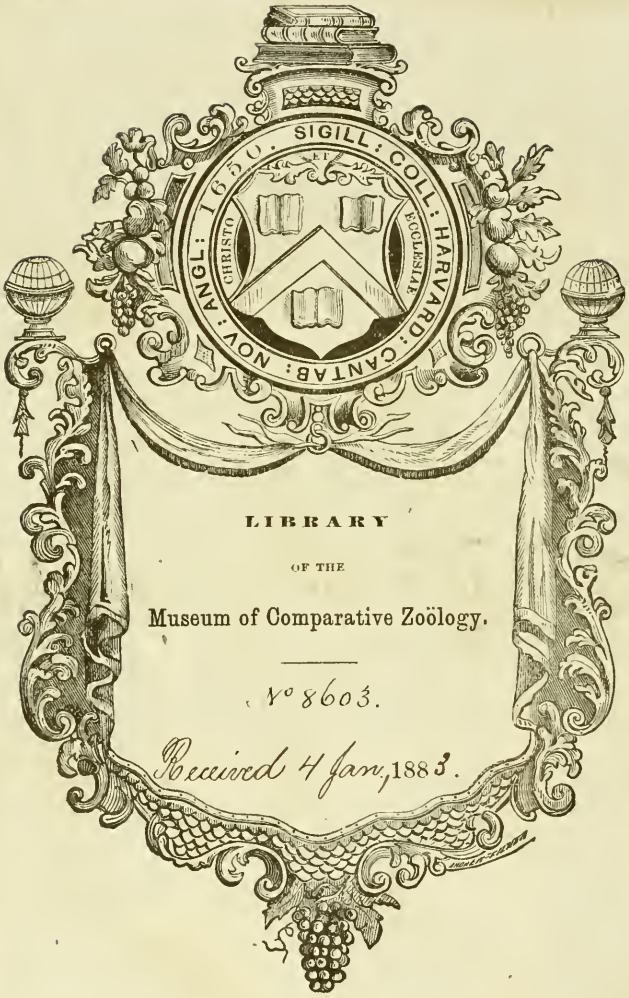

THE GENUS MONTICULIPORA

AND

ITS SUB-GENERA

BY THE SAME AUTHOR.

ON THE STRUCTURE AND AFFINITIES OF THE

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ON THE

STRUCTURE AND AFFINITIES

OF THE

GENUS MONTICULIPORA

AND ITS SUB-GENERA

WITH

CRITICAL DESCRIPTIONS OF ILLUSTRATIVE SPECIES

BY

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MDCCCLXXXI

PREFACE.

The present work has no claim to be called a "Monograph," since it does not even exhaust my own collection of Monticuliporoids, upon which it is entirely based; while a large amount of additional material, much of it new and important, is contained in the cabinets of others or in public museums. Moreover, the group of the Monticuliporoids, from the difficulties attending its study, has always been more or less neglected by palæontologists; and we may be quite sure that there exist many new and interesting types which yet remain to be discovered. The time, in fact, for writing a "Monograph" of the Monticuliporidæ has not yet arrived; and the present work is simply an attempt to ascertain and clearly record the structure of a number of well-marked species of Monticulipora, with special reference to the microscopic and really fundamental characters of these. Palæontologists, indeed, have now universally recognised that, in such difficult forms as the Monticuliporoids, the microscopic structure is the chief element in the determination of species; since surface-characters may not be recognisable, or may vary greatly according to the state of preservation of the specimens, or other similar circumstances, while mere external form is a most treacherous

and delusive guide. In some of my own earlier memoirs, dealing with species of Monticulipora, I relied, as all palæontologists did at that time, upon external characters, in so far as these could be observed with a moderate magnifying power; and I did not recognise the absolute necessity of thin sections for the proper examination of these and similar forms. The result, it need hardly be said, was that the memoirs in question contained various errors, with the nature and extent of which few, probably, are better acquainted than I now am myself. This being the case, I need only say that, with my improved knowledge, I have not in any way attempted to conceal these errors; but that, on the contrary, I have used at least as much freedom in correcting them as I should have done had I been dealing with the work of others.

The absolutely pressing difficulty which, in my opinion, is at present the chief obstacle to the full assumption by Palæozoology of its proper place as a truly scientific department of knowledge—a vital branch of the great science of Biology—is that it is almost impossible to recognise and identify so many of the extinct forms of life which have been described and named by the older observers. Every palæozoologist, I feel sure, will, so far as his own special department is concerned, bear me out in saying that in the Palæozoic rocks at any rate, and as regards many groups of animals, not a few types bearing long current titles are either so insufficiently defined that in using them one has no certainty that one is really dealing with the form so named by the original author of the species, or their names are applied by different observers to entirely different organisms. There are few public or private collections of any extent which would not afford conclusive proof of the truth of the above statement. Nor is it easy to exaggerate the ill effects of this condition of things upon the progress of stratigraphical geology. The determina-

tion of particular stratigraphical horizons by means of their characteristic fossils is attended with sufficient difficulties even in the Tertiary and Secondary rocks; but amongst the Palæozoic deposits it has been rendered largely unreliable as regards all but certain particular groups of organic remains, in consequence of the fact that it is next to impossible to be sure of the identification of such a large number of typical species. Thus, to take an example from the group now under consideration, one may find *Monticulipora petropolitana*, Pand., or *M. tumida*, Phill., or *M. pulchella*, E. and H., quoted in lists of characteristic fossils from particular horizons in the Palæozoic rocks; but it is not too much to say that in nineteen cases out of twenty there is no guarantee that the identification of such species has been based upon anything else than the almost wholly worthless characters of external form and aspect. Or, one finds such a form as *Stenopora fibrosa*, Goldf., or *Chætetes lycoperdon*, Say, quoted as characterising some particular horizon—the real truth being that each of these names has been used to designate several wholly unrelated forms; while it is almost or quite impossible to determine *what* is the actual species which the original author of the title had before him.

It is unnecessary to multiply examples, either from this particular group of organisms or from any other; but I take it for almost beyond dispute that the great necessity of Palæozoology at present is not so much to extend its domain indefinitely by the description of new species, as to ascertain the precise extent of its present frontiers by the more thorough elucidation of those forms which have been already named, but have not been sufficiently characterised. It is upon this basis that the present work has been written; and its main object has therefore been to record the characters of a number of already partially known forms, the description of new species having been quite subordinated to this. No species, also, has been

admitted that has not been subjected to a careful microscopic examination, and the minute structure is always figured as adequately and fully as considerations of space and cost will allow.

For the same reasons, I have not troubled myself greatly about matters concerning the bibliography and synonymy of the genus, chiefly because it will be impossible to take up this part of the subject with much satisfaction or utility until the actual specimens originally examined and described by the earlier workers in this department shall have been investigated by modern methods, and thus, for the first time, clearly and unmistakably identified. It is quite possible, therefore, that when the investigation I have just alluded to has been carried out, and its results published, it may be found that some of the forms which I have here identified with previously described species are in reality distinct from these.[1] This source of error, in the present state of our knowledge, seems to be absolutely unavoidable, even by the most careful observer; and it must be sufficient for me that my descriptions and

[1] As an example of this, we may take such a form as *Monticulipora mammulata*, D'Orb., commonly quoted as one of the characteristic fossils of the Cincinnati Group of Ohio. In determining what species *M. mammulata*, D'Orb., really is, we do not get any help from D'Orbigny himself, as his description is utterly worthless for purposes of identification. We have to fall back, therefore, upon the fuller description and the excellent figures given by Milne-Edwards and Haime of what *they* believed to be *M. mammulata*, D'Orb. (Polypiers fossiles). It so happens, however, that the Cincinnati Group of Ohio contains *three* Monticuliporoids, any one of which might be identified with the *M. mammulata* of Edwards and Haime, so far as form and external characters go, but which differ widely in their microscopic structure. Now, without microscopically examining the actual specimens upon which Edwards and Haime founded their description, it would be impossible to determine which of these superficially similar forms is the actual *M. mammulata* of the French observers; and one has therefore to choose between the total rejection of this long-current species or the arbitrary selection of any one of these three as really the form originally described. I have followed the latter course, but I freely admit that my selection has been an arbitrary one; and the form which I call *M. mammulata*, D'Orb., may possibly be shown ultimately not to be really the species which the authors of the 'Polypiers fossiles' described under this name.

figures should be so far accurate, that the forms described, whether rightly identified or not, should be capable of ready recognition by subsequent workers.

In my work on 'The Structure and Affinities of the "Tabulate Corals" of the Palæozoic Period' (1879), I treated generally of the characters and systematic relationships of *Monticulipora*, and its immediate allies. Part of the matter there given, greatly expanded, and improved by further and more extended investigations, is here reproduced. I have found it necessary, however, to restrict myself upon the present occasion entirely to the genus *Monticulipora* proper, using this term in its wide sense. Such closely allied types, therefore, as *Fistulipora*, M'Coy, *Constellaria*, Dana, and *Dekayia*, Edw. and Haime, will only be treated of incidentally.

I regret greatly that at the time when I wrote the above-mentioned work I was wholly unaware of the fact that Dr Dybowski had previously (1877) published a treatise on the Monticuliporoids (Die Chætetiden der Ostbaltischen Silurformation). I have now, however, had the opportunity of examining this important memoir, and shall, as occasion arises, make such observations upon it as may appear necessary.

The material upon which the present work is based is contained in my own cabinet, and has been mostly collected by myself from the Silurian, Devonian, and Carboniferous deposits of North America and Britain. I have, however, to thank the kindness of my friends Dr Gustav Lindström, Mr Richard Howse, Mr U. P. James, and Mr John M. Nickles, for the gift of various specimens of forms of interest and importance. I have also, where possible, consulted the collections contained in our public museums, though I have not been able to avail myself of this source of information as fully as I should have wished to do. I may add that I have personally prepared the whole of the numerous thin sections required for this work.

The illustrations, with the exception of two of the engravings, have been drawn by myself, and I am much indebted for the fidelity and skill shown by my friend Mr Charles Berjeau, F.L.S., in the transference of these to wood and stone. Where possible, I have employed wood-engravings in preference to lithographs, as it is an advantage in studying minute structures to have the representation of these along with the descriptive text; but considerations of cost have prevented my using woodcuts as freely as I should have wished. Except in three or four instances, where the contrary is explicitly stated, all the illustrations are original, and are taken from specimens and slides in my own collection,—the latter being drawn by means of the camera lucida.

Finally, I have to return my most hearty thanks, for kind assistance by way of specimens or advice, or both, to Mr U. P. James, Mr John M. Nickles, Mr Richard Howse, Dr Gustav Lindström, Mr R. Etheridge, Jun., F.G.S., Mrs Robert Gray, and Dr Daniel Œhlert. No one can be better aware than I am that the present work, at best, can be regarded as nothing more than a starting-point from which more extended and more final investigations can be carried on; but that it is not even more incomplete than it actually is, must be largely set down to the generous help that I have received from my fellow-workers.

United College, St Andrews,
March 15, 1881.

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THE GENUS MONTICULIPORA.

CHAPTER I.

THE GENERAL HISTORY OF THE GENUS MONTICULIPORA.

Genus MONTICULIPORA, D'Orbigny, 1850.

(Prodr. de Paléont., t. i. p. 25.)

Nebulipora, M'Coy, Ann. Nat. Hist., ser. 2, vol. vi. p. 282, 1850.
Orbitulites, Eichwald, Zool. spec., t. i. p. 180, 1829.
Orbipora, Eichwald, Leth. Rossica, t. i. p. 484, 1860.
Stenopora, M'Coy? (non Lonsdale), Brit. Pal. Foss., p. 24, 1851.

THE genus *Monticulipora* was founded by D'Orbigny in 1850 (Prodr. de Pal., t. i. p. 25, where the date of the genus is given as 1847), the only definition being: "cellules serrées, poriformes à la surface, d'un ensemble rameux ou encroûtant couvert de petites saillies coniques." The first species given under this definition is the *M. mammulata*, D'Orbigny, of the Lower Silurian of the United States, which must therefore be accepted as the type of the group. It will be quite obvious that the only character in the above definition which has the very remotest generic value, is the existence of conical elevations or "monticules" upon the surface, and even the nature of these elevations is left wholly undefined. I may add, also, that there are unquestionable species of *Monticulipora* in which "monticules" are wanting. The genus *Nebulipora*, M'Coy,

(Ann. Nat. Hist., ser. 2, vol. vi. p. 282, Oct. 1850), was founded in the same year as *Monticulipora*, and includes forms unquestionably congeneric with the latter, though I am unable from his figures and descriptions to be sure as to the precise species upon which M'Coy founded his genus. This point, indeed, could only be set at rest by an examination of the original specimens in the Woodwardian Museum, which I have unfortunately had no opportunity of inspecting. It is, however, a matter which, I think, will still admit of discussion, as to whether or not M'Coy's *Nebulipora* should not be adopted as the title for the fossils now under consideration, rather than the *Monticulipora* of D'Orbigny. I am not able to decide this point, and I will only remark further, that M'Coy, in his generic diagnosis, states that the walls of *Nebulipora* are "apparently perforated by rows of small foramina," though he does not allude to this character again, and seems to have been doubtful as to its actual existence. The typical *Monticuliporæ* are undoubtedly devoid of mural pores; but I have examined (through the kindness of my friend Mr R. Etheridge, jun.) a specimen from the Wenlock Limestone of Dudley in the collection of the British Museum, which has all the external and general characters of such a *Monticulipora* as *M. petropolitana*, Pand., but in which the walls of the corallites are unquestionably minutely porous. It is not impossible, therefore, that it is upon some such specimen as the preceding that M'Coy founded the statement that I have referred to.

Earlier than either *Monticulipora*, D'Orb., or *Nebulipora*, M'Coy, are the names *Orbitulites* and *Dianulites*, proposed by Eichwald (Zool. spec., 1829) for certain Silurian fossils, some of which, at any rate, are forms of *Monticulipora*. The first of these two names cannot, however, be retained, as it is identical with the previously named Foraminiferous genus *Orbitulites* (*Orbitolites*) of Lamarck (An. sans Vert., 1801), a genus which has subsequently held its ground. As for the genus *Dianulites*, Eichw., it is possible that the forms placed in it by this distinguished palæontologist are really referable

to *Monticulipora;* but as this certainly could not be definitely settled by an appeal to Eichwald's figures and descriptions, it would not be reasonable to allow this to supplant such later and well-defined names as *Nebulipora*, M'Coy. I shall afterwards discuss the question as to whether or not *Dianulites*, Eichw., has any claim to stand as a sub-genus of *Monticulipora.*

Since the establishment of M'Coy's genus *Nebulipora*, the name *Monticulipora*, D'Orb., has either been accepted as valid, or the fossils generally grouped under this head have been referred to *Chætetes*, Fischer.

The above are the most salient points in the earlier history of *Monticulipora* as a genus; but it may be advisable that I should give here a more detailed account of the chief papers and works which have dealt with this group of corals. In so doing, however, I shall not pretend to give an absolutely exhaustive bibliography; nor shall I, in general, notice memoirs which are simply descriptive of species, unless there should be some special reason to the contrary. My object, in fact, is simply to record in order the principal accessions to our knowledge of the genus since it was first founded, and to discuss briefly certain points which could not well be treated of except in such a historical summary.

Previous to the establishment of the genus *Monticulipora* by D'Orbigny, such species as were then known to palæontologists were placed under various genera. Thus, by Pander (Beiträge zur Geogn. des Russ. Reiches, 1830), Goldfuss (Petref. Germ., 1833), Phillips (Geol. Yorkshire, 1836), Lonsdale (in Murchison's Silurian System, 1839), Portlock (Geol. Rep., 1843), and De Koninck (An. Foss. des Terr. Carb., 1842), they were, wholly or in great part, referred to *Calamopora* or *Favosites;* while other writers either followed the same course, or referred them to genera equally remote from their true position. Of these older works, the one principally deserving of mention is Lonsdale's memoir in the 'Geology of Russia in Europe and the Ural Mountains' (Ap-

1833-1850.

pendix A, 1845), a memoir which, like all the productions of its author, bears ample proof both of conscientious labour and of unusual sagacity and acumen. In this, Mr Lonsdale accurately recognises the chief differences between *Chætetes*, Fischer, and the forms which we now group under *Monticulipora*, D'Orb.—a difference which many subsequent observers were slow to appreciate; though he erroneously refers to *Chætetes* the *M. petropolitana* of Pander (*op. cit.*, p. 596). The *Stenopora spinigera*, Lonsd., and *S. crassa*, Lonsd., of the same work (p. 632), are not described or figured with such fulness that it would be possible to arrive at any final decision as to whether they are true *Stenoporæ*, or are really referable to *Monticulipora*. As they are of Permian age, the presumption would be that they really belong to *Stenopora;* but nothing short of a microscopic examination of actual specimens could settle this point.

In 1850, as previously stated, the genus *Monticulipora* was founded by D'Orbigny (Prodr. de Paléont., t. i. p. 25), and four species (viz., *M. mammulata*, D'Orb., *M. ramosa*, D'Orb., *M. frondosa*, D'Orb., and *M. filiasa*, D'Orb.) were placed under it. Not only, however, was the generic definition exceedingly vague, but it is to be noted that on the same page of the same work D'Orbigny puts such well-marked types of *Monticulipora* as *M. petropolitana*, Pand., and *M. rugosa*, E. and H. (the last being really only a variety of *M. ramosa*, D'Orb.), under the head of *Chætetes*, Fischer. Various other species of *Monticulipora* are noted by D'Orbigny in other parts of the "Prodrome," but they are placed under different genera (*Ptilodictya*, *Ceriopora*, *Favosites*, &c.) It is, moreover, to be remarked, that in the case of the four species above mentioned as placed under *Monticulipora*, the descriptions, being unaccompanied by figures, are quite insufficient for specific identification, and that their survival at all is really due to the excellent work subsequently done by Milne-Edwards and Haime (Polypiers Fossiles).

1850.

In the same year (1850) as the publication of the genus

Monticulipora by D'Orbigny, but apparently at a somewhat later date, an important paper was published by M'Coy on "Silurian Radiata" (Ann. Nat. Hist., ser. 2, vol. vi. p. 282). In this memoir Professor M'Coy founded the genus *Nebulipora*, with the following definition :—

1850 continued.

"Corallum encrusting or forming lenticular masses, with a concentrically wrinkled epitheca below; composed of small prismatic tubes, perpendicular, or nearly so, to the upper surface on which they open; among the small tubes are regularly arranged clusters of similar tubes of rather larger size. All the tubes in contact, traversed by horizontal diaphragms at regular distances (walls apparently perforated by rows of small foramina)." The species described under this head are *Nebulipora explanata*, M'Coy, *N. lens*, M'Coy, and *N. papillata*, M'Coy, all from the Silurian rocks. I have never had the opportunity of examining authentic specimens of any of these forms; but the descriptions given of them, and the subsequently published figures (Brit. Pal. Foss., Pl. I. c), prove beyond a doubt that they belong to *Monticulipora*, D'Orb. Under these circumstances, the genus *Nebulipora*, M'Coy, must be taken as a synonym of *Monticulipora*, D'Orb., in spite of the fact that it was scientifically and recognisably defined, which certainly cannot be said of the latter. The only ground (presuming that *Monticulipora*, D'Orb., really was published first) upon which *Nebulipora* could be retained, would be its possession of perforated walls to the corallites; but this observation was only put forward doubtfully by M'Coy, and there can be little doubt that it is without a basis in fact.

In 1850, Professor King described a coral from the Permian rocks of England (Mon. Perm. Foss., p. 28) under the name of *Stenopora columnaris*, Schloth., which may possibly be a *Monticulipora*. This is of interest, as it is questionable if we can as yet definitely assert that we are acquainted with any species of *Monticulipora* from deposits later than the Car-

boniferous. The materials, however, for deciding the true affinities of the coral in question are insufficient; and it is quite possible that we have really to deal in this case with a *Stenopora*, to which genus the *Calamopora Mackrothii*, Gein., may also belong.

In 1851, Milne-Edwards and Haime published their great work on the Palæozoic Corals (Polypiers Fossiles des Terrains Palæozoiques), a work which will always be one of the classics of the zoophytologist. So far as the present genus is concerned, the French observers threw the weight of their high authority against the acceptance of the genus *Monticulipora*, D'Orb., though, as will afterwards be seen, they subsequently altered their views upon this subject. They described, however, a large number of species of *Monticulipora*, referring these to the genus *Chætetes*, Fischer. Though the descriptions of these species—as was inevitable at the time when the work was written—are not based upon the minute methods of modern palæontology, still it is not too much to say that Milne-Edwards and Haime laid here the foundations of our scientific knowledge of the genus *Monticulipora;* and most of the species which they described have since been accepted by later workers in the same field. It is not necessary to enumerate in this place the numerous species of *Monticulipora* which Milne-Edwards and Haime described or noticed in the "Polypiers Fossiles," nor to discuss the characters of these, especially as many of them will be fully treated of later on. It may be added, however, that the authors rejected the genus *Stenopora*, Lonsd., and grouped the species which had been referred to it under *Chætetes*, Fischer.[1]

1851.

In the same year M'Coy republished (Brit. Pal. Foss., p.

[1] In earlier publications (Comptes Rend., xxix. p. 261, 1849, and Introduction to the 'Monograph on the British Fossil Corals,' p. lxi., 1850) Milne-Edwards and Haime accepted the genus *Stenopora*, Lonsd., but take as their type *S. spinigera*, Lonsd., ignoring the characters upon which Lonsdale really based his genus, and introducing as the special characteristic of the genus the non-essential feature of the presence of spines at the angles of the calices.

22) his description of the genus *Nebulipora*, which had formerly appeared in the 'Annals of Natural History,' and figured the three species of the genus which had been described in the latter periodical. He also defined the genus *Stenopora* as follows :—

1851 continued.

"Polypidom polymorphous, composed of round or polygonal tubes radiating from an imaginary axis to the surface, where the bounding-ridges are tuberculated; young tubes interpolated by lateral budding between the old; tubes constricted at irregular distances in planes parallel with the surface, and partially closed at the orifice by a concave diaphragm perforated in the centre; no connecting tubuli nor foramina." The species described under the head of *Stenopora* are *S. fibrosa*, Goldf. sp. (with two varieties—viz., var. *lycopodites*, Say, and var. *regularis*, M'Coy), *S. ? granulosa*, Goldf. sp., *S. inflata*, De Kon. sp., and *S. tumida*, Phill. sp. With the exception of the last of these, it is probably impossible for any one who has not examined the original specimens which Professor M'Coy had in his possession, to decide with any preciseness what were the forms upon which he actually based his determinations of these species. It may, however, be taken as tolerably certain that the forms which M'Coy described under the names of *S. fibrosa* (with its varieties) and *S. tumida*, are, at any rate, *not* referable to *Stenopora*, Lonsdale, and that they are probably true *Monticuliporæ*. It is therefore certain that *Stenopora*, M'Coy, is not an equivalent of *Stenopora*, Lonsd., and it may be regarded as almost certain that it is a mere synonym of *Monticulipora*, D'Orb. As to what may be the true nature of the forms described by M'Coy under the names of *Stenopora ? granulosa*, Goldf. sp., and *S. inflata*, De Kon. sp., nothing positive could be said without the previous examination of the original specimens.

In the same year (1851) appeared the second volume of the magnificent 'Palæontology of New York,' by Professor James Hall. In this work Professor Hall figured a species of *Mon-*

ticulipora under the name of *Chætetes lycoperdon*, from the Niagara group of North America. The same so-called species had been previously (1847) described and figured, along with others, in the first volume of this work (p. 64, Pl. XXIII., figs. 1-1 *i*, 2, 2 *a*, 3, and Pl. XXIV., figs. 1 *a*-1 *o*), where it is stated to be founded upon the *Favosites lycoperdon* of Say, though it would seem that Say did not really publish this name, and that it was first actually made public by Vanuxem (Geol. 3d Dist. N. Y., p. 46, 1842) under the name of *Favosites lycopodites* (see Note by Professor C. A. White in 'The Palæontologist,' No. 3, p. 20, 1879). My object in mentioning this in this place is twofold. On the one hand, there are few corals which have been more commonly quoted by American geologists and palæontologists than *Chætetes lycoperdon*, Say, or *Chætetes lycopodites*, Vanuxem; and it would therefore be very desirable to establish, if possible, the precise nature and characters of the form to be understood by this name, though I am not aware that this has ever been satisfactorily accomplished. On the other hand, I wish to record the opinion that the generally laudable desire of preserving an old name, where this is possible, may sometimes be carried too far, and that this is, in my view, an instance in point. No definition of *Chætetes lycopodites*, Vanuxem, which can be regarded as in any sense a definition, was given by its original author, or has since been supplied by any subsequent observer, while it is certain that this name (or the equivalent, *C. lycoperdon*, Say) has been applied by different writers to wholly different forms. A reference to Professor Hall's plates (*loc. cit.*), for example, will at once show that even this accurate and accomplished observer included more than one specific form under this title. Nor, in the case of a genus like *Monticulipora*, where external form goes for so little, can Vanuxem's original *figure*, however good, be regarded as satisfactory proof as to the species upon which he really founded the name in question. Under these circumstances, therefore, I think, as I think about such names as *Favosites fibrosa*, Goldf., and vari-

1851 continued.

ous other similar titles, that it would be a real gain to science if there could be a general agreement that designations of this kind—published, in the first place, with wholly insufficient definitions, and subsequently employed by others in widely different senses—should be dropped altogether, and that no attempt should be made to revive them. I know that there is much that could be urged on the other side of this question and that it might be difficult to draw a line between cases such as I now speak of, and others where the original author had simply made more or less serious errors in the definition of his species; but I feel sure that every working naturalist must have experienced the hardship of finding himself confronted by specific names, which he cannot identify by reference to original descriptions, and which others have obviously applied to more than one class of objects; and I think it would not be very difficult to specify the cases in which this hardship is so great that the abandonment of the original name becomes a proper remedy for it.

In 1854, Milne-Edwards and Haime published the concluding portion of their admirable 'Monograph of the British Fossil Corals,' dealing with the corals of the Silurian formation. This work is chiefly deserving of notice in this connection because its authors here (p. 264) retracted the opinion which they had previously expressed as to the identity of *Monticulipora*, D'Orb., with *Chætetes*, Fischer, and accepted the former genus as sufficiently distinguished by its gemmiparous method of reproduction. The species which they describe are *M. petropolitana*, Pand., *M. papillata*, M'Coy, *M. Fletcheri*, E. & H., *M. pulchella*, E. & H., and *M. Bowerbanki*, E. & H.; while they reproduce M'Coy's descriptions of his *M.* (*Nebulipora*) *explanata* and *M.* (*Nebulipora*) *lens*. Of the above-mentioned forms, *M. Bowerbanki*, as I have elsewhere shown (Pal. Tab. Cor., p. 72), is a *Favosites*, while *M. pulchella* is a valid and genuine species of *Monticulipora;* but the forms described under the names of *M. petropolitana*, Pand., *M. papillata*, M'Coy, and *M. Fletcheri*, E. & H., must remain

1854.

to some extent uncertain, till it may be possible to examine microscopically the original specimens upon which Milne-Edwards and Haime founded their determinations.

1859. In 1859, Mr Billings described (Canad. Nat., vol. iv. p. 427) some species of *Monticulipora* from the Silurian rocks of Canada, referring these to the genus *Stenopora*. Of the forms in question, two (*S. patula* and *S. adhærens*) are described as new species; but the descriptions given are so vague and so brief, that it would be impossible to recognise their validity until the original specimens can be re-examined and described.

1860. In 1860, D'Eichwald published the first volume of the 'Lethæa Rossica,' in which various forms of *Monticulipora* were described. These were referred to the genera *Chætetes*, Fischer, *Dianulites*, Eichw., *Orbipora*, Eichw., and *Monticulipora*, D'Orb., and possibly to one or two other genera (such as *Myriolithes*). As the attempt has recently been made by Dybowski to resuscitate the genera *Dianulites*, Eichw., and *Orbipora*, Eichw., it may be as well to supply here a brief analysis of the account which D'Eichwald gives of the above-mentioned four genera, and of the forms which he includes under them. In so doing, I may premise that much of this portion of the 'Lethæa Rossica' was really published by Eichwald in the 'Zoologia specialis' (1829), to which, unfortunately, I have not access. At the same time, the 'Lethæa Rossica' contains the matured views of Eichwald as to these and other genera, and it seems only fair to take an author's *emended* diagnosis as the basis for any criticism of his views:—

With regard to the genus *Chætetes*, Fischer, Eichwald recognises that it is separated from *Monticulipora*, D'Orb., by its fissiparous mode of development, and he places under this head eight species—viz., *C. hemisphæricus*, Eichw., *C. pyriformis*, Eichw., *C. apiculatus*, Eichw., *C. annulatus*, Eichw., *C. fastigiatus*, Eichw., *C. cylindraceus*, Eichw., *C. radians*, Fisch. and *C. tumidus*, Phill. With regard to the great majority of these, it is quite within the mark to say that it would be

impossible to form any opinion as to their true nature by a mere perusal of the descriptions which are given of them, or an examination of the figures by which they are accompanied. No observer, therefore, who had not access to Eichwald's original specimens, could hope to arrive at any conclusion as to even the *generic* affinities of most of the above—to say nothing of their value as *species*. The most of them (excluding *C. radians*, Fischer) would *seem* to be probably *Monticuliporæ*, while the form described as *C. annulatus* looks like a *Polyzoön*, but would seem from Dybowski's description (Die Chætetiden, p. 86) to be a Monticuliporoid. This is probably the utmost that could be safely asserted.

The genus *Orbipora*, Eichw., is defined as having a discoid corallum, convex above and flat below, composed of vertical cylindrical tubes. The calices are said to be oval below and hexagonal above, all of them equal in size. Tabulæ are said to be wanting or rudimentary; multiplication is by gemmation, and there is a basal epitheca. The species described under this head are *Orbipora distincta*, Eichw., and *O. fungiformis*, Eich.; but neither could be identified by the descriptions or figures which are given, unless the observer possessed authentic specimens to refer to. All that can be stated is, they *appear* to be discoid forms of *Monticulipora*. It will be observed, however, that in his definition of *Orbipora*, Eichwald brings forward one structural character (namely, the absence or rudimentary condition of the tabulæ), which, if confirmed, and if found to be associated with other structural peculiarities, might possibly afford some justification for the revival of the generic title.

The genus *Dianulites*, Eichw. (Leth. Ross., p. 487), is defined as having an obconical, attenuated, gemmiparous, and ramose corallum, which is fixed by its base, and covered with a thick epitheca below. The corallum is composed of vertical tabulate tubes, which diverge irregularly from the base, and are surrounded by a spongy "cœnenchyma." The sides of the corallum are largely grooved, with transverse sulci, indi-

cating increments of growth. The two species described under this head are *D. detritus*, Eichw. (which Eichwald explicitly states to be the type of the genus—*loc. cit.*, p. 487), and *D. fastigiatus*, Eichw. The two species in question are quite indeterminable, so far as Eichwald's descriptions and figures would serve this purpose.[1] The figures which are given of these forms would seem to be *inverted;* but this may not really be the case. There is nothing, however, either in the figures or text, which would enable us to decide whether these types are referable to *Monticulipora*, or *Fistulipora*, or *Prasopora*, or to some other Monticuliporoid type. So far as the structural characters of the genus *Dianulites* are concerned, the presence of a thick lateral epitheca, though strongly insisted upon by Eichwald in his remarks upon the genus, cannot be regarded as of any special importance; and the only fundamental character mentioned is, that the tabulate corallites are *surrounded by a "spongy cœnenchyma."* This character, being common to many Monticuliporoids—since the "interstitial tubes" of these are the "cœnenchyma" of the older writers—cannot, however, constitute *alone* a basis for generic separation.

I shall subsequently give my reasons for rejecting *Dianulites*, Eichw. (emend. Dybowski), these reasons being partly that I do not regard the genus (as redefined) as a natural division, and partly that I do not admit the propriety of endeavouring to restore old generic names which were originally defined in an absolutely worthless manner.[2] In the meanwhile,

[1] Dybowski (Die Chætetiden, pp. 20, 21) states that *D. detritus* and *D. fastigiatus* are merely different conditions of the same species, for which he retains the latter name; and he further considers *Chætetes Panderi*, E. and H., to be a synonym of this. For my own part, I cannot recognise the reasonableness of setting aside a (by comparison) well-characterised type, such as the *C. Panderi* of Edwards and Haime, in favour of a type so defined originally as to be beyond possible recognition—even though an observer, fortunate enough to have access to the original specimens, should ultimately be able to show that these possess characters entitling them to generic or specific distinction.

[2] I entirely endorse, on the other hand, the proposed rule of the Committee of the International Geological Congress on Palæontological Nomenclature, that "le nom attribué à chaque genre et à chaque espèce est celui sous lequel ils ont été le plus anciennement designés, à la condition que ce nom ait été publié *et clairement defini*." The Eichwaldian genera of Monticuliporoids do not even approxi-

in justice to Dybowski, it must be stated that he has founded *his Dianulites*, not upon the later definition of this genus given in the 'Lethæa Rossica,' but upon the earlier definition given by Eichwald in the 'Zoologia specialis' (vol. i. p. 180, 1829). It is really not worth while taking up space with reproducing from Dybowski's work this earlier definition, which Dybowski justly speaks of as "diese nichtssagende Charakteristik." I will only notice, that the definition might apply to a score or more of known genera of Corals or Polyzoa, with equal propriety, as it does not include a single character of generic value; and that there is certainly no mention in it of the "spongy cœnenchyma" so strongly insisted upon in the later definition. At the same time, provided that, as in this case, no other observer has in the interval meddled with the genus, it is surely only reasonable to take an author's *latest and emended definition* as the basis for further and better investigation, rather than his earlier diagnosis.

Lastly, Eichwald defines *Monticulipora*, D'Orb. (Lethæa Ross., p. 492), as comprising forms with a semiglobose, ovate, or depressed corallum, the surface of which is covered with small elevations, while the base is flat and concentrically striated. The corallum is said to be composed of delicate tubes alternating with fascicles of larger corallites, with rounded calices, and the walls furnished with minute irregular communicating pores; while there are horizontal and close-set tabulæ. It is not necessary to discuss this definition, as the only species which D'Eichwald places under it (*M. ovulum*, Eichw.) appears to be undoubtedly a *Heliolites*, or, at any rate, to belong to the *Heliolitidæ*.

The next important contribution to our knowledge of the Monticuliporoids was a memoir by Dr Rominger, entitled "Observations on Chætetes and some related Genera, in regard to their Systematic Position; with an appended Description of some New Species" (Proc. Acad.

1866.

mate to a fulfilment of this last essential condition, and, in my opinion, ought to be unhesitatingly rejected.

Nat. Sci. Phil., 1866, p. 113). In this memoir Dr Rominger expresses the opinion that *Chætetes*, Fischer (under which he includes *Monticulipora*, D'Orb., and various allied types), is really referable to the *Polyzoa*, and not, as at that time generally believed, to the *Actinozoa*. He regards the interstitial corallites of the Monticuliporoids—which he rightly recognises as being more closely tabulate than the normal corallites—not as "real tubules," but as "merely vertical rows of independent cells, which, being crowded in between tubes, assumed themselves the form of tubules." He notices the existence of opercula in *M. rugosa*, E. and H., *M. ramosa*, D'Orb., and *M. frondosa*, D'Orb., pointing out that in the latter these structures (which, I may add, are morphologically only the last formed *tabulæ*) are concave and have an excentric opening. He also alleges that septal ridges sometimes occur, and instances some specimens of *M. frondosa*, D'Orb., from Cincinnati; but it is probable that in this case he has been misled by the inward protrusion into the visceral chambers of the large corallites of the "spiniform corallites" in the substance of their walls. In addition to describing various species of *Monticulipora* proper, Dr Rominger further describes a number of types of *Fistulipora* (and *Callopora*, Hall); but as the descriptions are short, and are unaccompanied by any figures, it will probably be difficult to identify many of these in future.

In the second edition of the 'Acadian Geology,' published in 1868, Principal Dawson figures and briefly describes two small Monticuliporoids from the Carboniferous rocks of Nova Scotia under the names of *Chætetes tumidus*, Phill., and *Stenopora exilis*, n. sp. Dr Dawson was good enough to send me specimens of these, but the material was unfortunately insufficient for a satisfactory examination by thin sections; while in the case of the latter form, the few specimens at my disposal were preserved so badly (apparently in dolomite) that I failed to prepare any workable slides from them. I should not, therefore, wish to express any opinion as to their precise nature.

1868.

The latest views of Professor De Koninck upon the genus *Monticulipora*, so far as I am aware, are contained in his
1872. 'Nouvelles Recherches sur les Animaux Fossiles du Terrain Carbonifère de la Belgique' (p. 141), published in 1872; though his earlier publications (An. Foss. du Terr. Carb.) contain also descriptions of species of the genus. In the work just mentioned, M. De Koninck briefly defines the genus *Monticulipora*, D'Orb., and describes under it as species *M. tumida*, Phill., and *M.? inflata*, De Kon. It is singular to find this eminent palæontologist doubtful, in his definition of the genus, as to two such important points as the presence or absence of septa, and the complete or incomplete condition of the tabulæ, and subsequently even inclined to question if tabulæ exist at all in the genuine species of *Monticulipora*. On the other hand, it is interesting to find so high an authority disposed to refer the genus to the *Alcyonaria*, rather than to the *Zoantharia*. With regard to the two species described by De Koninck, it may be observed that it is questionable if *M.? inflata* be a *Monticulipora* at all; while the form termed *M. tumida*, Phill., does not appear to be identical with the form understood generally under this name by British palæontologists, and, judging from the description and figures, would seem to probably include more than one species.

Mr Salter, in his last published work (Cat. Foss. Woodw. Mus., 1873), regards *Monticulipora* as a synonym of *Nebulipora*,
1873. M'Coy, while he, at the same time, places some species of the genus under *Stenopora*.

In 1874, I published a paper on species of *Chætetes* from the Lower Silurian rocks of North America (Quart. Journ. Geol.
1874. Soc., vol. xxx. pp. 499-515, Pls. XXIX., XXX.), in which were discussed the affinities of the genera *Chætetes*, *Stenopora*, and *Monticulipora*. As the microscopic structure of all these three genera was at that time unknown, or imperfectly known, I concluded that the external characters and more evident internal features did not afford sufficient basis for the establishment of the genus *Monticulipora*, as separate

from *Chætetes*, Fischer. I also came to the conclusion that the American corals usually referred to *Stenopora* could not be so placed, unless Lonsdale's definition of this genus were extended and modified. Several forms believed to be new were described, of which some are really synonyms of previously recorded species, while one (*C. delicatulus*) turns out, on microscopic examination, to be a Polyzöon. In the same year I also published descriptions of three new species of *Monticulipora*, which I described under the names of *Chætetes moniliformis*, *C. Barrandii*, and *C. quadrangularis* (the last possibly a Polyzöon), all from the Devonian rocks of Canada (Geol. Mag., Dec. 2, vol. ii., and Palæontology of Ontario, pp. 60, 61).

In the same year Mr R. Etheridge, jun., published (Ann. Nat. Hist., ser. 4, vol. xiii. p. 194, Pl. XI. figs. 1-3) some interesting observations on the structure and external characters of *M. tumida*, Phill., as based upon specimens derived from the Carboniferous rocks of Scotland.

In 1875, Mr U. P. James, an enthusiastic student of the Cincinnati fossils, to whom I am indebted for much friendly assistance, published the second edition of his 'Catalogue of Lower Silurian Fossils of the Cincinnati Group,' in which he described four new species of *Monticulipora*, under the names of *Chætetes? calycula*, *C. clavacoideus*, *C. Cincinnatiensis*, and *C. O'Nealli*. All these are excellent and interesting species, and will be described in detail in the later portion of this work. The last is the same as *C. sigillarioides*, Nich., which was published some two or three months subsequently to the appearance of Mr James's catalogue.

1875.

In the same year, but at a little later date than that of the publication of the preceding, appeared the second volume of the 'Palæontology of Ohio,' in which I gave descriptions of a number of Monticuliporoids. Many of these had been previously described by me in the 'Quarterly Journal of the Geological Society' (vol. xxx.), but some additional forms were here described as new. As in the paper just alluded to, and for

the reasons previously given, all the species of *Monticulipora* were placed under the head of *Chætetes*, Fischer.

In 1876, a paper was published by me (Ann. Nat. Hist., ser. 4, vol. xviii. p. 85, Pl. V.), in which I corrected several errors into which I had been led in my formerly published descriptions of species of *Monticulipora* from the Lower Silurian rocks of North America, and at the same time gave a brief account of some of the more salient features exhibited by microscopic sections of various species of the genus.

1876.

In 1877, Dr Dybowski published a most important work upon the Monticuliporoids, entitled 'Die Chætetiden der Ostbaltischen Silur-formation.' I regret greatly that I was not aware of the existence of this work till within the last two or three months, and that I was therefore entirely unacquainted with it at the time that I published my work upon the Palæozoic "Tabulate Corals." Dr Dybowski's work is, unfortunately, of much less value than it would otherwise have been, owing to the fact that his material was derived for the most part from a very limited area, and also that he has greatly hampered himself by his desire to restore the old Eichwaldian genera. For my own part, therefore, while doing every justice to the great advance in our knowledge effected by Dr Dybowski's work, I am sorry to find it impossible to accept the greater part of his general conclusions. At the same time, the work in question not only shows remarkable industry, but is the first systematic attempt to deal with the Monticuliporoids by means of modern methods of inquiry; and it thus is entitled to a full consideration. I shall therefore give in this place a tolerably full analysis of its contents; though I do not think it necessary to notice more than its most salient points, and I shall subsequently have occasion to speak of some of its secondary features.

1877.

In the first place, as regards nomenclature, Dr Dybowski proposes the following terms (*loc. cit.*, p. 9): Each individual corallite of the colony he designates by the name of a "Polypit;" but it hardly need be remarked that this term would be

regarded by English naturalists as a very objectionable one, since the term "polypite" has become indissolubly connected with the *Hydrozoa*. "Axenhöhle" is defined as the cavity found in the long axis of a cylindrical or dendroid corallum, which is not provided with a special lining membrane. So far as I have seen, the occurrence of such a cavity is purely accidental, and is due to the dissolution of the central portion of the corallum prior to fossilisation, or to the fact that the foreign body upon which the colony grew has been removed in a similar fashion. I do not think, therefore, that any special term is needed to indicate the presence of such a phenomenon. On the other hand, the name of "Axenrohr" is given to the axial tube of certain forms like *Stenopora columnaris*, Dyb., where the cavity is lined by a special membrane. I have never observed any such cavity in any Monticuliporoid—except, perhaps, in *M. calcicola*, Miller and Dyer—and can therefore pronounce no opinion as to its real nature and value. The term of "Wandröhrchen" or "Porenkanälchen" is proposed for delicate canals or tubuli which run in the walls of the corallites, and parallel with the long axes of these; and the name of "Höckerchen" is given to the superficial spiniform projections of these. These structures are identical with those which I shall subsequently describe under the name of "spiniform corallites," and I take an entirely different view as to their nature from that held by Dybowski. As will be subsequently seen, I regard them as being in no way analogous to the "intramural canals" of many "Tabulate Corals," but as representing a peculiarly modified series of corallites; and the name of "Wandröhrchen" would thus be an inappropriate one.

The name of "Wandstränge" is given by Dybowski to what he describes as "dendritic or streak-like ('streifenartig'), solid, sclerenchymatous structures which are situated on the inner side of the walls of the corallites." The above description would have left me quite in the dark as to the nature of the structures referred to by this name; but after examination of

Dybowski's figures of forms said to possess "Wandstränge," I have no doubt that the bodies thus named constitute an aborted series of "spiniform corallites," such as can be observed to occur in various Monticuliporoids. Dr Dybowski lays considerable stress upon the presence or absence of "Wandstränge;" but, with the views that I hold as to their nature, they cannot be regarded as possessing any classificatory value.

With regard to the other terms employed by Dybowski, it is only necessary to remark that, in accordance with the views generally held at the time, he regards the "interstitial tubes" of so many of the Monticuliporoids as being of a *cœnenchymal* nature. Whenever, therefore, he speaks of the absence or presence of "Cœnenchym" in any given species, he is to be understood as meaning that "interstitial corallites" are absent or present. Mr Moseley's researches on *Heliopora* and *Millepora* have rendered it almost certain that the interstitial tubes of the Monticuliporoids are of the nature of a peculiar group of modified corallites, and we can therefore no longer with propriety speak of them as "cœnenchymal."

With regard to the classification of the Monticuliporoids, Dr Dybowski gives the following synoptical table of the divisions of the group which he proposes to adopt:—

(I.) The corallum consists of tubular corallites.
  A. The walls of the corallites relatively thin and structureless.
    (1.) No "cœnenchyma" (*i.e.*, interstitial tubes); the corallites in direct contact with one another.
      (*a*) Tabulæ present; the corallites of comparatively considerable diameter.
        1. Genus *Dianulites*, Eichwald.
      (*b*) Tabulæ wanting; corallites capillary.
        2. Genus *Solenopora*, Dyb.
    (2.) "Cœnenchyma" (*i.e.*, interstitial corallites) present.
      (*a*) The individual corallites are surrounded by "cœnenchyma."
        (*a'*) Calices not exsert; "cœnenchyma" vesicular; corallites of inconsiderable diameter.
          3. Genus *Callopora*, Hall.
        (*a''*) Calices exsert; "cœnenchyma" of polygonal tubes; diameter of the corallites relatively considerable.
          4. Genus *Trachypora*, E. and H.

(*b*) Corallites arranged in compact groups, surrounded by "cœnenchyma."

5. Genus *Stellipora*, Hall.

B. Walls of the corallites thick and of lamellar structure.

(1.) No "cœnenchyma." Walls of contiguous corallites amalgamated.

(*a*) "Wandstränge" (*vide antea*) present.

6. Genus *Orbipora*, Eichwald.

(*b*) "Wandstränge" wanting.

7. Genus *Monticulipora*, D'Orb. (divided into two sections, according to the presence or absence of "Porenkanälchen" or "spiniform corallites").

(2.) A reticulate "cœnenchyma" present; the lamellæ of the walls of the corallites pass directly into the meshes of the "cœnenchyma." "Wandröhrchen" (*i.e.*, spiniform corallites) present.

(*a*) Corallites like one another.

8. Genus *Trematopora*, Hall.

(*b*) Corallites of two different kinds; thick-walled corallites alternating with thin-walled corallites.

9. Genus *Dittopora*, Dyb.

(II.) The corallum consists of vertical rods, which are united with one another by a series of vesicles.

10. Genus *Labechia*, E. and H.

As I find myself unable to regard the above classification of the Monticuliporoids as in any way a natural one, and as nearly all the subdivisions proposed in it are, in my opinion, inadmissible, I shall here proceed to analyse the above groups in greater detail.

The genus *Dianulites*, Eichw. (Dyb.) is defined by Dybowski (*loc. cit.*, p. 15) as including forms with a spherical, hemispherical, or botryoidal corallum, the surface being quite smooth or rarely exhibiting eminences. The corallites are more or less irregularly prismatic, of different sizes, the large and small ones irregularly mixed with one another. Tabulæ are widely remote, not placed at corresponding levels in different individuals. There is no "cœnenchyma," and the corallites are in direct contact with one another.

I have already (pp. 11, 12) given the reasons which would make me most unwilling to acquiesce in any attempt to revive the genus *Dianulites*, Eichw. These reasons seem to me to be so strong, that even if the above emended definition of Dybowski were found to embrace a natural group of Monticuli-

poroids, I should still think it expedient to create a new name for the division. As it is, however, the forms included by Dybowski under the head of *Dianulites*, Eichw., appear to me to be of different affinities, as regards some of them at any rate, while the asserted absence of a "cœnenchyma" (*i.e.*, of interstitial tubes) is certainly not true of them all. Thus, *Monticulipora petropolitana*, Pand., included by Dybowski under the genus *Dianulites*, possesses a "cœnenchyma" in the same sense that any Monticuliporoid can be said to do so—that is to say, it possesses a series of small interstitial corallites, which are perceptibly, if only slightly, more closely tabulate than is the case with the large ones. That these interstitial corallites are fewer and more scattered than is usually the case in the Monticuliporoids, does not alter their morphological significance, and would not justify us in excluding them from the category of what Dybowski calls "Cœnenchym." In addition to *M. petropolitana*, Pand., Dybowski places under *Dianulites*, Eichw., seven species or varieties—viz., *D. petropolitanus*, var. *hexaporites*, Pand., *D. apiculatus*, Eichw., *D. rhombicus*, Nich., *D. elegantulus*, Fr. Schmidt, *D. Haydenii*, Dyb., and *D. sulcatus*, Dyb. Not having seen any of the original examples upon which these species are founded, I can, of course, say little about them. Judging, however, from the descriptions and figures given by Dybowski, I should say that *D. fastigiatus*, Eichw. (= *D. detritus*, Eichw., according to Dybowski), is even nearer to the type of *M. petropolitana*, Pand., than the form to which Dybowski assigns the latter specific name. *D. petropolitanus*, var. *hexaporites*, Pand., would seem to be a separate species, and not a mere variety of *M. petropolitana*. *D. apiculatus*, Eichw., is a peculiar type, which is more clearly dimorphic than is even the case in *M. petropolitana*, Pand. The form termed *D. rhombicus*, Nich., is not sufficiently figured, but has nothing to do with the form which I described under the name of *Chætetes rhombicus*, and which is really identical with the *M. quadrata* of Rominger. The *D. elegantulus*, Fr. Schmidt, has obviously no relation with any of the preceding. It, also, is

clearly dimorphic, and therefore possesses a "cœnenchyma," in the sense in which Dybowski uses this term. The *D. Haydenii*, Dyb., seems to belong to that section of the Monticuliporoids to which I have given the name of *Monotrypa*. Lastly, the *Dianulites sulcatus*, Dyb., differs radically from all the preceding forms in the fact that it possesses *perforated tabulæ* in the large corallites; and it either belongs to *Prasopora*, Nich. and Eth. jun., as subsequently defined, or it is nearly allied to this.

Upon the whole, therefore, I find it impossible to accept *Dianulites*, Eichw., as emended by Dybowski, as being a natural group, and I cannot agree with the suggestion made by Dr Steinmann (N. Jahrb. für Min., 1880, p. 438) that this division ought to supplant *Diplotrypa*, Nich., or that it is in any way the equivalent of the latter.

The genus *Solenopora*, Dyb., is defined as including forms with an irregular spheroidal corallum. The corallites are prismatic, and of very small diameter; there is no "cœnenchyma," and tabulæ are wanting. The single species described under this head—viz., *S. spongioides* (*loc. cit.*, p. 124, Pl. II. figs. 11*a*, 11*b*)—is said to have a smooth and shining surface, and to show no obvious calicine apertures. It seems tolerably certain that this form can have no relationship with the Monticuliporoids, though it is difficult to say anything positive as to its real affinities. I should rather be disposed to suggest that it may prove, on further examination, to be related to the singular type described by Mr R. Etheridge, jun., and myself under the name of *Tetradium Peachii* (Ann. Nat. Hist. 1877, and Mon. Sil. Foss. Girvan, vol. i. p. 31, Pl. I. fig. 3, and Pl. II. figs. 1-1*b*).

The third genus of Monticuliporoids in Dr Dybowski's arrangement is *Callopora*, Hall. It is unnecessary to discuss the characters ascribed by Dybowski to this genus, as the forms included under it are of quite different affinities, and as, moreover, there is at present no sufficient reason to doubt that *Callopora*, Hall, is a synonym of *Fistulipora*, M'Coy, the latter

having the priority (see Nicholson, Pal. Tab. Cor., p. 304). As to the forms included by Dybowski under the head of *Callopora*, Hall, the first is identified with the *C. nummiformis* of Hall, and a number of figures illustrative of its structure are given (Pl. IV. figs. 1-1*k*), from which it can be seen that at least two distinct species have been placed under the same name. Thus, it is certain that there can be no specific relationship between forms like those represented in Pl. IV. figs. 1*c* and 1*b*, where the large corallites are prismatic and have *complete horizontal tabulæ*, and such as figs. 1*f* and 1*h* of the same plate, where the large corallites are circular and have *incomplete excentrically perforated tabulæ*. The former are certainly not *Fistuliporæ*, while the latter are undoubtedly referable to *Prasopora*, Nich. and Eth. jun., and are nearly allied to the form which I shall subsequently describe under the name of *P. Selwynii*, Nich.

As regards the other species referred by Dybowski to *Callopora*, Hall, one—viz., *C. maculata*, Dyb.—is an unquestionable member of the genus *Fistulipora*, M'Coy (and is therefore a *Callopora*); and *C. heterosolen*, Keys., is probably similarly referable to *Fistulipora*. On the other hand, *C. pyriformis*, Eichw., and *C. ligniformis*, Dyb., are almost certainly not referable to *Fistulipora*, M'Coy, and the last of these would seem to be a *Diplotrypa*.

The fourth genus adopted by Dybowski is *Trachypora*, E. and H., to which is referred the single species *T. porosa*, Dyb. The form so named is an exceedingly remarkable one, and, if its structure were sufficiently worked out, would probably prove to be the type of a new genus. Be this as it may, it has nothing whatever to do with the genus *Trachypora*, E. and H., the latter being now known to belong to the *Favositidæ*, and to be entirely destitute of a "cœnenchyma" (see Pal. Tab. Cor., p. 102).

The fifth genus is *Stellipora*, Hall (*Constellaria*, Dana), to which are referred two new species—viz., *S. Revalensis*, Dyb., and *S. constellata*, Dyb. With regard to these, it is sufficient

to say that there seems no reason to doubt the correctness of their reference to *Constellaria*.

The sixth genus is *Orbipora*, Eichw. (emend. Dybowski), which is defined as comprising forms with a polymorphic corallum, composed of tubular corallites, the thickened and lamellar walls of which are amalgamated with one another. Sclerenchymatous structures of a string-like character ("Wandstränge") are developed in the walls of the corallites; and there may or may not be tabulæ. The forms referred to it are *O. distincta*, Eichw., *O. fungiformis*, Eichw. (this last not described), *O. arborescens*, Dyb., and *O. Panderi*, Dyb. I have already given a brief account of *Orbipora*, Eichw. (p. 11), and need only add that the definition of the genus given by Dybowski, as indeed he himself admits, is in all essential points an entirely different one to that of its original author. I have also, already, in speaking of *Dianulites*, Eichw. (pp. 11, 12), given the reasons which render me, *in limine*, entirely opposed to all attempts to revive old generic names which were, to begin with, unrecognisably characterised; and I consider these reasons to be just as powerful in this particular case as in the instance of *Dianulites*. I need only add, therefore, a few remarks upon the species which Dybowski refers to *Orbipora* Eichw., so far as I have been able to study these without actual specimens. *O. distincta*, Eichw. (*loc. cit.*, Pl. II. figs. 10*a*, 10*b*), is apparently a Monticuliporoid, with numerous aborted spiniform corallites ("Wandstränge"), greatly thickened walls, and no tabulæ. I am not acquainted with any form which very closely resembles this. *O. arborescens*, Dyb. (Pl. II. figs. 8*a*, 8*b*), is a Monticuliporoid which is very closely allied to *M. tumida*, Phill., of the Carboniferous rocks. On the other hand, *O. Panderi*, Dyb., seems to be a true *Stenopora*, Lonsd., nearly allied to *S. crinita*, Lonsd. (of which I have examined typical specimens by means of thin sections), and, like it, not a normal type of the genus. The spine-like processes ("dornförmige Vorsprünge") which Dybowski describes and figures as seen in long sections of the corallites,

seem to be really the cut edges of perforated and incomplete tabulæ, such as are so characteristic of some types of *Stenopora*, Lonsd. (see the long section of *S. Howsii*, Nich., fig. 12, B).

The genus *Monticulipora*, D'Orb., in the restricted sense in which it is understood by Dybowski, is divided into two primary sections. The first of these is defined as comprising polymorphic coralla, with or without monticules ("Hügelchen"); the corallites tubular, of different diameters, with thick, lamellar, amalgamated walls. No "Wandstränge" or "Wandröhrchen" (*i.e.*, aborted or perfect spiniform corallites) are present. Tabulæ present. The forms included under this head are *M. rugosa*, E. and H., which is, in the main, rightly described and figured; *M. Wesenbergiana*, Dyb., which is very closely allied to the preceding; and *M. ædilis*, Eichw., which is related to *M. Trentonensis*, Nich. All these three forms belong to the section *Heterotrypa* as defined by me; but Dr Dybowski has failed to recognise that the interstitial corallites are other than young tubes, and he has not observed that they have the structural peculiarity of being much more closely tabulate than is the case in the large corallites. The absence of aborted or perfect "spiniform corallites" ("Wandstränge" and "Wandröhrchen"), upon which Dybowski relies in separating this section of *Monticulipora* from the second, as also from *Orbipora*, Eichw., is, according to my views, a matter of no classificatory value at all.

The second section of *Monticulipora*, D'Orb., according to Dybowski, comprises forms quite like those just mentioned, except that they possess numerous "spiniform corallites" ("Porenkanälchen"). As just remarked, I attach no weight to this circumstance. The only form described under this section is one which Dybowski thinks to be possibly the so-called *Chætetes lycoperdon*, Say; and the figures and descriptions given of it show it to be allied to *M.* (*Heterotrypa*) *moniliformis*, Nich.

The eighth genus in Dybowski's classification is one which

he identifies with *Trematopora*, Hall. I am not aware that any of the original types ascribed by Hall to *Trematopora* (Pal. N. Y., vol. ii. p. 149 *et seq.*) have as yet been investigated by means of modern methods, or that such investigations, at any rate, have up to this date been made public. In the absence of this essential preliminary, it seems impossible to decide whether or not *Trematopora*, Dyb., is identical with *Trematopora*, Hall. The forms included by Dybowski under this title appear, however, to constitute a peculiar group of Monticuliporoids, and I shall defer their more full consideration to an appendix at the end of this work.

The ninth genus of Dybowski's system is one which is founded for the first time under the name of *Dittopora*. This also appears, like the preceding, to embrace a peculiar group of Monticuliporoids; and I shall similarly consider its characters in an appendix, as I am personally unacquainted with any types that I could refer to it.

Finally, Dr Dybowski includes amongst the Monticuliporoids the extraordinary genus *Labechia*, E. and H. If, however, this type really has any genetic relation with the Monticuliporoids, as is very dubious, such relation cannot be a close one; and the genus is certainly the representative of a special family (see Pal. Tab. Cor., p. 330). On the other hand, there is the high authority of Dr Steinmann (Ueber die fossile Hydrozoen aus der Familie der Coryniden : Palæontographica) in favour of the view that *Labechia*, E. and H., truly belongs to the *Hydractiniidæ*.

In 1877, a peculiar type of Monticuliporoid was described by Mr R. Etheridge, jun., and myself under the name of *Prasopora* (Ann. Nat. Hist., ser. 4, vol. xx. p. 38).

1877 continued. We regarded this at first as a distinct genus; but I have since examined other allied types, and I am now disposed to regard it as a section or sub-genus of *Monticulipora*, D'Orb. Its distinctive characters will be fully treated of subsequently.

In the summer of 1878, Mr U. P. James commenced the publication of a palæontological serial, entitled 'The Palæontologist,' of which, so far as I know, only four numbers appeared, the last being dated July 1879. In it were given short descriptions of various fossils, unfortunately not accompanied by any figures. Amongst these Mr James described the following new species of *Monticulipora* (referring these to the genus *Chætetes*): viz., *C. crustulatus*, *C. Meeki*, *C. varians*, *C. subrotundus*, and *C. minutus*. I have no means of judging of the affinities of the three last of these; but I have examined the two species first mentioned, both macroscopically and microscopically. The first of these (*M.? crustulata*, James) is certainly a new form, but I am not prepared to assert positively that it is a *Monticulipora*, as it has some curious points of resemblance to some of the types which are usually placed under the genus *Ceramopora*, Hall. Of the latter, of which I have ample material, I am able to say that the name of *M. Meeki*, which Mr James only proposed provisionally, must be abandoned, as it is a mere variety of the previously described *M. gracilis*, James.

1878.

In 1878, Mr E. O. Ulrich published (Journ. Cincinnati Soc. Nat. Hist., Pl. IV. figs. 7, 7*a*) a description of a new species of *Monticulipora*, under the name of *Chætetes venustus*.

In the following year (1879) the same excellent observer published two further papers in the same Journal, in which various species of *Monticulipora* and allied types were described. In the first of these (*loc. cit.*, Pl. VII. figs. 25, 25*b*), the author described a new species of *Monticulipora* under the name of *Chætetes compressus*, but the form is one with which I am unacquainted. In the second paper in question (Pl. XII. figs. 9-12), entitled "Description of a New Genus and some New Species of Bryozoans from the Cincinnati Group," Mr Ulrich described as new species of *Monticulipora* the following types (placed under *Chætetes*): *C. granuliferus*, *C. irregularis*, *C. subglobosus*, and *C. elegans*. With regard to the first

1879.

of these the author observes that it is distinguished by the possession of thick strongly granulated "intercellular spaces;" and he adds that, "when slightly worn, the granules or spines are seen to be simply surface-extensions of curiously modified minute tubuli." This, so far as I know, is the first clear recognition of the singular "spiniform corallites" of so many of the *Monticuliporæ;* since Dybowski seems to regard his "Wandröhrchen" and "Wandstränge" as mere accessory structures. The author, moreover, refers *Monticulipora* (*Chætetes*) *Ortoni*, Nich., to a new genus of *Polyzoa*, which he names *Atactopora*, and of which he supplies descriptions of several new species, with which I am not acquainted. So far as *M. ? Ortoni*, mihi, is concerned, I shall afterwards give reasons for thinking that it will be difficult, with our present knowledge, to separate it definitely from *Monticulipora*, with some species of which it shows remarkable affinities, at the same time that it has equally singular features of its own. I fail, at any rate, to recognise in it the fundamental feature which Mr Ulrich considers to separate his genus *Atactopora* from *Monticulipora*, D'Orb.—namely, the presence of pseudo-septa.

Towards the close of 1879 I published a work on 'The Structure and Affinities of the "Tabulate Corals" of the Palæozoic Period,' in which I gave a general account of the structure, development, and systematic position of *Monticulipora* and various allied types. I also submitted a provisional classification of the forms included usually under the comprehensive genus *Monticulipora*, and I gave an account of the structure of typical examples of some of the more striking and characteristic forms of the group. I need not give any analysis of the above work, since the bulk of that portion of it which dealt with *Monticulipora* is incorporated, with great additions, and with some alterations, in the present treatise.

Lastly, in 1880, Mr E. O. Ulrich published a list of the species of *Monticulipora* and allied genera known to him as

occurring in the Cincinnati Group of Ohio (Cat. Foss. Cincinn. Group of Ohio, Indiana, and Kentucky). In this catalogue a number of new species are named; but as the names are not accompanied with any descriptions or figures, they have, of course, in the meanwhile no actual validity.

1880.

CHAPTER II.

THE GENERAL AND COMPARATIVE STRUCTURE OF MONTICULIPORA.

The genus *Monticulipora*, D'Orb., using this name in its wide sense, comprises a large number of Palæozoic fossils, which range from the Lower Silurian to the Carboniferous, inclusive. They attain their maximum in point of development, both as regards species and individuals, towards the middle or end of the Lower Silurian period, being much less abundant in the Upper Silurian, and still less numerous in the Devonian and Carboniferous deposits. Species of the genus have been stated to occur in the Permian rocks, but I am not aware that this observation rests upon microscopic examination.

As regards its generic[1] characters, *Monticulipora*, D'Orb., may be defined as including forms in which the corallum is composed of numerous closely approximated tubular corallites, the walls of which are never absolutely amalgamated with one another, though sometimes seemingly so. Walls of the corallites imperforate. Septa entirely wanting. Tabulæ always present in greater or less number, though sometimes nearly

[1] In the following definition, the name of *Monticulipora* is used in its widest sense, as embracing all the types known to palæontologists as *Monticulipora*, *Fistulipora*, *Dekayia*, and *Constellaria*. As will be afterwards shown, these types agree with one another so closely that they can be readily included under a common definition; and they therefore form a natural genus. At the same time, it is very inconvenient, as a matter of *practice*, to include many sub-genera under a single genus; and I shall therefore treat *Fistulipora*, M'Coy, *Constellaria*, Hall, and *Dekayia*, E. and H., as if they were so many distinct genera, though their distinctive structural features would not seem to be of sufficient importance to warrant our regarding them in actual fact as more than mere sub-genera of *Monticulipora*.

obsolete; generally "complete," and approximately horizontal; sometimes, in a peculiarly modified manner, "incomplete." Corallites usually divisible into two distinct groups, one of large and the other of small tubes, the latter being usually, but not always, more closely tabulate than the large tubes, or showing other peculiarities of structure. Surface often, but not always, exhibiting at regular intervals definite areas which are occupied by corallites which are either larger or smaller than the average. These areas may be elevated above the general surface, when they are called "monticules;" or they may be level with the surface, or slightly depressed below it, when they are called "maculæ."

The *form* of the corallum is extremely variable, though often tolerably, or even altogether, constant for the same species; the massive, discoid, dendroid, laminar or frondescent, and encrusting types of corallum constituting those most commonly met with.

The arrangement of the tubes which make up the skeleton of a *Monticulipora* necessarily varies with the form of the corallum, and the chief variations in this respect will be noticed immediately. There is, however, one character which has such an important practical bearing that it deserves to be noticed in this place. In many Monticuliporoids, namely, though not in all, the tubes which constitute the colony become specially modified in structure as they pass into their final stage of growth, and approach near to the surface. Thus it is very common to find that the corallites in the centre of the corallum are thin-walled, and nearly or quite free from tabulæ, whereas in the outer portion of their course, near the surface, their walls become thickened, and tabulæ are abundantly developed. Moreover, it is very usual to find that the colony contains elements, such as small corallites or specially modified tubules, which in general do not extend downwards into the deeper parts of the corallum, but which are only developed in a zone immediately below the actual surface. Hence, in most ordinary types of *Monticulipora*, such as the great majority of the den-

droid species, the corallum may be readily differentiated into two distinct regions, an *axial* and a *peripheral* region. In the axial region the corallites are generally thin-walled and angular, often with few tabulæ. On the other hand, in the peripheral region, the corallites are often thick-walled, commonly rounded in shape, and usually with many tabulæ; while it is in this region that we meet with "interstitial tubes" and "spiniform corallites," if these structures are present at all. There are, however, a few types in which the corallum does not exhibit this differentiation into a deep and a superficial region. The relations of these two regions to one another when developed at all, necessarily varies with the form of the corallum. The commonest arrangement is that found in the dendroid species of *Monticulipora*, where the axial region of the corallum is truly axial, and forms a central fasciculus of nearly vertical thin-walled tubes; while the peripheral region forms a thicker or thinner investment to the median axis, and is composed of the tubes of the latter as they become bent and curved outwards at varying angles in order to reach the surface.

It is most important to remember this common difference in the characters of the axial and cortical portions of the corallum in the Monticuliporoids, because it is impossible otherwise to prepare thin sections of such forms which will give any adequate or correct idea of their structure. If, for example, we take any dendroid type of the genus, where the corallum is composed of an axis of nearly vertical tubes, and a cortical region composed of the same tubes bent at all angles up to 90° from the vertical, it will be at once obvious what sections it is necessary to make, and also what any given section will show us. Thus a *longitudinal* or *vertical* section, taken through the median plane of the corallum, will give us a vertical section of the tubes of the axis, and will also divide longitudinally the outwardly-bent and curved tubes of the cortical portion. On the other hand, a genuine *transverse* section, taken at right angles to the long axis of the corallum, will give us a true cross-section of the corallites in their axial region, where they are nearly vertical;

but it will give us an *obliquely longitudinal* section of the corallites in the peripheral region of the corallum, where they are bent at greater or less angles away from the vertical. Neither of the above sections, therefore, would give us a *cross-section* of the tubes in their *peripheral* region, where they have attained their adult characters, and where it is, above all, important to be able to investigate them. In order to obtain what is wanted, it is necessary to make a third section which shall run along a plane *parallel with the surface, and just a little below it.* Such sections we may call *tangential*, and they are absolutely indispensable to any understanding of the true characters of the great majority of the Monticuliporoids. The precise direction in which it will be necessary to cut any given specimen in order to obtain cross-sections of the tubes in their final and fully developed condition, will necessarily vary with the form of the specimen; but in all instances the requirements of the case will be met by sections taken in a direction tangential to the calicular surface, and just below that surface. Moreover, the nearer to the actual surface is the plane of such a section, the greater is the probability of its fully revealing the adult characters of the tubes.

We may now pass on to consider in greater detail the general and comparative structure of the Monticuliporoids, with special reference to those points which require to be particularly studied in the determination of the different types of this large and variable group.

I. *Form of the Corallum.*—In the first place, as regards the mode of growth of the corallum, and the form ultimately assumed by the colony, we find, as before remarked, great variations, and we are obliged to conclude that the mere external shape of the corallum is a character of no classificatory value. It is not that individual species are specially variable in shape, for many types exhibit a tolerably constant form when adult; but it is the fact that so many structurally diverse species assume the *same* shape, that robs this feature of any special value that it might otherwise possess. Admitting,

however, the comparatively trivial weight which can be attached to the mere external shape, we find that the coralla of the Monticuliporoids usually exhibit one or other of the following conditions :—

(*a*) The simply *massive* corallum, which is attached by one point at its base, and may be more or less spherical or globose in form, or sometimes largely lobate. No epitheca is apparently developed in such types, and occasionally (*e.g.*, *M. irregularis*, Ulrich) no basal point of attachment exists (the corallum in some of these cases having grown round the stem of a Crinoid). The simply massive corallum is seen in *M. undulata*, Nich., and occurs as a variation in some normally laminar types (*e.g.*, *M. molesta*, Nich.)

(*b*) The *discoid* corallum, which has the form of a plano-convex or concavo-convex disc, the upper surface of which is occupied by the calices, while the lower surface is covered by a striated and wrinkled epitheca, and may either be nearly flat, or may be more or less deeply concave. In these cases there is every reason to believe that the corallum was free. This form of corallum is one very common among the Monticuliporoids, and is exhibited by various types which have no relationships in their internal structure. Thus, it is characteristic of *M. petropolitana*, Pand., *M. Winteri*, Nich., *M. petasiformis*, Nich., *M. Selwynii*, Nich., *M. Whiteavesii*, Nich., *Prasopora Grayæ*, Nich. and Eth. jun., and some forms of *Fistulipora*, in all of which the corallum, with some subordinate modifications, is of a proportionately considerable height as compared with its width. The same type of skeleton occurs constantly in *M. discoidea*, James, *M. calycula*, James, and *M. Newberryi*, Nich.; but in these cases the height of the corallum is greatly reduced, so that it becomes more or less leaf-like.

(*c*) The *dendroid* or *ramose* corallum, which consists of cylindrical or subcylindrical stems, which branch more or less extensively, the base being attached to some foreign object, and the entire free surface being covered by the calices. More or less striking modifications of this type may occur by

the great flattening of the branches, by their becoming palmate, or by their mutual anastomosis; and in one form (*M. briarea*, Nich.) there is no evidence that the base was fixed to a foreign body. The dendroid form of corallum may, however, be regarded as the commonest of all the types of figure assumed by the Monticuliporoids; and it is exhibited by *M. ramosa*, D'Orb., *M. pulchella*, E. and H., *M. tumida*, Phill., *M. gracilis*, James, *M. Andrewsii*, Nich., *M. Jamesi*, Nich., and very many other species, the internal structure of these bearing no relation at all to their externally similar shape.

(*d*) The *laminar* or *frondescent* form of corallum, which consists of a more or less widely expanded and laterally compressed frond, which is rooted at its base, and has its entire free surface covered with the calices. The corallum in such cases consists of two strata of corallites, which are placed back to back, so to speak, and diverge from a central plane to open on the two opposed surfaces of the frond. The central plane of the corallum may be marked merely by an irregular cellular layer, or by an apparently definite, more or less complete calcareous lamina, or more rarely (*M. Dawsoni*, Nich.) the corallites are vertical in the median line of the expansion, and simply diverge outwards as they grow upwards. The forms of this type are usually constant in certain species, though occasionally (as in *M. molesta*, Nich.) a normally laminar species may assume a massive mode of growth. The species which possess a frondescent corallum are *M. mammulata*, D'Orb., *M. frondosa*, D'Orb., *M. molesta*, Nich., *M. pavonia*, D'Orb., and *M. Dawsoni*, Nich.; and it is noticeable that while the *form* of the corallum is in these species remarkably similar, no two of them are at all closely related in their internal structure.

(*e*) The *encrusting* corallum, in which the colony consists of very short corallites, forming a thin crust, which is parasitically attached by the whole of the under surface to foreign objects. The Monticuliporoids of this type are more like the ordinary encrusting *Polyzoa* than are any others of the group; and some

forms which have been placed here are very probably really *Polyzoa*, and not referable to *Monticulipora* at all. Others, however, resemble the more normal types of the group in their internal structure; and I do not at present see how they can be definitely separated from the present genus. Among these I may mention *M. Cincinnatiensis*, James, *M. tuberculata*, E. and H., *M. crustulata*, James, and probably *M. Ortoni*, Nich., all of which I have examined by means of thin sections, and most of which will be subsequently described in detail.

(*f*) As a modification of the preceding may be mentioned certain types which consist of moderately but not excessively short corallites, forming a crust which is apparently invariably attached to some particular class of foreign bodies, and which, in consequence, acquires an apparently constant form. As a good example of this group, we may take the curious *M. clavacoidea*, James.

II. *The Structure of the Walls of the Corallites.*—Much more important, from a zoological point of view, than the mere form of the corallum, is the minute structure of the wall of the tubes; and in this respect the Monticuliporoids show wide differences. The corallites of *Monticulipora*, whatever their form may be, are always contiguous throughout their entire length; and, theoretically, each tube possesses a perfectly independent and complete wall. In some cases this theoretic and undoubtedly primitive independence of the calcareous investment of each individual tube is obviously and clearly preserved throughout the entire growth of the corallum. Hence, in thin tangential or longitudinal sections of such forms, the visceral chamber of each corallite is seen to be surrounded by its own investment of light-coloured sclerenchyma, and to be separated from the corresponding investment of all the tubes in immediate contiguity with it by a clearly-marked dark line, which is often thickened into larger or smaller nodes at the angles of junction of the corallites. This permanent preservation of the primitively duplex structure of the wall separating adjoining visceral chambers is seen in many forms, such as

M. pulchella, E. and H. (fig. 1, C), *M. petasiformis*, Nich. (fig. 2, B), *M. Girvanensis*, Nich., *M. Trentonensis*, Nich., *M. Jamesi*, Nich., &c. The actual thickness of the proper wall of each tube, internal to the dark boundary-line which marks the primordial wall, is very variable, being exceedingly limited

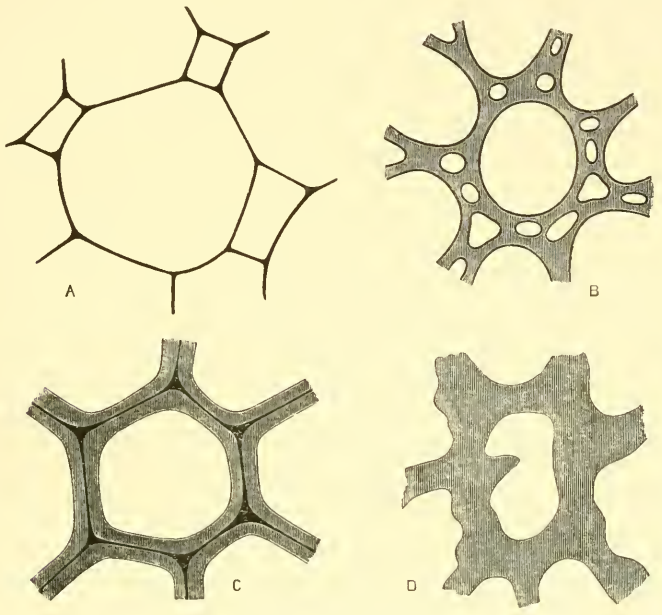

Fig. 1.—A, Tangential section of a few corallites of the typical *Monticulipora petropolitana*, Pand., from the Lower Silurian of Sweden; B, Tangential section of a corallite of a typical example of *Monticulipora ramosa*, E. and H., from the Cincinnati group of Ohio; C, Tangential section of a corallite of a typical example of *Monticulipora pulchella*, E. and H., from the Wenlock Limestone of Dudley; D, Tangential section of a corallite of the typical *Chætetes radians*, Pand., of the Carboniferous rocks of Russia. All the sections are taken just below the calices: A, B, and C are enlarged fifty times; D enlarged twenty-five times.

in forms like *M. petasiformis*, Nich. (fig. 2, B), while it is more extensive in forms like *M. pulchella*, E. and H., and is sometimes exceptionally great, as in types like *M. Trentonensis*, Nich. The internal secondary wall also is usually, though not always, rounded off internally, so as to give the whole tube a circular or oval aspect, while the thin line of the original wall is almost always markedly polygonal.

In another group of *Monticuliporæ*, represented by forms

like *M. petropolitana*, Pand. (fig. 1, A), and *M. undulata*, Nich. (fig. 2, A), the walls are so thin that the partitions between the

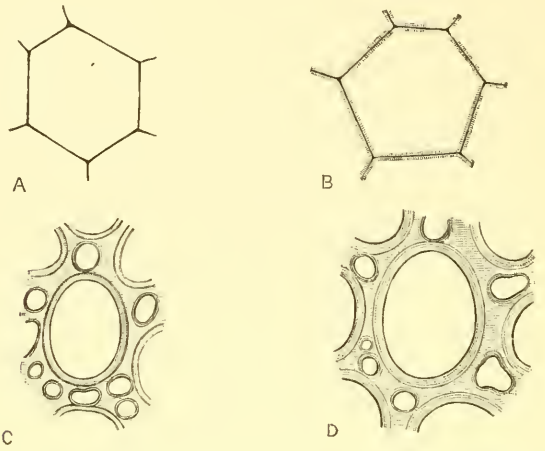

Fig. 2.—A, Tangential section of a single corallite of *Monticulipora undulata*, Nich.; B, Tangential section of a single corallite of *Monticulipora petasiformis*, Nich., showing the duplex character of the wall; C, Tangential section of a corallite of *Monticulipora rugosa*, Edw. and Haimes; D, Tangential section of a corallite of *Monticulipora Andrewsii*, Nich. All the sections are enlarged fifty times.

visceral chambers of contiguous corallites appear to be absolutely indivisible and without structure, presenting themselves in thin sections merely as delicate dark lines. Dybowski (Die Chætetiden) lays great stress upon this feature, and uses it as a basis for subdividing the Monticuliporoids into two primary sections. For my own part, I believe that in such a complex group as the present, no single character, such as this is, is of itself sufficient for the establishment of primary subdivisions; and I feel satisfied that this apparent amalgamation of the walls of contiguous corallites must be due to our imperfect methods of observation. That this is the case seems sufficiently proved by the consideration—which I shall have to speak of again—that even in forms like these (viz., *M. undulata*, Nich.), *rough fractures* will demonstrate what *thin sections* fail to show—namely, that the apparently structureless wall is really *double*. In rough fractures, that is to say, we find that the corallites always separate cleanly from one an-

other, each carrying with it its own wall, a phenomenon which could not be possible if the primitively duplex condition of the walls of adjoining tubes had in reality been destroyed.

In a third group of cases, embracing many of the most typical members of the group, such as *M. ramosa*, E. and H. (fig. 1, B), *M. rugosa*, E. and H. (fig. 2, C), *M. O'Neilli*, James, *M. nodulosa*, Nich., &c., there is no dark line running in the centre of the partition between contiguous tubes; and the walls thus at first sight appear to be amalgamated, as they actually are in *Chætetes* proper. In these cases, however (figs. 1, B, and 2, C), the state of matters really differs widely from that which exists in *Chætetes*, Fischer, since each visceral chamber is enclosed by a distinct dark line or marginal ring, usually circular or oval in outline, marking the original boundary of the tube, and the interspaces between these dark lines are filled in by sclerenchyma of a different texture and much lighter colour. In these cases, therefore, it would appear that the corallites are not only primitively distinct, but that in approaching the surface they do not touch each other at all to begin with, or only to a very limited extent, the ultimate union of the corallites being effected by means of a secondary deposit of calcareous matter. In such forms as these, therefore, the corallites in the deeper parts of the corallum are thin-walled, closely contiguous, and more or less polygonal; whereas they become much thickened and more conspicuously circular or oval in shape as their mouths are approached. The structure of the wall is, in fact, very similar in these cases to what is observable in *Stenopora*, Lonsd., except that the thickening of the tubes is uniform, and is not confined to the production of periodic rings.

In other cases, again, the apparent amalgamation of the corallites is carried still further, since the various visceral chambers are bounded by well-marked lines, and the space between these is simply filled with light-coloured sclerenchyma, which usually exhibits fine concentric laminæ of deposition in the immediate neighbourhood of the actual tube-cavity, but seems to be absolutely structureless just at that central point where we should

expect to find traces of the original boundaries between the corallites. This state of parts occurs in forms like *M. tumida*, Phill., *M. Andrewsii*, Nich. (fig. 2, D), *M. gracilis*, James, *M. moniliformis*, Nich., and various other allied types.

Some forms of Monticuliporoids show peculiarities in the structure of the wall slightly different to any of those alluded to above, but the preceding are the most important types with which we have to deal; and our knowledge on this subject, as derived from tangential sections, may be corroborated, and in some points supplemented, by an examination of longitudinal sections. In these we see the same great apparent differences that have been noted in tangential sections. Thus, in some

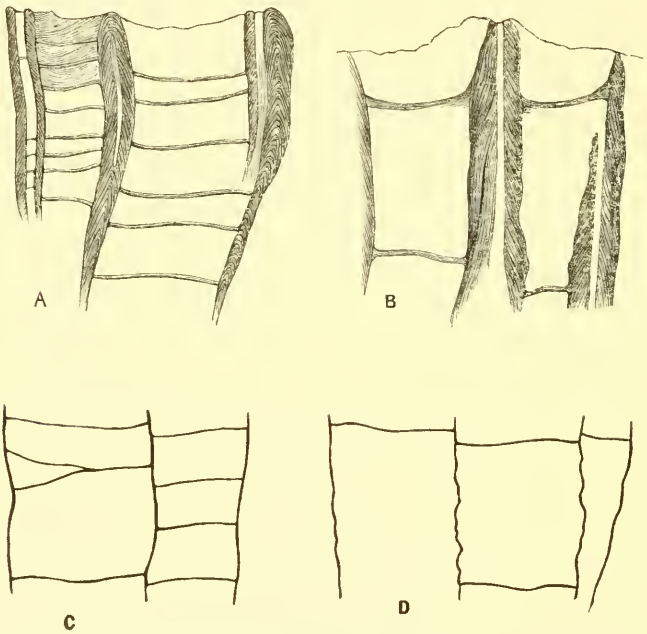

Fig. 3.—A, Long section of the corallites of *Monticulipora Ulrichii*, Nich., showing the structure of the wall close to the surface, as well as the "spiniform corallites;" B, Long section of two corallites of *Monticulipora moniliformis*, Nich., also close to the surface, showing the thickened wall and the hollow spines; C, Long section of two corallites of *Monticulipora petropolitana*, Pand.; D, Long section of the corallites of *M. undulata*, Nich. All the sections are enlarged fifty times.

forms, like *M. petropolitana*, Pand., and *M. undulata*, Nich. (fig. 3, C and D), the walls separating adjoining corallites appear as seemingly structureless, thin, and delicate dark lines, without

any trace of their originally duplex nature. In all cases, moreover, whatever may be the structure of the walls of the tubes in their final and most developed condition, the corallites *commence* with thin and apparently indivisible walls. Hence, in the axial and deeper regions of any Monticuliporoid, long sections always exhibit the thin and seemingly structureless walls which exist throughout the entire length of the tubes in forms like *M. petropolitana*, Pand.; and this feature is equally shown by *transverse* sections.

In very many Monticuliporoids, however, the walls of the corallites in their peripheral and more superficial portions become more or less extensively thickened by a secondary deposit of sclerenchyma. In some of these cases — as, for example, in *M. pulchella*, E. and H.—the original walls of the tubes can still be clearly recognised, traversing the centre of the light-coloured secondary sclerenchyma as so many thin dark lines. In other cases, as in forms like *M. tumida*, Phill., *M. Ulrichii*, Nich. (fig. 3, A), *M. moniliformis*, Nich. (fig. 3, B), and many others, the original lines of demarcation between adjoining tubes can be only indistinctly or not at all made out, and the corallites *seem* to be indistinguishably amalgamated. In such cases, longitudinal sections give us a clearer idea of the mode of formation of the thickened wall than we obtain from tangential sections. In such cases, namely, the longitudinal section of the wall (fig. 3, A and B) shows that it is composed of a succession of superimposed conical layers of sclerenchyma, which are deposited one above the other as the growing margin of the wall is carried upwards. The growth of the thickened wall is not, therefore, effected by the deposition of a new layer of sclerenchyma along the entire interior aspect of the already existing tube-cavity, but is carried on simply by the successive formation of new laminæ of calcareous matter at the margin of the old calice. The structure of the wall, therefore, is in these cases precisely similar to what is found in *Stenopora*, Lonsd., except that the production of new layers of sclerenchyma appears to take place continuously and regularly,

instead of periodically, so that the wall becomes uniformly thickened, instead of exhibiting alternate dilatations and contractions.

Apart, however, from the evidence of microscopic sections, which I have sufficiently discussed above, there is sufficient evidence from other sources that the tubes of *Monticulipora* never become absolutely amalgamated with one another, as they do in *Chætetes*, Fischer (fig. 1, D). In discussing the minute characters of various species of *Monticulipora* in the subsequent chapters of this work, I may speak of the tubes as being fused together, or as having their walls amalgamated; but in so doing, I must be understood simply as referring to the *apparent* fusion exhibited by microscopic sections. That this fusion is not real, but that the walls, even in such species as *M. undulata*, Nich., and *M. petropolitana*, Pand., remain really permanently distinct, seems to be incontrovertibly shown by the fact that fractured surfaces, so far as I have seen, invariably exhibit the *exterior* of the tubes. This was long ago noticed by Lonsdale, and was set down by him to the fact that the corallum of *Monticulipora* increased by gemmation, whereas that of *Chætetes* produced new tubes by a process of fission. In the latter, therefore, rough fractures exhibit the *interior* of the corallites. Of the correctness of Lonsdale's observations on this point—as observations—I can entertain no doubt; but I am not clear that the phenomena are really due to the cause which he assigns. That *Chætetes* increases fissiparously is certain; but I am not sure that gemmation is the regular or exclusive mode of growth amongst the *Monticuliporæ*. I have formerly expressed the opinion (Ann. Nat. Hist., ser. 4, vol. xviii. p. 86) that certain species of *Monticulipora* exhibited fissiparous growth; and though further observations have shown me that I relied upon evidence which admitted of misconstruction, and that gemmation is the common mode of increase in the *Monticuliporæ*, I am still inclined to think that the phenomena manifested by thin sections show that fission of the old tubes occurs at times

as well. At any rate, I feel sure that the difficulty of determining this point in the case of the smaller species is so great that I am right in the formerly expressed opinion that this character alone should not be accepted as an adequate generic distinction between *Chætetes* and *Monticulipora* (Quart. Journ. Geol. Soc., vol. xxx. p. 500).

We have at present no evidence as to the existence of "*mural pores*" in any species of *Monticulipora;* and there is every reason to believe that the walls are really imperforate. So many species of the genus, at any rate, have now been examined by means of thin sections, that it seems very unlikely that mural pores should have escaped notice, had such apertures in the walls really existed. This, therefore, is a point upon which the purely negative evidence may be legitimately accepted as of great weight. At the same time, there are some considerations which preclude our regarding the imperforate condition of the walls of the *Monticuliporæ* as a point settled absolutely beyond dispute or doubt. Thus, we find species of the singular genus *Stenopora*, Lonsd., in which mural pores can be certainly shown to be present, so that we can hardly suppose any member of the same genus to be without them; and yet there are well-marked species of *Stenopora* in which the closest microscopic examination has hitherto failed to reveal the existence of any apertures in the walls. There are also forms (such as *Favosites Bowerbanki*, E. and H. sp.) which have all the general aspect and structure of the Monticuliporoids, and which can only be separated from *Monticulipora* upon the ground that they are known to possess minute mural pores. Upon the whole, therefore, while I think the imperforate condition of the walls of the Monticuliporoids to be as certain as anything established by merely negative evidence can be, I am not prepared to assert absolutely that mural pores are totally wanting. It is certain, however, that if mural pores do exist in the Monticuliporoids, they must be much more minute, and much more irregular in their distribution, than is the case with these openings in the typical *Favositidæ*.

III. *Surface-characters.*—As regards the *surface-characters* of the Monticuliporoids, the appearances presented by the calices vary according as we have to deal with a form in which the walls of the corallites remain permanently more or less thin throughout their entire extent, or with one in which the tubes undergo a marked thickening before reaching the surface. In the former of these cases the calices are polygonal and sharp-edged, and thus resemble the calices in a *Favosites* of normal type. In the second case, the calices are rounded, oval, or subpolygonal, and exhibit thick and rounded margins—reminding us, so far as this particular character goes, of the calices of a *Pachypora* or a *Stenopora*. *Monticulipora petropolitana*, Pand., and its allies, may be taken as exemplifying the former condition; while *M. ramosa*, D'Orb., *M. mammulata*, D'Orb., *M. frondosa*, D'Orb., *M. Jamesi*, Nich., *M. tumida*, Phill., and many others, are examples of the latter state of parts.

Apart, however, from the mere characters of the calices, there are certain special superficial features present in various Monticuliporoids, either singly or in combination, which demand special consideration. Foremost amongst these are the structures which are known as "monticules" or "mamelons," from the presence of which, in many species, the name of *Monticulipora* is derived. The "monticules," in their most typical form, are circumscribed areas on the surface of the corallum, which are more or less elevated above the general level, so as to constitute a series of rounded, oval, or elongated eminences. Sometimes the "monticules" are composed of corallites which differ in no conspicuous feature from those which form the mass of the corallum (*e.g.*, in *M. ramosa*, D'Orb., and *M. Cincinnatiensis*, James), and it is generally in such cases that these eminences are most conspicuous and prominent. In other cases (*e.g.*, *M. pulchella*, E. and H.), the corallites which form the "monticules" are markedly larger than the average; but in such cases the monticules hardly deserve the name, as they are scarcely or not at all elevated above the general surface.

In other cases, in place of proper "monticules," we find other small areas which are occupied by corallites considerably smaller than the average, and which are either level with the general surface, or are even slightly depressed below it (as, for example, in *M. frondosa*, D'Orb., and *M. subpulchella*, Nich.) Such areas are usually called "maculæ," and they often exhibit a peculiar appearance, seemingly due to the closure of the mouths of their constituent tubes by a delicate calcareous membrane.

IV. *Spiniform Corallites.*—Another very remarkable superficial feature which is specially common in the thick-walled species, though occasionally present in the thin-walled types, and which is also generally present in the genus *Stenopora*, Lonsd., is the existence of peculiar blunt spine-like structures, which are placed, in greater or less numbers, round the calices, usually at the angles of union of the corallites. Various Monticuliporoid Palæozoic corals have been noticed by different observers to possess these calicine spines; and Milne-Edwards and Haime at one time (Brit. Foss. Cor. Intr., p. lxi) regarded the existence of these structures as diagnostic of the genus *Stenopora* as defined by them. Structures of this nature are, however, possessed by a large number of true *Monticuliporæ*, and notably by *M. frondosa*, D'Orb., *M. tumida*, Phill., *M. Jamesi*, Nich., *M. moniliformis*, Nich. (fig. 5), *M. implicata*, Ulrich (fig. 4), *M. gracilis*, James, and other forms. As viewed from the surface, these spines present themselves simply as so many blunt projections, which do not seem, so far as I have been able to observe, to be ordinarily perforated by any apical apertures. I have however, in some cases, detected minute circular apertures at the summits of these spines; and it is quite possible that they are really generally present, but that they are filled up by the matrix or by infiltrated calcite. On the other hand, when examined by means of thin sections, these spines are found to be in no way of the nature of mere superficial ornaments, but they extend into the substance of the corallum, between the ordinary corallites, to a depth equal

to that reached by the smaller tubes of the colony. Tangential sections taken a little below the surface (figs. 4 and 5) show that these apparent spines are composed of concentrically laminated sclerenchyma, exhibiting in their centre a dark circular spot or a clear circular space. There cannot, there-

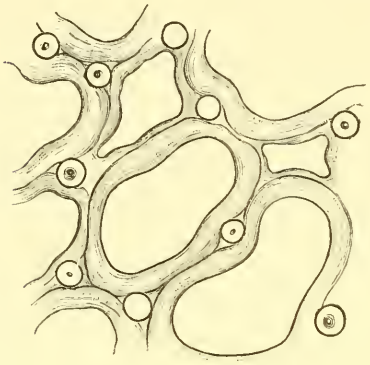

Fig. 4.—Portion of a tangential section of *Monticulipora implicata*, Ulrich, showing the hollow intracalicine spines, enlarged fifty times. From the Cincinnati Group of Ohio.

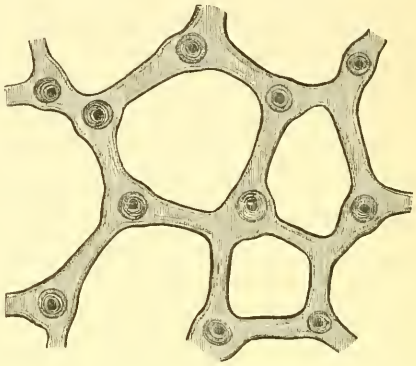

Fig. 5.—Portion of a tangential section of *Monticulipora moniliformis*, Nich., showing the intracalicine spines, enlarged fifty times. From the Hamilton Group of Ontario.

fore, be any doubt but that these structures are primitively hollow, though their central cavities often appear to become filled up by a secondary deposit of sclerenchyma, as growth proceeds. In this primordial hollowness of the spines is to be found, I believe, the real clue to their nature; and I can hardly doubt that instead of being merely appendages of the corallum, they are truly of the nature of peculiarly modified zoöids or corallites.[1] The correctness of this view is most readily recognised when we come to examine thin sections of those forms which

[1] These peculiar hollow spines have been described and accurately figured in various Monticuliporoids by Dybowski (Die Chætetiden, p. 9, &c.), under the name of "Wandröhrchen" or "Porenkanälchen." He regards them as of the same nature as the peculiar canals ("intramural canals") which are found in various "Tabulate corals" (such as *Columnopora*, *Lyopora*, *Pleurodictyum*, &c.) The "intramural canals" of forms such as those above mentioned are, however, not bounded by distinct proper walls of their own, and are quite irregular in their distribution. For these reasons, amongst others, I cannot regard them as being in any way comparable with the "spiniform corallites" of the Monticuliporoids, and I must in the meanwhile adhere to the views expressed in the text as to the nature of these latter structures.

have usually been separated from *Monticulipora* under the generic title of *Dekayia*, E. and H. In these cases the supposed spines are very much reduced in number, but they are quite exceptionally developed, and they constitute the well-known surface-projections which are characteristic of the genus. These surface-projections certainly seem to be imperforate at their apices, but thin sections demonstrate conclusively that they are hollow internally, and that they only differ from the ordinary corallites in the greater thickness and density of their walls and the apparent general absence of tabulæ. I do not myself entertain any doubt as to these being a peculiar form of corallites—doubtless tenanted in life by peculiar zoöids—the mouths of which became closed by secondary deposit as the corallum assumed its final characters. Nor have I any doubt that the spines of forms like *M. moniliformis*, Nich. (fig. 5), *M. Jamesi*, Nich., *M. tumida*, Phill., *M. gracilis*, James, and others, are similarly peculiarly modified corallites, the mouths of which commonly become finally closed. A further evidence of this is to be found in such species as *M. frondosa*, D'Orb., in which the spines do not necessarily appear as *spines* upon the surface, though thin sections exhibit appearances precisely similar to what has been indicated as occurring in the forms alluded to above. On the contrary, the spines often remain permanently open, and appear on the surface as minute thickened apertures between the ordinary calices, so that they have been both recognised and figured as a special group of corallites (Ann. and Mag. Nat. Hist., ser. 4, vol. xviii. p. 92, Pl. V. fig. 11). It is not, of course, essential that we should suppose these singular structures to be occupied by polypes; but I think them to be modified zoöids in the same sense as is true of the "avicularia" of the *Polyzoa*, and I shall therefore speak of them as "spiniform corallites."

In most cases, the central cavities of the "spiniform corallites" are easily recognisable in thin sections. In other instances, however, especially in cases where these structures are developed in great numbers (*e.g.*, in *M. tumida*, Phill., Pl. III.

fig. 1*d*), many of the spines become so far aborted that their central cavities are no longer to be detected, while others attain their full development. These aborted "spiniform corallites" appear to be in general what Dybowski has called "Wandstränge," though he has apparently included other structures as well under this name. As these aborted spines appear, however, in forms of very different affinities (such as *M. tumida*, Phill., and *M. Girvanensis*, Nich.), it seems clear that they are of no classificatory weight, whatever view we may take as to their real nature.

Lastly, if we admit the probable correctness of the views here advanced, we have a very interesting analogy established between certain forms of *Monticulipora* and some of the species of *Stenopora*, Lonsd., in which structures of a precisely similar nature occur. Thus, if we examine a tangential section of *Stenopora Tasmaniensis*, Lonsd., taken just below the surface (fig. 6), we see that the surface-spines are continued in-

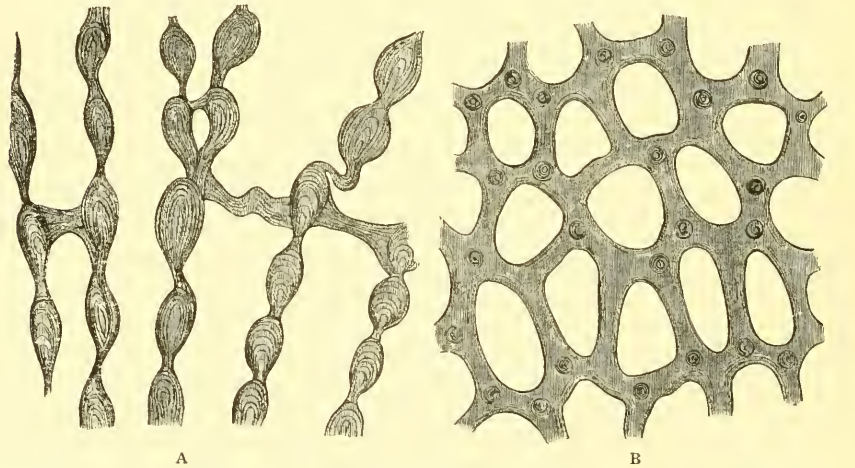

Fig. 6.—A, Vertical section of a few of the corallites of *Stenopora Tasmaniensis*, Lonsd., in the final portion of their course, enlarged twenty times, showing the annular thickenings of the tubes and the remote tabulæ; B, Tangential section of the same, taken just below the surface, similarly enlarged, showing the transversely divided spiniform corallites between the ordinary tubes. Carboniferous, Australia.

wards precisely as they are in *Monticulipora moniliformis* and allied types, while they are similarly composed of concentric-

ally disposed lamellæ of dense sclerenchyma. The central cavities of the spines seem, however, to be more or less completely obliterated with age; and the corallites in the outer portion of their course (fig. 6) exhibit the annular thickenings of their walls which are so characteristic of the genus *Stenopora*. In spite of these differences, the resemblance between the spines of the *Monticuliporæ* above alluded to and the similar structures in certain species of *Stenopora* is so striking that one can hardly resist the conviction that there must subsist between the two a relationship of real affinity.

V. *Dimorphism of the Corallum.*—Apart, however, from the very curious structures that I have just spoken of under the name of "spiniform corallites," microscopic examination brings out very clearly the important fact that the corallum in *Monticulipora* is in general *dimorphic*, and consists of two different sets of corallites, which must, during life, have been inhabited by different sets of zoöids. The existence of minute tubes, either scattered among the larger ones, or aggregated into special groups, has, of course, been long known to palæontologists; but these have, for the most part, been regarded either as merely young corallites or as "cœnenchymal tubuli."[1] Similarly, palæontologists have long known that certain species of *Monticulipora* (*e.g.*, *M. pulchella*, E. and H.) exhibit groups of large tubes distributed at intervals among those of average size; but the true import of these appearances hardly admitted of recognition save by the light of Mr Moseley's researches upon the living *Heliopora*. I have, however, now thoroughly satisfied myself that the corallum in *Monticulipora* is, in gen-

[1] Until the publication of Mr Moseley's researches upon the structure of the recent *Heliopora* (Phil. Trans., vol. clxvi. p. 92, 1876), the closely tabulate interstitial tubes of *Heliolites* and allied forms were generally, and very naturally, regarded as being of the nature of a vesicular "cœnenchyma." If, however, the interstitial tubes of *Heliolites* are to be regarded as formed by a special series of modified polypes—as Mr Moseley's researches seem to render certain—then we cannot avoid the conclusion that the interstitial tubes of so many of the Monticuliporoids are essentially of the same nature. We must therefore abandon the term of "cœnenchymal tubules," as applied to the small interstitial corallites of *Monticulipora* and its allies *Fistulipora*, M'Coy, *Constellaria*, Dana, &c.

eral, truly dimorphic, quite as genuinely as in *Heliopora* or *Heliolites*. One set of corallites may be much reduced in number, or may undergo much modification, but I believe that the existence of two different kinds of tubes can usually be demonstrated; and the importance of this fact, from a theoretical point of view, can hardly be overestimated. At the same time, there are forms, otherwise quite resembling the dimorphic species, in which all the corallites of the colony are apparently similar in their internal structure, and approximately equal in size; so that we are not able to assert positively that the corallum in *Monticulipora* invariably consisted of two different sets of tubes.

The nature and relative development of the two sets of corallites which are usually present in *Monticulipora* constitute important elements in the framing of any classification of the numerous forms included under this general name; though other considerations must be taken into account as well, if such a classification is to be in any way natural. Leaving this aspect of the question aside in the meanwhile, the following are the principal variations exhibited by different forms of *Monticulipora* as regards the nature and arrangement of the corallites :—

A. Forms with a single series of corallites, which exhibit no marked differences in internal structure.
   - *a*. Without spiniform corallites, and without well-marked groups of large or small tubes. *Ex.*, *M. quadrata*, Rom., *M. Winteri*, Nich., *M. irregularis*, Ulrich, *M. clavacoidea*, James.
   - *b*. Without spiniform corallites, but with well-marked groups of large tubes. *Ex.*, *M. pulchella*, E. and H., *M. undulata*, Nich., *M. petasiformis*, Nich.
   - *c*. With spiniform corallites, but without well-marked clusters of large or small corallites. *Ex.*, *M. discoidea*, James, *M. moniliformis*, Nich., *M. Barrandii*, Nich.

B. Forms with two sets of corallites, large and small, the small tubes being much more closely tabulate, or otherwise differing in structure from the large ones.
   - *a*. With no spiniform corallites, with or without clusters of large tubes. *Ex.*, *M. petropolitana*, Pand., *M. Newberryi*, Nich., *M. Cincinnatiensis*, James, *M. Andrewsii*, Nich., *M.* (*Prasopora*) *Grayæ*, Nich. and Eth. jun., *M. molesta*, Nich.

b. Without spiniform corallites, and having numerous interstitial tubes intercalated uniformly amongst the large ones. *Ex.*, *M. ramosa*, D'Orb. (with *M. rugosa*, E. and H., and *M. Dalii*, E. and H.), *M. O'Nealli*, James, *M. nodulosa*, Nich.

c. With spiniform corallites, and with numerous interstitial tubes intercalated among the large corallites. *Ex.*, *M. mammulata*, D'Orb., *M. calycula*, James, *M. Jamesi*, Nich., *M. Ulrichii*, Nich., *M. frondosa*, D'Orb., *M. Whiteavesii*, Nich.

d. With spiniform corallites, but with very few interstitial tubes (these latter sometimes almost obsolete). *Ex.*, *M. tumida*, Phill., *M. gracilis*, James, *M. Dawsoni*, Nich.

e. Spiniform corallites few or occasionally wanting, but with well-marked clusters of small tubes. *Ex.*, *M. subpulchella*, Nich., *M. Selwynii*, Nich.

The above rough grouping of a number of species of *Monticulipora* in accordance with the nature and disposition of the corallites forming the colony, will show that this feature cannot be relied upon as *singly* sufficient for a basis of natural classification; since, while it certainly brings together many nearly allied types, it widely separates others which in their main structural peculiarities are unquestionably closely related. At the same time, if due weight be attached to other important structural characters, such as the condition of the walls of the corallites, and the nature of the tabulæ, we may safely avail ourselves of the variations in the specialisation of the corallites as a guide to a sound classification of the species of this difficult genus.

VI. *Nature of the Tabulæ.*—The next point in the construction of the Monticuliporoids which needs notice is the form of the *tabulæ*, and the arrangement of these structures in the different corallites of the colony. So far as I have seen, tabulæ are never wholly absent in any Monticuliporoid, though they are sometimes (*e.g.*, in *M. irregularis*, Ulrich, and *M. clavacoidea*, James) reduced to a minimum, and may be entirely wanting in more or less extensive portions of the corallum. In the great majority of the Monticuliporoids, also, the tabulæ are "complete," and are either horizontal or slightly curved. In no case known to me do the tabulæ assume what is properly called the "incomplete" type of these structures (such as

occurs in forms like *Favosites hemisphærica*, Yand. and Shum.) In some members of the genus, however, we have a quite peculiar form of "incompleteness" of the tabulæ, such as I have never observed in any example of the *Favositidæ*. In the species alluded to (namely, *M. Newberryi*, Nich., *M. Selwynii*, Nich., *M. frondosa*, D'Orb., *M. Cincinnatiensis*, James, *M. molesta*, Nich., &c.), the large corallites are provided with a remarkable double tabulation, which produces appearances quite readily recognised both in vertical and tangential sections. When examined in longitudinal sections (fig. 7, A), the principal tabulæ of each large tube are seen to form a row of lenticular vesicles on one side of the visceral chamber, each tabula being curved in such a way as to join inferiorly with the tabula next below it in the series. On the other hand, the portion of the visceral chamber not occupied by the lenticular vesicles just spoken of, is usually intersected by a moderate number of horizontal plates, which pass from the vesicles on one side to the opposite wall. When examined in tangential sections (fig. 7, B), these peculiar vesicular tabulæ are seen to extend round about two-thirds of the circumference of the visceral chamber (or sometimes to encircle it), terminating internally, or on the face turned towards the axis of the tube, in a concave free margin. Hence, in tangential sections their cut edges are seen to form deeply curved lines enclosing an excentric tube on one side, or rarely in the centre, of each of the large corallites; while the horizontal plates which complete the tabulation of the tubes are necessarily not exhibited at all.

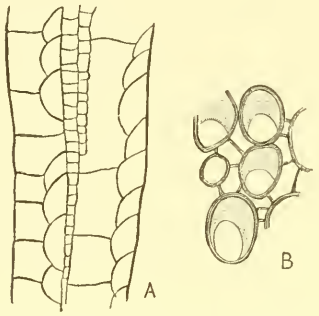

Fig. 7.—A, Long section of two large and two small corallites of *Monticulipora Selwynii*, Nich., enlarged eighteen times, showing the peculiar incomplete tabulæ of the large corallites; B, Part of a tangential section of the same, similarly enlarged, showing the characteristic appearance produced by these incomplete tabulæ, when the corallites are transversely divided.

Whether the tabulæ assume the form just described, or are of the more normal type, it is usual to find in the dimorphic coralla that there is a marked difference in the tabulation of the large and small corallites respectively. It is usual, namely, to find that the tabulæ of the small corallites (which are always "complete" and approximately horizontal) are conspicuously more numerous and more closely set than is the case in the large tubes. In other cases, again, even where clusters of large corallites constitute a noticeable feature (as in *M. pulchella*, E. and H.), there is no recognisable difference in the tabulation of any one series of corallites as compared with any other. Moreover, there is evidence, in some cases (as, for example, in *M. undulata*, Nich.), of a distinct periodicity in the production of the tabulæ, these structures being comparatively few in number, and being mostly placed at corresponding levels in contiguous tubes, thus more or less perfectly dividing the corallum into a series of concentric layers. Lastly, in those species of the group which have the corallum conspicuously divided into an axial and a peripheral zone, it is the rule to find the tabulæ very sparingly developed, or even wanting, in the central and deeper portions of the corallum, and becoming numerous as the corallites approach the surface.

VII. *Septa and Pseudo-septa.* — Nothing of the nature of "septa," in the proper sense of this term, has ever been detected in any Monticuliporoid; and we do not even meet with any structures that could be compared with the imperfect spiniform septa of so many of the *Favositidæ*. In a few forms (such as *M. implicata*, Ulrich), the tubes seem to be indented on one or more sides by blunt inward projections, which might, on cursory inspection, be regarded as of the nature of septa; but thin sections show that in these cases the apparent septa are caused by inward protrusions of the walls of the tubes, due to the development of "spiniform corallites." In one or two other cases (*e.g.*, *M. pavonia*, D'Orb.), I have occasionally detected a blunt, tooth-like projection into the interior of the

visceral chamber, but this is never more than a quite occasional thing; and though I cannot satisfactorily explain what these projections may be, there is no reason to regard them as septa. Lastly, Mr Ulrich has separated from *Monticulipora* certain forms for which he has constituted the new genus *Atactopora* (Journ. Cincinn. Soc. Nat. Hist., 1879), upon the ground that they possess pseudo-septa. I have only examined one of these forms—viz., *Monticulipora* (*?*) *Ortoni*, Nich.; but in its case I find the apparent pseudo-septa to be mere inward protrusions of the wall, due (as in *M. implicata*, Ulrich) to the development of "spiniform corallites."

VII. *Epithecal and Opercular Structures.*—The only remaining point in connection with the general structure of the Monticuliporoids which deserves a few words of notice concerns the development of an epitheca and of opercula to the corallites. An epitheca is, as a rule, only present in those types which possess a discoidal form of corallum; and in these the concave or flat under surface is normally protected by a thicker or thinner epithecal plate, which is usually concentrically wrinkled, and is sometimes marked with fine radiating striæ. In other cases, though no epitheca be present, the mouths of the corallites are liable to become closed, when maturity is reached, by a delicate calcareous membrane which constitutes an opercular growth of variable and partial development. Sometimes, when "maculæ," or clusters of small tubes, are present, these alone appear to become sealed up in this way. In other cases (as not uncommonly in the allied group of the *Fistuliporæ*), the small tubes in general become covered by a thin and uniformly diffused opercular membrane, the mouths of the large tubes alone remaining open; though I cannot say that I have ever noticed this condition of parts in any typical species of *Monticulipora*. Lastly, there are cases (as in *M. O'Nealli*, James) where certain of the calices become ultimately closed by the development in the mouth of each of a thin calcareous lid or operculum (Pl. III., fig. 3*b*). This phenomenon is precisely

similar to what occurs in certain species of *Favosites* (*e.g.*, *F. clausa*, Rom., and *F. Forbesi*, E. and H., var. *tuberosa*, Rom.); and, as in these, it does not appear that the opercula are developed in any uniform manner, some parts of the surface showing these structures, while in other parts the calices are open.

CHAPTER III.

DEVELOPMENT, AFFINITIES, AND SYSTEMATIC POSITION OF MONTICULIPORA.

DEVELOPMENT.

The subject of the *development* of the *Monticuliporæ*, so far as we can be said to know anything about it, is so closely connected with the subject of the systematic relations of the genus, that I shall here introduce the little I have to say on this head. My own actual observations upon this point, indeed, have been principally made in connection with an examination into the views published upon this subject by Dr Gustav Lindström (Ann. Nat. Hist., ser. 4, vol. xviii. p. 5 *et seq.*); and as I find myself in this matter unable to accept the conclusions of the distinguished Swedish palæontologist, it is only just that I should quote his account of the development of *Monticulipora* at length. Upon this point he remarks :—

"If numerous specimens of the common *M. petropolitana*, Pand., be closely scrutinised, it will be seen that its semi-globose colony, so closely resembling a *Favosites* in its initial development, has an origin that could hardly be suspected. It begins, indeed, as a Bryozoön, as a *Discoporella*, as what Hall has termed *Ceramopora imbricata* (Pal. N.Y., vol. ii. p. 169, Pl. 40 E, figs. 1 *a*-1 *i*). There can be no doubt that this is closely allied to the recent *Discoporella* (see Fr. Smitt, Öfv. Vet. Akad. Förhand., 1866, p. 476, Pl. XI. fig. 4). The basal surface of a *Monticulipora*, when the epitheca is very thin, clearly shows

that it is in its first origin a *Ceramopora*. The smallest *Ceramoporæ* which I have hitherto seen consist of a thin circular disc with elevated edges. From the smooth centre of the superior surface four or five wedge-shaped zoœcia radiate outwards, each of a length of 1-5th millim., their mouths being oblique, with the inferior lip somewhat protracted. On both sides of the mouth there is a short, pointed spine. In its interior such a zoœcium is transversely divided by some irregular tabulæ. The interstitial tubes which are so characteristic of the *Discoporellidæ* are also distinctly seen between the zoœcia of *Ceramopora*. New zoœcia are budded forth in quincunx from the corner of the old zoœcia, and in the periphery of the colony they become more crowded, having the mouth oval and erected. In the interstices is seen what might be taken for a cœnenchyma; but this in reality is composed of nothing but smaller irregular zoœcia. When the colony has spread out laterally, there are seen at the sides of the first smooth centrum several others regularly distributed on the surface, from which zoœcia radiate just as if the disc were composed of an aggregation of coalescent initial buds. When the colony has thus gained the expanse of an inch or more, the zoœcia grow vertically upwards, and the colony by-and-by assumes a semi-globular shape, and is converted into a *Monticulipora*. All the zoœcia are then tubular, their mouths quite circular, and armed with a pair of very short spines, their size varying in different cases. The larger zoœcia have around them either an empty space, or, as above stated, a cellular tissue resembling a cœnenchyma, and consisting of smaller circular or polygonal tubes. The walls of the zoœcia are solid, without any perforations, and interiorly quite smooth and destitute of projecting ridges or septa. The tabulæ are very irregular in the large tubes, being oblique or deeply sunk in the wall; in the narrower tubes they are dense and regular. The large zoœcia are clustered in groups at tolerably regular intervals, each group of six or eight members. In Upper Silurian specimens they very seldom project above the surface, and do not form the strange monticules which are so common

on the surface of the Russian Lower Silurian specimens.[1] I suppose that these clusters are continuations from the original and larger zoœcia, which were budded out round the smooth centra when the colony was in its *Ceramopora* stage. In some there is seen a sort of 'reversion,' the zoœcia on the surface of *Monticulipora* having again assumed the unmistakable characters of Bryozoön, becoming oblique and radiating as in a *Ceramopora*. Longitudinal sections, however, demonstrate that there is a direct continuation from the tubes of the *Monticulipora* into those of the *Ceramopora*, or that the former again have changed into the latter."

Having thus described what he believes to be the mode of development in *Monticulipora petropolitana*, Pand., Dr Lindström proceeds to give an account of the development of a Silurian fossil which he terms *Monticulipora ostiolata*, and which he identifies with the *Trematopora ostiolata* of Hall (Pal. N.Y., vol. ii. p. 152, Pl. XL. fig. 5), with the *Nebulipora papillata* of M'Coy (*M. papillata*, E. and H., Brit. Foss. Cor., p. 266, Pl. LXII. fig. 4), and with *Thecostegites hemisphæricus* of Ferd. Roemer (Sil. Faun. Tennessee, p. 25, Pl. II. figs. 3, 3 *a*). This form is stated by Dr Lindström to commence its existence as a *Discoporella*, and then to pass into what may be called the "*Fistulipora* stage," each cell being now "surrounded by a mass of small vertical, circular, or polygonal tubes having the appearance of a cœnenchyma," and all the tubes, both large and small, being "traversed by tabulæ of the same incomplete type as those which characterise *Monticulipora*."[2] From this "*Fistulipora* stage" the colony is stated to pass next into what Dr Lindström calls the "*Thecostegites* stage," in which the in-

[1] It is probable that Dr Lindström is in error in supposing that the Upper Silurian specimens to which he here alludes are really identical with *M. petropolitana*, Pand., as the latter would seem to be really an exclusively Lower Silurian species; but as I have not seen his specimens, I can only express myself on this point with much diffidence.

[2] I do not understand precisely what Dr Lindström may mean by "incomplete" tabulæ; but the tabulæ of almost all the *Monticuliporæ* that I have examined, except *M. frondosa*, D'Orb., *M. Selwynii*, Nich., and certain allied types, are just as "complete" as they are in the typical members of the *Favositidæ*.

terstitial tubes become covered with "a thin smooth calcareous membrane," leaving the larger tubes open, and causing their mouths to assume a circular or oval shape, and to project above the general surface. Lastly, the colony is said to change into a *Monticulipora* by the development of regular "monticules," which are "arranged in quincunx, and formed at the points where seven or eight large cells are clustered."

In the preceding I have endeavoured to give a faithful account of the views which Dr Lindström has published as to the development of the *Monticuliporæ*, and upon which he, in large part, bases his view that the fossils of this genus are really *Polyzoa*. Not having had the opportunity of personally examining the specimens upon which his views are based, it would be presumption on my part were I to impugn the accuracy of the description which he has given of the phenomena which he has observed—the more so as his justly deserved reputation is a guarantee that he has not arrived at the conclusions in question without sufficient consideration. At the same time, I regret to find myself in the meanwhile unable to accept these conclusions; and though I cannot here enter into the subject at length, I may just briefly indicate the principal reasons which lead me to dissent from the views of such a high authority upon this and kindred questions. In the first place, then, it is clear that the study of the development of a fossil organism is attended with difficulties much more serious than those which are incidental to a similar investigation in the case of a living animal; since in the latter it is generally possible to trace the actual transition from one stage of growth to another. This, by the nature of the case, is rarely—one might almost say never—possible in the case of a fossil. It is true that in the passage of what he has termed the "*Fistulipora* stage" to the "*Thecostegites* stage," Dr Lindström states that he has actually seen the same specimen exhibiting the characters of both stages in different parts of its skeleton. Still the passage between the two stages just referred to is a comparatively small step to make, and it does

not affect the fact that Dr Lindström has not observed—so far as I am able to understand his very clear account—the actual transition between an undoubted *encrusting Ceramopora* and an undoubted *free* and discoidal specimen of *Monticulipora petropolitana*, Pand. He has examined certain specimens which show characters linking the one on to the other; but I do not understand him to assert that he has examined specimens which in one portion show the unmistakable characters of *Ceramopora*, and which in another, demonstrably older portion, exhibit the features proper to *Monticulipora*. I cannot, however, accept any specimens except such as exhibit as *individuals* the characters of the two types, as being proof that either of the types in question has been developed out of the other. In the second place, apart from this general argument, which may easily be pushed too far, there are very strong grounds for regarding *Ceramopora* as an independent organism quite distinct from all the forms of *Monticulipora*. Thus *Ceramopora* is most abundant in Upper Silurian and Devonian strata, in which *Monticuliporæ* are comparatively rare fossils, while the genus is but poorly represented in Lower Silurian strata (such as the Cincinnati formation in North America), in which *Monticuliporæ* are excessively abundant. An additional proof of the distinctness of *Ceramopora* is found in the fact that it grows to a large size, preserving unchanged its normal and proper characters, while the general structure and form of its tubes are markedly unlike those of the corallites of the *Monticuliporæ*, being reclined, with oblique and often crescentic mouths, and being either devoid of tabulæ, or possessing but a small number of these structures. (A few tabulæ are present in *Ceramopora Ohioensis*, Nich., and they exist in larger numbers in what is probably an undescribed species of the genus from the Wenlock Limestone of Dudley; but I have not detected them in the more typical *C. Huronensis*, Nich., and in similar thin encrusting forms.) Moreover, the colonies of *Ceramopora* are usually (always ?) *fixed*, being attached parasitically by a portion or the whole of the lower surface to some foreign body;

whereas the corallum in the discoid species of *Monticulipora*, supposed to be developed out of the former, is usually and normally *free;* but it is very difficult to explain this fact if there be any developmental relationship between the two. Thirdly, as regards matters of actual observation, I have never been able to detect anything of the nature of a "*Ceramopora* stage" in young *Monticuliporæ*. This is a point which is most easily observed in young examples of the discoidal species of *Monticulipora*, such as *M. petropolitana*, and the various forms allied to this; and I can only say that the most minute examples of these forms which have come under my notice differ in no respect whatever, that I can detect, except size, as regards their external and internal characters, from fully-grown specimens. Fourthly, if it were the case that discoidal species of *Monticulipora*, such as *M. petropolitana*, Pand., grew out of the thin parasitic crusts to which Hall applied the name of *Ceramopora*, we ought to be able to detect the primitive "Ceramoporoid" portion of the colony at the base of thin vertical sections of colonies of the former. I have, however, examined a large number of such sections, and I have been unable to detect any difference in the structure of the lowest portion of the tubes, resting directly upon the basal epitheca, as compared with that of the fully-grown portion of the corallites. Dr Lindström states that the basal surface of a *Monticulipora*, when its epitheca is very thin, "clearly shows that it is a *Ceramopora;*" but I am unable to concur in this statement. If the specimen be undoubtedly one of *Monticulipora*, then I have never seen anything in its epithecal surface which could be compared with the structure of *Ceramopora*. All that can be said, in my opinion, on this point is, that we meet in the Palæozoic rocks with specimens of the thin discoidal epithecæ of certain fossils (the *Lichenaliæ* of Hall), which *look* like the under surface of the epithecal plate of *Monticulipora petropolitana*, Pand., but which might be really referable to quite different forms (as many of them *certainly* are), and which mostly cannot, without the preparation of thin sections, be

definitely referred either to the *Cœlenterata* or the *Polyzoa*. Lastly, as regards the assertion that certain *Monticuliporæ* pass through a "*Fistulipora* stage," and the apparent conclusion therefrom that *Fistulipora*, M'Coy, is only a temporary condition of *Monticulipora*, I think it may be said that the point at issue is narrowed essentially to a question of words; for, in one sense, it may be said that the great majority of the *Monticuliporæ* are truly *Fistuliporæ*. That is to say, I think it can be shown that the forms which M'Coy included under the name *Fistulipora*, and which Hall has subsequently termed *Callopora*, are, theoretically, mere subgeneric forms of *Monticulipora*. It is certain, namely, that the possession of a dimorphic corallum is a common feature in most of the *Monticuliporæ* properly so called, and that the *Fistuliporæ* are only peculiar in the fact that they exhibit a special development of the smaller tubes of the corallum. If this be admitted, it is clear that the passage of a given species of *Monticulipora* through a "*Fistulipora* stage" is a matter of comparatively small importance—from a theoretical point of view. At the same time, there is at present no reason to doubt that the forms included under the names of *Fistulipora*, M'Coy, and *Callopora*, Hall, have a real existence, in so far that the characters which distinguish these types are not of a merely temporary and transient nature, but that they exist in unquestionably adult examples; so that the retention of the *name Fistulipora*, as indicative of a distinct and recognisable group, is, at any rate, capable of justification, if only upon the score of practical convenience.

AFFINITIES AND ZOOLOGICAL POSITION.

As regards the *zoological affinities* of the Monticuliporoids, there has been of late years, as is well known, a strong tendency on the part of palæontologists to remove them from the *Cœlenterata*, and to place them among the *Cyclostomatous Polyzoa*. The only positive and *direct* evidence in favour of

this step, so far as I am aware, is to be found in the account of the development of the *Monticuliporæ* as given by Lindström, and I have above stated the reasons which prevent me from accepting that account. Apart from this, the chief grounds for placing *Monticulipora* among the *Polyzoa* seem to be based upon its resemblance to the genus *Heteropora*, De Blainv., which is a familiar Secondary and Tertiary fossil type, and of which at least two living species are now known to exist (see Waters, Journ. Roy. Micr. Soc., vol. ii. p. 390, Pl. XV., 1879; and Busk, Journ. Linn. Soc., vol. xiv. p. 724, Pl. XV., 1879). Under these circumstances, it will be advisable to append here a description of the external and internal characters of the genus *Heteropora*, so as to enable some conclusion to be formed as to the extent and validity of any affinities which may subsist between it and *Monticulipora*, D'Orb.; and I am enabled to do this with some advantage, as I possess specimens of one of the recent species of the genus (viz., the form described by Prof. Busk under the name of *H. neozelanica*, which name seems to be really only a synonym of the previously recorded *H. pelliculata*, Waters), and as I have submitted these specimens to a careful microscopical examination by means of thin sections,[1] the results of which have been published elsewhere (Ann. Nat. Hist., ser. 5, vol. vi. p. 329, 1880) and are here reproduced.

The genus *Heteropora* is thus defined by Professor Busk in his classical 'Monograph on the Fossil Polyzoa of the Crag' (1859):—

"Polyzoarium erect, cylindrical, undivided, or branched; surface even, furnished with openings of two kinds; the larger representing the *orifices* of the cells, and the smaller the *ostioles* of the interstitial canals or tubes."

[1] Mr Waters informs me, in a letter, that having examined specimens which I had sent him, he is of opinion that *H. neozelanica*, Busk, is identical with his previously described *H. pelliculata*. This conclusion is doubtless correct; but as Mr Waters has not yet published his view, and as Professor Busk has therefore had no opportunity of expressing a revised opinion on this point, I continue in the meanwhile to use the former name for my specimens.

The essential character of the genus is thus the possession of a skeleton made up of *two* kinds of tubes, larger and smaller, the latter being the most numerous. The former have always been regarded as the proper *zoœcia;* but the relations of the interstitial tubes or "*cancelli*" to the rest of the organism have not been as yet satisfactorily established, though they have been usually regarded as serving in some way to place the cavities of the polypides in direct communication.[1] With regard to the internal structure of the genus, the existence of cross partitions or "tabulæ" in the tubes was long ago pointed out by Jules Haime, as regards his *H. conifera* and *H. pustulosa* (Mém. de la Soc. Géol. de France, vol. v. p. 208, 1854). Mr Busk (Crag Polyzoa, p. 122) pointed out that the cancelli enter not at all or rarely into the central axis of the branches of the skeleton, this being made up of the thin-walled and polygonal proper zoœcia. The same observer also pointed out that the "ostioles," or apertures of the cancelli, are often "completely closed by a calcareous depressed lid, which in the majority of cases, however, is perforated in the middle;" and he expressed the belief that "the remains of these hymen-like lids," left behind at successive stages of growth, might probably account for the existence in the interstitial tubes of some species of "partial transverse, nearly equidistant septa," giving to the tubes in question a "peculiar moniliform aspect." Mr Busk further indicated that in one species of the genus (viz., *H. clavata* of the Crag) "the interstitial orifices, or many of them, exhibit a stellate appearance, owing to the projection into their interior of numer-

[1] As the difference between the cancelli and the proper zoœcia is one of size and shape merely, and as both sets of tubes are precisely alike in their internal structure, it may be regarded as tolerably certain that the former were occupied by a set of zoöids essentially similar to those inhabiting the zoœcia, but modified or specialised in some way. On this view the colony would be a truly dimorphic one. As for the perforated calcareous or chitinous opercula covering the mouths of the cancelli in parts of the skeleton (as described by Waters), we may suppose that these do not exist to begin with, but that they are developed in the last stages of the life of the zoöid, and that they are produced successively from below upwards as the area of active vitality is successively carried further from the fixed base of the organism (as we see to be the case in the coralla of various species of *Favosites*).

ous minute rays—affording thus another curious, false resemblance to a true coral." With this exception, nothing which could be compared with the "septa"[1] of the Cœlenterata has, until lately (so far as I am aware), been noticed as occurring in *Heteropora*.

The above are the most important structural features which had been brought to light by the study of the fossil species of *Heteropora;* but our knowledge of the anatomy of the genus has been greatly extended by the investigation of recent species by Mr Waters and Professor Busk, as already referred to. The leading additional character which has been thus brought to light is that the walls of the zoœcia and cancelli (in the outer portion of their course) are perforated by numerous canals, which open into the cavities of the tubes by well-defined circular openings, thus placing contiguous tubes in direct communication.

Having now shortly passed in review some of the more important characters of *Heteropora*, so far as our present inquiry is concerned, I may next give a short account of the general features of *H. neozelanica*, Busk, before describing in greater detail its minute internal structure. The zoarium of this species (fig. 8, A) is "erect, composed of short divergent branches springing from a short thick stem, and soon dividing once or twice dichotomously, and terminating in blunt rounded extremities. The diameter of the primary branches is .2 inch, and of the terminal ones about .1 to .15 inch. The surface presents orifices" (see fig. 8, B and C) "of two kinds, though scarcely distinguishable in size. The larger ones, in the older parts of growth, have a slightly raised peristome and

[1] Professor Busk, in his descriptions of the species of *Heteropora*, frequently employs the term "septa" to indicate the *transverse* plates which intersect the tubes of certain forms of the genus. Mr Waters has followed Professor Busk in this, or has sometimes employed the term "dissepiments" for the same structures. It need hardly be pointed out that these terms have such a totally different significance among the Cœlenterata, that their use in this connection is undesirable, and is apt to lead to confusion. The term "*septa*," in fact, should be in all cases confined to the *radiating* and *vertical* elements of a calcareous skeleton; and the plates so named in *Heteropora* are the analogues of the "*tabulæ*" of the Cœlenterates.

are quite circular; the others (*cancelli*), disposed more or less regularly round these, generally to the number of seven or eight, are more or less angular, and the border of the opening is never raised" (Busk, *loc. cit.*)

Mr Busk considers his *H. neozelanica* to be probably distinct from *H. pelliculata*, Waters, on the ground (1) of certain differences in the general form of the polyzoary, and (2) of the absence in the former of any external calcareous pellicle covering the surface, though there exists, in perfectly preserved parts of the specimen described, a thin chitinous covering closing the mouths of the tubes. Mr Waters, as before remarked, is inclined to believe that the two forms are

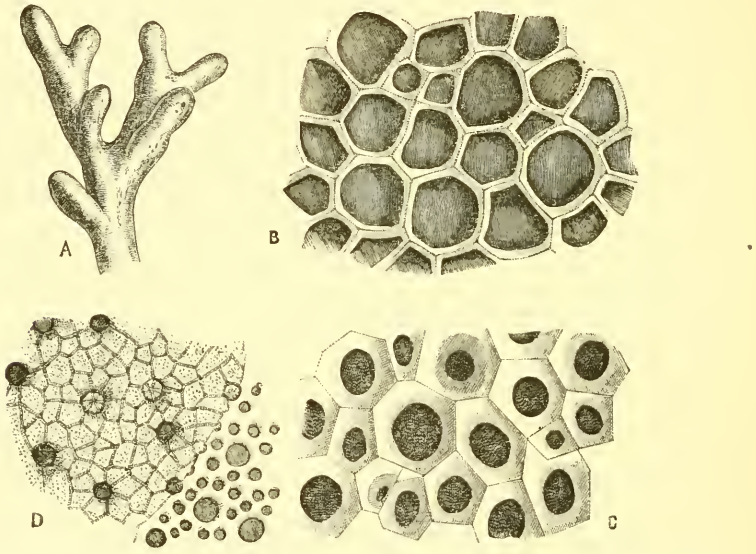

Fig. 8.—A, A fragment of the polyzoary of *Heteropora neozelanica*, Busk, of the natural size (original). B, A portion of the surface of the same, apparently somewhat altered by maceration in sea-water, greatly magnified (original). C, A portion of the surface of the same (copied from Busk), apparently in a more nearly natural state, greatly magnified. Both B and C show the apertures of the zoœcia and cancelli. D, Portion of the surface of *H. pelliculata*, Waters (copied from Waters), enlarged 25 times, and showing the zoœcia and cancelli. In the upper part of the figure the cancelli (and the zoœcia partially) are closed by a calcareous pellicle, which is wanting on the right-hand side of the figure.

identical, in which case the name *H. neozelanica* will have to be abandoned. In fig. 8, B and C, I have figured the two states of the surface which my specimen of *H. neozelanica*

exhibits, one of these being a reproduction of the excellent figure given by Professor Busk (*loc. cit.*) I have also reproduced the figure given by Mr Waters of the surface of *H. pelliculata*, as it shows characters which merit a moment's attention in this connection. The left-hand portion, namely, of this figure (fig. 8, D) shows the mouths of the interstitial tubes or cancelli, as well as some of those belonging to the proper zoœcia, to be closed by a thin calcareous pellicle, which is left after incineration, and which exhibits the peculiarity that it is perforated with numerous minute apertures opposite to the mouth of each of the interstitial tubes. The right-hand portion of the same figure shows the character of the surface, where the pellicle just alluded to has been removed. There can be no question that the existence of such a calcareous (or more usually chitinous), surface-pellicle, closing the cell-mouths, is a feature which speaks strongly for Polyzoan affinities; but it should not be entirely lost sight of that very similar structures occur in certain extinct types which would almost universally be referred to the corals, and which, at any rate, are very unlike the ordinary forms of Polyzoa. Thus it is well known that various species of *Favosites* (such as *F. Forbesi*, Ed. and H., var. *tuberosa*, Rominger, *F. turbinata*, Billings, and *F. clausa*, Rominger) are liable to have the mouths of the corallites closed by a calcareous pellicle, which may cover a large part of the surface of the colony.

It only remains to add, with regard to the general external characters of *H. neozelanica*, that the mouths of the tubes, even when fully exposed by maceration in sea-water (as in fig. 8, B), do not appear to show any signs of radiating spines ("septa"), though, as will be subsequently seen, such really exist in the interior of the cells. It may also be noted, as compared with any ordinary Monticuliporoid, that though the skeleton is clearly dimorphic, in the sense that it is made up of two sets of tubes, the difference between the large tubes (zoœcia) and the small ones (cancelli) is slight and sometimes

hardly recognisable. The cancelli, in fact, are often nearly or quite as large as the proper zoœcia (see fig. 8, B and C); and the chief distinction between them rests upon the generally more clearly angular shape of the former, and upon their mouths not being at all raised above the general surface. As regards the *internal structure* of *Heteropora neozelanica*, the skeleton, as of the species of *Heteropora* generally, is ramose or dendroid; and the branches resemble those of any similarly shaped coral in being composed of fasciculate tubes which are nearly vertical in the axis of the branch, but ultimately bend outwards to reach the surface. We can thus divide each branch into an *axial* and a *peripheral* or *cortical* portion; and not only do the tubes in these two portions of their course differ in *direction*, but they are markedly different (as we shall see) in their actual *structure*. That is to say, the structure of any particular tube is exceedingly different, according as we examine it in the axial or in the cortical part of its course. Moreover, it is in the cortical portion of the skeleton alone, or almost alone, that the interstitial tubes are developed, the axis consisting wholly, or almost wholly, of the proper zoœcia. We cannot, therefore, arrive at a proper understanding of the true structure of *Heteropora* (or of any similarly constructed skeleton) without making *three* distinct sections,—viz., one parallel to the surface *and just below it*, which we may call *tangential*, and which is the most important of all, as giving us the cross section of the tubes in their final and most fully developed condition; secondly, one at right angles to the branch (a *transverse* section); and thirdly, a *longitudinal* section, dividing the branch vertically through its median plane. The following are the principal points brought to light by an examination of these three sets of sections in *H. neozelanica*:—

(a) *Tangential Sections.*—As just remarked, there are no sections which yield more interesting and valuable results than those which intersect the skeleton tangentially, just below the surface upon which the tubes open. When we examine

such a section (fig. 9, A), we observe that it is generally quite

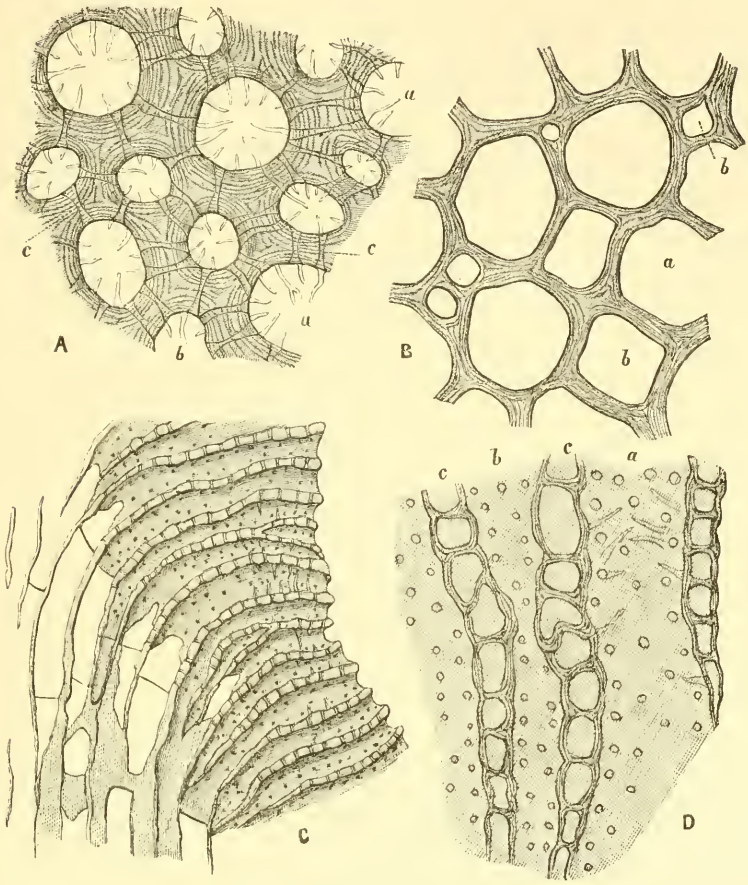

Fig. 9.—Thin sections of *Heteropora neozelanica*, Busk (recent). A, Part of a *tangential* section taken just below the actual surface, enlarged 50 times. The zoœcia are cut across in their outer thickened portion; and the canaliculi traversing their thick walls and communicating with the smaller interstitial tubes are well shown, as are the delicate radiating spines projecting into the cavities of both the sets of tubes. B, Part of a *transverse* section of a branch, showing the thin-walled angular condition of the zoœcia in the *axis* of the stems, the comparative paucity of interstitial tubes, and the total or almost total absence of connecting canaliculi in this region (enlarged 50 times). C, Part of the median *longitudinal* section of a branch (enlarged 18 times), showing principally the outer thickened portions of the zoœcia. The section shows distinct cross partitions (or "tabulæ") crossing the cavities of the tubes towards the deeper parts of the branch, as also the canaliculi crossing the walls, and the pores representing the openings of these on the backs of the tubes. D, Part of a transverse section in its outer portion, where the zoœcia are laid open *longitudinally* (enlarged 50 times). The section shows the peculiar structure of the thickened walls and the canaliculi crossing these. A few of the delicate radiating spines are also seen. *a a*, The proper zoœcia; *b b*, The interstitial tubes; *c c*, The walls, with the connecting canaliculi.

possible to distinguish the proper zoœcia from the interstitial

tubes by their size, but that these two sets of tubes are in no way distinguished from one another in point of structure, while their dimensions are often very nearly the same. The tubes are all rounded; and their walls are very thick, and are composed of delicate calcareous laminæ arranged concentrically around the cavity, and not showing any line of demarcation between each other. In this respect the walls have the structure of such species of *Monticulipora* as *M. ramosa*, *M. Jamesi*, &c., and differ altogether from such other species as *M. pulchella*. The most remarkable feature, however, in the structure of the wall consists in the presence of numerous canaliculi, which pass transversely across the thickened wall (fig. 9, A) and open at both ends by wide funnel-shaped apertures into the cavities of the tubes. In this way the zoœcia and interstitial tubes are placed in direct and free communication with one another throughout the entire colony. Sections of this nature also prove with absolute certainty that these canaliculi are strictly confined to the *walls* of the tubes—a point upon which, as will be seen, longitudinal sections might leave us in some doubt.

Another very interesting and important point brought out by tangential sections is, that both the zoœcia and cancelli are provided in this part of their course with numerous delicate radiating spines, which spring from the wall (fig. 9, A) and are directed inwards for a longer or shorter distance, usually falling short of the centre. I am not aware that the presence of these radiating spinules has hitherto been recognised as occurring in the zoœcia of the recent *Heteroporæ*, or in the extinct forms, except in *H. clavata*, Goldf. (according to Busk), and then only at the mouths of the interstitial tubes.[1] In *H. neozelanica* they are very slender and delicate, and often break up in thin sections, so that they may appear to be wanting in a greater or less number of the tubes; but I have never failed to

[1] Mr Waters has pointed out to me that he has described delicate radiating spines as occurring in the "cancelli" of *Discoporella radiata*, as well as in other species of the same genus. ("On the Bryozoa of the Bay of Naples," Ann. Nat. Hist., ser. 5, vol. iii. p. 276. 1879).

recognise their existence in some part or another of tangential sections, and have no doubt that they are in this species really present throughout the whole of the peripheral part of the skeleton. Their special interest arises from their being in appearance precisely similar to the "septal spines" of so many species of *Favosites* (using the term "septal" in its proper signification).

(b) *Transverse Sections.*—The appearances presented by transverse sections vary according to the part of the section which may be looked at. The central portion of such a section exhibits the tubes in the axial portion of the branch divided at right angles. In the circumference of the section, on the other hand, the tubes are divided more or less nearly longitudinally, owing to their curvature on nearing the surface; while this part also shows them in the thickened condition which they possess in the cortical portion of the branch. The appearances presented by the periphery of transverse sections are therefore the same as those shown in the corresponding region in *longitudinal* sections, and need not be considered till we come to speak of the latter. In the central region of a transverse section (fig. 9, B) we can study the condition of the tubes in the axis of the branches before they bend outwards to the surface; and we find that their structure is very different from that which they possess in the cortical region (as seen in tangential sections). Instead of being rounded and thick-walled, and provided with a largely developed canal-system, they are now thin-walled, and angular or polygonal in shape, and the canaliculi of the wall seem to have totally (or almost totally) disappeared. There is also an apparent total absence of the radiating spines which are developed in the cortical part of the tubes. Lastly, the tubes in this region appear to be almost entirely, or entirely, referable to the proper zoœcia, the interstitial tubes or cancelli existing only, or mainly, in the cortical region.

(c) *Longitudinal Sections.*—These show precisely the same differences, as regards their central and peripheral portions, as

have been already noted in transverse sections; but it is now necessary to briefly direct attention to both parts of the section (fig. 9, C and D). In the central portion of the section (supposing the slice to be taken in the median plane) the tubes are seen in the *axial* portion of their course, where they are nearly vertical, and where they exhibit the features which I have pointed out as characterising them in the central region of transverse sections. That is to say, they are here provided with thin and delicate walls, in which the canal-system of the cortical region seems to be very slightly developed or wanting. The chief point to notice about the tubes in this part of their course (and it is one that I have never failed to recognise) is, that their cavities are here crossed by transverse calcareous plates or "tabulæ" (the "septa" of Professor Busk and Mr Waters), which, though few in number, are "complete" and in every way well developed (fig. 9, C).

On the other hand, in the peripheral portion of their course (where the appearances are precisely the same as in the corresponding region of a transverse section) the tubes have very much thickened walls, and the walls are crossed at right angles by numerous canaliculi, which open at both ends into the cavities of the tubes by trumpet-shaped apertures. In all parts of the section, also, where the inner surfaces of the tubes are brought into view, these exhibit numerous rounded apertures or pores, which represent the mouths of the said canaliculi, and which have been well described and figured by Professor Busk and Mr Waters (*loc. cit.*) It is very difficult in the outer part of these longitudinal sections to distinguish between the proper zoœcia and the interstitial tubes or cancelli, their size being very much the same, and their internal structure being exactly alike; and this leads me to make a few remarks upon another point. When, namely, such a section as I now speak of is examined with the ¼-inch objective, it is seen that the wall separating contiguous tubes exhibits a central light space, limited on both sides by dark and definite boundaries, and crossed by the transverse canali-

culi which have been already described (fig. 9, D). There is thus created an appearance of a central tube in the interior of the wall; or rather, what I have here described as the *wall* might possibly be taken to be really *one of the smaller interstitial tubes divided longitudinally*. Apart, however, from the difficulty of conceiving how the canaliculi could be continued across and through the *cavity* of an interstitial tube, we have in tangential sections, as previously remarked, the conclusive proof that this is not the case, but that we really have to deal with the wall of the tubes. These sections, in fact (fig. 9, A), prove beyond a doubt that the canaliculi are entirely confined to the *walls* separating contiguous tubes, whether these be the proper zoœcia or the cancelli.

So far as I have seen, no "tabulæ," or but an occasional one, seem to be developed in the outer thickened portion of the tubes; but it is often possible to recognise the delicate radiating spines or "septa," which are so well displayed in tangential sections. Lastly, owing to the unequal thickening of the walls of the tubes, it is not uncommon for the longitudinal section of their cavities to assume a beaded appearance, though this is not constant, and, when present, varies much in amount.

Having now fully considered the structural characters of a recent species of *Heteropora*, it may be as well to summarise the chief points of resemblance and difference between *Heteropora* and *Monticulipora*, and to state the general conclusions at which I have arrived as regards the possible relationship of these two genera to one another:—

(1) As to the general *form* of the skeleton, the two genera are very similar, though this point is of itself wholly without significance, and the latter genus comprises types of very varied shape and mode of growth. If, however, we compare *Heteropora* with the ordinary dendroid types of *Monticulipora*, we have in both a skeleton made up of slender fasciculate tubes, which are nearly vertical in the centre of the branches, and then curve outwards, gently or abruptly, to reach the

surface. In both, therefore, there are established two distinct regions of the colony, an axial and a peripheral region. In both, moreover, these two regions are very different in internal structure, the tubes in the axial region of their course being thin-walled and polygonal, while in the peripheral region their walls are thickened, and they often become more or less rounded in form. In both, further, it would appear that any special interstitial tubes that may be present are developed in the peripheral region only, and extend either not at all, or to a very limited extent, into the axial part of the corallum.

(2) As regards the *dimorphism* of the corallum, all the most characteristic and typical species of *Monticulipora* consist of at least two, and sometimes of three, distinct sets of tubes, which generally differ both in size and in internal structure, and which are differently arranged in different cases. In *Heteropora* the skeleton consists of a series of large tubes surrounded by smaller interstitial tubes; but it does not appear that there is any special difference in the *internal structure* of these. In neither genus are we acquainted with the *soft parts;* and therefore we cannot assert positively that this dimorphism has precisely the same significance in the two genera, while there are grounds for thinking that the reverse is the case.

(3) As regards the structure of the *wall*, the visceral cavities of the tubes of *Monticulipora* appear to be always closed, no traces of any pores or canals in the wall having yet been clearly proved to exist. In the case of *Heteropora*, on the other hand, the thickened walls of the tubes, in the peripheral part of their course, are traversed by an exceedingly well-developed series of transverse *canaliculi*, which open into the cavities of the tubes by definite *pores*, and which thus place the body-chambers of contiguous zoöids in direct communication. These "canaliculi" differ structurally from the "mural pores" of the Favositidæ chiefly in being tubes with definite walls and dilated extremities, instead of being mere circumscribed deficiencies in the wall.

(4) No radiating "septa," in the form either of spines or of

lamellæ, are known to exist in any species of *Monticulipora*. In some species of *Heteropora*, on the other hand, the tubes, in the peripheral part of their course, are intersected by numerous delicate spinules, which are arranged in a radiating manner, and reach a considerable distance into the body-chamber (sometimes nearly to its centre). These spinules in form and arrangement precisely resemble the "septal spines" of many species of *Favosites;* but, admitting the Polyzoan affinities of *Heteropora*, it is obvious that they cannot be compared homologically with the septa of any Cœlenterate.

(5) Transverse partitions, or "tabulæ," are universally developed in the corallites of *Monticulipora;* and it is very common for the different kinds of tubes which make up the corallum to show marked differences in the nature and degree of their tabulation. In *Heteropora neozelanica*, Busk, tabulæ are, so far as I have seen, always present, though their number is comparatively small. They are also undoubtedly present in other species, and in greater numbers (*e.g.*, in *H. conifera*, Haime, and *H. pustulosa*, Haime). So far as *H. neozelanica* is concerned, the tabulæ seem to be confined to the axial region of the corallites, and not to be developed in the interstitial tubes at all, thus differing in both of these respects from the tabulæ of *Monticulipora*. As in the case of the radiating spines, however, just noticed, if we concede the Polyzoan affinities of *Heteropora*, then the transverse partitions which cross its tubes must have a different value and import from the "tabulæ" of *Favosites* and of the so-called "Tabulate Corals" in general.

(6) Lastly, as to the supposed relationship between *Monticulipora* and *Heteropora*, and as to the deduction which has been drawn from this as to the propriety of referring the former genus to the Polyzoa, it is clear that the points of likeness between the two are by no means so weighty as the points of difference. On the one hand, we have a strong external resemblance, a general similarity in the mode of construction of the skeleton, and an agreement in the fact that

in both genera the colony consists of two sets of tubes, while both have their tubes crossed by transverse partitions. Such transverse partitions of the tubes (or, as we may loosely call them, "tabulæ") occur, however, in organisms of such exceedingly diverse affinities, that we can, admittedly, attach no value to the last mentioned of the above resemblances. A mere similarity in general form, appearance, or mode of skeletal conformation is also of no classificatory weight, since we could find species of *Favosites* or *Pachypora* which in these respects are quite like either *Monticulipora* or *Heteropora*; so that, after all, the resemblances between the two genera under consideration dwindle down to a comparatively small quantity.

On the other hand, to set against the mostly superficial points of resemblance above noted, we have a number of fundamental structural differences. Thus, in *Monticulipora* the walls of the tubes are imperforate, there are no traces of radiating spines or "septa," and in the dimorphic or trimorphic species there are usually important structural differences as regards the different groups of corallites. In *Heteropora*, on the contrary, the walls of the tubes are traversed by a very remarkable and exceptionally developed canal-system, the tubes possess in their outer portions a well-developed series of radiating spines arranged in vertical rows (sometimes, at any rate, if not always [1]), and the interstitial tubes are in no way structurally different from the proper zoœcia.

In the face of the above distinctions, I feel compelled to believe, in the meanwhile, that there is no real relationship at all between *Heteropora* and *Monticulipora*. This belief would not, of course, constitute any valid ground for denying

[1] It is true that radiating spines have not generally been observed in *Heteropora*, and that even in *H. neozelanica*, where they are plentifully developed, they seem not to have been noticed by such excellent observers as Professor Busk and Mr Waters. I ascribe this, however, to their very fragile nature, and to the general neglect of *tangential* sections, in which alone they can be readily made out; and I entertain little doubt that they occur generally in the genus.

the possibility that *Monticulipora* may truly belong to the Polyzoa rather than to the Cœlenterata; and on this point I prefer at present to come to no absolutely final conclusion, though my opinions lean decidedly towards the latter as a proper resting-place for the genus. It must, however, be evident, that in supporting (as many palæontologists now do) the Polyzoan affinities of *Monticulipora*, little or no weight can in future be attached to the likeness which the genus shows to *Heteropora*. It may be also pointed out that, in our present ignorance of the *animal* of *Heteropora*, it is perhaps not entirely without hazard that we should unhesitatingly assign *it* to a place among the Polyzoa. I do not at all overlook its resemblance to many undoubted Cyclostomatous Polyzoa, nor am I in any way prepared to deny its Polyzoan affinities; but I cannot entirely ignore the fact that the pore-canals, septal spines, and tabulæ, which are now known to exist in some species of the genus *Heteropora*, are, at any rate, as reconcilable with its reference to the Cœlenterata as to the Polyzoa.

(7) Leaving *Heteropora* out of sight, there are no other forms of the *Polyzoa* to which *Monticulipora* makes such a near approach as to render any very close comparison necessary. In any case, also, it is clear that very little weight indeed can be attached to mere external resemblances in form and general aspect in a matter of this kind. Thus we find the common *Favosites Canadensis*, Billings, sp., of the Devonian of Canada, to be so entirely similar in the form and appearance of its colonies to examples of *Fistulipora*, M'Coy, that it was unhesitatingly referred to this genus (which Dr Lindström regards as clearly Polyzoan) by Mr Billings and myself. Dr Rominger, however, showed that it has "mural pores" of the regular *Favositoid* type — a discovery which I have myself verified—so that in place of being a *Fistulipora*, and therefore, according to Dr Lindström, a Polyzoön, it is a true Perforate Coral. A position among the *Favositidæ* has similarly been now established as the right one for *Stenopora*, Lonsd.,

which includes forms so like *Chætetes* and *Monticulipora* in general aspect as to have been commonly included under one or other of the latter heads. Apart from mere superficial appearances—which in this case speak at least as strongly for a Cœlenterate as a Polyzoan alliance—there is nothing in the actual structure of *Monticulipora* which would not entirely agree with its being a coral. The only point which could be mentioned which would in any fundamental manner distinguish the internal structure of a *Monticulipora* from that of, say, *Tetradium* or *Heliolites*, is the absence in the former of septa. I do not, however, attach any weight to this, partly because some undoubted corals are equally without septa, partly because the septa in *Heliolites* and its allies are now known by the researches of Moseley to be only "pseudo-septa," and partly because I do not think that any important change in classification should be based upon a merely negative character. On the other hand, there are strong resemblances between *Monticulipora* and its allies and various undoubted corals—principally, perhaps, the *Helioporidæ*. Thus the "tabulæ" of the Monticuliporoids are in all respects similar to those of such undoubted corals as *Favosites* among the *Zoantharia*, and *Heliolites* among the *Alcyonaria*. Again, there is the important character that the corallum of the Monticuliporoids can be shown to be so very commonly dimorphic, consisting of two distinct sets of corallites, of different sizes, and mostly with a different internal structure. This last character reminds us so strongly of the *Helioporidæ*—to which there are other mentionable points of likeness—that I am at present disposed to regard the *Monticuliporidæ* as an ancient group of the *Alcyonaria*, at the same time, of course, that I regard the group as a quite independent one, and as quite distinct from the former family.

CHAPTER IV.

RELATIONS OF MONTICULIPORA TO CHÆTETES, STENOPORA, TETRADIUM, CERAMOPORA, AND HETERODICTYA.

We have now considered the structure of *Heteropora*, Blainv., which, of all other types, is perhaps the one which presents the closest general resemblance to certain forms of the Monticuliporoids. There are, however, various extinct organisms which are so like *Monticulipora*, either in appearance or in actual conformation, or in both of these points, that it becomes necessary to examine how far this likeness is merely superficial, and how far it may be based upon real affinity.

Amongst the forms which require consideration in this connection, the first place must be given to those which are comprised in the genus *Chætetes*, Fischer (Oryct. de Gouv. de Moscou, p. 159, 1837). These forms, in fact, are so similar in most respects to the massive types of *Monticulipora* (such as *M. undulata*, Nich.), that it is only of late years that it has been found possible to indicate definitely the grounds upon which the latter genus might be separated with anything like scientific precision from the former. The corallum in *Chætetes*, Fischer, is massive, composed of long irregularly prismatic erect corallites, which are closely contiguous, and are completely amalgamated by means of their walls. The corallites are all of one kind, both as regards size and internal structure, and open upon the surface by irregularly polygonal non-oblique calices. There are no true *septa*, but the visceral chambers are often partially divided by an imperfect longitu-

dinal partition (or by two such partitions), resulting from the uncompleted fission of the tubes into two young corallites. Complete and remote tabulæ are also present. It will be seen from the above description how close is the general likeness between *Chætetes*, Fischer, and the massive forms of *Monticulipora*, D'Orb.; and there are only two characters by which the two groups may be satisfactorily differentiated. The most important of these characters concerns the structure of the *walls* of the corallites. Thus, in *Chætetes* it will be seen by thin sections (fig. 10) that the walls of contiguous corallites

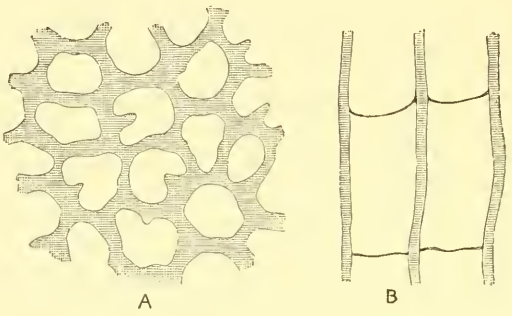

Fig. 10.—A, Tangential section of *Chætetes radians*, Fischer (var.), from the Carboniferous Limestone of Shap, Westmorland, enlarged 18 times; B, Vertical section of the same, similarly enlarged.

are invariably entirely and undistinguishably amalgamated or fused with one another, all traces of the originally duplex character of the partitions between neighbouring tubes being now lost. It is true that there are species of *Monticulipora* (as, for example, *M. tumida*, Phill.) in which the walls of contiguous tubes, as seen in tangential sections, are *apparently* fused with one another; but in such cases, we have seen that the fusion is only apparent, since *rough fractures always expose the exterior of the tubes.* In *Chætetes*, Fischer, on the other hand, the amalgamation of the walls of the corallites is shown to be real by the fact, long since pointed out by Lonsdale (Geol. of Russ., vol i. p. 595, 1845), that rough fractures expose the *interior* of the tubes. Mr Lonsdale at the same time pointed out that the corallum in *Chætetes* increases fissi-

parously, and that we might to this fact ascribe the second peculiarity of the genus—namely, the existence in many of the corallites of imperfect vertical partitions (generally one or two in number in any particular tube). These partitions appear in tangential sections of the corallum as blunt tooth-like processes projecting into the interior of the corallites (fig. 10, A), and they might be taken at first sight as being "septa." They are, however, wanting in many of the tubes; and there is little doubt that they are really due to the fact that the corallites which possess them have begun to divide by fission.

While the points above noted enable us to separate the species of *Chætetes*, Fischer, from those of *Monticulipora*, it is not so easy to definitely separate the latter from *Stenopora*, Lonsd. The typical species of *Stenopora*, Lonsd. (*non* M'Coy) possess a ramose or sublobate corallum, composed of tubular corallites, which are nearly vertical in the centre of the branches, and radiate outwards from an imaginary axis to open on all points of the free surface. In the centre of the branches the corallites (like those of the dendroid species of *Monticulipora*) are thin-walled and polygonal, but they become thickened as they approach the surface, and they are never amalgamated with one another by their walls. The thickening

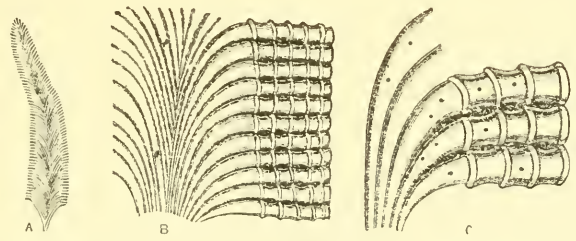

Fig. 11.—A, Portion of a branch of *Stenopora Jackii*, Nich. and Eth. jun., split open, of the natural size; B, Portion of the same enlarged, showing the annulations of the tubes in their outer portions; C, A few of the tubes of the same still further enlarged, showing the mural pores. Permo-Carboniferous formation, Queensland.

of the walls of the tubes in the latter portion of their course takes place in the same way as in many *Monticuliporæ* (*e.g.*, *M. tumida*, Phill.)—namely, by the deposition of superimposed lamellæ of sclerenchyma round the growing margins of the

corallites; but these lamellæ are produced intermittently instead of uniformly, and a marked difference in structure is thus caused. In those *Monticuliporæ*, namely, which possess thickened walls, rough fractures show that the walls of the tubes are approximately smooth and even, while longitudinal sections show that the thickening is uniformly augmented, or remains nearly the same, from the point where the tubes begin to bend outwards to their apertures (see Pl. III., figs. 1 *e*, 1 *f*). On the other hand, rough fractures of specimens of *Stenopora*, Lonsd., show that the thickening of the tubes is periodically effected, so that the outer surfaces of the tubes exhibit a number of annulations or ring-like accretions, separated by intervening flat spaces (fig. 11, B and C). Some species show this feature more conspicuously than others, but almost all (all the typical species) show the same fact in

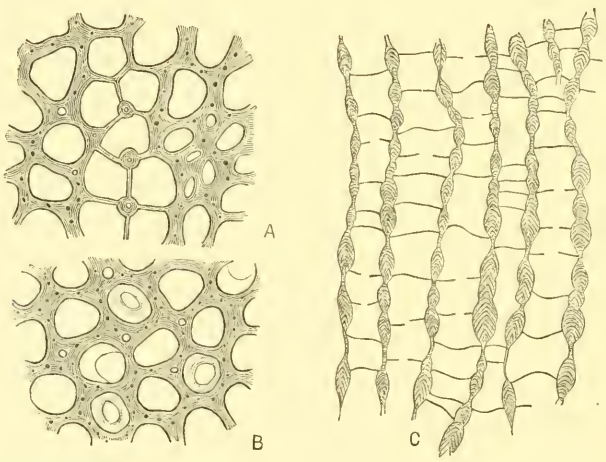

Fig. 12.—Minute structure of *Stenopora Howsii*, Nich. (spec. nov.), from the Carboniferous rocks of Redesdale, Northumberland. A, Part of a tangential section, enlarged eighteen times. B, Another part of the same section, similarly enlarged, showing the thick-walled corallites, with the numerous hollow spines in the wall. Some of the tubes also show the peculiar perforated tabulæ. C, Part of the exterior of a transverse section, where the tubes are cut longitudinally, enlarged eighteen times. This section shows the peculiarly thickened moniliform wall which is characteristic of *Stenopora*, some of the tabulæ being complete, while others show a central deficiency. (From the collection of Richard Howse, Esq.)

an even more striking and instructive manner when examined by means of thin longitudinal sections (fig. 6, A, and fig. 12.

c). In such sections the walls appear to be conspicuously moniliform, being composed of fusiform thickened regions, which alternate with comparatively delicate unthickened tracts of the wall. This peculiar structure of the wall is more or less strikingly characteristic of all the species of *Stenopora*, Lonsd., with which I am acquainted; and it constitutes the most marked structural feature, perhaps, by which we may readily separate this genus from *Monticulipora*. There are, however, other characters by which, when they can be detected, *Stenopora*, Lonsd., can be distinguished from any of the *Monticuliporoids*. The most important of these characters is the presence in *Stenopora* of "mural pores," precisely similar in their nature to the openings in the walls which go by this name in *Favosites*. Some species of *Stenopora* (as *S. Jackii*, Nich. and Eth. jun., fig. 11, c) show these pores in an unmistakable form; but they are always minute in point of size, and remote and irregularly distributed, and there are various species of the genus in which they have not yet been detected. In spite, therefore, of the fact that these apertures must always be present in the genus, it must be admitted that the difficulty which attends their recognition is so great that they are practically of little use in enabling us to distinguish the species of *Stenopora* from those of *Monticulipora*.

Another feature which is characteristic of *Stenopora* is, that many of the calices may be closed by a concave diaphragm, perforated with a central oval or circular aperture. This feature is well seen in examples of the form which I have named *Stenopora Howsii*,[1] and of which I have figured the

[1] *Stenopora Howsii*, Nich.—As this species—the only undoubted form of *Stenopora*, Lonsd., from British rocks with which I am acquainted—has not been previously described, I append here a brief diagnosis of its characters. Corallum ramose, of large size, fragments being over six inches in length, with a diameter of seven lines. Stems sub-cylindrical, with slight tumid enlargements at intervals, the branches remote, and given off alternately from opposite sides of the main stem. Large calices moderately thin-walled, polygonal, about 1-60th inch in diameter, with a larger or smaller number of intercalated minute tubules, the latter sometimes forming "maculæ" or irregular aggregations. Calices sometimes open; sometimes closed by a concave diaphragm, perforated centrally by an oval or circular aperture. Walls of the tubes periodically thickened, and annulated externally in the outer

internal structure above (fig. 12). It was also noticed by Mr Lonsdale, in his descriptions of the species upon which he originally founded the genus (Darwin's 'Geological Observations on the Volcanic Islands,' Appendix, 1844). Somewhat similar phenomena are, however, observable in some *Monticuliporæ;* and the character in question, so far as I have observed, is never more than a partial one in any species of *Stenopora.* That is to say, most of the calices in *Stenopora* will be found to be open, and it is only in some of them—generally in patches—that these peculiar perforated diaphragms can be detected. As a test of the relations of any given specimen, this character, therefore, cannot be relied upon. Another and a very striking feature, arising out of the preceding peculiarity, may be occasionally observed in longitudinal sections of the corallites of *Stenopora;* and that is, that certain of the tabulæ are perforated by a central aperture, thus showing themselves in section as two opposing ledges running out from opposite walls of the corallites, but not meeting in the centre. This remarkable imperfection of the tabulæ is one of the most striking characters of *Stenopora Howsii*, Nich.; but even this form possesses some tabulæ which seem to want this perforation (fig. 12, B), and I have not observed the same thing in any other species of *Stenopora.* Upon the whole, therefore, the most readily determinable peculiarity, and the one which appears to be most universally present, is the periodic thickening of the walls of the corallites in their outer portions in *Stenopora*, as compared with the uniform thickening, or the absence of thickening, which is characteristic of the corallites of *Monticulipora.*

The more massive species of *Monticulipora*, such as *M.*

portion of their course. Tabulæ sometimes complete, sometimes with a central perforation. No septa. Mural pores not observed.

The only specimens of this remarkable species that I have seen were collected by Mr Howse in the Carboniferous shales of Redesdale, Northumberland, and it is to his kindness that I am indebted for the opportunity of examining them. I shall describe them at greater length on another occasion; but in the meanwhile the above brief diagnosis will serve to characterise the species.

(*Monotrypa*) *undulata*, Nich., present a general resemblance to the forms which constitute the genus *Tetradium*, Dana. In both, the general aspect of the corallum is at first sight very similar, but there are fundamental differences in their internal structure. Thus, in *Tetradium* the walls of adjoining corallites are only doubtfully separate (probably they are really amalgamated, as in *Chætetes*, Fischer); while the corallites, as seen in section, have a peculiarly cruciform or petaloid form (fig. 13, B), due to the presence in each of three, or more com-

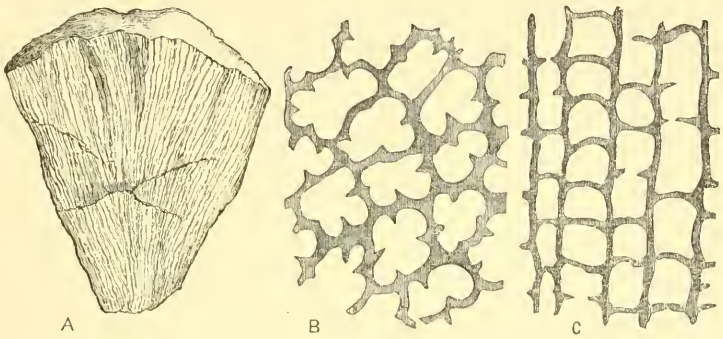

Fig. 13.—A, Fragment of a large corallum of *Tetradium minus*, Safford, from the Cincinnati Group of North America, of the natural size; B, Transverse section of the same, enlarged ten times, showing the petaloid form of the tubes and the short septa; C, Vertical section of the same similarly enlarged, showing the tabulæ.

monly four, delicate lamellar septa, which look as if they were formed by inward foldings of the wall, and which extend for a short distance only towards the centre of the visceral chamber. The tabulæ are usually complete and horizontal (fig. 13, C); and even when to some extent incomplete, they never show the peculiar structure which is characteristic of such forms of *Monticulipora* as those constituting the sections *Prasopora* and *Peronopora*. Moreover, the corallites of *Tetradium* are all of one kind, and there are none of the closely tabulate interstitial tubuli which form such a conspicuous feature in most Monticuliporoids.

From all the *Helioporidæ*, the Monticuliporoids are fundamentally separated by the total want of pseudo-septa in the large corallites of the colony. In other structural features,

many Monticuliporoids, especially those which are referable to *Fistulipora*, M'Coy, present a close general likeness to *Heliolites;* and it was not without considerable apparent reason that Milne-Edwards and Haime regarded the *Fistuliporæ* as referable to the same group as *Heliolites*. The absence of pseudosepta affords, however, sufficient ground for the separation of all the Monticuliporoids from the *Helioporidæ*, at the same time that the general likeness between the two groups is strongly suggestive of the existence of a real zoological relationship.

It only remains to briefly compare the Monticuliporoids with the singular Palæozoic Polyzoan genera *Ceramopora*, Hall, and *Heterodictya*, Nich. So far as the first of these is concerned, there is no difficulty in separating even the encrusting species of *Monticulipora* as distinct, if we take those forms of *Ceramopora* which, like *C. imbricata*, Hall, and *C. Huronensis*, Nich., form very delicate parasitic expansions on foreign bodies. In such cases, the colonies of *Ceramopora* are readily distinguished by the peculiar crescentic form of the mouths of the tubes; while I am not aware that they have been shown to possess tabulæ. On the other hand, there are forms apparently referable to *Ceramopora* (such as *C. Ohioensis*, Nich., and an abundant but undescribed species in the Wenlock Limestone of Dudley), which, though primitively, and generally permanently, encrusting, are nevertheless sometimes found to attain a considerable thickness, either by the simple upward growth of the tubes, or by the superposition of successive layers. Such forms may make a close approach to certain of the Monticuliporoids in general aspect, and may come to resemble the latter closely in their internal structure. I hope to find a future opportunity of discussing the structure of these peculiar types at greater length. In the meanwhile, therefore, I merely figure their minute internal structure (fig. 14), and make a few brief and general remarks. As above noted, the general aspect of such forms is not at all unlike that of certain *Monticuliporæ;* but even so far as this is con-

cerned, there are some peculiarities in the general *facies* of the former which would at once lead the observer to separate

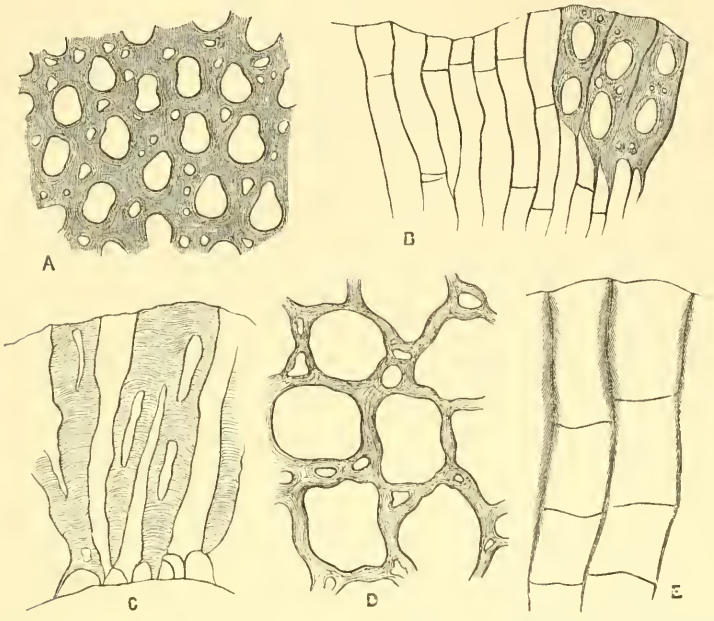

Fig. 14.—Minute structure of *Ceramopora*. A, Tangential section of *Ceramopora Ohioensis*, Nich., from the Cincinnati Group of Ohio, enlarged eighteen times; B, Part of a longitudinal section of the same, similarly enlarged, showing the presence of tabulæ; C, Part of a transverse section of the same, similarly enlarged, showing the thickened cell-walls; D, Part of a tangential section of an undescribed species of *Ceramopora*, from the Wenlock Limestone of Dudley, enlarged eighteen times; E, Vertical section of the same, similarly enlarged, showing the well-developed tabulæ.

them as distinct. Thus, the tubes of which the colony are composed always open upon the surface in an oblique manner, reminding one of *Alveolites* rather than of *Monticulipora*, and the calices are invariably either very irregular in shape, or are, more usually, distinctly crescentic or lunate, one lip of the aperture being strongly curved. As regards internal structure, the general conformation of the skeleton is quite like that of some of the *Heterotrypæ* amongst the Monticuliporoids, the tubes being comparatively thin-walled in the vicinity of their points of origin, but becoming thickened by a secondary deposit of laminated calcareous matter as they approach the surface. There are, also, small tubules intercalated among the proper tubes of the colony; and lastly, there exists a

larger or smaller number of well-developed complete tabulæ (fig. 14, B and E). On the other hand, the interstitial tubes are not provided with any tabulæ, instead of being closely tabulate, as they would be in any species of *Heterotrypa* or *Fistulipora* among the Monticuliporoids; and they appear, indeed, to be quite superficial, and not to extend inwards to such an extent as to render them a conspicuous feature in sections which cut the tubes longitudinally. Moreover, there are grounds for believing that distinct apertures are present in the walls of the species of *Ceramopora* in question, though I do not feel sure that this is the case. The above differences in structure, however, combined with the different external aspect, are sufficient to enable us to effect in general a satisfactory separation between the species of *Monticulipora* and any of the known forms of *Ceramopora*, Hall.

With regard to the Polyzoan genus *Heterodictya*, Nich., the only necessity for entering into any comparison of its structure with that of *Monticulipora* arises out of the fact that such an excellent observer as Mr E. O. Ulrich has referred (Cat. Foss. Cincinnati Group, 1880) the form which I believe to be *Monticulipora pavonia*, D'Orb., to the former. I am, however, quite unable to accept this conclusion, though I do not feel disposed to assert positively that *M. pavonia*, D'Orb., with its various abnormal characters, is an indisputable Monticuliporoid. In *Heterodictya*, Nich., we have to deal with an undoubted *Polyzoön*, of the general type of *Ptilodictya*. The colony forms a thin falciform expansion which is composed of two layers of tubes diverging in opposite directions from a definite striated median calcareous lamella, and which is bounded by perfectly definite margins, and has a perfectly definite shape. As regards internal structure, the only resemblance between *Heterodictya* and any of the Monticuliporoids is to be found in the existence in the former of well-developed tabulæ (fig. 15, A and B), which, however, are often incomplete. No interstitial tubes are present, nor are there any "monticules" or structures comparable with these.

I do not myself know of any Monticuliporoid which could be compared with *Heterodictya* except *M. pavonia*, D'Orb.: and

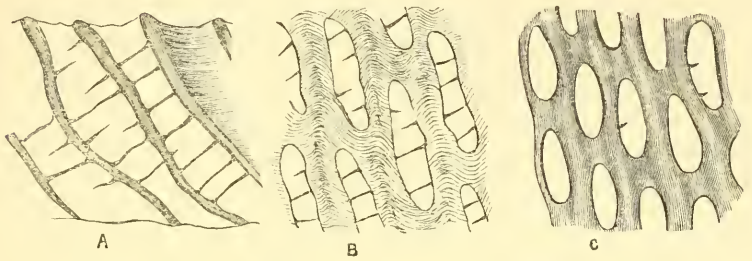

Fig. 15. — Minute structure of *Heterodictya gigantea*, Nich., from the Corniferous Limestone (Devonian) of Canada. A, Vertical and longitudinal section, showing the well-developed tabulæ; B, Vertical and transverse section, showing the incomplete condition of many of the tabulæ; C, Tangential section. All the figures are enlarged eighteen times.

this is, in my opinion, sufficiently separated from the former by its want of any definite form, or of definite and structurally differentiated margins; by the absence of a complete median calcareous lamina, which is so clearly a distinct structure that the layers of tubes can be readily stripped away from it; and by the possession of distinct "monticules." The tabulæ of *M. pavonia*, D'Orb., are even more feebly developed than in *Heterodictya;* but this is a feature of no importance—whereas the striking difference in general aspect, in the want of obliquity to the calices, in the permanent distinctness of the walls of adjoining tubes, and in the structural characters above noted, sufficiently prove that *M. pavonia* cannot, at any rate, be referred to the genus *Heterodictya*.

CHAPTER V.

THE SUBDIVISIONS OF MONTICULIPORA.

From a theoretical and strictly scientific point of view, the family of the *Monticuliporidæ* must be regarded as comprising only the single genus *Monticulipora*, D'Orb. That is to say, our present knowledge does not appear to be sufficient for the establishment of any subdivisions within the limits of this comprehensive genus, which are so markedly distinguished by their structural characters that they would take rank as natural and undoubted *genera*. Hence I have formerly divided the genus *Monticulipora* into the six sub-generic groups, *Fistulipora*, M'Coy, *Constellaria*, Dana, *Dekayia*, Edw. and H., *Diplotrypa*, Nich., *Heterotrypa*, Nich., and *Monotrypa*, Nich. (Pal. Tab. Cor., p. 291). While the above-mentioned six groups are so closely allied to one another that there is no difficulty in framing a generic diagnosis which will embrace them all, the first three of these—viz., *Fistulipora*, M'Coy, *Constellaria*, Dana, and *Dekayia*, Edw. and H.—possess certain marked structural features by which they can be readily separated from one another, often by a merely superficial examination. Upon the whole, therefore, it may perhaps be the best plan, as a matter of *practical convenience*, to regard these three groups as so many distinct *genera*, in spite of the fact that they have no theoretic claim to such a rank. The adoption of this method of procedure will leave *Monticulipora* proper as an independent genus, with the three subordinate groups, *Diplotrypa*, *Heterotrypa*, and *Monotrypa*, to which must be added as a fourth sub-

genus the *Prasopora* of Mr R. Etheridge, jun., and myself, while I shall institute a fifth sub-genus under the name of *Peronopora*. As the present work is concerned wholly with the genus *Monticulipora* proper, I shall here subjoin all remarks which I find it necessary to make upon *Fistulipora*, *Constellaria*, and *Dekayia*, at the same time briefly defining *Monticulipora* and its minor subdivisions.

It being understood, then, as above stated, that the term *genus* is here used in a purely artificial sense, I propose to divide the family *Monticuliporidæ* into the following four genera :—

(I.) Fistulipora, M'Coy, 1849.

(Ann. and Mag. Nat. Hist., ser. 2, vol. iii. p. 130.)

Callopora, Hall, Pal. N.Y., vol. ii. p. 144, 1852.

The corals of this group were separated by M'Coy to form his genus *Fistulipora*, with the following generic diagnosis :—

"Corallum encrusting, composed of long, simple, cylindrical, thick-walled tubes, the mouths of which open as simple, equal, circular cells on the surface, and having transverse funnel-shaped diaphragms at variable distances; interval between the tubes occupied by a cellular network of small vesicular plates." The type of the genus is the *F. minor*, M'Coy, of the Carboniferous Limestone of Derbyshire.

At a later period, Professor Hall proposed the name of *Callopora* for certain Upper Silurian corals, with the following generic diagnosis :—

"Ramose or encrusting species of corals, having a columnar structure; cells tubular, with the apertures circular or petaloid, not contiguous, and having the intermediate spaces occupied by angular cell-like openings which are transversely septate; tubular cells rarely septate." [1]

[1] The term "septate," used by Professor Hall in the above diagnosis, is employed in the same sense as "*tabulate*," and does not refer to the presence of true *septa*.

The identity of *Fistulipora*, M'Coy, and *Callopora*, Hall, has long been more than suspected, the chief difficulty in the way of uniting the two being that M'Coy states that the tabulæ in the large corallites of *Fistulipora* are infundibuliform, while Hall describes radiating septa (*i.e.*, true "septa") as sometimes present in the type-species of *Callopora*. M'Coy's statement as to the tabulæ is, however, clearly based upon imperfect observation, and this is also almost certainly the case as to the alleged occurrence of septa. At any rate, having carefully examined specimens of *F. minor*, M'Coy, the type of the genus *Fistulipora*, and having compared these with typical examples of Hall's genus *Callopora* from the Silurian and Devonian rocks of North America, I am satisfied that the two are unquestionably congeneric, and that both must be united under the older name of *Fistulipora*, M'Coy.

The species of *Fistulipora* agree in the possession of a dimorphic corallum, composed of two sets of corallites of con-

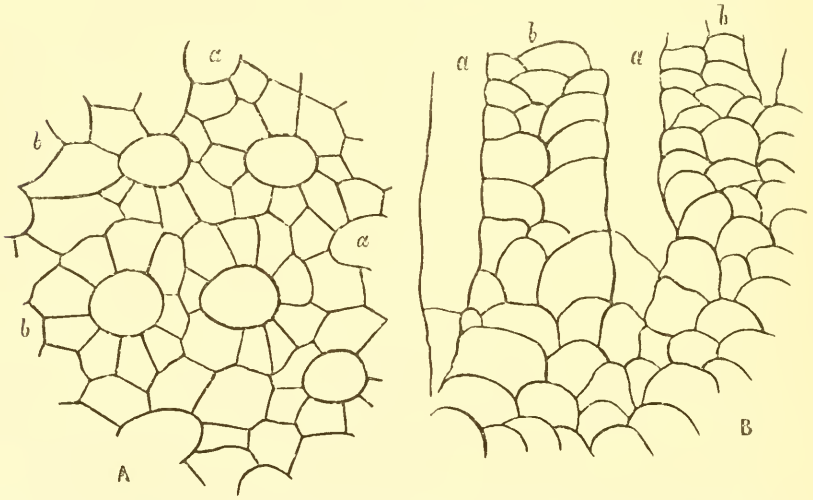

Fig. 16.—*Fistulipora minor*, M'Coy, the *type*-species of the genus *Fistulipora*, M'Coy. A, Portion of a tangential section, showing the rounded large tubes (*a a*) and the angular interstitial tubes (*b b*); B, Portion of a vertical section, showing two of the large tubes, almost free from tabulæ (*a a*), and the interstitial vesicular tissue formed by the tabulæ of the smaller tubes (*b b*). The sections are enlarged twenty-five times.

spicuously different sizes, and bearing definite relations to one another (fig. 16). The large corallites are markedly circular or

oval, in most forms, and are isolated in position, while their cavities are intersected by few and remote horizontal tabulæ, these structures being occasionally partially absent. The smaller corallites are distinctly angular in form, and surround the larger tubes completely, there being sometimes one and sometimes two rows between any given pair of the latter. The smaller corallites are furnished with numerous and close-set tabulæ, and may or may not be bounded by complete walls. In the former case the tabulæ are complete and horizontal, whereas in the latter case they anastomose with one another, and give rise to a tissue of convex lenticular vesicles (fig. 16, B), the variations observable in this respect being precisely parallel with those which obtain respectively in *Heliolites* and *Propora*. The walls of the corallites of both sets are thin, and are not conspicuously thickened towards their mouths. It should also be borne in mind that the interstitial and closely tabulate corallites are sometimes equal in size to the round and remotely tabulate corallites which they surround; so that in speaking of the former as the "small" corallites, we only employ this term in a conventional sense, as indicating their homology with the small tubes of the Monticuliporoids generally. The corallum in *Fistulipora* often exhibits "maculæ" or definite areas occupied by the smaller corallites only. These maculæ may be stellate in shape; but they are never elevated above the surface or surrounded by radiating elevated ridges, as is the case in *Constellaria*. Lastly, while the large rounded tubes always open the surface by open calices, the intermediate angular tubes often have their mouths closed in the adult condition by a thin calcareous membrane. In no case are septa present.

From the *Heliolitidæ*, *Fistulipora* is separated mainly by the total absence of septa in the latter, so far as certainly known; but, as has been pointed out, there is a striking resemblance in general structure between certain species of *Fistulipora* on the one hand, and the species of *Propora* and *Heliolites* on the other hand. "Mural pores" have not been detected in any typical form of *Fistulipora;* but Dr Rominger has shown

(Foss. Cor. of Mich., p. 29) that the coral described by Mr Billings from the Devonian of Canada, under the name of *Fistulipora Canadensis* (fig. 17), is provided with perforate

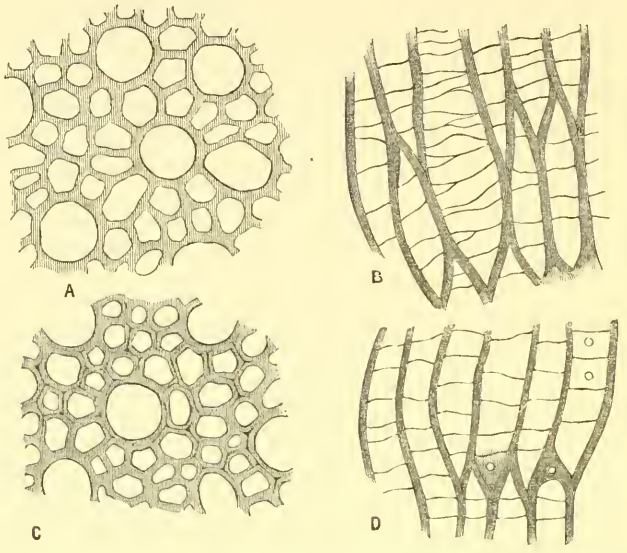

Fig. 17.—A, Tangential section of a completely silicified specimen of *Fistulipora Canadensis*, Bill., from the Corniferous Limestone of Ontario, enlarged seven times; B, Vertical section of the same specimen, similarly enlarged; C, Tangential section of a calcareous specimen of *Fistulipora Canadensis*, Bill., from the Hamilton Group of Ontario, enlarged seven times; D, Vertical section of the same specimen, showing "mural pores," similarly enlarged.

walls, and is therefore a genuine Favositoid type. We thus have a coral which precisely resembles the normal forms of *Fistulipora* in *appearance*, but which exhibits mural pores; and it becomes, therefore, a matter for future research whether or not these structures occur in any other species now referred to *Fistulipora*. Dr Steinmann (N. Jahrb. für Min., &c., Jahrg., 1880, p. 438) has recently stated that the coral which Billings described under the name of *Fistulipora Canadensis* has a minute structure (especially as regards the wall) quite different to that exhibited by *Callopora*, Hall, and has given a figure of a cross-section of what he believes to be *Fistulipora Canadensis*, Bill., in support of his opinion. This observer, also, states in the same place that his investigations into the struc-

ture of *Fistulipora Canadensis*, Bill. (so called), show, as above noted, that *Fistulipora*, M'Coy, cannot be identical with *Callopora*, Hall. I would remark, however, that Dr Steinmann's conclusions on the above points are rendered nugatory by the following considerations: In the first place, the *type* of the genus *Fistulipora*, M'Coy, is the *F. minor*, M'Coy, of the Carboniferous rocks of Britain, and not the (so-called) *F. Canadensis* of Billings. In determining, therefore, the relations which subsist between *Fistulipora*, M'Coy, and *Callopora*, Hall, the only evidence of any value is that afforded by *F. minor*, M'Coy, which is the type of the former genus; and it would not matter in the least what might be the structure of the subsequently described *F. Canadensis*, Billings. I must, thus, begin by denying that *any* evidence based upon the structure of *F. Canadensis*, Bill., could have any bearing upon the question as to whether *Fistulipora*, M'Coy, is the same as *Callopora*, Hall. In the second place, the figure given by Dr Steinmann as an enlarged drawing of a cross-section of the so-called *Fistulipora Canadensis*, Bill., is seemingly not a drawing of this species at all, but is apparently referable to some entirely different type (perhaps either a *Monticulipora* or a *Stenopora*). I do not pretend to know what form is actually represented in the figure given by Dr Steinmann; but I think it may be safely asserted that it is *not* the so-called *Fistulipora Canadensis*, Bill., or even apparently allied to it. I have a very large number of specimens of *F. Canadensis*, Bill., which I personally collected from the Devonian formation of Canada, and I have made many sections of these; and in confirmation of the above statement it will be quite sufficient to direct attention to the foregoing engraving representing enlargements of tangential and vertical sections of undoubted[1] examples of this species. An examination of these sections will

[1] In order that no doubt should exist as to the identity of my specimens with *F. Canadensis*, Bill., I have in figs. A and B purposely chosen sections from a specimen from the Corniferous Limestone which Mr Billings himself named and gave to me; though the specimens I collected myself are, of course, just the same.

show at once that the so-called *Fistulipora Canadensis*, Bill., has no claim whatever to be regarded as belonging either to *Fistulipora*, M'Coy, or to *Callopora*, Hall (if these generic names are regarded as anything short of identical). On the contrary, it is an unquestionable member of the *Favositidæ*, with well-marked mural pores, and agreeing in all respects with *Favosites* proper, except that the corallum consists of two well-marked groups of corallites of different sizes. The large corallites are oval or rounded, averaging from 1-24th to 1-28th inch in diameter, and surrounded by from one to three rows of small corallites, which are mostly about half the size of the large tubes, and are more or less angular in shape. The structure of the wall is obliterated in such silicified specimens as I have examined, or is, at any rate, imperfectly preserved; but it is seen in calcareous examples to be precisely that of *Favosites* or *Pachypora*, the walls being thickened, but the original lines of demarcation between adjoining tubes being mostly recognisable. In no case have I detected any traces of the minute interstitial tubuli figured by Dr Steinmann as present in the fossil which he regards as *Fistulipora Canadensis*, Bill. I cannot, therefore, doubt that the so-called *Fistulipora Canadensis*, Bill., is either referable to *Favosites* itself, or to some closely allied genus; and the propriety of referring it to *Favosites* (in spite of the different sizes of its corallites) is increased by the fact that it passes by seemingly almost insensible gradations into an ordinary and unquestionable *Favosites*, which has been described as such by Rominger under the name of *F. placenta*. It should be added, finally, that the radical difference between *F. Canadensis*, Bill., and all the forms of the genus *Fistulipora*, M'Coy, is shown by the fact that long sections of the former (fig. 17, B and D) show that the internal structure of the large and small tubes of the corallum is precisely the same, there being no difference whatever in their tabulation.

Having now shown that the structure of the so-called *Fistulipora Canadensis*, Bill., is no element in the problem as to the

validity of the genus *Fistulipora*, M'Coy, or in the question how far the later *Callopora* of Hall is identical with this, I need only add that the species of *Fistulipora* are mainly distinguished from the typical *Monticuliporæ* by the relative abundance of the small corallites of the colony. In all the typical *Fistuliporæ* with which I am acquainted, it is the rule that the large corallites are completely isolated from one another by the small interstitial tubes; and the latter are not only more closely tabulate than the former, but have their walls commonly obliterated by the anastomosis of their tabulæ. On the other hand, in all the true *Monticuliporæ* the large corallites are, to some extent, in contact, and the tabulæ of the interstitial tubes do not become vesicular. At the same time, it must be admitted that there are some species of *Monticulipora* which make a close approach in internal structure to *Fistulipora*, and that it is not always an easy matter to separate these two genera.

As regards its geological range, the typical species of *Fistulipora* appear to belong to the Upper Silurian, Devonian, and Carboniferous periods.

(II.) Constellaria, Dana, 1846.

(Zooph., p. 537, 1846.)

Stellipora, Hall, Pal. N.Y., vol. i. p. 79, 1847.

This section includes forms which, in many respects, are very nearly allied to *Fistulipora*, M'Coy, but which exhibit some very peculiar features. Some of the structural peculiarities of the type will require for their elucidation much more extended investigation than I have as yet been able to bestow upon them, and the following must be regarded as little more than a general and provisional statement as to the characters of the genus. The corallum in *Constellaria* is obviously and conspicuously dimorphic, the most striking of its features being the existence of a series of close-set, star-shaped, depressed

areas ("maculæ"), which are occupied by the smaller tubes, and which are surrounded each by a radiating circle of short elevated ridges carrying large tubes. The large tubes also occupy, mainly or wholly, the spaces between the star-shaped monticules, and each is oval or circular in shape, and surrounded by a strong and thickened wall, the intervals between them being occupied by the smaller tubes. The large corallites are traversed by a few remote tabulæ, and the small tubes are closely tabulate, their tabulæ often becoming sub-vesicular, while their walls become obsolete.

In its general structure, *Constellaria*, Dana, makes a very near approach to *Fistulipora*, M'Coy, and it is still doubtful if the two can be separated from one another. If they should be united, it is the name *Fistulipora* which must be abandoned, as of later date than *Constellaria*. The most obvious feature which separates the latter from the genus *Fistulipora* is its possession of the conspicuous star-shaped monticules which adorn the surface of the corallum. There are, however, various features in its internal structure which have been, as yet, imperfectly worked out, and I do not feel able at present to give any definite opinion as to the extent to which it really differs from *Fistulipora*, M'Coy.

So far as known, the species of *Constellaria* are confined exclusively to the Lower and Upper Silurian deposits.

(III.) Dekayia, Edwards and Haime, 1851.

(Pol. Foss. des Terr. Pal., p. 277.)

The name of *Dekayia* was proposed by Milne-Edwards and Haime for a little group of Monticuliporoids, distinguished from allied types only by superficial characters, and therefore, fundamentally, of no more than sub-generic value. In the general nature and structure of the corallum the species of *Dekayia* entirely resemble the dendroid forms of *Monticulipora*, and the only feature that would strike the observer is that the

surface of the former is studded with little quadrangular spines or columns, interspersed in great numbers among the ordinary tubes of the corallum. The structure of these columns was first investigated by me by means of thin sections (Ann. Nat. Hist., ser. 4, vol. xviii. p. 93, Pl. V. figs. 12 and 12 *a*); but it is only through more recent and more complete investigations that I have been able to arrive at any definite conception as to their real nature. I am, however, now satisfied that the corallum in *Dekayia* is truly dimorphic, that the surface-columns are the homologues of the spines which are so abundantly developed in *M.* (*Heterotrypa*) *tumida*, Phill., *M.* (*Heterotrypa*) *moniliformis*, Nich., and other forms of *Monticulipora*, and that these structures are properly to be regarded as a peculiarly modified series of corallites. Taking this view of the subject, the species of *Dekayia* are principally separable from the spiniferous species of *Monticulipora* by the fact that in the former the spines are much reduced in number and increased in size, while they are always isolated by the large tubes, these latter being of one kind only. It cannot be denied, however, that the separation of *Dekayia* from *Monticulipora*, so far as our present knowledge goes, is purely arbitrary, and is only defensible upon the ground that its surface-columns constitute a marked external character, by which its species can be readily and conveniently distinguished as a group apart.

The known species of *Dekayia* are confined to the Silurian rocks.

(IV.) Monticulipora, D'Orbigny, 1850.

In the restricted sense in which the name *Monticulipora* is here used (that is to say, with the exclusion of *Fistulipora*, *Constellaria*, and *Dekayia*), the genus may be defined as including coralla composed of tubular corallites, which are mostly, though not always, of two distinct kinds, differing from one another in relative size, and also in their tabulation. The

small corallites are never so greatly developed as to entirely isolate the large tubes, except in an occasional corallite, nor do they form star-shaped elevated monticules. Even when the small corallites are numerous, their tabulæ do not become vesicular, nor are their walls obliterated. Spiniform corallites are commonly present, and may project above the surface as blunt spines; but they do not form conspicuous surface-columns.

The above are the principal differential characters by which the species of *Monticulipora* proper may be distinguished from those referable to *Fistulipora*, M'Coy, *Constellaria*, Dana, or *Dekayia*, E. and H. As above defined, however, the genus *Monticulipora* includes a very large number of forms, and the variations in the internal structure of these are so great that it becomes necessary to split up the genus into sections, which must, for convenience' sake, be distinguished by separate names. The work of framing such minor sections is one of the greatest difficulty, and it may reasonably be doubted if our present knowledge has as yet advanced so far that it is possible for us to subdivide this difficult group in more than a merely tentative manner. I have previously (p. 20) given reasons for not accepting the classification proposed by Dybowski, and the arrangement which I propose myself can only be regarded as a provisional one. I formerly (Pal. Tab. Cor., p. 291) proposed to divide the group of forms here included under the name of *Monticulipora* proper into three sub-generic sections —viz., *Heterotrypa*, *Diplotrypa*, and *Monotrypa*. After a more extended investigation, however, I propose to add to these three the two additional sections of *Prasopora*, Nich. and Eth. jun., and *Peronopora*, Nich., the constitution of the three groups above mentioned being at the same time in some respects altered. I do not pretend that this arrangement is likely to be a final one, but I have endeavoured as far as possible to found my classification upon the *aggregate* of characters shown by the different species, rather than to base the dividing lines upon single peculiarities of structure, so that I may hope that

some, at any rate, of the groups adopted are natural. There are, however, certain forms which it is very difficult to classify, and the position of these must remain more or less uncertain in the meanwhile. I shall subsequently deal with the groups that I have adopted at greater length, but I may subjoin here a brief synopsis of the sub-genera into which I propose to subdivide the genus *Monticulipora*, D'Orb., as above restricted : [1]—

I. Heterotrypa, Nich.—Corallites of two kinds, the larger ones sub-polygonal, partially separated by the development of numerous smaller circular or irregularly shaped tubes, of which there is no more than a single row between any pair of large tubes. Walls thickened towards the mouths of the tubes, and often apparently amalgamated in this region. Spiniform corallites usually present, but sometimes wanting. Tabulæ conspicuously more numerous in the smaller tubes than in the larger ones. Type of the group, *Monticulipora mammulata*, D'Orb. (which is also the type of the whole genus).

(*a*) Walls of the corallites apparently fused, their duplex character being hardly or not at all recognisable in thin tangential sections. (*Ex.*, *M. tumida*, Phill., *M. mammulata*, D'Orb., *M. Ulrichii*, Nich., *M. gracilis*, James, *M. Andrewsii*, Nich., *M. ramosa*, D'Orb., and its varieties *M. rugosa*, E. and H., and *M. Dalii*, E. and H., *M. moniliformis*, Nich., *M. subpulchella*, Nich., *M. O'Nealli*, James, *M. nodulosa*, Nich., &c.)

(*b*) Walls of the corallites preserving their duplex character throughout. (*Ex.*, *M. Jamesi*, Nich., *M. implicata*, Ulrich, *M. Girvanensis*, Nich., *M. Trentonensis*, Nich., *M. Dawsoni*, Nich., &c.)

II. Diplotrypa, Nich.—Corallites of two kinds, with thin, structureless, apparently amalgamated walls; the larger ones conspicuously polygonal, with comparatively few and remote tabulæ. The large corallites may be aggregated at special points into conspicuous clusters ("monticules"), but they are at the same time scattered indiscriminately through the entire colony, and except where forming the groups just alluded to, they are partially separated by the intervention of the smaller corallites, which are always angular in shape, have

[1] There are two other groups—viz., *Trematopora*, Hall (Dybowski), and *Dittopora*, Dyb., which appear to represent additional sub-generic divisions of *Monticulipora*. I have not included these in the following synopsis, as I have no direct knowledge of their characters. I shall, however, give a brief account of the peculiarities ascribed to them by Dybowski in an appendix at the end of this work. It is also probable that some of the as yet undescribed forms which have been yielded by the prolific Silurian strata of Ohio to the researches of Messrs Nickles, Ulrich, &c., will be so far different from any of the above as to require the formation of new sections for their reception. Lastly, among the species here described there are several which are so far abnormal that it is quite possible that they will ultimately find a resting-place in some other section of the genus to that in which I have temporarily placed them.

thin walls, are never so far developed as to completely isolate all the larger tubes, and are always provided with more numerous and more closely-set tabulæ than is the case in the latter. Spiniform corallites present or absent. Type of the group, *Monticulipora petropolitana*, Pand.

(*a*) Corallites prismatic. (*Ex.*, *M. petropolitana*, Pand., *M. Whiteavesii*, Nich.)

(*b*) The large corallites oval or rounded. (*Ex.*, *M. calycula*, James.)

III. Monotrypa, Nich.—Corallites of one kind only, so far as their internal structure is concerned; though there may be well-marked clusters (or "monticules") of tubes appreciably larger than the average. Corallites usually conspicuously prismatic, their walls thin and apparently structureless, or retaining their primitively duplex character. Spiniform corallites mostly wanting (present in *M. discoidea*, James). Tabulæ complete, uniformly distributed throughout all the corallites, without respect to the size of these; sometimes nearly obsolete. Type, *Monticulipora undulata*, Nich.

(*a*) With thin, apparently structureless walls. (*Ex.*, *M. undulata*, Nich., *M. Winteri*, Nich., *M. irregularis*, Ulrich, *M. clavacoidea*, James, *M. quadrata*, Rom., *M. calceola*, Miller and Dyer, &c.)

(*b*) Walls appreciably thickened, but preserving their duplex character. (*Ex.*, *M. petasiformis*, Nich., *M. pulchella*, E. and H., *M. discoidea*, James, *M. pavonia*, D'Orb., *M. briarea*, Nich., &c.)

IV. Prasopora, Nich. and Eth. jun.—Corallites of two kinds, the smaller ones interspersed throughout the colony, or partially aggregated into clusters. Large tubes with peculiarly incomplete tabulæ, which form a series of marginal vesicles, enclosing a lateral or central space, which is usually crossed by a few straight tabulæ. Small tubes angular, with numerous complete and close-set tabulæ. Spiniform corallites wanting, or very sparingly developed. Walls of the corallites thin and apparently structureless. Corallum usually discoid. Type, *Prasopora Grayæ*, Nich. and Eth. jun. Other examples are *M.* (*Prasopora*) *Newberryi*, Nich., and *M.* (*P.*) *Selwynii*, Nich.

V. Peronopora, Nich.—Corallites of two kinds, the larger ones with tabulæ of the same peculiarly incomplete type as in *Prasopora*. Small tubes with close-set complete tabulæ. Walls of the corallites thickened, and apparently more or less completely amalgamated, so that their primitive duplex character is lost. Spiniform corallites usually largely developed (apparently wanting in *M. molesta*, Nich.) Corallum laminar or encrusting. Type of the group, *M. frondosa*, D'Orb. (= *M. decipiens*, Rom.) Other examples are *M. molesta*, Nich., *M. Cincinnatiensis*, James, and probably *M. Ortoni*, Nich.

CHAPTER VI.

Sub-genus Heterotrypa, Nich., 1879.

(Pal. Tab. Cor., p. 293).

This section includes many of the most typical and most familiar of the species of *Monticulipora*, comprising among them the *M. mammulata*, D'Orb., which, as the species first on the list of *Monticuliporæ* given by D'Orbigny (Prodr. de Paléont., p. 25), has the right to be considered as the *type* of the whole genus. In addition to *M. mammulata*, D'Orb., we must place here *M. ramosa*, E. and H., *M. Andrewsii*, Nich., *M. Ulrichii*, Nich., *M. subpulchella*, Nich., *M. O'Nealli*, James, *M. Jamesi*, Nich., *M. moniliformis*, Nich., *M. tumida*, Phill., *M. gracilis*, James, and various other more or less certainly established species. In all these forms the corallum is conspicuously dimorphic, and consists of two sets of corallites of different sizes. The larger tubes are sub-polygonal or sometimes rounded in shape, and are more or less conspicuously thickened towards their mouths, while they usually possess few and remote tabulæ, or may be in great part devoid of these structures. They are usually to some extent contiguous; but they are always partially separated by the corallites of the smaller series, which are also sub-polygonal, sub-angular, or rounded, and more or less thickened towards their mouths. In all the corallites the tabulæ are complete, and the small tubes are more closely tabulate than the large ones. Spiniform corallites are often very well developed, but at other times are

few or wanting. The structure of the *wall*, as in almost all the groups of *Monticulipora*, varies in different forms of the group, according to the extent to which the originally duplex character of the wall is preserved. In all, the tubes become thickened and lamellated as the surface is approached; but in some (such as *M. tumida*, Phill., *M. gracilis*, James, &c.) they become to all appearance so completely united with one another in this part of their course, that thin tangential sections fail to show any traces of the original lines of demarcation between adjoining tubes. In other cases (as in *M. ramosa*, D'Orb., and its varieties), these lines of demarcation can be to some extent recognised, though the apparent fusion has largely obliterated them. Lastly, there are forms (such as *M. Trentonensis*, Nich.) in which the primitive boundaries between the tubes are quite well preserved, in spite of the thickening of the walls.

The section *Heterotrypa* includes many of the most typical species of *Monticulipora* proper, and it is also the section most nearly allied to *Fistulipora*, M'Coy. Its characters will be more fully understood from the following descriptions of illustrative species.

Monticulipora (Heterotrypa) mammulata, D'Orb.

(Pl. VI. figs. 1-1*g*.)

Monticulipora mammulata, D'Orbigny, Prodr. de Paléont, vol. i. p. 25, 1850.
Chætetes mammulatus, Edwards and Haime, Pol. Foss. des Terr. Pal., p. 267, Pl. XIX. fig. 1, 1851.
Monticulipora mammulata, Edwards and Haime, Brit. Foss. Cor., p. 265, 1854.
Chætetes mammulatus, Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 508, Pl. XXX. figs. 3-3*a*, 1874. Pal. Ohio, vol. ii. p. 207, 1875.
Monticulipora (*Heterotrypa*) *mammulata*, Nicholson, Pal. Tab. Cor., p. 294, Pl. XIII. figs. 1-1*b*, 1879.

Spec. Char.—Corallum in the form of thin undulated expansions, from two to four lines in thickness, and often several

inches in height, consisting of two layers of corallites, which diverge from an imaginary central plane to open on both sides of the frond. (Occasionally assuming a massive form ?) Surface covered with rounded, conical, or elongated elevations or "monticules," which are sometimes but slightly raised above the general surface, whilst in other examples they are conspicuously elevated. These monticules are composed of corallites which sometimes appear to be slightly larger than the average, and which at other times are decidedly smaller than the ordinary tubes; while in some specimens the sides of the monticules are covered by full-sized tubes, and the summit is occupied by smaller corallites. The distance between the monticules is mostly from half a line to a line. Ordinary corallites of two kinds—large and small. Large corallites, polygonal or subpolygonal, from 1-100th to 1-80th inch in diameter, their walls amalgamated with one another, and moderately thickened as they approach the surface. Small corallites moderately but not excessively numerous, intercalated in the intervals between the large tubes, variable in size and shape, but always angular or sub-angular. A variable, but often considerable, number of minute thick-walled circular tubuli ("spiniform corallites") developed between the normal corallites. Large corallites with comparatively few and remote tabulæ; small corallites with numerous close-set tabulæ; all the tabulæ complete and approximately horizontal.

Obs.—This well-marked species—the identification of which with *M. mammulata*, D'Orb., will be subsequently discussed—resembles *M. frondosa*, D'Orb., *M. molesta*, Nich., and *M. Dawsoni*, Nich., in being normally frondescent (Pl. VI. fig. 1), and in consisting of two strata of corallites which diverge in opposite directions, and nearly at right angles, from a median plane, which may be considered as dividing the corallum into two leaf-like halves. This median plane, however, is an imaginary one, not marked by any mesial calcareous lamina; so that, in this respect, the structure of the corallum differs from what we shall see to exist in *M. frondosa*. The calices are

thin-walled and polygonal, and interspersed amongst them are the small angular or sub-angular apertures of the interstitial corallites (Pl. VI. fig. 1*c*), the number of which varies much in different specimens, and which are sometimes almost wanting. The surface always exhibits "monticules," though the extent to which these are developed varies greatly in different examples. In some forms (Pl. VI. fig. 1*a*) the monticules are low and rounded, and, though quite recognisable, are certainly not striking features in the corallum. In other specimens, proved by microscopical examination to be identical with the preceding, the monticules are conical, or at other times elongated and compressed, in either case rising conspicuously above the general surface (Pl. VI. fig. 1*b*).

As regards the minute structure, the appearances presented by tangential sections vary according to the depth below the surface at which these may be taken. In sections passing just below the actual surface (Pl. VI. figs. 1*d* and 1*e*), the corallites are seen to be moderately thick-walled, and divisible into a series of large tubes and one of small tubes. The large corallites are surrounded each by its own ring of laminated sclerenchyma, but they are nevertheless apparently fused with one another at the points where they come in contact. Their form is sub-polygonal, and all the interspaces left between them are occupied by much smaller angular or sub-angular corallites. Intercalated in the thickened walls of the corallites there is, also, a quite considerable number of minute circular, darkly-outlined hollow tubules or "spiniform corallites," the terminations of which have not been observed by me.

In tangential sections taken at a slightly deeper level than the preceding (Pl. VI. fig. 1*f*), the appearances to be observed are somewhat different to those above described. The walls of the corallites are now reduced in thickness, causing their cavities to be proportionately increased in size. Hence the large corallites appear to be of somewhat larger size, and more strikingly polygonal, while the dimensions of the small tubes are similarly increased, and the number of the "spini-

form corallites" has notably diminished, showing that these latter do not extend to great depths below the surface.

I have not succeeded in definitely recognising the "monticules" in tangential sections, which may be taken as showing that, on the whole, they do not differ materially in structure from the bulk of the corallum. Sometimes, certainly, the tubes of which they are composed *look* a little larger than the average; but this may very possibly be an illusory appearance, and may be due to their greater nearness to the eye of the observer. In other cases, beyond a doubt, many of the tubes which are present in the monticules are below the average size.

Vertical sections, taken at right angles to the plane of the frond (Pl. VI. fig. 1*g*), show, as before remarked, that the corallites of the opposed sides of the corallum do not spring from a definite mesial lamina, but simply diverge from one another at their bases. At first slightly oblique and thin-walled, they almost immediately bend outwards, their walls at the same time being moderately thickened by a deposit of light-coloured sclerenchyma, and they are then continued nearly at right angles to the surface on which they ultimately open. Sections of this kind show that all the tabulæ are complete and approximately horizontal; but there is a marked difference in the tabulation of the large and small corallites respectively, the tabulæ of the former being few and remote, while in the latter they are numerous and close set.

There is no doubt that the normal form of the corallum in this species is that of a flattened undulating frond; but I possess one large and massive specimen, some three inches in height by four in width, and two inches in thickness, which has all the superficial characters of this form, and most of its microscopic features. It differs, in fact, from the normal examples of this species in no other peculiarity except that the number of the small interstitial corallites is markedly reduced, while its monticules are, perhaps, rather more pronounced than is common in this type. So far, however, as I

can judge from an examination of thin sections of this single specimen, I am disposed to regard it as a mere variety of the present species.

Before leaving this form, it is necessary to inquire briefly what grounds there are for regarding it as the *M. mammulata* of D'Orbigny; and on this point, I regret to say, there is but little that can lead in the meanwhile to any positive conclusions. Good observers, indeed, are of opinion that the present form is really the *M. frondosa* of D'Orbigny, and that the form which I shall describe afterwards under the name of *M. molesta* is the true *M. mammulata;* and though I myself decidedly differ from this view of the subject, I not only cannot pretend to establish my own view beyond controversy, but I am obliged to admit that there exists much ground for a legitimate difference of opinion on this point. The difficulties which environ this question arise from the fact that there are at least three, possibly four, distinct structural types of *Monticulipora* which occur in the Cincinnati Group of Ohio, all of which are more or less identical in *external* characters, and any one of which might therefore be supposed to be the genuine *M. mammulata* of D'Orbigny, and of Milne-Edwards and Haime. These three or four types are the following :—

(*a*) The form which I have here described as *M. mammulata*, which grows in thin undulated fronds, and has its surface covered with monticules, which are sometimes low and rounded, sometimes conical, sometimes elongated.

(*b*) The form which I have spoken of above as probably a variety of the preceding, which it resembles generally in its microscopical characters, except that it has a much smaller number of interstitial corallites. In its mode of growth it is *massive*, and its monticules are pronounced and conical or elongated.

(*c*) The form which I shall describe subsequently under the name of *M. molesta*, and which reliable investigators regard as the true *M. mammulata*. This form is most commonly frondescent, and has the form of a thin undulated lamina, but it is

occasionally massive; its surface is covered with well-marked conical monticules, which are sometimes elongated; and its microscopic structure is entirely different to that of the two preceding types.

(*d*) A form which has a frondescent corallum, and a surface covered with prominent elongated monticules, but which has an entirely peculiar microscopic structure, unlike that of any of the forms previously mentioned. This will be subsequently described under the name of *M. Dawsoni*, Nich.

As before remarked, any one of the above, so far as its external features go, might very well stand for *M. mammulata*, D'Orb.; and in attempting to decide to which of these this title really belongs, we do not get much help from the descriptions given either by D'Orbigny, or by Milne-Edwards and Haime—as was to be expected, in view of the fact that these descriptions relate solely to superficial characters. D'Orbigny's original description of *M. mammulata* (Prodr. de Paléont., p. 25, 1850) is simply,—"Espèce en lame, dont les monticules sont allongés." This, clearly, might apply to any of the forms I have enumerated (except *b*), since all are frondescent, and all have the monticules sometimes or always elongated and compressed. The description given by Milne-Edwards and Haime is much fuller than the above, and is accompanied by figures (Pol. Foss. des Terr. Pal., p. 267, Pl. XIX. fig. 1, 1851). It is as follows:—

"Polypier de forme très-variable, diversement gibbeuse et lobée, en général en frondes larges, épaisses de 6 millimètres environ; mamelons bien prononcés, souvent un peu allongés, distant d'une fois ou deux leur largeur. Calices polygonaux, peu inégaux, larges d'un cinquième de millimètre, a peine distincts sur le sommet des mamelons."

The above-quoted diagnosis would quite well apply to any one of the four similar-looking forms I have previously enumerated. The *figure* of the species given by Milne-Edwards and Haime represents a lobate sub-massive specimen, and is perhaps more like the form which I have above

designated by the letter *b* than it is like any of the others. It seems tolerably evident, however, that without a microscopic examination of the actual specimens described by Milne-Edwards and Haime, it must remain an impossibility to determine accurately which of the above types formed the basis for their description. Being unwilling to abandon a name so long current and familiar, I have elected to give this title to the present type; but I must frankly admit that my selection was an arbitrary one, and that the name of *M. mammulata* may ultimately be found to belong to one of the two forms which I shall describe hereafter under the names of *M. molesta* and *M. Dawsoni.* In the meanwhile, therefore, the identification of *M. mammulata*, D'Orb., must remain a matter of individual preference or individual opinion; and nothing like certainty can be obtained upon this point until it may be found possible to examine the original types of the genus by means of modern methods.

Horizon and Locality.—Common in the Cincinnati Group, Cincinnati, Ohio.

Monticulipora (Heterotrypa) ramosa, D'Orbigny.

(Fig. 18, and Pl. II. figs. 2, 2*a*.)

Monticulipora ramosa, D'Orbigny, Prodr. de Paléont., t. i. p. 25, 1850.
Chætetes ramosus, Edwards and Haime, Pol. Foss. des Ter. Pal., p. 266, Pl. XIX. figs. 2, 2*a*, 1851.
Monticulipora ramosa, Edwards and Haime, Brit. Foss. Cor., p. 265, 1854.
Chætetes Dalii, Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 501, Pl. XXIX. figs. 1, 1*a*, 1874; Pal. of Ohio, vol. ii. p. 192, Pl. XXI. figs. 1, 1*a*, 1875.
Chætetes ramosus, Nicholson, Ann. Nat. Hist., ser. 4, vol. xviii. p. 88, 1876.
Monticulipora (*Heterotrypa*) *ramosa*, Nicholson, Pal. Tab. Cor., p. 296, Pl. XIII. figs. 2, 2*a*, 1879.

Spec. Char.—Corallum dendroid, of cylindrical or elliptical branches which divide dichotomously, and vary from one to, generally, three or four lines in diameter. Surface covered with numerous conical or somewhat elongated "monticules,"

which are placed at intervals of from half a line to a line, and are not occupied by corallites of specially large or small dimensions. Calices sub-polygonal, with slightly thickened margins, about 1-90th inch in long diameter, surrounded by the openings of numerous small interstitial tubes. Corallites conspicuously divided into two series, the small ones being very numerous, and surrounding the larger tubes in a single row, sometimes completely isolating the latter, and being exceedingly variable in shape and size. In internal structure, both sets of corallites are traversed by complete horizontal tabulæ, which are, however, much more numerous in the small tubes than in the large ones. Walls thickened towards their mouths, and apparently fused with one another.

Obs.—The external characters of this species (Pl. II. figs. 2, 2*a*) are so well known that they require no further remark here, its numerous conical monticules and the abundance of the interstitial corallites being sufficiently distinctive features. As regards internal structure, thin tangential sections (fig. 18, A, B, and C) exhibit in a striking manner the conspicuous division of the corallites into two sets of tubes, large and small, and the great development of the latter. The large tubes are very uniform in size, generally oval or circular in shape, and moderately thick-walled — the thickening of the wall, however, never proceeding to the extent that obtains in forms such as *M.* (*Heterotrypa*) *gracilis*, James, *M.* (*Heterotrypa*) *tumida*, Phill., and allied types. The small corallites are very variable in size and form, and are principally developed at the angles of junction of the large tubes; but they are commonly so numerous as to form a complete zone round the large corallites, though such a zone never consists of more than a single row. In tangential sections taken just below the surface (fig. 18, C), each of the large corallites is seen to be surrounded by a well-marked ring of sclerenchyma, all the tubes, however, being firmly united together. Between the bounding-rings of the larger corallites are situated the small tubes, which, in sections of this nature, are mostly oval or

rounded. On the other hand, in tangential sections taken at a somewhat deeper level (fig. 18, A and B) the marginal

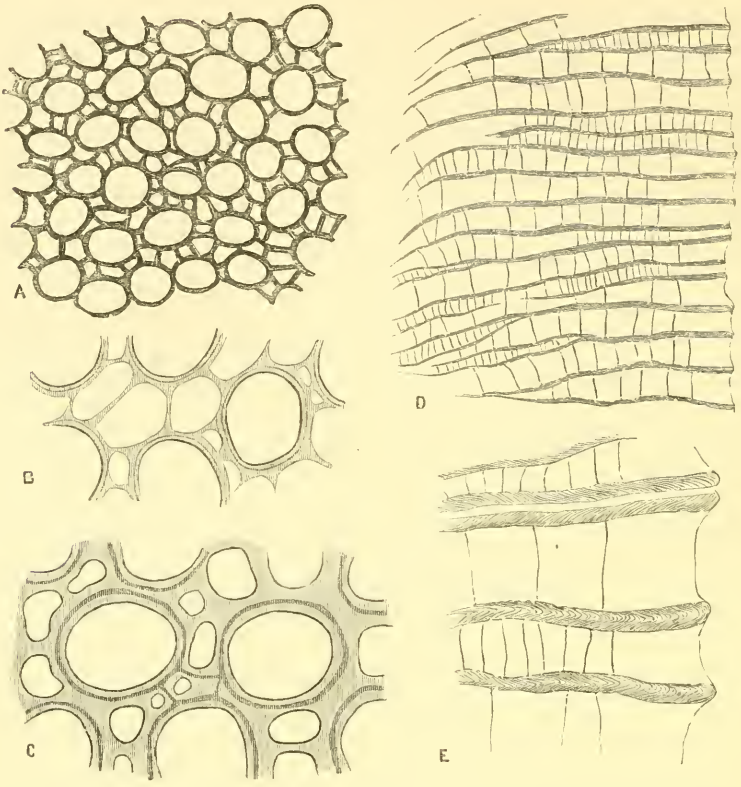

Fig. 18.—Internal structure of *Monticulipora ramosa*, E. and H., from the Cincinnati Group of Ohio. A, Tangential section, taken at a little distance below the surface, showing the two sets of corallites, enlarged eighteen times; B, Portion of the same section, enlarged fifty times; C, Part of another tangential section, taken just below the surface, enlarged fifty times; D, Part of the exterior of a vertical section, enlarged eighteen times, showing the different tabulation of the large and small corallites; E, Part of the same section, enlarged fifty times, showing the structure of the wall in the outer zone of the branches.

rings of the larger corallites are more completely separated from one another, and the small corallites are increased in size by the reduction of their bounding-walls, while their shape becomes more or less angular.

Vertical sections (fig. 18, D and E) show that the internal structure of the large and small tubes is conspicuously different, both sets of corallites being traversed by complete horizontal tabulæ, which are greatly more numerous in the small tubes

than in the large ones. The "monticules" do not appear, as a rule, to differ in structure from the general mass of the corallum, but they seem sometimes to comprise a larger proportion of small tubes than is usually the case in the intervening parts of the skeleton. In the axial region of the corallum, as shown both in longitudinal and transverse sections, the corallites are thin-walled and polygonal, but they possess an abundance of tabulæ. In the outer portion of their course, the corallites become thickened, their walls assuming a fibrous and laminated structure (fig. 18, E).

The internal structure of *M.* (*Heterotrypa*) *rugosa*, E. and H., as I have elsewhere pointed out (Ann. Nat. Hist., ser. 4, vol. xviii. p. 88), appears to be essentially the same as that of *M. ramosa*, D'Orb.; and a careful examination of thin sections of the form which I take to be the *M. Dalii* of Edwards and Haime (=*Chætetes approximatus*, Nich.) has satisfied me that the same is the case in this instance also. I shall therefore insert here a brief description of the two types just alluded to, regarding them merely as well-marked varieties of *M. ramosa*, D'Orb.

Var. I.—**M. ramosa**, D'Orb., var. **rugosa**, E. and H.

(Fig. 19, A and B; and Pl. II. fig. 3.)

Monticulipora rugosa, Dybowski, Die Chætetiden, p. 92, Pl. III. fig. 1, 1877.

Obs.—This form was originally defined as a distinct species by Milne-Edwards and Haime (Pol. Foss., p. 268, Pl. XX. figs. 6, 6*a*), and is at first sight readily distinguished from typical examples of *M. ramosa*, D'Orb., by its external characters. In place, namely, of the conical monticules of the latter, the surface now exhibits numerous well-defined elevations, which are transversely elongated, so as to constitute so many discontinuous transverse ridges (Pl. II. fig. 3). These ridges vary in length; but they do not extend round the stems, and are usually sharp-edged, and are placed about half a line

apart. In spite of this conspicuous difference, the more minute external and internal characters of *M. rugosa*, E. and H., are precisely similar to those of *M. ramosa*, D'Orb. Not only are the characters of the calices and interstitial tubes identical, but no difference of the smallest specific weight can be detected on a comparison of corresponding thin sections of the two forms. This will be rendered evident by a comparison of

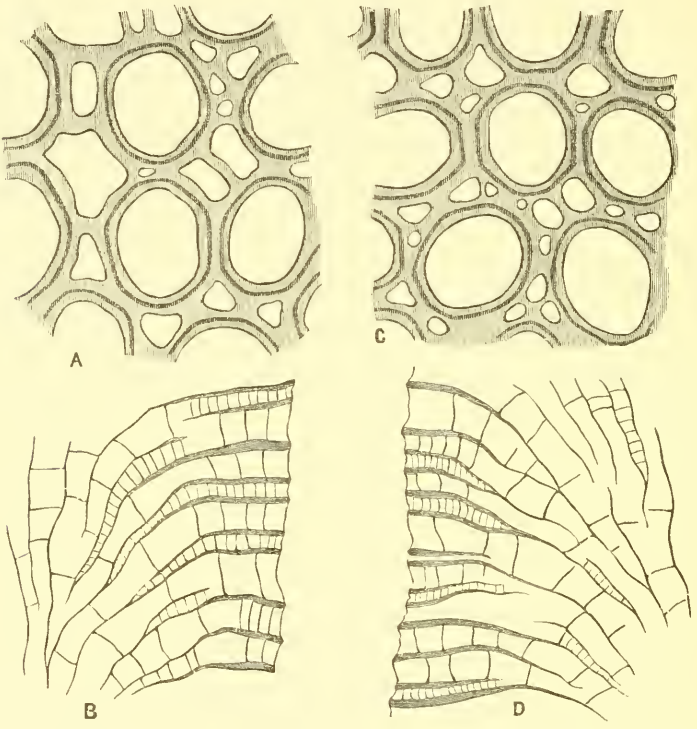

Fig. 19.—A, Tangential section of *Monticulipora rugosa*, D'Orb., enlarged fifty times; B, Vertical section of the same, enlarged eighteen times; C, Tangential section of *M. Dalii*, E. and H. (=*M. approximata*, Nich.), enlarged fifty times; D, Vertical section of the same, enlarged eighteen times. All the figures show the two sets of corallites. From the Cincinnati Group, Cincinnati, Ohio.

tangential and vertical sections of the type-form of *M. ramosa*, D'Orb., with similar sections of *M. rugosa*, E. and H. In the latter, as in the former, the corallum is composed conspicuously of two series of corallites, the large ones being oval or subpolygonal, about 1-90th to 1-80th inch in diameter, and surrounded by numerous small tubes (fig. 19, A). The structure

of the walls of the corallites is also the same, and both show exactly corresponding features in longitudinal sections (fig. 19, B). Upon the whole, therefore, there can be no hesitation in concluding that the mere external difference in the form of the monticules, being unaccompanied by any features of internal or structural difference, ought not to be allowed to count as of more than varietal value.

Var. II.—**M. ramosa**, D'Orb., var. **Dalii**, E. and H.

(Fig. 19, C and D; and Pl. II. fig. 4.)

Obs.—Not having had the opportunity of examining the original specimens upon which Milne-Edwards and Haime founded their *Chætetes Dalii* (Pol. Foss., p. 266, Pl. XIX. figs. 6, 6*a*, 1851), I cannot be absolutely certain that I have correctly identified it. Judging, however, from their figures and descriptions, I have little doubt that the form which I described as *Chætetes approximatus* (Quart. Jour. Geol. Soc., vol. xxx. p. 502, Pl. XXIX. figs. 3, 3*a*, 1874) is really the same. Accepting this conclusion, the differences and resemblances between *M. ramosa*, D'Orb., and *M. Dalii*, E. and H., may be briefly stated as follows: As regards external characters, *M. Dalii* precisely agrees with the type-form of *M. ramosa*, D'Orb., except that the monticules are much reduced in size, and that the interstitial tubuli are sometimes not quite so conspicuous or numerous. The monticules (Pl. II. fig. 4) are no longer boldly prominent or conical, but are much smaller, and in general either gently rounded or somewhat elongated transversely. With the above slight external difference, there is associated a complete agreement in internal structure, both tangential and longitudinal sections (fig. 19, C and D) showing features precisely similar to those exhibited by corresponding sections of typical examples of *M. ramosa*, D'Orb. I cannot doubt, therefore, that as in the case of the so-called *M. rugosa*,

E. and H., we have to deal in *M. Dalii*, E. and H., with nothing more than a well-marked variety of *M. ramosa*, D'Orb.

Horizon and Locality.—Abundant in the Cincinnati Group, Cincinnati, Ohio. Both of the two varieties, *rugosa*, E. and H., and *Dalii*, E. and H., occur associated in the same beds with the type-form of the species.

Monticulipora (Heterotrypa) nodulosa, Nich.

(Pl. I. figs. 4-4*d*.)

Chætetes? nodulosus, Nicholson, Quart. Jour. Geol. Soc., vol. xxx. p. 506, Pl. XXIX. figs. 9, 9*a*, 1874.

Chætetes nodulosus, Nicholson, Pal. Ohio, vol. ii. p. 200, Pl. XXI. figs. 10, 10*a*, 1875.

Chætetes nodulosus, Nicholson, Ann. and Mag. Nat. Hist., ser. 4, vol. xviii. p. 87, Pl. V. fig. 3, 1876.

Spec. Char.—Corallum minute, dendroid, of small cylindrical stems, which vary from two-thirds of a line up to one line in diameter, and branch dichotomously at intervals of about two lines. The surface exhibits numerous conical or transversely elongated tubercles or "monticules," which are placed at distances of about half a line apart. The calices are oval, with their long axes corresponding with the long axis of the corallum, separated by numerous smaller interstitial apertures. The corallites are vertical in the axis of the corallum, and only bend outwards in the extreme portion of their course, so that the axis bears an unusually large proportion to the circumferential portion of the stems. Their outward inclination is also very slight, so that they open obliquely on the surface. In the centre of the branches the large corallites are thin-walled and polygonal, but in the short outer part of their course they become thickened, and assume an oval shape. They are separated from one another by numerous small corallites, the form of which is angular or sub-angular. The tabulæ are comparatively few in number, but increase in amount as the surface is approached, being always complete and approximately hori-

zontal. In the small corallites the tabulæ are more numerous and closely set.

Obs.—Superficially, this species is readily distinguished by its minute size and the numerous well-defined monticules which cover the surface (Pl. I. fig. 4); while its internal structure is nearly as characteristic. Tangential sections (Pl. I. fig. 4*b*) show, as does the surface, that the corallum is composed of two distinct sets of corallites, large and small, the latter more or less completely encircling the former. The large corallites differ in different parts of their course. In the central region of transverse sections (Pl. I. fig. 4*c*) they are thin-walled and entirely angular, still having a number of smaller tubes intercalated amongst them. In the outer portion of their course, however, they become moderately thick-walled, and oval in shape, their average diameter being, in this region, about 1-60th inch. As, however, they widen out much on approaching the surface, they have a much smaller diameter in the interior of the branches. Each of the large corallites is surrounded by a distinct wall, and they are hardly or not at all in contact with one another, the interspaces between them being occupied by a well-developed series of small, more or less angular interstitial corallites, the size of which is variable. Longitudinal sections (Pl. I. fig. 4*d*), as transverse ones, show that the corallites are remarkably straight during the whole of their course, the extent to which they bend outwards as they near the surface being exceedingly slight. The result of this, as seen in transverse sections (Pl. I. fig. 4*c*), is, that the central axis of the corallum bears an unusually large proportion to the circumferential zone. In the centre of the branches the tabulæ are comparatively few in number, but they become more numerous as the surface of the corallum is approached, while the walls of the tubes become at the same time thickened. The tabulæ are always complete, but the small interstitial tubes differ structurally from the large ones in possessing much more closely-set partitions than the latter.

In its internal structure this species very nearly approaches

the *Monticulipora O'Nealli*, James, of the Cincinnati formation. The large corallites are, however, on the whole, decidedly larger than in the latter species, while the more minute proportions of the corallum and the presence of the well-marked superficial monticules would appear to sufficiently establish its distinctness, since *M. O'Nealli* is a decidedly more robust species, and does not appear to be ever furnished with external prominences.

Horizon and Locality.—Cincinnati Group, Ohio. The specimens upon which the preceding description is founded were obligingly furnished to me by Mr U. P. James of Cincinnati.

Monticulipora (Heterotrypa) O'Nealli, James.

(Pl. III. figs. 3-3*f*).

Chætetes? O'Nealli, James, Cat. Foss. Cincinnati Group, 1875, p. 2.
Chætetes sigillarioides, Nicholson, Pal. Ohio, vol. ii. p. 203, Pl. XXII. figs. 9-9*a*, 1875.

Spec. Char.—Corallum dendroid, of small dichotomously dividing branches, which vary in diameter from less than a line to about two lines. Surface without monticules, the calices being in general regularly oval, their long axes corresponding with that of the branches, and their long diameter being usually from 1-110th to 1-100th inch. The larger calices are separated, especially at their upper and lower ends, by a considerable number of the minute apertures of a series of interstitial tubuli. The walls of the larger corallites are seemingly amalgamated, and are thickened in the outer portion of their course. In the axis of the stems the corallites are polygonal and remarkably thin-walled, and they bend outwards with an exceptionally gradual inclination. Complete horizontal tabulæ are either absent, or are very sparingly developed in the central region of the stems; but similar structures are present in moderate numbers in the outer thickened region of the corallum, and the small interstitial corallites are much more closely tabulate than the large tubes.

Obs.—The name of *Chætetes sigillarioides* was given by me to this well-marked species in 1874; but my description was not published (in vol. ii. of the 'Palæontology of Ohio') till the middle of 1875, before which time Mr U. P. James had described the same form under the name of *C. O'Nealli*. This latter name, as having the priority, must therefore be retained for the species.

In its external characters *Monticulipora O'Nealli* is readily recognised by its slender cylindrical, smooth branches, its regularly oval, vertically arranged calices, and the presence of numerous interstitial apertures between the upper and lower ends of the larger calices (Pl. III. fig. 3*a*). The openings of the calices are often quite free; but in other cases, often over considerable areas, the large calices are closed by curious centrally perforated opercula (Pl. III. fig. 3*b*), which may be regarded morphologically as representing the last formed tabulæ.

Tangential sections (Pl. III. figs. 3*c*, 3*d*) show that the corallum is composed of two distinct sets of corallites, large and small. The larger corallites are oval, about 1-100th inch, or rather less, in their long diameter, and, in this region, furnished with thickened walls. Each tube (Pl. III. fig. 3*d*) is surrounded by a ring-like wall of its own, and adjacent tubes are united to one another by sclerenchyma, in which run the numerous small corallites, these latter varying much in shape and size, but being usually sub-angular.

Transverse sections (Pl. III. fig. 3*e*) show that in the central region of the corallum all the tubes are thin-walled and polygonal, only becoming thickened in the circumferential portion. Lastly, vertical sections (Pl. III. fig. 3*f*) show that the corallites in the axial region are not only thin-walled, but also remarkable in the shortness and slight curvature of their outer thickened portions. These sections also show that tabulæ are nearly or quite absent in the centre of the stems, but developed in fair numbers in the peripheral region, their direction, owing to the slight curvature of the corallites, being often nearly parallel to the outer surface. The small interstitial corallites are also

seen to be provided with much more numerous and more closely-set tabulæ than is the case in the large tubes. All the tabulæ are, as a rule, complete, and horizontal or slightly curved; but in some cases a few of the tabulæ in the throat of the large tubes may become so bent as to unite with one another, and to form a small number of lenticular vesicles in this region.

The species to which this is most nearly allied in its minute structure is *M. nodulosa*, Nich., and it clearly belongs to the same group of *Monticuliporæ* as *M. ramosa*, D'Orb. Apart from minor differences, it is distinguished from *M. nodulosa* by its stouter form, its want of clearly-marked monticules, and its common possession of opercula to the large corallites.

Horizon and Locality.—Cincinnati Group, Cincinnati, Ohio.

Monticulipora tumida, Phillips.

(Pl. III. figs. 1-1*f*.)

Calamopora tumida, Phillips, Geology of Yorkshire, vol ii., Pl. I. figs. 49-57, 1836.
Favosites tumida, Portlock, Geol. Report, p. 326, Pl. XXII. fig. 4, 1843.
Favosites tumida, M'Coy, Synopsis Carb. Foss. Ireland, p. 193, 1844.
Stenopora tumida, M'Coy, Brit. Pal. Foss., p. 82, 1850.
Chætetes tumidus, Milne-Edwards and Haime, Pol. Foss. des Ter. Pal., p. 270, 1851; and Monograph Brit. Foss. Cor., p. 159, 1852.
Monticulipora tumida, De Koninck (?), Nouv. Rech. Anim. Foss. Terr. Carb., Pt. I. p. 143, 1872.
Chætetes tumidus, R. Etheridge, jun., Ann. Nat. Hist., ser. 4, vol. xiii. p. 194, Pl. XI. figs. 1-3, 1874.

Spec. Char.—Corallum dendroid, of cylindrical stems varying from two to more than three lines in diameter, which branch dichotomously at irregular intervals. The calices are irregularly polygonal, circular or oval, their apertures being about 1-90th inch in diameter, and their walls being very thick. In well-preserved specimens the walls separating the calices are adorned with numerous blunt spines, and there is also a variable number of minute interstitial apertures intercalated

among the ordinary calices, and sometimes aggregated together to form distinct maculæ. The walls of the corallites, so far as appearances go, are undistinguishably fused together, their substance being perforated by numerous minute tubules, which usually form a single row between adjoining corallites. In the axis of the stems the corallites are thin-walled, but their walls become excessively thickened as they bend outwards to reach the surface. Complete horizontal tabulæ are developed in moderate numbers, both in the axis of the branches, and also in the outer portion of the corallites.

Obs.—This very remarkable species, which is so abundant in the Carboniferous rocks of Britain, exhibits structural features of an unusual character. In its general form (Pl. III. fig. 1) it is dendroid, and the most constant of its superficial peculiarities is the great thickness of the walls surrounding the oval or sub-polygonal calices (Pl. III. fig. 1*a*). Some specimens exhibit an apparently smooth surface, and none have "monticules" in the proper sense of the term; but, when well preserved, the surface usually exhibits numerous prominent blunt spines (Pl. III. figs. 1*a* and 1*c*), which give a characteristically rough appearance to the exterior, as viewed under the lens or microscope, and which surround the mouths of the calices in a single row. In some specimens, the surface shows no other apertures than those of the proper calices (Pl. III. fig. 1*a*), or, perhaps, only an occasional minute opening. In other specimens, again, we find a moderate number of much smaller openings intercalated amongst the normal calices; and the former are also not unusually aggregated into star-like groups or "maculæ." In the normal form of the species, however, these interstitial openings are never excessively developed; and except where a "macula" may be situated, there is never more than a limited number of tubules at the angles of junction of the larger tubes.

As regards internal structure, tangential sections (Pl. III. fig. 1*d*) show that the walls of the corallites are seemingly completely fused together, no sign of any line of demarcation between

adjoining tubes being recognisable. The actual orifices of the corallites are surrounded by a fibrous and laminated ring, and the intervening spaces between them are occupied by structureless sclerenchyma perforated by numerous minute thick-walled apertures, belonging to the interstitial tubuli of the colony. Some of these interstitial tubes are of comparatively large size, and show a well-defined central cavity; others are much smaller, and show only a very limited lumen, or none at all, appearing in the latter case merely as dark spots. In any case, numerous as are these interstitial tubes, they normally form only a single row between adjacent corallites, and there can be no doubt but that the surface-spines which surround the margins of the calices are really their upper terminations.

Longitudinal sections (Pl. III. figs. 1*e* and 1*f*) show that the corallites are vertical in the centre of the stems, bending outwards at a considerable angle to reach the surface. In the axial part of their course they are provided with thin and delicate walls, but their visceral cavities are considerably contracted in the outer portion of their course by a secondary deposit of laminated sclerenchyma, by which the walls become greatly thickened. I am, however, not able to confirm M'Coy's statement that this thickening is periodic, and gives rise to a moniliform structure of the wall, such as is characteristic of the genus *Stenopora*, properly so called—all my observations going to prove that the thickening of the walls of the corallites is effected continuously, and leads to results precisely similar to those observed in many other species of *Monticulipora* (*e.g.*, *M. gracilis*, James). Longitudinal sections also show that complete horizontal tabulæ are developed in moderate numbers, both in the axial and circumferential portions of the corallites. There is therefore no reason to accept the views of those who are disposed to think that tabulæ are wanting in this species; while I have found no evidence of the perforated tabulæ which M'Coy states he has observed closing the mouths of the corallites in this species. The interstitial "spiniform corallites" are only

recognised in longitudinal sections with difficulty; but one may occasionally detect the narrow cavity of one of these, perforating the thick fibrous wall between two of the ordinary corallites (Pl. III. fig. 1*f*).

M. tumida, Phill., is a common fossil in the Carboniferous rocks of all parts of Britain, and the foregoing description is founded upon specimens which I collected in the Carboniferous shales of Redesdale, Northumberland, where the species is very abundant, and remarkably well preserved. Along with the normal type of the species, however, I have met with a limited number of examples which appear to me to differ from the usual type so far as to be, at least, entitled to separation as a distinct variety; and I shall now proceed to give a brief description of the characters of this :—

Monticulipora tumida, Phill., var. **miliaria**, Nich.

(Pl. III. figs. 2, 2*a*.)

Corallum dendroid, about one-tenth of an inch in diameter, branching at short intervals. Calices thick-walled, their apertures varying from 1-100th to 1-120th inch in diameter, separated by interspaces occupied by the minute apertures of very numerous interstitial tubuli, which are in places aggregated into star-shaped maculæ. These interstitial tubuli vary a good deal in size, sometimes being mere circular dark spots (as seen in section), sometimes exhibiting well-defined central cavities; but their number is always very great, and, even when not aggregated into maculæ, they commonly form a double row between adjoining corallites. In other respects, this form agrees entirely with the normal type of *M. tumida*, its corallites being thin-walled in the centre of the branches, and becoming thickened as they bend outwards to reach the surface, their walls becoming at the same time completely fused together, while their visceral chambers are crossed by a moderate number of horizontal tabulæ.

In our ignorance of the complete corallum of *Monticulipora*

tumida, it is impossible to assert positively that this apparently well-marked variety may not be really merely founded upon some particular *part* of the adult skeleton, as, for example, the young, actively growing branches. In the meanwhile, it will be of advantage, considering its conspicuous differences, to regard it as at least a variety of *M. tumida*, and to give it a distinct title in accordance with this view.

There is no species of *Monticulipora* which comes so near in its characters to *M. tumida*, Phill., so far as I know, as to demand any detailed comparison. At the same time, it is not unworthy of notice that in many of its minute structural features *M. tumida* certainly presents a very curious resemblance to certain species of the genus *Stenopora*, Lonsd. (*non* M'Coy). So far as our present knowledge extends, the only points which would definitely separate *M. tumida*, Phill., from *Stenopora* are, that it certainly shows no traces of the peculiar moniliform and periodic thickening of the walls of the corallites which is characteristic of the latter genus, and that there is no evidence as to the presence of mural pores. Till, however, the very anomalous and remarkable characters of the genus *Stenopora*, Lonsd., are completely elucidated—which will not be the case until a large number of examples have been submitted to careful examination by modern methods—it would be premature to attempt any definite conclusions as to the real affinities of *M. tumida*, Phill.

Horizon and Locality.—Common in the Lower Carboniferous rocks of Great Britain generally. The specimens which I have examined microscopically are from the Carboniferous rocks of Redesdale, Northumberland, and Reagill, Westmorland.

Monticulipora (Heterotrypa) gracilis, James.

(Fig. 20, and Pl. II. figs. 1, 1*b*.)

Chætetes gracilis, James, Cat. Foss. Cincinnati Group, 1871 (named, but not figured or described).
„ „ Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 504, Pl. XXIX. figs. 7, 7*a*, 1874.
„ „ Nicholson, Pal. Ohio, vol. ii. p. 198, Pl. XXI. figs. 8, 8*b*, 1875.
„ „ Nicholson, Ann. and Mag. Nat. Hist., ser. 4, vol. xxviii. p. 90, Pl. V. fig. 13, 1876.

Spec. Char.—Corallum dendroid, the branches cylindrical or sub-cylindrical, from less than a line to three lines or more in diameter, dividing dichotomously at short intervals. Surface smooth, without monticules, covered by the calices, which are approximately oval, with their long axes corresponding with that of the branch, and which are surrounded by much thickened walls. The ordinary calices have an average long diameter (as regards the aperture) of about 1-145th inch, and they open obliquely to the surface, a moderate number of much smaller interstitial apertures existing between them.

The corallites in the axis of the branches are vertical in direction, and are thin-walled and polygonal in outline, very few or no tabulæ being developed in this region. As they bend outwards to reach the surface, their walls become greatly thickened, and tabulæ are now abundantly developed, these structures being always complete and horizontal. The corallites, in the outer portion of their course, are seemingly completely amalgamated by their walls, and three distinct types of tubes may be recognised amongst them. Firstly, there are the normal tubes, which have an average diameter (as regards their visceral chambers) of about 1-145th inch or less, any given pair of tubes occupying a space of about 1-60th or 1-50th inch. These corallites have a moderate number of horizontal tabulæ, which in some cases are much reduced in amount. Secondly, intercalated with the preceding, we find

a variable number of much smaller corallites, which are provided with more numerous and closely-set tabulæ. Thirdly, there exists a variable number of very minute, thick-walled tubuli ("spiniform corallites") which are situated in the thick walls separating the normal corallites, and which are easily recognised by their dark margins.

Obs.—This pretty little species is readily distinguished by both its external and its internal characters. Externally it is characterised by its smooth surface, without monticules; by its

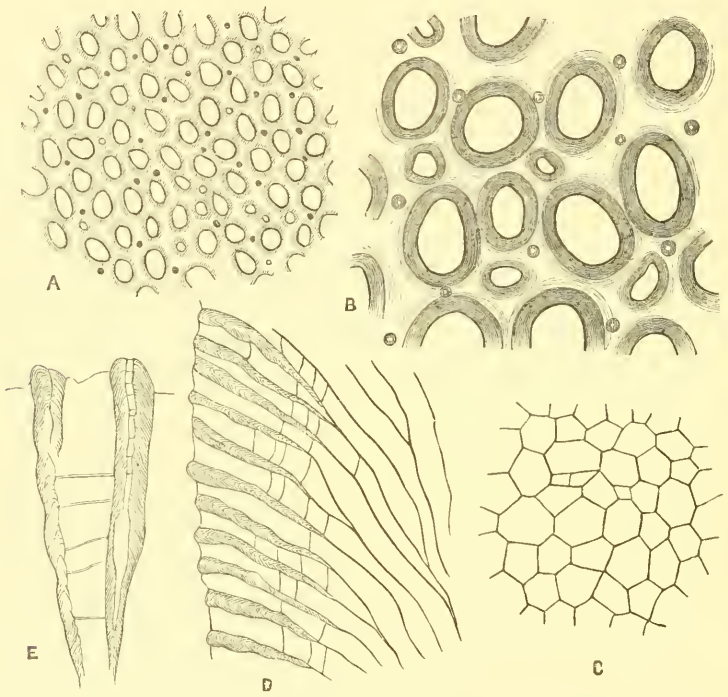

Fig. 20.—*Monticulipora gracilis*, James. A, Part of a tangential section, enlarged eighteen times, showing the two sets of corallites and the hollow spiniform corallites; B, Part of the same section enlarged fifty times; C, Part of the central axis of the corallum, enlarged eighteen times, showing the thin-walled and polygonal condition of the corallites in this region; D, Part of a vertical section, enlarged eighteen times; E, A single corallite of the same section, enlarged fifty times, showing the fibrous structure of the wall—on one side, the wall is traversed by one of the minute spiniform corallites. From the Cincinnati Group, Cincinnati, Ohio.

minute, crowded, thick-walled, and oblique calices, with occasionally interspersed small tubuli (Pl. II. figs. 1*a*, 1*b*); and, to

a less extent, by its general form and proportions. In this last-mentioned respect it is superficially not unlike *M. Ulrichii*, Nich. (the so-called *M. Fletcheri* of the Cincinnati Group).

As regards internal structure, tangential sections (fig. 20, A and B) show the ordinary corallites to be of very small size, and to be completely fused by means of their greatly thickened walls, their general shape being oval, rounded, or sub-polygonal. A moderate number of small corallites are developed at the angles of junction of these, and minute dark "spiniform corallites" are developed in some number. Transverse sections show that the central axis of the branches is of comparatively large size, and that this region of the corallum is occupied by thin-walled polygonal tubes (fig. 20, C), the corallites only becoming thickened in their circumferential zone. Longitudinal sections show that tabulæ are very sparsely, or not at all, developed in the axis of the corallum, where the tubes are delicate and thin-walled; while the outer portions both of these (fig. 20, D) and of transverse sections show that the tabulæ are fairly well developed throughout the outer thickened portion of their course, being always horizontal and complete, and being much the most numerous in the small corallites. These sections also show (fig. 20, E) that the walls of the corallites in the outer part of their course have the peculiar fibrous structure characteristic of those *Monticuliporæ* in which the walls are seemingly fused together, while they are sometimes seen to be traversed by tubuli representing the spiniform corallites.

The typical *M. gracilis*, James, is a small form, its stems being mostly from a line to two or three lines in diameter. At a higher horizon in the Cincinnati Group, however, there occurs abundantly a larger form, the branches of which range from two to four or five lines in diameter. For this latter, Mr U. P. James has provisionally proposed the name of *Chætetes Meeki* (The Palæontologist, No. 1, p. 1, 1878). I have, however, made a careful microscopic examination of this form by means of thin sections, and am satisfied that it is merely a

larger growth of *M. gracilis*, James, with which it agrees in all the fundamental characters of its internal structure.

Horizon and Locality.—Cincinnati Group, Ohio (Cincinnati, Waynesville, &c.)

Monticulipora (Heterotrypa) Andrewsii, Nicholson.

(Fig. 21, and Pl. V. figs. 1, 1*a*.)

Chætetes pulchellus, Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 503, Pl. XXIX. figs. 5-5*b*, 1874. Pal. Ohio, vol. ii. p. 195, Pl. XXI. figs. 5, 5*a*.

Spec. Char. — Corallum variable in form, but essentially dendroid, usually of sub-cylindrical branches, which have a diameter of from two to six lines, are sometimes flattened and expanded, and sometimes inosculate. Calices polygonal or sub-polygonal, mostly about 1-90th inch in diameter, separated by the much smaller openings of a moderate number of interstitial tubes, which are principally developed at the angles of junction of the large corallites. The surface also shows rounded groups or clusters of from five to seven corallites of a rather larger size than the average; but these clusters, though readily recognised, are not so far elevated above the general level as to constitute regular "monticules." In the centre of the branches the corallites are thin-walled, and polygonal in shape; but their walls become much thickened as the tubes bend outwards to the surface, becoming at the same time completely amalgamated with one another. No "spiniform corallites" are present. The tabulæ are always complete and horizontal, and are well developed in all the corallites and throughout their entire extent; but the small interstitial corallites are far more closely tabulate than are the large tubes.

Obs.—The present species is one which has generally been recognised by American palæontologists as identical with the *M. pulchella*, Edw. and H., of the Wenlock Limestone of

Britain. So far, in fact, as its external characters are concerned, it is very like *M. pulchella*, resembling it especially in the existence of clusters of thin-walled polygonal corallites, interspersed at short intervals among similarly-shaped but slightly smaller tubes. In the absence, therefore, of any accurate microscopic knowledge of the internal structure of the two forms, it was almost inevitable that they should have been grouped together, though their minute characters, as will appear hereafter, are very different.

Superficially, *M. Andrewsii* is readily recognised by its sub-equal, polygonal, or sub-polygonal calices, with the numerous

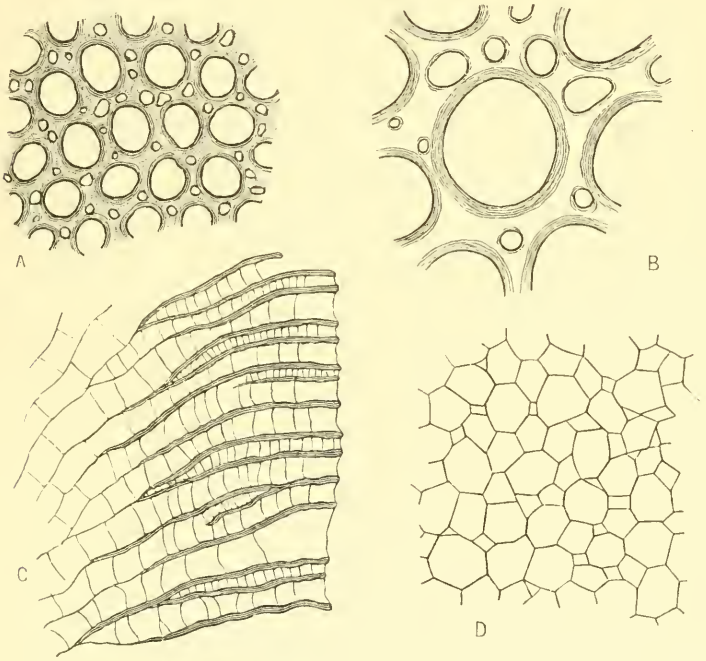

Fig. 21.—Minute structure of *M. Andrewsii*, Nich., from the Cincinnati Group of Ohio. A, Tangential section enlarged eighteen times, and B, part of the same enlarged fifty times, showing the structure of the wall, and the two sets of corallites; C, Vertical section, enlarged eighteen times, showing the different tabulation of the large and small corallites; D, Part of the axial region of a transverse section, enlarged eighteen times, showing the thin-walled and polygonal condition of the tubes in the centre of the branches.

little clusters of slightly larger-sized apertures. Intermingled with the ordinary calices, and especially at their angles, the

microscope shows the existence of a moderate, but not excessive, number of the minute openings of the small corallites (Pl. V. fig. 1*a*). The clusters of the larger tubes are also not conspicuously elevated above the general level.

Tangential sections (fig. 21, A and B) show that the corallites in the outer portion of their course have much-thickened walls, their visceral chambers becoming rounded or oval. Their walls, also, become seemingly completely fused in this region, so that the original lines of demarcation between adjacent tubes cannot be recognised at all. In the thickened walls between the larger tubes are seen the openings of a considerable number of interstitial tubules, which vary much in size, and are mostly circular or oval.

In the axis of the branches, transverse sections (fig. 21, D) show that the corallites are at first quite thin-walled and polygonal in shape, the same thing being shown in the central parts of longitudinal sections. These latter (fig. 21, C) also show that the thickening of the walls of the corallites begins almost as soon as they commence to bend outwards to the surface, while a marked difference in the tabulation of the larger and smaller corallites is displayed,—the latter having much more numerous tabulæ than the former. In all the corallites, however, the tabulæ are well developed, and they are always complete and approximately horizontal.

A consideration of the preceding characters will show that *M. Andrewsii*, Nich., has no real affinity to *M. pulchella*, E. and H. This is sufficiently proved by the complete amalgamation of the walls of the corallites in the circumferential region of the corallum, and by the presence of a set of closely tabulate interstitial tubes intermingled with the ordinary corallites. On the other hand, *M. pulchella*, E. and H., has no series of interstitial corallites, and the original lines of demarcation between the tubes remain permanently recognisable.

The species to which *M. Andrewsii* is perhaps most nearly allied is *M. ramosa*, D'Orb.; but the two are readily distinguished not only by the marked difference in their external

characters, but also by numerous more or less important features in their internal structure.

I have ventured to name this species in honour of the late Professor E. B. Andrews, who is well known to geologists by his published labours in connection with the geological survey of Ohio.

Horizon and Locality.—Cincinnati Group, Cincinnati, Ohio.

Monticulipora (Heterotrypa) Ulrichii, Nicholson.

(Fig. 22.)

Chætetes Fletcheri, Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 504, Pl. XXIX. figs. 6-6*a*, 1874. Pal. Ohio, vol. ii. p. 197, Pl. XXI. figs. 7-7*a*, 1875. Ann. Nat. Hist., ser. 4, vol. xviii. p. 90, Pl. V. fig. 14, 1876.

Spec. Char.—Corallum ramose, of cylindrical or sub-cylindrical branches, which divide dichotomously at irregular intervals, and vary in diameter from less than two lines to about four lines. The surface is smooth and destitute of monticules, but in well-preserved specimens minutely spinose; the calices sub-polygonal or rounded, mostly from 1-100th to 1-90th inch in diameter. Interspersed with the openings of the ordinary corallites are the minute irregularly rounded apertures of a largely developed series of small interstitial corallites.

As regards internal structure, the corallites are at first thin-walled, but become thickened in the outer part of their course, their walls becoming at the same time seemingly fused together. The small angular interstitial corallites occupy all the intervals left between the oval or rounded large tubes, and there is a largely developed series of thick-walled hollow tubuli ("spiniform corallites"), placed at the angles of junction of the normal corallites. Tabulæ are wanting, or are very sparingly developed in the axial region of the branches, but are abundantly present in the outer portion of the tubes, and are much more closely set in the small interstitial corallites than in the large ones. In all cases, the tabulæ are complete and approximately horizontal.

Obs.—In common with various American observers, I have formerly identified the present form with the *M. Fletcheri*,

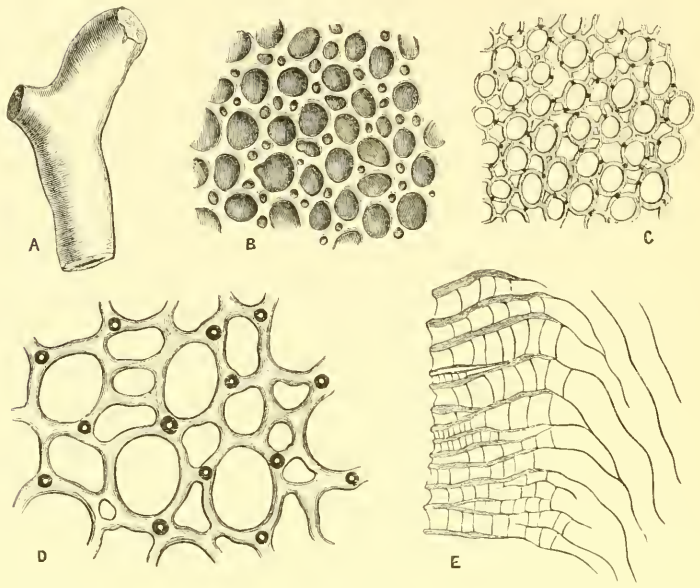

Fig. 22.—*Monticulipora Ulrichii*, Nich. (the so-called *M. Fletcheri* of the Cincinnati formation). A, A fragment of the corallum of the natural size; B, Part of the surface, enlarged eighteen times; C, Tangential section of the same, similarly enlarged; D, Part of a tangential section, enlarged fifty times, showing the two sets of corallites, and the tubular spines; E, Part of a vertical section, enlarged eighteen times. From the Cincinnati Group, Cincinnati, Ohio.

Edw. and Haime, of the Wenlock Limestone of Britain.[1] I am, however, now satisfied that the examples from the Cincinnati Group certainly cannot be properly thus identified, with our present knowledge. We are not at present acquainted with the minute structure of the type-specimens upon which the distinguished French writers above mentioned founded the species *M. Fletcheri*, so that any identification of these with the form now under consideration is necessarily exceedingly

[1] After a careful investigation, I have failed to satisfactorily identify any of the specimens in my collections from the Wenlock Limestone with *M. Fletcheri*, E. and H. Judging from external characters only, there were several specimens which I should have thus identified; but on making a microscopic examination of these by means of thin sections, I found these to be really referable to a species of *Fistulipora*, and to be therefore, at any rate, entirely distinct from the so-called *M. Fletcheri* of the Cincinnati Group.

hazardous; while even so far as external characters go, there are differences in size and in the relative abundance of the small interstitial corallites, which clearly point to the specific distinctness of the latter. For this, therefore, I now propose the name of *M. Ulrichii*, in honour of Mr E. O. Ulrich, whose published papers have added so materially to our knowledge of some of the more difficult fossils of the Cincinnati Group.

In general form and aspect, *M. Ulrichii* most nearly resembles the larger examples of *M. gracilis*, James, having cylindrical stems, with a smooth surface, and comparatively minute corallites of two sizes. It is, however, distinguished from *M. gracilis* by the fact that the corallites do not open obliquely upon the surface, by the thinner walls of the calices, and by the greater abundance of the interstitial corallites.

As regards its internal structure, tangential sections of *M. Ulrichii* (fig. 22, C, D) show that the normal corallites of the colony are divided into two distinct groups, which are uniformly intermingled with one another, but differ in size and in other characters. The large corallites are mostly oval or sub-circular, mostly from 1-90th to 1-100th inch in diameter, and only partially and to a very limited extent in actual contact. Occupying all the intervals between the large tubes are numerous smaller interstitial corallites, which vary much in shape and size, but are always more or less angular. These are never so far developed as to isolate the large tubes, and there is never more than one row of them between any given pair of the latter. In addition to the preceding, there are numerous circular, thick-walled, and darkly-outlined hollow tubuli ("spiniform corallites"), which are intercalated at most of the angles of junction of the normal corallites. With the terminations of these upon the surface I am not acquainted, except in a few instances, in which they appear as a series of short spines.

The axial region of the corallum, as seen in transverse sections, is very largely developed as compared with the circumferential portion, and the corallites are here thin-walled and polygonal in shape, while they are also almost, or sometimes

quite, without tabulæ. As the tubes turn outwards towards the surface, as shown in long sections (fig. 22, E), their walls thicken and become fused together; while complete horizontal tabulæ are now abundantly developed. There is also seen to be a decided structural distinction between the larger corallites and the interstitial tubes, the latter being much more closely tabulate than the former. Lastly, the thick-walled "spiniform corallites" may be occasionally detected in long sections.

Horizon and Locality.—Cincinnati Group, Cincinnati, Ohio.

Monticulipora (Heterotrypa) subpulchella, Nicholson.

(Fig. 23, and Pl. V. figs. 2, 2*a*.)

Chætetes subpulchellus, Nicholson, Pal. Ohio, vol. ii. p. 196, Pl. XXI. figs. 6, 6*a*, 1875.

Spec. Char.—Corallum ramose, of compressed, often greatly flattened branches, which may be quite frondescent, and are commonly partially hollow centrally. An average specimen has a height of over two inches, a width of one inch, and a thickness of four-tenths of an inch. The ordinary calices are circular or polygonal in form, from 1-80th to 1-70th inch in diameter, with moderately thick walls, and having the apertures of a moderate number of small sub-angular interstitial corallites interspersed amongst them. These latter, however, are mostly aggregated into somewhat stellate clusters or maculæ, which are not conspicuously elevated above the general surface, and which are placed at intervals of about one line apart. The larger corallites, which immediately surround the clusters of small tubes, sometimes appear to be of rather more than the average size.

As regards internal structure, the corallites are thin-walled in the centre of the branches, but become thickened as they bend outwards, their walls becoming at the same time seemingly fused together. Complete horizontal tabulæ are developed in all parts of the corallum, but are much more abundant

in the thickened peripheral portion of the tubes than centrally; while the interstitial tubes are more closely tabulate than the average corallites.

Obs.—As far as external characters go, this species is distinguished by its flattened, sub-frondescent form, and by the presence of numerous star-shaped "maculæ," formed by clusters of small corallites, and not elevated above the general surface (Pl. V. figs. 2, 2*a*).

As concerns its minute structure, tangential sections (fig. 23, A and B) show that the corallites in the outer part of the

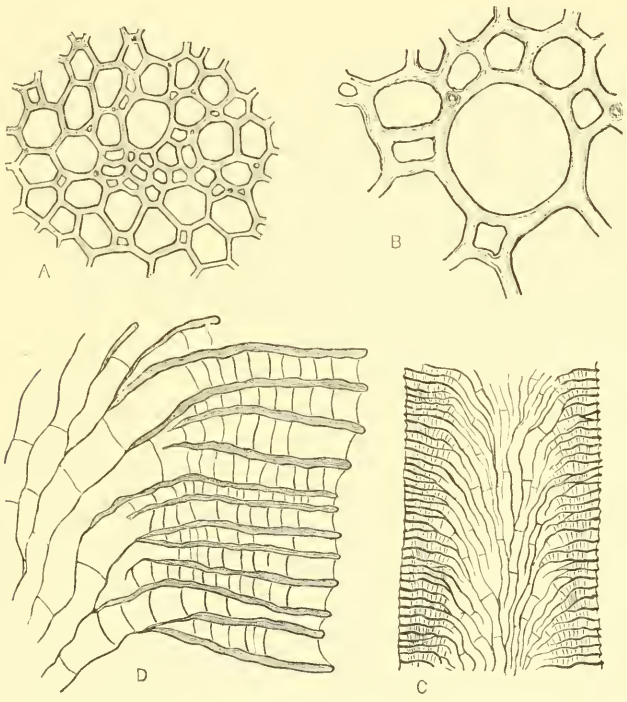

Fig. 23.—Minute structure of *M. subpulchella*, Nich., from the Cincinnati Group of Ohio. A, Part of a tangential section, embracing one of the maculæ, enlarged eighteen times; B, Small portion of the same section, enlarged fifty times; C, Vertical section of the corallum, enlarged six times, showing the different structure of the corallites in the axial and peripheral portions of their course respectively; D, Part of the preceding section, enlarged eighteen times.

corallum have thickened walls, and are apparently completely amalgamated with one another. The average corallites are

polygonal or sub-polygonal in form, and interspersed among them we see a variable number of much smaller tubes, together with an occasional thick-walled "spiniform corallite." The clusters of small tubes, which are so conspicuous at the surface, are readily recognised in tangential sections, provided these are not made at too great a depth.

In vertical sections taken at right angles to the compressed surfaces of the corallum (fig. 23, C and D) the corallites are seen to be at first thin-walled, and to radiate outwards on both sides of the middle line, becoming thickened as the surface is approached. Even in the axis of the corallum a moderate number of complete and horizontal tabulæ can be detected; but these become much more numerous in the outer deflected portion of the tubes. It is also to be noted that there is a distinct structural difference between the large and small corallites, the latter having the tabulæ much more closely set than is the case in the former.

From *M. Andrewsii*, Nich., the present species is distinguished by its general form, and by various structural characters of importance, the most striking of these being that the "maculæ" are composed of the small interstitial tubes of the colony; whereas in the former the corresponding parts of the corallum are formed by tubes which are larger in size than the average large corallites. The only species, with which I am acquainted, in which there exist similar clusters of small tubes, is *M. Selwynii*, Nich., from the Trenton Limestone of Canada. This latter, however, is not only a discoid species, but is separated, among other features, by the possession of incomplete tabulæ.

Horizon and Locality.—Rare in the Cincinnati Group, Cincinnati, Ohio. (The specimens in my collection were kindly presented to me by Mr U. P. James of Cincinnati.)

Monticulipora (Heterotrypa) moniliformis, Nich.

(Plate I. figs. 1-1*c*.)

Chætetes moniliformis, Nicholson, Geol. Mag. Dec. II., vol. i. p. 57, Pl. IV. figs. 7*a*, 7*b*, 1874.
„ „ Nicholson, Palæontology of Ontario, 1874, p. 60, fig. 17.

Spec. Char.—Corallum dendroid, the branches usually having a diameter of from three to five lines, or occasionally more. The surface may be nearly smooth, but is usually provided with bluntly rounded tubercles or monticules, which seem to be composed of corallites of a very slightly larger size than the average. The calices are polygonal, and the thick walls between them exhibit at all their angles of junction well-marked blunt spines, which, in slightly worn examples, produce a very characteristically rough superficial aspect. The walls of the corallites are completely amalgamated, and are mostly of tolerably equal dimensions, averaging 1-70th to 1-60th inch in diameter, though occasional smaller corallites are intercalated among them. There is also a great number of thick-walled hollow spines ("spiniform corallites"), which are of unusually large size, and are placed at almost all the angles of the junction of the normal corallites, as well as often in the substance of their walls. The tabulæ are complete, horizontal, or slightly curved, from 1-100th to 1-80th inch apart.

Obs.—*Monticulipora moniliformis* presents itself, so far as I have seen, always in the form of stout branching stems, the surface of which is usually marked by moderately conspicuous rounded monticules (Pl. I. fig. 1), though these may be wanting. By examination with a lens, the calices are seen to be polygonal; and, if the surface be at all worn, their angles of junction always project as very conspicuous nodal spines, which will usually enable the spines to be recognised even by an external inspection (Pl. I. fig. 1*a*).

As regards the internal structure of the corallum, thin tangential sections (Pl. I. fig. 1*b*) show a seeming entire amalgamation

of the walls of the corallites, not the slightest trace of any line of demarcation between adjoining tubes being recognisable. The corallites are as a whole very uniform in size, and are polygonal or sub-polygonal in shape. Small corallites, in limited number, are usually intercalated among the larger tubes; but the amount of these varies even in different parts of the same section, and as they show no peculiarities of structure, they are apparently merely young tubes. At almost all the angles of junction of the large tubes, however, and commonly in the thickness of their lateral walls, are developed large hollow spines ("spiniform corallites"), which exhibit a central dark or light space surrounded by a conspicuous thickened wall (fig. 24, and Pl. I. fig. 1*b*). The upper ends of these peculiar structures project as intracalicine spines upon the surface, and I have not been able to detect that they are open above; though they are clearly hollow, and they can often be traced in longitudinal sections as distinct tubular cavities in the axis of the thickened wall of the corallites (see fig. 3, B).

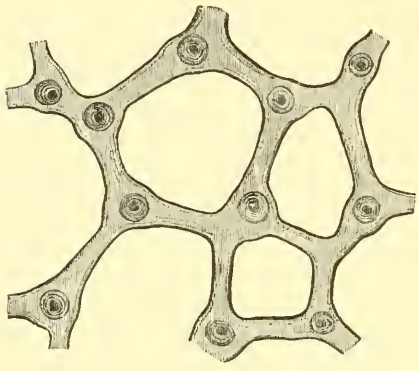

Fig. 24.—Portion of a tangential section of *Monticulipora moniliformis*, Nich., taken just below the surface, showing the intracalicine spines, enlarged fifty times. From the Hamilton Group of Ontario.

Longitudinal sections (Pl. I. fig. 1*c*) show that the corallites in the axis of the branches are thin-walled, with comparatively few tabulæ. In the outer part of their course, however, where they bend outwards to reach the surface, they become thickened, and the walls assume the peculiar fibrous aspect characteristic of all those *Monticuliporæ* in which a complete amalgamation of the corallites occurs. In this part of their course, also, the tabulæ increase considerably in number; but they are never very closely arranged, and they are always complete.

The only species known to me with which the present form would be likely to be confounded is the *M. Barrandi*,

Nich., of the same formation; and in treating of the latter I shall point out such features as seem to render a separation between these two types desirable.

Formation and Locality. — Not very uncommon in the Hamilton Group (Devonian) of Widder, Ontario.

Monticulipora (Heterotrypa) Barrandi, Nich.

(Pl. I. figs. 2-2*d*).

Chætetes Barrandi, Nicholson, Geol. Mag. Dec. II., vol. i. p. 57, Pl. IV. fig. 7*c*, 1874.
„ „ Nicholson, Palæontology of Ontario, 1874, p. 60.

Spec. Char. — Corallum dendroid, or sometimes forming small lobate masses, the diameter of the stems in the former case varying from two to five lines. Surface smooth, without spines, and devoid of any marked tuberosities, though exhibiting groups of corallites of slightly larger dimensions than the average. Calices polygonal, thin-walled, sub-equal. Corallites exhibiting a seeming complete amalgamation of their walls, mostly of very uniform dimensions, averaging about 1-80th inch in diameter, with a few much smaller tubes intercalated here and there amongst them. Small thick-walled hollow tubes ("spiniform corallites") are occasionally developed at the angles of junction of the normal corallites. Tabulæ complete, horizontal, only slightly developed in the axis of the stems, but moderately numerous in the peripheral portion of the tubes.

Obs.—The present species is in many respects nearly allied to the preceding (*M. moniliformis*, Nich.), with which it agrees in its general form and aspect, as well as in the apparent complete amalgamation of the walls of the ordinary corallites, and in the entire absence of any proper series of small and peculiarly constructed interstitial tubes (exclusive of the "spiniform corallites"). The corallites, however, are of decidedly smaller size; the calices (Pl. I. fig. 2*a*) are more markedly

polygonal, and have sharper edges; there are no evident surface-spines; and there are no "monticules" or tuberosities. The value of this last character is, however, reduced by the fact that there are specimens of *M. moniliformis* in which the tubercles are inconspicuous; while there are specimens undistinguishable in internal structure from *M. Barrandi*, in which "monticules" are quite well developed.

As regards internal structure, a tangential section of a typical specimen of *M. Barrandi* shows that the corallites are for the most part approximately equal in size, and that they are invariably united by their walls (Pl. I. figs. 2*b* and 2*c*), in such a way as to show no distinct lines of demarcation between adjoining tubes. There are occasional small tubes; but these are apparently only young corallites, as they seem to agree in internal structure with their larger neighbours. Their shape is distinctly polygonal, and not uncommonly there are developed at their angles of junction thick-walled hollow tubuli, which are obviously of the same nature as the "spiniform corallites" of *M. moniliformis*. These structures are, however, not only very much smaller than they are in the last-mentioned species, but they are present in very small numbers, and are therefore a by no means conspicuous feature in sections of this nature (Pl. I. fig. 2*c*).

Longitudinal sections (Pl. I. fig. 2*d*) show that the tubes in the central part of the corallum are thin-walled and comparatively free from tabulæ, while in the outer parts of the colony they become thick-walled, and are intersected by a considerable number of horizontal or slightly curved tabulæ, which are always complete.

Horizon and Locality.—Common in the Hamilton Group (Devonian) of Arkona and Widder, Ontario.

Monticulipora (Heterotrypa) Dawsoni, Nich.

(Pl. V. figs. 3-3*f*.)

Spec. Char.—Corallum having the form of an undulated expansion, of unknown size, and about two lines in thickness. Surface covered with numerous close-set prominent monticules, which are markedly elongated, are placed about a line, or less, apart, and are occupied by corallites which do not differ conspicuously in size from those forming the mass of the corallum. Calices polygonal, thin-walled, about 1-90th inch in diameter, without any regular series of small apertures, but occasionally exhibiting at their angles of junction a minute circular opening. Normal corallites sub-equal, polygonal, at first thin-walled, but becoming slightly thickened as they approach the surface. In the centre of the flattened corallum they are furnished with delicate, wavy, or crimped walls, and are vertical in direction, being in this part of their course entirely free from tabulæ. They then gradually bend outwards, with a very slight inclination, their walls becoming at the same time thickened, and a moderate number of complete horizontal tabulæ being developed.

In addition to the normal corallites (which are mostly of one kind) there are numerous thick-walled, circular tubuli ("spiniform corallites") developed at the angles of junction of the former, or in the thickness of their walls.

Obs.—In its general form, mode of growth, and external appearance, this species might perfectly well pass as an example of either *M. mammulata*, D'Orb., or *M. molesta*, Nich. The only superficial characters which would lead to its separation are, that the normal calices are not intermingled with a series of smaller apertures (Pl. V. fig. 3*b*), and that the prominent monticules are certainly more elongated and compressed than is usual in examples of the above (Pl. V. fig. 3*a*). In its internal structure, however, *M. Dawsoni* is fundamentally

different from either *M. mammulata*, D'Orb., or *M. molesta*, Nich., and exhibits a quite peculiar assemblage of characters.

In tangential sections (Pl. V. figs. 3*c*, 3*d*) the corallum is seen to be composed almost wholly of one series of normal corallites, which are similar in internal structure, and approximately equal in point of size. Near to the surface, the walls of these corallites are moderately thickened, though the lines of demarcation between adjoining tubes are not obliterated; and they are uniformly polygonal in shape. Only an occasional interstitial corallite, properly so called, is present; but there are numerous minute, circular, thick-walled, darkly-outlined tubuli ("spiniform corallites"), the apertures of which upon the surface may occasionally be detected (Pl. V. fig. 3*b*). So far as can be made out, the corallites of the monticules are in no important respect different from those making up the bulk of the corallum; though this point is one difficult to settle absolutely, as a tangential section necessarily cuts the tubes of the monticules at a lower level than it intersects those of the corallum generally, and therefore exhibits the former at a point where their walls are relatively thinner.

Vertical sections (Pl. V. figs. 3*e* and 3*f*), taken at right angles to the plane of the frond, show that the precise arrangement of the tubes differs from what is observable in *M. frondosa*, D'Orb., on the one hand, and in *M. mammulata*, D'Orb., and *M. molesta*, Nich., on the other hand. In *M. frondosa*, D'Orb., the corallites of the two sides of the colony spring from the opposite sides of a more or less complete calcareous lamina, which occupies the mesial plane of the colony, and which is seen in a still more perfect form in *M. pavonia*, D'Orb. In *M. mammulata*, D'Orb., and *M. molesta*, Nich., again, the corallites of the two halves of the corallum have their origin in an apparently irregular mesial mass of cellular tissue, formed by the bases of the tubes, and there is no sign of any central lamina. In the present species no central lamina exists, but the tubes are quite vertical in the middle line of the frond, each bending outwards, with a very gradual

inclination to reach the surface on one side or the other. In the vertical portion of their course, the corallites are thin-walled, and their walls are wavy or are sharply undulated from side to side, and I have not been able to detect any tabulæ in this region. In the outer part of their course, on the other hand, the walls are somewhat thickened, while a moderate number of tabulæ are now developed. There is mostly no difference observable in the tabulation of the corallites, though here and there a small-sized tube with close-set tabulæ may be detected; and the tabulæ are in all cases complete and approximately horizontal.

The only two species of *Monticulipora*, known to me, with which the present form could be confounded, are *M. mammulata*, D'Orb., and *M. molesta*, Nich.; and the differences in its minute structure, as above described, are so marked as to render it unnecessary to compare it in detail with either of these types.

I have named the species in honour of my friend Principal Dawson of Montreal, whose name has been so long and so honourably associated with the investigation of Canadian geology and palæontology.

Horizon and Locality. — Rare in the Cincinnati Group, Ohio.

Monticulipora (Heterotrypa) Jamesi, Nich.

(Figs. 25 and 26.)

Chætetes Jamesi, Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 506, Pl. XXIX. figs. 10-10*b*, 1874. Pal. Ohio, vol. ii. p. 200, Pl. XXI. figs. 11, 11*a*, 1875. Ann. Nat. Hist., ser. 4, vol. xviii. p. 89, Pl. V. fig. 5, 1876.

Spec. Char.—Corallum dendroid, the branches varying in diameter from about a fifth of an inch up to half an inch, dividing dichotomously, terminating in rounded free ends, and sometimes becoming palmate by partial fusion. Calices oval or rounded, sometimes obtusely indented on one or more sides, thick-walled, from 1-70th to 1-60th inch in diameter.

The spaces between the ordinary calices may appear almost or quite solid, but in other specimens the apertures of a larger or smaller number of small variably-shaped interstitial tubes may be recognised; while blunt tubercles or spines, representing the upper terminations of "spiniform corallites," can sometimes be detected on the margins of the calices. Surface smooth, or with barely perceptible eminences, sometimes with a few irregularly disposed stellate maculæ, which are not raised above the general surface, and seem to consist of small tubules. Large corallites angular, polygonal, and thin-walled in the centre of the branches; but becoming thickened as they approach the surface, each being in the outer portion of the branches surrounded by a distinct ring-like wall. Small interstitial corallites very variable in size and shape, occupying all the intervals between the large corallites. Between the latter, also, or in the substance of their walls, are developed numerous thick-walled, circular or oval, darkly-outlined tubuli ("spiniform corallites"). Tabulæ wanting, or very sparsely developed in the axis of the branches; remote in the larger corallites, but numerous and close-set in the small tubes. In all cases the tabulæ are complete, and are horizontal or slightly bent.

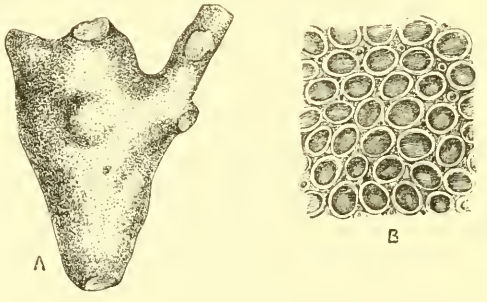

Fig. 25.—A, Fragment of the corallum of *Monticulipora Jamesi*, Nich., from the Cincinnati Group of Ohio, of the natural size. B, Part of the surface of the same, enlarged. This figure is apt to convey the erroneous impression that the apertures of the large corallites are *raised* above the general surface; but this is not really the case.

Obs.—The superficial characters of this well-marked type (fig. 25) are sufficiently treated of in the preceding diagnosis;

but I may give a short account of the appearances presented by thin sections. In tangential sections (fig. 26, A and B) the greater part of the section is seen to be occupied with the

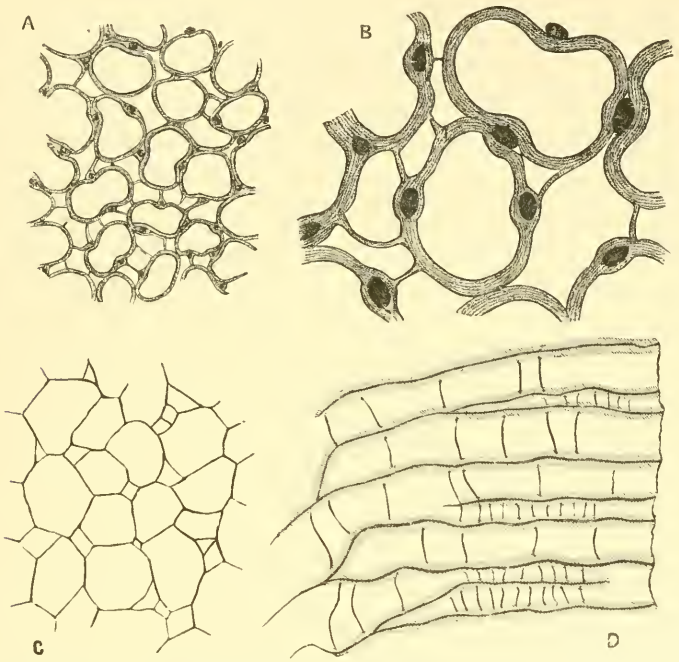

Fig. 26.—Thin sections of *Monticulipora Jamesi*, Nich. A, Part of a *tangential* section, taken just below the surface, enlarged eighteen times, showing the large and small corallites and the interspersed spiniform corallites. B, Part of the same section, enlarged fifty times. C, Part of a *transverse* section of a branch, in the *axial* region, enlarged eighteen times, showing the thin-walled, polygonal, and unequal-sized corallites of this part of the corallum. D, Part of a *longitudinal* section in the median plane, showing the corallites in the *outer* portion of their course, where their walls are thickened: the section shows the larger and smaller corallites, the former with remote, and the latter with close-set, tabulæ. From the Cincinnati Group, Ohio.

rounded or oval apertures of the large corallites. The walls of the corallites are largely thickened by a secondary deposit of sclerenchyma, but in all cases the thin dark lines marking the original boundaries between contiguous tubes can be readily recognised, the precise appearances exhibited varying with the depth below the surface at which the section may be taken. Thus, in some sections the large and small tubes alike can be seen to be bounded by distinct delicate dark lines, which represent the original walls, and which show that all the

corallites were primitively angular. In other tangential sections, again, the large corallites are bounded each by its own thickened ring-like wall of sclerenchyma, and the small corallites seem to have no distinct walls other than those which separate them laterally from one another (fig. 26, B). The large corallites are never in contact for more than a limited portion of their circumference, and all the interspaces between them are filled with numerous small tubes, which differ from the preceding both in size and in their very irregular though mostly angular shape. Lastly, placed at the angles of junction of the two sets of corallites above noted, or intercalated in the wall between two contiguous tubes, we observe a great number of the dark and dense sections of the "spiniform corallites." These are oval or circular in shape, and, though a central cavity cannot always be detected, they are undoubtedly the sections of strong thick-walled tubes, with a minute median cavity. The upper terminations of these upon the surface can often be recognised as blunt projecting tubercles, placed between contiguous calices, or, I think, sometimes as very minute pore-like apertures.

Transverse sections of the corallum show that the corallites in the central part of their course (fig. 26, C) are polygonal in shape, and are bounded by very thin and delicate walls. Their size in this region appears to be very variable, numerous small tubes appearing to be intercalated with the larger ones. This, however, is a mere appearance, due to the fact that a section of this kind cuts the different tubes at different levels above their points of origin, and hence at points where their diameter necessarily varies. In reality, the small interstitial corallites do not seem to extend at all into the axial region of the branches.

In longitudinal sections (fig. 26, D) the thin-walled corallites of the axis of the branches are nearly, or sometimes quite, free from tabulæ; but these structures are present in moderate quantity in all the corallites in the outer thickened portion of their course. They are always complete and horizontal, or but

slightly curved; and they are developed in much larger numbers in the small interstitial corallites than in the large tubes.

Horizon and Locality.—Cincinnati Group, Cincinnati, Ohio.

Monticulipora (Heterotrypa) implicata, Ulrich.

(Pl. II. figs. 7-7*c*.)

Chætetes implicatus, Ulrich, Cat. Foss. Cincinnati Group, p. 12, 1880.

Spec. Char.—Corallum dendroid, of small flattened stems, which average about three lines in width, and from a line and a half to two lines in thickness, giving off branches at short intervals (Pl. II. figs. 7, 7*a*). The calices are mostly about 1-70th to 1-80th inch in diameter, irregularly oval, often indented on one or both sides, thick-walled, with numerous blunt spines projecting from their margins (Pl. II. figs. 7*b*, 7*c*). Between the ordinary calices are the occasional apertures of smaller tubes. The average corallites are thin-walled in the centre of the corallites, but become greatly thickened as they approach the surface, the original lines of demarcation between adjoining tubes being never entirely obscured. Smaller corallites are developed in variable number between those of average dimensions. Interspersed also in the thickness of the walls of the corallites, or occupying their angles of junction, are numerous circular hollow tubes, the upper terminations of which appear on the surface as the blunt spines previously alluded to. Remote, complete, and approximately horizontal tabulæ are developed in the tubes, being somewhat more numerous in the small corallites than in the large ones.

Obs.—Not having met with any published account of this species, I am not sure that it has been actually described by Mr Ulrich, to whom we already owe so much excellent work on the fossils of the Cincinnati Group; but it has been named by him in his Catalogue of the Fossils of the Cincinnati Group, and Mr Nickles has been good enough to present to me some specimens of it. Under the circumstances, I should not have

been justified, perhaps, in treating of it at all in this place; and my only apology for giving even the above short description of its characters is, that it possesses a structural feature which I should have felt unwilling to have passed over without notice. It illustrates, namely, in a remarkable manner, those peculiar structures which occur in so many of the *Monticuliporæ* and *Stenoporæ*, and which I have termed "spiniform corallites." Thus, if we examine a tangential section (fig. 27), we observe at the angles of junction of the normal corallites, or between the thick walls of two adjoining tubes, a number of clear circular spaces of comparatively large size (from 1-500th to 1-450th inch in diameter). Some of these clear spaces preserve the same character throughout, but most of them exhibit centrally either a dark spot or small clear ring. These spaces are, therefore, clearly sections of tubes, and there can be no doubt that the spines which stud the thick walls of the calices (Pl. II. fig. 7*c*) are the upper terminations of these same tubes. I have not succeeded in detecting any opening at the apices of these spines, though their tubular nature would lead one to expect that such must exist. I have, however, I think, succeeded in satisfying myself that their cavities, as seen in long sections, are crossed by distinct horizontal *tabulæ*. This is a point of importance, as tending to confirm my view that these hollow spines, in this and in the many other cases in which they occur, are really of the nature of very peculiarly modified and specialised corallites.

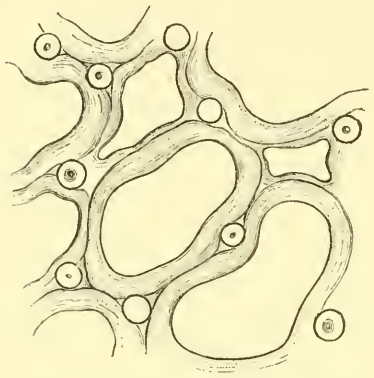

Fig. 27.—Tangential section of a few corallites of *Monticulipora implicata*, Ulrich, enlarged fifty times, showing the larger and smaller ordinary tubes, and the peculiar "spiniform corallites."

Horizon and Locality.—Cincinnati Group, Ohio.

Monticulipora (Heterotrypa) Trentonensis, Nicholson.

(Fig. 28.)

Spec. Char.—Corallum dendroid, of small dichotomously dividing branches, which are cylindrical in shape, and have a diameter of from one to three lines. The surface is smooth, without monticules, and destitute of clearly recognisable groups of either large or small corallites. Some specimens, however, seem to show faintly marked groups of tubes slightly larger than the average. The calices are polygonal, about 1-90th inch in average diameter, having sharp-edged angular lips, surrounded internally by a depressed oval or circular ring, which bounds the actual aperture of the visceral chamber. The corallites are nearly vertical in the centre of the branches, with thin walls and of polygonal shape, and they only turn outwards in the extreme termination of their course, so that the axial region of the corallum is unusually large as compared with the peripheral. In the latter part of their course, where they bend outwards, they are much thickened by an internal deposit of laminated sclerenchyma, but the true walls are never obliterated. In this part of their course they also have a variable but never very large number of small corallites intercalated amongst those of average size. In the axis of the branches the corallites seem to be destitute of tabulæ; but numerous complete, horizontal, or slightly bent tabulæ are developed in the outer portion of the tubes, and especially at the point where they begin to bend outwards.

Obs.—The largest example of this species that I possess is about two inches in length, with a diameter of about two lines, dividing dichotomously at intervals of six to nine lines. Tangential sections (fig. 28, c and d) show that the majority of the tubes are from 1-90th to 1-100th inch in diameter, and have intercalated amongst them a variable number of smaller tubes, which have a diameter of 1-150th inch or less. In all the tubes the primitive polygonal walls are thoroughly recognis-

able, and are slightly thickened at the angles of junction of the corallites. In all, also, the visceral chambers are encroached

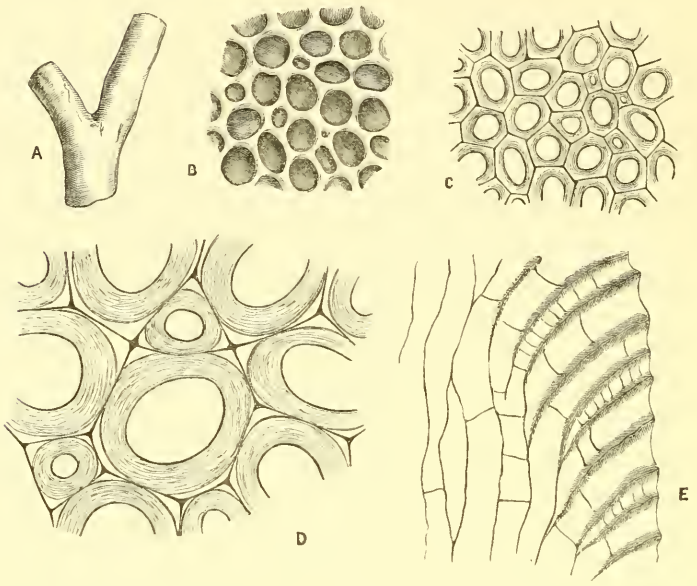

Fig. 28.—*Monticulipora Trentonensis*, Nich. A, A fragment, of the natural size; B, Portion of the surface, enlarged eighteen times; C, Part of a tangential section, enlarged eighteen times; D, Part of the same section, enlarged fifty times, showing the original polygonal walls, and their dense secondary infilling; F, Part of a longitudinal section, enlarged eighteen times, showing the large and small corallites. From the Trenton Limestone of Peterboro', Ontario.

upon by a dense secondary deposit of sclerenchyma, of a light colour and laminated texture, so that the cavities of the tubes become oval or rounded. This thickening of the tubes is entirely confined to their final or peripheral portions, and long sections (fig. 28, E) show that the tubes in the central region of the corallum are provided with exceedingly thin and delicate walls, and are apparently devoid of tabulæ, these latter structures not being developed till the corallites begin to turn outwards. Transverse and longitudinal sections further show that the species is remarkable for the disproportionate development of the axial region as compared with the circumferential: thus, in a transverse section of a diameter of 30-100ths of an inch about 20-100ths of an inch are taken up by the central axis, the

thickened peripheral portion of the corallites thus extending inwards only to a depth of about 5-100ths of an inch. This fact, taken together with the circumstance that the tubes open very obliquely to the surface, renders the preparation of tangential sections very difficult. The small tubes, as seen in long sections, are decidedly more closely tabulate than the large ones, but appear to agree with the latter otherwise in their structure.

I originally believed (Pal. of Ontario, 1875, p. 11), from a merely macroscopic examination, that this form might be identified with the *Monticulipora pulchella,* E. and H., of the British Silurian deposits. Its microscopic structure is, however, quite peculiar, and is so distinctive that it is unnecessary to institute a detailed comparison between it and any other species known to me.

Horizon and Locality.—Abundant in the Trenton Limestone of Peterboro', Ontario. (Collected by Dr George Jennings Hinde, F.G.S.)

Monticulipora (Heterotrypa) Girvanensis, Nicholson.

(Fig. 29.)

Chætetes sp., Nich. and Eth. jun., Mon. Sil. Foss. Girvan, vol. i. p. 43, Pl. III. figs. 2-2*b*, 1878.

Spec. Char.—Corallum dendroid, of small branches which have a cylindrical or sub-cylindrical shape, and are from rather more than a line to three lines in diameter. Surface devoid of tubercles or of groups of either large or small corallites, but showing the oval or circular, slightly prominent calices of the larger tubes, sometimes with the apertures of the smaller tubes between them. Corallites of two kinds, large and small. The large corallites have a diameter of about 1-70th inch on an average, and each is surrounded, in the outer part of its course, by a well-developed and thickened wall, their form being oval or circular, and the points at which they come in contact being thus very limited. There is, also, no actual or apparent amal-

gamation of the walls of contiguous tubes at the points where they abut against one another. The interspaces between the large tubes are filled up by numerous small tubes, which are very irregular in size and form, and cannot be said to be enclosed by definite walls of their own, being limited simply by the adjacent larger corallites. Attached to, or intercalated between, the walls of the larger tubes, are also numerous aborted spiniform corallites which are seen as so many dark spots in tangential sections (fig. 29, D and E). In the axis of

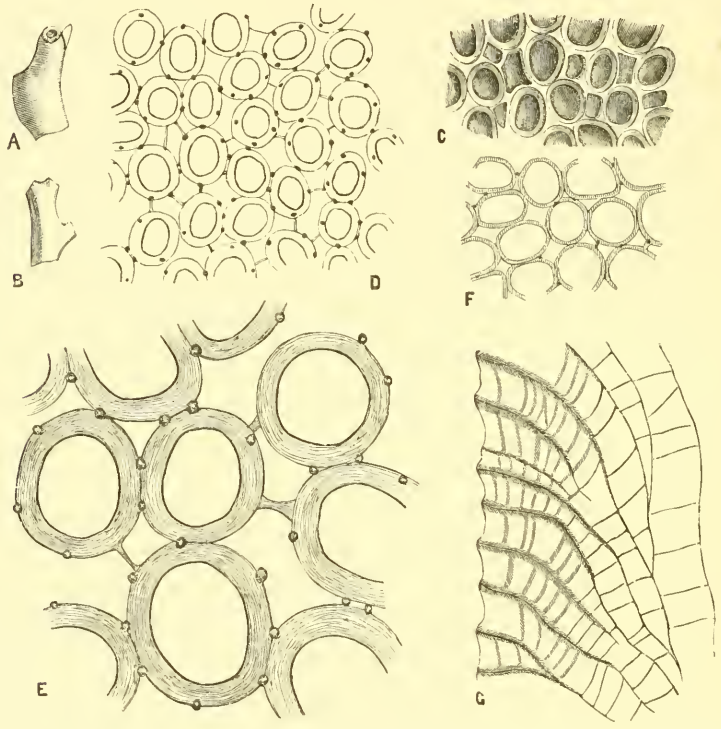

Fig. 29.—*Monticulipora Girvanensis*, Nich. A and B, Two fragments, of the natural size; C, Part of the surface of the same, enlarged eighteen times; D, Tangential section, enlarged eighteen times, and taken just below the surface; E, Part of the preceding section, enlarged fifty times, showing the oval or circular thick-walled large corallites, with the singular spiniform bodies on their margins, and the smaller irregularly shaped intermediate tubes; F, Part of a tangential section, at a deeper level below the surface than D, enlarged eighteen times; G, Part of a vertical section, enlarged eighteen times. From the Lower Silurian (Craighead Limestone) of Girvan, Ayrshire. (Coll. Mrs R. Gray.)

the branches the tubes are thin-walled, the axis bearing a large proportion to the periphery. Tabulæ, which are complete,

horizontal, and sometimes inosculating, are abundantly developed in both the axial and the circumferential portions of the corallum. No marked difference exists in the tabulation of the larger and smaller tubes.

Obs.—The general form and external characters of *M. Girvanensis* are sufficiently noticed above; but I wish here to draw attention more closely to some points connected with its microscopic structure. Tangential sections (fig. 29, D and E) show very clearly that the corallum is composed of a uniformly distributed series of large corallites, between which (but never in more than a single row) are intercalated numerous variably sized and angular small corallites. The large corallites are peculiar in the complete distinctness of the wall of each from the walls of its neighbours. Each tube is surrounded with a thick wall of its own, and being oval or circular, the points of contact between adjoining tubes are very few; while even where the walls come together, there is absolutely no amalgamation between them. Nor do we find that the thick oval or circular wall is a secondary development (as, for example, in *M. Trentonensis*, Nich.), since there are no signs of any primitive polygonal wall to the tubes, as is so commonly the case in other species. Again, there is the singular feature in tangential sections that there exist numerous well-marked dark spots (the "Wandstränge" of Dybowski), either in the substance of the walls of the tubes, or more commonly where two corallites come together. No clearly defined lumen or central cavity can be detected (so far as I have seen) in these, but they would appear to certainly represent the hollow spines, or "spiniform corallites," of so many species of *Monticulipora*, in an aborted condition. On the other hand, the small corallites, which occupy all the interstices left by the large tubes, appear not to be bounded by definite walls, but to be limited simply by the walls of the larger corallites. Where, however, they abut against each other, instead of against the large tubes, they are separated by thin partitions. In tangential sections which pass at a little depth below the

actual surface (fig. 29, F), the walls of the large corallites are shown to be gradually diminishing in thickness as they proceed to the axis of the branch, while the interstitial corallites become more clearly defined, and the dark spots which seem to represent sections of spiniform corallites become much reduced in number.

In longitudinal sections (fig. 29, G), it is seen that the corallites in the axis of the branch have quite thin and delicate walls, the thickening not commencing till the tubes begin to bend outwards to the surface. Complete, horizontal tabulæ are very largely developed in the axis of the branches, and are even more numerous in the circumferential parts of the tubes. Lastly, I have found it difficult to recognise any distinction between the larger and smaller corallites in longitudinal sections, and they do not appear to differ conspicuously in their tabulation, or in any other point of internal structure.

Though the mere external form and surface-characters of *M. Girvanensis* are not so strongly marked as to separate it unmistakably from various other smooth types of the ramose *Monticuliporæ*, its internal structure is so peculiar that it is not necessary to compare it closely with any other form with which I am at present acquainted.

This species is identical with the form which was noted by Mr R. Etheridge, jun. and myself from the Craighead Limestone (op. cit. supra) as an undetermined species of *Chætetes* (or *Monticulipora*). The material in our possession was exceedingly limited, and quite insufficient for specific determination; and the additional specimens which have enabled me to decide upon the distinctness of *M. Girvanensis*, and to describe it fully, unfortunately escaped notice until it was too late to insert an account of the species in the Third Fasciculus of our Monograph of the Silurian Fossils of Girvan.

Horizon and Locality.—Lower Silurian (Craighead Limestone), Craighead, near Girvan, Ayrshire. (Coll. Mrs Robert Gray.)

CHAPTER VII.

Sub-genus Diplotrypa, Nich., 1879.

(Pal. Tab. Cor., p. 312.)

The corallum in the species included in this section is discoid, sometimes globose, sometimes leaf-like, with a thin basal epitheca. The corallites are of two kinds, all of which have thin, structureless, and apparently fused walls. The corallites are mostly prismatic, but the larger ones may be oval (*M. calycula*, James). Spiniform corallites may be wholly wanting (as in *M. petropolitana*, Pand.), or may be present in smaller or larger numbers (as in *M. Whiteavesii*, Nich., and *M. calycula*, James). There may be well-marked "monticules," formed of the larger tubes; but in general the large and small corallites are uniformly intermingled. The tabulæ in all the tubes are *complete*, and those of the small corallites are more numerous and more closely set than those of the large tubes.

Dr Steinmann (N. Jahrb. für Min., &c., 1880, p. 438) has expressed the opinion that the section of Monticuliporoids which I have named *Diplotrypa* is properly identical with the earlier *Dianulites*, Eichw. As has been seen previously (p. 11), *Dianulites*, Eichw., is absolutely unrecognisable; and in expressing this opinion Dr Steinmann is doubtless to be understood as referring to *Dianulites*, Eichw., as re-defined and emended by Dybowski (Chætetiden der Ostbaltischen Silurform., 1877). Even, however, if I were to admit the desirability of the attempt to revive an old and hopelessly ill-defined genus like *Dianulites*, Eichw., I should find it impossible to accept as

its equivalent the modern *Dianulites*, Dyb. My reasons for arriving at this conclusion have been previously stated (p. 21), and may be briefly summarised as follows: *Dianulites*, Eichw., is entirely unrecognisable; and there is therefore, in the first place, a strong theoretic objection to its revival. In the second place, *Dianulites*, Eichw. (emend. Dybowski), is not a natural group, as it includes forms which unmistakably differ from one another in their fundamental structure. In the third place, Eichwald in his second definition of *Dianulites* strongly insisted upon the presence of a "spongy cœnenchyma" as one of the essential characters, whereas Dybowski makes the *absence of a "cœnenchyma"* a vital feature in his definition of the same genus. Moreover, it is certain that in some of the forms included by Dybowski under the head of *Dianulites* a "cœnenchyma," though not a "spongy" one, *is* present, or, in other words, there exist "interstitial corallites."

I therefore retain the section *Diplotrypa*, Nich., and shall elucidate its characters more fully in the description of the following species:—

Monticulipora (Diplotrypa) petropolitana, Pander.

(Fig. 30.)

Favosites petropolitanus, Pander, Russ. Reiche, p. 105, Pl. I. figs. 6, 7, 10, 11, 1830.

Dianulites petropolitanus, Dybowski, Die Chætetiden, p. 24, Pl. I. figs. 4 and 5, 1877. Compare also *D. fastigiatus*, Eichw. (Dyb.), *loc. cit.*, p. 20, Pl. I. figs. 1-3.

(Non *Chætetes petropolitanus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 510, Pl. XXX. figs. 5-8, 1874; Geol. Mag. Dec. ii., vol. ii. p. 175, 1875; Pal. Ohio, vol. ii. p. 204, Pl. XXI. figs. 14-14*b*, 1875; Ann. Nat. Hist., ser. 4, vol. xviii. p. 88, Pl. V. figs. 6-6*a*.)[1]

Spec. Char.—Corallum discoid when young, but spheroidal, or hemispherical when fully grown, the base being circular,

[1] Beyond pointing out that the forms which I have previously considered and described as *M. petropolitana*, Pand., are really distinct from the original Russian type of the species, I have not thought it—for reasons to be subsequently given—of any use to attempt to give a synonymy of this form.

more or less deeply concave, and covered with a concentrically striated epitheca, while the calices cover the whole of the upper surface. The corallites are of two sizes, large and small, these being uniformly interspersed with one another throughout the entire colony, while the former also constitute small clusters or monticules. The large corallites are about 1-50th inch in diameter, provided with uniformly thin and delicate walls, not thickened towards the surface, and for the most part very regularly hexagonal in shape. The small corallites are wedged in at the angles of junction of the large tubes, which they sometimes to a large extent separate from one another, their diameter varying from 1-50th or less to 1-100th inch. They resemble the large corallites in being uniformly thin-walled and strictly angular, their shape being very variable, but mostly oblong, square, or sub-triangular. Both sets of tubes are provided with complete horizontal tabulæ, which increase in number towards the surface; and the tabulæ in the smaller tubes are more numerous than in the larger ones, though this disproportion is not so marked as is usually the case in the species of *Monticulipora*.

Obs. — A great number of corals have been described or quoted by different authors from the Lower Silurian deposits of different parts of the world under the name of *Monticulipora petropolitana* or *Chætetes petropolitanus*, Pand. In most cases, however, the determination of particular specimens as belonging to this species has been founded upon the well-marked *external form* of the corallum and the general nature, often with difficulty recognisable, of its *surface-characters*. That this should be the case was inevitable, seeing that the internal structure of the corallum does not admit of being made out properly save by means of carefully prepared sections; and further, that the minute characters of the genuine Russian types have only been investigated and published within quite recent times (Dybowski, Die Chætetiden der Ostbaltischen Silurformation, 1877). At the time when I published my work upon the 'Structure and Affinities of the Palæozoic Tabulate

Corals' (1879), I was unfortunately ignorant of even the existence of Dybowski's treatise; and the description of the characters of the present species which I published at that time, and which is here reproduced, was based upon specimens from the Lower Silurian deposits of Sweden, for which I was indebted to the kindness of my friend Dr Lindström.

Starting, therefore, upon the basis that microscopic examination by means of thin sections is essential to any safe progress in identifying the various types of the *Monticuliporæ*, it is clear that all determinations of the present species which are founded simply upon resemblances in external form and surface-characters are absolutely useless and unreliable. Thus, all the corals which I have myself examined and described from the Lower Silurian rocks of North America, and which I have formerly identified with *M. petropolitana*, Pand., on account of their general form and appearance, turn out on microscopic examination to differ widely in internal structure from the similar-looking Russian species. In fact, I am now acquainted with some half-dozen types, which all more or less closely resemble the true *M. petropolitana* in external characters and form, but all of which, as tested by the facts of their minute structure, are distinct from this, and distinct from one another. Considering, therefore, that almost all the determinations of *M. petropolitana*, in different deposits and in different countries, have been based solely upon macroscopic investigation, and that this is clearly insufficient for specific diagnosis, it has appeared to me to be quite useless to give any synonymy of the species. With our present knowledge, in fact, such a synonymy would simply give us the information that certain authors had identified from certain regions and formations corals which are doubtless referable to *Monticulipora* in its wide sense, and which resemble *M. petropolitana* in form and habit.

In the Swedish specimens of *M. petropolitana*, Pand., which I shall take as the type of the species, the corallum has the well-known hemispherical or sub-globular form, its circular and

concave base being covered with a thin concentrically striated epitheca (fig. 30, A and B). In thin sections no feature is more

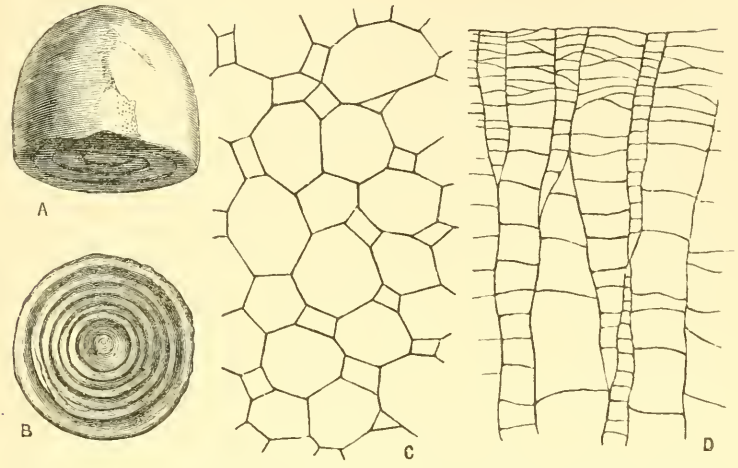

Fig. 30.—*Monticulipora petropolitana*, Pander. A, A specimen viewed in profile, of the natural size; B, Under view of the same, showing the basal epitheca, of the natural size; C, Part of a tangential section of the same, enlarged twenty times; D, Part of a vertical section of the same, enlarged twenty times. From the Lower Silurian rocks of Sweden.

striking than the extreme delicacy and tenuity of the walls of all the corallites. The walls are so thin that they appear as mere simple and undivided dark lines, the originally duplex character of the boundaries between contiguous corallites being entirely lost. Nor, again, do the walls become in any way thickened as the surface is approached. In this respect, therefore, there is a marked and important difference in the structure of this form as compared with the more normal types of *Monticulipora* (*Heterotrypa*). In tangential sections (fig. 30, C) another marked peculiarity is the strictly angular form of all the tubes, and the very regularly hexagonal or pentagonal outline of the larger corallites. Each of the larger tubes is usually in contact with a tube of the same series on one or two sides, but the other faces usually abut against corallites of the smaller series, these being generally oblong or quadrate in shape. In vertical sections (fig. 30, D) the two sets of corallites are chiefly recognisable by the difference in their respective

sizes, their tabulation being more uniform than is usual in the genus. The small corallites are, however, always to some extent, and sometimes quite conspicuously, more closely tabulate than is the case with the large tubes.

Though many other species resemble *M. petropolitana*, Pand., in general form and external aspect, I know of none which could be confounded with it, when it comes to a comparison of thin sections. The types which, on the whole perhaps, are most like *M. petropolitana*, are forms like *M.* (*Monotrypa*) *Winteri*, Nich., *M.* (*Monotrypa*) *undulata*, Nich., in some of its varieties, and *M.* (*Monotrypa*) *petasiformis*, Nich. In all these types, however, there is the important difference, as compared with *M. petropolitana*, Pand., that there is no proper series of small tubes interspersed among the ordinary corallites of the colony, while all the corallites are similarly and uniformly tabulate.

Horizon and Locality.—Lower Silurian (Chasmops Limestone), Ostrogothia, Sweden. Collected by Dr Lindström.

Monticulipora (Diplotrypa) Whiteavesii, Nicholson.

(Fig. 31.)

Chætetes petropolitanus (pars), Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 510, Pl. XXX. figs. 5, 5*c*, 1875.
,, *petropolitanus* (pars), Nicholson, Pal. of Ohio, vol. ii. p. 204, Pl. XXI. figs. 14, 14*b*, 1875.
,, *petropolitanus* (pars), Nicholson, Ann. Nat. Hist., ser. 4, vol. xviii. p. 88, Pl. V. fig. 6*a* (*not* Pl. V. fig. 6), 1876.
,, *petropolitanus* (pars), Nicholson, Geol. Mag. Dec. ii., vol. ii. p. 175, 1875.
,, *petropolitanus*, Nicholson, Rep. Pal. of Ontario, p. 10, Pl. IV. figs. 3 and 4, 1875.
Monticulipora (*Diplotrypa*) *Whiteavesii* (pars), Nicholson, Pal. Tab. Corals, Pl. XIII. figs. 4-4*b*—*not* Pl. XIV. fig. 1.

Spec. Char.—Corallum discoid when young, hemispheric when adult, often with the lateral margins widely extended, the base being usually deeply concave, sometimes flattened, and being covered by a concentrically striated epithecal plate.

Corallites directed upwards nearly at right angles to the entire basal plate, and opening upon the upper aspect of the colony. Surface with scattered and very slightly raised "monticules" composed of corallites slightly above the average in size. Corallites of two principal kinds, large and small, the tubes of both series intermingled throughout the entire corallum. Large tubes, mostly from 1-100th to 1-60th inch in diameter, more or less thin-walled, angular or sub-angular, often hexagonal, in shape, and sometimes arranged in small groups or rosettes of four or five tubes each. Small corallites very numerous and very variable in size and form, but always thin-walled and angular, and wedged into all the interspaces left between the large tubes. Along with the ordinary small corallites there exists a variable number of thick-walled spiniform corallites, or hollow spines, distributed here and there at the angles of junction of the thin-walled tubes. In internal structure all the tubes (except the spiniform ones) are equally thin-walled, but the large corallites are crossed by remote horizontal and *complete* tabulæ, while the intermediate smaller corallites are traversed by tabulæ of the same type, but much more closely set.

Obs.—In the description of this species which I gave in my recently published work on the 'Palæozoic Tabulate Corals' (*loc. cit. supra*), I fell into a curious and unlucky mistake, which led to my drawing up of my diagnosis from specimens really referable to two quite distinct forms. My collection from the Trenton Limestone of Peterboro', Ontario, included, namely, a number of discoid specimens of a *Monticulipora* which (being from the same formation and locality) I concluded to belong to a single species, since they presented no special external features to separate them. I made thin sections[1] of two or three of these, without taking special care that the sections

[1] The sections now alluded to were made by me some years ago, and the error which resulted from their intermixture not only remained undetected by me until the last three or four months, but was actually published as long ago as 1876 (see "Notes on the Palæozoic Corals of the State of Ohio," Ann. and Mag. Nat. Hist., ser. 4, vol. xviii. p. 88, Pl. V. figs. 6, 6*a*).

were taken from the same specimen; and, as I know now, I unfortunately took my horizontal sections from the true *M. Whiteavesii*, and my vertical ones from a similar-looking but really different specimen (*M. Selwynii*, mihi). Nor did the error stop here; for I had at the same time prepared vertical sections of another set of specimens, from the Cincinnati Group of Ohio, which I believed to be the same as the preceding, and which are really identical with one of the Trenton Limestone types (*M. Selwynii*), or at most a well-marked variety of it. One of the vertical sections of the Cincinnati Group specimens, by a singular mischance, became mixed with the other sections, and was accordingly wrongly labelled as *M. Whiteavesii*, and duly figured as such (Pal. Tab. Cor., Pl. XIV. fig. 1). Having recently had occasion to make an entirely fresh series of sections from the specimens in question, I was enabled to unravel this complicated series of mistakes; and I am therefore now able not only to give a correct statement of the true characters of *M. Whiteavesii*, and to define its *simulacrum* (viz., *M. Selwynii*), but also to give the solution of one or two difficulties which, in the former confusion, had appeared to me to be absolutely inexplicable.

Average examples of the true *M. Whiteavesii*, Nich., are in general discoidal, sometimes considerably elevated, their diameter varying from less than half an inch up to an inch and a quarter or more, and their height from two to six lines. The base of the corallum may be simply flat, but is in general deeply concave (fig. 31, B), and is always covered with a well-marked striated epitheca. Thin sections, taken in any direction, show that the corallites are uniformly thin-walled, not being thickened as they approach the surface, and being so amalgamated with each other that the originally duplex character of the wall cannot be recognised at all.

Tangential sections vary somewhat in the appearances which they present, according to the precise depth below the surface at which they intersect the corallum. When taken just below the surface (fig. 31, C and D), the corallum is most clearly seen

to be made up to two sets of corallites, of only little different size, the general appearance being not at all unlike what is

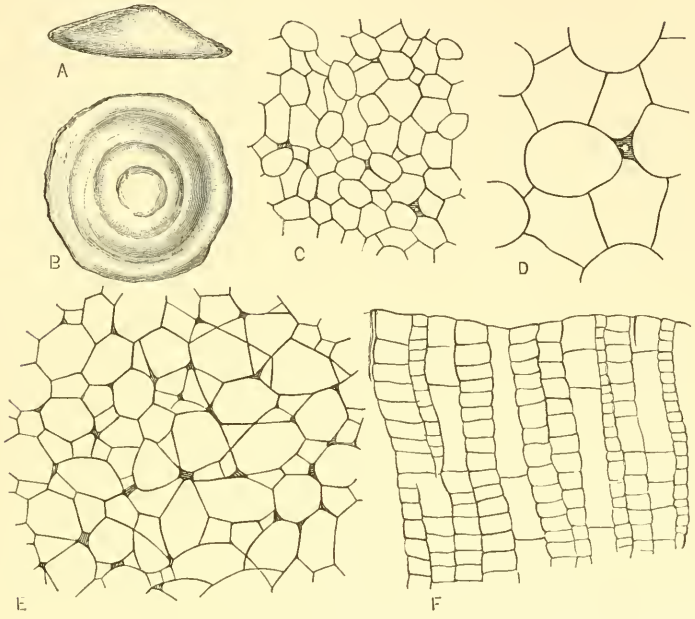

Fig. 31.—The external characters and internal structure of *Monticulipora Whiteavesii*, Nich., from the Trenton Limestone of Canada. A, A specimen viewed in profile, of the natural size; B, The same, viewed from below, showing the basal epitheca, of the natural size; C, A tangential section, taken just below the surface, enlarged eighteen times, showing the two chief sets of corallites and the interspersed spiniform tubes; D, Small part of the preceding, enlarged fifty times; E, Another tangential section, taken at a rather deeper level than C, enlarged twenty times, showing the different kinds of corallites; F, Vertical section, enlarged eighteen times, showing the remote and complete tabulæ of the large tubes, and the numerous close-set tabulæ of the smaller corallites.

seen in some *Fistuliporæ*. The larger corallites, though still angular, have their angles rounded off, so as to become more or less oval; and their usual diameter is about 1-90th inch, though they sometimes attain larger dimensions than this. Many of the large corallites are quite isolated, and it is only occasionally that more than two of them actually come in contact, and then only at limited points. The entire space between the large corallites is filled up by the intermediate tubes, which vary in diameter from 1-150th to 1-90th inch, and are always strictly angular in shape. Here and there also, especially at the points where the large corallites come

in contact, are seen dark, thick-walled, hollow tubes, which are undoubtedly identical with the "spiniform corallites" of so many of the *Monticuliporæ*, though I am not acquainted with the method in which they terminate at the surface.

In tangential sections which intersect the corallum at a deeper level (fig. 31, E), the large tubes are comparatively larger, and are more strictly angular, while they are often arranged in stellate groups or rosettes, consisting of four or five tubes. The small intermediate corallites, being now divided at a point nearer to their actual origin, appear to be smaller in size as compared with the large tubes, and also, upon the whole, less numerous. The thick-walled "spiniform corallites" are also very marked in sections of this kind, one being generally placed at the point at which two or three of the large corallites meet together.

Vertical sections (fig. 31, F) show that the corallites, though slightly bent at their actual point of origin, are essentially everywhere perpendicular to the basal epithecal plate. They are uniformly thin-walled throughout, and the larger corallites are at once recognisable in consequence of the very limited number of the tabulæ which they possess, these structures being often wanting over considerable spaces, and being always remote. When present, the tabulæ are complete and horizontal. In the small intermediate corallites the tabulæ are likewise complete and horizontal, but they are now comparatively close-set, and crowded together.

From *M. petropolitana*, Pand., the present species is separated by the great development of the small interstitial corallites as compared with the large tubes, the presence of spiniform corallites, the comparative isolation of the large corallites, and the remarkable difference in the tabulation of the two sets of corallites.

On the other hand, *M. Selwynii*, Nich., is separated from the present species by the greater proportionate development of the large corallites, the much smaller size of the interstitial corallites, and their aggregation at intervals into groups or

"maculæ," and, above all, by the peculiar perforated or incomplete tabulæ of the large tubes, by the presence or absence of which thin sections of either form may be at once distinguished.

I have named the species after my friend Mr Whiteaves, the accomplished palæontologist of the Geological Survey of Canada.

Horizon and Locality. — Not uncommon in the Trenton Limestone of Peterboro', Ontario, in association with *M. Selwynii*, Nich.

Monticulipora (Diplotrypa) calycula, James.

(Pl. IV. figs. 4-4*b*.)

Lichenalia? calycula, James, Cat. Foss. Cincinn. Group, 1871 (named, but not figured or described).
Chætetes? calycula, James, Cat. Foss. Cincinn. Group, 1875, p. 1.

Spec. Char.—Corallum free, forming a thin, circular, concavo-convex, leaf-like expansion, of about 1-60th inch in thickness, and from half an inch to nearly two inches in diameter. The under surface is in general deeply concave, and is covered with a thin epitheca, which shows fine radiating striæ, and occasionally a few concentric wrinkles. Upper surface carrying the calices, which (according to James) are oval or circular in shape, and are not disposed so as to form clusters or "monticules." Ordinary corallites of two kinds, large and small. The large corallites are oval, from 1-75th to 1-80th inch in their long diameter, rarely in contact, and then only touching each other at limited points. The small corallites are variable in shape and size, more or less angular in outline, and wedged in at all the interspaces left between the large oval tubes. In addition to the two sets of normal corallites, there is an abundantly developed series of thick-walled, somewhat quadrangular tubuli ("spiniform corallites"), which are mostly situated at the points where the large oval corallites would

otherwise come into direct contact. Tabulæ wanting (?) or incomplete (?) in the large corallites; but numerous, closely set, complete, and horizontal in the smaller corallites.

Obs.—The corallum of this species is almost always found imbedded in the matrix in such a manner that the concave under side, with the striated epitheca, is alone visible (Pl. IV. fig. 4), while the convex upper side, carrying the calices, is completely concealed from view. I myself have never seen any specimens save in the condition above mentioned; but Mr James has described examples in which the upper surface is shown, and he states that these exhibit a series of oval or circular calices, without any monticules or groups of large tubes. The corallum is remarkable for its extreme tenuity, and the resulting shortness of the corallites, and, in all the ordinary specimens, tangential sections can only be prepared by the process of grinding away the thick matrix from the upper side. All the examples that I have seen are deeply concave below, but Mr James states (*loc. cit.*) that he has seen specimens which are nearly flat.

As regards the internal structure, tangential sections (Pl. IV. fig. 4*a*) show that the ordinary corallites are divisible into two quite distinct series, intermingled regularly with one another. The large tubes are oval in shape, each surrounded by a thin wall, and quite distinct from neighbouring corallites of the same series. As seen in sections of this nature, there is commonly a ring of transparent calcite immediately within the wall, and then the visceral chamber is filled centrally with the dark matrix. The appearance thus produced is similar to what is seen when perforated tabulæ exist, but the phenomenon is not constant, and is irregular in its development; while I can find no traces of such incomplete tabulæ in long sections. The small corallites are more or less angular in shape, occupying the intervals between the large tubes, though never completely isolating these, no more than a single row ever existing between any given pair of the latter. Interspersed with the preceding, and especially occupying the points where the large

tubes approach each other, are numerous "spiniform corallites," which agree with the same structures in other forms of the genus in having a small circular central cavity, surrounded by exceptionally dense dark-coloured walls. In this case, however, these peculiar tubules have generally a more or less quadrangular outline. The upward terminations of these on the surface are unknown.

Vertical sections (Pl. IV. fig. 4*b*) show the extreme thinness of the corallum, and the shortness of the corallites. The two sets of ordinary corallites are now quite easily recognised, both by their different sizes, and also by the marked difference in their internal structure. The large corallites do not seem to be provided with tabulæ,—at least I have not succeeded in certainly detecting any,—but their cavities often show a funnel-shaped inward extension of the matrix along the axis of the visceral chamber. The small angular corallites, on the other hand, are provided with numerous, complete, and horizontal tabulæ. Occasionally, also, a few of the thick-walled tubuli may be recognised in sections of this nature.

The forms with which one would be disposed, upon the basis merely of external features, to compare *M. calycula*, James, are *M. Newberryi*, Nich., and *M. discoidea*, James. The present species, however, differs entirely in its internal structure from either of the types just mentioned; and I know of no species which is structurally so nearly allied to it as to demand a close comparison.

The specimens upon which the above description is founded were collected by Mr U. P. James of Cincinnati.

Horizon and Locality.—Cincinnati Group, Cincinnati, Ohio.

CHAPTER VIII.

Sub-genus Monotrypa, Nich., 1879.

(Pal. Tab. Cor., p. 320.)

The section *Monotrypa*, Nich., includes those species of *Monticulipora* proper in which the internal structure of all the corallites of the colony is the same. The size of the corallites may be uniformly the same, or there may be clusters of tubes slightly larger than the average, which may be elevated above the surface to form low "monticules." The internal structure of the large corallites (if present) is, however, the same as that of the average tubes. Closely tabulate interstitial corallites, also, are never developed. Spiniform corallites are usually absent, but may be present (*e.g.*, *M. discoidea*, James). The walls are in some cases (*e.g.*, *M. undulata*, Nich., *M. Winteri*, Nich., *M. irregularis*, Ulrich, &c.) thin, seemingly structureless, and apparently amalgamated with one another. In other cases (*e.g.*, *M. petasiformis*, Nich., *M. pulchella*, E. and H., *M. discoidea*, James, *M. pavonia*, D'Orb., &c.), the walls of the corallites are appreciably, or even considerably, thickened; but they always preserve in such cases the original lines of demarcation separating adjoining tubes. The *tabulæ* are always *complete*, and are uniformly distributed; but they are always comparatively few in number, and they are sometimes almost wanting (*e.g.*, *M. irregularis*, Ulrich). Type of the group, *M. undulata*, Nich.

The above diagnosis is in several important points emended and altered, as compared with that which I originally gave

(*loc. cit. supra*). More particularly, I find that it is necessary to admit into this section forms in which the walls may be more or less thickened, though the thickening is never of such a nature as to lead to an apparent fusion of the walls of adjoining corallites. The presence of clusters of tubes somewhat larger than the average is also not a constant feature. The chief distinctive character of *Monotrypa* is that there are no closely tabulate interstitial tubes, such as exist in all the other sections of *Monticulipora*. There is thus no direct evidence that the corallum was dimorphic. The large tubes of the clusters may have lodged specialised zoöids; but this is doubtful, since they are not always present, and, in any case, their internal structure is precisely the same as that of the average corallites. It is possible, also, that two sets of zoöids were really present, but that the corallites which these inhabited are not distinguishable by any marked structural feature. When present (as in *M. discoidea*, James), the spiniform corallites may be taken as a sign of dimorphism; but these structures are usually wanting in *Monotrypa*, and their presence does not alter the fact that the normally present, closely tabulate interstitial tubes are uniformly wanting. The *form* of the corallum in the Monticuliporoids of this section is extremely variable, being massive, discoidal, ramose, laminar, or encrusting, in different types. From *Chætetes*, Fischer, *Monotrypa* is sufficiently distinguished, among other characters, by the fact that the corallites never become truly united by their walls. From the other sections of *Monticulipora*, as from *Fistulipora*, M'Coy, the species of *Monotrypa* are sufficiently separated by the want of a proper series of interstitial tubes.

Dr Steinmann (N. Jahrb. für Min., &c., 1880, p. 438) is disposed to think that the section *Monotrypa* cannot be maintained because the form which I have named *M. Winteri* is really a *Favosites*. I am not, however, able to admit (as elsewhere more fully shown) that there are any good grounds at present for regarding *M. Winteri*, Nich., as a *Favosites;* and even if there were, it would not affect the validity of the section *Mono-*

trypa, since the *type* of this section is not *M. Winteri*, but *M. undulata*, Nich. In the meanwhile, therefore, I must retain this section; and the following descriptions of species belonging to it will serve to elucidate its characters more fully.

Monticulipora (Monotrypa) undulata, Nich.

(Figs. 32 and 33.)

Chætetes undulatus, Nicholson, Geol. Mag. Dec. ii., vol. ii. p. 176, 1875.
„ *undulatus*, Nicholson, Rep. on the Pal. of Ontario, 1875, pp. 10, 33, Pl. IV. fig. 1.
Monticulipora (*Monotrypa*) *undulata*, Nicholson, Pal. Tabulate Corals, p. 321, Pl. XIV. figs. 3 and 4, 1879.

Spec. Char.—Corallum forming large, lobed or laterally indented masses; or occurring as smaller hemispherical or spheroidal masses, of from half an inch to more than an inch in diameter. Corallites uniformly thin-walled, angular, and prismatic in shape, sub-equal in size, the average tubes varying from one-fifth or one-sixth of a line up to a quarter of a line or rather more. The bulk of the corallum is made up of corallites of the smaller of the above dimensions, while the slightly larger tubes form clusters of six or more, which appear on the surface as patches or "monticules," which are but faintly or not at all elevated above the general level. Small corallites are also often present at the angles of junction of the larger tubes, but they may be wanting: they are never a conspicuous feature, and their internal structure is the same as that of the normal corallites. Tabulæ horizontal, complete, remote, equally distributed through all the tubes of the colony, and often placed at corresponding levels in contiguous tubes, so that the corallum breaks up into a series of concentric strata.

Obs.—The type of this species is a large and massive coral, which occurs in the Trenton Limestone of Canada. With this I formerly associated certain large and lobate *Monticuliporæ* from the Cincinnati Group of Ohio and the Hudson River for-

mation of Canada, similar in form to some of those included by Hall under the name of *Chætetes lycoperdon*, Say (Geol. Mag., Dec. ii., vol. ii. p. 177). I have now had the opportunity of examining these latter forms microscopically, and I find that I was in error in associating these with the Trenton Limestone

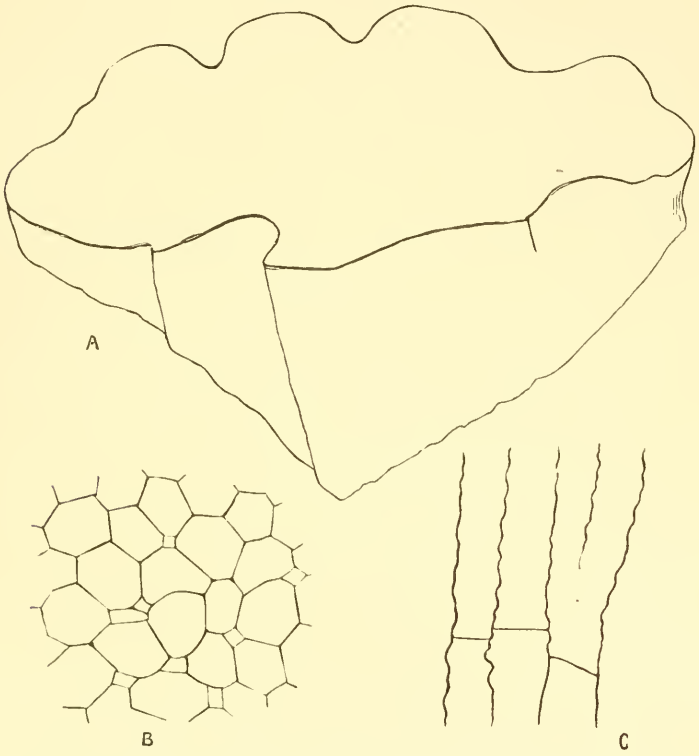

Fig. 32. — *Monticulipora* (*Monotrypa*) *undulata*, Nich., from the Trenton Limestone of Canada. A, Part of the type-specimen, in outline, of the natural size; B, Tangential section, enlarged eighteen times, showing the thin-walled angular corallites; C, Part of a longitudinal section, similarly enlarged, showing the wavy walls and the sparse tabulæ.

species. On the other hand, a minute examination of the corals of the Hudson River Group of Canada, which have commonly been spoken of as "puff-ball varieties of *Stenopora fibrosa*," and which I used to regard (*op. jam cit.*, p. 176) as a mere variety of *M. petropolitana*, Pand., has shown me that these are in all essential respects entirely identical in internal structure with the *M. undulata* of the Trenton Limestone, from which they differ principally in their smaller size and

hemispherical or spheroidal shape (fig. 33, A). I have figured thin sections of both for comparison.

Tangential sections of both the Trenton Limestone and Hudson River Group examples of *M. undulata* (figs. 32, 33, B) show the corallites to be strikingly thin-walled and markedly angular, while, except for the occasional presence of a cluster of somewhat extra-sized tubes, their dimensions are very uniform. Small corallites are present, not unfrequently, at the angles of junction of the large tubes; but they are obviously young tubes, and do not form part of a series of special corallites. That this view is correct is shown by their inconstant occurrence, but is still more conclusively proved by vertical sections (fig. 32, C). These show that all the corallites—those forming the clusters as well as those composing the mass of the colony —are precisely similar in their structure, and are not divisible into a series with remote and one with crowded tabulæ. All alike have thin, flexuous, often closely undulated walls, and in all alike the tabulæ are delicate horizontal plates, situated at distances of from a quarter of a line to nearly a line. In fractured surfaces the tubes separate cleanly from one another, and their faces are seen to be crossed by numerous delicate transverse striæ, corresponding with the undulations of their walls. In all the specimens I have examined there is, also, an evident periodicity of growth, tabulæ being periodically developed at corresponding levels in all the tubes, so that the entire corallum breaks up into concentric layers.

As before remarked, I see no reason to doubt that the massive examples of *M. undulata* from the Trenton Limestone are specifically identical with the smaller rounded masses which occur in the Hudson River Group; at the same time that I regard the former as the *type* of the species. The chief differences between these two forms may be advantageously added here, their chief points of agreement having been previously noticed. The typical example from the Trenton Limestone (fig. 32, A) is a large undulated and folded mass, with a maximum diameter of about four inches, and a height of about

two inches, the calice-bearing upper surface being nearly flat. Tangential sections (fig. 32, B) show that the ordinary corallites have an average diameter of from 1-70th to 1-50th inch, while at the angles of junction of these are often small angular tubes of 1-300th inch diameter or less. The angles of junction of adjoining corallites are often slightly thickened, though never conspicuously so, and the corallites are otherwise uniformly thin-walled.

On the other hand, the specimens from the Hudson River Group (fig. 33, A) form rounded or irregularly spheroidal

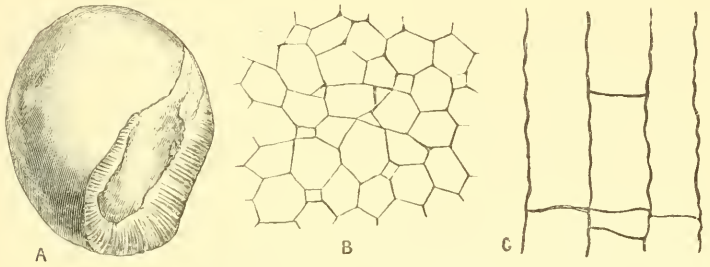

Fig. 33.—A, A specimen of *Monticulipora undulata*, Nich., from the Hudson River Group of Canada, of the natural size, partly broken away on one side; B, Tangential section of the same, enlarged eighteen times; C, Vertical section of the same, similarly enlarged, showing the wavy walls and the remote tabulæ.

masses, generally from an inch to an inch and a half in diameter, and sometimes growing round the stem of a Crinoid. None of my specimens exhibit an unworn surface. Tangential sections (fig. 33, B) show that the ordinary corallites have an average diameter of from 1-90th to 1-60th of an inch, and that they are therefore, upon the whole, slightly smaller in their dimensions than is the case with the corresponding corallites in the Trenton Limestone specimens. A considerable number of small angular corallites, of an average diameter of 1-300th inch, are wedged in at the corners of the larger tubes. As a rule, the corallites in tangential sections exhibit the same thin-walled and delicate structure that is characteristic of the Trenton Limestone examples; but in some parts of these sections (probably the parts nearest the original surface) the walls become decidedly thickened, and very conspicuous nodes

are developed at the angles of junction of adjoining tubes. Longitudinal sections (fig. 33, c) show no appreciable differences as compared with corresponding sections of the specimens from the Trenton Limestone.

Upon the whole, I am disposed to think that there is not sufficient ground for regarding the Hudson River Group specimens as even a permanent variety of the type-form of *M. undulata*.

Formation and Locality.—Rare in the Trenton Limestone of Peterboro', Ontario. Common (the "puff-ball variety") in the Hudson River Group of Toronto, Weston, and other localities in Ontario.

Monticulipora (Monotrypa) Winteri, Nich.

(Fig. 34.)

Monticulipora Winteri, Nicholson, Pal. Tab. Corals, p. 323, Pl. XIII. figs. 5, 5*a*, and Pl. XIV. figs. 2, 2*a*, 1879.

Spec. Char.—Corallum when young, discoid and concavo-convex; when adult, hemispherical or sub-globular. Young examples may be three or four lines in diameter, and less than two lines in greatest height; while fully grown specimens may be more than an inch and a half in diameter, and more than an inch in height. The base is free, or attached to some foreign body at one point, and it is either flat or concave, and is covered by a concentrically striated epithecal membrane. The corallites radiate from the base and open upon the upper surface by thin-walled polygonal calices. The surface shows clusters of slightly extra-sized corallites, which are only occasionally elevated to form low "monticules." The corallites are all uniformly thin-walled, strictly angular or prismatic in form, and sub-equal in size, averaging a quarter of a line in diameter. In internal structure they are all alike, all being provided with delicate, remote, complete, and horizontal tabulæ.

Obs.—Examples of this species are of common occurrence in the Devonian Limestone of Gerolstein, and are so entirely similar in form (fig. 34, A) to the Lower Silurian *M. petropoli-*

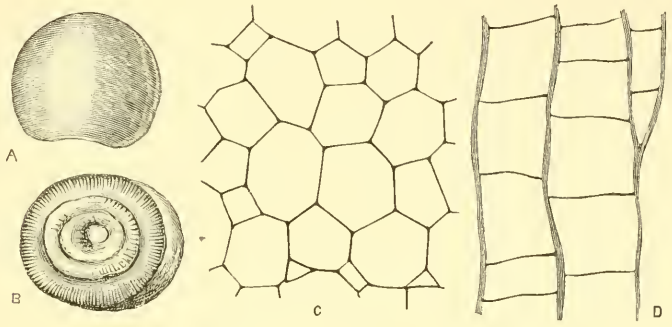

Fig. 34.—*Monticulipora Winteri*, Nich., Devonian, Gerolstein, Eifel. A, A specimen, of the natural size, viewed in profile; B, Base of the same specimen, of the natural size; C, Part of a tangential section of the same, enlarged eighteen times; D, Part of a vertical section, showing the remote tabulæ, similarly enlarged.

tana, Pand., that a merely macroscopic examination would almost certainly have led to their being identified with the latter form. A microscopic examination, however, shows that their structure is that of *Monotrypa*, and not that of *Diplotrypa*, all the tubes alike being essentially similar in their internal characters. Tangential sections (fig. 34, C) show that the tubes are essentially uniform in size, a few slightly larger ones forming scattered clusters, while such intercalated small ones as are present are obviously merely young corallites. All the tubes also are bounded by very delicate walls, and are regular, angular, and prismatic. Vertical sections (fig. 34, D) show a complete identity in structure in all the corallites, the tabulæ being complete and remote, and sometimes placed at corresponding levels in many of the tubes.

Recently, Dr Daniel Œhlert, of Laval, has been good enough to send me a number of specimens, from the Inferior Devonian deposits of La Baconnière, Laval, which agree precisely both in their external characters and their minute structure with examples of *M. Winteri* from the Eifel.

With regard to the Eifel specimens, Dr Steinmann, whose

authority upon such a subject is justly of great weight, has suggested (N. Jahrb. für Min., Geol., und Pal., 1880, p. 438) that the species is really the same as the previously described *Favosites fibroglobosus* of Quenstedt, which occurs at the same locality (Gees, near Gerolstein). In a careful examination, however, of both my German and French specimens, carried on both externally and by means of microscopic sections, I have been quite unable to detect any evidence of the existence of mural pores. I do not in the least desire to call in question the validity of Professor Quenstedt's species; nor, though I unfortunately have not at this moment access to its description, do I question its external resemblance to *M. Winteri*. It is, however, quite clear that in a point of this kind no reliance can be placed upon anything of the nature of external similitude, however close, or, in fact, upon anything but identity of internal structure as demonstrated by the examination of thin sections. Now, I find that in the comparatively small collection which I myself made at Gees, *three* quite distinct forms are really present, all so like each other that, prior to microscopic examination, I had unhesitatingly placed them together as belonging beyond doubt to the same species. Thin sections of these, however, show that these three forms are all widely different from one another in internal structure. One of them is the form here described under the name of *Monticulipora Winteri;* another is a true *Fistulipora*, as that genus is defined by M'Coy; and the third is a genuine *Alveolites*, and is provided with numerous and well-marked mural pores. The form described by Quenstedt under the name of *Favosites fibroglobosus* (Petref. Deutschlands, Bd. VI. S. 15, Taf. 143) is one that, as previously remarked, I am not acquainted with; but, so far as its external form is concerned, it might quite well be any one of the three forms which I have just mentioned, or it might be a quite distinct form.[1] At any rate, the facts

[1] In this connection I may point out a source of fallacy in a number of the specimens of the Eifel corals. In many of these the fossil is largely impregnated with globular grains of peroxide of iron, and these in thin sections often simulate mural

which I have here brought forward entitle me to claim that it is not in the meanwhile proved that my *M. Winteri* is identical with *Favosites fibroglobosus*, Quenstedt. Not being myself in the position to examine microscopic sections of the latter form, I do not feel able to deny that the two may prove to be really the same; but I do not think the evidence would at present be sufficient to demonstrate this. In any case, I may point out that the validity of the section *Monotrypa* will not be affected by the ultimate fate of *M. Winteri*, since the *type* of this section is the *M. undulata* of the Trenton Limestone.

From *M. undulata* the present species is distinguished by its concavo-convex or regularly hemispherical form, by the more rapid intercalation of the new tubes, and by the greater abundance of the tabulæ, while it never attains the dimensions, or assumes the lobate habit, of the former.

I have named the species in honour of Herr Winter of Gerolstein, from whom I received much friendly assistance while collecting in the Eifel.

Formation and Locality.—Not uncommon in the Devonian of Gees, near Gerolstein, Eifel. Also not uncommon in the Inferior Devonian deposits of La Baconnière, Laval. (Coll. Dr Daniel Œhlert.)

Monticulipora (Monotrypa) irregularis, Ulrich.

(Fig. 35.)

Chætetes irregularis, Ulrich, Journ. Cincinnati, Soc. Nat. Hist., 1879, Pl. XII. figs. 10-10*b*.

Spec. Char.—Corallum of small size (generally about three-quarters of an inch in diameter), apparently free, and approximately spheroidal in shape, the surface being usually covered with irregular and well-marked nodulations. No monticules

pores, especially where (from their soft and friable nature) they have been worn away in the process of preparing thin sections. Their true nature is, however, at once recognised when it is seen that they are just as conspicuous in tangential as in longitudinal sections.

or defined groups of either large or small corallites. Corallites of one kind only, thin-walled, polygonal in shape, radiating outwards from a basal point towards all parts of the surface. Average diameter of the corallites from 1-100th to 1-80th inch, a few small corallites being occasionally present, but there being no interstitial tubuli. Tabulæ almost obsolete, though complete transverse partitions are occasionally developed in certain regions, and generally at corresponding levels in contiguous tubes.

Obs.—This singular species has been excellently described by Mr E. O. Ulrich (*loc. cit. supra*), and I am able to corroborate most of his observations from a careful investigation of specimens for myself. Its small size, apparently free habit, and nodulated surface (fig. 35, A) are well-marked external

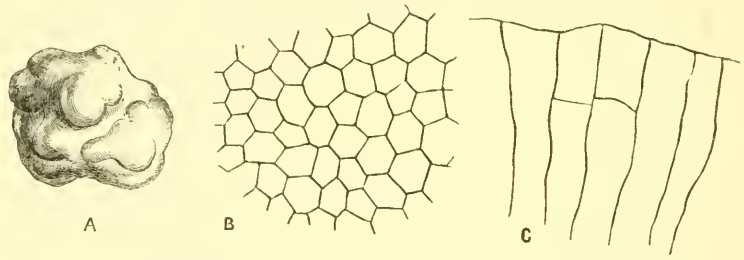

Fig. 35.—*Monticulipora irregularis*, Ulrich, from the Cincinnati Group of Ohio. A, A specimen of the natural size ; B, Tangential section of the same, enlarged eighteen times ; C, Vertical section of a few of the tubes of the same, similarly enlarged, showing a couple of tabulæ.

characters, though, according to Ulrich, the surface may be nearly smooth. In internal structure, this species belongs to that group of *Monticuliporæ* which I have associated together under the name of *Monotrypa*. In tangential sections (fig. 35, B) the corallites are seen to be of one kind only, tolerably equal in point of size, thin-walled, polygonal, and wholly without minute interstitial tubules of any kind. In longitudinal sections (fig. 35, C) the tubes are seen to preserve the same thin-walled character throughout, the walls being slightly flexuous, but not sharply undulated. In the specimens that

I have examined, the tubes seem to radiate from a point near the base; but Mr Ulrich describes the normal arrangement to be that the tubes "radiate from various centres, which correspond in number to that of the prominent nodules observed on the surface." This observer also states that, after examining transparent sections, he had been unable to detect any tabulæ; and this observation is so far correct that tabulæ are certainly totally wanting throughout a great part of the corallum. I find, however, that there is commonly a single tabula (sometimes two or three) developed in many of the tubes at a short distance inwards from their termination on the surface, and that these tabulæ are commonly placed at corresponding levels in contiguous tubes. An occasional tabula may also be observed in the interior of the corallum.

M. irregularis, Ulrich, is most nearly allied in internal structure to the smaller types of *M. undulata*, Nich. (which may possibly constitute a separate species), but it is sufficiently distinguished by its external characters, and its much more limited development of tabulæ.

Horizon and Locality.—Cincinnati Group, Ohio (according to Ulrich, it marks an horizon of about 550 feet above low-water mark in the Ohio River, Cincinnati).

Monticulipora (Monotrypa) quadrata, Rominger.

(Fig. 36.)

Chætetes quadratus, Rominger, Proc. Acad. Nat. Sci. Phil., 1866, p. 115.
,, *rhombicus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 507, Pl. XXIX. figs. 11-11*b*, 1874. Pal. Ohio, vol. ii. p. 201, Pl. XXI. figs. 12, 12*a*, 1875. Ann. Nat. Hist., ser. 4, vol. xviii. p. 86, Pl. V. figs. 1-1*b*, 1876.
(*Non Dianulites rhombicus*, Dybowski, Die Chætetiden, p. 33, 1877.)

Spec. Char. — Corallum dendroid, of cylindrical or sub-cylindrical branches, which vary from rather more than two up to five lines in diameter, and often terminate in rounded or bulbous extremities. Corallites primitively thin-walled,

and becoming slightly thickened towards their mouths, but always retaining their original boundary-lines. They are all of one kind, sub-equal, from 1-70th to 1-80th inch in diameter, being rhomboidal in shape in the centre of the branches, but often becoming pentagonal as they approach the surface. Calices often polygonal, but usually in parts obliquely rhombic, and arranged in regular diagonal rows, the direction of which changes within short distances, thus communicating to the surface a characteristic aspect. No monticules or maculæ are present, and the lips of the calices are thin. Tabulæ appear to be wanting, or to be very sparingly developed, in the axial region of the corallum; but there exists a considerable number of complete, straight, or slightly curved tabulæ in the outer thickened portion of the corallites, the tabulation of all the tubes being alike.

Obs.—Superficially, this species is readily distinguished from the other dendroid species of *Monticulipora* by the commonly rhombic or diamond-shaped form of many of the calices, these openings being then arranged in curved diagonal lines, which cross each other obliquely. Even when the calices are simply polygonal, as is sometimes the case, over large parts or over the whole of a given specimen, this characteristic appearance may still usually be recognised by an examination of the weathered ends of the stems where the invariably rhomboidal tubes of the axial region are brought into view. The remaining superficial characters that are of the most importance are the want of marked thickening in the edges of the calices, and the total absence of small interstitial corallites, as well as of monticules or of groups of either large or small tubes.

As regards its internal structure, *M. quadrata*, Rominger, exhibits characters of such marked peculiarity, that there is no other species of the genus, so far as I know, with which it requires to be compared. In the axis of the branches, the corallites are always provided with very thin and delicate walls, and have no tabulæ, or hardly any. In this region, also, as shown by the central part of a transverse section (fig. 36, D),

they exhibit their most highly characteristic shape, being strictly rhombic or square, and being arranged in regularly

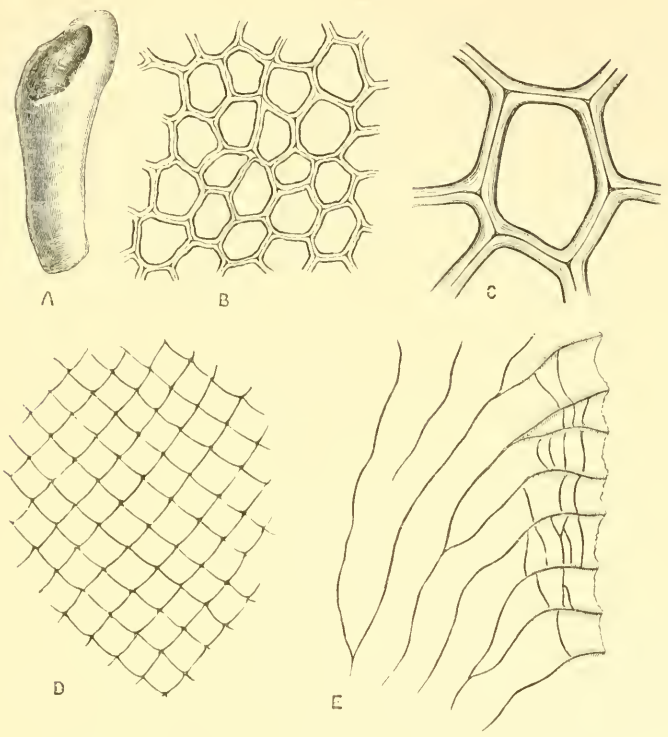

Fig. 36.—A, A fragment of *Monticulipora quadrata*, Rominger, from the Cincinnati Group of Ohio, of the natural size; B, A tangential section of the same, passing just below the calices, enlarged eighteen times; C, Part of the preceding section, enlarged fifty times, showing the structure of the walls of the corallites; D, Part of the central area of a transverse section, showing the peculiar rhombic form of the tubes in this region, enlarged eighteen times; E, Part of a vertical section, enlarged eighteen times.

decussating oblique lines. Thin as their walls are here, there is usually a more or less conspicuous nodal enlargement at each of the angles of junction of the corallites. The cavities of the tubes are filled with transparent calcite, and each has its rhomboidal area very distinctly and regularly divided into four equal triangles by a cruciform divisional line. These divisional lines in the interior of the tubes are perfectly regular in their arrangement, and are quite uniform in their direction in each specimen: they therefore give rise to a second, fainter, double series of diagonal lines, which intersect the

more strongly marked series of diagonals formed by the walls of the tubes themselves. Similar, but less conspicuous and less regular, divisional lines are visible in the calcite which fills the tubes of the corallites in many species of *Monticulipora* and in *Constellaria;* but I have been unable to satisfy myself as to the true cause of this phenomenon. In the outer portion of the course of the corallites, when they have turned out towards the surface, their walls always become recognisably thickened, and they often, though not always, lose their quadrangular form, and become pentagonal or hexagonal (fig. 36, B and C). The thickening of the walls of the tubes, however, does not go so far as to entirely obliterate the original distinctness of the corallites. On the contrary, the primitive boundary lines between adjoining tubes can always be readily made out (fig. 36, D); and along these lines the corallites readily separate from one another.

Not only are all the corallites of one kind, in the sense that there are no "interstitial corallites" of any kind, but long sections show that the tabulation of all the tubes is the same. All, namely, possess a moderate number of strong and complete tabulæ, which are developed in the curved portion of the tubes just below the surface. Many of the tabulæ are slightly curved, either convex or concave, and they often join with one another; but others are straight.

Horizon and Locality.—Cincinnati Group, Cincinnati, Ohio.

Monticulipora (Monotrypa) clavacoidea, James.

(Fig. 37.)

Chætetes clavacoideus, James, Cat. Lower Sil. Foss., 1871. (Named but not described.)
,, ,, James, Cat. Lower Sil. Foss., 1875, p. 1.

Spec. Char.—Corallum forming a crust, which is attached by the whole of its base to foreign objects, and is composed of corallites which are uniformly disposed at right angles to the

surface of attachment. The species seems to be constantly parasitic upon the tapering ends of minute species of Orthoceratites, and the corallum is constantly cylindrical in form, sometimes becoming slightly fusiform or clavate. In general the Orthoceras has disappeared, and the space which it originally occupied is filled up with calcite or with the matrix, or may be simply hollow.

Corallites thin-walled, polygonal in shape, and generally nearly equal in point of size, their long diameter being, as a rule, between 1-100th inch on the one hand, and 1-80th inch on the other hand. Surface either smooth, or sometimes showing groups of corallites of rather larger size than the average, these groups being elevated to form low and ill-defined tubercles. Tabulæ absent throughout the greater part of the tubes, but apparently not wholly wanting in any given section, an occasional complete partition being developed here and there in the deeper parts of the corallum, or, still more frequently, close to the mouths of the tubes.

Obs.—The external form and superficial characters of *M. clavacoidea* have been accurately described by Mr U. P. James (Cat. Lower Sil. Foss., 1875), to whose kindness I am indebted for specimens of this, as of many other types. I am not aware, however, that its microscopic structure has hitherto been noted. In its mode of growth and its resulting form, *M. clavacoidea* is quite peculiar. The colony is never large, its length varying from half an inch to at least two inches, and its width from three or four to eight lines; while its form is constantly cylindrical, or bluntly fusiform, or somewhat clavate (fig. 37, A). This form is in all cases due to the fact that the corallites at all points of the corallum spring perpendicularly from a central elongated cone, one end of which is closed, and is consequently usually completely covered with the tubes, while the other end is open. Sometimes both ends of the colony are open. The conical space in the centre of the corallum is, in all my specimens, filled with calcite or with the surrounding matrix, or is simply hollow; but I entertain no doubt that Mr James is

correct in his statement that the colony really grew parasitically upon the closed and tapering extremities of the dead shells of

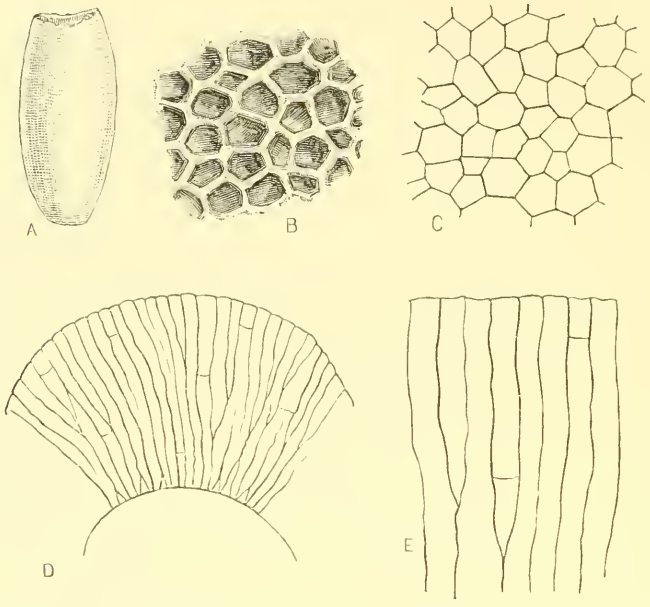

Fig. 37.—*Monticulipora clavacoidea*, James. A, An average specimen of the natural size; B, Part of the surface of the same, enlarged eighteen times; C, Portion of a tangential section, enlarged eighteen times; D, Part of a transverse section of the same, showing the corallites radiating outwards from the foreign body to which they are attached inferiorly, enlarged seven times; E, Part of the same section, enlarged eighteen times, showing the uniformly thin-walled corallites, and their few and remote tabulæ. From the Cincinnati Group, Cincinnati, Ohio.

Orthocerata. This is, therefore, a curious instance of the persistence with which a particular species attaches itself to some particular object, never seeming to fix itself upon any other.

Apart from its very peculiar and apparently constant form and mode of growth, *M. clavacoidea* is readily distinguished by its minute structure. Tangential sections (fig. 37, C) show that the corallites are uniformly thin-walled and polygonal, slight nodes being often formed at the angles of junction of contiguous tubes. Their size is very uniform, though groups of corallites of slightly larger dimensions than the rest are certainly occasionally developed. In any case, there exists no series

of small interstitial tubes. Vertical sections (fig. 37, D and E) show that there is no difference whatever in structure between any one set of corallites and any other. In none are the walls thickened towards the surface, but they are uniformly thin throughout, and are often slightly wavy. The course of the tubes is straight, there being no curvature near their bases, and they increase in number in passing outwards by the interpolation of fresh tubes. In a great number of the tubes no tabulæ exist at all; but an occasional tabula is sometimes developed near the mouth of the tube, or at some depth below the surface.

In internal structure, *M. clavacoidea*, James, is most nearly allied to *M. irregularis*, Ulrich; but the form of the corallum and the mode of growth afford a sufficient means of separation.

Horizon and Locality.—Cincinnati Group, Cincinnati, Ohio. (Coll. U. P. James.)

Monticulipora (Monotrypa) calceola, Miller and Dyer.

(Pl. I. figs. 3-3*e*.)

Monticulipora calceola, Miller and Dyer, Journ. Cincinnati Soc. Nat. Hist., vol. i. 1878.

Spec. Char.—Corallum free (?), of small size, varying from less than one line up to more than six lines in diameter, helicoid in shape, and traversed by a horn-shaped cavity, which opens upon the exterior by a well-marked circular aperture, the inner lining of which shows encircling striæ, and which varies from half a line or less up to more than two lines in diameter. Surface smooth, or covered with low rounded tuberosities. Calices approximately equal, thin-walled, and polygonal in shape. Corallites radiating from the outer surface of the afore-mentioned central tube to open in a nearly rectilinear manner upon all points of the surface except the external aperture of the central tube. Corallites polygonal, thin-walled, from 1-90th to 1-70th inch in diameter, very minute angular or

rounded tubes being situated at their angles of junction. Tabulæ fairly developed, complete and horizontal, increasing in number as the mouths of the tubes are approached.

Obs.—This very singular species was originally described by Messrs Miller and Dyer (*loc. cit.*); but I have, unfortunately, not been able to refer to the original paper. Its peculiar helicoidal shape (Pl. I. figs. 3, 3*a*), and the fact of its being built round a curved central tube which opens externally by a round aperture, would alone distinguish the species, quite apart from its internal characters. I do not know what view was adopted by Messrs Miller and Dyer as to the origin of this very unusual and apparently constant form, but I gather from a letter from Mr Nickles, of Cincinnati, that after studying the numerous specimens in his extensive collection, he is disposed to regard its form as something peculiar to itself, and not as due to the fact that it has grown round some foreign organism. In such thin sections as I have made, it seems certain that the central horn-like cavity is lined by a well-defined calcareous layer (Pl. I. fig. 3*e*), the structure of which seems to be quite distinct from that of the corallites themselves; and I was therefore at first disposed to regard the colony as parasitic upon some such foreign object as a Tubicolar Annelide, to which fact its peculiar form might be ascribed. Mr Nickles, however, is of the opinion that this calcareous lining of the tube is really the epitheca of the colony; and as his opportunities of observation have been much greater than mine, it is quite possible, and indeed probable, that he is right in this opinion. Certainly, the fact that specimens no bigger than the head of a moderate-sized pin should show the same peculiar form and the same strange central tube as occur in fully-grown examples, would militate very strongly against the view that the spiral tube can be foreign to the corallum. It reminds one of the "worm-like body" of *Pleurodictyum*, though it is not possible to assert that the two structures are the same.

In external characters the calices of *M. calcicola* are thin-

walled and polygonal, and of tolerably equal dimensions (Pl. I. fig. 3*b*). As regards internal structure, tangential sections (Pl. I. figs. 3*c* and 3*d*) show that the ordinary polygonal corallites have a few smaller ones intercalated amongst them—these, however, being shown to be only young tubes by the fact of their having no special peculiarities of internal structure, and by their inconstant development. On the other hand, in carefully prepared tangential sections, I find a number of small triangular or sub-circular tubes to be present at the angles of junction of the ordinary corallites (Pl. I. fig. 3*d*). These do not seem to be bounded by definite walls of their own; and as I have wholly failed to detect their existence in longitudinal sections, I am inclined to think that they are not really corallites or interstitial tubules, in any proper sense, but merely vacuities in the wall, such as undoubtedly occur in some allied types of corals. Longitudinal sections (Pl. I. fig. 3*e*) show that the corallites spring nearly at right angles to their base of origin, and follow a tolerably straight course to the surface, their thin walls being slightly thickened as they approach their termination. Tabulæ, which, I believe, are stated to be absent by Messrs Miller and Dyer, are, so far as I have seen, well developed, being always complete and approximately horizontal, and increasing in number as the calicine surface is approached.

I am indebted for the specimens upon which the preceding description has been founded to Mr John M. Nickles, of Cincinnati, who has specially devoted himself to the study of these minute and difficult Palæozoic fossils.

Horizon and Locality.—Cincinnati Group, Cincinnati, Ohio.

Monticulipora (Monotrypa) pulchella, Edwards and Haime.

(Figs. 38, 39.)

Chætetes pulchellus, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 271, 1851.

Monticulipora pulchella, Edwards and Haime, Brit. Foss. Cor., p. 267, Pl. LXII. figs. 5-5*b*, 1854.

(*Non Chætetes pulchellus,* Nich., Quart. Journ. Geol. Soc., vol. xxx. p. 503, 1874, and Pal. Ohio, vol. ii. p. 195, 1875.)

Spec. Char.—Corallum ramose, the branches cylindrical or compressed, from two to six lines in diameter. Surface not exhibiting regular monticules, but having clusters of comparatively large-sized corallites, which are not markedly elevated above the general surface, interspersed at intervals among the average tubes. Calices thin-walled and polygonal in shape, those of the average corallites having a general diameter of about 1-60th inch, while those of the clusters have a diameter of from 1-45th to 1-40th inch. *Structurally,* all the corallites of the corallum are of one kind, the large tubes of the clusters only differing from those of average dimensions in point of size. The walls of the tubes become thickened as they approach the surface, but the primitive boundaries between contiguous corallites remain permanently recognisable. The tubes are all equally provided with a moderate number of complete approximately horizontal tabulæ.

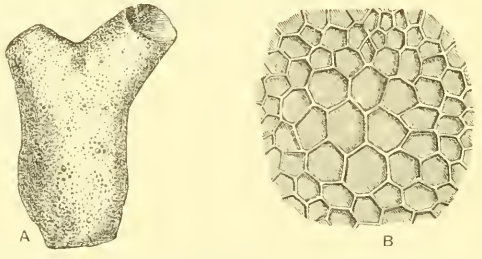

Fig. 38.—A, Part of a typical specimen of *Monticulipora pulchella,* E. and H., from the Wenlock Limestone of Dudley, of the natural size; B, Part of the surface of the same, embracing one of the clusters of large corallites, enlarged.

Obs.—As regards its external aspect, this species is chiefly distinguished by the polygonal thin-walled calices (fig. 38, B),

and by the presence of numerous clusters of corallites of from one-fourth to nearly one-half larger size than the average. These clusters of large calices can hardly be said to constitute "monticules," in the strict sense of this term, as they are not, so far as I have seen, conspicuously elevated above the surface. There are, moreover, no small calices representing the mouths of a series of interstitial corallites.

As regards its internal structure, *M. pulchella*, E. and H., exhibits a remarkable simplicity. Thus, in tangential sections (fig. 39, A) the corallites are seen to be regularly polygonal, in

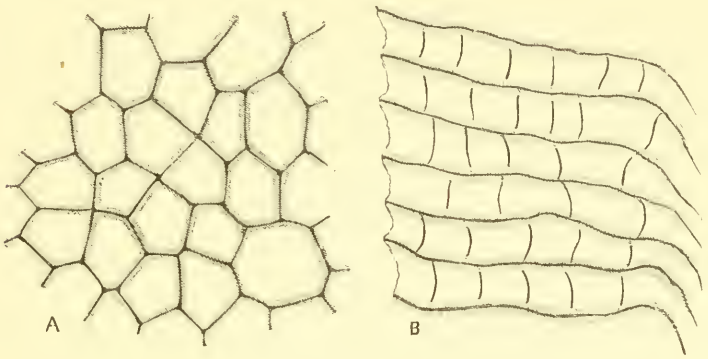

Fig. 39.—Thin sections of a typical example of *Monticulipora pulchella*, E. and H., from the Wenlock Limestone of Dudley. A, Part of a *tangential* section, enlarged eighteen times, not passing through one of the groups of larger corallites; B, Part of a longitudinal section, enlarged eighteen times. Both sections show that the *wall* of the tubes has the same structure as is characteristic of *Favosites*; and the latter exhibits the remote tabulæ which intersect the cavities of the tubes.

contact at all points of their circumference, and provided with moderately, but not excessively, thickened walls. Moreover, there is never even an apparent fusion of the walls of contiguous corallites, each tube retaining, on the contrary, its own calcareous investment as a distinct structure. Hence, the wall which separates any two contiguous corallites is always composed of two more or less distinct calcareous laminæ, separated by a thin and dark boundary line, which is often conspicuously thickened at the points where three or more tubes come in contact. These nodal thickenings sometimes simulate thick-walled tubes, having a minute central cavity;

but I do not think that this is more than a mere result of imperfect calcification, and I have not detected any "spiniform corallites." Small interstitial tubes are also entirely wanting.

Longitudinal sections (fig. 39, B) show the duplex character of the wall quite as conspicuously as do tangential slices. They show, also, that there is no difference in the tabulation of the tubes of the clusters as compared with those which constitute the bulk of the colony. All alike are furnished with remote and complete tabulæ, which are approximately horizontal, and which continue to be developed till close upon the surface.

Monticulipora pulchella, E. and H., is sufficiently distinguished from all other species of the genus known to me, both by its marked superficial characters and its exceptionally simple internal structure. The form which I formerly described under the name of *Chætetes pulchellus*, from the Cincinnati Group of Ohio, proves on microscopic examination to be entirely distinct, and has been previously described under the name of *M. Andrewsii*.

Horizon and Locality.—Wenlock Limestone, Dudley. So far as my limited experience goes, the species is a very rare one.

Monticulipora (Monotrypa) petasiformis, Nicholson.

(Fig. 40.)

Spec. Char.—Corallum small, discoidal, from six to eighteen lines in diameter, somewhat variable in shape, but always with a flat or concave base, which may be in part attached parasitically to some foreign body, but is always covered with a concentrically striated epitheca over the rest of its extent. From this basal plate the short corallites spring nearly at right angles throughout, and they either form a thin disc, or they give rise, more commonly, to an expansion which is thin at its edges, but is prominently elevated towards its centre, thus resembling in form the "cap" of many kinds of mushrooms. In other

cases, there may be two of these prominences; and, whether single or double, the superior elevation may project above the base to a considerable height as compared with its width at the base. The maximum height varies from three lines to nearly one inch. The upper surface is covered with the calices, which are thin-walled, polygonal, and approximately equal in size, varying from about 1-80th inch to 1-60th inch in diameter. There are no small interstitial corallites of any kind; but the surface shows numerous clusters of tubes which are slightly larger than the average, and which are very slightly elevated above the general level. The walls of all the corallites are thin and delicate, no thickening taking place as the surface is approached. The tabulæ are numerous, complete, equally developed throughout the entire length of the corallites, straight or slightly curved, and mostly from 1-100th to 1-90th inch apart.

Obs.—This form from its general aspect would be set down as a near relation of *Monticulipora petropolitana*, Pand., from

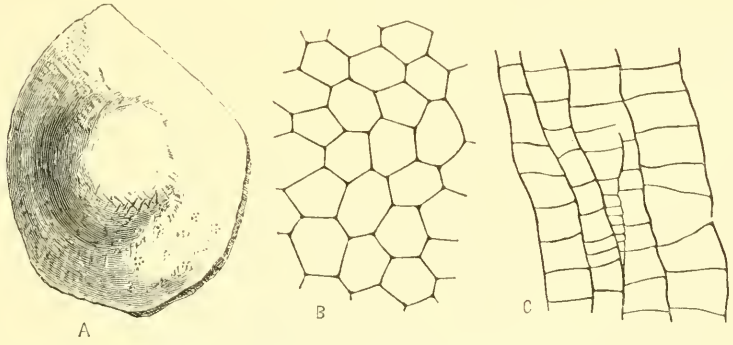

Fig. 40.—A, A specimen of *Monticulipora petasiformis*, Nich., of the natural size, viewed from above, and showing the prominence of the central part of the disc; B, Tangential section of the same, enlarged eighteen times, showing the absence of interstitial tubes and the delicate character of the walls; C, Vertical section of the same, enlarged eighteen times, showing the thin walls and the numerous and equally developed tabulæ. Cincinnati Group of Ohio.

which, however, it is even superficially separable by its peculiar and seemingly constant form (fig. 40, A). In its minute structure the present species is quite distinct from *M. petropolitana*,

Pand., and, in fact, possesses peculiar characters which sufficiently distinguish it from all the forms externally like it. Tangential sections (fig. 40, B) show that there is a total absence of small interstitial tubuli, and that, except for the previously mentioned existence of clusters of corallites of a size slightly above the average, the tubes are approximately alike in size. The walls are exceedingly thin, but nevertheless, in sections sufficiently thin, show a distinctly duplex character, the boundary lines between the walls of contiguous tubes being expanded into angular nodal points at their angles of junction (*see* fig. 2, B). Long sections (fig. 40, C) show that there is no difference in internal structure between the average corallites and the clusters of slightly larger tubes which are interspersed amongst these, all being furnished with numerous complete tabulæ. The two species most nearly allied in structure to the present form are *M. undulata*, Nich. (the rounded examples from the Hudson River Group), and *M. irregularis*, Ulrich. From the former of these, *M. petasiformis* is distinguished by its different external shape, by the fact that its corallites spring perpendicularly from a basal epithecal plate, instead of radiating from a basal or central point, by the absence of even a few small corallites, and by the much greater development of the tabulæ, these structures not being disposed at corresponding levels in contiguous tubes. From *M. irregularis*, Ulrich, the present species is readily separated by its want of the nodulated surface and radiated corallites of the former, and by the great abundance of its tabulæ.

The specimens of *M. petasiformis* upon which I have founded the species were kindly furnished to me by Mr John M. Nickles, of Cincinnati, who has devoted much time to the collection and study of the corals of the Cincinnati Group.

Horizon and Locality.—Cincinnati Group, Ohio.

Monticulipora (Monotrypa) discoidea, James.

(Pl. IV. figs. 3, 3*f*.)

Chætetes discoideus, James, Cat. Foss. Cincinnati Group, 1871. (Named, but not figured or described.)

Chætetes discoideus, Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 511, Pl. XXX. figs. 4-4*d*, 1874. Pal. Ohio, vol. ii. p. 206, Pl. XXI. figs. 15-15*c*, 1875. Ann. Nat. Hist., ser. 4, vol. xviii. p. 88, Pl. V. figs. 7, 7*a*, 1876.

Spec. Char. — Corallum free, discoid, concavo-convex or plano-convex, sharp-edged, from five to eight lines in diameter, and about one-tenth of an inch in thickness in the centre. Under surface more or less concave, as a rule, covered with a thin, smooth, and irregularly striated epitheca, which usually exhibits two or three marked concentric wrinkles. Upper surface carrying the calices, gently convex, and not exhibiting any monticules. Calices polygonal, thin-walled, sub-equal, mostly about 1-80th inch in diameter. There is no proper series of small corallites; but there is a largely developed series of thick-walled hollow tubuli ("spiniform corallites"), one being usually situated at each angle of junction of adjacent tubes. The corallites are directed at right angles to the basal plate, being thin-walled at first, but ultimately becoming moderately thickened; and the visceral chambers are crossed by a moderate number of complete horizontal tabulæ, which are often placed at corresponding levels in adjacent tubes.

Obs.—The external characters and mode of growth of *M. discoidea*, James, are sufficiently alluded to in the preceding description (Pl. IV. figs. 3-3*b*), and need not be further referred to here. The internal structure is highly characteristic, and places the validity of the species beyond doubt.

Tangential sections taken just below the upper surface show that the ordinary corallites (Pl. IV. figs. 3*c* and 3*d*) are polygonal in shape, tolerably equal in size (about 1-80th inch in their longest diameter), and moderately thick-walled, the lines of demarcation between adjacent tubes remaining dis-

tinct. There are no interstitial tubes,[1] or proper series of small corallites; but there is a remarkable development of the singular "spiniform corallites" which constitute such a striking feature in many other species of *Monticulipora*. These curious structures present their usual characters, each exhibiting a central circular clear spot, surrounded by a thick, laminated, and dark-coloured wall. Usually, one of these tubules is developed at each angle of any given large corallite; and though they can often be traced in longitudinal sections (Pl. IV. fig. 3*f*) running in the substance of the wall, I have not been able to discover how they terminate upwards, as none of my specimens have the superior aspect of the corallum in a sufficiently well-preserved condition.

Vertical sections of the corallum (Pl. IV. figs. 3*e*, 3*f*) show that the corallites are throughout approximately perpendicular to the basal epitheca, their walls gradually thickening as the upper surface is approached. Tabulæ are always present, and are always complete and horizontal; but their number is comparatively small, and they often show a periodic development, being placed at the same level in adjoining tubes.

In the general conformation of the corallum, *M. discoidea*, James, is most nearly related to *M. Newberryi*, Nich., and *M. calycula*, James, though quite distinct from these in internal structure. Thus, *M. Newberryi*, Nich., has the colony divided into two quite distinct sets of corallites, the large tubes having incomplete tabulæ, while the small ones have close-set complete tabulæ. *M. calycula*, James, on the other hand, has a much thinner corallum than *M. discoidea*, and

[1] I formerly (Ann. Nat. Hist., ser. 4, vol. xviii. p. 89, Pl. V. fig. 7) described and figured small corallites as existing in *M. discoidea*, James; but though my *figure* was correct, my conclusion therefrom was erroneous. I was not, namely, at that time aware of the value and importance of *tangential* sections, and the section that I described and figured was a *transverse* one, passing through the corallum parallel with its under surface and just above the line of the epitheca. Consequently, it intersected the corallites at a level just above the point where they spring from the basal plate, and where many of them are quite young. Hence the appearance of a series of small corallites intermixed with the larger ones. Hence, also, the absence in the section which I figured of the curious spiniform tubes which are so conspicuous in tangential sections.

possesses two sets of corallites, which differ not only in size, but also in their tabulation.

Horizon and Locality.—Cincinnati Group, Ohio. An outwardly similar form occurs in the Hudson River Group of Canada; but not having prepared thin sections of this, I am not certain of its identity with the Cincinnati type.

Monticulipora (Monotrypa) pavonia, D'Orbigny.

(Fig. 41, and Pl. VI. figs. 3, 3*a*.)

Ptilodictya pavonia, D'Orbigny, Prodr. de Paléont., vol. i. p. 22, 1850.
Chætetes pavonia, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 267, Pl. XIX. figs. 4, 4*a*, 1851.
„ „ Rominger, Proc. Acad. Nat. Sci. Phil., 1866, p. 116.
Stictopora clathratula, James, Cat. Foss. Cincinnati Group, 1871.
Chætetes? clathratulus, Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 509, Pl. XXX. figs. 1-1*b*, 1874. Pal. Ohio, vol. ii. p. 209, Pl. XXII. figs. 2, 2*b*, 1875. Ann. Nat. Hist., ser. 4, vol. xviii. p. 91, Pl. V. figs. 9, 9*a*, 1876.
Heterodictya pavonia, Ulrich, Cat. Foss. Cincinnati Group, p. 10, 1880.

Spec. Char.—Corallum forming a thin undulating expansion, often of considerable extent, and varying from half a line to about two lines in thickness. The expansion grew in an erect position, and it consists of two layers of corallites, which have their bases fixed to a median plane marked by a delicate undulating calcareous membrane, and which open on opposite sides of the corallum. The corallites vary from a quarter of a line to a line in total length, and though oblique at their origin, they almost immediately bend outwards, so as to open nearly at right angles to the general surface, or with only a slight obliquity to it. The calices have the form of elongated pentagons, with rounded angles, their long diameter being from 1-110th to 1-90th inch. Their size is tolerably uniform, and there are no minute interstitial tubes. The calices are often arranged in tolerably regular obliquely intersecting lines; and the surface shows low rounded elevations, which are often obscurely marked, are arranged in diagonal rows

at intervals of from a line to a line and a half, and are occupied by calices which are not conspicuously larger or smaller than the average. The walls of the corallites are at first thin; but they rapidly become thickened, the lines of demarcation between adjacent tubes still remaining recognisable. A few remote, complete, and horizontal tabulæ are developed in the interior of the tubes; but these are not recognisable in all the corallites, and are often placed at corresponding levels in adjoining tubes.

Obs.—This beautiful form presents a considerable superficial resemblance to *Ptilodictya*, and has been referred to this genus. It wants, however, the definitely circumscribed and peculiarly marked lateral margins of the fronds of this Polyzoan type, and, what is more important, it is without the peculiarly striated central lamina of the *Ptilodictyæ*. It is true that the bases of the corallites in *M. pavonia*, D'Orb., are so united with one another as to give rise to an irregular calcareous membrane, which separates the two halves of the corallum; but none of the specimens that I have seen exhibit any tendency to split along the line of this membrane, nor can the corallites be forcibly removed from one side of it, exposing the median lamina as a definite structure. In both these respects the *Ptilodictyæ* would show quite different phenomena. The reasons just given would equally prevent my accepting the view held by Mr E. O. Ulrich that this form should be referred to *Heterodictya*, Nich., since this genus differs from *Ptilodictya* principally in the possession of tabulæ. On the other hand, the general aspect of *M. pavonia*, D'Orb., is not at all remarkably different from that of the thin fronds of *M. frondosa*, D'Orb., while it exhibits low "monticules;" and there is nothing in its internal structure which is irreconcilable with the view that it is a *Monticulipora*. In the meanwhile, therefore, I shall leave this type within the limits of the genus *Monticulipora*, till more definite evidence may be forthcoming as to its proper position.

So far as external characters go, *M. pavonia*, D'Orb., is

easily recognised by its thin undulated corallum, which carries on both sides the sub-equal, oval, or pentagonal calices, these being often arranged in decussating lines, and elevated at intervals into low and inconspicuous monticules (Pl. VI. figs. 3, 3*a*). As regards its internal structure, we have seen that the corallites are bilaterally disposed on the two sides of a central plane, as is shown by vertical sections taken at right angles to

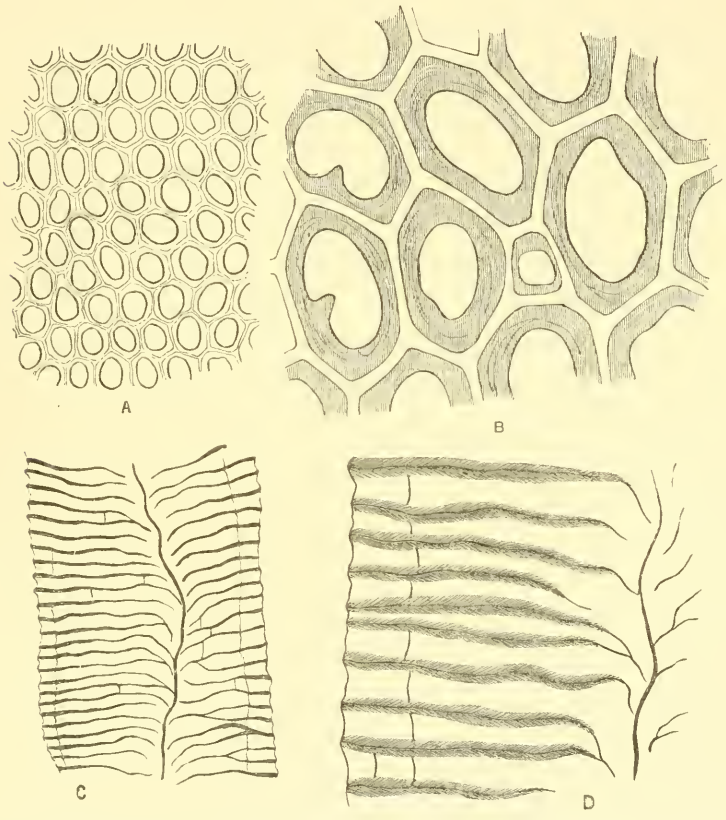

Fig. 41.—Minute structure of *M. pavonia*, D'Orb. A, Tangential section, enlarged eighteen times; B, Part of the same section, enlarged fifty times, showing the structure of the walls of the tubes—in two of the tubes there is a curious tooth-like projection on one side of the visceral chamber; C, Part of a vertical section, taken at right angles to the flat surfaces of the corallum, and embracing its entire thickness, enlarged seven times; D, Part of the preceding section, enlarged eighteen times, showing the central membrane and the remote tabulæ. From the Cincinnati Group of Ohio.

the flat surfaces of the corallum (fig. 41, C and D). All the corallites are of the same kind, approximately equal, and

averaging 1-100th inch in diameter. At first thin-walled, they rapidly have their cavities contracted by a secondary deposit of sclerenchyma. When viewed in tangential sections (fig. 41, A and B), the visceral chambers of the corallites thus appear to be oval; but the original independence of the corallites is shown by the persistence of the pentagonal boundary lines between adjoining tubes, occupying the middle line of the thickened wall. In these sections the visceral chambers are sometimes encroached upon by a single blunt tooth-like projection on one side; but I can give no precise explanation of this phenomenon. There is no appearance of any interstitial series of tubes between the ordinary corallites, nor are any "spiniform corallites" present. Tabulæ, as seen in long sections, are few in number, sometimes apparently wanting, but, when developed, always complete and horizontal, and often placed at the same level in adjoining tubes, and thus marking stages of growth.

Horizon and Locality.—Cincinnati Group, Cincinnati, Ohio.

Monticulipora (Monotrypa) briarea, Nicholson.

(Pl. II. figs. 5-5*c*.)

Chætetes briareus, Nicholson, Pal. Ohio, vol. ii. p. 202, Pl. XXI. figs. 13-13*b*, 1875.

Spec. Char.—Corallum free (?), commencing in a pointed base, which does not show any indication of having been at any time attached to any foreign body. Above the base the corallum expands, so as to form an inverted and compressed cone, from the summit of which proceed a variable number of cylindrical branches, generally from two and a half to four lines in diameter, the final terminations of which are unknown, though they may branch more than once. The surface is smooth, without monticules, the calices being oval or circular, mostly about 1-80th inch in diameter, not separated (so far as observed) by any small interstitial tubes. The corallites are

thick-walled in the outer portion of their course, and are to a large extent fused with one another, though the original lines of demarcation between adjoining tubes can still be recognised. Centrally, the corallites are thin-walled and polygonal. Tabulæ, which are always complete and approximately horizontal, are present both in the axial and the peripheral portions of the corallum, but are most abundantly developed at the point where the corallites begin to bend outwards to reach the external surface.

Obs.—The peculiar form and mode of growth of the corallum of this species (Pl. II. fig. 5), taken alone, would render its distinctness highly probable; and its internal characters are likewise quite peculiar. Tangential sections (Pl. II. figs. 5*a* and 5*b*) show that the corallites are very uniform in point of size (about 1-80th inch in diameter), and are exclusively (so far as I have seen) of one kind. The original polygonal walls of the tubes can still be readily recognised; but their internal cavities are much contracted by a thick deposit of sclerenchyma, by which their shape is, on the whole, rendered oval or circular. No "spiniform corallites" are developed. Axial sections, whether longitudinal or transverse, show that the corallites in this region are thin-walled and polygonal in shape, the thickening of the corallites only commencing when they begin to bend outwards. Longitudinal sections (Pl. II. fig. 5*c*) further show that there is no difference in internal structure in any of the corallites, and that all alike are furnished with a moderate number of horizontal and complete tabulæ, which become somewhat fewer in the axis of the stems.

I know of no species of *Monticulipora* with which it is necessary to compare *M. briarea* closely, both its external and internal characters being quite peculiar. The specimen from which the foregoing description was mainly drawn up, was kindly presented to me by Mr U. P. James of Cincinnati, to whom the first recognition of the form as new is really due.

Horizon and Locality.—Cincinnati Group, near Cincinnati, Ohio.

Monticulipora (Monotrypa) tuberculata, Milne-Edwards and Haime.

(Pl. IV. figs. 2-2*d*.)

Chætetes tuberculatus, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 268, Pl. XIX. figs. 3, 3*a*, 1851.
Chætetes corticans, Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 512, Pl. XIX. figs. 13, 14, 1874. Pal. Ohio, vol. ii. p. 210, Pl. XXII. figs. 6, 6*a*.
Chætetes tuberculatus, Nicholson, Ann. Nat. Hist., ser. 4, vol. xviii. p. 91.

Spec. Char.—Corallum parasitic, forming a thin crust, generally from 1-40th to 1-35th inch in thickness, attached to the external surfaces of the shells of *Orthocerata*. Surface exhibiting a number of long, narrow, compressed tubercles or monticules, which are all occupied on their sides by the ordinary corallites, though sometimes apparently more or less compact at their summits. The monticules are mostly from two-thirds of a line to two lines in their long diameter, with a width of about half a line, and a height generally about equal to their width, their distance apart being from half a line to two-thirds of a line. The corallites are thin-walled, polygonal, sub-equal, generally from 1-100th to 1-120th inch in diameter, and seemingly not separated by any intercalated series of interstitial tubuli, though an occasional small tube may be present. The walls of the corallites are thickened as they approach the surface, and the visceral chambers appear to be either open, or to be intersected by occasionally developed complete tabulæ.

Obs.—So far as I am aware, this species is universally parasitic upon the dead shells of *Orthoccrata*, and often covers very extensive surfaces. The most striking and characteristic feature in its expansions is the elongated and compressed form of its monticules, which are arranged in irregular diagonal lines, and always have their long axes coincident in direction with the major axis of the Orthoceras upon which they grow (Pl. IV. fig. 2). The calices are always thin-walled and polygonal, and there are no traces of the intercalated tubuli which

form such a conspicuous feature in many of the *Monticuliporæ* (Pl. IV. fig. 2*a*).

Tangential sections (Pl. IV. figs. 2*b* and 2*c*) show that the walls of the corallites are, near the surface, seemingly amalgamated, though the lines of demarcation between adjacent tubes still remain visible, and they are also considerably thickened in this region. An occasional small tube may be recognised here and there in such sections, but these are probably only young tubes, and certainly do not seem to belong to any special series of interstitial corallites.

Vertical sections (Pl. IV. fig. 2*d*) show that the corallites are slightly and regularly inclined to their surface of attachment, being at first thin-walled, but becoming thickened as they grow upwards. Tabulæ are either wanting, or are but occasionally developed, so far as I have seen. When present, they seem to be complete and approximately horizontal.

Both in its external features and its internal structure this species is so far distinct from any other form of the genus known to me as to require no detailed comparison with any allied type. In spite of its encrusting character and its general external resemblance to the colony of a Polyzoön, I have not detected in its internal structure any marked character by which it could be definitely separated from the genus *Monticulipora*. Its tabulæ appear to be very sparsely developed, or, possibly, to be sometimes altogether wanting in some instances; but it is very difficult to prepare completely satisfactory vertical sections of its corallum, and this may be due simply to imperfect observation. At any rate, it is not a character which would of itself separate the present form from *Monticulipora*, as a similar paucity of tabulæ occurs in types like *M. irregularis*, Ulrich, and *M. clavacoidea*, James.

Horizon and Locality.—Cincinnati Group, Cincinnati, Ohio.

CHAPTER IX.

Sub-genus Prasopora, Nich. and Eth. jun., 1877.

(Ann. Nat. Hist., ser. 4, vol. xx. p. 388.)

The name of *Prasopora* was originally proposed by Mr R. Etheridge, jun., and myself as a generic title for the reception of a small coral from the Craighead Limestone of Girvan. I have, however, now discovered that two other Monticuliporoids (*M. Selwynii*, Nich., and *M. Newberryi*, Nich.) have essentially similar characters to *P. Grayæ*, the original type of *Prasopora;* and I have therefore come to the conclusion that it is best to regard *Prasopora* as simply a well-marked subgenus of *Monticulipora*. The admission of the above-mentioned species to *Prasopora*, also, necessitates some slight changes in the diagnosis of the section, which will now include forms with the following characters: Corallum concavo-convex or discoid in form, sometimes free and with a concentrically striated basal epitheca, more rarely attached by its base to some foreign object. Corallites of two kinds; the smaller ones interspersed uniformly amongst the larger ones, or sometimes partially disseminated through the colony, and partially aggregated into clusters. Large corallites furnished with tabulæ of a twofold and peculiarly incomplete character, those of one series forming a succession of marginal lenticular vesicles, enclosing a central or lateral tubular space; while the tabulæ of the second series are in the form of remote horizontal plates, crossing the space included by the vesicular tabulæ. The small

corallites are angular, and are furnished with numerous complete, closely-set tabulæ. The large tubes are prismatic, or sometimes oval. Spiniform corallites are wanting, or are very sparingly developed (*e.g.*, in *Prasopora Selwynii*, Nich.) The walls are thin, apparently structureless, and seemingly amalgamated in adjoining tubes (though really not fused with one another). Type of the group, *Prasopora Grayæ*, Nich. and Eth. jun.

From those sections of *Monticulipora* which have been here distinguished under the names of *Heterotrypa*, *Diplotrypa*, and *Monotrypa*, the species of *Prasopora* are at once separated by the very peculiar nature of the tabulæ of the large tubes.[1] In this respect, *Prasopora* differs from all the Monticuliporoids except the small group which I have included in the succeeding section *Peronopora*. From the species of this last-named division, however, the *Prasoporæ* are distinguished by the thin and apparently structureless condition of the walls of the corallites, by the absence or limited development of spiniform corallites, and by the constantly semi-globose or discoid form of the corallum.

The characters of *Prasopora* will be more fully brought out in the descriptions of the following three species, comprising all the forms which I am able at present to refer to this section.

Monticulipora (Prasopora) Grayæ, Nich. and Eth. jun.

(Figs. 42 and 43.)

Prasopora Grayæ, Nich. and Eth. jun., Ann. Nat. Hist., ser. 4, vol. xx. p. 392, 1877; Monograph Sil. Foss. Girvan, vol. i. p. 48.

Spec. Char.—Corallum forming small hemispheric or concavo-convex masses, from half an inch to three-quarters of an inch in diameter, and from a quarter to half an inch in height.

[1] Owing to an unfortunate intermixture of some of my microscopic sections, I was formerly led to ascribe tabulæ of this peculiar type to *M.* (*Diplotrypa*) *Whiteavesii*, Nich.; but this species, as previously shown, has really the complete tabulæ which distinguish all the species of *Diplotrypa*.

Large corallites more or less markedly prismatic, their size being variable in different specimens, though tolerably uniform in any given example. They vary from 1-50th to about 1-80th inch in diameter, but they seem usually to be about 1-60th to 1-50th inch across. The small tubes are exceedingly variable in size and shape, but are always angular. The large tubes are furnished with the peculiar incomplete tabulæ which are characteristic of the group, while the small tubes have very closely-set complete and horizontal tabulæ. Walls of the tubes thin, structureless, and apparently fused. Corallum free, provided basally with a concentrically wrinkled epitheca.

Obs.—In general form and aspect (fig. 42), the corallum of *Prasopora Grayæ* closely resembles that of moderately young examples of *Monticulipora* (*Diplotrypa*) *petropolitana*, Pand., with which a merely external examination would almost certainly lead the observer to place it. This, therefore, affords another example of the uselessness of attempting to decide the true structure and position of any Monticuliporoid by an appeal to its form and general appearance. The corallum is conspicuously and very remarkably dimorphic, the large and small corallites being uniformly distributed throughout the entire colony, and being singularly different in internal structure. The structure of the large corallites is most easily recognised in longitudinal sections (fig. 43, B), in which each is seen to possess a central tube, occupying the axis of the visceral chamber, and entirely surrounded by a circumferential zone of peculiarly modified tabulæ. The central tube may be open throughout, but it is usually intersected, at remote intervals, by delicate horizontal tabulæ. Surrounding the central tube on all sides, and forming its walls, is a zone of tabulæ, which spring from the wall of the corallite, and are then bent downwards so as to become parallel to the long axis of the corallite, finally joining the next tabulæ below. There is thus formed a

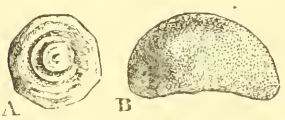

Fig. 42.—A, Under surface of a small specimen of *Prasopora Grayæ*, natural size, showing the epitheca; B, Side view of another, larger specimen, of the natural size.

series of large circumferential vesicles, the convexities of which are directed upwards and towards the centre of the corallite.

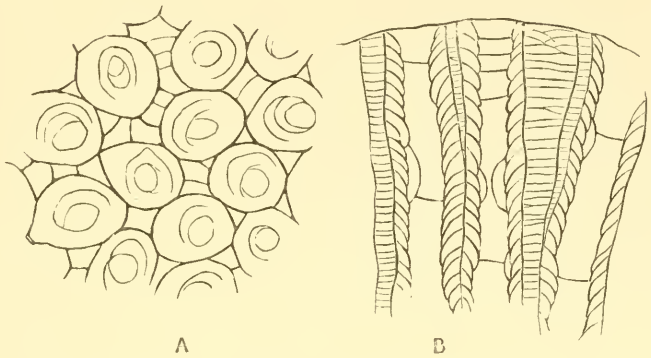

Fig. 43. — Minute structure of *Prasopora Grayæ*, Nich. and Eth. jun., from the Lower Silurian of Girvan, Ayrshire. A, Part of a tangential section, enlarged eighteen times, showing the two sets of corallites, and the singular perforated tabulæ of the large tubes; B, Part of a vertical section, similarly enlarged, showing the entirely different nature of the tabulation in the two sets of corallites respectively.

When the section does not pass accurately through the median plane of the corallites (as it very commonly does not), then it comes to intersect the exterior tabulate zone, and the cut edges of the vesicular tabulæ appear as transverse lines and simulate ordinary tabulæ; so that in most sections parts of the tubes exhibit one set of appearances, and parts show the other. When examined in tangential sections (fig. 43, A), the large corallites are seen to be hexagonal, prismatic, or sub-polygonal, and in the centre of each is a rounded or oval opening representing the transverse section of the central tube of the corallite. This opening is surrounded by a variable number of curved lines, which are tangents to the margin of the median aperture, or are concentric with it, or intersect one another. These lines are the cut edges of the vesicular tabulæ which form the exterior zone of the corallite; and when thus exhibited they closely resemble the similar lines produced by the transverse section of the central tube and the infundibuliform tabulæ in *Syringopora*.

The smaller corallites of the colony are seen in tangential sections (fig. 43, A) to be wedged in among the large tubes,

round which they are disposed in a single row. The circle thus formed is, however, rarely or never quite complete, and each of the large tubes usually comes into contact at different points with one, two, three, or even four of its neighbours. The small corallites are angular in shape, mostly oblong or trapezoidal, and are very variable in size, being always very much inferior in size to the larger corallites. Vertical sections (fig. 43, B) show also that their internal structure differs entirely from that of the large tubes, and resembles that of the smaller corallites among the *Monticuliporidæ* generally, the visceral chamber being simply crossed by crowded, complete, and horizontal tabulæ.

It is only necessary to compare *P. Grayæ* with *P. Newberryi*, Nich., and *P. Selwynii*, Nich., from both of which it is readily distinguished. From *P. Newberryi*, Nich., it is separated by the different form of the corallum (which is never leaf-like), by the resulting length of the corallites, and by the prismatic form of the large tubes, as well as by other structural features. From *P. Selwynii*, Nich., the present form is distinguished by the prismatic, not oval or circular, form of the large tubes, by the want of spiniform corallites, by the fact that the tabulæ of the large tubes are not *excentrically* incomplete, and by the fact that the small tubes are not aggregated into clusters.

Horizon and Locality.—Abundant in the "Craighead Limestone" (Lower Silurian), Girvan, Ayrshire.

Monticulipora (Prasopora) Selwynii, Nich.

(Figs. 44 and 45.)

Spec. Char.—Corallum (in the typical examples from the Trenton Limestone of Canada) of comparatively large size, varying from an inch and three-quarters up to three inches and a half in diameter, the height in either case being about an inch in the centre. In form the corallum is discoid, or

conical, with a flat base, the amount to which the margins are extended varying in different examples. The base may be flat or concave, and is covered with a concentrically striated epithecal plate, while the upper surface is covered with the calices.

As regards internal structure, the corallum is made up of two kinds of corallites, large and small. The large tubes are provided with perfectly distinct walls, and are oval or irregularly circular in shape, and from 1-50th to 1-60th inch in diameter. From their shape, they are only in contact at limited points, and the interspaces between them are filled with the small corallites, the amount and number of these being somewhat variable. The small tubes are angular or sub-angular in shape, with a diameter of 1-150th inch to 1-200th inch, and at intervals are collected into stellate groups or "maculæ." The tabulæ of the large tubes are of two kinds, being mostly convex, and so arranged as to form a series of convex vesicles on one side of the visceral chamber, whilst others run straight from the preceding to the opposite wall, or cross the tube directly from side to side. The tabulæ of the small corallites are complete and horizontal, and are very numerous and close-set.

Obs.—This species was formerly (Pal. Tab. Cor., p. 316) confounded by me with *M. Whiteavesii*, Nich., as I have explained in speaking of the latter form—an error which will appear not unnatural when it is remembered that the two species occur in the same formation and at the same locality, and have a general similarity to one another in their shape and mode of growth. *M. Selwynii*, however, so far as I can judge from the specimens which have been actually determined by microscopic examination, is, in its type-form, of much larger size than *M. Whiteavesii*, while the internal structure of the two is extremely different.

Tangential sections of *M. Selwynii* (fig. 44, B and C) show that the corallum is composed of two quite different sets of corallites, which are not only different in size, but also in

internal structure. The large corallites are, on the whole, rounded, with distinct walls, and invariably showing the

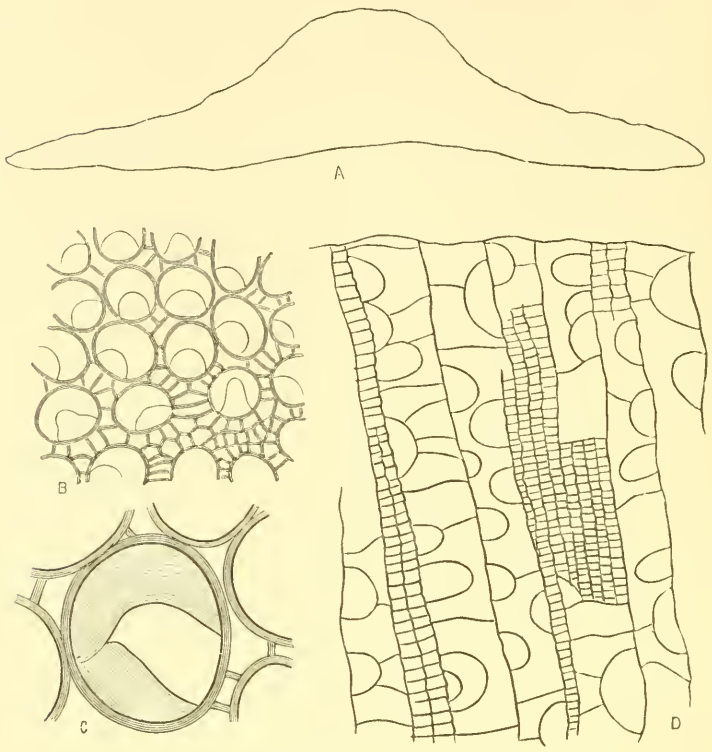

Fig. 44.—A, Outline of a large specimen of *Monticulipora Selwynii*, Nich., from the Trenton Limestone of Ontario, viewed in profile. B, Tangential section of the same, enlarged eighteen times, showing the two sets of corallites, and the incomplete tabulæ of the large tubes: one of the groups of small corallites is also shown in the section. C, A small portion of the preceding section, enlarged fifty times. D, Vertical section of the same, enlarged eighteen times, showing the peculiar double tabulation of the large tubes, and the close-set complete tabulæ of the small tubes. The section passes in part through one of the groups of small corallites.

peculiar feature that the visceral chamber is intersected by a crescentically incomplete tabula, the true structure of which is fully brought out in vertical sections. The small tubes fill all the interspaces between the large corallites, but vary very much in amount in different sections, being, however, always more or less angular in shape. In some specimens the number of the interstitial tubes is comparatively small, whereas in others there is a very extensive development of these intermediate corallites.

They also become much reduced in number in the deeper parts of tangential sections, when the large corallites become at the same time more markedly polygonal, and more entirely united by their walls. In any case, the small corallites are aggregated at intervals to form clusters or "maculæ," which have a star-shaped form, and branch out between the larger tubes.

Long sections (fig. 44, D) show a most remarkable structure as regards the tabulæ of the large corallites, these structures being of two distinct kinds in the same tube. The tabulæ of one kind form a series of large closed lenticular vesicles generally on one side only of the tube, and usually not actually in contact with one another. It is the cut edges of these singular curved tabulæ which give rise to the peculiar excentrically perforated plates seen in tangential sections of the large corallites. In addition to these, there exist in the large corallites perfectly straight horizontal tabulæ, which are never numerous, and which may pass completely from side to side of the tube, or may, more commonly, merely extend from the wall on one side to one of the convex closed tabulæ on the other side. The *small* corallites always have numerous complete and horizontal tabulæ.

The type-form of *M. Selwynii* occurs in the Trenton Limestone of Canada; but there is found in the Cincinnati formation of Ohio a form which possesses a very similar internal structure, and which I propose, in the meanwhile, to separate as a distinct variety, under the name of *M. Selwynii*, var. *hospitalis*, Nich. In its habit and size, and in some of the minor points of its organisation, this form differs considerably from the typical examples from the Trenton Limestone, which I have selected as the basis for the preceding specific diagnosis; but as it is clearly a very close ally of *M. Selwynii*, I prefer to regard it at present as nothing more than a strongly marked variety.

M. Selwynii, var. *hospitalis*, is invariably an attached form, all the numerous examples which I have seen being fixed to the exterior of the shells of Brachiopods. In form they are hemispheric, rarely nearly globular, and their general size is

from six to ten lines in diameter, and from three or four to seven or eight lines in height (fig. 45, A and B). Tangential sections (fig. 45, C) show a close correspondence in general structure with the type-form of *M. Selwynii*, from the Trenton Limestone. The corallum is composed of large and small

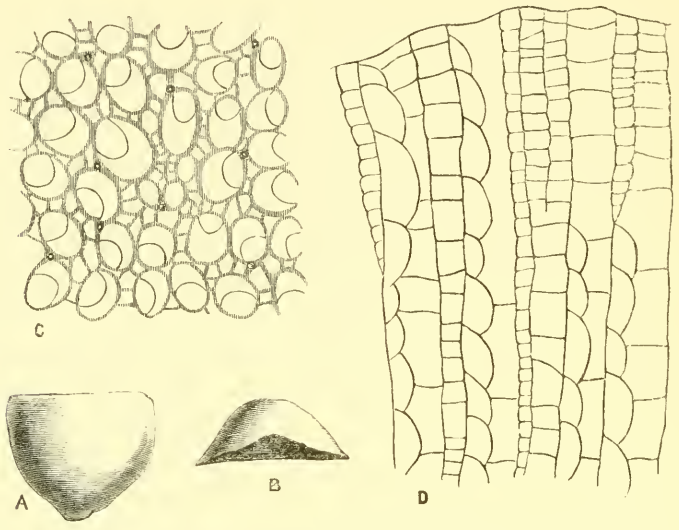

Fig. 45.—A, Upper view of a specimen of *Monticulipora Selwynii*, var. *hospitalis*, Nich., from the Cincinnati formation of Waynesville, Ohio, of the natural size: the corallum is attached by its base to the shell of *Strophomena nutans*, James. B, Side view of the same specimen, of the natural size. C, Tangential section of the same, enlarged eighteen times. D, Vertical section of the same, enlarged eighteen times.

corallites, the former being oval or circular in shape, and varying from 1-50th to 1-70th inch in diameter, each showing an excentrically perforated tabula. The small corallites are numerous, sub-angular, and wedged in between all the larger tubes, occasionally being aggregated into star-shaped groups or "maculæ." Besides the normal two kinds of corallites, a considerable number of thick-walled hollow spines ("spiniform corallites") may be observed, which I have not detected as present in the examples from the Trenton Limestone.

Vertical sections (fig. 45, D) show the same marked difference in the tabulation of the large and small corallites as has been previously noticed in the type-form, with some differ-

ences. The large tubes are always doubly tabulate, one set of tabulæ forming a series of large lenticular vesicles, the convex sides of which are directed inwards towards the centre of the visceral chambers, while the remaining tabulæ are horizontal and remote, and extend from the lateral wall of the corallite to the inner margin of the above-mentioned vesicles. In some of the tubes we may occasionally notice the convex tabulæ to form isolated vesicles, as they usually do in the specimens from the Trenton Limestone; but they are more commonly so apposed to one another as to form vertical rows of lenticular cells, the inner margins of which unite so as to constitute an apparent median septum to the corallite. The small corallites are uniformly furnished with numerous complete, horizontal tabulæ. Upon the whole, I have little doubt that the specimens now described from the Cincinnati Group of Ohio are not specifically separable from the true *M. Selwynii* of the Trenton Limestone.

In form and general aspect, *M. Selwynii* closely resembles such types as *M. petropolitana*, Pand., or *M. Whitcavesii*, Nich. In its internal structure, however, it is clearly allied to quite another group of types—namely, to such forms as *M. Cincinnatiensis*, James, *M. frondosa*, D'Orb., *M. Newberryi*, Nich., and *M. molesta*, Nich., all of which agree with *Prasopora Grayæ*, Nich. and Eth. jun., in the possession of a peculiarly modified structure of the tabulæ of the larger corallites. In fact, *M. Selwynii* is more nearly allied to *Prasopora Grayæ*, Nich. and Eth. jun., than to any other type known to me, and it must be regarded as a member of the sub-genus *Prasopora*, as I have previously defined it. In its purely specific characters, however, it is so far distinct that it requires no close comparison with any other form with which I am acquainted.

Horizon and Locality.—In the Trenton Limestone of Peterboro', Ontario (the type-form). In the Cincinnati Formation of Waynesville, Ohio (var. *hospitalis*).

Monticulipora (Prasopora) Newberryi, Nicholson.

(Pl. IV. figs. 1-1*c*.)

Chætetes Newberryi, Nicholson, Palæontology of Ohio, vol. ii. p. 212, Pl. XXII. figs. 4, 4*a*, 1875.

Spec. Char.—Corallum forming thin, sub-circular or semi-circular expansions, which may be from ten lines to an inch or more in diameter, and have a thickness of about 1-40th inch. Judging from thin sections, the corallum does not seem to have been parasitic, but to have possessed a thin basal epitheca. Surface exhibiting groups of corallites which are slightly larger than the normal tubes, but which do not form distinctly raised tubercles. Calices thin-walled and polygonal, often apparently without small interstitial apertures, though these can be occasionally detected, and must be generally present. Average diameter of the ordinary corallites about 1-70th inch or rather more. As seen in sections, the large corallites are oval, only touching each other at limited points, and having the interspaces between them filled up by numerous smaller and irregularly shaped interstitial corallites. The large corallites possess imperfect tabulæ, which form a series of convex vesicles on one side of the tube, the other side being open and non-tabulate. Small interstitial corallites with numerous close-set straight tabulæ.

Obs.—My original diagnosis of this species was founded only upon its external characters, and was principally erroneous in the fact that I had not detected any interstitial tubuli—an error which may be excused, since large parts of the surface, when examined with a lens or with the microscope, really do not show any openings of the smaller corallites. In fact, when thus examined, the surface (Pl. IV. fig. 1*b*) is principally noticeable for the polygonal form, the thin walls, and the seemingly close contact of the calices. Nevertheless, thin sections prove conclusively that interstitial tubes are abundantly present; and the most probable explanation of this apparent discrepancy

between the results of external and internal observation may be that the apertures of the small tubes on the surface are in general concealed by their overgrowth with a calcareous membrane. A few, however, of the minute openings of the interstitial tubes, may usually be detected in one part or another of the surface of the corallum by a sufficiently careful search with a one-inch objective.

From the great thinness of the expanded corallum, it would naturally be supposed that the colony was parasitic upon foreign bodies; and none of my specimens would disprove this supposition, as in all the upper surface alone is shown, and the under surface is buried in the matrix. Thin vertical sections, however, so far as I have seen, do not show any foreign body beneath the thin crust of corallites, but show that the under surface is covered with a thin epithecal membrane.

The general form and surface-characters of this species are quite peculiar; but the internal structure is even more distinctive. Tangential sections (Pl. IV. figs. 1 *c* and *d*) show that the corallum is composed of two distinct sets of tubes, which differ not only in size, but, very markedly, in their internal structure. The larger tubes, instead of showing the polygonal form which they have at the actual surface, are oval in shape, and are therefore only in contact at very limited points of their circumference. They possess thin but quite well defined walls, and their tabulæ are imperfect, appearing (in sections of this kind) as if perforated by crescentic apertures on one side. The interspaces left between the large tubes are occupied by a series of small corallites, which never completely isolate any single large corallite, and of which no more than a single row is ever present between any given pair of the large tubes. These small corallites are very variable in size, and are angular in their shape. In vertical sections (Pl. IV. fig. 1*e*), the differences between these two sets of tubes are very clearly marked, quite apart from the difference in size. The large corallites are now seen to be furnished with purely unilateral tabulæ, which are convex, with their convexities turned towards

the centre of the visceral chamber, and which form a row of lenticular vesicles on one side of the tube. The other side of the tube is entirely free and open, and is not crossed by any horizontal tabulæ. On the other hand, the small tubes are furnished with numerous, close-set, complete, and horizontal tabulæ.

The species to which *M. Newberryi* most nearly approaches in internal structure is *M. Selwynii*, Nich. The form of the corallum in the two species is, however, entirely different, and there are important structural differences as well. Thus, in *M. Selwynii* the imperfect vesicular tabulæ of the large corallites are supplemented by a smaller number of horizontal tabulæ, which cross the opposite side of the tubes; while the small corallites are aggregated at particular points into star-shaped maculæ.

Horizon and Locality.—Rare in the Cincinnati Group, Cincinnati, Ohio. (Coll. U. P. James.)

CHAPTER X.

Sub-genus PERONOPORA, Nich., 1881.

I PROPOSE the sub-generic name of *Peronopora* for a peculiar group of Monticuliporoids in which the corallum is either laminar or encrusting. Two distinct sets of corallites are present, distinguished by their size and internal structure. The large corallites are furnished with incomplete tabulæ of the type of those found in the corresponding tubes of *Prasopora*—that is to say, the tabulæ form a series of lenticular vesicles on one side of each large corallite, these vesicles limiting an excentric lateral tube, which is crossed by a few complete horizontal plates. The small corallites are numerous, interspersed among the larger ones, sometimes partially aggregated into clusters, their tabulæ being always numerous, close-set, horizontal, and complete. Spiniform corallites are usually largely developed, though occasionally apparently wanting (*e.g.*, in *M. molesta*, Nich.) The walls of the corallites are thickened and seemingly fused together in adjoining tubes, their primitively duplex character being entirely lost. Type of the group, *M. frondosa*, D'Orb. (=*M. decipiens*, Rom.)

The species of this section are distinguished from those of all the other groups of *Monticulipora*, except *Prasopora*, by the peculiar structure of the tabulæ of the large tubes. From *Prasopora* they are separated principally by the different form and mode of growth of the corallum, by the amalgamation of the walls of the tubes and their thickened character in

the vicinity of the surface, as well as, generally, by the abundance of their spiniform corallites.

I propose to include under the head of *Peronopora* the following species of *Monticulipora*—viz., *M. frondosa*, D'Orb. (=*M. decipiens*, Rom.), *M. Cincinnatiensis*, James, *M. molesta*, Nich., and *M.? Ortoni*, Nich., the last being an aberrant and ill-understood form; and I subjoin descriptions of these as illustrating the structure of this peculiar group.

Monticulipora (Peronopora) frondosa, D'Orbigny.

(Figs. 46, 47, and Pl. V. figs. 4, 4*a*, and 5, 5*a*.)

Monticulipora frondosa, D'Orbigny, Prodr. de Paléont., vol. i. p. 25, 1850.
Chætetes frondosus, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 267, Pl. XIX. figs. 5, 5*a*, 1851.
Chætetes decipiens, Rominger, Proc. Acad. Nat. Sci. Phil., p. 116, 1866.
Chætetes frondosus, Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 508, Pl. XXX. figs. 2-2*b*, 1874; Pal. Ohio, vol. ii. p. 208, Pl. XXII. figs. 1-1*b*, 1875; Ann. Nat. Hist., ser. 4, vol. xviii. p. 91, figs. 11, 11*a*, 1876.

Spec. Char.—Corallum composed of erect, flattened, undulating expansions, of unknown but often considerable height, varying in thickness from less than one line to about four lines. Surface covered at short intervals with numerous rounded or stellate spaces which are often elevated to form low but quite distinct monticules, while at other times they are level with the general surface, and which are occupied, wholly or mainly, by small tubuli, such as separate the ordinary calices. The larger calices are moderately thick-walled, irregularly circular or oval in shape, and about 1-100th inch in diameter on an average. They are surrounded by a variable, but always large, number of smaller irregularly shaped corallites, which occupy all the intervals between the preceding, and sometimes almost surround them. In addition to these there exist very many minute, circular, thick-walled tubuli ("spiniform corallites"), which appear on the margins of the ordinary calices as very minute circular apertures or as apparently closed tubercles.

The corallites spring from both sides of a median plane, which divides the corallum into two flat laminæ, and which is sometimes marked by a thin calcareous membrane (probably not a definite structure). The corallites are at first oblique and thin-walled; but they almost immediately bend outwards, and proceed straight to the surface, their walls becoming at the same time moderately thickened. The larger and smaller corallites of the colony exhibit a totally different form of tabulation. The large tubes possess, in part or throughout their entire length, peculiar incomplete tabulæ, which form a series of overlapping lenticular vesicles on one side of the visceral chamber, and which may or may not be connected with the opposite wall of the tube by a few straight and horizontal plates. On the other hand, the interstitial corallites are furnished with numerous, close-set, horizontal, and complete tabulæ.

Obs.—In its general conformation and mode of growth this species resembles normal examples of *M. mammulata*, D'Orb., and *M. molesta*, Nich. That is to say, it forms flattened, irregularly undulating fronds, the size and thickness of which vary with age, and which are composed of two strata of corallites, the apertures of which are placed on the opposing flat faces of the corallum, while they spring at their bases from the opposite sides of a median plane. This plane, in thin sections taken at right angles to the flat faces of the corallum, is marked by a delicate line representing, apparently, the cut edge of a mesial calcareous lamina (fig. 46, D). As, however, the corallum shows no tendency to split along this line, and as neither of the apposed strata of corallites can be stripped off separately, it appears doubtful if this lamina is a definite structure, and it seems more probable that it is simply formed by the union of the bases of the two sets of tubes.

The surface-characters of the species vary considerably. All alike show the large openings of the larger corallites surrounded by numerous intercalated small corallites, and all alike show rounded or somewhat stellate spaces, which are occupied

by small tubes, either alone or with a few tubes of larger size mixed with them. Different specimens, however, vary con-

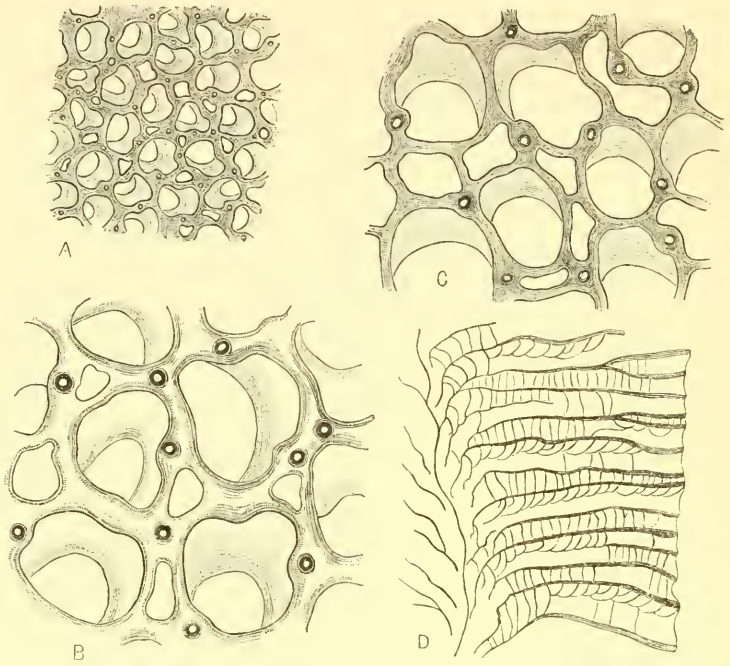

Fig. 46.—The minute structure of *Monticulipora frondosa*, D'Orb. A, Part of a tangential section, enlarged eighteen times; B, Part of the same section, enlarged fifty times, showing the large tubes with their singular incomplete tabulæ, the smaller intercalated tubes, and the numerous spiniform corallites; C, Part of another tangential section, taken at a deeper level than the preceding; D, Part of a vertical section, at right angles to the flat surfaces of the corallum, showing the peculiar form of the tabulæ in the large corallites, enlarged eighteen times. From the Cincinnati Group of Ohio.

siderably as to the extent to which these clusters of small tubes are elevated above the general surface. Sometimes, especially in young examples, they may not be perceptibly elevated at all; but more commonly (Pl. V. fig. 5), they are so far raised as to constitute low rounded "monticules." In no case, however, are the monticules so conspicuous as they are in *M. molesta*, Nich., *M. Dawsoni*, Nich., and most examples of *M. mammulata*, D'Orb.

As regards its internal structure, *M. frondosa*, D'Orb., exhibits features of a very remarkable character. In tangential sections which are taken just below the surface (fig. 46, A and

B), the ordinary corallites are seen to be of two kinds, large and small. The large corallites are irregularly oval or circular, the irregularity of the outline of the visceral chamber being due to the projection into it of from one to three "spiniform tubes," which cause an inward deflection of the wall at the point where they occur. Each large corallite, also, exhibits in its interior a delicate horizontal calcareous lamina, which exhibits a larger or smaller semicircular deficiency on one side. This excentrically perforated lamina represents the singularly incomplete vesicular tabulæ of the large corallites, as seen when transversely divided. Tangential sections, further, exhibit a variable number of smaller corallites, which occupy the intervals between the larger tubes, and are very variable in shape and size, their numbers also varying in different parts of the same specimen, or in different specimens, but which do not show the incomplete tabulæ of the large tubes. We can also readily detect in such sections the stellate groups of small corallites; and these are seen to consist of a larger or smaller collection of the interstitial corallites, with occasionally a few of the large tubes intermingled with them. One of the most conspicuous features in tangential sections, however, is the presence of a great number of thick-walled, darkly-outlined tubuli, of circular shape and very minute size, each presenting a definite central hollow or lumen, and often causing by their presence an inward projection of the walls of the large corallites.

These "spiniform corallites" vary in number in different specimens, but they are always present; and by microscopic examination they can usually be readily detected at the surface, appearing either as very minute, circular, thick-walled apertures, or as blunt and rounded tubercles which show no apparent opening. Lastly, tangential sections show that the walls of the corallites in this region are apparently fused with one another, no traces of the original lines of demarcation between adjoining tubes being recognisable.

Tangential sections taken at a rather deeper level below

the surface than the preceding (fig. 46, c) show essentially the same appearances as have been described above, but the walls of the large corallites now appear to be reduced in thickness, and there is a corresponding increase in the size of the smaller interstitial corallites.

Vertical sections (fig. 46, d) show, as their most important feature, the very different tabulation of the large and small corallites respectively. In the large corallites we find the same type of incomplete tabulæ as characterises *M. Cincinnatiensis*, James, *M. Selwynii*, Nich., and other species. That is to say, the tabulæ are bent downwards to form a series of overlapping lenticular vesicles on one side of the visceral chamber, these vesicles (as shown in tangential sections) terminating on the side turned to the axis of the tube, by a concave excavated border. The remainder of the visceral chamber is either free from tabulæ, or is crossed by a few remote horizontal plates, which pass from the line of vesicles on one side to the opposite wall of the corallite on the other side. The small interstitial tubes of the corallum are furnished, on the contrary, with very numerous, complete, and horizontal tabulæ.

I have never seen a complete example of this species in its adult state, though fragments three or four inches in length and three or four lines in thickness are not uncommon. Young and seemingly nearly complete examples (Pl. V. fig. 4) may be little over an inch in width or height, and only about a line in thickness. These immature examples are generally smoother superficially than large specimens, and differ in some other trivial particulars; but I have figured (Pl. V. fig. 4*a*) a tangential section of one of them to show that in internal structure they are essentially identical.

It only remains to consider—and the point is one of unusual difficulty—whether this form really is the *M. frondosa* of D'Orbigny or not; and on this head I regret to find myself at variance with some excellent observers, for whose opinions I entertain the highest respect. *Monticulipora frondosa*, D'Orbigny, was originally described (Prodr. de Paléont., vol. i. p. 25) with

the following definition: "Espèce a larges frondes dont les monticules sont coniques et très-espacés." Now it is evident, to begin with, that this definition is absolutely worthless, and might apply to any one of three or four quite different frondescent species of *Monticulipora*. Indeed I know of *no* frondescent form of the genus in which the monticules could, with any special propriety, be described as "très-espacés;" so that almost the only positive character mentioned by D'Orbigny is thus rendered useless in the present inquiry.

Milne-Edwards and Haime, in their great work on the Palæozoic Corals, figure *M. frondosa*, D'Orb., and give the following description of its characters:—

"Polypier en larges frondes, épaisses de quelques millimètres; mamelons arrondis, peu saillants, subradiés, larges d'un millimètre et demi, et distant d'une fois et demi, rarement deux fois leur largeur, présentant à leur sommet les plus grands calices: ceux-ci ont un tiers de millimètre, et les plus petits un cinquième."

It will be observed that in the above description Milne-Edwards and Haime describe the monticules as rounded, somewhat stellate, and slightly prominent, whereas D'Orbigny describes them as conical; and the distances which they give as separating the monticules (variable as this character always is) would certainly not justify us in applying the term "très-espacés" to these structures. Now, a perusal of the above definition by Milne-Edwards and Haime will at once show that it is not sufficient for anything like a satisfactory determination of the true characters of *M. frondosa*, D'Orb. We do not know that these accurate and painstaking observers actually had D'Orbigny's specimens under their examination; and, in any case, their description, as was inevitable at the time it was written, embraces purely external characters, and is therefore necessarily vague and unsatisfactory.

Under these circumstances, the really wisest plan, perhaps, would be to abandon the name of *M. frondosa* altogether in the meanwhile, until D'Orbigny's original specimens can be

subjected to microscopical examination, and to apply to the present species the name of *M. decipiens*, Rominger; since it was certainly this form which Dr Rominger described under the above title. My only reason for not following this course, and for retaining the name of *M. frondosa* for the form now under consideration, is that my specimens of this present such a close resemblance to the figures of *M. frondosa*, D'Orb., given by Edwards and Haime, that I can hardly believe that they are not in reality identical. It is true that Milne-Edwards and Haime distinctly state that the monticules in the form which they call *M. frondosa* are occupied by corallites larger than the average, whereas in the present form they are made up of corallites smaller than the normal. But the figures given in the "Polypiers fossiles" do not show this alleged feature, and I am not acquainted with *any* frondescent species of *Monticulipora* from the Cincinnati Group of which it can be truly said that the corallites of the monticules are larger than the average size, to any extent, at any rate, at all comparable with the difference stated to exist by Edwards and Haime. We must either believe, therefore, that this observation of the writers just mentioned was founded on a misapprehension, or we must suppose that their *M. frondosa* has not been subsequently recognised by any who have examined the *Monticuliporæ* of the Cincinnati formation.

Upon the whole, therefore, and with the above-mentioned reservations, I prefer in the meanwhile to retain for the present species the name of *M. frondosa*, D'Orb. At the same time, I fully recognise the worthlessness of D'Orbigny's original definition for purposes of identification, and the impossibility of entirely reconciling the description given by Milne-Edwards and Haime with the characters either of this or of any other frondescent species of the genus with which I am acquainted. I also fully recognise that the *M. decipiens* of Rominger is undoubtedly identical with the form now under consideration. That this is the case will be sufficiently evident from an examination of the annexed sections (fig. 47) of a typical example

of *M. decipiens*, Rominger, without any necessity for my entering into a detailed verbal comparison. The only point worthy

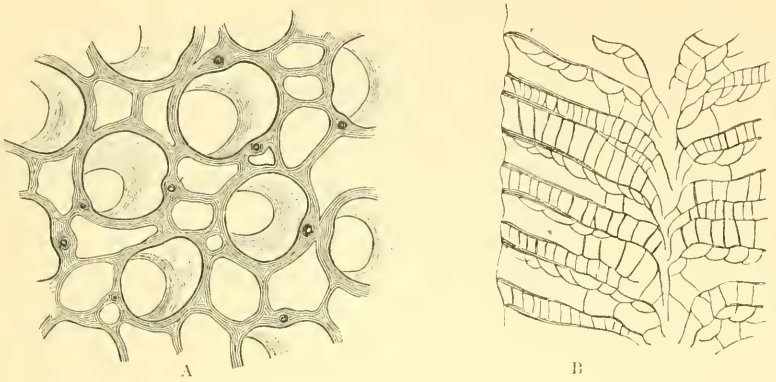

Fig. 47.—Minute structure of *Monticulipora decipiens*, Rominger, from the Cincinnati Group of Ohio. A, Tangential section, enlarged fifty times; B, Vertical section, enlarged eighteen times.

of notice in this connection is that Rominger himself recognises (Proc. Acad. Nat. Sci. Phil., 1866, p. 116) the similarity of his *M. decipiens* to *M. frondosa*, D'Orb., and merely says that it is "more delicate in all respects," and that its "inter-tubular tissue" is less developed. The "delicacy" of the specimen examined is, however, largely a matter of age, while I know of no frondescent species of *Monticulipora* in which the "inter-tubular tissue" is as largely developed as it is in typical examples of *M. decipiens*, Rom. If, however, the name of *M. frondosa*, D'Orb., should be ultimately abandoned, as given to a form which cannot now be precisely determined, then it is certain that the present species must stand under the title of *M. decipiens*.

The form now under consideration is nearly allied to *M. mammulata*, D'Orb., in its general conformation; and, when its monticules are well developed, is with difficulty distinguished from it by a merely superficial examination. It differs, however, wholly from this, as from all other species of the genus, in its minute structure, and therefore needs no detailed comparison with any other form.

Horizon and Locality.—Cincinnati Group, Cincinnati, Ohio. (Common.)

Monticulipora (Peronopora) molesta, Nich.

(Pl. VI. figs. 2-2*d*.)

Spec. Char.—Corallum usually frondescent, having the form of extended and undulated, sometimes lobed or palmate, expansions, which may attain a considerable size, and vary in thickness from two to four or five lines. Rarely, the corallum is massive. Surface covered with numerous prominent, conical, or slightly elongated monticules, placed at distances of half a line to a line apart, and composed of corallites which do not differ conspicuously in size from those forming the mass of the corallum. Calices polygonal, thin-walled, sub-equal, from 1-85th to 1-90th inch in diameter, with a few smaller interstitial apertures scattered amongst them. Corallites of two kinds, large and small. The large corallites are much the most numerous, are thin-walled and polygonal, and are furnished for the most part with incomplete tabulæ. In these tubes the tabulæ form a series of lenticular vesicles along one side of the visceral chamber, and a moderate number of straight or slightly concave tabulæ extend from these to the opposite side of the cavity of the corallite. The small corallites are comparatively few in number, are angular in shape and variable in size, and are crossed by numerous, complete, horizontal tabulæ.

Obs.—In its general form and mode of growth, as well as in almost all its superficial characters, this species precisely resembles *M. mammulata*, D'Orb., and without the preparation of thin sections it is often quite impossible to definitely determine to which of the two types a given specimen may belong. Almost the only superficial character that is of any use in this connection is the comparative paucity of the small interstitial corallites in this form (Pl. VI. fig. 2*a*), as compared with what we find in *M. mammulata*. The monticules also are more uni-

formly of a pronounced and markedly elevated character than is the case in all specimens of the latter. The normal mode of growth in *M. molesta* is certainly that of an expanded frond, composed of two strata of corallites, which diverge in opposite directions from an imaginary mesial plane to open on the two flat surfaces of the expansion (Pl. VI. fig. 2). As in the case of *M. mammulata*, the central line of the corallum is not marked by any even imperfectly developed calcareous lamina, such as exists in *M. frondosa*, D'Orb., and *M. pavonia*, D'Orb. Though usually frondescent, I possess one large massive and lobate specimen (four inches in length, three inches in width, and two and a half inches in height) which is proved by microscopic examination to be unquestionably identical with the more ordinary examples of the species.

As regards its internal structure, tangential sections (Pl. VI. figs. 2*b*, 2*c*) show that the large corallites of the colony are polygonal and thin-walled, the lines of demarcation between adjoining tubes not being persistent, and the walls (in all the slides I have examined) exhibiting a peculiar granular appearance. The visceral chamber of each of the large corallites is also crossed by a delicate lamina, which is deeply excavated on one side in a crescentic or triangular manner, and the presence of which is due to the intersection of the peculiar vesicular tabulæ on one side of the tube. Interspersed among the large corallites, but never in large numbers, are smaller angular interstitial corallites, which are recognisable not only by their dimensions, but also by wanting the peculiar excentrically perforated tabulæ of the large tubes.

Vertical sections (Pl. VI. fig. 2*d*) show that the walls of all the corallites are thin, and that there is a conspicuous difference in the tabulation of the large and small tubes respectively. The small corallites are uniformly provided with numerous, close-set, complete, and horizontal tabulæ. On the other hand, the large corallites possess the same singular incomplete tabulæ as are seen in such forms as *M. Selwynii*, Nich., *M. Cincinnatiensis*, James, *M. Newberryi*, Nich., &c. That is to

say, the tabulæ are twofold, those on one side of the tube forming a longitudinal series of lenticular vesicles, while those on the other side run from these vesicles to the opposite wall, and are either straight or slightly concave. Occasionally, one of the large corallites shows only complete tabulæ, but this is probably due to its being intersected on one side.

Good observers regard this as the real type of the *M. mammulata* of D'Orbigny; and its superficial characters, undoubtedly, would justify such a reference, as they agree very well with the description given by Milne-Edwards and Haime. For reasons previously stated, however, superficial characters alone will not settle this point, and I have preferred to regard another externally similar species as the type of *M. mammulata;* though I quite admit that the present form might be selected in its place with perfect propriety. From the form which I have called *M. mammulata*, D'Orb., the present species is entirely separated by its minute structure, and, especially, by the smaller number of the interstitial corallites, the absence of "spiniform corallites," the greater thinness of the walls, and the presence of incomplete tabulæ in the large corallites.

Horizon and Locality.—Common in the Cincinnati Group, Cincinnati, Ohio.

Monticulipora (Peronopora) Cincinnatiensis, James.

(Pl. II. figs. 6-6*c*.)

Chætetes Cincinnatiensis, James, Cat. Sil. Foss., 1875, p. 2.

Spec. Char.—Corallum encrusting, forming a layer of a line or less in thickness, attached by the whole of the under surface to foreign objects. External surface covered with numerous bluntly conical and very prominent monticules, the bases of which are close together. Calices sub-polygonal, thick-walled, with a moderate number of interstitial tubes in the intervals between them. Corallites of two kinds, the larger ones generally oval or circular, about 1-90th inch in diameter, the smaller

ones very variable in shape, but always of minute dimensions and more or less angular form. The small corallites are furnished with numerous complete and horizontal tabulæ. The large corallites, though sometimes furnished with similarly horizontal and complete tabulæ, are mostly provided throughout part or the whole of their course with incomplete curved tabulæ, which form a series of vesicles on one side of the tube, the remainder of the visceral chamber being occupied by simple transverse partitions.

Obs.—In the general aspect of its surface, this species is not unlike the type-form of *M. ramosa*, D'Orb., of which it might be taken to be a variety. It is, however, distinguished from this, apart from its encrusting habit, by the more pronounced character and greater prominence of its monticules (Pl. II. fig. 6), the smaller number of the interstitial tubes (Pl. II. fig. 6*a*), and its entirely different internal structure.

Tangential sections (Pl. II. fig. 6*b*) show that the corallum is composed of two sets of corallites of different sizes and entirely different structure. The large corallites are oval or sub-polygonal in shape, with only moderately thickened walls, each exhibiting in its centre, or on one side, a perforation due to its possession of the same peculiar incomplete tabulæ as exist in *M. frondosa*, D'Orb., *M. Newberryi*, Nich., and *M. Selwynii*, Nich. All the intervals between the large corallites are filled in with the small angular or sub-angular tubes. No "spiniform corallites" appear to exist.

Vertical sections (Pl. II. fig. 6*c*) bring out, even more clearly, the distinctions between the large and small corallites. The large tubes are only slightly thickened as they approach the surface, and some of them seem to possess only horizontal tabulæ, placed at moderate distances. Most of them, however, possess tabulæ of the same peculiar double type as is seen in the species above alluded to. One side of the visceral chamber, namely, is occupied by a series of strongly curved tabulæ, which have their convexities directed towards the centre of the corallite, and are so apposed as to give rise to

a longitudinal series of lenticular vesicles on one side of the tube. These vesicular tabulæ terminate inwards by a concave margin, and it is their cut edges which give rise to the peculiar appearances presented in tangential sections. The remainder of the corallite is occupied by a few straight tabulæ, which extend from the inner side of the lenticular vesicles above mentioned to the opposite wall of the tube. The small tubes, on the other hand, are crossed by numerous, close-set, horizontal, and complete tabulæ.

The external and internal characters of this species are so distinctive as to render a close comparison with other forms unnecessary. I am much indebted to Mr John M. Nickles of Cincinnati for kindly furnishing me with specimens.

Horizon and Locality.—Cincinnati Group, Cincinnati, Ohio.

Monticulipora (Peronopora) (?) Ortoni, Nich.

(Pl. III. figs. 4-4*d*.)

Chætetes Ortoni, Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 513, Pl. XXIX. figs. 15-15*b*, 1874; Pal. Ohio, vol. ii. p. 211, Pl. XXII. figs. 3-3*b*, 1875.
Atactopora Ortoni, Ulrich, Cat. Foss. Cincinnati Group, p. 13, 1880.

Spec. Char.—Corallum forming excessively thin sub-circular crusts, which are attached parasitically by the whole of their under surface to foreign bodies, and vary in thickness from 1-90th to 1-50th inch, the breadth of the entire expansion being usually under one inch. Surface exhibiting numerous minute rounded or conical monticules placed at intervals apart of half a line, less or more. Apertures of the calices about 1-125th inch in length along their longest diameter, usually irregular in shape, and often indented by one or more tooth-like and blunt projections into the visceral chamber. Margins of the calices very thick, studded with numerous blunt and rounded tubercles, which give to the surface a peculiar granular aspect. In the centre of the expansion the corallites are often nearly

vertical to the surface of attachment, but as the margins are approached they become more reclined, and open by oblique apertures on the surface. The ordinary corallites have the same irregularly indented outline as is shown by the calices, and are generally from 1-125th to 1-120th inch in diameter. Interspersed with these are very numerous thick-walled circular tubules, the upper extremities of which appear on the surface as the tubercles or spines previously alluded to; while it is by their inward projection into the visceral chambers of the large corallites that the tooth-like indentations of the latter are produced. The tabulæ are mostly complete, concave, or horizontal, and are fairly numerous; while incomplete crescentic tabulæ (of the type of those of *M. frondosa*, D'Orb., &c.) appear to be commonly developed close to the mouths of the calices.

Obs.—Owing to the extreme tenuity and fragility of the skeleton of this very peculiar form, it is exceptionally difficult to prepare satisfactory sections showing its minute structure. I have, however, succeeded in making both tangential and vertical sections which enable a fair idea of its most important structural features to be acquired, though there are still various points which I have been unable to clear up, and it will be needful to make further preparations before it will be possible to entirely work out its characters.

Tangential sections (Pl. III. fig. 4*b*) are in many respects very like similar sections of *M. frondosa*, D'Orb. The corallites are irregularly oval or circular in shape, the irregularity being due to the fact that the visceral chambers are encroached upon by blunt tooth-like inward projections, due to the existence in the thick walls of numerous thick-walled circular tubuli ("spiniform corallites"). These tubuli, as seen in section, have dense dark borders surrounding a central clear spot, and the blunt tubercles surrounding the margins of the calices are unquestionably their upper extremities. Many of the corallites, though not all, show an excentrically perforated lamina, partially extending across the visceral chamber, and appa-

rently quite similar to the incomplete tabulæ of forms like *M. frondosa*, D'Orb., *M. Newberryi*, Nich., &c. I have not, however, succeeded in detecting any traces of these incomplete tabulæ in vertical sections, and the above interpretation is therefore rendered uncertain.

Tangential sections which pass at a little distance below the surface, and which (owing to the curved surface on which the corallum grows) cut the corallites obliquely, show the corallites to be intersected with numerous complete tabulæ (Pl. III. fig. 4*d*).

Vertical sections (Pl. III. fig. 4*c*), if passing through the central part of the expansion, show the short corallites to be approximately vertical, and to be intersected by many horizontal and complete tabulæ. As before said, I have not been able in the few sections which I have prepared to find any incomplete tabulæ, though tangential sections would lead to the belief that such must exist in, at any rate, some of the tubes.

As regards the affinities of this remarkable form, Mr E. O. Ulrich refers it (Journ. Cincinnati Soc. Nat. Hist., 1879) to a new genus, which he regards as referable to the Polyzoa, and which he names *Atactopora*. This genus is defined as sometimes encrusting, sometimes ramose, composed of imperforate tubes, the walls of which are supplied with pseudo-septa, which may or may not be visible at the surface, and which are never more than five or six in a single tube. Tabulæ, if present, are said to be complete, interstitial tubuli are "rather sparingly developed," and monticules are usually present. With most of the types which Mr Ulrich refers to *Atactopora* I have no acquaintance; but so far as *Monticulipora* (?) *Ortoni* is concerned, I am unable to discover one of the most important of the diagnostic marks above enumerated as characteristic of the genus. I cannot, namely, recognise the "pseudo-septa," which are stated to exist in the genus *Atactopora*. It is true that the calices and visceral chambers of the corallites are commonly indented by blunt inward projections; but these are not what I should call "pseudo-septa." On the contrary, they

are shown in tangential sections to be due to bendings of the *wall* of the corallite, caused by the presence of the "spiniform corallites" between adjacent tubes. Precisely similar irregularities of the walls of the corallites are caused, in a similar manner, in such *Monticuliporæ* as *M. implicata*, Ulrich, and *M. frondosa*, D'Orb. (=*M. decipiens*, Rominger).

In the meanwhile, I think it is perhaps safest to provisionally refer the present form to the genus *Monticulipora*, though it certainly exhibits peculiarities which may ultimately lead to its separation from the more normal types of this genus. At any rate, I should not think it advisable to remove it from *Monticulipora* proper without at the same time removing elsewhere such forms as *M. frondosa*, D'Orb., and *M. implicata*, Ulrich, with which it shows a remarkable relationship in internal structure, at the same time that its external form is very different.

Horzion and Locality.—Common in the Cincinnati Group, Cincinnati, Ohio. All the specimens I have seen are attached to the valves of *Strophomena alternata*, Conrad; and I believe this to be its almost invariable habitat.

APPENDIX.

I PROPOSE here to give a very brief account of two groups of Monticuliporoids which have been described by Dr Dybowski (Die Chætetiden, 1877), under the names of *Trematopora*, Hall, and *Dittopora*, Dyb. Not having access to any specimens which I could refer to either of these groups, I am able to do little more than to reproduce the essential features of Dybowski's descriptions, and to append two or three illustrations in elucidation of these.

Trematopora, Hall (Dybowski).

Under the name of *Trematopora*, Hall, Dybowski describes a number of Monticuliporoids, to which he assigns the following characters: The corallum is polymorphic; the corallites thick-walled, cylindrical, in cross-section elliptical. The thick-walled elliptical calices project slightly above the general level of the "cœnenchyma." The "cœnenchyma" appears superficially to be compact, but is formed of transverse lamellæ, which unite with one another to form a network. The walls of the corallites consist of very delicate, closely contiguous lamellæ, which are directly continuous with the individual meshes of the "cœnenchyma." Within the walls run very narrow hollow canals ("Wandröhrchen" = "spiniform corallites"). Tabulæ are present (Die Chætetiden, p. 69).

The forms included by Dybowski under this head are *T. colliculata*, Eichw. sp., *T. cingulata*, Dyb., *T. pustulifera*, Dyb., and *T. variabilis*, Dyb.

How far Dybowski may be correct in referring the above forms to the genus *Trematopora*, Hall, is a matter upon which I do not feel competent to pass an opinion; since I am not aware that any descriptions of the minute structure of this genus, taken from authentic American examples, have as yet been made public, either by the distinguished

author of the genus or by any other observer. Judging from the descriptions and figures which Dybowski has given of the forms which he has included under the name of *Trematopora*, Hall, it seems safe, however, to conclude that we have to deal here with a peculiar type of Monticuliporoids, which differ in important respects from all the forms which have been described in the preceding portion of this work. From the brief diagnosis above given, and the accompanying engraving (fig. 48), it will be seen that these types possess a dimorphic corallum, composed of large and small corallites, which differ both in size and in their internal structure, while a third series of corallites is represented by an abundance of "spiniform corallites." The large corallites are oval, with thick lamellar walls (fig. 48, A), and with a very

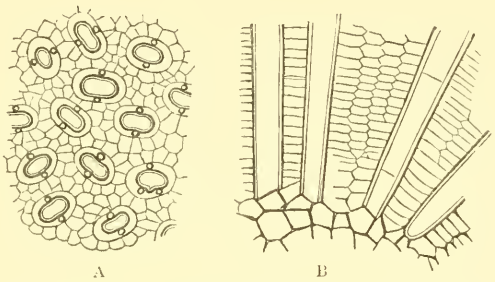

Fig. 48.—A, Tangential section of *Trematopora colliculata*, Eichw. (Dyb.), enlarged, showing the large tubes surrounded by small angular corallites, and having "spiniform corallites" developed close beside them; B, Outer portion of a transverse section of the same, where the tubes are cut longitudinally, enlarged, showing the large corallites, with their few and remote tabulæ, and the closely tabulate interstitial corallites. From the Lower Silurian of Russia. (Copied from Dybowski.)

small number of complete horizontal tabulæ (fig. 48, B). The small corallites are numerous, angular in shape, with imperfect walls, and with very numerous, close-set, horizontal tabulæ (fig. 48, B), which may become more or less vesicular. On the lateral margins of each of the large corallites are also developed two or three conspicuous "spiniform corallites." The interstitial corallites, lastly, are present in such numbers as to completely isolate the large tubes, two or three rows of the former seeming usually to intervene between any given pair of the latter.

As to the affinities of the forms included by Dybowski under the head of *Trematopora*, Hall, they differ from all the species of *Heterotrypa*, Nich., in the fact that the large corallites are completely isolated from one another by the development of an excessive number of interstitial corallites. On the other hand, while they resemble the species of *Fistulipora*, M'Coy, in the fact just mentioned, they are fundamentally distinguished from these by the great thickening of the walls of

the large tubes, and by the presence of "spiniform corallites." I need only add that the incomplete condition of the walls of the interstitial corallites, and the often vesicular nature of their tabulæ, are no grounds for supposing that we have to deal here with a genuine "cœnenchyma;" since precisely similar conditions are found in species of *Plasmopora* and *Propora*, where there is no room for reasonable doubt that the small tubes are a peculiarly modified series of corallites.

Dittopora, Dybowski.

The name of *Dittopora* has been proposed by Dybowski for a group of Monticuliporoids to which he assigns the following characters: Corallum polymorphic; corallites of two kinds, one series being cylindrical and separated by a reticulate cœnenchyma, and the other consisting of irregularly prismatic tubes which are in close contact. Both kinds of corallites are either arranged in alternating zones, or are confined to particular parts of the colony. "Spiniform corallites" ("Wandröhrchen") are developed in connection with both kinds of corallites. Tabulæ are present.

The typical species of *Dittopora*, Dyb., are distinguished by a peculiar form of dimorphism, certain portions of the corallum being occupied by corallites which differ in form from the rest. Thus in *D. clavæformis*, Dyb., the lower pedunculate end of the clavate corallum is occupied by prismatic corallites, while the upper bulbous portion is occupied by cylindrical corallites which are separated by sub-angular interstitial tubes. On the other hand, in *D. annulata*, Eichw. sp., the different kinds of corallites are arranged in zones, thick-walled cylindrical tubes alternating in successive rings with thin prismatic tubes (fig. 49).

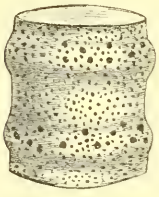

Fig. 49.—A fragment of the corallum of *Dittopora annulata*, Eichw. sp., from the Silurian of Russia, enlarged. (Copied from Eichwald.)

As regards the minute structure of the corallum, it would appear that the bulk of the corallum is made up of circular corallites of large size, separated by a series of angular interstitial tubes, which are so largely developed as to entirely isolate the large tubes (fig. 50, A). There also exists an exceedingly well-developed series of circular "spiniform corallites," which are remarkable for their exceptionally large size. In long sections (fig. 50, B) it is seen that the large corallites are furnished with a very small number of remote horizontal and complete tabulæ; whereas the small interstitial angular corallites (the "cœnenchyma" of Dybowski) are provided with numerous closely-set horizontal tabulæ, their walls being partially imperfect.

From the above brief account, and from the accompanying illustrations, it will be seen that *Dittopora*, Dyb., includes Monticuliporoids of very much the same type as those placed by Dybowski under *Trematopora*, Hall, but distinguished by the comparatively unthickened walls of the large corallites, and the large size and smaller amount of the angular interstitial tubes. In the complete isolation of the large corallites by the interstitial tubes, they resemble the species of *Fistulipora*, M'Coy, but they are distinguished by the peculiar dimorphism of the corallum above spoken of, and also by the presence of the numerous large-sized "spiniform corallites."

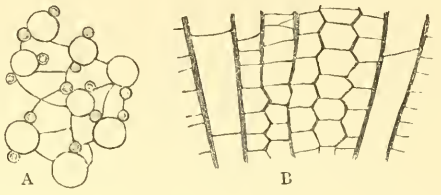

Fig. 50. — A, Tangential section of *Dittopora clavæformis*, Dyb., from the Silurian of Russia, enlarged, showing the circular large corallites, the angular interstitial tubes, and the large-sized spiniform corallites; B, Vertical section of the same, showing the large corallites, with their very remote complete tabulæ, and the closely tabulate interstitial tubes. (Copied from Dybowski.)

The known species of *Dittopora*, Eichw., are from the Silurian rocks of Russia; but I am not acquainted with any form belonging to it, and I can give no more detailed account of its characters than the above.

INDEX.

The names of genera and species actually described in this work are distinguished by means of an asterisk (*). Names of genera and species that are regarded as synonyms are printed in italics.

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PLATE I.

Fig. 1. Fragment of the corallum of *Monticulipora* (*Heterotrypa*) *moniliformis*, Nich., from the Hamilton Formation (Devonian) of Arkona, Ontario, of the natural size. The specimen shows more conspicuous "monticules" than is usually the case in this species.

Fig. 1 *a*. Portion of the surface of the same, enlarged eighteen times, showing the blunt tubercles or spines (spiniform corallites) between the calices.

Fig. 1 *b*. Portion of a tangential section of the same, enlarged eighteen times, showing the normal corallites, with an occasional small corallite at their angles of junction, and the numerous thick walled hollow spines (spiniform corallites).

Fig. 1 *c*. Part of a vertical section of the same, enlarged eighteen times, showing the numerous tabulæ, and the thickening of the walls of the corallites as they approach the surface.

Fig. 2. Fragment of the corallum of *Monticulipora* (*Heterotrypa*) *Barrandi*, Nich., from the Hamilton Group (Devonian) of Arkona, Ontario, of the natural size.

Fig. 2 *a*. Portion of the surface of the same, enlarged eighteen times.

Fig. 2 *b*. Tangential section of the same, enlarged eighteen times, showing the thick-walled corallites and the occasional development of spiniform tubes.

Fig. 2 *c*. Part of the same section, enlarged fifty times.

Fig. 2 *d*. Vertical section of the same, enlarged eighteen times.

Fig. 3. A specimen of *Monticulipora* (*Monotrypa*) *calceola*, Miller and Dyer, from the Cincinnati group of Ohio, of the natural size.

Fig. 3 *a*. A smaller example of the same, of the natural size.

Fig. 3 *b*. Part of the surface of the same, enlarged eighteen times.

Fig. 3 *c*. Tangential section of the same, enlarged eighteen times.

Fig. 3 *d*. Part of the preceding section, enlarged fifty times, showing the peculiar small tubes at the angles of junction of the corallites.

Fig. 3 *e*. Vertical section of the same, embracing the entire thickness of the corallum, enlarged eighteen times.

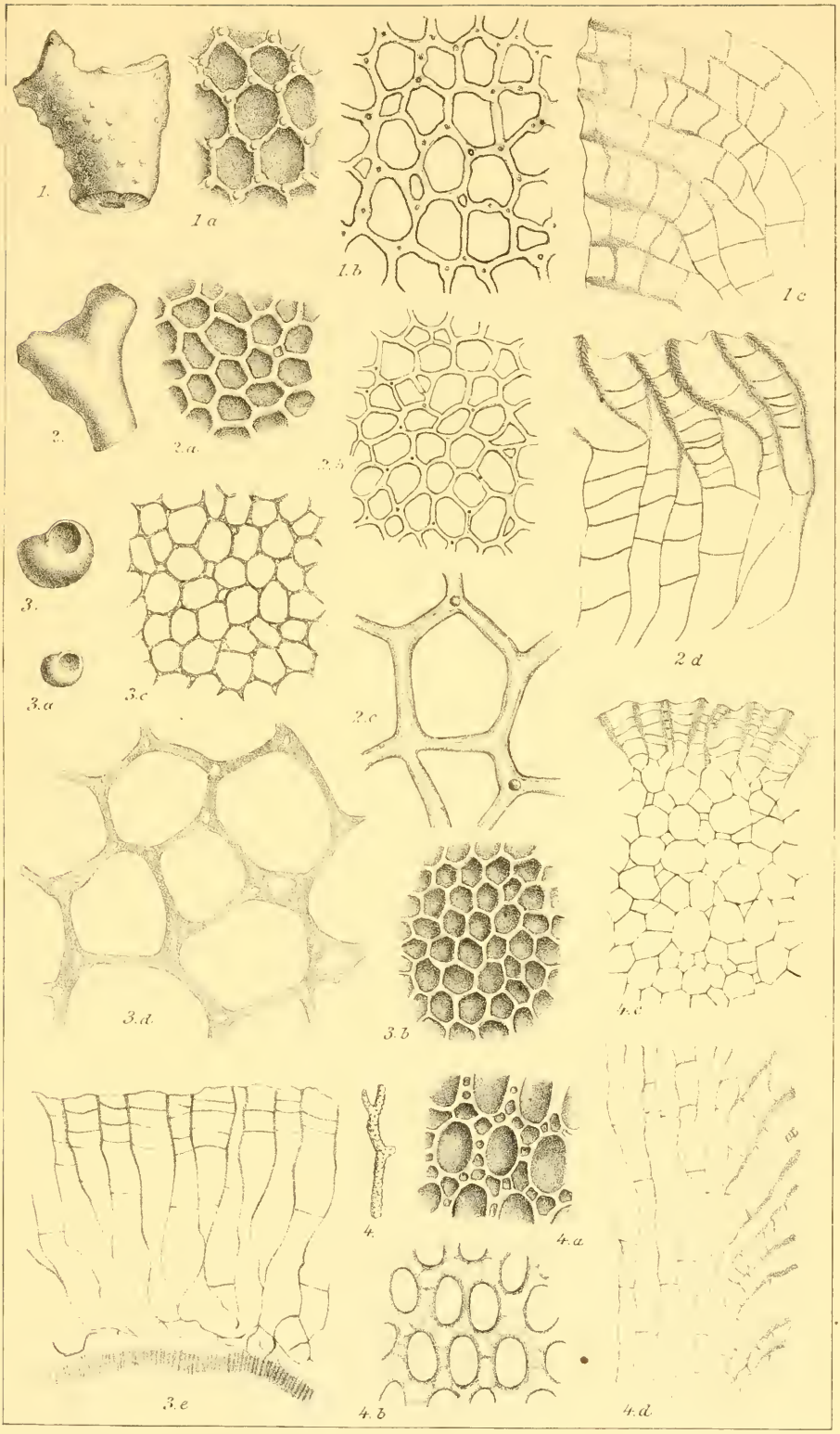
Fig. 4. A fragment of *Monticulipora* (*Heterotrypa*) *nodulosa*, Nich., of the natural size, from the Cincinnati group of Ohio.

Fig. 4 *a*. Part of the surface of the same, enlarged eighteen times.

Fig. 4 *b*. Tangential section of the same, enlarged eighteen times.

Fig. 4 *c*. Part of a transverse section of the same, including the narrow peripheral zone, and the greater part of the axis, enlarged eighteen times.

Fig. 4 *d*. Part of a vertical section, enlarged eighteen times.



C Berjeau, lith.

Waterston & Sons Lith^rs Edin^r

PLATE II.

Fig. 1. A specimen of *Monticulipora* (*Heterotrypa*) *gracilis*, James, from the Cincinnati group of Ohio, of the natural size.

Fig. 1 *a*. Surface of the same, enlarged eighteen times.

Fig. 1 *b*. Small portion of the surface of the same, enlarged fifty times.

Fig. 2. A specimen of *Monticulipora* (*Heterotrypa*) *ramosa*, D'Orb., of the natural size. From the Cincinnati group of Ohio.

Fig. 2 *a*. Surface of the same, enlarged eighteen times.

Fig. 3. A specimen of *Monticulipora rugosa*, Edw. and Haime, of the natural size. From the Cincinnati group of Ohio.

Fig. 4. A specimen of *Monticulipora Dalii*, Edw. and Haime, of the natural size. From the Cincinnati group of Ohio.

Fig. 5. A specimen of *Monticulipora* (*Monotrypa*) *briarea*, Nich., of the natural size. From the Cincinnati group of Ohio.

Fig. 5 *a*. Tangential section of the same, enlarged eighteen times.

Fig. 5 *b*. Part of the preceding section, enlarged fifty times.

Fig. 5 *c*. Vertical section of the same, enlarged eighteen times.

Fig. 6. Fragment of the crust of *Monticulipora* (*Peronopora*) *Cincinnatiensis*, James, of the natural size, showing the prominent monticules. From the Cincinnati group of Ohio.

Fig. 6 *a*. Part of the surface of the same, enlarged eighteen times.

Fig. 6 *b*. Part of a tangential section of the same, enlarged eighteen times, showing the large tubes with their incomplete tabulæ and the intercalated small tubes.

Fig. 6 *c*. Vertical section of the same, enlarged eighteen times, showing the incomplete tabulæ of the large tubes.

Fig. 7. A specimen of *Monticulipora* (*Heterotrypa*) *implicata*, Ulrich, of the natural size. From the Cincinnati group of Ohio.

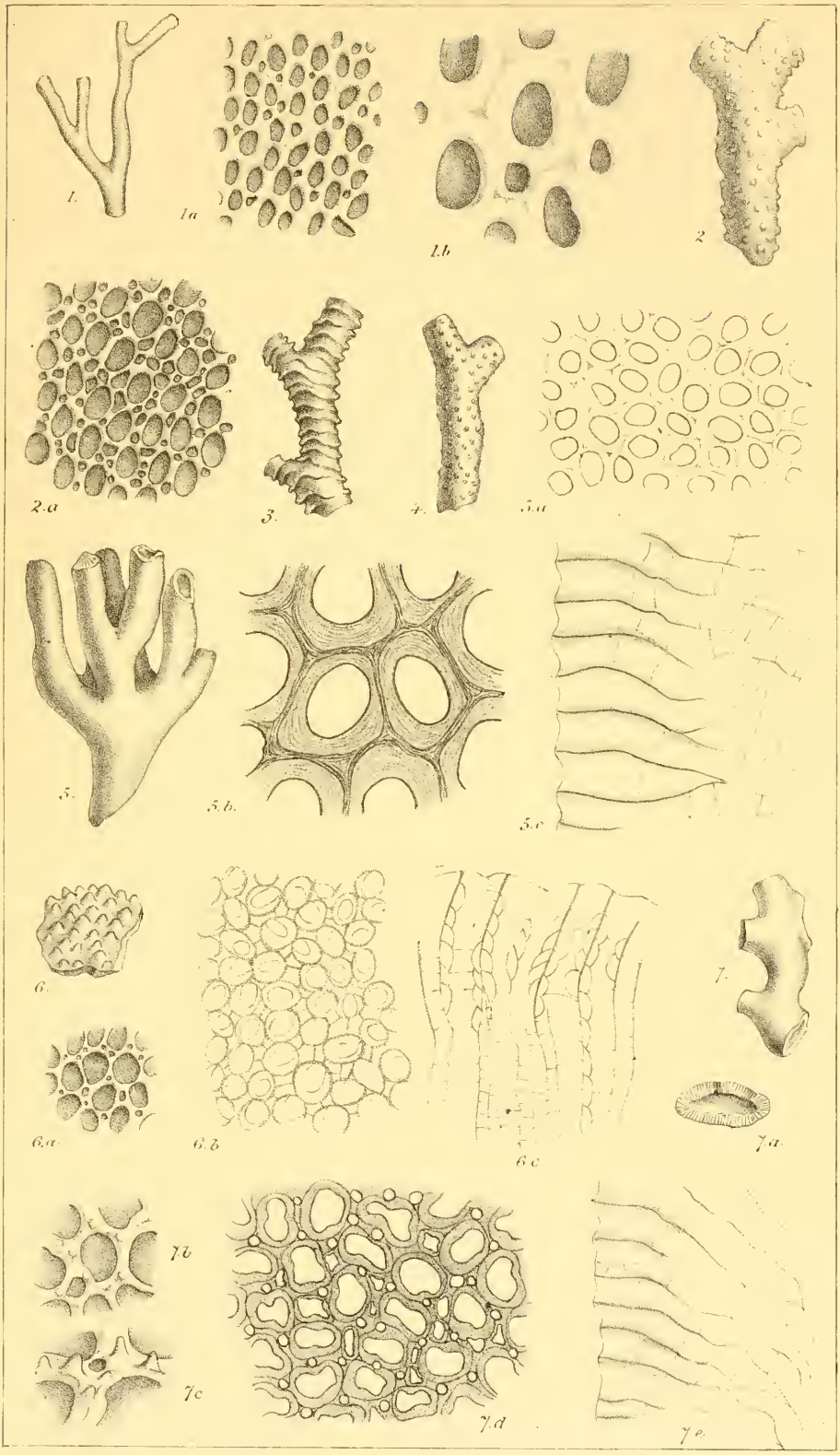
Fig. 7 *a*. Fractured extremity of the same specimen, enlarged three times, showing the arrangement of the tubes.

Fig. 7 *b*. Portion of the surface of the same, enlarged eighteen times.

Fig. 7 *c*. A small part of the surface of the same, enlarged fifty times, showing the prominent blunt spines (spiniform corallites) between the large tubes.

Fig. 7 *d*. Tangential section of the same, enlarged eighteen times.

Fig. 7 *e*. Part of a vertical section of the same, enlarged eighteen times.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7e.

PLATE III.

Fig. 1. A fragment of *Monticulipora* (*Heterotrypa*) *tumida*, Phill., from the Carboniferous rocks of Redesdale, Northumberland, of the natural size.

Fig. 1 *a*. Part of the surface of the same, enlarged eighteen times.

Fig. 1 *b*. Another part of the same specimen, showing a group of small corallites, similarly enlarged.

Fig. 1 *c*. A calice of the same, enlarged fifty times, showing the blunt spines round the margin.

Fig. 1 *d*. Tangential section of the same, enlarged eighteen times, showing the thick walls of the corallites, and the numerous hollow spines (spiniform corallites).

Fig. 1 *e*. Vertical section of the same, enlarged eighteen times.

Fig 1 *f*. Vertical section of a single corallite of the same, close to its mouth, enlarged fifty times, showing the peculiar structure of the wall. In the wall on the right-hand side is seen one of the hollow spines.

Fig. 2. Fragment of *Monticulipora tumida*, Phill., var. *miliaria*, Nich., from the Carboniferous rocks of Redesdale, Northumberland, of the natural size.

Fig. 2 *a*. Part of the surface of the same, enlarged eighteen times, showing the numerous interstitial tubes.

Fig. 2 *b*. Part of a tangential section of the same, enlarged eighteen times.

Fig. 2 *c*. Part of the preceding section, enlarged fifty times.

Fig. 3. A specimen of *Monticulipora* (*Heterotrypa*) *O'Nealli*, James, from the Cincinnati group of Ohio, of the natural size.

Fig. 3 *a*. Part of the surface of the same, where the calices are open, enlarged fifteen times.

Fig. 3 *b*. Part of the surface of another specimen where the larger calices are closed by opercula, enlarged fifteen times.

Fig. 3 *c*. Part of a tangential section of the same, enlarged eighteen times, showing the large and small corallites.

Fig. 3 *d*. Small portion of the preceding section, enlarged fifty times, showing the structure of the wall.

Fig. 3 *e*. Part of the axial region of a transverse section of the same, enlarged eighteen times, showing the thin walls and angular form of the corallites.

Fig. 3 *f*. Part of a vertical section of the same, enlarged eighteen times.

Fig. 4. Fragment of the shell of *Strophomena alternata*, Conrad, with a small colony of *Monticulipora* (*Peronopora*) (?) *Ortoni*, Nich., growing upon it, of the natural size. From the Cincinnati group of Ohio.

Fig. 4 *a*. Portion of the surface of the same, enlarged fifty times, showing the peculiar form of the calices, and the rounded tubercles surrounding them.

Fig. 4 *b*. Part of a tangential section of the same, enlarged sixty times, showing the peculiar shape of the corallites and their incomplete tabulæ, together with the numerous hollow spines (spiniform corallites).

Fig. 4 *c*. Vertical section of the same, embracing the entire thickness of the colony, enlarged eighteen times.

Fig. 4 *d*. Part of an oblique tangential section, cutting the tubes longitudinally. enlarged eighteen times.


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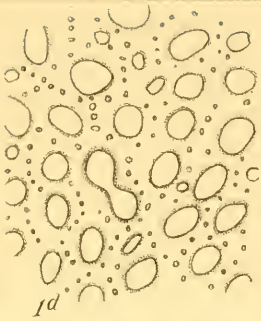
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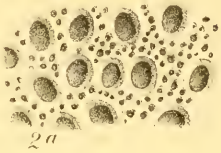
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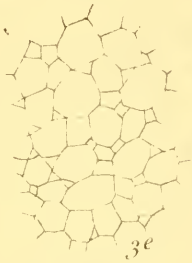
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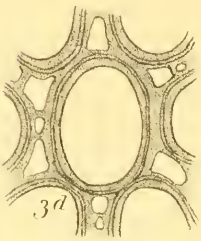
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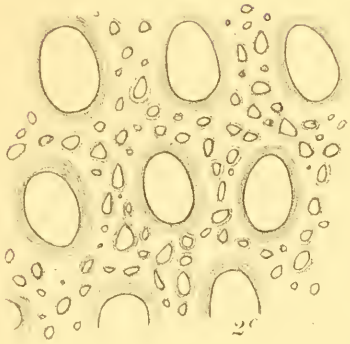
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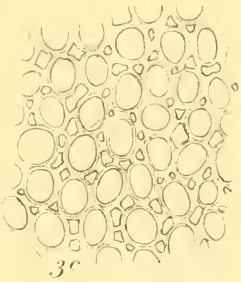
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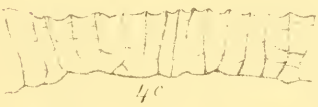
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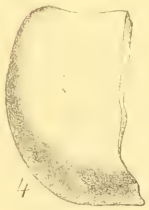
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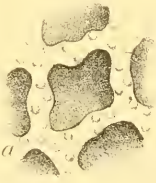
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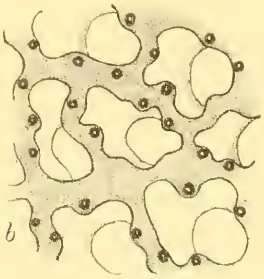
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4d

PLATE IV.

Fig. 1. A specimen of *Monticulipora* (*Prasopora*) *Newberryi*, Nich., from the Cincinnati group of Ohio, viewed from above, of the natural size. The thin corallum is fractured in various directions.

Fig. 1 *a*. View of the margin of the same, of the natural size, showing the thickness of the corallum.

Fig. 1 *b*. Part of the surface of the same, enlarged eighteen times.

Fig. 1 *c*. Tangential section of the same, enlarged eighteen times, showing the two kinds of corallites, and the incomplete tabulæ of the large tubes.

Fig. 1 *d*. Part of the preceding section, enlarged fifty times.

Fig. 1 *e*. Vertical section, enlarged eighteen times, embracing the entire thickness of the corallum, and showing the different tabulation of the larger and smaller corallites.

Fig. 2. Outline of a portion of an Orthoceras covered by a colony of *Monticulipora* (*Monotrypa*) *tuberculata*, Edw. and Haime (= *M. corticans*, Nich.), of the natural size, showing the form of the elongated tubercles. From the Cincinnati group of Ohio.

Fig. 2 *a*. Part of the surface of the same, enlarged eighteen times.

Fig. 2 *b*. Part of a tangential section of the same, enlarged eighteen times.

Fig. 2 *c*. Small portion of the preceding section, enlarged fifty times, showing the structure of the wall.

Fig. 3. A specimen of *Monticulipora* (*Monotrypa*) *discoidea*, James, viewed from above, of the natural size. From the Cincinnati group of Ohio.

Fig. 3 *a*. Under side of the same specimen, showing the basal epitheca.

Fig. 3 *b*. Side-view of the same, showing the thickness of the corallum.

Fig. 3 *c*. Tangential section of the same, enlarged eighteen times, showing the hollow spines (spiniform corallites) at the angles of the ordinary tubes.

Fig. 3 *d*. Part of the preceding section, enlarged fifty times.

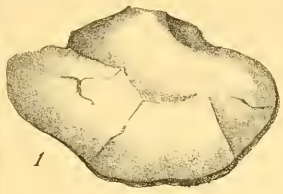
Fig. 3 *e*. Part of a vertical section, of the natural size, embracing the whole thickness of the corallum.

Fig. 3 *f*. A single tube from the preceding section, enlarged fifty times, showing the structure of the wall.

Fig. 4. A specimen of *Monticulipora* (*Diplotrypa*) *calycula*, James, of the natural size, from the Cincinnati group of Ohio. The surface bearing the calices is buried in the matrix, and all that is seen is the deeply concave basal epitheca.

Fig. 4 *a*. Tangential section of the same, enlarged eighteen times.

Fig. 4 *b*. Vertical section of the same, embracing the whole thickness of the corallum, enlarged eighteen times.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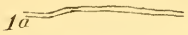
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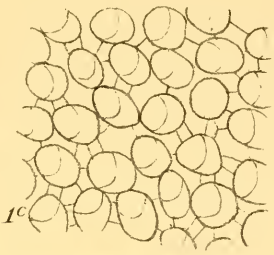
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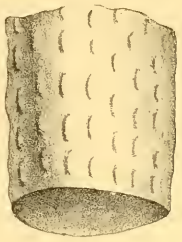
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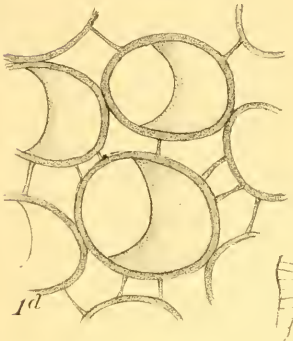
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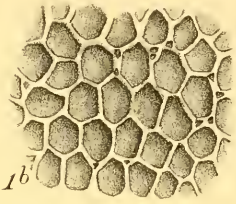
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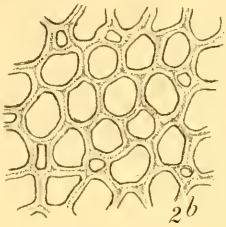
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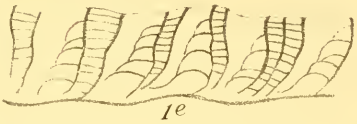
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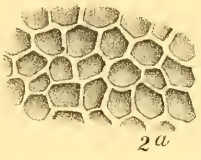
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3a


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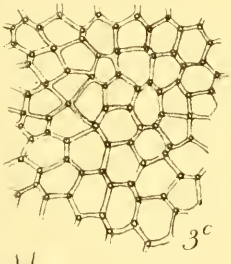
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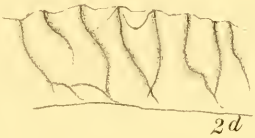
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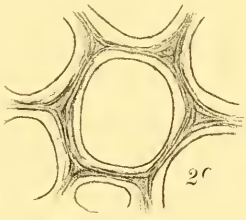
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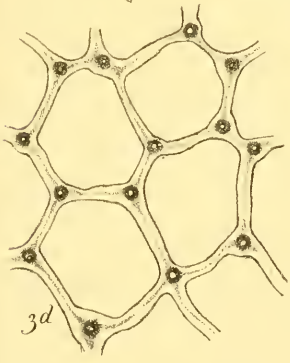
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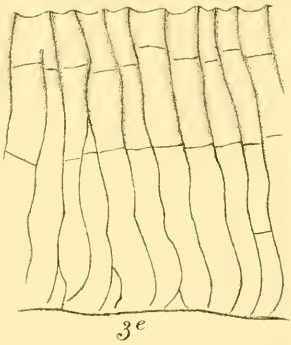
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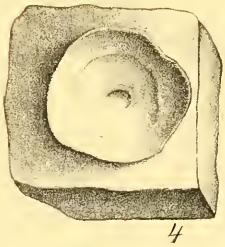
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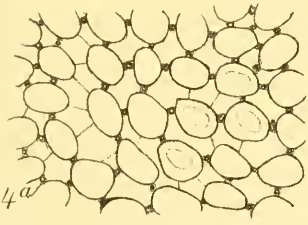
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4b

PLATE V.

Fig. 1. A specimen of *Monticulipora* (*Heterotrypa*) *Andrewsii*, Nich., from the Cincinnati group of Ohio, of the natural size.

Fig. 1 *a*. Part of the surface of the same, embracing one of the clusters of large tubes, enlarged twenty-five times.

Fig. 2. A specimen of *Monticulipora* (*Heterotrypa*) *subpulchella*, Nich., from the Cincinnati group of Ohio, of the natural size.

Fig. 2 *a*. Part of the surface of the same, including one of the clusters of small tubes, enlarged twenty-five times.

Fig. 3. Outline of a specimen of *Monticulipora* (*Heterotrypa*) *Dawsoni*, Nich., of the natural size. From the Cincinnati group of Ohio.

Fig. 3 *a*. Part of the surface of the same, of the natural size, showing the prominent elongated tubercles.

Fig. 3 *b*. Part of the surface of the same, enlarged eighteen times.

Fig. 3 *c*. Tangential section of the same, enlarged eighteen times.

Fig. 3 *d*. Part of the preceding section, enlarged fifty times.

Fig. 3 *e*. Vertical section of the same, embracing the whole thickness of the corallum, enlarged eight times.

Fig. 3 *f*. Part of the outer margin of the preceding section, enlarged eighteen times.

Fig. 4. A thin variety of *Monticulipora* (*Peronopora*) *frondosa*, D'Orb., from the Cincinnati group of Ohio, of the natural size.

Fig. 4 *a*. Tangential section of the same, enlarged fifty times, showing the imperfect tabulæ of the larger corallites, the intercalated small corallites, and the moderate development of "spiniform corallites."

Fig. 5. A fragment of *Monticulipora* (*Peronopora*) *frondosa*, D'Orb., from the Cincinnati group of Ohio, of the natural size, showing the faintly marked monticules.

Fig. 5 *a*. Broken edge of the same specimen, of the natural size, showing the general arrangement of the corallites.

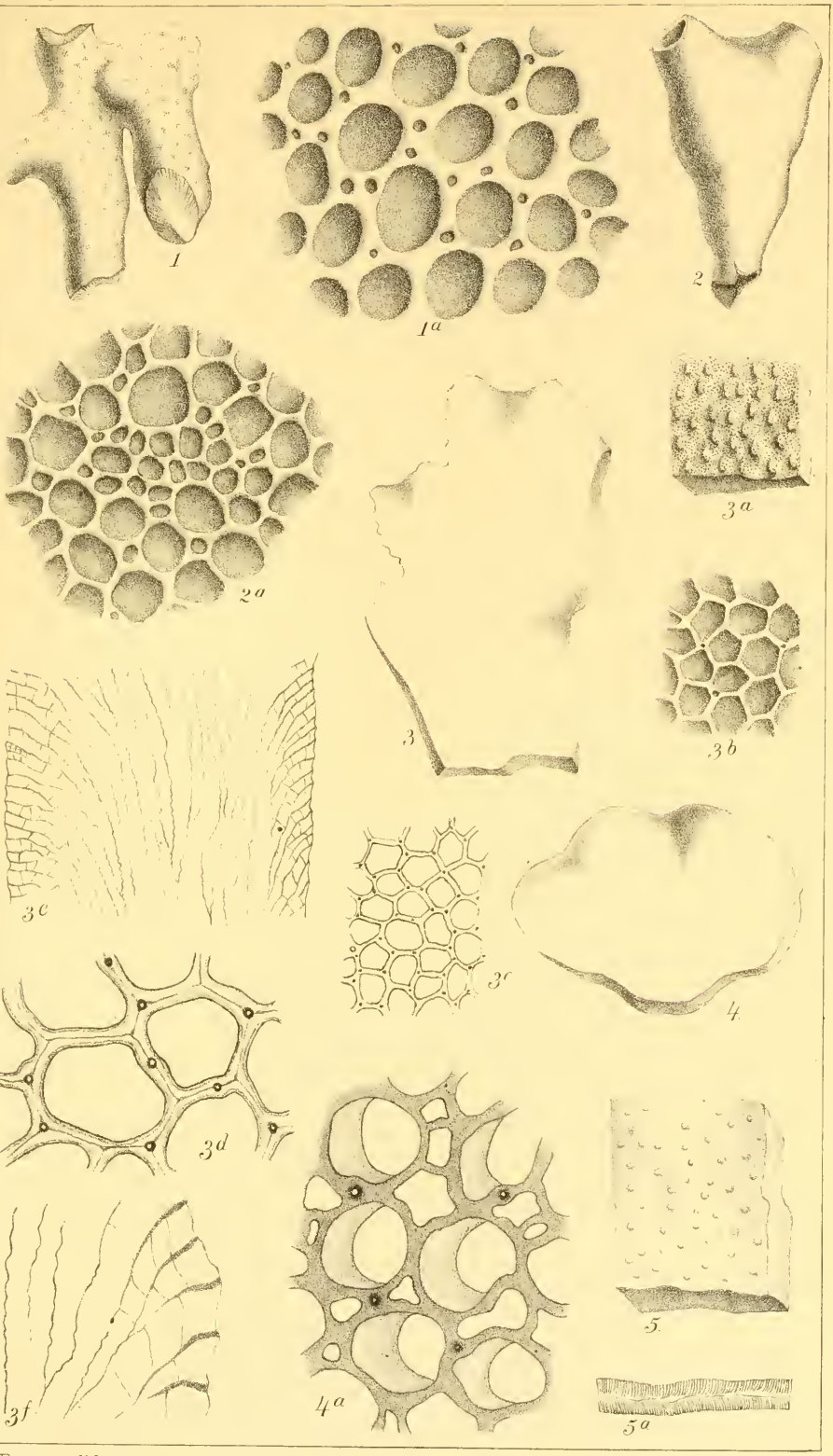
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PLATE VI.

Fig. 1. Outline of a specimen of *Monticulipora* (*Heterotrypa*) *mammulata*, D'Orb., from the Cincinnati group of Ohio, of the natural size.

Fig. 1 *a*. Portion of the surface of a specimen of the same, showing very faintly marked monticules, of the natural size.

Fig. 1 *b*. Portion of the surface of another specimen of the same, showing more conspicuous tubercles, of the natural size.

Fig. 1 *c*. Surface of the same, enlarged eighteen times.

Fig. 1 *d*. Tangential section of the same, taken just below the surface, showing the larger and smaller tubes, and the occasional hollow spines, (spiniform corallites).

Fig. 1 *e*. Part of the same section, enlarged fifty times.

Fig. 1 *f*. Another tangential section, taken at a deeper level than the preceding, enlarged twenty times.

Fig. 1 *g*. Portion of a vertical section of the same at right angles to its flat surfaces, enlarged eighteen times, showing the different tabulation of the larger and smaller tubes.

Fig. 2. A specimen of *Monticulipora* (*Peronopora*) *molesta*, Nich., from the Cincinnati group of Ohio, of the natural size, showing the well-marked monticules.

Fig. 2 *a*. Part of the surface of the same, enlarged eighteen times.

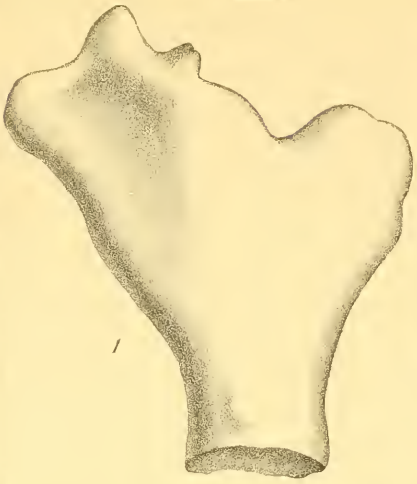
Fig. 2 *b*. Tangential section of the same, enlarged eighteen times, showing the large and small corallites, and imperfect tabulæ of the former.

Fig. 2 *c*. Part of the preceding section, enlarged fifty times.

Fig. 2 *d*. Part of a vertical section of the same, showing the close tabulation of the small corallites, and the incomplete tabulæ of most of the large tubes.

Fig 3. A specimen of *Monticulipora* (*Monotrypa*) *pavonia*, D'Orb. (= *M. clathratula*, James), from the Cincinnati group of Ohio, of the natural size.

Fig. 3 *a*. Portion of the surface of the same, enlarged eighteen times.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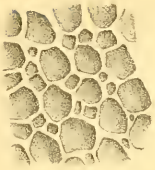
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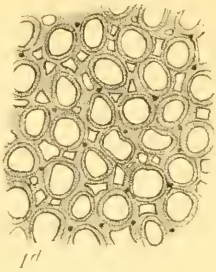
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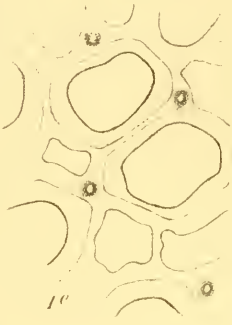
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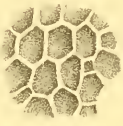
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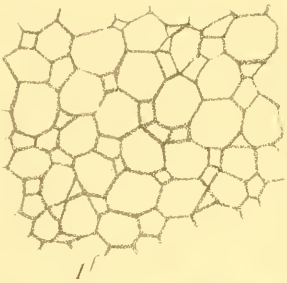
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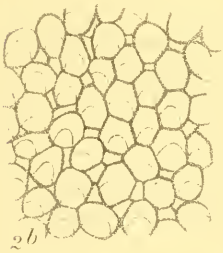
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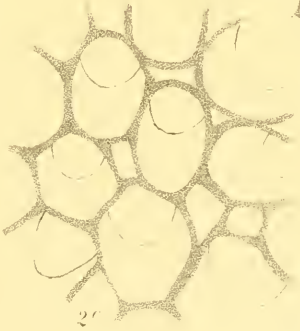
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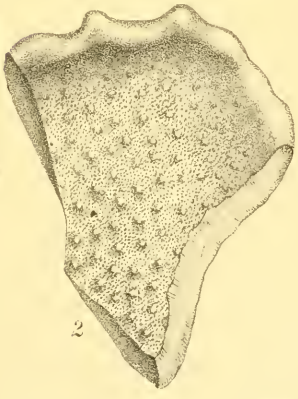
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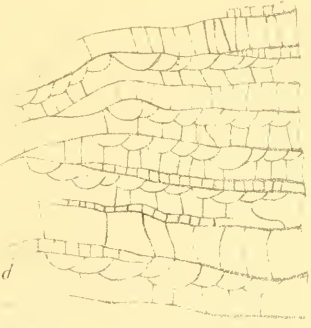
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