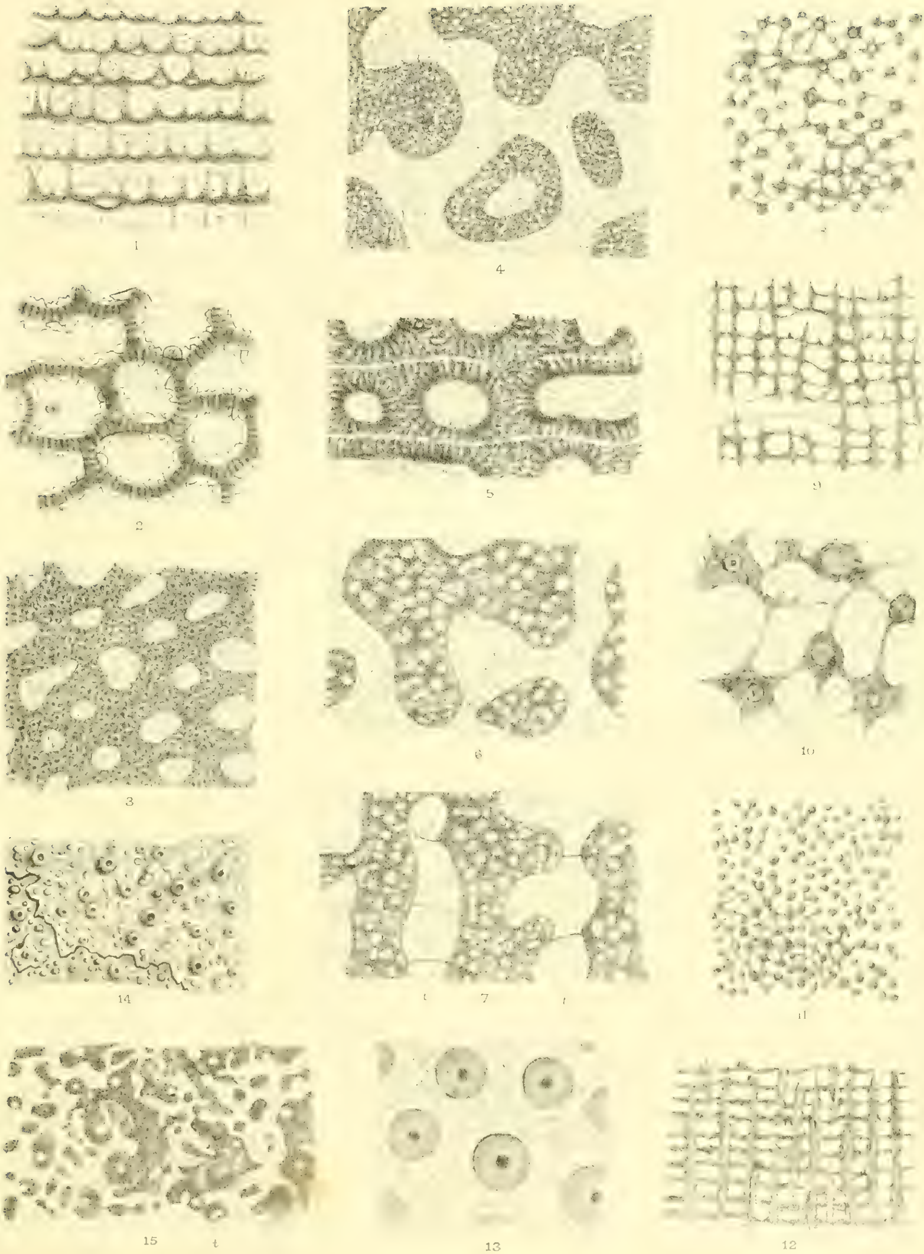
Fig. 11.—*Actinostroma clathratum*, Nich.; tangential section, enlarged 12 times. The section passes partly along the plane of one of the laminæ, and partly through one of the interlaminar spaces. Middle Devonian, Gerolstein.

Fig. 12.—Vertical section of the same, similarly enlarged.

Fig. 13.—Part of tangential section of the same, enlarged 48 times, passing along an interlaminar space, and showing the axial canals in the radial pillars.

Fig. 14.—*Stromatoporella granulata*, Nich.; surface magnified, and showing the openings of the zoöidal tubes on large round tubercles, the radial pillars terminating in blunt imperforate tubercles. Corniferous Limestone, Ontario.

Fig. 15.—*Stromatoporella granulata*, Nich.; tangential section, enlarged 12 times, showing the transversely-divided, irregular zoöidal tubes (*t*). Hamilton Formation, Arkona, Ontario.



H.A.Nicholson del.
A.T.Hollick, lith.

West, Newman & Co imp.

PLATE II.

Fig. 1.—*Labechia ohioensis*, n. sp.; vertical section, enlarged 12 times. Cincinnati group, Waynesville, Ohio.

Fig. 2.—Tangential section, similarly enlarged. In this specimen the cavities of the skeleton have been filled with opaque calcareous mud, and the skeleton has been subsequently dissolved out, and replaced by transparent calcite.

Fig. 3.—*Labechia canadensis*, Nich. and Mur. sp.; vertical section enlarged $2\frac{1}{2}$ times. Trenton Limestone, Peterboro', Ontario. The skeleton has been "replaced" by calcite, so that the rows of dark oblong masses represent the dense matrix filling the chambers, and the clear spaces of the drawing represent the original skeletal framework.

Fig. 4.—Another vertical section of the same, enlarged 12 times.

Fig. 5.—The same drawn as if it had been preserved in the usual way, *i. e.* having the chambers of the cœnosteum filled with transparent calcite, and the skeletal framework opaque.

Fig. 6.—*Parallelopora ostiolata*, Barg.; tangential section, enlarged 48 times. Devonian, Büchel (Paffrath district).

Fig. 7.—Vertical section of the same, similarly enlarged. The sections show the reticulate skeleton-fibre, traversed by numerous minute, dark, rod-like bodies, which appear to be really tubuli injected with some opaque material. *t t*, tabulate zoöidal tubes.

Fig. 8.—*Clathrodictyon regulare*, Rosen; vertical section, enlarged 24 times. The concentric laminæ show a delicate median line. Wenlock Limestone, Dudley.

Fig. 9.—*Stromatoporella eifeliensis*, Nich. (?); tangential section, enlarged 12 times, showing the irregular zoöidal tubes (*t t*) transversely divided. Devonian, Teignmouth.

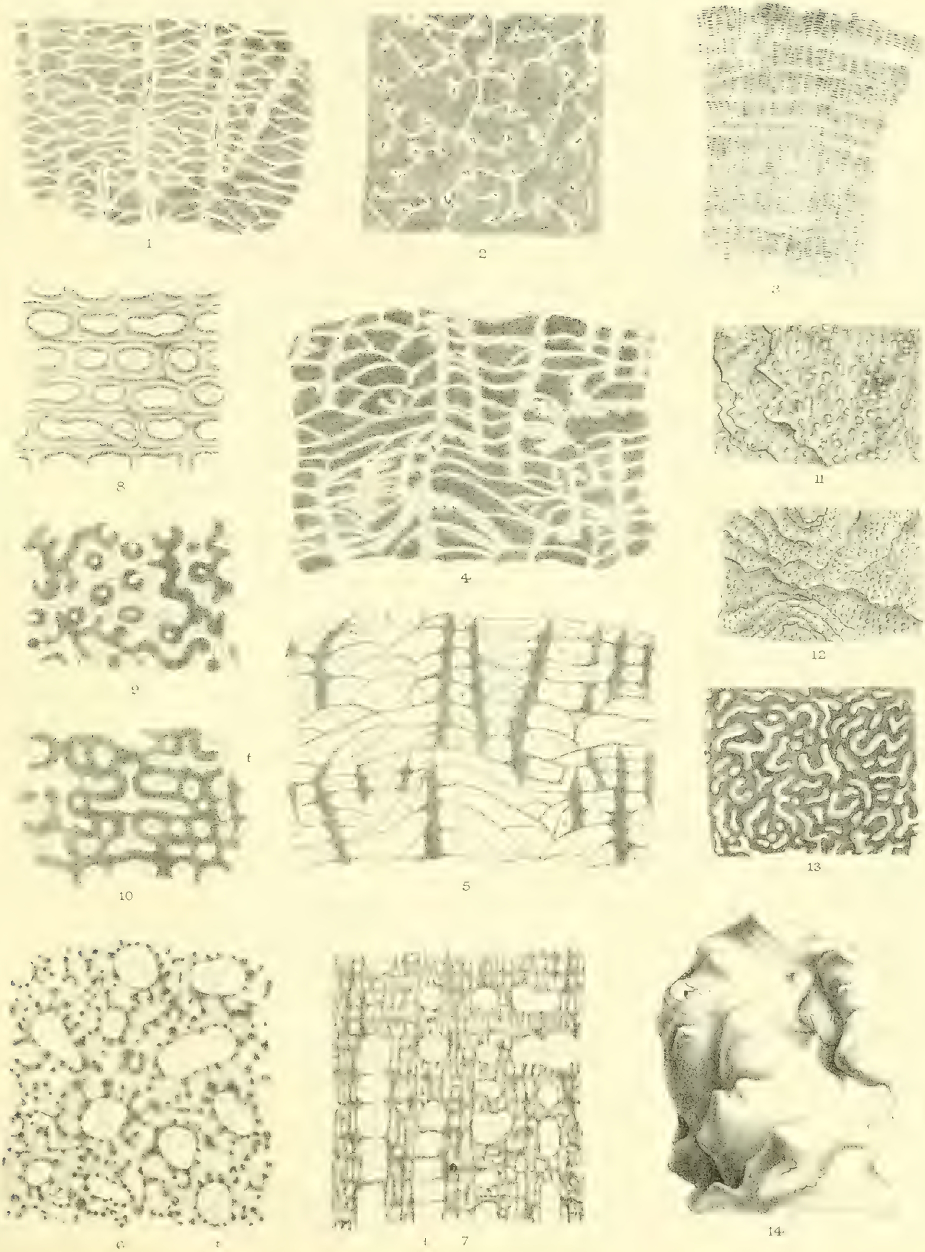
Fig. 10.—Vertical section of the same, similarly enlarged. The irregular zoöidal tubes are here seen to be crossed by tabulæ, and to extend from one interlaminar space to the next above, or to the one above that.

Fig. 11.—*Actinostroma clathratum*, Nich.; surface enlarged about 12 times. Devonian, Hebborn (Paffrath district).

Fig. 12.—*Clathrodictyon regulare*, Rosen; surface enlarged about 12 times. Wenlock Limestone, Dudley.

Fig. 13.—*Clathrodictyon fastigiatum*, n. sp.; surface enlarged about 12 times. Wenlock Limestone, Dormington.

Fig. 14.—*Stromatoporella* sp. (? *S. curiosa*, Barg.). A broken fragment of the natural size, having the surface covered with a smooth and apparently imperforate calcareous membrane. Middle Devonian, Büchel (Paffrath district).



H. A. Nicholson del.
A. T. Hollick lith.

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PLATE III.

Fig. 1.—*Hermatostroma Schlüteri*, n. sp.; tangential section enlarged 12 times. Devonian, Hebborn (Paffrath district).

Fig. 2.—Vertical section of the same, similarly enlarged. In both these sections we see the wide axial canals of the radial pillars, and the extensions of these canals into the horizontal connecting-processes by which the concentric laminæ are constituted. The entire canal-system is injected with some opaque material, probably oxide of iron.

Fig. 3.—One of the astrorhizæ of *Stromatopora discoidea*, Lonsd., enlarged 6 times. Wenlock Limestone, Wisby, Gotland.

Fig. 4.—*Stromatopora* (*Stachyodes?*) *polyostiolata*, Barg., of the natural size. Middle Devonian, Eifel. The specimen shows nipple-shaped prominences, at the summits of which are placed the surface-openings of a system of large canals, which traverse the skeleton at regular intervals, and which represent either the axial tubes of a *Stachyodes* or the central canals of the astrorhizal systems. [This figure is copied from Goldfuss ('Petref. Germ.,' pl. lxiv, fig. 8, *f*), and represents one of the forms which he included under the name of *S. polymorpha.*]

Fig. 5.—*Stromatopora concentrica*, Goldf. var. *colliculata*, Nich. A broken specimen, of the natural size. Middle Devonian, Gerolstein. The prominent monticules on the surface correspond in general with the axes of the astrorhizæ.

Fig. 6.—*Stromatoporella ? incrustans*, Hall and Whitf. sp.; portion of the surface, showing the openings of the astrorhizæ on prominent chimney-like elevations. Devonian Formation, Iowa. [Copied from Hall and Whitfield, 'Twenty-third Ann. Rep. on the State Cabinet,' pl. ix, fig. 3.]

Fig. 7.—*Labechia conferta*, Lonsd.; under side of a large specimen, of the natural size, showing the concentrically-wrinkled epitheca. Wenlock Limestone, Benthall.

Fig. 8.—A small example of *L. conferta*, from the Wenlock Limestone of Gotland, of the natural size.

Fig. 9.—Under surface of a very young example of *L. conferta*, Lonsd. (*Labechia*, n. sp.?), of the natural size. Wenlock Limestone, Dudley.

Fig. 10.—Upper surface of the same, nat. size.

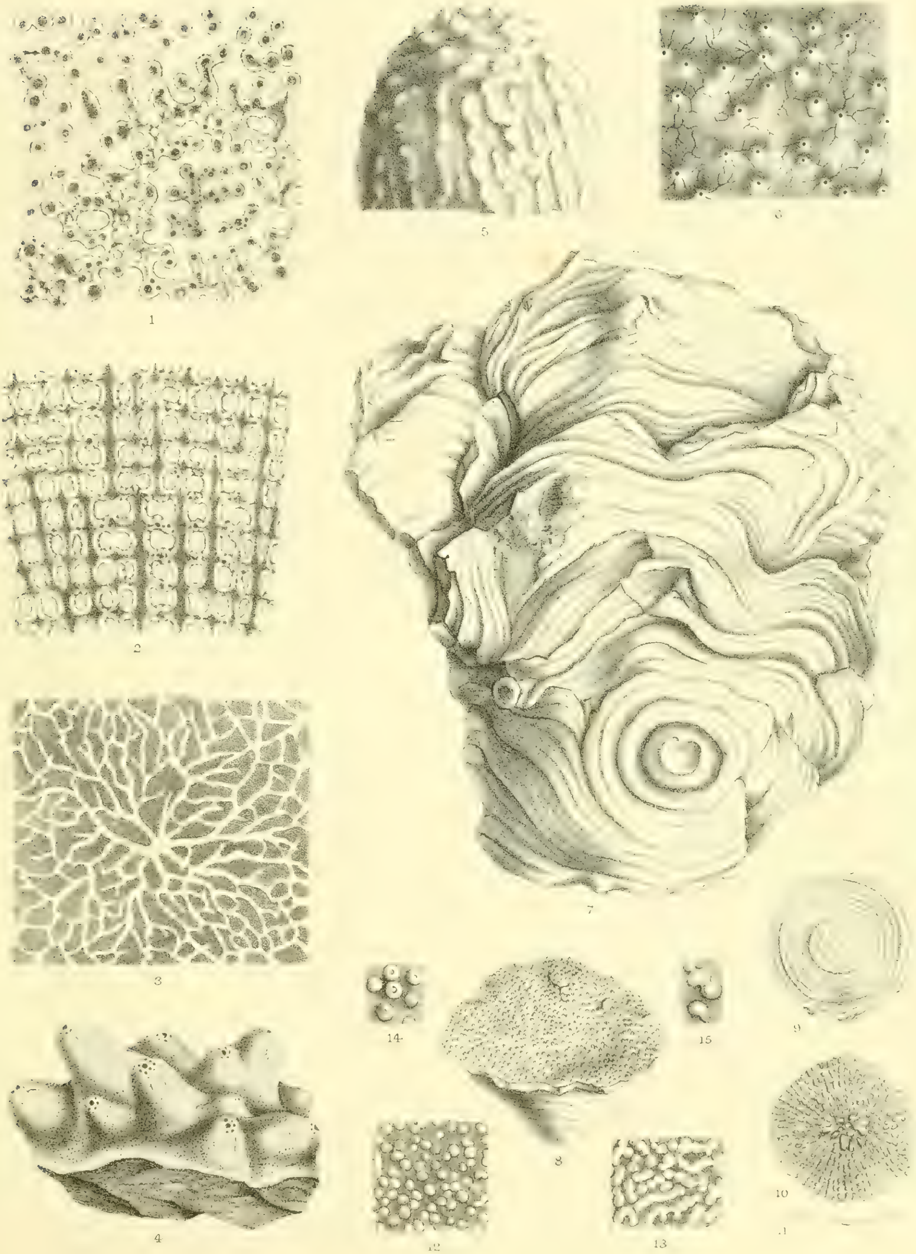
Fig. 11.—Profile of the same.

Fig. 12.—Surface of *Labechia conferta*, Lonsd., showing the upward termination of the radial pillars in round tubercles. Enlarged.

Fig. 13.—Surface of another specimen, in which the tubercles are largely confluent. Enlarged.

Fig. 14.—A few tubercles of *L. conferta*, Lonsd., enlarged, showing apparent perforations at their summits.

Fig. 15.—Completely imperforate and confluent tubercle of young *Labechia* (Fig. 9). Enlarged.



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A.T. Hollick lith.

West, Newman & Co. imp.

PLATE IV.

Fig. 1.—The central portion of the astrorhiza of *Stromatopora ? dartingtonensis*, Cart. (=*Stromatopora elegans*, Carter), enlarged 12 times. Devonian, Teignmouth. The specimen is a "reversed" one, the skeleton being replaced by transparent calcite, and the cavities of the skeleton being opaque.

Fig. 1 *a*.—The same *restored*, showing the skeleton opaque and the canal-system filled with calcite, as is the case in ordinary specimens. [It is to be remembered that the process of replacement, by which such "reversed" specimens as the above are produced, is necessarily an imperfect process. Had the replacing agent been *silica*, instead of *calcite*, the replacement might possibly have been perfect. Hence in such a restoration of a "reversed" specimen as is here attempted, the dark skeletal framework shown in the restoration can only be regarded as giving the *general* form of the skeleton, and not as giving minute structural details.]

Fig. 2.—*Stromatoporella eifeliensis*, n. sp.; portion of the surface of an encrusting specimen, showing the large astrorhizæ, of the natural size. Devonian, Gerolstein.

Fig. 3.—*Actinostroma stellulatum*, n. sp.; tangential section, enlarged 12 times, showing one of the astrorhizæ. Devonian, Teignmouth.

Fig. 3 *a*.—Vertical section of another specimen of the same, similarly enlarged. The section traverses one of the wall-less vertical canals connecting successive astrorhizal systems.

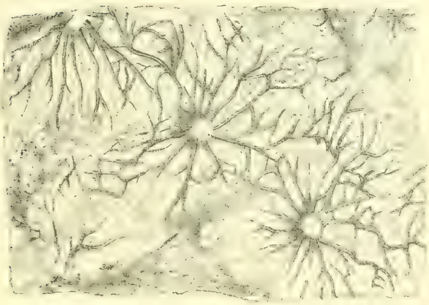
Fig. 4.—*Distichopora coccinea*, Gray (recent); tangential section, enlarged 24 times, showing the cœnosarcal canal-system, the gastropores (*g*), and the dactylopores (*d*).

Fig. 5.—Tangential section of the skeleton of a species of *Millepora* (*M. tortuosa*, Dana ?), enlarged 24 times, showing the cœnosarcal canal-system. *g*, One of the gastropores; *d*, one of the dactylopores.

Fig. 6.—*Stromatoporella granulata*, Nich.; part of the surface of a specimen from the Devonian rocks (Hamilton formation), Canada, enlarged about 6 times. The figure shows a conical eminence, upon which opens one of the vertical astrorhizal canals, and from which radiate shallow superficial astrorhizal grooves, formed by lines of elongated or vermiculate tubercles. Some of the larger tubercles show at their summits the apertures of zoöidal tubes; and part of the surface is covered with a smooth calcareous membrane, penetrated by minute isolated circular perforations.

1

1 a



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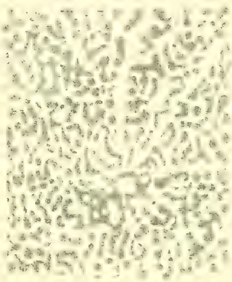

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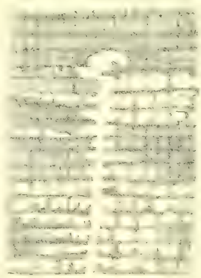

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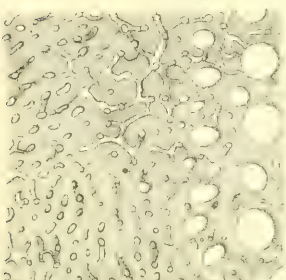

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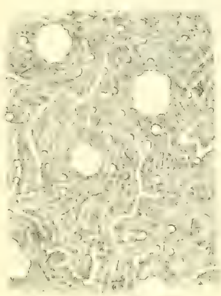

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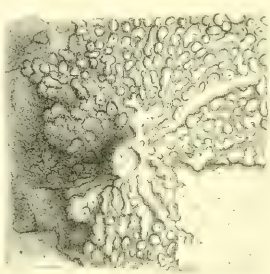

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PLATE V.

Fig. 1.—*Clathrodictyon regulare*, Rosen; vertical section, enlarged 12 times. Wenlock Limestone, Dudley.

Fig. 2.—Tangential section of the same, similarly enlarged.

Fig. 3.—*Clathrodictyon striatellum*, D'Orb.; vertical section, enlarged 12 times. Wenlock Limestone, Benthall.

Fig. 4. Tangential section of the same, similarly enlarged.

Fig. 5.—*Clathrodictyon vesiculosum*, Nich. and Mur.; vertical section, enlarged 12 times. From the type-specimen of the species, Yellow Springs, Ohio (Clinton Formation).

Fig. 6.—*Clathrodictyon variolare*, Rosen; vertical section, enlarged 12 times. *as*, *as*, cut ends of the astrorhizal canals. Wenlock Limestone, Dormington.

Fig. 7.—Tangential section of the same, similarly enlarged.

Fig. 8.—*Stromatopora antiqua*, Nich. and Mur.; a weathered specimen, of the natural size, showing the "latilaminæ." Niagara Limestone, Thorold, Ontario.

Fig. 9.—Part of a vertical section of the same, enlarged about twice. The "latilaminæ" are only partly in contact, and the spaces between them are filled with the matrix.

Fig. 10.—Vertical section of the same, enlarged 12 times, showing the delicate tabulate zoöidal tubes.

Fig. 11.—Tangential section of the same, enlarged 12 times, showing the cross-sections of the zoöidal tubes as minute apertures in the skeletal framework.

Fig. 12.—*Stromatopora Benthii*, Barg.; tangential section, enlarged 12 times. The section shows the coarsely-porous skeleton-fibre and the persistence of the radial pillars, the cut ends of which (*p p*) appear immersed in the general reticulation. Devonian, Hebborn (Paffrath district).

Fig. 13.—Vertical section of the same, similarly enlarged, showing the tabulate zoöidal tubes, and the persistence of the radial pillars (*p p*) in the interior of the skeleton-fibre.

Fig. 14.—*Stromatopora typica*, Rosen; tangential section, enlarged 12 times. The section shows the completely reticulate character of the skeletal tissue and the minutely porous structure of the skeleton-fibre. The apertures in the skeletal network are the cross-sections of the zoöidal tubes. No traces of the radial pillars, as distinct structures, can be detected. Wenlock Limestone, Ironbridge.

Fig. 15.—Vertical section of the same, similarly enlarged. The figure takes in the thickness of a single "latilamina," and shows the tabulate zoöidal tubes.

Fig. 16.—*Stromatopora concentrica*, Goldf., var. *colliculata*, Nich.; tangential section, enlarged 12 times. Middle Devonian, Gerolstein.

Fig. 17.—Vertical section of the same, similarly enlarged. The figure shows that the reticulated skeleton exhibits traces of the concentric laminæ. The section is slightly oblique, and the tabulate zoöidal tubes are, therefore, not well shown.

PLATE V.

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PLATE VI.

Fig. 1.—*Hydractinia echinata*, Flem. (recent); tangential section of a thick crust, enlarged 90 times. *p p*, Radial pillars, transversely divided. *c c*, Horizontal connecting processes or "arms" given out by the pillars at successive levels.

Fig. 2.—Portion of a young colony of the same, consisting of a single lamina, viewed as a transparent object, and enlarged 90 times. Letters as before.

Fig. 3.—Portion of the surface of *H. echinata*, greatly enlarged. On the left half of the figure the spines (*s*) and the astrorhizal grooves (*g*) are alone shown; while on the right half of the figure are shown the small tubercles (*b*) which represent the free ends of the radial pillars and also the openings of the zoöidal tubes (*t t*).

Fig. 3 *a*.—Part of the surface of the same, free from the large spines, still more highly enlarged. The tubercles representing the free ends of the radial pillars (*p p*) and their horizontal connecting-processes are shown, as well as a few of the openings of the zoöidal tubes.

Fig. 4.—Vertical section of the skeleton of *Hydractinia echinata*, enlarged, showing three laminæ (*l*, *l′*, *l″*) with their interlaminar spaces (*i i*), and a single spine (*s*). [Copied from Carter.]

Fig. 5.—Part of a vertical section of *H. echinata*, enlarged 90 times. Showing the radial pillars (*p p*) and the connecting-processes or concentric laminæ (*c c*), with the intervening interlaminar spaces.

Fig. 6.—Spine of *Hydractinia echinata*, greatly enlarged.

Fig. 7.—*Hydractinia circumvestiens*, S. V. Wood, Red Crag, Suffolk. Vertical fracture of the skeleton, enlarged 3 times, showing the zoöidal tubes (*t t*) and the rows of chambers representing the interlaminar spaces.

Fig. 8.—Part of the surface of a worn example of the same, enlarged, showing the large perforated radial pillars (*p*) and the mouths of the zoöidal tubes.

Fig. 9.—Surface of an unworn example of the same, enlarged 24 times, showing the large perforated pillars (*p*), the surface-tubercles representing the small radial pillars (*b b*), the astrorhizal grooves (*g*), and the zoöidal apertures (*t*).

Fig. 10.—Portion of the same, further enlarged. These two figures are from a beautiful specimen of *H. circumvestiens* in the British Museum, and were kindly drawn for me by Mr. Arthur H. Foord.

Fig. 11.—Vertical section of *H. circumvestiens*, enlarged 12 times, showing the zoöidal tubes (*t t*), the irregular interlaminar chambers (*i i*), and the large radial pillars (*p p*). These last have their axes traversed by irregular canals, giving them a cribriform structure.

Fig. 12.—Tangential section of the same, similarly enlarged, showing the transversely divided radial pillars and zoöidal tubes.

Fig. 13.—Part of the last section, enlarged 24 times, showing the apparent composition of the skeleton out of irregular calcareous granules.

p
r
11
p
12

PLATE VII.

Fig. 1.—*Stromatopora discoidea*, Lonsd.; tangential section, enlarged 12 times. Wenlock Limestone, Ironbridge.

Fig. 2.—Vertical section of the same, similarly enlarged, showing the minute tabulate zoöidal tubes. A single latilamina alone is shown.

Fig. 3.—*Stromatoporella eifeliensis*, n. sp.; tangential section, enlarged 12 times. *c c*, astrorhizal canals crossed by "astrorhizal tabulæ."

Fig. 4.—Vertical section of the same, similarly enlarged. *c c*, Cut ends of the astrorhizal canals, showing the astrorhizal tabulæ. The general structure of the skeleton in this form is very similar to that of *S. granulata*, Nich., but it seems to be sufficiently separated from the latter by the great development of the astrorhizal system and by other minor characters.

Fig. 5. *Stromatoporella granulata*, Nich.; tangential section, enlarged 12 times. Devonian (Hamilton Formation), Arkona, Ontario.

Fig. 6.—Vertical section of the same, similarly enlarged.

Fig. 7.—*Stylodictyon columnare*, Nich.; a fragment, of the natural size, showing a vertical polished section. Devonian (Corniferous Limestone), Sandusky, Ohio.

Fig. 8.—Upper surface of the preceding specimen, of the natural size.

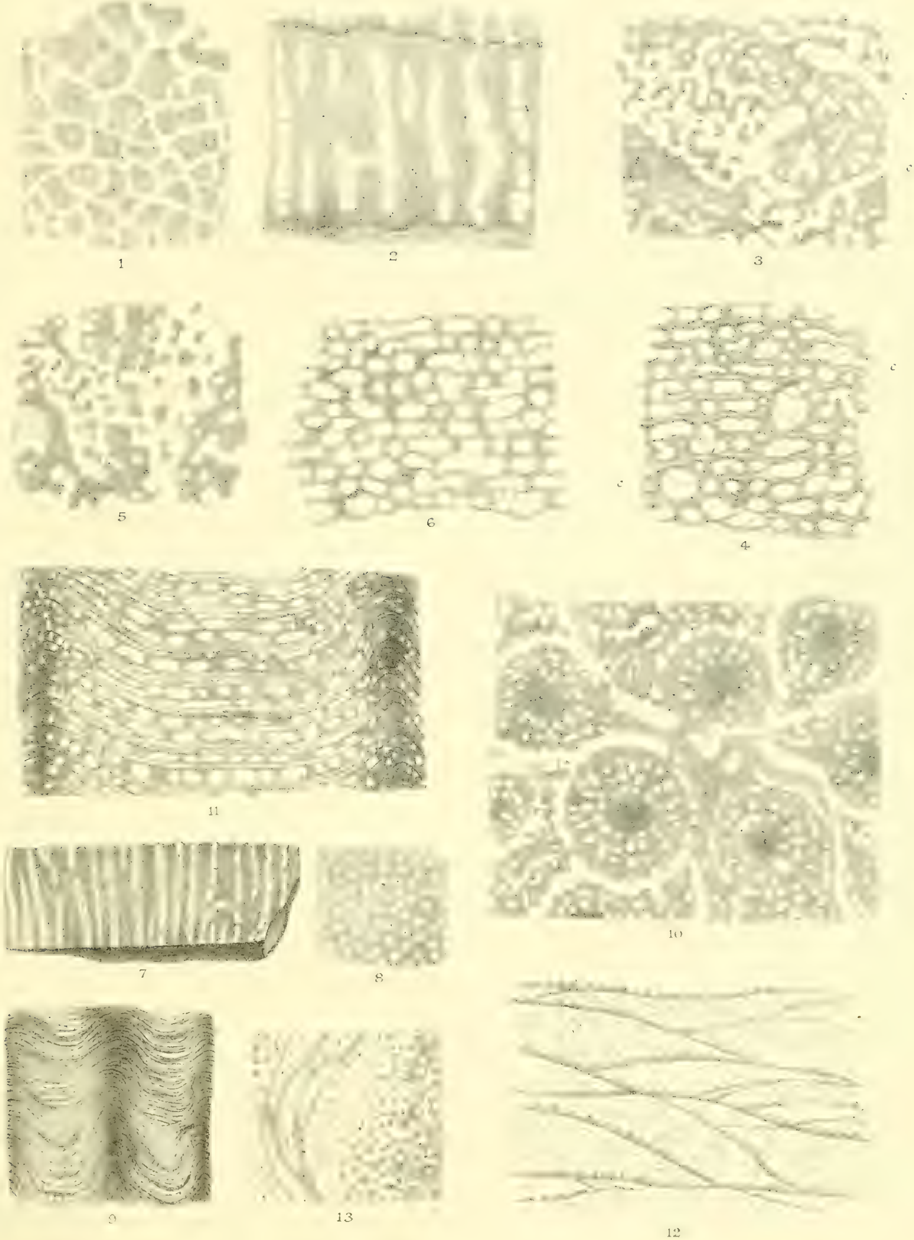
Fig. 9.—Vertical section of the same, enlarged 5 times.

Fig. 10.—Tangential section of the same, enlarged 12 times. The portion figured exhibits the centre of an astrorhiza.

Fig. 11.—Vertical section of the same, enlarged 12 times, embracing one of the intervals between a pair of the vertical columns.

Fig. 12.—*Rosenella macrocystis*, Nich; vertical section enlarged 12 times. Wenlock Limestone, Wisby, Gotland. [Coll. Dr. George J. Hinde.]

Fig. 13.—Tangential section of the same, similarly enlarged.



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A. T. Hollick lith.

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PLATE VIII.

Fig. 1.—*Beatricea nodulosa*, Bill.; a fragment from the Cincinnati Group of Marion County, Kentucky. Of the natural size.

Fig. 2.—Transverse section of the same, enlarged twice.

Fig. 3.—Vertical section of the same, enlarged twice.

Fig. 4.—Part of a transverse section of another specimen of the same species, enlarged 12 times. Hudson River Group, West-End Lighthouse, Anticosti. [Collected by Mr. Richardson, Canad. Geol. Survey.] The section shows radial pillars, similar to those of *Labechia*, traversing the vesicular tissue.

Fig. 5.—Part of the preceding section, enlarged 24 times. In the interior of the vesicles the granular calcareous matter is so disposed as to leave clear vertical linear spaces.

Fig. 6.—Part of the periphery of a very large specimen of the same, in transverse section, enlarged 6 times, showing radial pillars and concentric laminæ. In parts of the section the ordinary lenticular vesicles characteristic of *Beatricea* are preserved. Hudson River Group, West-End Lighthouse, Anticosti. [Collected by Mr. Webster, Canad. Geol. Survey.]

Fig 7.—Part of a tangential section of the preceding specimen, enlarged 6 times.

Fig. 8.—Portion of the surface of the same specimen, enlarged 6 times, showing different-sized apertures, the larger of which are disposed in indistinctly spiral rows.

Fig. 9.—*Stachyodes verticillata*, McCoy, sp. (= *S. ramosa*, Barg.); a fragment, the natural size. Devonian, Hebborn (Paffrath district).

Fig. 10.—Longitudinal section of another specimen of the same, from the same locality, enlarged twice, showing the axial tabulate tube, the growth of the skeleton by successive convex layers, and the radiating zoöidal tubes. [For the sake of clearness, the zoöidal tubes are placed rather farther apart than they should be in a figure drawn strictly to the scale of two diameters.]

Fig. 11.—Transverse section of the same, enlarged twice.

Fig. 12.—Surface of the same, enlarged 6 times, showing the apertures of the zoöidal tubes. The lower part of the figure shows these openings concealed by a thin calcareous membrane.

Fig. 13.—Small portion of the tangential section of the same, enlarged 12 times, showing the minutely tubulated character of the skeleton-fibre. Owing to the direction of the tubuli, they are necessarily cut across transversely in a tangential section.

Fig. 14.—Part of a longitudinal section of the same, showing the zoöidal tubes, and the minute tubuli running parallel with these, enlarged 12 times. In this preparation the minute tubuli above spoken of are injected with some opaque material.

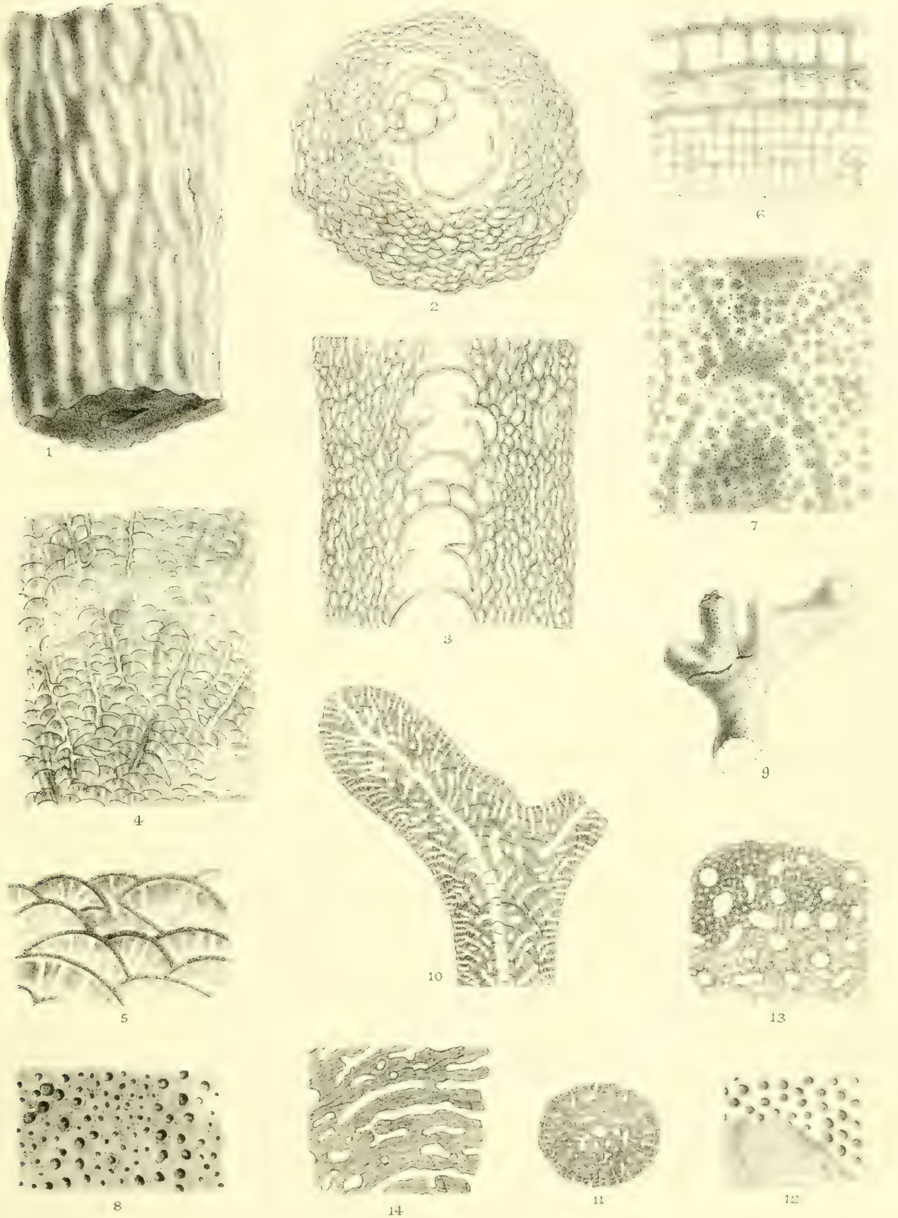

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PLATE IX.

Fig. 1.—A fragment of limestone from the "*Ramosa*-Bänke" of Schulz, Middle Devonian, Hebborn, Paffrath district, natural size. The rock is almost wholly composed of the broken stems of *Amphipora ramosa*, Phill., sp., some being covered with a thin imperforate membrane, while others have a vermiculate or tuberculated exterior.

Fig. 2.—Longitudinal section of a stem of *Amphipora ramosa*, Phill., sp., enlarged 12 times, showing the axial tube and the large marginal vesicles, with the intermediate reticulated tissue. Hebborn.

Fig. 3.—Transverse section of the same, similarly enlarged.

Fig. 4.—Longitudinal section of another specimen of the same, from the same locality, enlarged 8 times. In this specimen marginal vesicles are not developed, and the axial canal is intersected by well-developed tabulæ.

Fig. 5.—Part of the longitudinal section of the cœnosteum of the recent *Distichopora coccinea*, Gray, taken in the plane of the zoöidal tubes, showing the cœnenchymal canal-system, enlarged 12 times.

Fig. 6.—Portion of a mass of *Idiostroma Roemeri*, n. sp., from the Devonian Limestone of Hebborn (Paffrath district), of the natural size.

Fig. 7.—Transverse section of one of the cylindrical stems of the same, enlarged twice, showing the axial tube and the tabulate zoöidal tubes.

Fig. 8.—Longitudinal section of the same, enlarged twice, showing the axial tube with its funnel-shaped tabulæ and its lateral branches. The section traverses a second smaller longitudinal tube running parallel with the main one.

Fig. 9.—Part of the surface of the same, enlarged, showing the vermiculate ridges and the apertures of the zoöidal tubes.

Fig. 10.—Tangential section of the same, enlarged 12 times.

Fig. 11.—Part of the outer zone of a transverse section of the same, enlarged 12 times, showing the tabulate zoöidal tubes.

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PLATE X.

Fig. 1.—*Stromatoporella laminata*, Barg., sp. (= *Diapora laminata*, Barg.). Tangential section, enlarged 12 times. Middle Devonian, Büchel (Paffrath district).

Fig. 2.—Vertical section of the same, similarly enlarged. The funnel-shaped tabulæ of the " *Caunopora*-tubes " are well shown.

Fig. 3.—Part of the surface of an unworn specimen of the same, enlarged 3 times, showing the mouths of the " *Caunopora*-tubes," connected here and there by horizontal stolons. Büchel.

Fig. 4.—Part of the surface of another beautifully preserved example of the same, from the same locality, enlarged 12 times, showing that the surface-tubercles are perforated by circular apertures at their summits.

Fig. 5.—*Stromatopora bücheliensis*, Barg., sp.; part of a dendroid example, of the natural size, from the Middle Devonian of Büchel. This is the *Caunopora bücheliensis* of Bargatzky, and is not uncommon in the Devonian of both Britain and Germany, occurring both with and without the " *Caunopora*-tubes," which are present in the specimen figured.

Fig. 6.—Tangential section of the same specimen, enlarged 12 times.

Fig. 7.—Vertical section of the same specimen, similarly enlarged.

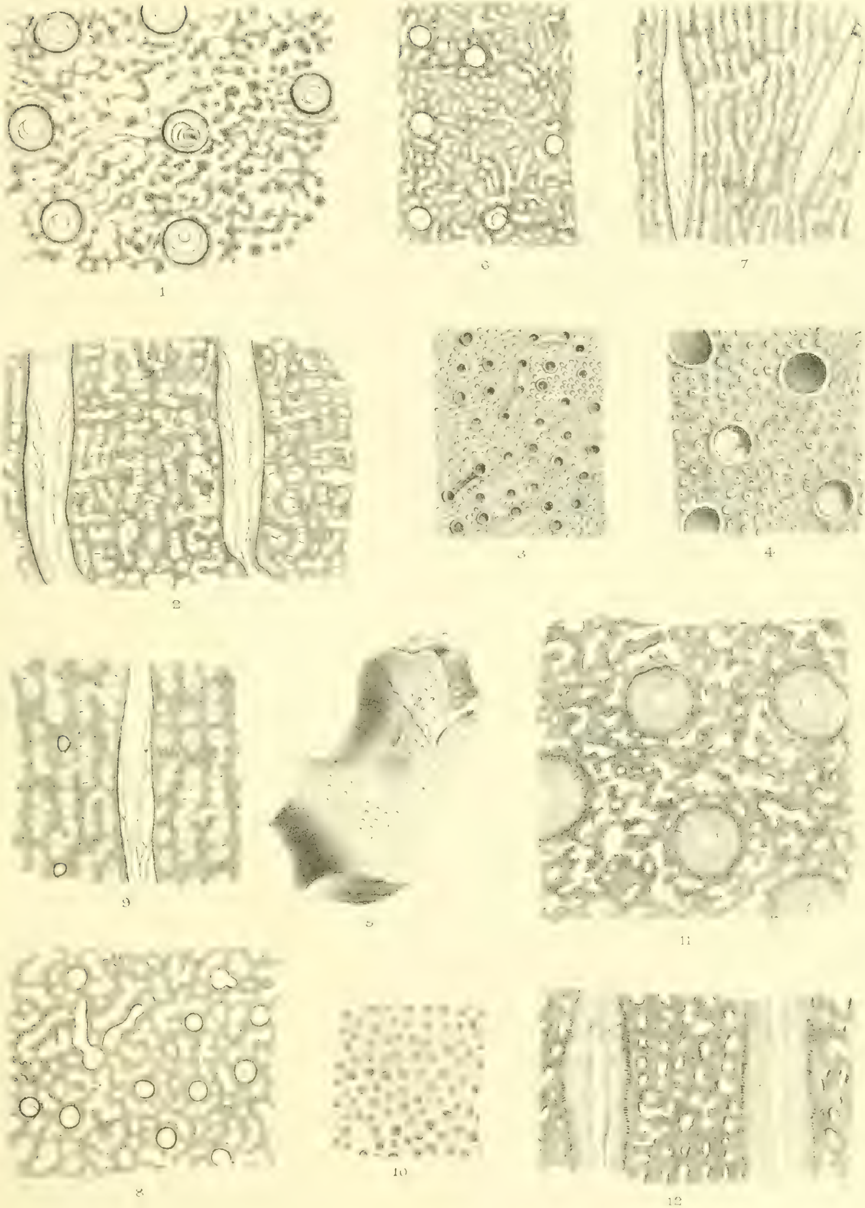
Fig. 8.—*Stromatopora Hüpschii*, Barg., sp.; tangential section, enlarged 12 times. Middle Devonian, Büchel. This is the *Caunopora Hüpschii* of Bargatzky. It occurs in the Middle Devonian of both Britain and Germany, sometimes with and sometimes without the " *Caunopora*-tubes," which are present in the specimen figured.

Fig. 9.—Vertical section of the same specimen, enlarged 12 times. The section cuts through one of the " *Caunopora*-tubes," with its funnel-shaped tabulæ, and also divides transversely two of the horizontal connecting-tubes belonging to the same system.

Fig. 10.—Small portion of a polished specimen of *Stromatopora Beuthii*, Barg. (?), of the natural size, from the Devonian Limestone, Teignmouth. In this specimen the " *Caunopora*-tubes " are of exceptionally large size.

Fig. 11.—Tangential section of the preceding, enlarged 12 times. The specimen, like many of those from South Devon, and particularly those found in the pebbles of the Triassic conglomerates, has undergone much crystallisation and squeezing. The " *Caunopora*-tubes," as is commonly the case, have their cavities largely filled up with a deposit of light-coloured sclerenchyma.

Fig. 12.—Vertical section of the same, enlarged 12 times. The minute structure of the skeleton is considerably altered and distorted by crystallisation and pressure.



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A.T. Hollick lith.

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PLATE XI.

Fig. 1.—Vertical section of *Stromatoporella eifeliensis*, n. sp., enlarged 24 times, showing the minute tubuli occupying the axes of the pillars and concentric laminæ. Middle Devonian, Gerolstein.

Fig. 2.—Tangential section of the same, similarly enlarged, showing the system of minute branching tubuli in the substance of the skeleton-fibre. The section traverses part of an astrorhizal system.

Fig. 3.—Vertical section of *Stromatoporella*, sp., enlarged 50 times, showing the minute tubulation of the skeleton-fibre. Middle Devonian, Gerolstein. This species is peculiar in having the interlaminar spaces crossed by innumerable vesicular tabulæ.

Fig. 4.—Tangential section of the same, similarly enlarged.

Fig. 5.—Tangential section of *Stachyodes verticillata*, M'Coy, sp., enlarged 24 times, showing the tubuli of the skeleton-fibre filled with opaque matter. Devonian, Teignmouth.

Fig. 6.—Part of a tangential section of another specimen of the same, from the Middle Devonian of Hebborn (Paffrath district), in which the tubuli of the skeleton-fibre are filled with transparent calcite. Enlarged 24 times.

Fig. 7.—Part of the tangential section of *Idiostroma?* sp. (? = *Stromatopora capitata*, Goldf.), enlarged 24 times, showing numerous dark rounded spots in the interior of the transparent skeleton-fibre. Middle Devonian, Hebborn.

Fig. 8.—Vertical section of the same, similarly enlarged, showing two radial pillars and the intervening tabulate zoöidal tubes. Dark rod-like tracts and lines are seen in the interior of the skeleton-fibre.

Fig. 9.—Part of a tangential section of the original specimen of *Parallelopora Goldfussi*, Barg., enlarged 24 times. The skeleton-fibre is in the main opaque, but exhibits in its interior numerous clear round spots or vacuities filled with transparent calcite. Middle Devonian, Hand (Paffrath district).

Fig. 10.—Part of a tangential section of *Stromatoporella* (*Diapora*) *laminata*, Barg., enlarged 24 times, showing the porous skeleton-fibre. Middle Devonian, Büchel.

Fig. 11.—Tangential section of *Syringostroma? ristigouchense*, Spencer, sp., enlarged 12 times. Upper Silurian, Ristigouche. (From a specimen presented to the writer by Professor Spencer.) The section shows that the skeleton-fibre has the porous structure of that of the *Stromatoporidæ*, while the large radial pillars with their radiating connecting-processes are arranged as in the genus *Actinostroma*.

Fig. 12.—Vertical section of the same, similarly enlarged, showing the porous skeleton-fibre, the large radial pillars, and the regularly-developed horizontal "arms."

Fig. 13.—Tangential section of the original specimen of *Syringostroma densum*, Nich., enlarged twelve times, showing the porous structure of the skeleton-fibre and its generally reticulated character. The cut ends of a number of large-sized radial pillars are also shown. Devonian (Corniferous Limestone), Ohio.

Fig. 14.—Vertical section of the same, similarly enlarged.

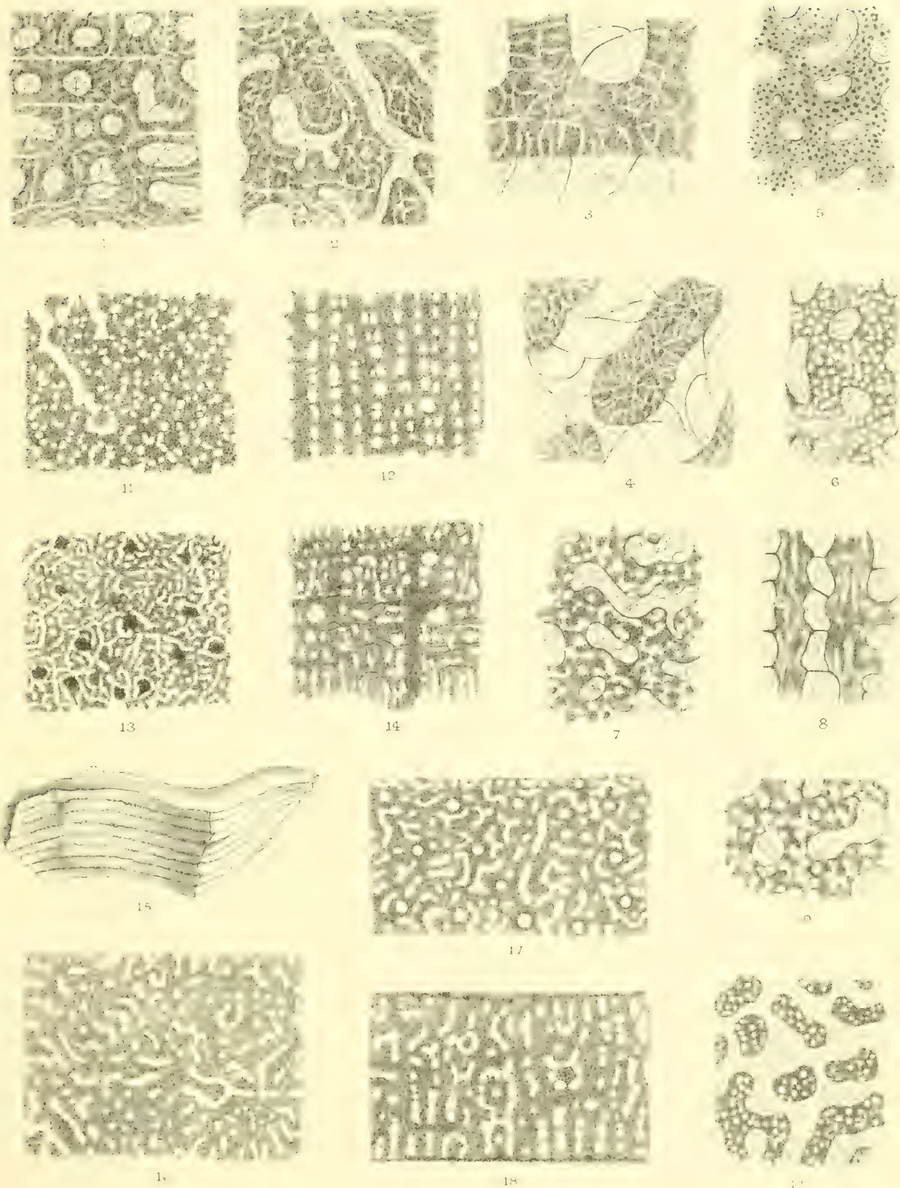
Fig. 15.—A small fragment of *Stromatopora concentrica*, Goldf., from the Middle Devonian of Gerolstein, of the natural size. The specimen, both as regards general structure and mode of preservation, is absolutely identical with the original example of the species figured in the 'Petrefacta Germaniæ.'

Fig. 16.—Tangential section of the same, enlarged 12 times, showing the porous and reticulated character of the skeletal tissue.

Fig. 17.—Tangential section of another specimen of the same, in the "*Caunopora*-state." The "*Caunopora*-tubes" are exceedingly minute and very regularly placed, but have all the characters of the tubes of "*Caunopora*" generally. They are much smaller than the tubes of any known species of *Aulopora* or *Syringopora* in the Devonian Series.

Fig. 18.—Vertical section of the same, enlarged 12 times, showing the irregular, tabulate zoöidal tubes. The portion figured embraces the thickness of a single "latilamina."

PLATE XI.



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A. T. Hollick lith.

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PLATE XII.

[The figures representing the minute structure of the specimens are based upon photographs, and the scale of magnification, even with the same objective, is therefore not absolutely constant. In most cases a two-inch objective has been used, and the scale of enlargement may be taken as varying from ten to twelve times, though as a matter of convenience I have generally stated it at being twelve times the natural size. Very often, however, the enlargement is only ten or eleven times the natural size. Where a higher objective has been used this is specially stated.]

Fig. 1.—Under surface of an example of *Actinostroma clathratum*, Nich., of the natural size. Middle Devonian, Dartington. Presented to the author by Mr. Champernowne. (Page 131.)

Fig. 2.—Tangential section of *Actinostroma clathratum*, Nich., enlarged 10—12 times. Middle Devonian, Dartington.

Fig. 3.—Vertical section of the same specimen, similarly enlarged.

Fig. 4.—Portion of the surface of a weathered specimen of *Actinostroma clathratum*, Nich., enlarged, showing the radial pillars and their connecting "arms." Middle Devonian, Hebborn (Paffrath District).

Fig. 5.—Portion of the surface of a weathered example of *A. clathratum* from the Middle Devonian of Dartington enlarged. The specimen is dolomitised, and the stellate pores are the spaces left by the solution out of the matrix of the pillars and their connecting "arms."

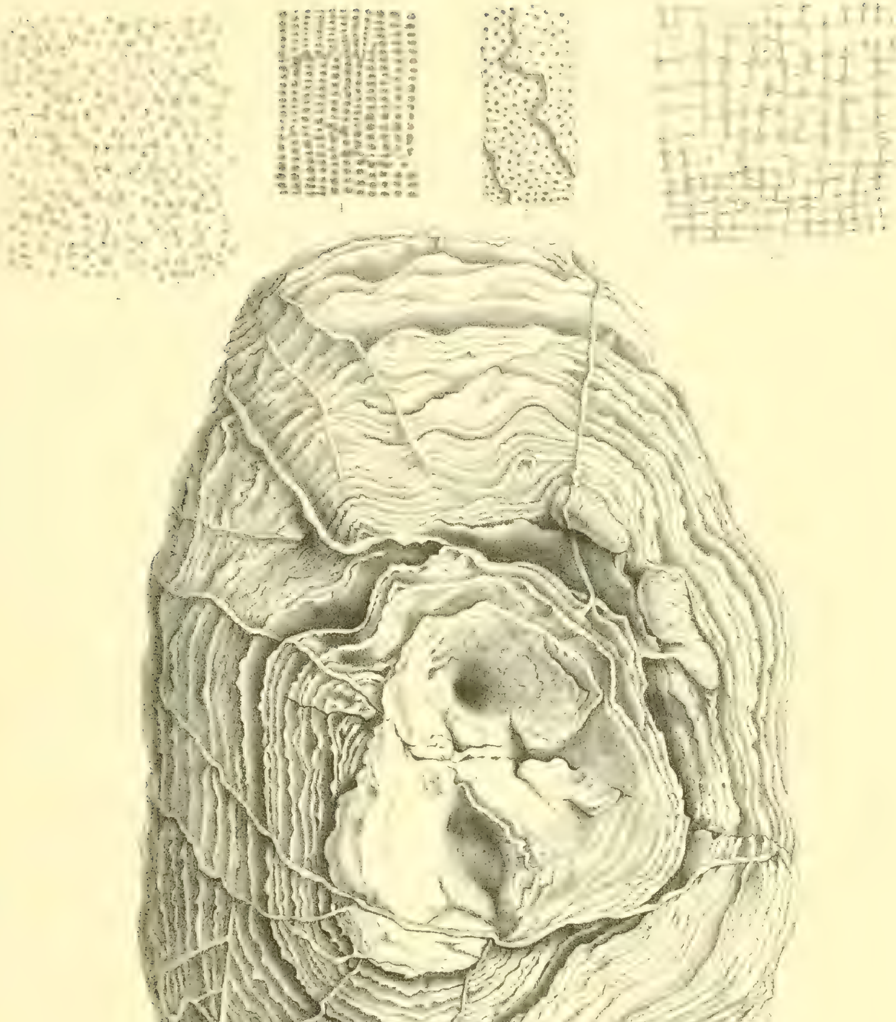

PLATE XIII.

Fig. 1.—Tangential section of a specimen of *Actinostroma clathratum*, Nich., enlarged 10—12 times. This form possesses strong but irregularly developed radial pillars. Middle Devonian, Teignmouth. (Page 133.)

Fig. 2.—Vertical section of the same specimen similarly enlarged.

Fig. 3.—Portion of a polished specimen of *Actinostroma bifarium*, Nich., of the natural size. Middle Devonian, Teignmouth. (Page 136.)

Fig. 4.—Tangential section of *Actinostroma bifarium*, Nich., enlarged 10—12 times. Middle Devonian, Teignmouth.

Fig. 5.—Vertical section of the same, similarly enlarged.

Fig. 6.—Tangential section of a specimen of the same from the Middle Devonian of Büchel (Paffrath District), enlarged 10—12 times.

Fig. 7.—Vertical section of the preceding, similarly enlarged.

Fig. 8.—Upper surface of a broken discoidal specimen of *Actinostroma intertextum*, Nich., of the natural size. Wenlock Limestone, Ironbridge. (Page 138.)

Fig. 9.—Part of the surface of the same, enlarged twice. The specimen shows much more conspicuous astrorhizæ than is usually the case in this species.

Fig. 10.—Tangential section of *Actinostroma intertextum*, Nich , enlarged 12 times. Wenlock Limestone, Ironbridge.

Fig. 11.—Vertical section of the same, similarly enlarged.

H A Nicholson del
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PLATE XIV.

Fig. 1.—Portion of a polished slab of *Actinostroma stellulatum*, Nich., from the Middle Devonian, Lummaton, Devonshire, of the natural size. (Page 140.)

Fig. 2.—Portion of another polished slab of the same species, from the Middle Devonian Limestone of Dartington, Devonshire, of the natural size. The specimen is composed of parallel columns, each of which is traversed by one of the vertical canals of the astrorhizal system. Presented to the author by Mr. Champernowne.

Fig. 3.—Tangential section of *Actinostroma stellulatum*, Nich., enlarged 10—12 times. The specimen is a massive one. Middle Devonian, Teignmouth, Devonshire.

Fig. 4.—Vertical section of the same specimen, similarly enlarged. The larger rounded openings are the cut ends of the radiating astrorhizal canals.

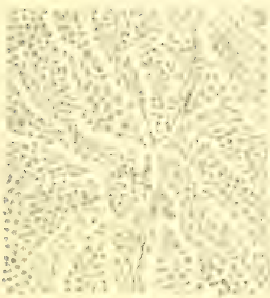
Fig. 5.—Tangential section of a laminar example of the same species from Gerolstein, similarly enlarged. The section shows numerous capillary "arms," given off from the radial pillars.

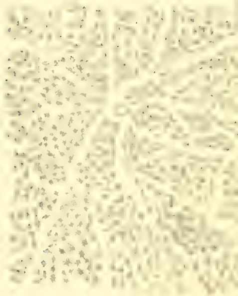
Fig. 6.—Vertical section of the same specimen, similarly enlarged.

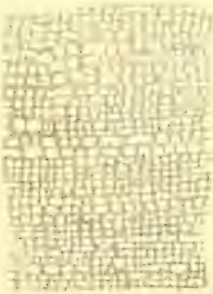
Fig. 7.—Tangential section of an example of the same species from the Middle Devonian of Dartington, similarly enlarged. The specimen is formed of numerous parallel columns, and the section shows part of the centre of one column.

Fig. 8.—Vertical section of the preceding specimen, similarly enlarged. The art figured embraces half of one of the columns.

PLATE XIV







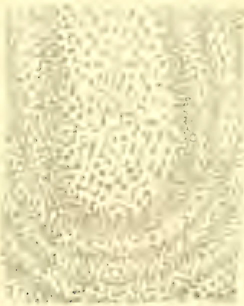


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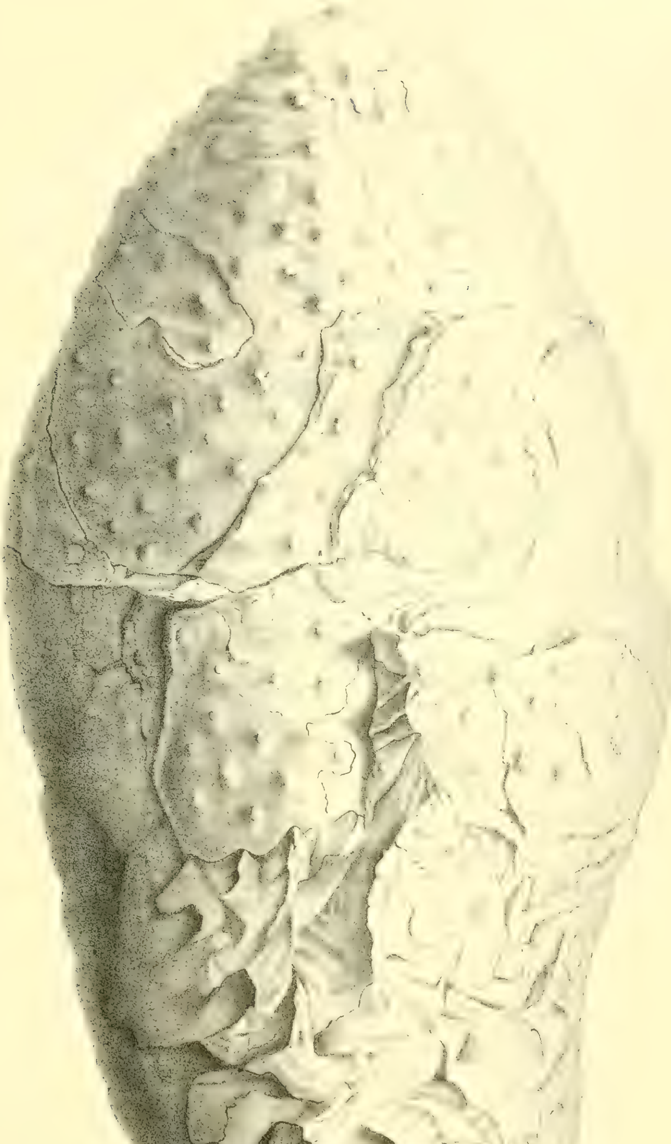
PLATE XV.

A large, partially exfoliated specimen of *Actinostroma stellulatum*, Nich., of the natural size, from the collection of Mr. Vicary. Middle Devonian, Chircombe Bridge Quarry, Newton Abbot, Devonshire. So far as the British Devonian series is concerned, this beautiful specimen is probably unique, but very similar examples occur in the Eifel. It belongs to a variety of *A. stellulatum*, in which the cœnosteum is massive and the surface is covered with small pointed eminences corresponding with the centres of the astrorhizæ. (Page 140.)



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A.T.Hollick lith.

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PLATE XVI.

Fig. 1.—Part of a polished slab of *Actinostroma verrucosum*, Goldf. sp., of the natural size. Middle Devonian, Teignmouth. (Page 134.)

Fig. 2.—Tangential section of the same, enlarged 10—12 times. The skeleton (as so commonly is the case in specimens from the Devonian Limestones of Britain) has undergone crystallization, and has been distorted by pressure.

Fig. 3.—Vertical section of the same, similarly enlarged.

Fig. 4.—A specimen of *Actinostroma verrucosum*, Goldf. sp., from the Middle Devonian of Büchel (Paffrath district), of the natural size.

Fig. 5.—Tangential section of the same, enlarged 10—12 times. The section traverses one of the astrorhizal cylinders.

Fig. 6.—Vertical section of the same, similarly enlarged.

Fig. 7.—Tangential section of another example of the same species from Büchel, enlarged 24 times, showing the axial canals of the radial pillars.

Fig. 8.—One of the "mamelons" of *Actinostroma verrucosum*, enlarged about 3 times, showing the central opening of a vertical astrorhizal canal, and the radiating canals of the last astrorhiza.

Fig. 9.—Fragment of *Actinostroma hebbornense*, Nich., from the Middle Devonian of Hebborn (Paffrath district), of the natural size. The specimen shows the surface of one of the concentric laminæ as exposed by fracture. (Page 137.)

Fig. 10.—Tangential section of the same, enlarged 10—12 times.

Fig. 11.—Portion of the preceding section, enlarged 24 times.

Fig. 12.—Vertical section of the same specimen, enlarged 10—12 times.

Fig. 13.—Tangential section of *Actinostroma hebbornense*, Nich., from the Middle Devonian of Teignmouth, enlarged 10—12 times. The structure of this specimen is finer and closer than is usual in the species, and the skeleton has been distorted by pressure, and partially obliterated by crystallization.

Fig. 14.—Vertical section of the same, similarly enlarged.

Fig. 15.—Tangential section of another example of *Actinostroma hebbornense*, Nich., from the Middle Devonian of Teignmouth, enlarged 10—12 times. This specimen agrees with the type of the species in the proportions of its skeleton, and likewise exhibits astrorhizæ; but, like the preceding, it has been much affected by crystallization and pressure.

Fig. 16.—Vertical section of the same, similarly enlarged.

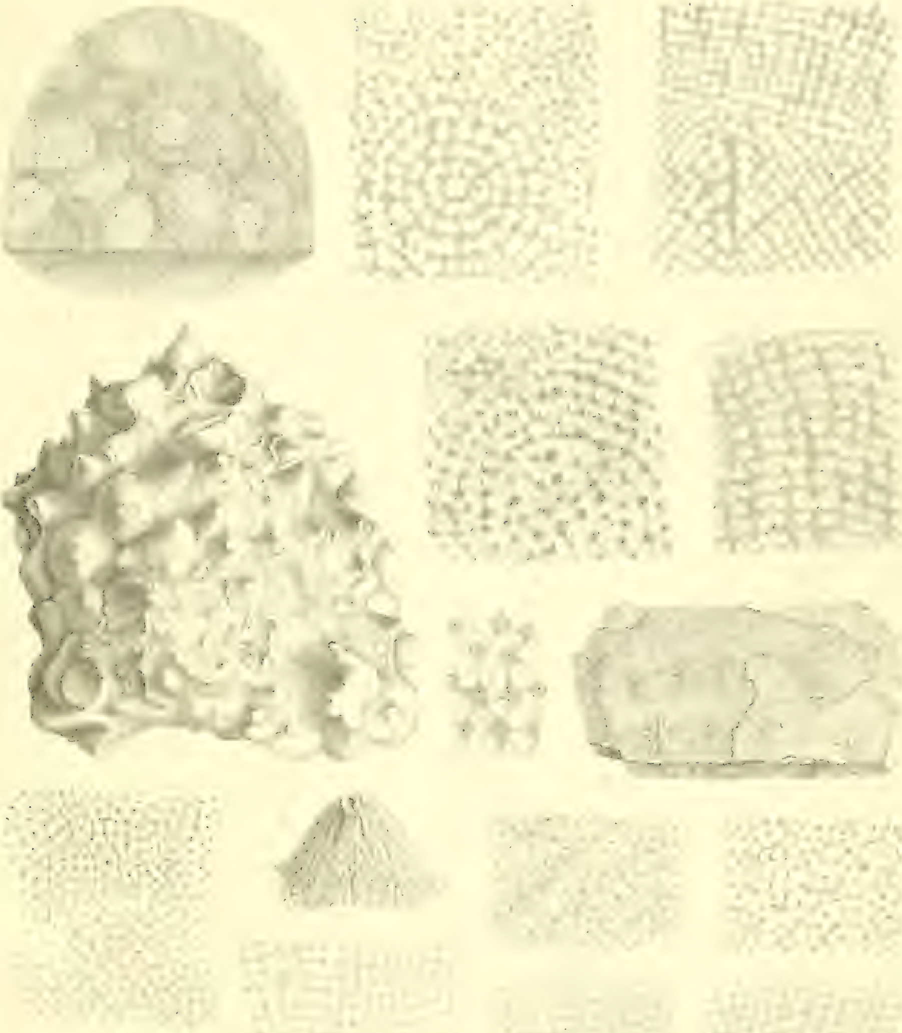


PLATE XVII.

Fig. 1.—Fragment of *Actinostroma astroites*, Rosen sp., from the Silurian (Upper Oesel Group) of Kaugatoma-Pank, Esthonia, of the natural size. The specimen shows the surface of one of the concentric laminæ as exposed by fracture, and exhibits the faintly-marked astrorhizæ. (Page 143.)

Fig. 2.—Tangential section of a specimen of *Actinostroma astroites*, Rosen, from the Wenlock Limestone of Much Wenlock, enlarged 10—12 times. The minute structure is better preserved in this than in any Russian specimen which I have examined.

Fig. 3.—Vertical section of the same, similarly enlarged, showing the dark concentric lines of growth.

Fig. 4.—Portion of the preceding section, enlarged about 24 times.

Fig. 5.—Tangential section of another specimen of *Actinostroma astroites*, Rosen, from the Wenlock Limestone of Much Wenlock, enlarged 10—12 times. The specimen is traversed by numerous minute "Caunopora-tubes."

Fig. 6.—Vertical section of the preceding, similarly enlarged.

Fig. 7.—Vertical section of specimen of *Actinostroma astroites*, Rosen, sp., from the Wenlock Limestone of Ironbridge, enlarged 10—12 times. The minute structure of the skeleton, as in most examples of the species, is imperfectly preserved, and the cœnosteum contains embedded in it numerous *Spirorbes*, arranged in vertical rows as they became successively buried in the growing Stromatoporoid.

Fig. 8.—Tangential section of *Actinostroma fenestratum*, Nich., from the Middle Devonian of Teignmouth, enlarged 10—12 times. (Page 146.)

Fig. 9.—Vertical section of the same, similarly enlarged. The minute structure of the skeleton is much obscured by crystallization and pressure.

Fig. 10.—Vertical section of the type-specimen of *Clathrodictyon vesiculosum*, Nich. and Mur., from the Clinton Formation, Yellow Springs, Ohio. Enlarged 10—12 times. (Page 147.)

Fig. 11.—Tangential section of the same, similarly enlarged.

Fig. 12.—Vertical section of a specimen of *Clathrodictyon vesiculosum*, Nich. and Mur., from the Wenlock Limestone of Much Wenlock, enlarged 10—12 times. (P. 147.)

Fig. 13.—Tangential section of the same, similarly enlarged.

Fig. 14.—A fragment of *Clathrodictyon variolare*, Rosen sp., of the natural size, from the Silurian ("Raiküllsche Schichten") between Saage and Ridaka, Esthonia. The laminæ in this specimen exhibit rounded "mamelons," but these are by no means invariably present in this species. (Page 150.)

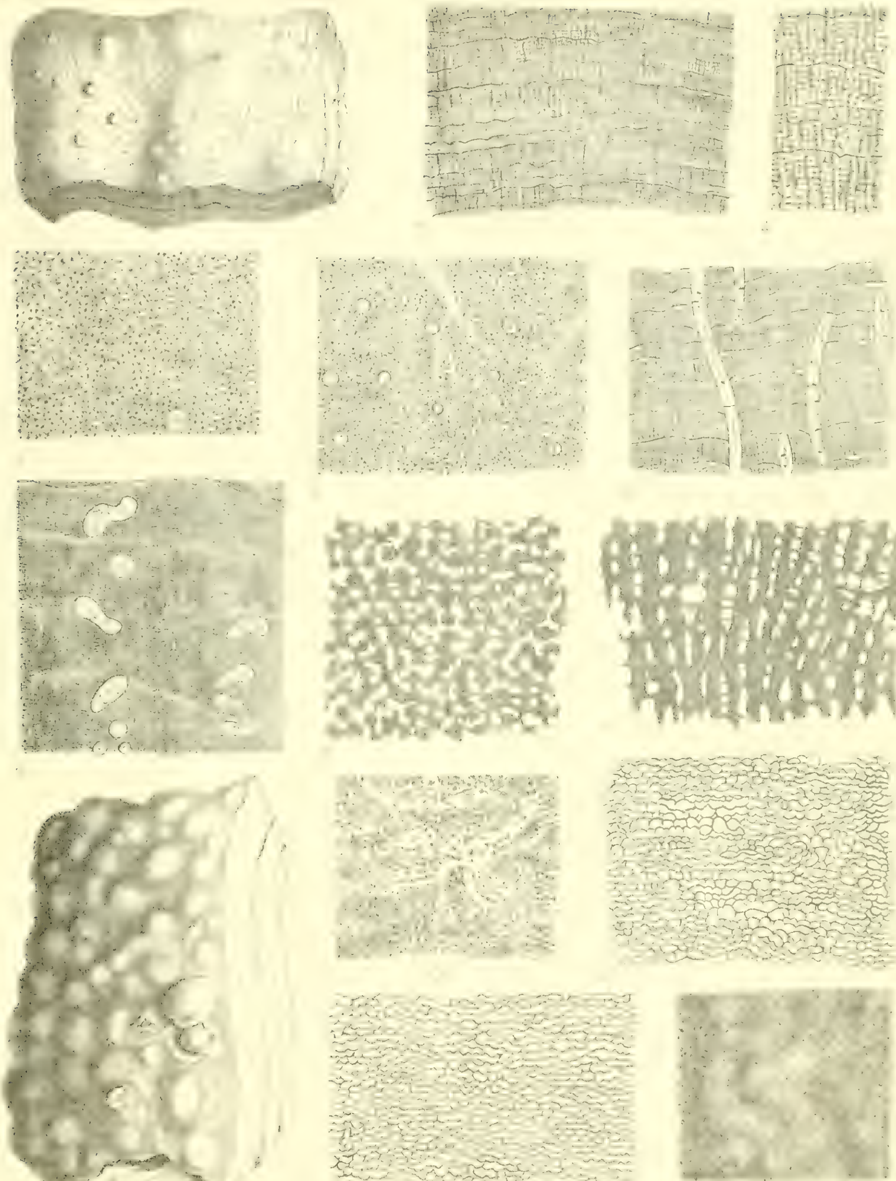


PLATE XVIII.

Fig. 1.—Vertical section of *Clathrodictyon variolare*, Rosen, enlarged 10—12 times. From a specimen from the Silurian Limestones (zone of *Pentamerus esthonus*) Kattentack, Esthonia. (Page 150.)

Fig. 2.—Tangential section of the type specimen of the same species enlarged 10—12 times, from the Silurian Rocks of Errinal, Esthonia, from a fragment presented to the author by Magister Friedrich Schmidt.

Fig. 3.—Vertical section of the preceding, similarly enlarged.

Fig. 4.—Vertical section of a variety of *Clathrodictyon variolare*, Rosen, from the Wenlock Limestone of Dormington, enlarged 10—12 times.

Fig. 5.—Tangential section of the preceding specimen, similarly enlarged. The section traverses one of the astrorhizæ.

Fig. 6.—Vertical section of *Clathrodictyon crassum*, Nich., from the Wenlock Limestone of Ironbridge, enlarged 10—12 times. (Page 151.)

Fig. 7.—Tangential section of the preceding specimen, similarly enlarged.

Fig. 8.—Half of a specimen of *Clathrodictyon regulare*, Rosen, from the Wenlock Limestone of Dudley of the natural size. (Page 155.)

Fig. 9.—Portion of the surface of the same, similarly enlarged.

Fig. 10.—Vertical section of the same, enlarged 10—12 times.

Fig. 10 *a*.—Small portion of the preceding, enlarged 22 times.

Fig. 11.—Tangential section of the same, enlarged 10—12 times.

Fig. 11 *a*.—Small portion of the preceding, enlarged about 22 times.

Fig. 12.—Under surface of a small specimen of *Clathrodictyon vesiculosum*, Nich. and Mur., from the Wenlock Limestone of Dudley, of the natural size. The missing half of the specimen is restored in outline. (Page 147.)

Fig. 13.—*Clathrodictyon confertum*, Nich., Middle Devonian, Dartington. Vertical section, enlarged 10—12 times. From a specimen presented to the author by Mr. Champernowne. (Page 154.)

Fig. 14.—Tangential section of the same, similarly enlarged.

PLATE XIX.

Fig. 1.—*Clathrodictyon fastigiatum*, Nich., a small specimen from the Wenlock Limestone of Ironbridge, showing the upper surface, of the natural size. (Page 152.)

Fig. 2.—Under surface of the same, showing the wrinkled epitheca.

Fig. 3.—Surface of a specimen of the same from the Wenlock Limestone of Dudley, of the natural size.

Fig. 4.—Tangential section of a specimen of the same from the Wenlock Limestone of Ironbridge, enlarged 10—12 times.

Fig. 5.—Vertical section of the preceding, enlarged 10—12 times.

Fig. 6.—A specimen of *Clathrodictyon striatellum*, D'Orb. sp., from the Wenlock Limestone of Dudley, showing the upper surface, of the natural size. (Page 156.)

Fig. 7.—Portion of the weathered surface of another specimen of the same from Dudley, showing zoöidal pores, enlarged.

Fig. 8. Vertical section of a specimen of the same, from the Wenlock Limestone of Ironbridge, enlarged 10—12 times. The vertical sections of this species figured in Part 1 of this Monograph (Plate I, fig. 1, and Plate V, fig. 3) have been inadvertently reversed in position, and their lower margin should properly be placed uppermost.

Fig. 9.—Tangential section of the preceding specimen, enlarged 10—12 times. Part of the section corresponds with an interlaminar space, and part corresponds with one of the concentric laminæ.

Fig. 10.—Part of the surface of a silicified specimen of *Stromatopora mammillata*, Fr. Schmidt, from the "Borkholm'sche Schichten" of Esthonia, enlarged 3 times. From a specimen presented to the author by Magister Schmidt. (Page 158.)

Fig. 11.—Vertical section of the preceding specimen, enlarged about 14 times.

Fig. 12.—Tangential section of the same, enlarged 14 times. The appearance of a dark centre to the radial pillars is the result of silicification.

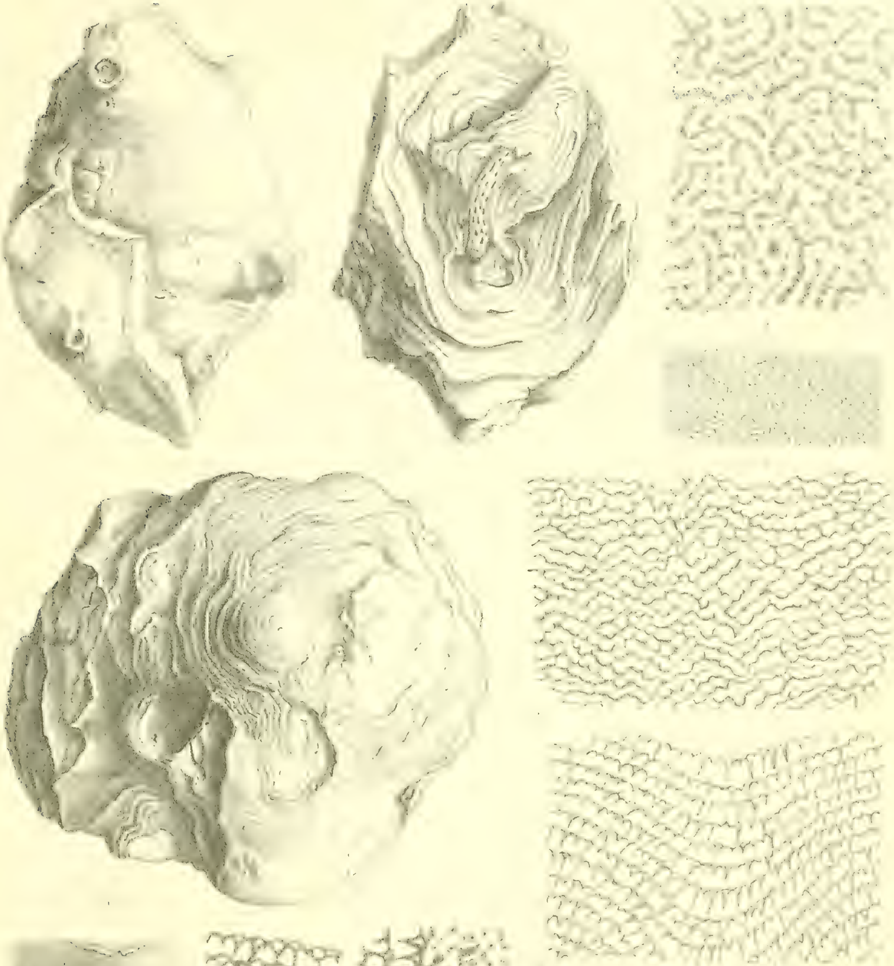


PLATE XX.

Fig. 1.—Vertical section of a specimen of *Labechia conferta*, Lonsd. sp., from the Wenlock Limestone of Dudley, enlarged about 10 times.

Fig. 2.—Tangential section of the same specimen, similarly enlarged.

Fig. 3.—Small portion of the preceding section, enlarged about 30 times.

Fig. 4.—Upper surface of a specimen of *Labechia scabiosa*, Nich., from the Wenlock Limestone of Dudley, of the natural size.

Fig. 5.—Under surface of the same, of the natural size.

Fig. 6.—Surface-tubercles of *Labechia scabiosa*, enlarged.

Fig. 7.—Portion of a polished slab of *Labechia stylophora*, Nich., from the Middle Devonian of Shaldon, Devonshire, of the natural size.

Fig. 8.—A single cylinder of the same transversely divided, enlarged 5 times.

Fig. 9.—Vertical section of *Labechia canadensis*, Nich. and Mur. (?), from the Ordovician Rocks of Aldons, near Girvan, enlarged 10 times. Collected by Mrs. Robert Gray.

Fig. 10.—Polished slab of *Stromatopora concentrica*, Goldf., cut vertically to the surface, of the natural size. From the Middle Devonian, Lummaton, Devonshire.

Fig. 11.—Tangential section of a specimen of *Stromatopora concentrica*, Goldf., from the Middle Devonian of Lummaton, Devonshire, enlarged 10 times.

Fig. 12.—Vertical section of a specimen of *Stromatopora concentrica*, Goldf., from the Middle Devonian of Teignmouth, enlarged 10 times.

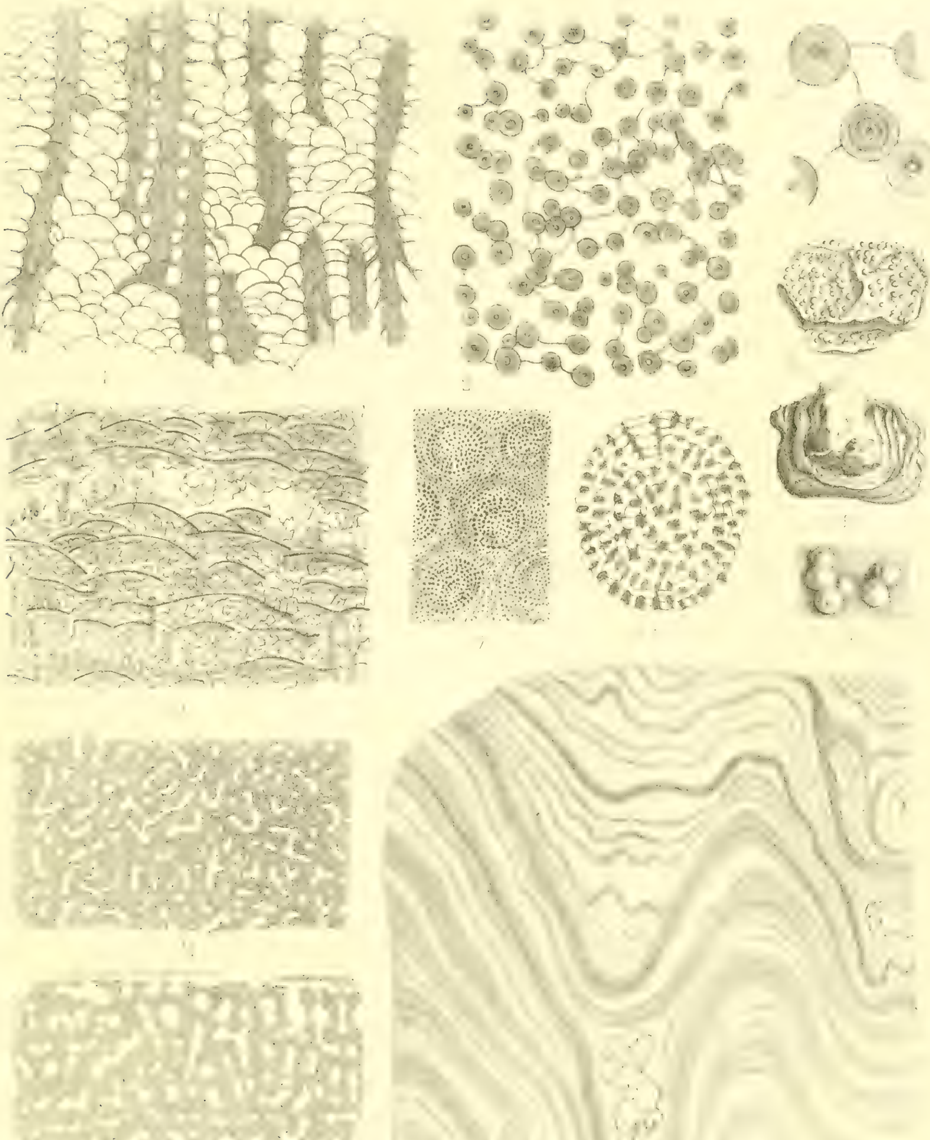


PLATE XXI.

Fig. 1.—A massive weathered specimen of *Stromatopora concentrica*, Goldf., from the Middle Devonian of Gerolstein, of the natural size. The specimen shows excellently the growth of the cœnosteum in latilaminæ, and is closely similar in aspect to the original example of this species described and figured by Goldfuss.

Fig. 2.—Portion of the skeleton-fibre of *Stromatopora concentrica*, Goldf., enlarged about 40 times, showing the sieve-like and porous structure of the fibre. The section is tangential, and taken from a specimen from the Middle Devonian of Sötenich, in which the minute structure is unusually well preserved.

Fig. 3.—Portion of the surface of a large specimen of *Stromatopora concentrica*, Goldf., from the Middle Devonian of Gerolstein, enlarged about 3 times. The specimen is traversed by minute "Caunopora-tubes," and the surface-characters are unusually well shown.

Fig. 4.—Upper side of a small specimen of *Stromatopora typica*, Rosen, from the Wenlock Limestone of Ironbridge, of the natural size.

Fig. 5.—Under side of the same, showing the epitheca, of the natural size.

Fig. 6.—Profile view of the same, of the natural size.

Fig. 7.—Part of the surface of the same, enlarged about 3 times.

Fig. 8.—Sketch of a medium-sized specimen of *Stromatopora typica*, Rosen, from the Wenlock Limestone of Dudley, of the natural size. The specimen has been bisected, and shows the latilaminar mode of growth of the cœnosteum.

Fig. 9.—Portion of the skeleton-fibre of another specimen of the same, from the Wenlock Limestone of Ironbridge, enlarged about 40 times. The section is tangential.

Fig. 10.—Portion of a vertical section of the preceding, similarly enlarged.

Fig. 11.—Part of the surface of a specimen of *Stromatopora typica*, Rosen, of the natural size, in which the cœnosteum is traversed by numerous irregular "Caunopora-tubes," which in this case seem to certainly belong to a species of *Aulopora*. The specimen is from the Drift of Northern Germany, and was presented to the author by Prof. Ferdinand Roemer.

PLATE XXII.

Fig. 1.—Tangential section of *Stromatopora typica*, Rosen, from the Wenlock Limestone of Ironbridge, enlarged about 10 times.

Fig. 2.—Vertical section of the same, similarly enlarged, showing the tabulate zoöidal tubes.

Fig. 3.—Vertical section of *Stromatopora Hüpschii*, Barg., from the Middle Devonian of Teignmouth, enlarged 10 times.

Fig. 4.—Tangential section of the same, similarly enlarged.

Fig. 5.—Surface of a polished specimen of the same from the same locality, of the natural size.

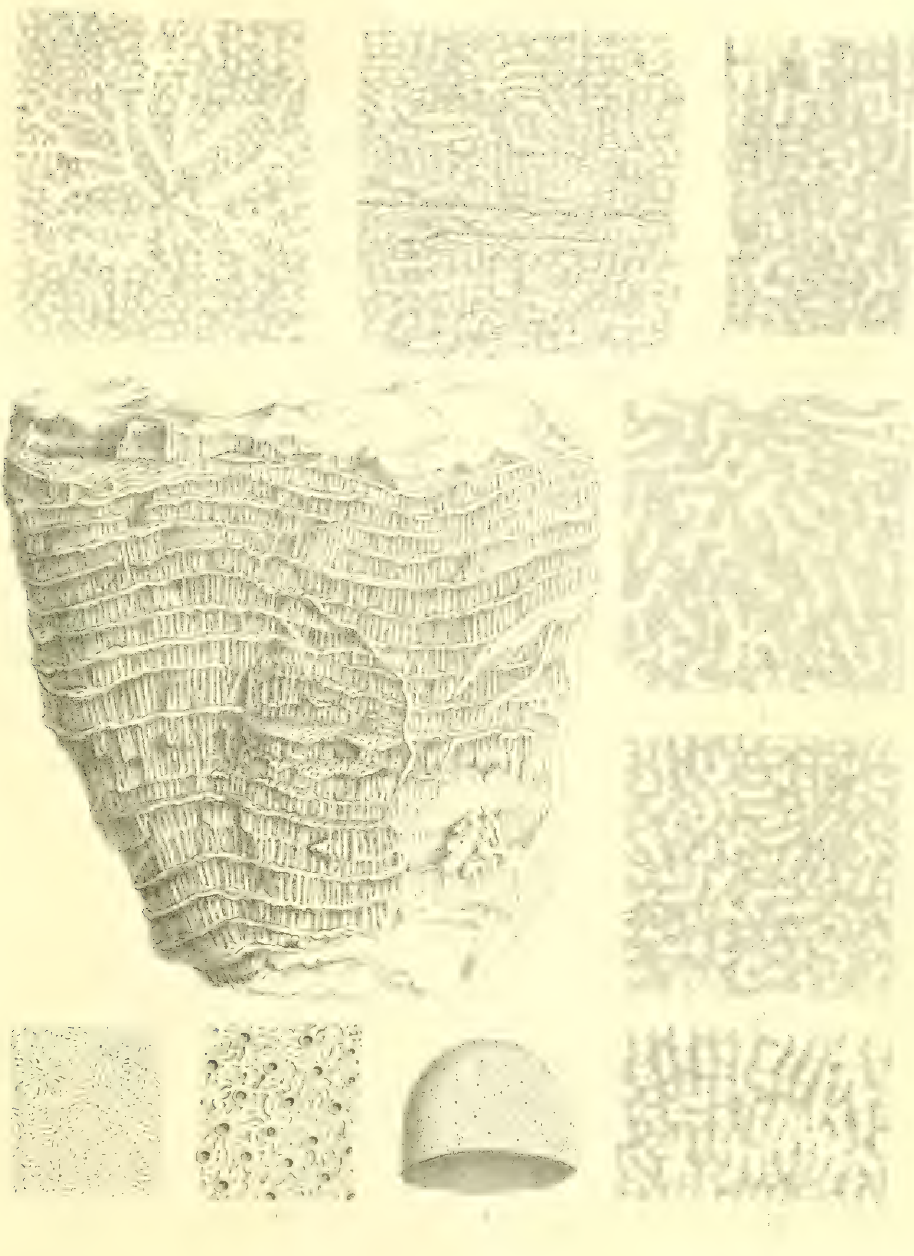
Fig. 6.—Surface of a specimen of *Stromatopora Hüpschii*, Barg., from the Middle Devonian of Büchel (Paffrath district), enlarged 5 times, showing the mouths of "Caunopora-tubes."

Fig. 7.—A weathered example of *Stromatopora Hüpschii*, Barg., in the "Caunopora-state," of the natural size. Middle Devonian, Dartington, South Devon.

Fig. 8.—A small polished example of *Stromatopora florigera*, Nich., of the natural size, from the Middle Devonian of Teignmouth.

Fig. 9.—Tangential section of the same, enlarged 10 times.

Fig. 10.—Vertical section of the same, similarly enlarged.



H. A. Nicholson del.
A. T. Hollick, lith.

PLATE XXIII.

Fig. 1.—Portion of a polished specimen of *Stromatopora Carteri*, Nich., of the natural size, showing the growth of the cœnosteum in latilaminæ. From the Wenlock Limestone of Ironbridge.

Fig. 2.—Vertical section of the same, enlarged about 10 times.

Fig. 3.—Tangential section of the same, similarly enlarged.

Fig. 4.—A fragment of *Stromatopora Büchelienis*, Barg., var. *digitata*, Nich., of the natural size. Middle Devonian, Pit Park Quarry, Dartington.

Fig. 5.—Part of a polished transverse section of another specimen of the same species from the same locality, natural size.

Fig. 6.—Vertical section of a specimen of *Stromatopora Bücheliensis*, Barg., from the Middle Devonian of Teignmouth. Enlarged about 10 times.

Fig. 7.—Transverse section of the preceding specimen, similarly enlarged.

Fig. 8.—Portion of a polished specimen of *Stromatopora Beuthii*, Barg., cut tangentially, of the natural size. Middle Devonian, South Devonshire.

Fig. 9.—Portion of a similar polished specimen of the same species, cut vertically, of the natural size. Middle Devonian, Teignmouth.

Fig. 10.—Tangential section of *Stromatopora Beuthii*, Barg., enlarged about 10 times. Middle Devonian, Pit-Park Quarry, Dartington.

Fig. 11.—Vertical section of the same specimen, similarly enlarged.

Fig. 12.—Tangential section of a specimen of *Stromatopora Beuthii*, Barg., from the Middle Devonian of South Devonshire (Bishopsteignton ?), enlarged about 10 times. The section shows, more distinctly than fig. 10, the cut ends of the radial pillars immersed in the general reticulation.

Fig. 13.—Tangential section of *Stromatopora Beuthii*, Barg. (?), in the "Caunopora-state," enlarged about 10 times. In this condition sections of *S. Beuthii* are hardly, or not at all, distinguishable from similar sections of *S. Hüpschii*, Barg. Middle Devonian, Teignmouth.

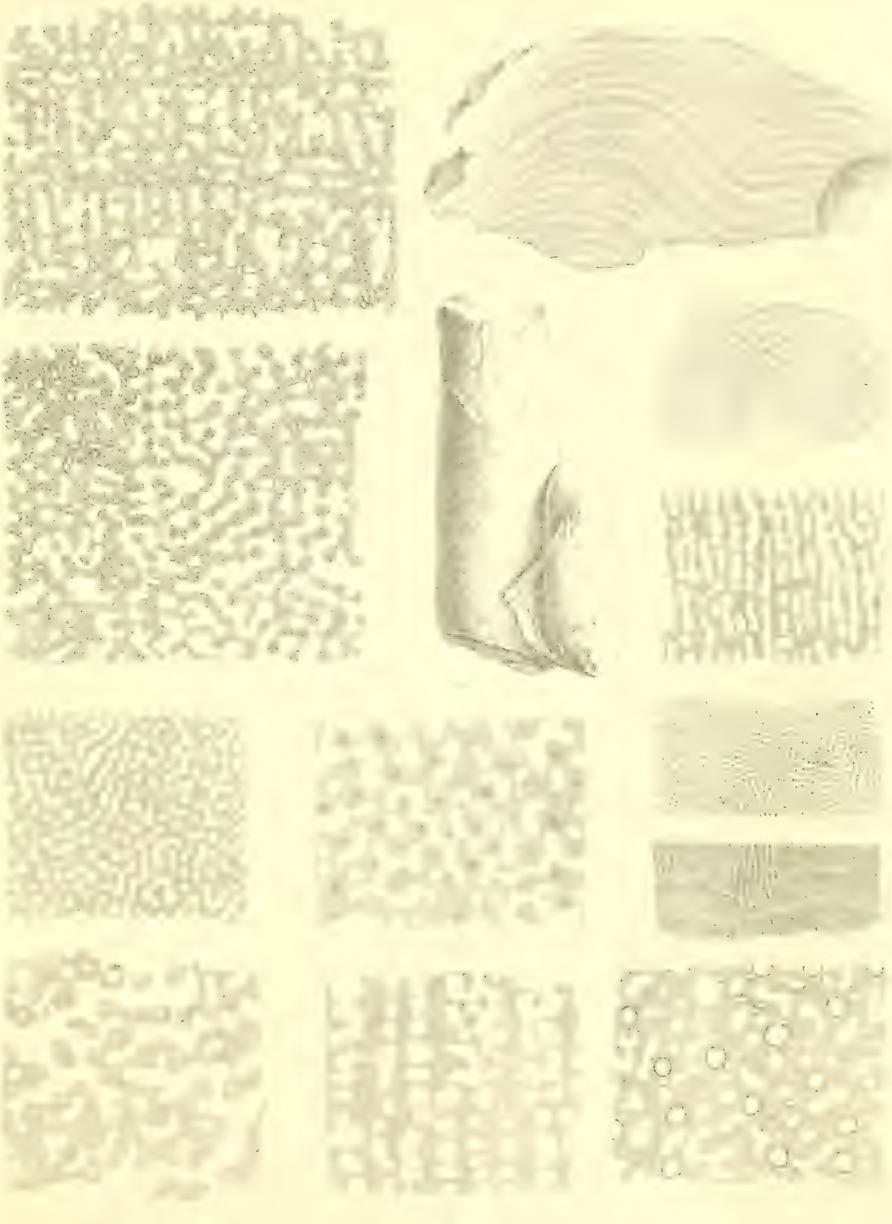


PLATE XXIV.

Fig. 1.—Vertical section of *Stromatopora Beuthii*, Barg. (?), in the "Caunopora-state," enlarged about 10 times. Middle Devonian, Teignmouth.

Fig. 2.—Part of the surface of a specimen of *Stromatopora discoidea*, Lonsd., of the natural size, showing the form and arrangement of the astrorhizæ. Wenlock Limestone, Dudley.

Fig. 3.—Small portion of the surface of a specimen of *Stromatopora discoidea*, Lonsd., enlarged 5 times. Wenlock Limestone, Gotland.

Fig. 4.—Part of the surface of the preceding specimen, still further enlarged.

Fig. 5.—Skeleton-fibre of *Stromatopora discoidea*, enlarged about 40 times.

Fig. 6.—Tangential section of a very well preserved specimen of *Stromatopora discoidea*, Lonsd., enlarged about 10 times. Wenlock Limestone, Ironbridge.

Fig. 7.—Vertical section of the preceding specimen, similarly enlarged.

Fig. 8.—Tangential section of the *Stromatopora elegans* of von Rosen, enlarged ten times. This form is in reality based on an example of *S. discoidea*, Lonsd., in a considerably altered state, and the specific name "*elegans*" must therefore be abandoned. The specimen is from the Silurian Rocks of Kleine Ruhde, in Esthonia.

Fig. 9.—Part of a tangential section of *Stromatopora concentrica*, Goldf., var *astrigera*, Nich., enlarged 10 times. The specimen is in a much altered and partially "reversed" condition, and the part figured shows the centre of an astrorhiza. Middle Devonian, Teignmouth.

Fig. 10.—Surface of a polished specimen of the preceding, of the natural size, showing the form and arrangement of the astrorhizæ, from the same locality. The astrorhizæ have been drawn for distinctness' sake as if darker in colour than the general skeleton, but they are really lighter.

Fig. 11.—Portion of the surface of a polished specimen of *Stromatopora inæqualis*, Nich., enlarged about twice. Middle Devonian, Teignmouth.

Fig. 12.—Tangential section of the same, enlarged about 5 times, from the same locality. The specimen is in the "reversed" condition.

Fig. 13.—Portion of a polished tangential section of *Parallelopora dartingtonensis*, Carter sp., of the natural size, showing the astrorhizæ. Middle Devonian, Teignmouth.

Fig. 14.—Portion of a polished tangential section of a "reversed" specimen of the same, enlarged twice. Middle Devonian, Teignmouth. The minute structure of this specimen, as displayed in thin tangential section, is shown in Plate IV, fig. 1.

Fig. 15.—Tangential section of a specimen of *P. dartingtonensis*, Cart. sp., from the Middle Devonian of Pit-Park Quarry, Dartington, enlarged 10 times.

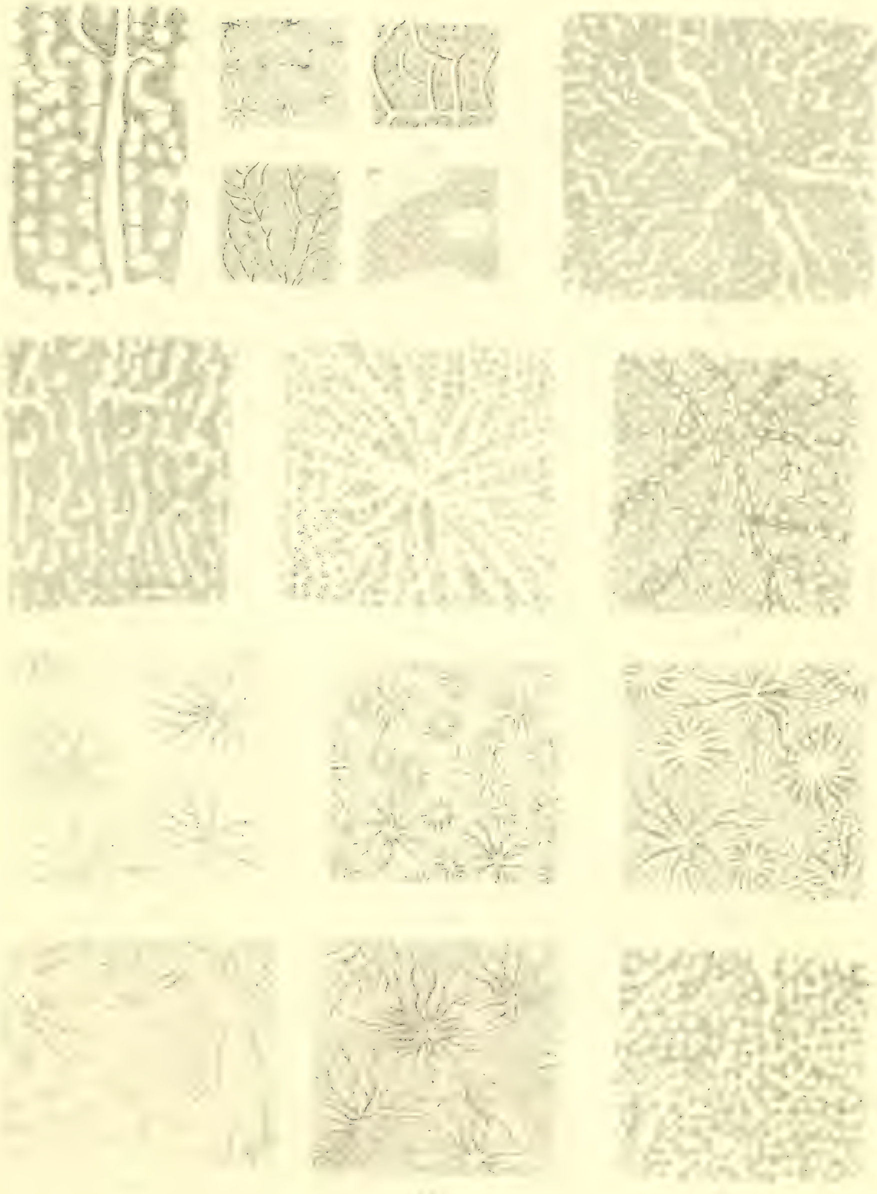


PLATE XXV.

Fig. 1.—Vertical section of the preceding specimen of *Parallelopora dartingtonensis,* Cart. sp., enlarged 10 times.

Fig. 2.—Tangential section of *P. dartingtonensis*, var. *filitexta*, Nich., from the Middle Devonian of Teignmouth, enlarged 10 times.

Fig. 3.—Vertical section of the preceding specimen, similarly enlarged.

Fig. 4.—Tangential section of a typical example of *Parallelopora Goldfussii*, Barg., enlarged 10 times, showing the perforate structure of the skeleton-fibre, the apertures of the zoöidal tubes, and the transversely partitioned astrorhizal canals. Middle Devonian, Steinbreche, Refrath.

Fig. 5.—Vertical section of the same, similarly enlarged, showing the characters of the skeleton-fibre, the radial pillars, and the tabulate zoöidal tubes.

Fig. 6.—Tangential section of the skeleton-fibre of a specimen of *P. Goldfussii*, Barg., from the Middle Devonian of Devonshire, enlarged 40 times.

Fig. 7.—Vertical section of the same, similarly enlarged. (Figs. 7 and 8 of Plate XI, erroneously referred to *Idiostroma ? capitatum*, Goldf., really belong to this species.)

Fig. 8.—Tangential section of the preceding specimen of *P. Goldfussii*, Barg., from the Middle Devonian of Devonshire, enlarged 10 times. The specimen is in the " Caunopora-state."

Fig. 9.—Vertical section of the same, similarly enlarged. The section shows the infundibuliform tabulæ of the " Caunopora-tubes."

Fig. 10.—Tangential section of a specimen of *Parallelopora capitata,* Goldf. sp., from the Middle Devonian of Teignmouth, showing the tabulate astrorhizal tubes, enlarged 10 times.

Fig. 11.—Tangential section of another specimen of the same from the same locality and formation, similarly enlarged.

Fig. 12.—Vertical section of the preceding specimen of *Parallelopora capitata*, Goldf. sp., showing tabulate zoöidal tubes and supposed " ampullæ," enlarged 10 times.

Fig. 13.—Tangential section of a specimen of *Parallelopora capitata,* Goldf. sp., from the Middle Devonian of Hebborn, showing the structure of the skeleton-fibre, enlarged 10 times.

PLATE XXVI.

Fig. 1.—Surface of a specimen of *Stromatoporella granulata,* Nich., of the natural size. Devonian (Hamilton Formation), Arkona, Ontario.

Fig. 1 *a.*—Tangential section of the same, enlarged about ten times.

Fig. 1 *b.*—Vertical section of the same, similarly enlarged.

Fig. 2.—Surface of a specimen of *Stromatoporella Selwynii*, Nich., enlarged. Devonian (Corniferous Limestone), Port Colborne, Ontario. This figure is repeated from Pl. I, fig. 14, where it is referred to *Stromatoporella granulata*, Nich.

Fig. 3.—Tangential section of the same, enlarged about ten times. (The section is slightly oblique.)

Fig. 4.—Vertical section of the same, similarly enlarged.

Fig. 5.—Tangential section of *Stromatoporella socialis*, Nich., showing part of one of the astrorhizal cylinders, enlarged about ten times. Middle Devonian, Teignmouth [pebble in the Triassic conglomerates].

Fig. 6.—Tangential section of another specimen of the same, from the same locality, showing "*Caunopora*-tubes." Enlarged about ten times.

Fig. 7.—Vertical section of the preceding specimen, similarly enlarged.

PLATE XXVI.

H.A.Nicholson del.
A.T. Hollick lith.

PLATE XXVII.

Fig. 1.—Surface of *Stromatoporella eifeliensis*, Nich., enlarged. Middle Devonian, Gerolstein.

Fig. 2.—Tangential section of the same, enlarged ten times, from the same formation and locality.

Fig. 3.—Vertical section of the preceding specimen, similarly enlarged.

Fig. 4.—Specimen of *Stromatoporella solitaria*, Nich., of the natural size, showing the characters of the surface. Middle Devonian, Gerolstein.

Fig. 5.—Tangential section of the same, across one of the astrorhizal mamelons, enlarged ten times, from the same formation and locality.

Fig. 6.—Tangential section of the same, traversing a space between two astrorhizal mamelons, similarly enlarged [erroneously referred in a paper in the 'Ann. and Mag. Nat. Hist.,' ser. 5, vol. xvii, pl. viii, fig. 5, to *S. eifeliensis*].

Fig. 7.—Vertical section of the same, similarly enlarged.

Fig. 8.—Tangential section of *Stromatoporella damnoniensis*, Nich., enlarged about ten times. Middle Devonian, Devonshire. (From the pebble beds in the Trias of Teignmouth.)

Fig. 9.—Vertical section of the same, similarly enlarged.

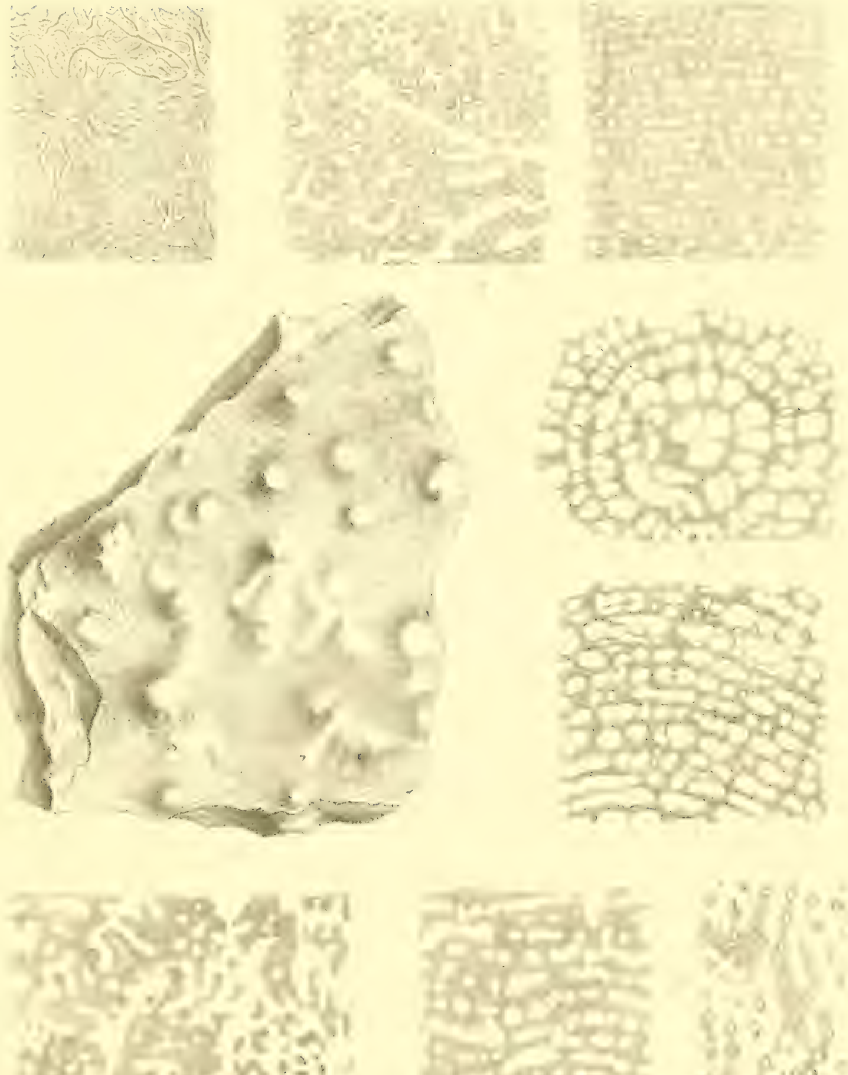


PLATE XXVIII.

Fig. 1.—A specimen of *Stromatoporella curiosa*, Barg., of the natural size, forming a crust upon a Rugose Coral. Middle Devonian, Büchel (Paffrath District).

Fig. 2.—Tangential section of the same, enlarged between 10 and 12 times.

Fig. 3.—Vertical section of the same, similarly enlarged.

Fig. 4.—Portion of a polished section of *Hermatostroma episcopale*, Nich., of the natural size. Middle Devonian (pebble in Triassic conglomerate), Teignmouth.

Fig. 5.—Tangential section of another specimen of the same, from Shaldon, South Devon, enlarged 10 times.

Fig. 6.—Vertical section of the preceding specimen, similarly enlarged.

Fig. 7.—Tangential section of another example of the same, enlarged about 15 times. Devonian, Shaldon.

Fig. 8.—Tangential section of another example of the same, enlarged about 15 times. Teignmouth.

Fig. 9.—Vertical section of the preceding, similarly enlarged.

Fig. 10.—Portion of a tangential section of *Hermatostroma episcopale*, Nich., from the Devonian of Shaldon, enlarged rather more than 20 times, showing the porous nature of the skeleton-fibre.

Fig. 11.—Part of a vertical section of the preceding specimen, similarly enlarged, showing the canal-system infiltrated with some opaque material.

Fig. 12.—Fragment of *Hermatostroma Schlüteri*, Nich., of the natural size. Middle Devonian, Hebborn (Paffrath District).

Fig. 13.—Part of the surface of a concentric lamina of the same, greatly enlarged.

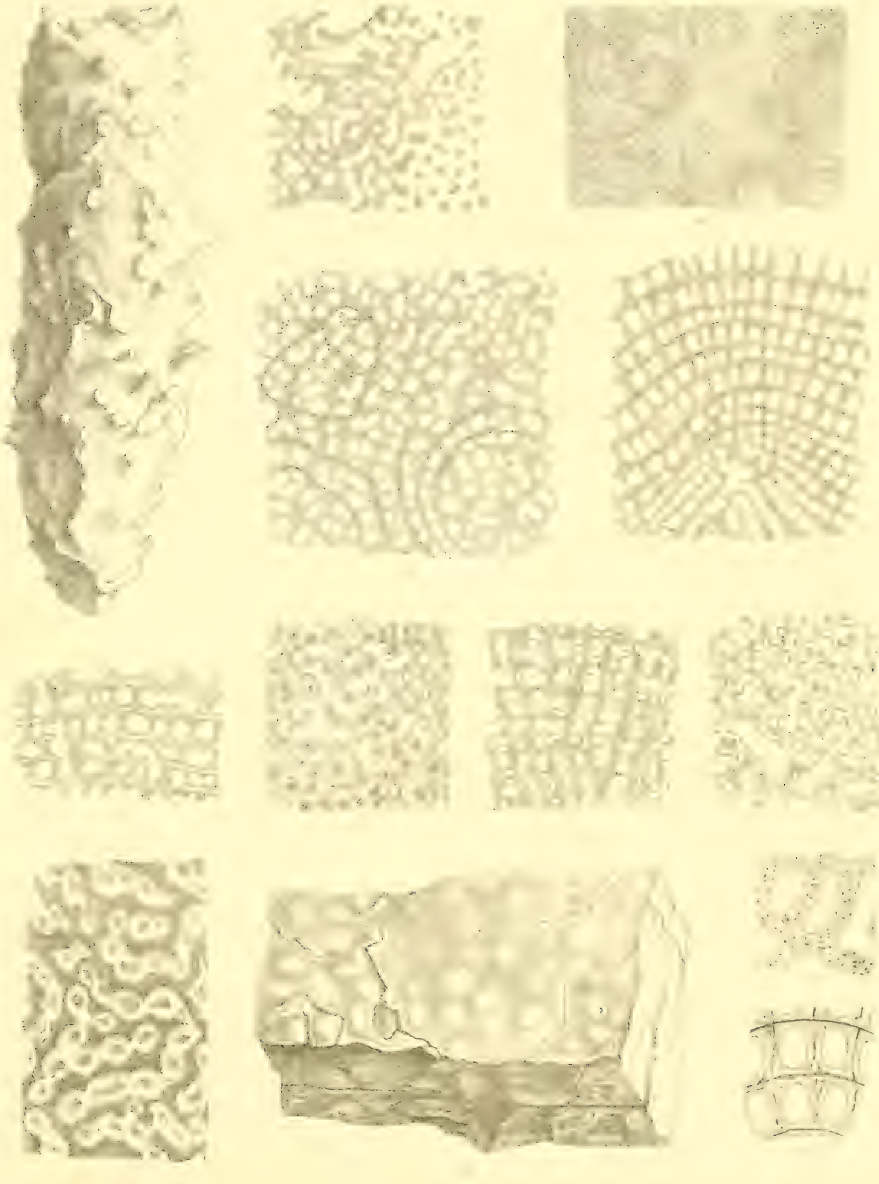


PLATE XXIX.

Fig. 1.—Part of a polished transverse section of a specimen of *Stachyodes verticillata*, M'Coy sp., of the natural size. From a Devonian pebble in the Triassic conglomerates of Teignmouth.

Fig. 2.—Part of a polished vertical section of the same species, of the natural size. From the same locality.

Fig. 3.—Part of a polished section of a specimen of Devonian limestone containing numerous stems of *Amphipora ramosa*, Phill., sp., of the natural size. Shaldon, South Devon.

Fig. 4.—Part of a longitudinal polished section of *Amphipora ramosa*, Phill. sp., enlarged about 10 times. Shaldon, South Devon.

Fig. 5.—A transverse polished section of a stem of the same species, similarly enlarged. Shaldon, South Devon.

Fig. 6.—Part of transverse thin section of a stem of *Amphipora ramosa*, Phill., sp., in which no axial canal is shown, and the marginal vesicles are comparatively small, similarly enlarged. Shaldon, South Devon.

Fig. 6 *a*.—A portion of the preceding section, enlarged still further, showing the structure of the skeleton-fibre.

Fig. 7.—A polished transverse section of a stem of *Amphipora ramosa*, Phill., sp., enlarged about 10 times. No axial canal is seen in this section, and the marginal vesicles are comparatively small. Shaldon, South Devon.

Fig. 8.—Part of a transverse section of a specimen of Devonian limestone containing a colony of *Idiostroma oculatum*, Nich., of the natural size. Shaldon, South Devon.

Fig. 9.—Part of a thin section of the preceding specimen, showing a single stem transversely divided; enlarged 10 times. Shaldon, South Devon.

Fig. 10.—Part of a tangential section of a stem of *Idiostroma oculatum*, Nich., enlarged 10 times, showing Caunopora-tubes (?) and tabulate canals. Middle Devonian, Büchel (Paffrath District).

Fig. 11.—Part of the vertical section of the preceding specimen, similarly enlarged, showing the axial tabulate canal, and a (?) Caunopora-tube.