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XLIX.—On the genus *Fistulipora*, M'Coy, with descriptions of several species

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EXPLANATION OF PLATE XIV.

- Fig. 1.* Transverse section (male *Gastrosteus* sp.) of renal mass, urinary bladder &c. *in situ*, $\times 150$ diam. A, kidneys (coalesced portion): *a, a*, right and left ureters passing longitudinally along outer ventral borders of kidneys; *b*, urinary tubules, nuclei of epithelial cells indicated. B, urinary bladder, behind the cervix: *a*, epithelium; *b*, fibrous layer; *c, c*, right and left ureters (on opposite sides of bladder); *d*, contained thread-like secretion from kidneys; C, intestine; D, D', testes.
- Fig. 2.* Fragment of hyaline capsule of ovum, showing the rows of pits and lamellæ, $\times 300$.
- Fig. 3.* Ditto, in transverse section, showing numerous lamellæ, $\times 350$.
- Fig. 4.* Portion of mucous secretion, showing funicular structure, $\times 350$.
- Fig. 5.* Sketch of nest (diagrammatic), one third nat. size, the pockets containing ova exposed. *a, a*, transversely-arranged intersecting threads; *b, b*, masses of ova contained in the interspaces of nest.
- Fig. 6.* Dissection of male, showing viscera of posterior portion of abdominal cavity, about nat. size. *a*, enlarged urinary bladder; *b*, left flexure of ditto (cervix); *c*, right flexure of ditto (near posterior termination); *d*, genital pore; *e*, cloacal depression; *f*, anus; *g*, urinary aperture; *h*, alimentary canal; *i, i*, right and left testes; *j, j*, kidneys; *j l*, ureters; *k*, swim-bladder.

XLIX.—*On the Genus Fistulipora, M^cCoy, with Descriptions of several Species.* By H. ALLEYNE NICHOLSON, M.D., D.Sc., Regius Professor of Natural History in the University of Aberdeen, and ARTHUR H. FOORD, F.G.S., late of the Geological Survey of Canada.

[Plates XV.-XVIII.]

INTRODUCTION.

In the course of our study of various species of *Fistulipora* a most interesting and suggestive structural feature has come under our observation. This consists of a very peculiar modification of the walls of the autopores*, which gives them quite a distinct *facies*, and as it appears to have an important bearing upon the question of the zoological affinities of the genus (and consequently upon that of the Monticuliporidae in general) we shall describe it as minutely as possible.

* We avail ourselves of this opportunity to offer a few words of explanation to the reader with reference to this and other terms we have found it expedient to introduce in substitution for the older ones hitherto in use. The principal tubes in *Fistulipora* and other genera of the Monticuliporidae have been called "large corallites," or simply "corallites;" the tubes or tubuli filling the interspaces among these received the name of "interstitial tubes;" while the minute tubuli situated at the angles of

In well-preserved specimens, with the aid of a lens, the autopores are seen to possess a strong fold or sinus on one side of the cell-aperture, raised above the general surface (woodcut, fig. 2). That this fold is not superficial is proved by the fact that it occurs at all levels in the corallum at which a section may be made. It is seen also in longitudinal sections throughout the whole length of the autopores. In a transverse section this fold imparts a trilobate or floriform

junction, or in other parts of the thickness of the walls, of the other tubes were entitled "spiniform corallites" (H. Alleyne Nicholson, 'Palæozoic Corals,' Monticulipora, 1881, chap. ii.). Finding these terms inconvenient for purposes of description, we propose to substitute for them the following:—*Autopores* (= "large corallites"), *Mesopores* (= "interstitial tubes"), and *Acanthopores* (= "spiniform corallites").

The term "corallites" will be used only in a general sense when referring to the tubes of which the colony is made up.

Fig. 1.

Fig. 2.

Fig. 1.—A few corallites of *F. eriensis*, Rom. : *a*, autopores; *m*, mesopores; *ac*, acanthopores. Enlarged about forty times.

Fig. 2.—*a*. Profile view of a portion of the surface of *Dekayia aspera*, Milne-Edw. & Haime (also one of the Monticuliporidae), to show acanthopores; *b*, the same viewed from above. Enlarged about forty times.

There are two other words we shall have occasion to employ in the descriptions that follow; these are "monticules" and "maculae." They have been used by one of the writers (*loc. cit.*) and by other authors to designate those minute areas or spots, either raised above the general surface of the corallum (monticules) or a little below it, or on a level with it (maculae), which constitute the characteristic ornamentation of the Monticuliporidae. It seems evident that these "maculae" and "monticules" (consisting sometimes of cells larger than the average size of the corallites) are centres from which the growth of the colony proceeded. As illustrating this suggestion the reader is invited to look at the transverse section of *Fistulipora utriculus*, Rominger (Pl. XVI. fig. 1 *c*), which shows (in section) one of these spots, in this instance composed of mesopores; and the autopores, with their folds directed inwards, surrounding it. This condition of things subsists throughout the entire colony. Had the section been made larger it would have shown that similar areas occur adjacent to each other, thus presenting a series of "maculae," around which the autopores range themselves in concentric rows.

aspect to the cells (Pl. XVI. fig. 1 c), interrupting the continuity of their outline and forming by its free ends two tooth-like projections in the interior of the cell. It will be noticed that the fold is of a lighter colour than the other part of the cell-wall. This lighter portion consists of crystalline calcite of a similar character to that of the matrix or infilling of the cells, though very slightly darker, while the remaining portion of the cell-wall and the walls of the mesopores are composed of a dense, granular, opaque calcite. This difference in the mineral composition in the two parts of the cell-wall must certainly have originated in the living tissues of the organism, because the same phenomenon is met with in species from such widely separated localities as Canada and Westphalia.

Concerning the morphological significance of the peculiar modification of the cell-wall we have just described, a valuable suggestion has been made to one of the writers by Prof. H. N. Moseley and Mr. G. B. Howes, after examining many specimens and sections of *Fistulipora*, to the effect that these structures may have formed a portion of the endo-skeleton supporting in the animal a ciliated groove (siphonoglyphe) similar to that which is found in the stomodæum of the Alcyonarians*.

This suggestion seems in our judgment to yield the only explanation which, in the present state of our knowledge, can be afforded in reference to this most interesting question. Some further observations upon it, however, appear to be needful.

We have seen that the folds in *Fistulipora* are present only in the autopores (= *autozooids* of the Alcyonarians?) and not in the mesopores (= *siphonozooids* of the Alcyonarians?). Their strong development in the former may be explained by supposing that the mesopores, becoming aborted, threw upon the autopores the task of supplying by their strong cilia the circulation of sea-water requisite for the nourishment of the colony. The peculiar condition of the mesopores in *Fistulipora* lends support to this view, as the close vesiculose tabulation which characterizes them would be difficult of explanation upon any other hypothesis.

With reference to the (assumed) occurrence of such a strongly marked ciliated groove in the autopores of the *Fistulipora*-colony it may be alleged that this is a somewhat rare condition to meet with in living Alcyonarians; but it is not altogether wanting in that group, for we find in the genus *Sarcophyton* (a dimorphic form) that the autozooids possess a

* Sydney J. Hickson, "On the Ciliated Groove (Siphonoglyphe) of the Stomodæum of the Alcyonarians," Phil. Trans. Royal Soc. part iii. 1883.

siphonoglyphe, though it is not so well marked as in the siphonozooids*.

We must not overlook the fact, however, that in *Sarcophyton* the siphonoglyphe is present only along the inner third of the stomodæum†, whereas in *Fistulipora* the fold, which we have assumed to have supported this ciliated groove, extends uninterruptedly throughout the entire length of the autopores, and, moreover, it appears upon the surface of the corallum in the form of a prominent arched lip in the apertures of those cells.

The occurrence of folds in the walls of the autopores of the *Fistuliporæ* has been observed by Dr. Rominger‡, of Ann Arbor, Michigan, who, however, does not appear to have attached any importance to it. Though unaccompanied by figures his descriptions are generally of sufficient exactness to enable the species to be identified. One of them, *Fistulipora utriculus*, is described and figured in this article. One of the writers has also noted and illustrated the structure in question in *Fistulipora incrassata*§. Mr. Ulrich of Cincinnati has published descriptions of a number of species of *Fistulipora*||; but he makes no mention of folds in the walls of the autopores, the apertures of which he figures as rounded or oval in outline with more or less thickened margins. His omission of the folds in the autopores is not difficult to account for, as when not distinct they may be easily overlooked, especially in sections which have not been cut exactly at right angles to the longer axis of the corallites. The folds are represented, however, in an unmistakable manner in a figure Mr. Ulrich gives of *Lichenalia concentrica*, Hall¶, and they form the subject of some remarks upon the genus *Lichenalia*, which are here condensed. Mr. Ulrich proposes to eliminate from the genus *Fistulipora*, and place in *Lichenalia*, those species possessing "thin, lamellate, or bifoliate zoaria, and more or less distinctly bidenticulate apertures" [=folds]. As, however, *Fistulipora incrustans*, the type of the genus *Fistulipora*, possesses such "bidenticulate apertures" as one of its most marked characters, it is clear that Mr. Ulrich's proposal cannot be entertained, and that *Lichenalia*, as he has characterized it, is a *Fistulipora*.

It has now become necessary to give a new diagnosis of the genus *Fistulipora*, so as to introduce into it the peculiar structural features which we have been dwelling upon.

* *Loc. cit.* p. 695.

† *Ibid.*

‡ Proc. Acad. Nat. Sci. Philadelphia, 1866, p. 113.

§ H. A. Nicholson, Pal. Tab. Corals, 1879, p. 308.

|| Journ. Cincinnati Soc. Nat. Hist. vol. vii. April 1884, p. 43.

¶ *Loc. cit.* pl. iii. fig. 5.

Genus *FISTULIPORA*, M'Coy, 1849, emend.
Nicholson & Foord.

Corallum variously shaped, dimorphic; consisting of two, more rarely of three, kinds of corallites; the first series (autopores) of a cylindrical or subcylindrical form with distinct walls, which on one side are thrown into two more or less well-developed longitudinal folds, giving to the cross section of the tube a characteristic trifoliate form. Apertures with raised margins, and prominent arched lips on one side corresponding with the folds. Tabulæ numerous, horizontal. The second series (mesopores) generally numerous, with imperfectly developed walls and very abundant tabulæ, which by their coalescence give rise to a vesicular tissue*. The third series (acanthopores), sometimes absent, consist of very minute tubuli, situated at the angles of junction, or in other parts of the thickness of the walls of the autopores and mesopores; they have distinct cells, are devoid of tabulæ, and project from the surface of the corallum in the form of blunt spines. No mural perforations.

Type: *Fistulipora incrustans*, Phillips, sp.

Fistulipora incrustans, Phill., sp.

Calamopora incrustans, Phillips, Geology of Yorkshire, part ii. p. 200, pl. i. figs. 63, 64 (1836).

Berenicea megastoma, M'Coy, Synopsis of the Carboniferous Fossils of Ireland, p. 195, pl. xxvi. fig. 13 (1844).

Fistulipora minor, M'Coy, Ann. & Mag. Nat. Hist. ser. 2, vol. iii. p. 130 (1849); id. Brit. Pal. Foss. p. 79 (1851).

Ceramopora megastoma, Vine, Quart. Journ. Geol. Soc. vol. xxxvi. p. 359, pl. xiii. (1880).

Ceramopora (Berenicea) megastoma, John Young, Ann. & Mag. Nat. Hist. ser. 5, vol. x. p. 427 (1882).

[Non *Fistulipora minor*, Nich. Pal. Tabulate Corals, p. 306 (1879).]

Spec. char. Corallum incrusting, growing upon the stems of Crinoids or other foreign bodies, and in the initial stages of growth taking the form of small circumscribed patches, often of a circular form. Adult crusts usually from 1 to 2 millimetres or more in thickness, the corallites being often more or less reclined in the young crusts, but becoming erect in old examples. The mode of growth is from definite centres (primitively one), from which the corallites radiate, and which ultimately constitute so many stellate "maculæ." The autopores average $\frac{1}{2}$ millim. in diameter, and are slightly but quite distinctly trifoliate in section. The apertures in well-preserved specimens show very clearly the arched lip, which depends upon the trifoliate form of the tubes. About three autopores occupy a space of $1\frac{1}{2}$ millim. (=to about fifty auto-

* See note p. 516.

pores in an inch). Acanthopores are wanting. The autopores are intersected by comparatively remote complete tabulæ. The mesopores are crossed by more closely-set tabulæ,

Fig. 3.

Fistulipora incrustans, Phill., sp. A. Fragment of the corallum of the natural size. B. Section of the same, to show vertical thickness. C. Portion of surface, showing the autopores with their raised lips, and the mesopores occupying the intervening spaces, enlarged about twenty times. D. Transverse section, similarly enlarged, showing fission in some of the mesopores. E. Longitudinal section, similarly enlarged: *a*, autopores; *m*, mesopores; *c*, primary cells.

which, owing to the incomplete nature of the walls of the mesopores, often give rise to a sort of vesicular tissue. The "maculae" are composed wholly of mesopores.

Obs. As regards the *synonymy* of this species, we have examined the original specimen of the *Calamopora incrustans* of Phillips, from the Carboniferous Limestone, now preserved in the British Museum, and we are satisfied as to its identity with the Northumbrian and Scotch examples of *Fistulipora*

minor, M'Coy, the originals of which were also obtained from the Carboniferous Limestone. Phillips's specimen of *F. incrustans* is not well preserved, especially as regards its external surface; but we are not able to see in thin sections of it any characters which would in any way separate it from *F. minor*, M'Coy. Under these circumstances the species must stand as *Fistulipora incrustans*, Phill., sp., and M'Coy's name must hence be regarded as a synonym.

As to the propriety of ranking the fossil which M'Coy described (*loc. cit.*) under the name of *Berenicea megastoma*, as also a synonym of *Fistulipora incrustans*, we cannot speak with the same certainty, since we have had no opportunity of examining M'Coy's original specimen. There can, however, be no doubt that the fossil which has usually been identified (notably by Mr. Vine and Mr. John Young) with *Berenicea megastoma*, M'Coy, is truly the young stage of *Fistulipora incrustans*. Mr. John Young (*loc. cit.*) has fully demonstrated this point. Whether, however, the fossil usually identified with *Berenicea megastoma*, M'Coy, is really the fossil so named by M'Coy is a point which could only be positively decided by an examination of M'Coy's original example. We are, however, disposed to believe that the identification is correct, and we therefore place *Berenicea megastoma*, M'Coy, as a synonym of *F. incrustans*, Phill.

On the other hand, the Carboniferous coral described by one of us (Nicholson, Pal. Tab. Corals) under the name of *Fistulipora minor*, M'Coy, appears to be a distinct but closely-related species, to which we shall here give the name of *F. muscosa*. It does not differ essentially, however, from typical examples of *F. incrustans*, Phill. (= *F. minor*, M'Coy), in anything except the rather smaller dimensions of the autopores and the proportion which these bear to the mesopores.

The most distinctive characters of the minute structure of *F. incrustans* are the comparatively large size of the autopores and their being usually separated by no more than one or two rows of mesopores. The general shape of the autopores is oval or circular, and the trifoliate form of the tubes in cross section is not nearly so marked as it is in many species of *Fistulipora*, though it is quite commonly recognizable. That the autopores really have the form characteristic of the genus is shown not only by tangential sections, but also by an examination of the actual surface, many examples showing the peculiar arching of one side of the aperture of the autopores which is associated with this peculiar type of corallites.

F. incrustans shows clearly, as does its near ally *F. muscosa*, the interesting phenomenon of the increase of the mesopores

by fission. In tangential sections the mesopores often exhibit a septum-like process extending to a greater or less distance into the cavity of the tube. This phenomenon, so well known as occurring in the genus *Chaetetes*, Fischer, is the result of the fissiparous development of the corallites. We have observed precisely similar phenomena in the mesopores of *Constellaria antheloidea*, Hall, and in the autopores of *Monotrypa pulchella*, E. & H. In our opinion this fissiparous mode of development is a strong argument in favour of the reference of these forms to the Actinozoa rather than to the Polyzoa.

In the earliest stages of growth *F. incrustans* forms thin subcircular crusts upon foreign bodies, each crust commencing with a single "macula," from which the corallites radiate. In the progress of growth fresh "maculae" are formed, and the crust gradually spreads over the invested body. In older colonies the original crust becomes thicker by the gradual elongation of the corallites in a direction at right angles to the invested surface. Sometimes also there may be a temporary cessation of growth, and then a second layer of corallites is formed above the old one. At the point where the corallites are attached to the body which the colony invests they are slightly bent, in a fashion which occurs in all the Monticuliporidae as also in all the Favositidae, where the colony springs from an extended surface, whether this surface belong to an invested foreign body or whether it be the natural epitheca. The obliquity of the young corallites thus produced is rendered in *F. incrustans* apparently greater than it really is, owing to the arching of the lips of the aperture of the autopores on one side. As growth proceeds the corallites become, however, quite erect. Even in the youngest colonies the existence of both the autopores and the intervening mesopores may be recognized quite clearly. Nor is there any difference whatever in the internal structure of young and old colonies; the only distinction, in fact, between the earlier and the later stages being merely the slight obliquity of the corallites of the former.

There seems to be little doubt that the fossil which M'Coy described (*loc. cit.*) under the name of *Berenicea megastoma* was really a specimen of the young stage of *Fistulipora incrustans*. As before remarked, however, it is not possible to be absolutely certain of this without an examination of M'Coy's original specimen, especially as M'Coy's figure of *Berenicea megastoma* does not exhibit any mesopores, nor does his description of the species contain any allusion to the presence of "interstitial tubes."

Mr. John Young, in the paper previously cited, not only pointed out that the so-called *Berenicea megastoma* of M'Coy is really the young of *Fistulipora minor*, M'Coy, but also accepted Mr. Vine's reference of the fossil to the genus *Ceramopora*, Hall. In this we are unable to agree with Mr. Young, and we may briefly state the reasons which, in our opinion, render inadmissible the course he has adopted. In the first place, supposing it to be proved that the genera named respectively *Fistulipora* and *Ceramopora* by their founders were synonymous, it would be the genus *Fistulipora*, M'Coy, which would have to be retained, and *Ceramopora*, Hall, suppressed. This is a mere matter of priority, *Fistulipora*, M'Coy, having been founded in 1849, whereas *Ceramopora*, Hall, was not established until two years later (Pal. N. Y. vol. ii. 1851). Even, therefore, if we were able to accept Mr. Young's views on this point, the species now under consideration would still have to be placed under the generic title of *Fistulipora*. In the second place, we are unable to feel any certainty as to what the genus *Ceramopora*, Hall, really is supposed to include. The most recent definition of this genus is that given by Mr. E. O. Ulrich ("American Pal. Bryozoa," Journ. Cin. Soc. Nat. Hist. no. 3, vol. v. 1882), who defines the genus as including types with "angular" cells and oblique apertures, either with no "interstitial cells" or few, generally with "mural pores" and "occasionally" with tabulæ*. Now *F. incrustans*, Phill., does not possess "angular" corallites, always has numerous mesopores ("interstitial tubes"), unquestionably has no mural pores, and always possesses a larger or smaller number of tabulæ. It is therefore quite clear that *F. incrustans* cannot be placed under *Ceramopora*, Hall, as this genus is understood by Mr. Ulrich. It is also clear from Hall's figures and description of the type species of his genus *Ceramopora* (viz. *C. imbricata*, Hall), that, whatever may be the precise structure of this form, it has nothing in common with the coral here in question.

It need only be added that, supposing it had been shown that the young stages of *Fistulipora incrustans*, Phill., were identical in appearance with a presumed Polyzoan genus such

* The genus *Ceramopora*, as defined by Ulrich, can hardly be regarded as a natural group, seeing that it is said to comprise forms with or without "interstitial tubes," with or without mural pores ("connecting foramina"), with or without tabulæ ("diaphragms"). The only character as to which no option is given is that the apertures of the tubes are oblique, with an arched "lip." This character is, however, the principal one given in the diagnosis of the family Ceramoporidæ, Ulrich, and it cannot therefore be also used as a generic character of *Ceramopora*.

as *Ceramopora*, Hall, we should not for that reason adjudge the evidence as to its zoological position derived from its adult characters to be in any way invalidated. All that we should feel inclined to say would be that, in the case supposed, *Fistulipora incrustans* passed through a "Ceramo-poroid stage" or a "Polyzoan stage," in precisely the same way that a Brachiopod may pass through an Annelidan stage in its development, and yet may not become an Annelid. As a matter of fact, however, we do not admit that *Fistulipora incrustans* was at any period of its growth a *Ceramopora*, or, indeed, in any way essentially different from what it became when fully matured. On the contrary, thin sections of the youngest specimens which we have been able to examine show an internal structure in all respects precisely similar to that exhibited by adult specimens. All that we can admit is that in its early condition of a very thin investing crust *Fistulipora incrustans* may have the general aspect of a Polyzoan; but here the resemblance ceases, and its intimate structure shows no indication of any alliance with the Polyzoa.

We think that from the evidence we have brought forward there is now good ground for assigning to the genus *Fistulipora*, M'Coy, a place among the Actinozoa, and probably in that division of it known as the Alecyonaria.

Formation and Locality. *Fistulipora incrustans*, Phill., is found in the Carboniferous Limestone, Bolland, Yorkshire (Phillips); Derbyshire and Ireland (M'Coy). Also in the Carboniferous rocks of Redesdale, Northumberland, where it is common, and in the west of Scotland (John Young).

Fistulipora muscosa, Nich. & Foord.
(Pl. XV. figs. 3, 3 a.)

Fistulipora minor, Nicholson, Pal. Tab. Corals, p. 306, fig. 39 (1879)
[non *Fistulipora minor*, M'Coy].

Spec. char. Corallum forming thin irregular crusts, more or less extensively attached to foreign bodies. Autopores in the main oval, but commonly showing the trifoliate form characteristic of the genus. The autopores are rather less than half a millim. in diameter, about three of them occupying a space of 2 millim. (=about thirty-six in the space of an inch). The mesopores are angular and of variable size, two rows usually intervening between any given pair of autopores. The walls of the mesopores are very incompletely developed, and the close-set tabulæ coalesce to form a vesicular tissue.

The autopenes have a few remote tabulæ, which in some tubes are seemingly altogether absent.

This species was originally described by one of us as *Fistulipora minor*, M'Coy (*loc. cit.*). In point of fact it is very closely allied to this species (*i. e.* to *F. incrustans*, Phill.), and differs from it only in certain minute characters. The principal points which distinguish *F. muscosa* from *F. incrustans* are the slightly smaller size of the autopenes and their separation from one another to a proportionately greater distance than in the latter species, this last feature depending upon the more extensive development of the mesopenes. Moreover the mesopenes of *F. muscosa* are furnished with more imperfect walls than those of *F. incrustans*, while the autopenes of the former are much more sparsely tabulate than is the case in the latter.

Formation and Locality. Rare in the Lower Carboniferous Limestone, Courland, near Edinburgh (collected by Dr. Ramsay H. Traquair).

Fistulipora crassa, Lonsdale, sp. (Pl. XV. fig. 1.)

Heteropora crassa, Lonsdale, Sil. Syst. pl. xv. figs. 14, 14 a (1839).

Fistulipora crassa, Nicholson, Ann. & Mag. Nat. Hist. ser. 5, vol. xiii. p. 118, pl. vii. figs. 1, 1 a, 2, 2 a (1884). [Non *Fistulipora crassa*, Rominger, Proc. Acad. Nat. Sci. Phil. p. 121 (1866).]

The fine specimen we have figured is from the collection of the late Mr. Johnson, of Dudley. The species has already been described and its microscopic structure illustrated by one of the writers in this journal (*loc. cit.*). The small dark spots upon the surface of the specimen represent the "maculæ." The name of Dr. Rominger's species (*loc. cit.*) must now be changed, and we propose for it that of *Fistulipora Romingeri*.

F. crassa is not uncommon in the Wenlock Shales at Dudley, and it is found also at Benthall Edge and at Dormington.

Fistulipora nummulina, Nich. & Foord.
(Pl. XV. figs. 2-2 c.)

Spec. char. Corallum discoid, lenticular, concavo- or plano-convex, also forming thin, irregular, crust-like expansions; sometimes the corallum rises into a conical mass, with tapering margins, the central portion thus attaining a thickness greatly disproportionate to that of the margins. The surface is dotted over with numerous "monticules" (consisting of mesopenes), which are slightly raised above the general level; they were doubtless more elevated originally, but have been reduced in height by the attrition which the whole of the corallum has

undergone. The autopores are sufficiently large to be distinctly seen with the naked eye; this arises in some measure from their infilling being of a lighter colour than that of the walls of the cells, otherwise they could hardly be perceived. They are oval or subcircular in form, the folds (which are plainly visible under a 1-inch objective) occupying about one fourth of the circumference of the walls and always pointing towards one of the centres of growth. About four of the autopores may be contained within the space of 1 millim.; a few of a somewhat larger size are grouped around the "monticules." Mesopores as seen in transverse section polygonal, very variable in size, sometimes equalling that of the autopores, sometimes much smaller. Longitudinal sections show that the autopores are provided with tabulæ, which are horizontal or a little curved, and that the mesopores are filled with closely-set tabulæ which have produced by their coalescence a vesicular tissue.

F. nummulina, showing folds in the autopores.

Obs. The species to which *F. nummulina* is most closely allied is undoubtedly *F. crassa*. Externally the distinction between the two is very obvious, as appears on looking at the figures (Pl. XV. figs. 1, 2), one being of a discoid or flattened shape, and the other branching. In their microscopic characters also the two species are distinct enough; the autopores in *F. nummulina* being larger than those of *F. crassa*, only four of them being required to fill the space of a millimetre in the former species, while in the latter five must be taken.

Further, the tabulation of the mesopores is not nearly so dense in *F. nummulina* as it is in *F. crassa*, and its vesicular character is therefore not so strongly marked as it is in that species.

The present species is not unfrequently met with in the grey and greenish shales of the Wenlock group. The specimen figured was presented to one of the writers by Mr. W. Madeley, of Dudley, who has for many years collected the fossils of that region with much industry and discrimination. Other specimens referred to in drawing up the foregoing description are from the cabinet of Mr. C. Holcroft, also of Dudley.

Fistulipora utriculus, Rominger.(Pl. XVI. figs. 1-1 *e*, & Pl. XVII. figs. 1, 1 *a*.)*Fistulipora utriculus*, Rominger, Proc. Acad. Nat. Sci. Phil. p. 121 (1866) [no figures].

Corallum small, irregular, subramose, hollow, thin, subcylindrical or compressed; varying from $\frac{1}{2}$ millim. to 1 millim. or rather more in thickness. The surface is covered with monticules, which take the form of warty outgrowths, whose summits consist of clusters of mesopores. The latter may be seen with a strong hand-lens.

Under the microscope the surface of the corallum is observed to be minutely granulose (Pl. XVI. fig. 1 *b*), the granules being apparently the free ends or summits of the walls of the mesopores. The autopores can generally be seen without a lens; about four of them fill the space of 1 millim., and, as appears to be always the case, some of slightly larger size occur in the region of the "monticules" or areas of growth. The mesopores are of the usual angular form. The folds of the autopores are in this species remarkably well developed; they occupy from one third to one fourth of the circumference of the apertures; the latter are surrounded by a shallow depression, and their margins are slightly exsert. The outlines of the walls of the mesopores can be very distinctly made out in weathered specimens (Pl. XVII. fig. 1).

In tangential sections the autopores are seen to be of an irregular oval shape and of variable dimensions; the mesopores are sufficiently abundant to make three or four rows around the autopores. The areas of growth, as already stated, are found to be occupied entirely by the mesopores, and around them the autopores are ranked in three or four concentric rows (Pl. XVI. fig. 1 *c*). Longitudinal sections show that the autopores have but few tabulæ, while those of the mesopores are abundant and are of the usual vesicular description.

Obs. We give some additional figures of this very characteristic and interesting species. Fig. 1, Pl. XVII., is a microscopic view of the slightly weathered surface. It is drawn on the same scale as fig. 1 *b*, Pl. XVI. * (enlarged about forty times), and shows the walls of the mesopores; the interior of these cells, as well as that of the autopores, being filled with crystalline calcite. Fig. 1 *a*, Pl. XVII., is intended to illustrate the projection of the autopores above the general surface of the corallum and the prominence of the arched lips (folds).

Dr. Rominger (*loc. cit.*) has compared this species with two

* In this figure the walls of the mesopores are not indicated, because they are not visible in this part of the specimen, owing, it would seem, to their uniformity of colour with the rest of the surface.

others described by him, viz. *F. eriensis* and *F. spinulifera*. We cannot corroborate the accuracy of his comparison with reference to the latter of these forms, for we do not possess specimens of it; but with regard to *F. eriensis* we find ourselves quite unable to agree with Dr. Rominger. It is in every way a coarser form than *F. utriculus*; it occurs in large laminate folded masses, and the autopores greatly exceed in magnitude those of *F. utriculus*. *F. eriensis*, moreover, is provided with acanthopores, which are wanting in *F. utriculus*.

The present species resembles *Fistulipora trifoliata*, Schlüt. (Pl. XVIII. figs. 1-1 c), in the strong development of the folds of the autopores, but in other details of its structure as well as in its habit of growth it is sharply distinct from that form. There is another species, however, to which *Fistulipora utriculus* is very closely related, viz. *F. Goldfussi*; and it was not without hesitation that we resolved to keep them apart. Both are exactly similar in habit of growth and external markings, and there is also a general conformity in their minute structure. The points in which the two species are dissimilar are these: the autopores are larger and less numerous in *F. utriculus* than they are in *F. Goldfussi*, and the folds are more strongly developed in the former species than they are in the latter.

Formation and Locality. Common in the shales of the Hamilton group (Devonian), at Thetford (formerly called Widder), and at Arkona, in the Province of Ontario, Canada.

Fistulipora Torrubia, De Verneuil & Haime, sp.
(Pl. XVI. figs. 2, 2 a; 2 b.)

Chaetetes Torrubia, De Verneuil & J. Haime, Bull. Soc. Géol. de France, 2^e sér. t. vii. p. 162 (1850) [no description or figures]; Milne-Edwards & Haime, Polyp. Foss. des Terr. Pal. p. 268, pl. xx. figs. 5, 5 a (1851).

Monticulipora Torrubia, Milne-Edwards, Hist. Nat. des Coralliaires, tom. iii. p. 277 (1860).

Spec. char. Corallum subramose, or in large sublobate masses, which present a coarsely mamillated appearance and are made up of a succession of concentric superimposed laminæ. Surface monticulose; the monticules rather inconspicuous, distant from each other 3 or 4 millim. Autopores subcircular or oval in general outline, closely approximated; rarely in contact; readily distinguishable by the naked eye. About three of those of average size occupy the space of 1 millim., and about two of the larger ones, which are in the region of the "monticules," fill a similar space. The folds of

the autopores may be seen on well-preserved surfaces under the microscope; they are small, occupying not more than about one sixth of the circumference of the walls. A few autopores have been drawn on an enlarged scale (Pl. XVI. fig. 2 *a*) to show the folds. The latter become very obscure in sections cut below the surface layers of the corallum, and they were overlooked in the larger section (fig. 2). The autopores, as shown in longitudinal sections (fig. 2 *b*), are crossed by tabulæ, which are comparatively numerous, and are separated from each other by variable spaces, measuring roughly from one to two tube diameters. The mesopores are in this species remarkably few in number, so that it frequently happens that only a single row of them is interposed between two of the autopores. The tabulæ in the mesopores are unusually wide apart, and sometimes occur at the same level in contiguous tubes, which appear at first sight to be separated by distinct walls. In other parts of the corallum, however, the characteristic vesicular tabulæ are met with.

Obs. This species was first described and figured in the 'Polypiers Fossiles des Terrains Paléozoïques' (*loc. cit.*). The first notice of it, however, appeared in a list of Devonian fossils from the district of Sabero (Léon) by M. de Verneuil (*loc. cit.*). The description of *Fistulipora Torrubia* by the authors of the 'Polypiers Fossiles' refers only to its external characters.

The species to which this is most nearly allied is *Fistulipora incrassata*, Nich. (Pal. Tab. Corals, p. 308, pl. xv. figs. 3-3 *b*, 1879), from the Hamilton group (Devonian) of Canada. The corallites in that species are, however, somewhat larger than those of *F. Torrubia*, the mesopores less numerous, and the folds of the autopores more strongly developed.

Formation and Locality. *F. Torrubia* is somewhat widely distributed geographically, and is reported to have been found in Devonian rocks at the following localities:—Asturias (Spain), Eifel (Westphalia), Boulonnais &c. (France).

Fistulipora Goldfussi, Michelin, sp.
(Pl. XVII. figs. 2, 2 *a*, 2 *b*.)

Ceriopora Goldfussi, Michelin, Leonogr. Zoophyt. p. 190, pl. xlviii. fig. 9 (1847).

?*Chateles Goldfussi*, Quenstedt, Petref. Deutschl. Abtheil. i. p. 83, t. cxlvi. figs. 28, 29 (1878).

Corallum ramose, hollow, subcylindrical. Surface uneven, irregularly dilated here and there. "Maculæ" not very conspicuous. Corallites very minute; about seven of the autopores

may be contained within the space of 1 millim. The folds occupy from one fourth to one fifth of the circumference of the autopores.

Obs. The relationship between *Fistulipora utriculus* and this species has already been pointed out.

We are indebted to Dr. Henry Woodward, F.R.S., for his kindness in permitting us the use of specimens contained in the collections of the British Museum (Nat. Hist.) in preparing the foregoing description.

Fistulipora dobunika *, Nich. & Foord.
(Pl. XVII. figs. 3, 3 a, 3 b.)

Corallum extremely thin, incrusting; attaching itself to various foreign bodies, whose surface contour it follows in all its irregularities; occasionally, however, putting forth short hollow cylindrical prolongations, generally at right angles to the surface (fig. 3). Surface dotted with maculæ. The corallites, though very minute, can usually be seen by the naked eye. About six of the autopores are contained within the space of 1 millim.; others, of a little larger size, occur in the vicinity of the maculæ. The folds in the autopores are well developed and occupy nearly one third of the circumference of the walls of those corallites (fig. 3 a). There is nothing remarkable in the microscopic structure as seen in longitudinal sections.

Obs. As might be supposed, some difficulty was experienced in obtaining satisfactory sections from such an extremely thin corallum.

Some of the autopores have been shaded, the better to distinguish them from the mesopores.

We are unacquainted with any species with which to compare *F. dobunika*. The extreme tenuity of its corallum and its incrusting habit resulting from this, together with the minuteness of its corallites, are the distinguishing marks of this species. The specimen figured is from the collection of Mr. Madeley, of Dudley.

Formation and Locality. *F. dobunika* appears to be tolerably plentiful in the Wenlock Shales (Upper Silurian) at Dudley.

Fistulipora eriensis, Rominger. (Pl. XVII. figs. 4, 4 a.)

Fistulipora eriensis, Rominger, Proc. Acad. Nat. Sci. Phil. p. 121 (1866).

Corallum in large, irregular, laminated and folded masses;

* The Dobunii were a tribe of ancient Britons, neighbours of the Silures.

growing in concentric layers measuring as much as 8 centim. in breadth and 2 centim. in thickness. Surface monticulose; the monticules conspicuous, from 2 to 3 millim. apart, consisting of mesopores. Autopores comparatively large, readily distinguishable by the naked eye. About three of them fill the space of 1 millim. The folds are of average size and occupy about one fourth of the circumference of the walls of the autopores. Acanthopores may be seen in transverse sections at the angles of the walls of the mesopores. Longitudinal sections show considerable regularity in the disposition of the vesicular tabulæ in the mesopores. The autopores have very few tabulæ.

Obs. The presence of acanthopores distinguishes *Fistulipora eriensis* from all other species of the genus with the exception of *F. ludensis*, Nich. (this journal, p. 119, Feb. 1884), from which it is completely separated by its habit of growth and the much larger dimensions of its corallites. The occurrence of acanthopores is in fact the only feature which these two species possess in common. The expression "spinuloso-granulose," employed by Dr. Rominger in reference to the surface of this species, no doubt refers to the acanthopores, which may be visible externally on well-preserved specimens. We have only detected them in transverse sections.

Formation and Locality. Hamilton Group (Devonian), Canandaigua, Ontario Co., New York.

Fistulipora eifeliensis, Schlüter, sp.

Callopora eifeliensis, Schlüt. Sitzungsberichte der niederrheinischen Gesellschaft in Bonn (Physikalische Section), p. 72, Feb. 14, 1881.

Corallum hemispherical, with a slightly conical base, which may have been furnished with an epitheca. The surface is provided with slightly raised "monticules," upon which there are clusters of the mesopores. In weathered specimens the corallites may be very distinctly made out; they measure about $1\frac{1}{2}$ millim. in their longer diameter by about 1 millim. in their shorter. The autopores are irregularly oval or subcircular in outline, and are in general completely isolated from each other by the mesopores, but occasionally two come into contact either at their sides or at their extremities. The folds are very small in this species, as may be seen in the section, fig. B. The mesopores vary greatly both in size and in shape; in some instances four of them encircle an autopore, in others six.

Longitudinal sections show that the autopores are divided

by a few remote tabulæ, while the mesopores exhibit the characteristic vesicular tabulation of the genus, especially near the base of the colony. As growth proceeds this tabulation assumes a more regular appearance, and may consist of two or more rows of cells as it were dovetailed into each other (fig. 5, D).

Fig. 5.

Fistulipora eifeliensis, Schlüt. sp. A. Corallum, natural size; the shading is given merely to show the rotundity of the specimen and the somewhat conical base. B. Transverse section, enlarged about twelve times. C. One of the autopores, showing the fold, enlarged about twenty times. D. Longitudinal section, enlarged about twelve times. *a*, autopores; *m*, mesopores.

Obs. An interesting feature is noticeable in the mesopores of this species. Certain of them, larger than the average and of a subelliptical form, are partially divided by a projection as thick as the cell-walls, which extends from those walls about halfway across the cell-cavity (woodcut, fig. 6).

These projections appear to indicate very clearly a fissiparous mode of growth in such cells.

In drawing attention to the substitution of the generic name *Fistulipora* for that of *Callopora*, to which latter genus Prof. Schlüter assigned the present species, we have only to observe that there exists a well-marked distinction between the two genera, which may be briefly stated as follows:— In *Fistulipora*, as has been shown above, the mesopores are crossed by imperfect tabulæ, which, coalescing, form a vesicular tissue; in *Callopora*, on the other hand, the tabulation of the mesopores is not essentially different from that of the autopores, except that the tabulæ are much more numerous in the former cells than they are in the latter. The mesopores in *Callopora* are further, as a rule, bounded by perfect walls. It is scarcely necessary to point out that the structure of the present form accords with that of *Fistulipora* and not with that of *Callopora*.

Fistulipora eifeliensis stands alone in the remarkably large size of its corallites, which exceed in their dimensions those of any other species of *Fistulipora* with which we are acquainted.

Formation and Locality. Not uncommon in the Middle Devonian of Gees, near Gerolstein, Eifel.

Fistulipora trifoliata, Schlüter. (Pl. XVIII. figs. 1–1 c.)

Fistulipora trifoliata, Schlüt. Sitzungsberichte der niederrheinischen Gesellschaft in Bonn (Naturwissenschaftliche Section), p. 147, May 11, 1885.

Corallum hemispherical, growing on the shells of mollusks and other foreign objects. Surface not well preserved in any of the specimens examined, apparently smooth. Corallites extremely minute, barely distinguishable by the naked eye. "Maculæ" distant from each other from 3 to 4 millim. About six of the autopores fill the space of 1 millim., while some of a larger size invest the "maculæ." On looking at a tangential section (figs. 1 *a*, 1 *b*) it is found that the autopores have their outline interrupted by the very strong folds in their walls, which impart a distinctly trifoliate aspect to them. The free edges of the folds sometimes extend far into the lumen

Fig. 6.

a, autopore; *m*, mesopore;
f, fission.

of the cells. The mesopores are sufficiently numerous to completely isolate the autopores from each other; they exhibit the usual polygonal form. A few, of a comparatively large size, occupy the central portions of the "maculæ," and towards these the folds of the autopores are directed. Longitudinal sections show the finely vesicular character of the tabulæ in the mesopores and the growth of the corallum in concentric layers. These sections also show that the autopores diverge in a flabellate manner from their centres of growth. A like feature is also noticeable in *F. cornavica* (Pl. XVIII. fig. 2 c).

Obs. The present form has been well known to us for more than a year, but we have not till now been in a position to publish a description of it. In the meantime Professor Schlüter, of Bonn, has been before us in the matter. As, however, that author has given neither figures nor measurements of his species, we have felt ourselves justified in re-describing it and supplying those deficiencies, more especially as it exhibits in a marked degree one of the most characteristic features of the genus, viz. those remarkable folds in the walls of the autopores.

In its general structural features this species resembles *F. cornavica*, Nich. & Foord (*infra*). The two species are figured upon the same Plate (XVIII.) to facilitate comparison. It will be seen that the corallites of *F. cornavica* are larger than those of *F. trifoliata*, and also that the autopores in the latter are more highly developed than they are in the former.

We are indebted to Prof. Schlüter for sections of *F. trifoliata*, which place beyond question the specific identity of his species with ours, a point which we were unable to decide from his description alone.

Formation and Locality. Somewhat rare in the Middle Devonian of Gees, near Gerolstein, Eifel.

*Fistulipora cornavica**, Nich & Foord.
(Pl. XVIII. figs. 2-2 c.)

Corallum subhemispherical, attached by its base to shells or other marine objects; composed of a succession of thin concentric layers, which apparently mark periodical cessations of growth. Surface monticulose, the "monticules" consisting of mesopores. Autopores, as seen in transverse sections, irregularly ovate, the folds occupying about one fourth of the circumference of their walls. About four of the autopores fill the space of 1 millim. Mesopores nume-

* The Cornavii were a tribe of ancient Britons who, along with the Ordovices, inhabited Shropshire at the time of the Roman invasion.

rous and mostly of large size. Longitudinal sections show that the tabulæ by which the cavities of the autopores are crossed are placed at irregular distances apart. The divergence of the autopores from their centres of growth may also be observed in these sections (fig. 2 c).

Obs. A comparison has already been made between this form and *F. trifoliata* in treating of the latter.

Formation and Locality. Appears to be rare in the Wenlock Shales (Upper Silurian) at Buildwas, Shropshire.

NOTE.—In his Hist. Nat. des Coralliaires (vol. i. p. 67, 1860) M. Milne-Edwards gives a highly suggestive explanation of what he conceives to have been the origin of vesicular tabulæ. We beg permission to lay before the reader the following translation of it :—

“According to the known disposition of the soft parts of the polyps it is evident that the tabulæ should correspond to the spaces left open by the atrophy or the successive retreating of the inferior extremities of the mesenteric folds [*lames*], and the degree of their separation would depend upon the length to which this retreating or atrophy was carried in proportion to the growth of the animal. If this upward movement [of the animal] was effected rapidly and completely in each cell [*loge*] it would result in the tabulæ being simple and apart from each other. But if the movement was made little by little in an incomplete and limited manner in the different parts of the cells there would be formed a series of blisters or vesicles, of which the general appearance would be that of a cellular or vesicular tissue.”

EXPLANATION OF THE PLATES.

PLATE XV.

Fig. 1. *Fistulipora crassa*, Lonsd. sp. View of corallum in the matrix, nat. size. (Coll. Johnson, Dudley.)

Fig. 2. *Fistulipora nummulina*, Nich. & Foord. View of upper surface of corallum, nat. size.

Fig. 2 a. Side view of the same specimen, to show thickness of corallum.

Fig. 2 b. Transverse section, enlarged about twenty times.

Fig. 2 c. Longitudinal section, similarly enlarged.

Fig. 3. *Fistulipora muscosa*, Nich. & Foord. Transverse section, enlarged about twenty times.

Fig. 3 a. Longitudinal section, enlarged to the same extent.

PLATE XVI.

Figs. 1, 1 a. *Fistulipora utriculus*, Rom. Two examples of the corallum of this species, nat. size.

- Fig. 1 b.* Surface, showing arched lips (folds) at the apertures of the autopores, enlarged about forty times.
Fig. 1 c. Transverse section, showing one of the "maculae," with the autopores ranged around it; enlarged about twenty times.
Fig. 1 d. A portion of the same section, enlarged about forty times.
Fig. 1 e. Longitudinal section, enlarged about twenty times.
Fig. 2. *Fistulipora Torrubiæ*, De Vern. & Haime. Transverse section, enlarged about twenty times.
Fig. 2 a. Portion of another section, to show folds in the autopores, enlarged about forty times.
Fig. 2 b. Longitudinal section, enlarged about forty times.

PLATE XVII.

- Fig. 1.* *Fistulipora utriculus*, Rom. Surface partially weathered, showing autopores and mesopores, enlarged about forty times.
Fig. 1 a. Surface of the same, viewed in profile, showing prominence of the arched lips of the autopores. Similarly enlarged.
Fig. 2. *Fistulipora Goldfussi*, Mich. Corallum of the natural size.
Fig. 2 a. Transverse section, enlarged about twenty times.
Fig. 2 b. Longitudinal section, enlarged to the same extent.
Fig. 3. *Fistulipora dobunica*, Nich. & Foord. View of the corallum of the natural size.
Fig. 3 a. Transverse section, enlarged about twenty times.
Fig. 3 b. Longitudinal section, similarly enlarged.
Fig. 4. *Fistulipora eriensis*, Rom. Transverse section, enlarged about twenty times.
Fig. 4 a. Longitudinal section, similarly enlarged.

PLATE XVIII.

- Fig. 1.* *Fistulipora trifoliata*, Schlüt. View of the corallum of the natural size.
Fig. 1 a. Transverse section of one of the "maculae," enlarged about twenty times.
Fig. 1 b. Transverse section, enlarged about forty times.
Fig. 1 c. Longitudinal section, enlarged about twenty times.
Fig. 2. *Fistulipora cornavica*, Nich. & Foord. View of the corallum, growing on a Brachiopod shell. Nat. size.
Fig. 2 a. Transverse section, enlarged about twenty times.
Fig. 2 b. One of the autopores, enlarged about forty times.
Fig. 2 c. Longitudinal section, enlarged about twenty times.

BIBLIOGRAPHICAL NOTICE.

Contributions to the Knowledge of the Older Mesozoic Flora of Virginia. By WILLIAM MORRIS FONTAINE. *Monographs of the United States Geological Survey.* Vol. VI. Pp. 144, with 54 plates. Washington: 1883.

THE present volume contains a very full account of the older Mesozoic flora of Virginia. The author introduces the subject by a short geological sketch of the area from which the fossil plants were collected, in which is pointed out that the Mesozoic strata of Virginia are divisible into two well-marked groups, an older and a younger, both of which are characterized by plants of a totally different aspect. It is only those from the older Mesozoic group, however, with which the present monograph deals.

2 a.

2.

1.

3.

2 b.

2 c.

3 a.

L. S. F. and A. H. F. del.

L. S. F. and A. H. F. imp.

1b.

1c.

1d.

1.

1a.

1e.

2b.

2.

2a.

1.

1a.

2.

3.

3a.

4a.

3b.

2b.

2a.

Mintern Bros. imp.

A. S. Ford. lith. A. H. F. del.