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"TABULATE CORALS"

OF THE

PALÆOZOIC PERIOD

ON THE

STRUCTURE AND AFFINITIES

OF THE

"TABULATE CORALS"

OF THE

PALÆOZOIC PERIOD

WITH CRITICAL DESCRIPTIONS OF
ILLUSTRATIVE SPECIES

BY

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TO

J. N.

IN GRATEFUL ACKNOWLEDGMENT

OF IMMEMORIAL LOVE, OF PRICELESS COUNSEL,

AND OF UNFAILING HELP,

This Work

IS AFFECTIONATELY INSCRIBED BY

THE AUTHOR.

PREFACE.

The present work is a record of a series of researches which I have been engaged in carrying out, with intermissions, for some years, into the minute structure and relations of the Palæozoic "Tabulate Corals." The space, means of illustration, and leisure at my command have not permitted me to make this an even approximately exhaustive account of the numerous and interesting forms of Corals embraced by Milne-Edwards and Jules Haime, under the name of "Zoantharia Tabulata." I have, therefore, restricted myself, in the meanwhile, to the elucidation of the anatomy of the principal Palæozoic genera of the "Tabulata," which I have been able to personally investigate; and I have usually given in addition short descriptions of one or more of the *species* of each genus, as illustrative of the structural type under consideration.

The general result of my investigations is that I am able to corroborate the views of Verrill and Lindström as to the necessity of abolishing the "Tabulata" as a distinct and separate division of the *Zoantharia.* I have also been led to conclude that under the old name of "Tabulata" there are included at least twelve distinct groups of corals, and that, while some of these are *Hydrozoa*, and others are true *Zoan-*

tharia, a large number may be referred, with greater or less certainty, to the order of the *Alcyonaria*—a few forms being of quite uncertain affinities. I have not, however, been induced to think that the so-called "Tabulate Corals" are, to any extent, referable to the *Polyzoa*;[1] and I do not think that any but the aberrant *Milleporidæ* can be at present regarded as possessing Hydrozoan affinities. On many minor points I have been led to form conclusions different from those that are ordinarily held, and I have no right to expect that these will be in all cases immediately or generally accepted; while I have the certainty that many of the results which I have

[1] Since this work has passed through the press, Professor Busk has published a description and figures of the recent species of *Heteropora* referred to on p. 256, giving to it the name of *H. Neozelanica* (Journ. Linn. Soc., vol. xiv., p. 724). Two other living species have also been described by Mr W. Waters (Journ. Roy. Mic Soc., June 1879). Mr Busk has shown that the walls of the zoœcia and interstitial tubes ("cancelli") of *H. Neozelanica* are perforated by minute pores, a phenomenon not unknown in species of the genus now extinct. In the comparatively limited investigation of *H. Neozelanica* made by me, these pores escaped notice. The connecting-pores just alluded to certainly admit of a comparison with the "mural pores" of the *Favositidæ*, but the comparison is not much closer in their case than in the instance of the pores in the walls of species of *Lepralia* or *Alecto*. Nor does their similar appearance and position prove these apertures to be absolutely homologous. At any rate the likeness between the pores of *Heteropora* and the mural pores of the *Favositidæ* is, to say the very least, no closer than the resemblance between the latter and the apertures in the walls of such undoubted *Actinozoa* as *Porites* and *Alveopora*. Giving due weight to this last consideration, and combining this with the fact that the true zoœcia of *Heteropora* do not appear to be "tabulate," while the typical "*Tabulata*" exhibit so many and such important points of affinity with unquestionable living corals, both Alcyonarians and Zoantharians, I do not at present feel inclined to alter the opinion which I have formed as to the Cœlenterate nature of the *Favositidæ*, the *Chætetidæ*, and the *Monticuliporidæ*. At the same time, it is undeniable that there is a remarkably close resemblance between some of these forms (and especially the Monticuliporoids) and *Heteropora*. This resemblance is enhanced by the fact that one of the species of *Heteropora* described by Mr Waters exhibits the usually chitinous surface-pellicle in a calcified and thickened condition, thus reminding us forcibly of the state of parts in some of the species of *Favosites*, and in various of the *Monticuliporidæ*. These resemblances, as above pointed out, are counterbalanced by weighty points of dissimilarity; but they are more than sufficient to make us await with the greatest interest any observations upon the *animal* of *Heteropora*.

obtained will not be arrived at except by those who are willing to adopt the modes of investigation here followed.[1]

To those acquainted with the subject, it is unnecessary for me to point out that I have been greatly assisted in the task I have attempted by the previous labours of Milne-Edwards and Haime, Martin Duncan, Lindström, and other distinguished palæontologists, and especially by the investigations of Louis Agassiz, Verrill, and Moseley into the structure and relations of the few existing Tabulate Corals. At the same time, almost all the actual facts recorded in this volume have been verified or worked out by myself, and any facts which I have not personally been able to test are invariably accredited to their original authority.

In this connection I should further add that I have not been able to refer to the fifth volume of the 'Palæontology of New York,' by Professor James Hall, which, I believe, contains numerous illustrations of Palæozoic Tabulate Corals; the cause of my inability to consult this important work being that, after repeated attempts, I found it impossible to obtain a copy through the ordinary channels. Under these circumstances I can only leave it to my fellow workers to decide how far a scientific work, which apparently cannot be obtained by purchase, is to be regarded as actually published; and in making this remark I need hardly say that I am merely anxious to account for an apparent omission on my part, and do not wish to express any opinion upon the method in which Professor Hall has seen fit to bring out his work.[2]

[1] In this connection I may specially refer the reader to the remarks made at p. 270 as to the proper method of sectioning the coralla of the Tabulate Corals, with a view to microscopic examination.

[2] The work here referred to appeared, I believe, in 1877. With regard to its publication, Professor C. A. White states (Bibliography of N. Amer., Invert. Pal., p. 38, 1878) that he had been unable to consult a copy, "search for it in the libraries of Washington and Philadelphia having been unsuccessful." He adds: "Only one hundred copies are reported to have been published."

The material upon which this work is based is principally, though not exclusively, contained in the extensive collections of Corals which I have made from the Palæozoic formations of Britain, the Continent of Europe, and North America; but I have also had the opportunity of consulting the collections of the British Museum, the Museum of Practical Geology, and the Edinburgh Museum of Science and Art. The method of investigation which I have adopted has been largely that of microscopic sections, and the present work is, therefore, much more extensively occupied with detailed descriptions of minute structure than has been usual in treatises or memoirs dealing with the fossil Corals. For the same reason I have been more concerned to investigate the actual anatomy and systematic relations of even perfectly well known types, than to describe new forms or to discuss difficult and disputed points of specific determination. The necessary sections, with few exceptions, have been personally prepared by myself, and the illustrations of microscopic structure are from drawings made by the camera lucida. Unless otherwise explicitly acknowledged, all the illustrations, whether in the text or the plates, are from original drawings of my own; and I have to return my best thanks to my friend Mr Berjeau for the care and fidelity with which he has reproduced these on wood and stone.

I have, finally, to express my gratitude for the varied and valuable assistance which has been freely accorded to me by my friends Mr R. Etheridge, F.R.S., Mr R. Etheridge, jun., F.G.S., Mr George Jennings Hinde, F.G.S., Dr Gustav Lindström, and Dr Ramsay H. Traquair, F.R.S.E.

United College, St Andrews,
September 10, 1879.

LIST OF ILLUSTRATIONS.

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PALÆOZOIC TABULATE CORALS.

CHAPTER I.

THE CLASSIFICATION AND AFFINITIES OF THE "TABULATE CORALS."

THE "*Tabulata,*" as originally understood, constitute one of the four primary divisions of the Zoantharian *Actinozoa*, as laid down and defined by Milne-Edwards and Haime in their great works upon the fossil Corals (Brit. Foss. Corals, Introduction, 1850; and Polypiers Foss. des Terr. Pal., 1851). In this division was included a large assemblage of Corals, ranging from the Silurian period to the present day, and often of very diverse structure, but characterised by the possession of well-developed "walls," by the separation of the visceral cavities of the corallites into distinct chambers by transverse partitions or "tabulæ," and by the rudimentary condition of the "septa." The distinguished French zoophytologists just quoted remark of this division of the Corals, that its principal character "is founded on the existence of the lamellar diaphragms that close the visceral chamber of the corallites at different heights, and differ from the dissepiments of the *Astræidæ* by not being dependent on the septa, and forming as many complete horizontal divisions extending from side to side of the general cavity, instead of occupying only the one or two loculi. It is also to be remembered that the septal apparatus, though more or less rudimentary, has the same general mode of arrangement as in the preceding sub-orders" (*Aporosa* and *Perforata*), "and never presents the crucial character which we shall find in the *Zoantharia Rugosa*." They also divide the "*Tabulata*" into the following four families, comprising the under-mentioned genera :—

Fam. I. MILLEPORIDÆ.—Corallum principally composed of a very abundant cœnenchyma, distinct from the walls of the corallites, and of a tubular or cellular structure. Septa not numerous; tabulæ numerous and well formed. Genera—*Millepora*, Lam.; *Heliopora*, De Blainv.; *Heliolites*, Dana; *Fistulipora*, M'Coy; *Plasmopora*, Edw. and H.; *Propora*, Edw. and H.; *Axopora*, Edw. and H.; *Lobopora*, Edw. and H.

Fam. II. FAVOSITIDÆ.—Corallum essentially formed by lamellar walls, with little or no cœnenchyma. Visceral chambers divided by numerous and well-developed complete tabulæ.

Tribe 1. *Favositinæ*.—Corallum massive. Walls perforated. Septa rudimentary. No cœnenchyma. Genera—*Favosites*, Lam.; *Michelinia*, De Kon.; *Koninckia*, Edw. and H.; *Alveolites*, Lam.

Tribe 2. *Chætetinæ*.—Corallum massive. Walls not perforated. Neither septa nor cœnenchyma. Genera—*Chætetes*, Fischer; *Dania*, Edw. and H; *Stenopora*, Lonsd.; and *Constellaria*, Dana.

Tribe 3. *Halysitinæ*.—Corallum composed of corallites constituting vertical laminæ or fasciculi, but more or less free laterally, and united by means of connecting tubes or mural expansions. Walls well developed, and not porous. Septa distinct, but small. Genera—*Halysites*, Fischer; *Harmodites*, Fischer (subsequently abandoned for *Syringopora*, Goldf.), and *Thecostegites*, Edw. and H.

Tribe 4. *Pocilloporinæ*.—Corallum massive, gibbous, or subdendroid, with thick imperforated walls, forming towards the surface an abundant compact cœnenchyma. Septa quite rudimentary. Genus—*Pocillopora*, Lam.

Fam. III. SERIATOPORIDÆ.—Corallum arborescent or bushy, with an abundant compact cœnenchyma. Visceral chambers filling up by the growth of the columella and the walls, and showing but few traces of tabulæ. Genera—*Seriatopora*, Lam.; *Dendropora*, Michelin; *Rhabdopora*, Edw. and H.

Fam. IV. THECIDÆ.—Corallum massive, with an abundant, compact, spurious cœnenchyma, produced by the septa becoming cemented together laterally. Tabulæ numerous. Genus—*Thecia*, Edw. and H.

Various additions, modifications, and improvements in the above classification of the "*Tabulata*" were made by Milne-

Edwards and Haime during the progress of their classical monograph on the Fossil Corals of Britain ; many new genera were added ; and the tribe of the *Stylophyllinæ*, to include the curious Cretaceous genus *Stylophyllum*, Reuss, was inserted in the family of the *Favositidæ*. Most of the changes here indicated, which it would be needless to point out in detail, are to be found incorporated in the systematic account of the "Tabulata" given by Milne-Edwards in his masterly 'Histoire Naturelle des Coralliaires' (vol. iii., 1860).

The first serious attack upon the classification of Milne-Edwards and Haime, and upon the position of the "*Tabulata*," was made by Professor Louis Agassiz, who in 1857 examined the living animal of *Millepora*, and arrived at the conviction that this genus was truly Hydrozoal (Amer. Journ. Sci. and Arts, ser. 2, vol. xxvi. p. 140, 1858 ; Proc. Bost. Soc. Nat. Hist., vol. vi. p. 373, 1859). This conclusion has since been fully borne out by the researches of Mr Moseley, to be subsequently referred to ; but Professor Agassiz based upon his discovery a further conclusion which certainly was not warranted by the known facts—namely, that the Hydrozoal nature of *Millepora* sufficiently proved *all* the so-called "Tabulate Corals" to be referable to the *Hydrozoa*.

Shortly after the publication by Professor Agassiz of his unexpected discovery as to the Hydrozoal nature of *Millepora*, Professor Verrill investigated the anatomy of the "Tabulate" genus *Pocillopora*, Lam., and showed that the animal of this Coral was a true Zoantharian, referable to the *Aporosa*, and allied to the *Oculinidæ* (Review of the Corals and Polypes of the W. Coast of America, Trans. Conn. Acad., vol. i. pp. 2, 523, 1870 ; and Affinities of the Tabulate Corals, Proc. Amer. Assoc. for Adv. of Science, p. 148, 1867). Professor Verrill likewise, even at this date (Trans. Conn. Acad., *loc. cit.*), powerfully supported the view that the *Favositidæ* are not only true *Actinozoa*, but that they are really referable to the *Zoantharia*. In the year 1872 the same high authority published an important memoir upon "The Affinities of the Palæozoic Tabulate Corals with existing Species" (Amer. Journ. Sci. and Arts, ser. 3, vol. iii. p. 187), in which he forcibly pointed out that the discovery of the Hydrozoal nature of *Millepora*, Lam., did not necessarily carry with it the reference of the whole of the "Tabulata" to the *Hydrozoa*. On the contrary, he affirms that, "as to the great majority of the 'Tabulata' and 'Rugosa,' there can no longer be any reasonable doubt" that they are essentially animals of the same nature as "the existing Corals" (*i.e.*, *Zoantharia*). The family of the *Pocilloporidæ* is further established for the reception of *Pocillopora* and its allies; *Columnaria* is regarded as either a member of the *Astræidæ*, or as referable to a closely allied family; and the *Favositidæ* are merged with the *Poritidæ*, doubt being expressed as to whether the group can be retained as even a sub-family.

In the year 1872, also, was published the admirable "Third Report on the British Fossil Corals," by Professor Martin Duncan, which was laid before the British Association for the Advancement of Science in 1871, and published in the Report of the Association. In this important memoir Professor Duncan deals very largely with the structure and affinities of the "Tabulate Corals"—his wide knowledge of both living and extinct *Actinozoa* rendering his views upon this subject particularly valuable and suggestive. Various of these views will be noticed subsequently; and it will be sufficient to state here that he retains the "*Tabulata*" of Edwards and Haime as a great division of the *Zoantharia*, subdividing it as shown in the following table:—

Section TABULATA.

FAMILIES.

With cœnenchyma, . .	*Milleporidæ.*	Cœnenchyma cellular.
	Acroporidæ.	Cœnenchyma compact.
Without cœnenchyma, . .	*Favositidæ.*	Walls perforated.
	Halysitidæ.	Walls imperforate.
	Alveolitidæ.	Septa tridentate.

	Genera.
Milleporidæ, . . .	*Millepora.*[1] *Heliolites, Heliopora, Polytremacis. Propora, Plasmopora, Thecia. Lyellia. Thecostegites. Axopora.*
Acroporidæ, . . .	*Acropora, Seriatopora, Pocillopora, Dendropora, Rhabdopora.*
Favositidæ, . . .	*Favosites, Koninckia, Favositipora, Michelinia, Rœmeria, Emmonsia. Syringopora. Aulopora.*
Halysitidæ, . . .	*Halysites. Stylophyllum. Chonostegites. Columnaria. Beaumontia.*
Alveolitidæ, . . .	*Alveolites. Cœnites.*
Incertæ sedis, . . .	*Fistulipora. Fletcheria.*

Alcyonaria.

Chætetes, Monticulipora, Dania, Stellipora, Labechia.

Another very important memoir upon the "Tabulate Corals" was published in 1873 by Dr Gustav Lindström (Några anteckningar om Anthozoa Tabulata, Öfversigt af. Kongl. Vetensk. Akad. Förhandl., 1873. Translated in the Ann. and Mag. Nat. Hist., ser. 4, vol. xviii. p. 1, 1876). In this paper the distinguished Scandinavian palæontologist entirely abandons the "*Tabulata*" of Edwards and Haime as a distinct division of the Corals; *Labechia*, E. and H., is placed among the *Hydrozoa*, near to *Hydractinia; Monticulipora*, D'Orb., *Fistulipora*, M'Coy, and some other forms, are regarded as *Polyzoa ;* the *Favositidæ* are placed in the *Poritidæ*, among the Perforate Corals; the *Heliolitidæ* are considered as forming a

[1] In a note, Dr Duncan adds that though not satisfied (1872) that *Millepora* is a Hydrozoön, he has great doubt about its Madreporarian affinities. He also points to the extremely close relation between *Heliolites* and *Heliopora*, since so entirely confirmed by Mr Moseley.

special group of uncertain zoological position; *Columnaria*, Goldf., is placed among the *Cyathophyllidæ*, in the section of the *Rugosa; Fletcheria*, E. and H., and *Michelinia*, De Kon., are referred to the *Cystiphyllidæ;* and *Syringopora*, Goldf., is regarded as a Rugose Coral, allied to *Lithostrotion* or *Diphyphyllum*. I shall have occasion to notice many of the views expressed by Dr Lindström in greater detail in dealing with the families and genera of the Palæozoic Tabulate Corals; and the general results of his investigations will be best understood if I append here the following list, in which the various genera of the "*Tabulata*" of Edwards and Haime are referred to what Dr Lindström considers to be their true place in the zoological system :—

Name of Genus.	To be removed to
Millepora, . . .	*Hydrozoa ?*
Heliopora, . . .	*Alcyonaria* (Moseley).
Polytremacis, . . .	*Alcyonaria*.
Heliolites, ...	*Heliolitidæ* (special family).
Fistulipora, . . .	Some species to *Heliolites;* others to the *Polyzoa*.
Plasmopora, . . .	*Heliolitidæ*.
Propora, ...	*Heliolitidæ* (probably inseparable from *Plasmopora*).
Lyellia, ...	*Heliolitidæ*.
Axopora, ...	*Hydrozoa ?*
Battersbyia, . . .	*Astræidæ* (Duncan).
Favosites / *Emmonsia* . . .	Sub-family *Favositinæ* of the *Poritidæ*.
Michelinia, . . .	*Cystiphyllidæ*.
Alveolites, ...	Partly *Favositinæ*, partly *Polyzoa*.
Rœmeria / *Koninckia* . . .	*Favositinæ*.
Chætetes / *Monticulipora* / *Dania* / *Stellipora* . .	*Polyzoa*.
Dekayia, ...	*Polyzoa ?*
Beaumontia, . . .	*Favositinæ*.
Labechia, ...	*Hydrozoa*.
Stylophyllum, . . .	*Hydrozoa ?*
Halysites, ...	*Heliolitidæ*.
Syringopora, . . .	Vicinity of *Lithostrotion* and *Diphyphyllum*.

Name of Genus.	To be removed to
Thecostegites, ...	*Heliolitidæ.*
Chonostegites, ...	*Michelinia.*
Fletcheria, ...	*Cystiphyllidæ.*
Pocillopora, ...	*Oculinidæ* (Verrill).
Cœnites, ...	*Polyzoa ?*
Seriatopora, ...	*Oculinidæ ?*
Thecia, ...	*Heliolitidæ ?*
Columnaria, ...	*Cyathophyllidæ.*

In a paper published by M. G. Dollfus in 1875 (Comptes Rend., t. lxxx.), the *Heliolitidæ* are regarded as unquestionably the representatives of the recent *Milleporidæ*—a view which Mr Moseley's researches have rendered altogether untenable; and the *Pocilloporidæ* are regarded, along with the preceding, as *Hydrozoa*—an opinion which the researches of Professor Verrill have sufficiently disproved. *Syringopora*, *Halysites*, *Aulopora*, and allied forms, are regarded as being either *Polyzoa* allied to *Hippothoa* and *Idmonea*, or else *Alcyonaria*. The family of the *Chætetidæ* is considered as having a direct relationship with the Jurassic *Polyzoa* of the genus *Heteropora* and the Cretaceous *Radiopora*. The *Favositidæ* are regarded as most probably truly referable to the *Polyzoa*, the "mural pores" being compared with the intercellular pores of certain *Escharæ* and *Lepraliæ*, and of some of the Cyclostomatous *Polyzoa* (*Fungella* and *Heteroporella*). It is clear, however, that the author's conception of the real structure of the *Favositidæ* has been grounded upon very imperfect materials. Lastly, *Dendropora* and *Trachypora*—which we now know to be true members of the *Favositidæ*—are placed among the *Polyzoa*, and are regarded as allied to *Hornera*.

In 1876 Mr Moseley published his exceedingly important papers on the anatomy of the recent *Millepora* and *Heliopora* (Notes on Two Species of Millepora, &c., Phil. Trans., 1876; Structure of a Species of Millepora occurring at Tahiti, Ann. and Mag. Nat. Hist., 1876; Structure and Relations of the Alcyonarian Heliopora cærulea, Phil. Trans., 1876), which at once threw a flood of light upon the subject of the structure and affinities of the Palæozoic "*Tabulata*." I shall have again to refer to the investigations of Mr Moseley, as published in the above-mentioned and later memoirs; and I shall merely say here that their general result was to complete the disintegration of the "*Tabulata*" of Edwards and Haime, and to fairly remove from the *Zoantharia* certain groups that had previously been referred to this order of the *Actinozoa*. Thus, *Millepora* and its allies, as formerly asserted by Agassiz, are definitely proved to be true *Hydrozoa*, in which class they form, with the *Stylasteridæ*, the new order of the *Hydrocorallinæ; Heliolites* and its numerous allies, instead of being relations of *Millepora*, are shown conclusively to be *Actinozoa*, but to be at the same time referable to an unsuspected order of this class—namely, to the *Alcyonaria;* while various familiar types of the Palæozoic "*Tabulata*" are brought by these discoveries into more or less probable relationships with either the *Hydrozoa* or the *Alcyonaria;* and light of the most important character is afforded as to certain structural features in the Palæozoic types, which have hitherto proved obscure or inexplicable.

In the article "Corals" in the 'Encyclopædia Britannica' (9th ed., vol. vi., 1877), I gave a short account of the then existing state of our knowledge as to the structure and affinities of the "Tabulate" Corals. In this article the researches of Moseley are accepted; the *Favositidæ* are referred with some doubt to the Perforate *Zoantharia;* the *Chætetidæ* are separated from the *Favositidæ*, and regarded as possibly *Alcyonarian;* the *Syringoporidæ* are shown to have affinities with the *Favositidæ;* and the conclusion is arrived at, that if any forms can be retained as a "Tabulate" order of the *Zoantharia*, it is probably those represented by *Syringopora* and *Halysites*, with their allies.

Lastly, Professor Zittel (Handbuch der Palæontologie, Bd. i. Lief. ii., 1879) accepts in the fullest sense the abolition of the "Tabulata" of Milne-Edwards and Haime, and disposes of the members of this group in different directions. *Millepora* and its allies are placed, as is proper, in the *Hydrozoa*—as also, with less reason, is *Labechia;* the family of the *Favositidæ* is referred, as is also probably correct, to the Perforate Corals, and is regarded as a sub-family of the *Poritidæ*, *Koninckia* being removed from it, and placed with *Alveopora* in another sub-family (the *Alveoporinæ*) of the same group; *Syringopora*, *Aulopora*, *Halysites*, and their allies, are placed (without sufficient reasons adduced) among the *Alcyonaria*, in the family of the *Tubiporidæ*; and the *Chætetidæ* are entirely excluded from the *Actinozoa*, being presumably regarded as truly belonging to the *Polyzoa*.

The preceding historical sketch is necessarily extremely brief and imperfect, the limited space at my disposal not allowing it to be otherwise; but it will be sufficient to show the principal tendencies of the more recent researches of naturalists and palæontologists with regard to the old group of the "Tabulate Corals." These researches, though still incomplete, are so far advanced that the abandonment of the "*Tabulata*" as a distinct group of the *Zoantharia* can hardly be avoided; while the removal elsewhere of some of the principal forms previously included under this head is already a fact accomplished. It is, indeed, now quite clear that the chief character relied upon by Milne-Edwards and Haime, in their definition of the "*Tabulata*"—namely, the presence of "tabulæ"—is one of very limited classificatory value. Thus, tabulæ occur in *Pocillopora*, *Cyathophora*, *Cœlastræa*, *Clausastræa*, and occasionally in *Lophohelia*, among the *Zoantharia Aporosa*; in *Alveopora*, and the allied *Favositipora*, among the recent *Zoantharia Perforata*; in *Heliopora* and its allies, in the *Alcyonaria*, as well as occasionally in *Tubipora*; in the great majority of the Rugose Corals; in *Millepora* and its allies among the *Hydrozoa*; and lastly, in a few extinct types of the *Polyzoa* (*e.g.*, *Radiopora* and *Heterodictya*). The mere fact of the occurrence of tabulæ in so many forms of such diverse zoological affinities, is sufficient proof that these structures cannot be used in forming a classification of the Corals; but it is at the same time conclusive that the "tabulæ" of these different types, though undistinguishable in appearance and performing identical functions, cannot be precisely and in all cases homologous structures. With regard to the "tabulæ" in the true *Actinozoa*, Professor Verrill concludes that "they are formed after each discharge of ova: the vacuity thus produced, being useless, is cut off from the visceral cavity above it by the formation of a septum. Therefore, if the eggs be discharged from all the radiating chambers simultaneously, or if from any other cause the polyp abandons all the chambers simultaneously, it is obvious that a complete septum or transverse plate will be formed across the entire tube; but if the eggs be discharged at different times from the ovaries occupying the various radiating chambers, the septa formed below them in the different chambers will not be coincident, or exactly at the same level in all. It would seem, therefore, that the existence or non-existence of complete transverse plates is simply a matter of periodicity in the discharge of ova" (Amer. Journ. Sci. and Arts, ser. 3, vol. iii. p. 187). Dr Lindström has further adduced a considerable body of evidence in support of the view that the "tabulæ" are only a modification of the endothecal "dissepiments" (Ann. and Mag. Nat. Hist., ser. 4, vol. xviii. pp. 2, 3). That this is the case in certain instances (such as *Cœlastræa*, Verrill) seems quite unquestionable; and it is indeed easy to see how the simultaneous production of dissepiments in all the intermesenteric chambers, at one level, would give rise to a structure entirely undistinguishable from a "tabula." There are, however, some considerations which should not be lost sight of, before it is concluded that the "tabulæ" of the tabulate *Actinozoa* are merely modified interseptal dissepiments. Thus it is to be remembered that in the Rugose Corals there is generally a simultaneous development of *both* these structures, and that the "tabulæ" are best developed in the axial region of the visceral chamber, into which the septa either only penetrate slightly (*Diphyphyllum*) or do not enter at all (*Amplexus*), and in which, therefore, "dissepiments" are either scanty or totally absent. Again, in various members of the *Favositidæ*, the septa are obsolete; and there are therefore necessarily no "interseptal dissepiments," in the ordinary acceptation of this term, though the "tabulæ" are well developed. Moreover, it begs the question at issue to speak of the vesicular plates of the *Cystiphyllidæ* as being of the nature of "crowded and regular horizontal *dissepiments*," which simulate "tabulæ;" since it is just as likely that they are crowded and anastomosing *tabulæ*, which simulate "dissepiments." In the entire family of the *Chætetidæ* (assuming these in the meanwhile to be *Actinozoa*) the "tabulæ" are well developed; but there are no septa, and therefore no "dissepiments," unless the latter are represented by the tabulæ. Lastly, in the *Helioporidæ* it has been shown by Mr Moseley that the so-called septa are not homologous with the septa of the *Zoantharia;* and it is therefore improbable that the well-developed tabulæ of the former should be homologous with the "interseptal dissepiments" of the latter.

Whatever may be, however, the nature of the "tabulæ" in the various groups of *Actinoza* which possess them, and whether or not they are always periodic partitions formed after the discharge of the ova (Verrill), or mere modifications of the interseptal dissepiments (Lindström), it is clear that they cannot be homologous with the apparently identical structures in certain other sections of the old group of the "Tabulata." Mr Moseley, for example, has shown that the *Milleporæ* are truly *Hydrozoa*, and that their ova are therefore not produced within the visceral chambers. It is clear, therefore, that in these forms the "tabulæ" cannot be modified "dissepiments," and still less partitions formed subsequent to the extrusion of the ova. It must also be admitted that any transverse plates which may be found to intersect the cells of undoubted *Polyzoa* (such as *Heterodictya*, Nich.) must be of a fundamentally different nature to the "tabulæ" of either the "tabulate" *Actinozoa* or of the Millepores, though they may not be distinguishable from these in appearance.[1]

[1] It follows from the above that if the name of "tabulæ" be retained for the transverse partitions found in the visceral chamber of certain *Actinozoa*, it can hardly be said in any strict scientific sense that "tabulæ" are present in certain *Hydrozoa* (*Milleporidæ*) and certain *Polyzoa* (*Heterodictya*). The proper course,

With the abandonment of the "tabulæ" as structures of classificatory significance, the "*Tabulata*" of Milne-Edwards and Haime must necessarily be broken up and undergo redistribution. It remains, however, for consideration, what groups are really included under the old name of "*Zoantharia Tabulata*," and whether or not this name may still be retained, in a restricted sense, for any of the forms originally placed under it. By the investigations of Agassiz, Verrill, Lindström, Duncan, Moseley, Rominger, and others, we have been made acquainted with the true structure and relationships of several of the groups which constituted the old division of the *Tabulata*, and my own researches upon the varied and numerous Palæozoic types have enabled me to throw some light upon the nature and position of some of the others. Our present knowledge is admittedly imperfect; but it would appear that the division of the *Zoantharia Tabulata*, as until very recently understood, comprises about twelve distinct groups of animals. Of these groups, the first two are not known (with any certainty, at any rate) to have had any Palæozoic representatives, and I shall therefore say here what appears to me to be necessary concerning them; while I shall merely summarise the characters of the remaining groups, all of which I shall have to treat of hereafter at greater length:—

I. Milleporidæ.—The corallum in this group is usually foliaceous, lobate, or sub-massive, and it is composed of an extremely porous cœnenchyma, traversed in every direction by tubular canals, which freely communicate with one another, and which also open into the visceral chambers of the polypites themselves. The surface (fig. 1, c) exhibits two sets of apertures, one large and the other small, the larger ones being much the fewest. The large openings (the true "calices") are the mouths of tubes which are crossed by well-developed transverse partitions or "tabulæ" (fig. 1, b), the living animal inhabiting only the outermost of the chambers thus formed.

in fact, would be to give another name to the structures in the two latter groups which *simulate* the "tabulæ" of the first group.

The smaller tubes are similarly "tabulate." No "septa" are present. The living animal of *Millepora* was first examined by Professor Louis Agassiz, as the result of which he pronounced it to be a Hydrozoön, allied to *Hydractinia;* but its anatomy was first thoroughly studied and worked out by Mr Moseley (Phil. Trans., vol. clxvii. p. 117, 1877), who showed that it was in reality the type of a special group of *Hydrozoa*,

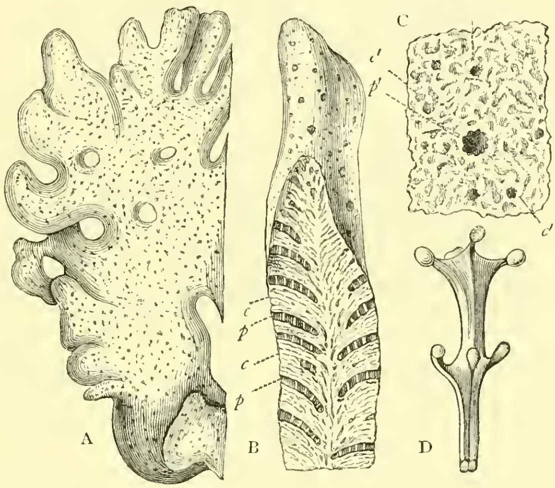


Fig. 1.—A, Portion of a mass of *Millepora alcicornis*, of the natural size; B, Portion of the same, cut open vertically to show the larger tabulate tubes (*p*, *p*), and the spongy cœnosarcal skeleton (*c*, *c*), enlarged; C, Small portion of the surface, enlarged to show the larger and smaller openings (*p'*, *c'*) inhabited by the different zoöids, and the reticulated calcareous tissue of the skeleton; D, Part of a polypite, enlarged, showing two whorls of knobbed tentacles. (A, B, and C are after Milne-Edwards and Haime; D is after Martin Duncan and Major-General Nelson.)

to which he gave the name of *Hydrocorallinæ.* According to the observations of this naturalist, the colony of *Millepora* consists of two kinds of zoöids, differing from one another in size, in structure, and in function. The larger zoöids—the "gastrozoöids" of Mr Moseley—occupy the larger tubes of the coral-lum, and have the form of short polypites, each of which possesses four tentacles, surrounding a central mouth, which opens into the gastric cavity of the zoöid (fig. 2, *a*). Mixed with the "gastrozoöids," or surrounding these in definite systems, are more numerous long and slender zoöids—the "dactylozoöids" of Mr Moseley—which carry numerous clavate tentacles (fig. 2, *b*), and are destitute of any mouth. The "dactylozoöids" perform the functions of prehension for the colony, and supply food to the "gastrozoöids," by which the work of digestion

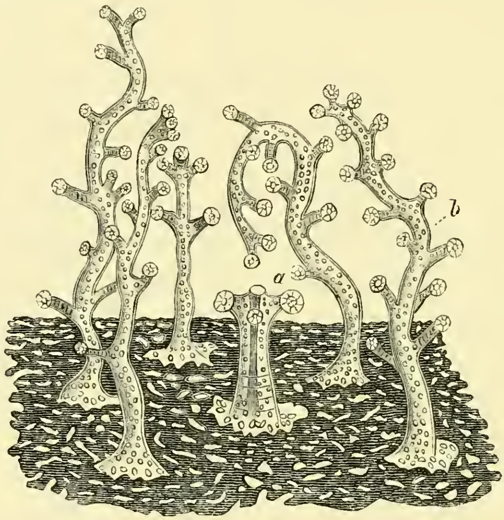


Fig. 2.—Enlarged view of a portion of the surface of a living colony of *Millepora nodosa*, showing the expanded zoöids of a single system. *a*, Central "gastrozoöid;" *b*, One of the mouthless "dactylozoöids." (After Moseley.)

and assimilation is carried on. The nutritive fluid thus elaborated is distributed over the entire colony by means of branched cœnosarcal canals, which communicate with the body-cavities of the zoöids, and ramify in every direction through the spongy cœnenchyma.

Of the genera associated by Edwards and Haime with *Millepora*, *Heliopora* and its Palæozoic and Secondary allies are now known to be referable to the *Alcyonaria; Fistulipora*, M'Coy, belongs undoubtedly to the family of the *Monticuliporidæ;* and the Tertiary *Axopora*, with its fasciculate columella, is of uncertain affinities. *Millepora* itself is only known as a Tertiary fossil, and as living; but the Cretaceous genus *Porosphæra*, Steinm., appears to be closely related to *Millepora*, and therefore also to belong to the *Hydrocorallinæ*.

II. Pocilloporidæ.—The corallum (fig. 3) of *Pocillopora*, the type of this group, is dendroid or foliaceous, composed of numerous tubular corallites, which are surrounded by an imperforate compact cœnenchyma; are provided with six, twelve, or twenty-four septa, sometimes obsolete; and are intersected by complete transverse tabulæ. A rudimentary columella is present. The animal of *Pocillopora* has been examined by Professor Verrill (*loc. jam cit.*), who describes the polypes as being "exsert in expansion, with a regular circle of twelve nearly equal, stout, tapering tentacles surrounding the circular disc; and twelve internal, radiating, fleshy lamellæ show through the disc. Thus they closely resemble the polypes of *Stylophora*, *Porites*, and *Madrepora*, which are among the most typical of the true polypes. The existence of stellate cells

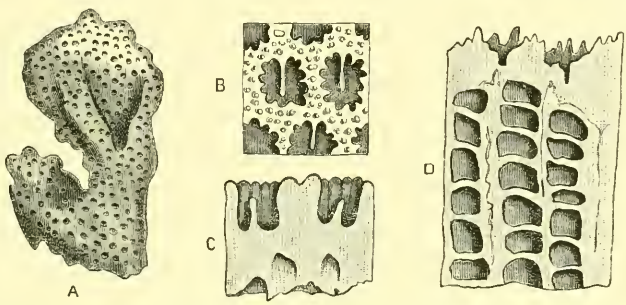


Fig. 3.—A, Portion of the corallum of *Pocillopora aspera*, var. *lata*, Verrill, of the natural size; B, Part of the surface of same enlarged; C, Section of the corallites of the same, showing the columella, enlarged; D, Vertical section of the same, enlarged, showing tabulæ. (After Dana.) Recent.

with six or even twelve well-developed radiating septa in several species of *Pocillopora* (*e.g.*, *P. elongata*, Dana, *P. plicata*, D., *P. stellata*, V.), should be sufficient evidence that such Corals have no Acalephian affinities whatever, even without the conclusive evidence derived from a study of the living polypes" (Amer. Journ. Sci. and Arts, ser. 3, vol. iii. p. 191).

It cannot be doubted, then, that *Pocillopora*, Lam., is a true Aporose *Zoantharian*, most nearly allied to the *Oculinidæ;* but there is some doubt as to the forms which should be associated with it, since in none of the allied types are we acquainted with the structure of the animal itself. The corallum of *Seriatopora*, Lam., however, so closely resembles that of *Pocillopora* in its general structure, that this genus must almost certainly be placed alongside of the latter, even if not actually united with it, as proposed by Professor Martin Duncan. We may thus abolish the family *Seriatoporidæ*, of which *Seriatopora* was the type. The genus *Pocillopora* is Recent and Kainozoic, and it is questionable if any fossil forms of *Seriatopora* are known. It may at any rate be taken as certain that the alleged forms of *Seriatopora* from the Palæozoic deposits will be proved to have different affinities. The Palæozoic genera *Trachypora*, *Dendropora*, and *Rhabdopora*, usually associated with *Seriatopora*, Lam., are, again, truly Perforate Corals destitute of a cœnenchyma, and belonging to the *Favositidæ*.

III. FAVOSITIDÆ.—The corallum in this family is of very variable form, but is composed of polygonal or subcylindrical corallites, which are usually in close contact throughout their entire extent, and are furnished with well-developed walls. The walls are, however, perforated by a greater or smaller number of rounded apertures—the "mural pores" (fig. 4, B) —by which the visceral chambers of contiguous polypes are placed in direct communication. There is no true cœnenchyma; and the condition of the septa is extremely variable,

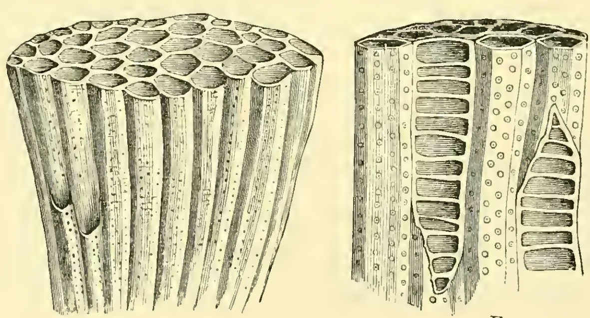


Fig. 4.—A, Portion of the corallum of *Favosites favosa*, of the natural size; B, Portion of four corallites of *Favosites Gothlandica*, enlarged, showing the tabulæ and the "mural pores."

these structures being sometimes obsolete (some forms of *Trachypora*, &c.), sometimes in the form of marginal lamellæ or ridges (*Nyctopora*, Nich.), and most commonly represented by vertically-disposed rows of spinules (most species of *Favo-*

sites). The tabulæ are usually well developed and complete, but they are sometimes imperfect (*Favosites hemispherica*, Yand. and Shum.)

After an extended study of the minute structure of the *Favositidæ*, I cannot doubt but that Professor Verrill and Dr Lindström are right in referring all the Corals usually included under this head to the *Zoantharia Perforata*. I also fully recognise the many points of resemblance between the *Favositidæ* and the *Poritidæ*, but I am not prepared to follow the above-mentioned distinguished authorities in regarding the present group as a mere *sub-family* of the *Poritidæ*. On the contrary, I think that the group *Favositidæ*, as here understood, embraces a large number of types (mostly Palæozoic), all of which are more or less allied to the *Poritidæ*, and some of which may perhaps be capable of final removal to the latter family, but which really represent a series of separate though allied groups. The reasons for this opinion will be stated at greater length hereafter. I need only say here that there is not the slightest ground, in my opinion, for regarding the *Favositidæ* as anything but true *Actinozoa*, or for removing them from the order of the *Zoantharia*. They are not connected with the *Heliolitidæ* by any links sufficiently close to lead us to suppose that they are *Alcyonaria*; and the hypothesis of Dollfus (Comptes Rend., t. lxxx., 1875), that they are truly referable to the *Polyzoa*, hardly requires serious refutation.

IV. Columnariadæ.—Under this head I provisionally place a few Palæozoic Corals, of which the only typical and undoubted examples known to me are *C. alveolata*, Goldf. (*Favistella stellata*, Hall), and *C. calicina*, Nich. Both of these have coralla composed of polygonal or subcylindrical corallites, with well-developed compact walls, not penetrated by "mural pores." The septa are lamellar, in two series, those of the longer set extending nearly or quite to the axis of the visceral chamber. There is no columella; and though the corallites may be to some extent disjunct, there is nothing of the nature of a cœnenchyma. The tabulæ are always remarkably well developed. *Columnaria? Halli, mihi* (the *C. alveolata* of American palæontologists), may be temporarily included in this group, though there are grounds for believing that the walls of its corallites are perforated, and its septa are of the marginal character of *Nyctopora Billingsii*, Nich., which has unquestionable "mural pores," and must therefore be placed among the *Favositidæ*. We may also provisionally place in or near the *Columnariadæ* the singular genus *Lyopora*, Nich. and Eth. jun., though it differs from the typical *Columnariæ* in the great thickness of its walls and the very rudimentary condition of its septa.

As to the precise position of the typical *Columnariæ* in the zoological series, it does not seem at present possible to speak with anything like certainty. The typical forms of the group exhibit certain curiously Rugose features in the disposition of the septa, and may really form a special type of the *Rugosa*. On the other hand, they present some conspicuous points of resemblance to the *Astræidæ* among the *Zoantharia Aporosa*.

V. Syringoporidæ.—In this group the corallum is fasciculate (figs. 5-7), commencing in the form of a creeping stoloniferous network, which sends up vertical and more or less cylindrical corallites, which are never in absolute contact, ex-

Fig. 5.—*Syringopora reticulata formis.* Silurian.

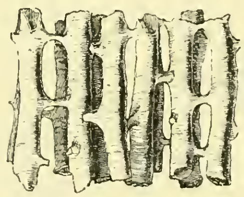


Fig. 6.—*Syringopora verticillata.* Silurian.

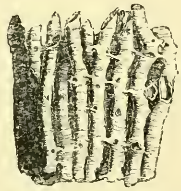


Fig. 7.—*Syringopora Dalmani.* Silurian.

cept, perhaps, at quite limited intervals, and are enclosed by strong compact walls. The visceral chambers of contiguous corallites are placed in direct communication by means of hollow connecting-processes. Septa, of a spiniform and rudimentary character, are present as a rule. The tabulæ are well developed, more or less funnel-shaped, and sometimes giving rise to an axial tube in the median line of the visceral cavity. There is no columella. The entire group, so far as known, is confined to the Palæozoic period.

It is probably impossible, with our present knowledge, to assign an absolutely final place to the *Syringoporidæ* in the zoological series. I am quite unable to agree with the opinion held by Dana, Hæckel, and Zittel, that the true place of *Syringopora* and its allies is in the immediate neighbourhood of the recent *Tubipora;* as I can see nothing but resemblances of an analogical nature between these two genera. Nor can I accept the view advocated by Lindström (Ann. and Mag. Nat. Hist., ser. 4, vol. xviii. p. 14), that *Syringopora* is truly a Rugose Coral, with relationships to *Lithostrotion* and *Diphyphyllum.* Nor, again, am I at present inclined to admit that the Corals usually grouped together under the generic titles of *Aulopora* and *Cladochonus* (= *Pyrgia*, E. and H.) are really nothing more than young forms of *Syringopora;* though I fully grant that the immature stages of the latter may be undistinguishable from the fully-grown condition of the former. On the contrary, I am upon the whole disposed to think that the real relationships of the *Syringoporidæ* are with the *Favositidæ*, and that they should therefore find a place, though a special one, in the series of the *Zoantharia Perforata.* I regard the connecting-tubes (when present, as apparently they are not invariably) as being the homologues of the "mural pores" of the *Favositidæ;* and the curious genus *Syringolites*, Hinde, which I shall subsequently describe, affords an unquestionable link between these two groups. This singular type, in fact, possesses the infundibuliform tabulæ, and even the axial tube, of certain *Syringoporidæ*, along with the polygonal, contiguous corallites, and the serially-disposed "mural pores," of the *Favositidæ.* The septa of *Syringopora* are furthermore of the spiniform and rudimentary character so distinctive of the *Favositidæ;* and there is no solid reason, so far as I am aware, for regarding them as being really of the nature of the "pseudo-septa" of certain Alcyonarians.

VI. Auloporidæ.—This group is at present in such a totally chaotic condition, that it is almost impossible to come to any positive conclusion as to its true relationships or as to the forms which it may contain. The genera *Aulopora* and *Cladochonus* (= *Pyrgia*) were, as is well known, raised by Milne-Edwards and Haime to the rank of a distinct sub-order of the *Zoantharia*—the *Z. Tubulosa* (Pol. Foss. des Terr. Pal., 310, 1851)—having been previously placed by them in the *Alcyonaria*. The alleged characters of the family are, that the pyriform corallites are destitute of "tabulæ," and possess nothing but vertical striæ representing the septa, while there are no mural pores or connecting-tubes by which the visceral chambers of contiguous corallites are placed in direct communication. Taking *Aulopora* itself (fig. 8, A) as the type of this group, the corallum is creeping, and attached by the whole of its lower

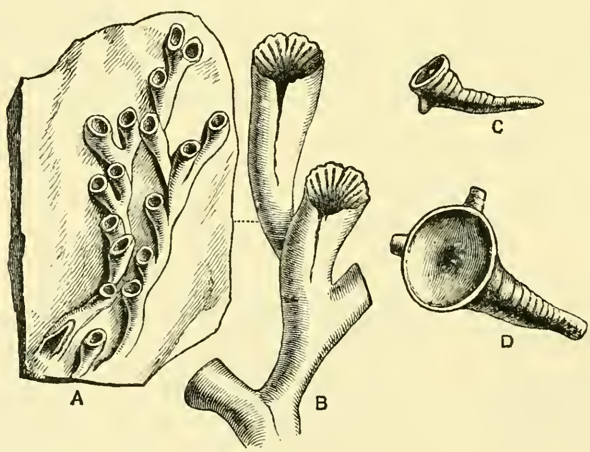


Fig. 8.—A, Portion of the corallum of *Aulopora tubæformis*, Goldf., from the Devonian of the Eifel, of the natural size; B, Two corallites of the same enlarged, showing septal striæ; C, *Cladochonus* (*Pyrgia*) *Michelini*, E. and H., Carboniferous, of the natural size; D, The same slightly enlarged, showing the interior of the calice.

surface to some foreign body. The basal stolons divide and send up the tubular or trumpet-shaped corallites, the terminal portions of which are free and erect; but in no case is the process carried to the extent of producing a fasciculate corallum. The tubes are for the most part not in contact with one another, and there is no evidence of the existence of "mural pores" in such parts of their extent as they may be actually contiguous. The septa are reduced to marginal striæ; and horizontal complete tabulæ are known to be present in certain forms, though they have not yet been detected in others.

It is well known that the basal and young portion of the corallum of *Syringopora* is in the form of a creeping stoloniferous expansion, almost undistinguishable from the adult colony of *Aulopora* in *appearance*. This fact has led high authorities to the belief that the genus *Aulopora* has no existence, and that it is merely based upon young colonies of *Syringopora*. This view of the subject appears to me to be untenable—with our present knowledge—and I think *Aulopora* to be really quite distinct from *Syringopora*. I base this belief upon the fact that the corallum in *Aulopora* is always prostrate and parasitic, never becoming erect; that there are no traces of hollow connecting-processes between the corallites; and that the tabulæ (when known to be present) are horizontal, or if infundibuliform, do not give rise to an axial tube. There is also the strong geological argument for the distinctness of the genus, that formations abounding in *Syringoporæ* (such as the Carboniferous Limestone series of Britain) are almost (in most places wholly) destitute of *Auloporæ;* whereas the latter are extremely plentiful in deposits (such as the Devonian Limestone of Gerolstein in the Eifel) in which *Syringoporæ* are almost or quite unknown. The genus *Cladochonus*, M'Coy (which is apparently the same as *Pyrgia*, Edw. and H.), seems to comprise forms of different affinities. Some of the species seem to be tabulate, with horizontal tabulæ, and may perhaps be identical with *Aulopora* proper. The *Cladochonus crassus* of M'Coy, however, has an entirely peculiar internal structure, which must remove it altogether from the *Auloporidæ*.

VII. Halysitidæ.—In this group, typified by the common "Chain-corals," the corallum is composed of long cylindrical corallites, united with one another successively on opposite sides of the tubes, so as to give rise to flattened laminar expansions, each composed of a single layer of corallites, these layers frequently anastomosing and uniting with one another (fig. 9, *a* and *b*). Between each pair of corallites, and forming the medium of junction between their opposed faces, is generally a much smaller tabulate tube, with close-set tabulæ (fig. 9, *d*).

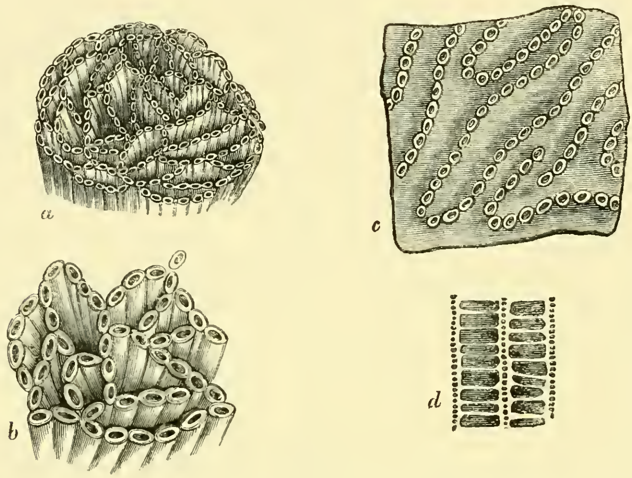


Fig. 9.—*a*, *Halysites catenularia*, Linn., small variety, of the natural size; *b*, Large variety of the same, of the natural size; *c*, *Halysites agglomerata*, Hall; *d*, Section of two corallites of the same, enlarged. Niagara Limestone.

The larger tubes are crossed by complete, generally horizontal tabulæ, which are much farther apart than those in the smaller intermediate tubes. The septa are minute and spiniform, and the walls of the corallites are entirely compact and imperforate, nor are there any connecting-tubes by which the visceral chambers of different polypes are placed in communication.

By Milne-Edwards and Haime the family of the *Halysitidæ* was made to include the *Syringoporæ;* and that there are certain alliances between these groups cannot be denied. I consider, however, that the fact that the polypes of *Halysites* are destitute of any communication with their neighbours is sufficient of itself to warrant the separation of the genus from the *Syringoporidæ*. The latter, as has been seen, may perhaps be regarded as aberrant Perforate Corals; but it is difficult to speak at all positively as to the systematic position and affinities of the *Halysitidæ*, as here restricted. Upon the whole, I am inclined to think that *Halysites* will find its nearest ally in the *Helioporidæ*, which it resembles in one important fact —namely, in the general possession of two sets of tubes (indicating the existence of two sets of zoöids). Moreover, the tubes of the one series are of large size, with remote tabulæ; while those of the other set are small, and have close-set or vesicular tabulæ. If this conjecture be correct, then *Halysites* must be removed from the *Zoantharia* to the *Alcyonaria* (a course which several authorities have already followed); but it will in any case form the type of a distinct group.

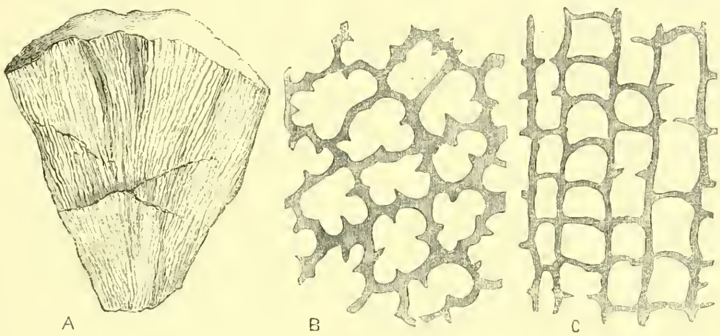


Fig. 10.—A, Fragment of the corallum of *Tetradium minus*, Safford, from the Lower Silurian of North America, of the natural size; B, Transverse section of the same, enlarged ten times, showing the petaloid form of the tubes and the short septa; C, Vertical section of the same similarly enlarged, showing the tabulæ.

VIII. Tetradiidæ.—This group includes only the singular Silurian genus *Tetradium*, Dana, in which the corallum is massive, and is composed of polygonal or subcylindrical corallites of great length, and closely contiguous. No "mural pores" or other openings in the walls are present. The tabulæ are numerous and complete, and the septa are few in number, typically four, short, and seeming as if formed by inflections of the wall (fig. 10). Most of the examples of *Tetradium* have the form and general appearance of *Chætetes radians*, Fischer, and its allies; but Safford (Amer. Journ. Sci. and Arts, ser. 2, vol. xxii. p. 236, 1856) records the occurrence of specimens in which the corallites are united in single intersecting series, as in *Halysites*, and Billings has figured similar forms (Geol. of Canada, fig. 71, *b*). Professor Safford regarded the genus as referable to the *Rugosa*, on account of the quadripartite character of the septa; but the relations of the genus to *Halysites* were pointed out by Mr R. Etheridge, jun., and myself (Ann. Nat. Hist., ser. 4, vol. xx. p. 163). It approaches *Halysites* in its long tubular corallites, its imperforate walls, and occasionally in its mode of growth; but its peculiar septa, and the want of smaller tubes among the larger ones, would show it to be the type of a special group. Its septa are much more like those of *Heliolites* than of *Halysites*, looking as if they were formed by inflections of the wall inwards along its whole length; and I think that the genus will probably have to be referred to the *Alcyonaria*, though I know of no group of this order to which it could be definitely referred.

IX. Thecidæ.—This group comprises only the singular Silurian genus *Thecia*, Edw. and H., the corallum of which forms laminar expansions, covered below by an epitheca, and having the calices placed upon the upper surface. The tubular corallites cannot be said to be bounded by distinct proper walls; but they are embedded in and surrounded by a dense tissue composed of minute polygonal vertical tubuli, which normally open on the surface by very small and irregular, often stelliform, apertures. A few blunt septal ridges (five to ten in number) project into the visceral chambers of the polypes, which are crossed by irregular but well-developed tabulæ, and likewise often communicate with neighbouring tubes by means of canals passing horizontally through the intervening tissue. The smaller tubuli, which separate the larger corallites, do not appear to be distinctly tabulate.

The structure of this genus is so extraordinary that it must clearly form the type of a special group, as it was made to do by Milne-Edwards and Haime. Nor need we wonder that its anatomy has been so little comprehended, seeing that its real structure can only be made out by means of microscopic sections, and that, owing to the great density of its tissues, even the finest of these leave certain important points obscure. I shall have to deal with the genus at greater length at a later period, and will only say here that it seems to form in some respects a link between the Perforate Corals and the Alcyonarian family of the *Helioporidæ*. It resembles the former in the fact that the visceral chambers of contiguous corallites are placed in communication by a well-developed system of horizontal canals; and, on the other hand, it approaches the latter in the fact that the ordinary polypes are surrounded by what has been generally regarded as a tubular "cœnenchyma," though not truly of this nature. The so-called "cœnenchymal tubuli"—judging from the analogy of the recent *Heliopora*—are really tenanted by special zoöids, and are therefore not truly cœnenchymal. In the possession, then, of a series of large polypes surrounded by a much more numerous series of smaller specialised polypes, *Thecia* agrees with *Heliopora* and *Heliolites;* and the genus is therefore probably Alcyonarian. It differs, however, from the above in the fact that the corallites do not possess distinct walls; the septa of the large tubes are broad and tooth-like, and the interstitial tubuli are apparently destitute of tabulæ, irregular, and opening on the surface by very minute, often stellate, apertures; while the larger polypes are directly connected by lateral canals. These peculiarities fully entitle it to be regarded as the type of a special family.

X. Helioporidæ.—This family has been founded by Mr Moseley (Phil. Trans., vol. clxvi. p. 92, 1876) for the reception of the extraordinary recent *Heliopora*, and the long extinct *Heliolites*, *Plasmopora*, and allied forms. The corallum in this family (fig. 11) is composed of two sets of corallites, a larger and smaller—the latter hitherto, but wrongly, termed "cœnenchymal tubuli." The larger tubes are furnished with delicate septa (generally twelve in number), and are traversed by remote complete tabulæ (fig. 11, c). The smaller tubes everywhere surround the larger ones, have no septa, and are crossed by more numerous tabulæ. *Heliolites* and most of its allies are Palæozoic, *Polytremacis* is Secondary, while *Heliopora* commences in the Chalk and still survives. The true affinities of this singular group of Corals were quite unknown

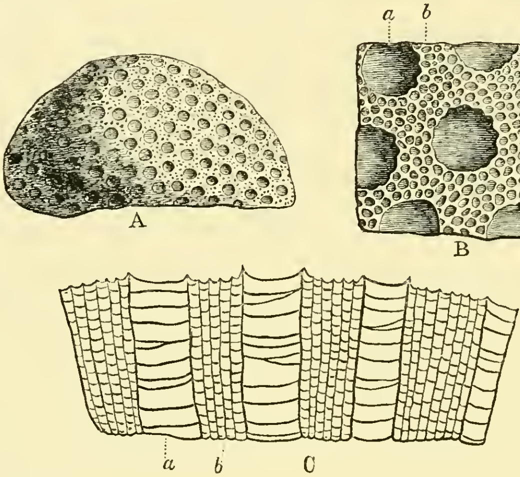


Fig. 11.—A, Small colony of *Heliolites megastoma*, of the natural size ; B, Small portion of the surface of the same, magnified, showing the calices of the large and small tubes (*a* and *b*); C, Vertical section of the same, enlarged, showing the large tabulate corallites (*a*) and the smaller tabulate tubes of the so-called cœnenchyma (*b*).

till Mr Moseley examined the living animal of *Heliopora cærulea*, from which he was enabled to prove conclusively that *Heliopora* and its ancient relatives are truly *Alcyonaria*, and not *Zoantharia*. The corallum in *Heliopora cærulea* is in all essential features entirely similar to that of *Heliolites*. As in the latter genus, the corallites are tubular, with well-developed tabulæ, and having their walls folded in such a manner as to give rise to a variable number (generally twelve) of septal laminæ. The cœnenchyma, so called, is composed of slender tubes, of smaller size than the true corallites, packed closely side by side, crossed, like the corallites, by regular transverse tabulæ, but destitute of septa. The soft parts occupy only the parts of the corallum above the uppermost tabulæ, and therefore only a surface-layer of the colony is actually alive. The polypes are completely retractile, with eight pinnately-fringed tentacles and eight mesenteries. The mesenteries, however, have no correspondence with the septa, which are twelve in number as a rule. The septa are thus seen to be pseudo-septa, and they cannot be regarded as being homologous with the septa of the *Zoantharia sclerodermata*. The so-called cœnenchymal tubes are occupied by sacs lined by the endoderm, which are closed externally, but communicate freely with the body-cavities of the polypes by means of transverse canals; and Mr Moseley suggests, with great probability, that these are really of the nature of rudimentary sexless polypes.

XI. Chætetidæ.—This group is almost certainly made up of very heterogeneous materials, and will undergo disintegration when subjected to a sufficiently searching investigation. As it is even, the lines along which this disintegration will take place can be to some extent discerned. Taking the miscellaneous assemblage of forms at present included in it, no other general definition of the group seems possible than that it comprises very variably-formed corals, composed of contiguous, thin-walled, mostly prismatic corallites, which have imperforate walls, are intersected by well-developed tabulæ, and are destitute of septal laminæ or spines.

Taking the typical members of the *Chætetidæ*—viz., *Chætetes radians*, Fischer, and its few immediate allies—we find that we have to deal with corals in most essential respects similar to those of the typical *Favositidæ*, except that "mural pores" or other openings in the walls are wanting, while there are (in reality) no traces of septa, and the walls of the corallites are completely amalgamated. These differences are of course such as to show that the place of *Chætetes* in the system must be far removed from that of *Favosites*. I am nevertheless satisfied that *Chætetes radians*, Fischer, and the forms immediately related to it, are genuine *Actinozoa*, though I am not able to assign to them any certain place in this class. So far as one can judge, they seem to have more affinities with the *Alcyonaria* than with any other group.

The position of the numerous forms referred to *Monticulipora*, *Fistulipora*, and other allied types (which I shall provisionally regard as a separate group, the *Monticuliporidæ*) is, again, uncertain. Strong evidence has been brought forward to prove that all these forms are *Polyzoa;* but it certainly cannot be said that this conjecture has yet been sufficiently established. I shall consider this subject again at greater length; and I need only add here, that though some of these forms may possibly turn out to be *Polyzoa*, I am strongly disposed to think that the majority will prove to be true *Actinozoa.* This seems to be indicated, as a *general* conclusion, by their close resemblance in many cases to types of an undoubted Cœlenterate nature; by the fact that their coralla are usually or always composed of two sets of corallites, pointing to a heteromorphic condition of their zoöids, such as is highly characteristic of many of the *Cœlenterata*, and especially of certain of the *Alcyonaria;* and lastly, by the fact that no forms possessing their characteristic features *in conjunction* have as yet been pointed out as existing among either recent or fossil *Polyzoa.*

XII. LABECHIDÆ. — This extraordinary group comprises only the anomalous genus *Labechia*, E. and H., at present only known as a Silurian fossil. The skeleton in this genus forms a laminar or expanded mass (fig. 12), the under sur-

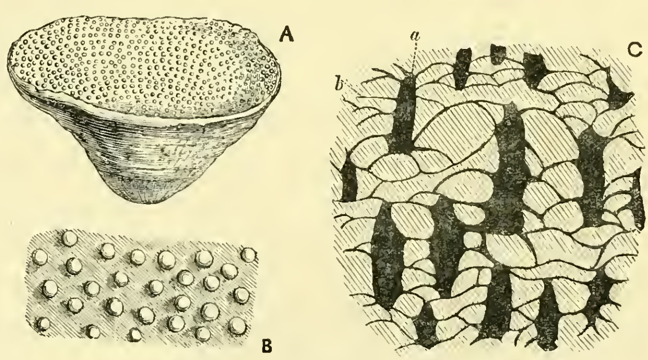


Fig. 12.—A, A small specimen of *Labechia conferta*, E. and H., from the Upper Silurian of Gotland, of the natural size. B, Portion of the upper surface of the same, enlarged. C, Part of a vertical section of the same, enlarged: *a*, the calcareous columns, represented as opaque; *b*, the lenticular vesicles filled with calcite.

face of which is covered by an epitheca, while the upper expanse shows an apparently imperforate surface, rising above which are close-set tubercles. Microscopic sections show that these tubercles are the projecting summits of a series of short, calcareous, and entirely solid, though seemingly primitively tubular, columns, separated from one another by a loose vesicular tissue, formed by the anastomosis of curved calcareous lamellæ. Dr Lindström has strongly supported the view that *Labechia*—originally placed by Edwards and Haime among the *Chætetidæ*—is truly a *Hydrozoön*, allied to *Hydractinia.* The peculiarities in its structure are, however, so numerous, and the apparent total absence of any superficial openings of any kind is so puzzling, that I do not at present see how it can be placed among either the *Hydrozoa* or the *Actinozoa;* nor am I able to give any definite opinion as to its affinities beyond the negative one, that it certainly has no relationships with the *Chætetidæ* proper; while such resemblances as it shows to certain of the *Monticuliporidæ* are largely counterbalanced by special and apparently inexplicable peculiarities of its own.

CHAPTER II.

THE FAVOSITIDÆ.

The principal characters of this family have been already given, and merely need brief recapitulation here. The corallum—whatever its form may be—is usually composed of more or less prismatic corallites, which are generally in complete contact throughout, and have well-developed walls, which are perforated by a greater or less number of "mural pores," or apertures, by which the visceral cavities of contiguous polypes are placed in direct communication. There is no true cœnenchyma, and the condition of the septa is extremely variable, while tabulæ are usually numerous and complete.

As regards the above characters, the general form of the corallum is for the most part either massive or dendroid; but it is sometimes lamellar or frondescent (some types of *Pachypora* and *Cœnites*); and *Romingeria*, Nich., affords an example of a subfasciculate corallum, as to a less extent does also the genus *Vermipora*, Hall. The corallites radiate from the base in the massive forms, from an imaginary axial line in the dendroid types, and from an imaginary axial plane in the frondescent species; and their general form is more or less conspicuously prismatic or polygonal. This is seen in almost all those coralla in which the corallites are closely contiguous (*Favosites*, Lam., *Syringolites*, Hinde, *Michelinia*, De Kon., *Nyctopora*, Nich., &c.) There are species, however, even of such forms as the above, in which the corallites are subcylindrical. In other cases (*Alveolites*, Lam., *Cœnites*, Eichw., and some forms of *Pachypora*, Lindstr.) the corallites are very much compressed and flattened in form, becoming oval or subtriangular in shape. In other cases, again, the corallites are partly contiguous and partly free (*Vermipora*, Hall, *Romingeria*, Nich., *Chonostegites*, E. and H., &c.), and in these cases the corallites are prismatic where in contact, and more or less cylindrical where free. In all the *Favositidæ*, however, the corallites of the colony are in contact in *some* portions of their extent. Wherever contact occurs, the walls of the corallites enter into a certain degree of union, though the extent of this varies in different cases. In most of the *Favositidæ* (including all the typical forms) thin sections show that the corallites always retain their proper walls, however closely amalgamated they may appear to be; so that the boundaries of contiguous tubes are distinctly marked out by conspicuous dark lines. Hence, also, weathered or fractured surfaces usually (though not always) show the *outsides* of the corallites. In one genus only (*Nyctopora*, Nich.) the fusion of the walls of contiguous corallites appears to be complete.

As a general rule the walls of the corallites are not specially thickened; but in certain types (*Pachypora*, Lindstr., *Striatopora*, Hall, *Trachypora*, E. and H., and *Cœnites*, Eichw.), the visceral chambers of the polypes become contracted by the secondary deposition of dense sclerenchyma in concentric lamellæ, the amount of this deposit increasing as the calices are approached. In *Stenopora*, Lonsd., this thickening of the tubes takes place periodically, and the terminal portions of the corallites become thereby periodically annulated on their outer surface, the intervening non-thickened portions being not in actual contact. In some cases this thickening of the walls of the corallites takes place to such an extent (as in *Trachypora*, E. and H.) as to give rise to all the appearances which would be produced if the tubes were embedded in a dense "cœnenchyma;" and the existence of such a structure has often been affirmed. Microscopic sections, however, show that the calcareous tissue separating the actual visceral cavities is of endothecal origin; and I have seen nothing of the nature of a true "cœnenchyma" in any of the *Favositidæ*.

Wherever the walls of the corallites in the *Favositidæ* come in contact with one another, a communication between the visceral chambers of the polypes is effected by means of the "mural pores." These are, typically, very definite apertures, usually arranged in some serial order; and for the most part so small and so widely apart, that they do not appreciably interfere with the compactness and integrity of the wall as a distinct structure. In the Silurian genus *Columnopora*, Nich., the pores are so numerous and close-set that, though regular in form and arrangement, they give the wall a cribriform aspect; in the Cretaceous *Koninckia*, E. and H., the pores are equally numerous, but apparently irregular; while in the Devonian *Aræopora*, Nich. and Eth. jun., the trabecular condition of the wall is quite like that of the typical Perforate Corals. In these forms, therefore, we have a more or less complete approximation to the condition of parts in *Alveopora* (fig. 13), a recent Madreporarian, in which tabulæ are developed. It is hardly

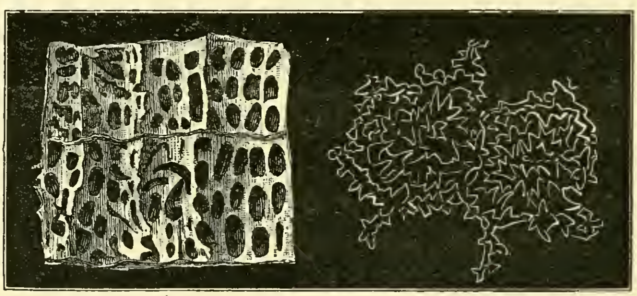


Fig. 13.—A, Vertical section of *Alveopora spongiosa*, Dana, showing the porous walls and the tabulæ and (B) two calices of the same, enlarged. Recent. (After Dana.)

necessary to add that in those members of the *Favositidæ* in which the corallites are partially disjunct, the mural pores only exist in places where the tubes are in actual contact.

The condition of the septa varies extremely in the *Favositidæ*, though it is only in some few forms that these structures appear to be wholly obsolete (*e.g.*, in *Stenopora*, Lonsd.) The most typical condition of matters is, that the septa should be present in the form of vertically disposed rows of longer or shorter spinules. The number of these vertical rows varies, but is most commonly between ten or twenty. In *Cœnites*, Eichw., the septa are reduced to one or more tooth-like ridges, which appear to be confined to the thickened portions of the tubes, close to their mouths; and in *Alveolites*, Lam., a similar reduction of the septa may take place, though the walls are not thickened, and the septa may be wholly wanting. In *Aræopora*, Nich. and Eth. jun., the septa subdivide and anastomose with one another to a greater or less extent; and in *Nyctopora*, Nich., they assume the form of marginal ridges or lamellæ, their typical spiniform character being lost.

Lastly, the visceral chamber in all the *Favositidæ* is intersected by a greater or less number of transverse partitions or "tabulæ." Typically, these tabulæ are "complete"—that is to say, they pass completely across the visceral chamber as so many unbroken horizontal plates; but this is not invariably the case. Sometimes, however (as in *Favosites hemispherica*, Yand. and Shumard), the tabulæ are "incomplete," having the form of tongue-shaped laminæ, which project to a greater or less extent into the visceral chamber, often anastomosing or dividing at their free edges, but not passing quite across the tube. Very commonly "complete" and "incomplete" tabulæ are found coexisting; and this is particularly the case with the comparatively rudimentary and imperfect tabulæ which occur in many species of *Favosites*, and which Dr Rominger terms "squamulæ," assigning to them, as I think erroneously, a septal origin. Finally, there are genera, such as *Michelinia*, De Kon., in which the tabulæ are convex, and unite so freely among one another as to give rise to a kind of subvesicular tissue, not unlike the cellular tissue which fills the visceral chamber of the *Cystiphyllidæ*, though usually much less perfectly vesicular, and interrupted every now and then by a complete tabula.

The zoological affinities of the *Favositidæ*, as has been seen, are with the *Zoantharia Perforata*, and the family may find a place close to the *Poritidæ*. The typical genera of the *Favositidæ* (*Favosites*, Lam., *Alveolites*, Lam., *Michelinia*, De Kon., &c.) are distinguished from the typical *Poritidæ* by the much more complete development of the walls of the corallites, by the reduction of the channels of communication between the visceral chambers of contiguous polypes to comparatively minute and for the most part serially-arranged "pores," and by the presence of well-developed tabulæ. On the other hand, the Cretaceous *Koninckia*, E. and H., and the Devonian *Aræopora*, Nich. and Eth. jun., have the walls so highly cribriform and the tabulæ so greatly reduced that they might perfectly well be placed in the family of the *Poritidæ*, in the vicinity of the recent *Alveopora*, Quoy and Gaim. (fig. 13), and *Favositipora*, Sav. Kent. The link between these extreme forms is effected by such a type as the Lower Silurian *Columnopora*, Nich., which has highly but regularly perforated walls, combined with numerous complete tabulæ and lamellar though rudimentary septa. Another group of the *Favositidæ* is constituted by *Pachypora*, Lindström, *Striatopora*, Hall, *Trachypora*, E. and H., *Dendropora*, Mich., and *Cœnites*, Eichw.—in all of which the cavities of the polypes are more or less contracted by the deposition of sclerenchyma on the interior of the walls of the corallites. Many of these forms consequently assume an appearance extremely similar to that of the recent *Pocillopora*, Lam., and *Seriatopora*, Lam., from which, however, they are fundamentally separated by the absence of a cœnenchyma and by their perforated walls. The genus *Stenopora*, Lonsd., though possessing peculiarly thickened walls, exhibits so many other anomalous features that it cannot be associated with the preceding, but must rather be regarded as a special type. The genus *Syringolites*, Hinde, though in many respects entirely like a *Favosites*, possesses funnel-shaped tabulæ, which give rise to an axial tube in the centre of each corallite —thus forming an interesting link between the *Favositidæ* and the *Syringoporidæ*. The genus *Romingeria*, Nich. (= *Quenstedtia*, Rom.), is, again, curiously transitional between the *Favositidæ* and the *Auloporidæ*, having the mural pores of the former combined with corallites of the general type of the latter. Lastly, the genus *Nyctopora*, Nich., affords a link between the *Favositidæ* on the one hand, and the apparently Aporose group of the *Columnariadæ* on the other hand.

The following is a list of the genera which I include under the *Favositidæ*, with the geological distribution of each. It must be remembered, however, that two or three of these types are at present imperfectly understood, and may prove to have different affinities; while two or three might with almost equal propriety be included in the family of the *Poritidæ;* and future researches will doubtless show that other generic forms will have to be added to the list:—

Genus.	Geological range.
Favosites, Lam.,	Silurian to Carboniferous.
Alveolites, Lam.,	Silurian and Devonian.
Vermipora, Hall,	Silurian and Devonian.
Michelinia, De Kon.,	Upper Silurian (?), Devonian and Carboniferous (perhaps = *Pleurodictyum*, Goldf.)
Pleurodictyum, Goldf.,	Upper Silurian? and Devonian.
Chonostegites, E. and H. (= *Haimeophyllum*, Bill.),	Devonian.
Pachypora, Lindstr.,	Upper Silurian and Devonian.
Striatopora, Hall,	Upper Silurian and Devonian.
Trachypora, E. and H. (with *Dendropora*, Mich., and *Rhabdopora*, M'Coy),	Devonian and Carboniferous.
Cœnites, Eichw.,	Silurian and Devonian.
Columnopora, Nich.,	Silurian.
Koninckia, E. and H.	Cretaceous.
Favositipora, Sav. Kent (? *Poritidæ*),	Recent.
Aræopora, Nich. and Eth. Jun. (? *Poritidæ*),	Devonian.
Rœmeria, E. and H. (? *Syringoporidæ*),	Devonian.
Syringolites, Hinde,	Upper Silurian.
Nyctopora, Nich.,	Lower Silurian.

Genus.	Geological range.
Romingeria, Nich. (= *Quenstedtia*, Rominger),	Devonian.
Stenopora, Lonsd.	Carboniferous and Permo-Carboniferous; (?) Permian also.
Billingsia, De Koninck,	Devonian.
Laceripora, Eichw. (imperfectly known),	Upper Silurian and Carboniferous.
Nodulipora, Lindstr.	Upper Silurian.

An examination of the above list shows that of the twenty-two genera placed in the *Favositidæ* no less than twenty are Palæozoic; so that this group of Perforate Corals enjoyed, therefore, a great extension at this early period. *Koninckia* is the only Cretaceous genus, and *Favositipora* the only recent one; and both might find a place in the *Poritidæ*, near *Alveopora*. Moreover, the group attained its maximum development in Upper Silurian and Devonian times; very few types survive into the Carboniferous period; and perhaps the only one existing in the Permian is *Stenopora*. Indeed the great abundance of these Palæo-Perforate Corals in the Devonian, and their very scanty representation in the Carboniferous, may be taken as one of the strongest of the palæontological proofs that the periods so named are geologically distinct. Lastly, the almost total absence of examples belonging to the *Favositidæ* in Secondary and Tertiary deposits affords an indication that the family is more than a mere sub-group of the now widely distributed *Poritidæ*.

CHAPTER III.

GENERA OF FAVOSITIDÆ.

Genus FAVOSITES, Lamarck, 1816.

(Hist. des An. sans Vert., vol. ii. p. 204.)

Calamopora, Goldfuss, Petref. Germ., vol. i. p. 77, 1826.
Emmonsia, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 246, 1851.
Astrocerium, Hall, Pal. N.Y., vol. ii. p. 120, 1851.

Gen. Char.—Corallum massive or branched, composed of numerous more or less conspicuously polygonal corallites, which are in close contact with one another, but are not amalgamated by their walls. Walls lamellar, perforated with one or more rows of circular "mural pores," by which the separate corallites are placed in communication. Visceral chamber intersected by a greater or less number of complete or incomplete transverse partitions or "tabulæ." Septa obsolete, or represented by vertical rows of tubercles or pointed spines.

The general form of the corallum in this genus is very variable, but the most typical species (*e.g.*, *F. Gothlandica*, Lam.) possess a discoidal, hemispherical, or subglobular skeleton, of a massive character, and often attaining very considerable dimensions. Other forms, again, have the habit of growing in cylindrical or flattened ramose expansions; but most of the so-called "dendroid" species of *Favosites* may be placed under allied generic types. The forms with a discoidal or expanded, and those with a hemispherical or globose corallum, have the lower surface covered with a thinner or thicker, concentrically-striated epitheca, while the calices are placed upon the upper surface. The ramose species possess no true epitheca.

In the massive and more typical species the corallum is fixed by a portion of its base to some foreign body; and from this point the long and prismatic corallites radiate to the surface, those in the centre of the mass being nearly vertical in direction, while those towards the margins become more and more inclined, till they become nearly or quite parallel with the lower surface. New corallites are intercalated by gemmation, as the tubes proceed towards the surface. In the ramose species, the corallites are vertical in the centre of the branches, and gradually bend outwards, in a radiating manner, till they open on the circumference in a direction more or less nearly rectangular to the surface.

The corallites are typically markedly prismatic, usually pentagonal or hexagonal, but they may become more or less cylindrical in whole or in part. The tubes are never united by the actual fusion of their walls, though always in contact, and their walls are typically of no great thickness. In some forms, however, which have been commonly referred to *Favosites*, but which will here be placed under the allied genus *Pachypora*, Lindström, the walls are extraordinarily thickened by a secondary deposit of sclerenchyma, and we find an approximation to this in some species which must still be left in *Favosites* proper. In all the species of *Favosites*, further, the visceral chambers of contiguous corallites are placed in communication by means of a series of circular apertures or "mural pores." These foramina are usually arranged in a regular manner; and though this arrangement is not absolutely constant for, perhaps, any given species, still it is approximately uniform in its character, and thus affords a useful guide in specific diagnosis. Thus, in certain species (*e.g.*, *F. turbinata*, Bill.) the pores are typically uniserial—that is to say, each of the flat faces of the prismatic corallites carries a single row of these apertures. In another series of types (*e.g.*, *F. Gothlandica*, Lam.) the pores are bi-serial, each prismatic face of the corallites carrying two rows, usually placed alternately. In other forms, again, the pores are triserial; while some species (*e.g.*, *F. alveolaris*, Goldf., and *F. aspera*, D'Orb.) are distinguished by the peculiarity that the pores are situated in the angles formed by the prismatic walls of the corallites, instead of on their flat faces. Very commonly the pores are surrounded each by a raised rim or margin, but this may be replaced by a circular pit, or the surface may be quite plane. It should, lastly, be noticed in this connection, that the mural pores are commonly very difficult of detection, even in specimens otherwise perfectly well preserved, by even the closest external examination. Very commonly in calcareous specimens, and sometimes in those which are silicified (especially in those where the silica has assumed the "orbicular" form), the walls of the corallites appear to be completely imperforate under a hand-lens, or even under the microscope. Thin sections, however, when taken parallel with the axis of the tubes, will generally, in some part or another, coincide with the plane of the wall of a corallite, and will then exhibit the mural pores with greater or less distinctness.

The calices of the typical species of *Favosites* are placed parallel with, and not elevated above, the general surface; but in some forms which have not yet been clearly separated from this genus, the calices open more or less obliquely to the surface, and the lower lip of the calice is more or less elevated and projecting. In a few singular types (*F. turbinata*, Bill., *F. Forbesi*, var. *tuberosa*, Rom., *F. clausus*, Rom., &c.) there is the singular feature that the calices in a larger or smaller number of the corallites become closed by a calcareous lid or "operculum." Sometimes this seems to be merely the result of a continuous growth of the epitheca upwards; but in other cases the operculum would seem to be formed by successively deposited concentric layers of calcareous matter, which spring from the margins of the calice, and gradually close in towards its centre. In the species above mentioned—all of which are

Devonian—this curious feature seems to be one normal to the species, being more or less fully developed in all perfect examples. In other species, however, it would appear to be only an occasional phenomenon. Dr Lindström has recognised the same peculiarity—as an occasional thing—in examples of the Upper Silurian *F. Forbesi*, E. and H., and also in his *Vermipora* (*Fletcheria*) *clausa*, from the same formation (Öfversigt af K. Vetensk. Akad Förhandlingar, 1865, Pl. XXX.)

Septa are so commonly obsolete in *Favosites*, or are so rudimentary, that these structures were supposed to be generally altogether absent in the species of this genus. In reality, however, the septa must be regarded as constituting one of the most variable of the structures of a very variable group, and not even specific value can be attached to their presence or absence, or to the degree of their development when present. In some cases there are absolutely no traces of septa, even in specimens examined by means of microscopic sections. More commonly the septa can be recognised as so many longitudinal striæ or ridges on the interior of the tube, each ridge being really made up of a vertical series of tubercles. In other cases, again, the septa have the form of radiating spines, which may reach very nearly to the centre of the visceral chamber, though usually considerably shorter than this. In no case are regular lamellar septa developed. All the above conditions of the septa—namely, their presence as radiating spines in superposed rows, their development as tubercles arranged in ridges, or their total absence—may be occasionally recognised in different examples of the same species, or even in different parts of the same specimen. The number of the septal ridges or spines, when developed at all, is not constant, but appears to be most commonly from twelve to fifteen.

The genus *Astrocerium*, Hall (*loc. cit.*), was founded upon examples of *Favosites*, in which spiniform septa are developed; but the variability of this character renders this division an untenable one.

The tabulæ in the most typical forms of *Favosites* are complete transverse partitions, which are placed at variable distances, and rarely anastomose. Most usually, the tabulæ are approximately horizontal; but they may be markedly convex or concave. Certain species (*F. favosa*, Goldf.) have been distinguished by the curvature of the tabulæ; but this appears to be a very variable character, differing even in different parts of the same specimen, and it cannot be employed in the diagnosis of species. Similarly, it is not uncommon to find that the tabulæ are so bent as to give rise to a series of marginal pits or depressions, which in some specimens are extremely regular, and impart an apparently characteristic appearance to the tubes. This feature, however, is also not constant, even in the same individual, and cannot be looked upon as of specific value.

While the typical species of *Favosites* possess "complete" tabulæ, there are others in which these structures have the form of imperfect plates, which extend into the visceral chamber transverse to its axis, but do not divide it into a succession of completely separate vertical storeys. These "incomplete" tabulæ were regarded by Milne-Edwards and Haime as being of generic value, and these authors placed all those forms possessing them in the genus *Emmonsia* (*loc. jam cit.*) The fact, however, that it is by no means uncommon to meet with single specimens in which some of the tubes have the irregular and incomplete tabulæ of *Emmonsia*, while others have the regular and complete tabulæ of the type-forms of *Favosites*—the same tube sometimes exhibiting both these conditions in different parts of its course—is quite sufficient to show that the separation of *Emmonsia* as a distinct genus cannot be carried out in practice.

Lastly, there are various species of *Favosites* in which, in addition to, or in the absence of, complete tabulæ, the inner surfaces of the tubes are rendered rough by the presence of numerous horizontal projecting lamellæ, which extend only a short distance into the visceral chamber, and which often have a more or less leaf-like or tongue-like character. These singular structures—the "squamulæ" of Dr Rominger—are particularly characteristic of certain Devonian forms, but they occur also in the Upper Silurian *F. Forbesi.* We cannot, therefore, accept the statement made by Dr Rominger (Foss. Cor. of Michigan, p. 19), that "the Silurian forms differ from the Devonian *Favosites* by invariably having simple diaphragms, and by the spinulose character of their radial crests." At least one Silurian species of the genus, on the contrary, is known to possess imperfect tabulæ as a variation; and many forms exhibit no septa ("radial crests") at all, or only rows of tubercles. Nor can we accept the view held by Dr Rominger, that the "squamulæ" of certain species of *Favosites* are really of the nature of *septa.* On the contrary, the fact that their direction is one transverse to the axis of the visceral cavity, and that they commonly occupy the entire width of one of the prismatic faces of a corallite, entirely precludes our believing that they can have been situated in the inside of one of the "mesenteries" of the living animal, and is thus fatal to the conception of their septal character. They must, on the other hand, be regarded as a peculiar modification of the *tabulæ* of the more typical species, and they not uncommonly coexist with these.

In no case known to me are the tabulæ of *Favosites* infundibuliform, or invaginated one into the other; and this leads me to say a few words as to the genus *Calamopora* of Goldfuss, and as to the propriety of the course followed by many Continental palæontologists in substituting the latter name for the former. The actual definition of *Calamopora* given by Goldfuss (Petref. Germ., p. 72) is as follows:—

"*Stirps calcarea, e tubis prismaticis parallelis contiguis divergentibus. Tubi diaphragmatibus transversis* (*e siphone prolifero*) *intersepti, et poris lateralibus communicantes.*"

Not only do his subsequent descriptions and figures render it certain that the forms included under this head by Goldfuss are precisely the same as those long before placed by Lamarck under *Favosites*, but he himself admits this; and the only new characters which he gives are to be found in the words "e siphone prolifero," as indicating the structure of the tabulæ. Goldfuss himself, however, in the vernacular description which follows the brief Latin diagnosis, confesses that "nur bei einer Art erscheinen sie" (the tabulæ) "als trichterförmige Proliferation eines Sipho." The one species to which he alludes is his *Calamopora infundibulifera*, which is in all its characters very distinct from the older genus *Favosites* of Lamarck, and which is only very doubtfully referable to the family of the *Favositidæ* at all, since it has never been proved to possess mural pores. Nor can it even be asserted that the tabulæ in this type spring from or form an actual central tube or "siphon"—they simply appear to be funnel-shaped and invaginated. Considering, then, that all the other species included by Goldfuss under *Calamopora* are undoubtedly destitute of the median siphon implied by this generic name, and that most of them are clearly identical with the forms previously designated *Favosites* by Lamarck, it does not appear that there is the slightest ground for the course adopted by some of the most distinguished of living German palæontologists, who still regard *Favosites*, Lam., as a mere synonym of *Calamopora*, Gold.

I shall have occasion, however, to point out subsequently that there really does exist a coral (*Syringolites*, Hinde) which actually possesses the median tube imagined by Goldfuss to be present in his *Calamopora*, and for which, therefore, this name might be retained, if it were at all advisable to try and revive a genus founded upon so many forms of different affinities. The coral in question, however, in no way agrees with any of the forms included by Goldfuss under the head of *Calamopora*—not even with *C. infundibulifera*, now known as *Rœmeria infundibulifera;* and it is fully entitled to receive the new generic designation *Syringolites*, Hinde, under which name I shall briefly describe it later on.

Of the other genera of the *Favositidæ*, *Alveolites*, Lam., *Pachypora*, Lindst., and *Striatopora*, Hall, are probably those which are most difficult to separate from *Favosites* proper. Palæontologists have recently shown a tendency to suppress

Alveolites altogether, as including types of very different affinities; but the name may be advantageously retained, in the meanwhile at any rate, for forms like *A. suborbicularis*, Lam.; though it is difficult to point to any characters which definitely separate these from *Favosites* except their inclined corallites and oblique calices. *Pachypora* and *Striatopora*, again, are hardly separable from the dendroid forms of *Favosites* by anything else except by the thickening of the walls of the corallites near their mouths; and, in fact, even this distinction would fail unless we remove from the latter category, as will here be done, some forms which are usually included in it (such as *F. cristata*, E. and H., and *F. cervicornis*, De Blainv.) The position of *Cladopora*, Hall, I shall consider in dealing with *Pachypora*. *Fistulipora*, M'Coy, can in general be readily distinguished from *Favosites*, both by the existence of two distinct series of corallites, and by the absence in the former of mural pores. There is, however, one species—viz., *Favosites* (*Fistulipora*) *Canadensis*, Bill., from the Devonian of Canada, which ordinarily has all the external features of *Fistulipora*, but which has been shown by Rominger to possess the mural pores of *Favosites*, a fact which I can corroborate from an examination of microscopic sections. Moreover, this transitional form sometimes loses the characteristic of possessing a series of large corallites interspersed among numerous smaller ones, and passes by insensible gradations into a type so similar to the ordinary examples of *Favosites*, that it has been separated by Dr Rominger, as I think without sufficient reason, to constitute a new species under the name of *F. placenta* (Foss. Cor. of Michigan, p. 32).

Michelinia, De Kon., is another close ally of *Favosites*, for I am unable to agree with Dr Lindström in thinking that there is any essential difference in the nature of the mural pores in these two genera (On the Affinities of the Anthozoa Tabulata, Ann. and Mag. Nat. Hist., ser. 4, vol. xviii. p. 12). It differs from *Favosites* almost exclusively in the complex character of its tabulæ.

Syringolites, Hinde, while possessing the general structure and habit of *Favosites*, is entirely separated from it by the fact that the tabulæ are infundibuliform, giving rise to a central tube in the axis of the visceral chamber of each corallite; the genus thus forming a connecting-link between *Favosites* and certain forms of *Syringopora*.

Lastly, *Columnopora*, Nich., is closely allied to *Favosites*, but is distinguished by the less intimate union of the corallites, and by the greater development of the system of mural pores, the walls thus becoming completely cribriform.

As regards the geological range of *Favosites*, it may be stated with certainty that the genus attained its maximum during the Upper Silurian and Devonian periods. It probably existed during the Lower Silurian, though the evidence available on this point is not absolutely satisfactory; and it was certainly continued into the Carboniferous. The existence, also, of a recent coral which is hardly separable from *Favosites* proper—namely, the *Favositipora* of Saville Kent—would indicate that the genus will yet be found in the Secondary and Tertiary deposits, either unmodified or under some allied form. *Koninckia*, E. and H., of the White Chalk, differing from *Favosites* chiefly in its larger and more approximated mural pores, offers one of these desired continuations of this ancient Cœlenterate type; and my friend Professor C. A. White has recently shown me a coral from the Cretaceous deposits of North America, which assuredly could not be separated from *Favosites* otherwise than by the apparent—possibly only apparent—absence of mural pores.

As illustrative species of *Favosites*, I have selected *F. Gothlandica*, Lam., *F. Forbesi*, E. and H., *F.* (*Emmonsia*) *hemispherica*, E. and H., *F.* (*Chætetes*) *Bowerbanki*, E. and H., and *F. clausa*, Rom.—the first three of these being massive forms, while the last is a true dendroid species, and *F. Bowerbanki* offers a transition between these two types.

Favosites Gothlandica, Lamarck.[1]

(Pl. I., figs. 1-6.)

Favosites Gothlandica, Lamarck, Hist. des An. sans Vert., vol. ii. p. 206, 1816.
Calamopora Gothlandica, Goldfuss, Petref. Germ., Pl. XXVI., figs. 3 *a*, 3 *b*, 3 *c*, 3 *e* (cæt. exclusis), 1829.
„ *favosa*, Goldfuss, Petref. Germ., Pl. XXVI., 2 *a*-2 *c*, 1829.
Favosites Goldfussi, D'Orbigny, Prodr. de Paléont., vol. i. p. 107, 1850.
„ *Gothlandica*, M'Coy, Brit. Pal. Foss., p. 20, 1851.
„ *Gothlandica*, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 232, 1851; and Brit. Foss. Cor., p. 256, Pl. LX., figs. 1, 1 *a*, 1854.
„ *Goldfussi*, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 235, Pl. XX., fig. 3, 1851; and Brit. Foss. Cor., p. 214, Pl. XLVII., figs. 3-3 *c*, 1853.
„ *Niagarensis*, Hall, Pal. N.Y., vol. ii. p. 125, Pl. XXXIV., A, bis, fig. 4, 1851.
„ *favosa* (?), Hall, ibid., p. 126, Pl. XXXIV., bis, fig. 5, 1851.
Calamopora Gothlandica, Ferd. Roemer, Sil. Fauna des Westlichen Tenn., pp. 18 and 19, figs. 9-9 *b* and 11, 1860.
„ *favosa*, Ferd. Roemer, ibid., p. 18, fig. 8, 1860.
Favosites Gothlandica, Billings, Canad. Journ., new ser., vol. iv. p. 99, 1859.
„ *Gothlandica*, Nicholson, Report on the Palæontology of Ontario, 1874, p. 45.
„ *favosa*, Nicholson, ibid., 1875, p. 51.
„ *favosa*, Nicholson, Palæontology of Ohio, vol. ii. p. 229, 1875.
„ *favosus*, Rominger, Fossil Corals of Michigan, p. 20, Pl. IV., figs. 1-4, and Pl. V., fig. 2, 1876.
„ *Niagarensis*, Rominger, ibid., p. 22, Pl. V., fig. 1.
„ *Winchelli*, Rominger, ibid., p. 31, Pl. IX., figs. 3 and 4, and Amer. Journ. Sci. and Arts, 1862.
„ *Billingsii*, Rominger, ibid., p. 28.

Spec. Char.—Corallum composite, forming discoidal, spheroidal, turbinate, or hemispherical masses of irregular shape and size, the under surface being usually covered with an epitheca, while the whole of the upper surface is occupied by the calices. Corallites prismatic, usually between one line and one and a

[1] In the list of references appended to this, as well as to the other species subsequently described, I have not attempted to give an absolutely exhaustive synonymy. On the contrary, I have simply given those references which I have myself verified. In some cases, of course, my verification has been based simply upon an author's description or figures, and must therefore be considered merely as an expression of personal opinion. In the majority of cases, however, my determination has been founded upon an examination of actual specimens derived from the same formation as that which yielded examples to the author quoted.

half line in diameter, sometimes less, and often more. Calices regularly polygonal, with thin walls, generally tolerably uniform in size in any given specimen, but always having smaller and younger ones intercalated among those of average size. Walls of the corallites not thickened towards their mouths, sometimes longitudinally striated on their flat faces, and furnished with two (sometimes one or three) rows of mural pores on each prismatic face. Pores alternately placed, surrounded by an elevated margin. Tabulæ complete, rarely inosculating; sometimes incomplete and inosculating in parts of a colony, while complete in others. Septa usually obsolete or irrecognisable, sometimes represented by rows of tubercles or even by well-developed radiating spines.

Obs.—If the forms which I have here admitted under the head of *F. Gothlandica*, be really referable to this form, then it must be allowed that we have to deal here with one of the most variable species of a variable genus. All the above, however (with some others not included in this list), are clearly descendants of a single stock, belonging to the same type-form, differing only in characters of comparatively trivial importance, and for the most part insensibly passing into one another by the intervention of examples possessing intermediate characters. Some of the forms included in the series are so far distinct that they may well retain distinct varietal appellations; but their general relationships are so close that I have thought it best to collect them under a single specific title, rather than to follow some high authorities in treating each as a separate species.

Favosites Gothlandica was originally described from specimens found in the Wenlock Limestone of the island of Gotland (Lamarck, *loc. cit.*), and this name was restricted by Milne-Edwards and Haime to forms occurring in the Silurian, the species not being admitted as a Devonian one. We may therefore properly regard the form which occurs so commonly in the Upper Silurian of Europe, and which palæontologists have so long recognised under the name of *F. Gothlandica*, as the *type* of the species. Examples specifically inseparable from this are, however, found in the Devonian of both the Old and New Worlds; so that the species had a very wide

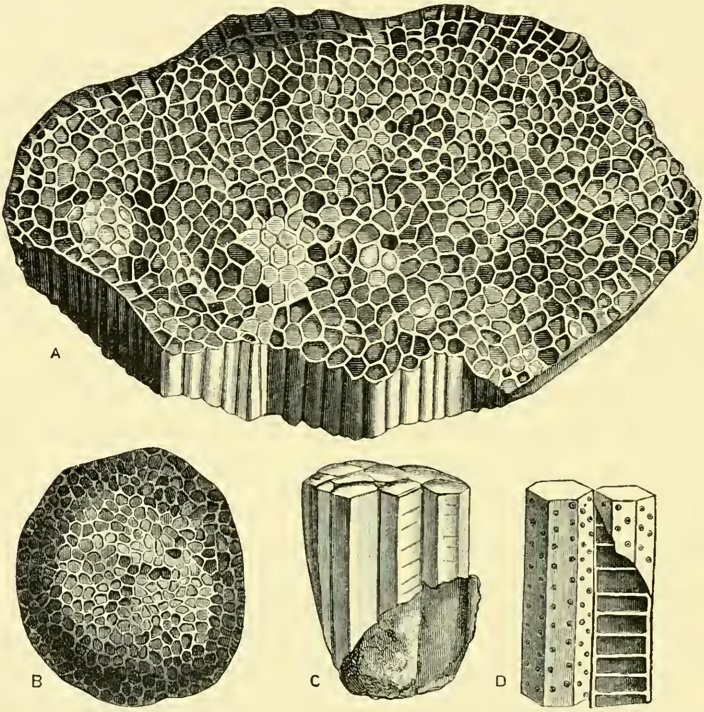


Fig. 14.—A, A specimen of *Favosites Gothlandica*, Lam., from the Niagara Limestone (Wenlock) of Owen Sound, Ontario, of the natural size; B, A small example of the same species from the Wenlock Limestone of Dudley, with comparatively minute corallites, of the natural size; C, Fragment of the same species, with large-sized corallites, from the Wenlock Limestone of Gotland, of the natural size; D, Part of two corallites of the same species, from the Corniferous Limestone (Devonian) of Woodstock, Ontario, slightly enlarged.

range both in space and in time: and there are various other Silurian and Devonian forms of *Favosites* which, as before said, appear to be nothing more than variations of this type-form. Having had the opportunity of making a careful examination, microscopic and macroscopic, of a very extensive series of such forms, collected from the Silurian and Devonian deposits of both America and Europe, I shall in what follows briefly record the results of my researches as bearing upon the structural characters of the species.

The general *shape* of the corallum of *Favosites Gothlandica* is very variable; and its *size* differs still more either in specimens of different ages, or in specimens derived from different formations. Typical examples, from the Upper Silurian, are generally more or less hemispherical or discoidal, with a depressed or slightly convex upper surface (fig. 14, B), the corallum being attached to some foreign body by the centre of its base, which is sometimes drawn out into a short peduncle. The lower surface is also covered with a thin, smooth, or concentrically-striated epitheca, which is commonly worn off in old specimens, though sometimes greatly thickened. Average examples of this kind are usually two or three inches in diameter, sometimes more, with a height of three quarters of an inch to an inch; but I have figured a small example—the youngest I have seen — from the Wenlock Limestone of Dudley, in which the diameter is only about eight lines, with a height of three lines (Pl. I., fig. 3). In the Devonian, the species seems to have assumed a much greater luxuriance of growth, examples of much larger size and of very variable form being far from uncommon. Even the larger specimens, however, seem to preserve the same general type—namely, that of a flattened or hemispherical expansion, attached by a portion of its base, and having its inferior surface covered by an epitheca.

The *corallites* in the typical Upper Silurian examples of *F. Gothlandica* are prismatic, thin-walled, usually pentagonal or hexagonal, and very regular in form and size in any given example (*see* fig. 14, A and B, and Pl. I., figs. 1 and 2). The calices, of course, have a corresponding polygonal form and regularity of outline; and here we seem to reach one of the most distinctive characters of the species. It need hardly be said that in no specimen are the corallites absolutely uniform in size or form. In every individual example, the corallum consists of younger and older, and therefore of smaller and bigger, tubes, and the form of these necessarily varies with variations in the pressure to which each is subjected by its neighbours. Still, the *average* corallites of any particular specimen of *F. Gothlandica* are wonderfully similar in size and shape, being strikingly and often regularly pentagonal or hexagonal, and being further distinguished in thin sections by the thinness of their walls (Pl. I., figs. 1 and 2). In no case do the larger calices assume the rounded character of those of *F. Forbesi*, nor is there the same conspicuous interpolation of small tubes among the larger ones. All the forms which I have here included under *F. Gothlandica* agree in the possession of these regularly prismatic, thin-walled tubes; and this being the case, it remains to be considered if the *size* of the average corallites can be properly considered as a specific character. Most palæontologists have answered this question in the affirmative, and have given names to species separated from the typical *F. Gothlandica* principally or solely on account of the average size of the corallites. Mr Billings, however, long ago gave reasons for thinking that this character was one upon which little stress could be laid (Canad. Journ., new ser., vol. iv.), and my own researches have led me to entirely coincide in this opinion. The examples which I have examined from the Upper Silurian, and about the determination of which I entertain no doubt, show conclusively the small weight that can be attached to the mere size of the corallites. Those from the Wenlock Limestone of Dudley, Longhope, and Benthall Edge, have tubes of an average size of one line, some a little less, some a little more (as stated by M'Coy, and also by Milne-Edwards and Haime in their Monograph of the British Fossil Corals). Those from the Wenlock Limestone of Gotland (kindly sent to me and specifically determined by my friend Dr Lindström) have usually a diameter of from one and a half to two lines (agreeing, on the whole, with the measurements given by Milne-Edwards and Haime in their work on the Polypiers fossiles des terr. Pal.); but in one example the tubes have a diameter of fully three lines (fig. 14, c). Lastly, those from the Niagara Limestone (Wenlock) of North America have mostly tubes of an average diameter of a line and a half, this being sometimes reduced to a line or less, or increased to three lines (Pl. I., figs. 4 and 5). The Devonian examples which I should place in this species, possess an equal variability in this respect; and it is therefore clear that the diameter of the corallites—even when we look only to the *average* tubes of a given specimen—cannot, in the case of *F. Gothlandica*, be regarded as a character of specific value. It is further clear that forms said to be specifically distinct from *F. Gothlandica* must be proved to possess some character of greater constancy and persistence than the mere size of the average corallites, before their claims for separate recognition can be allowed.

The *walls* of the corallites of *F. Gothlandica* usually have the outer surface smooth, or marked with delicate transverse lines, which indicate the position of the tabulæ within. In specimens, however, which cannot be otherwise separated from *F. Gothlandica* (as previously shown by Mr Billings, *loc. cit.*), it is not unusual to find the flat outer faces of the corallites exhibiting one or two longitudinal lines or striæ separating the rows of mural pores. This is the chief or only character of importance which Milne-Edwards and Haime adduce in their definition of *F. Troostii*, as separating this species from allied forms; and its occurrence in well-marked Devonian examples of *F. Gothlandica*—as here understood—would seem to greatly diminish or altogether destroy its value as a test of specific distinctness.

The *mural pores* of all the typical examples of *F. Gothlandica*, both from the Upper Silurian and Devonian, are arranged in a double row upon each of the prismatic faces of the corallites, those of the two rows alternating with one another, and each being separated from its neighbour by a space of about half a line, measured vertically, and surrounded by a slightly raised rim or border (fig. 14, D). These are certainly the general characters of the mural pores in *F. Gothlandica*, and they would serve as admirable guides to a specific determination if they could be at all constantly determined, or were in themselves constant in their occurrence. In a great many specimens, however, even though apparently excellently preserved otherwise, and whether calcareous or silicified, it is quite impossible to determine the arrangement of the mural pores, or even to satisfy one's self of their existence; while microscopic sections afford only a casual help, since they do not show these openings except when and where they happen to coincide with the plane of one of the bounding walls of a corallite. Moreover, the arrangement of the pores does not seem to be absolutely constant, as has been already pointed out by M'Coy and by Billings; though, of course, one is here confronted with the difficulty that it is open to any one to assert that all specimens in which the mural pores are not biserial are *not* specimens of *F. Gothlandica*, but are referable to some distinct species, even though their other characters are identical with those of the former type. I can, for instance, quite corroborate the observation of Mr Billings (*loc. cit.*) that specimens apparently inseparable from *F. Gothlandica* in other respects, occur in the Devonian rocks of North America, in which the prismatic faces of the corallites bear sometimes one, sometimes two, and sometimes three rows of corallites, but for the most part two. Such specimens, according to the views of Milne-Edwards and Haime, ought to be separated from *F. Gothlandica* as a distinct species (*F. Goldfussi*); but it appears to me—though it is only with much diffidence that I differ from the views of such justly distinguished authorities—that the mere fact of such great variation in a single specimen is strong proof that the character itself is liable to much variation, and is not, therefore, of specific importance. With regard to *F. basaltica*, Goldf., which resembles *F. Gothlandica* in general features, but is stated to possess uniserial mural pores, I can express no definite opinion, for I have seen no specimens with this character. Unquestionably, if it were shown that there existed a species of *Favosites* in other respects like *F. Gothlandica*, but *uniformly* possessing but a single row of pores on each of the prismatic faces of the corallites, there would be good grounds for regarding this as a distinct species; but the evidence—or want of evidence—on this point, would at present rather lead one to believe that

M'Coy and Lonsdale were right in regarding *F. basaltica*, Goldf., as a mere variety of *F. Gothlandica*.

The *tabulæ* in *F. Gothlandica* are typically "complete"—that is to say, they pass completely from one side of the visceral chamber to the other. I am able, however, from specimens in my own possession, to entirely corroborate the statement of Mr Billings (Canad. Journ., new ser., vol. iv. p. 102, fig. 2) that single examples, otherwise inseparable from this species, exhibit in certain tubes the complete and comparatively remote tabulæ characteristic of *F. Gothlandica* and its allies; while in others they show the incomplete, close-set, and interlocking tabulæ of *F. hemispherica*, Yand. and Shumard, in virtue of which this latter was raised by Milne-Edwards and Haime to the rank of a distinct genus (*Emmonsia*). In type-specimens of *F. Gothlandica* from the Upper Silurian, there are generally six to eight tabulæ in the space of two lines; but this number may be exceeded, or may not be reached. Ordinarily the tabulæ are more or less flat and horizontal, but they are very commonly conspicuously arched upwards, or more rarely concave. The specimens with convex tabulæ have usually been separated as a distinct species, under the name of *F. favosa*, Goldf.; but a careful examination of a large number of examples has led me to agree with Dr Rominger in thinking that this character is very variable, and that it cannot be relied upon as a specific distinction. Another peculiarity not uncommonly present is, that the tabulæ are bent downwards at their periphery into a series of infundibuliform depressions, giving to the upper surfaces of the diaphragms a plicated or sinuated appearance (Pl. I., fig. 4). There are very often twelve of these marginal depressions; but there may be more or fewer, and they are generally easily to be recognised in thin transverse sections of the corallum (Pl. I., fig. 2).

Lastly, the condition of the *septa* in *F. Gothlandica* is as variable as that of the other elements of the corallum. In most of the specimens the septa are quite obsolete, or can only be recognised by the practised eye as minute inequalities of the inner surfaces of the walls of the corallites, arranged in vertical series. In other cases, the septa have the form of delicate but unequally distributed spinules, which roughen the interior of the tubes. Finally, there are specimens in which the septa are so far developed as to assume the form of regular radiating spines (Pl. I., fig. 5), which may extend nearly to the centre of the visceral chamber, and are usually from twelve to fifteen in number. It is upon examples of this kind that Professor Hall founded his genus *Astrocerium;* but there can be no doubt that these forms with spiniform septa are simply a varietal condition of this and other species of *Favosites.*

Before leaving this species, it may be as well to make a few remarks upon some of the forms which I have included under it. As has been previously said, *F. Gothlandica* was regarded by Milne-Edwards and Haime as essentially a Silurian species, and the corresponding Devonian forms were separated by them under the name of *F. Goldfussi.* This latter species is separated by its authors from *F. Gothlandica* simply upon the ground that its corallites are said to be larger, and that the mural pores are more closely set than in the Silurian form. The size of the tubes (one and a half line) is, however, frequently exceeded by typical Upper Silurian examples of *F. Gothlandica*, and, under any circumstances, cannot be regarded as a character of the smallest specific value, while the mural pores exhibit at least an equal variability. I am therefore quite unable to accept the separation of *F. Goldfussi* from *F. Gothlandica.*

F. favosa of Goldfuss has at first sight more claims for separation from *F. Gothlandica*, the strong convexity of the tabulæ (which led Milne-Edwards and Haime to speak of their possessing a small central columellar eminence) being a very marked feature in some specimens, which otherwise entirely agree with the latter form. The arching of the tabulæ is, however, very variable, and one and the same specimen may exhibit both convex and flat tabulæ; so that in the absence of any distinctive character of a more constant nature, I think

F. favosa, Goldf., must be united with *F. Gothlandica*, Lam., or at most retained as a distinct variety.

F. Niagarensis, Hall, from the Niagara group of North America, seems to be certainly founded upon young specimens of *F. Gothlandica;* and it is possible, as Mr Billings thinks, that *Astrocerium parasiticum*, Hall, and *A. pyriforme*, Hall, really belong to the same species. Upon this latter point, however, I can offer no opinion.

Favosites Winchelli, Rominger (*loc. cit.*), is founded upon forms from the Corniferous and Hamilton groups (Devonian) of North America, which agree with *F. Gothlandica* in all general features, but have large tubes (one and a half to two lines in diameter), which are occasionally somewhat rounded, while there are only three or four tabulæ in the space of two lines. After examining excellently preserved examples from Canada, I am unable to regard this as more than a varietal form of *F. Gothlandica.*

Lastly, the name of *F. Billingsii* has been given by Dr Rominger to a form of *Favosites* which occurs commonly in the Hamilton group of Ontario, and which grows in large convex discs, varying from one, two, or three inches up to as many feet in diameter. The corallum is attached to some foreign body by a point usually placed in the centre of the base, and the entire lower surface is covered by a striated epitheca. The corallites vary from a line to a line and a half in diameter; and though of the same essentially prismatic or polygonal form as in typical examples of *F. Gothlandica*, they are slightly less rectilinear and more irregular in shape and size than in the latter (Pl. I., fig. 6). Dr Rominger states that the mural pores are uniserial, and they often are so; but they are just as commonly arranged in two alternating rows, as in *F. Gothlandica*, and the tabulæ resemble those of that species. I have figured a transverse section of this form for comparison with the typical *F. Gothlandica*, and need only say that as examined in this way the trivial difference in the form of the corallites is much more conspicuous than it is when the calices of the two are compared together. To the supposed peculiarities in its mode of growth, I think no weight can be attached, as *F. Gothlandica* has commonly a similar habit; and there are no other points of separation worth alluding to. Upon the whole, after minutely examining *F. Billingsii*, in the ordinary manner and by means of microscopic sections, I cannot consider it as more than varietally distinct from *F. Gothlandica*, of which it may be regarded as a local variation.

Formation and Locality.[1]—Upper Silurian (Wenlock Limestone), Dudley and Benthall Edge; also near Shalloch Mill, Girvan. Wenlock Limestone, Gotland. Niagara Group (Wenlock Limestone), Owen's Sound and Manitoulin Island, Ontario. Guelph Formation (Upper Silurian), Cedarville, Ohio. Corniferous Limestone (Devonian), Port Colborne, Woodstock, and various other localities in Ontario; also in the same formation, Phelps, State of New York. Hamilton Formation (Devonian), Erie Co., State of New York, and Arkona, Ontario (var. *Billingsii*, Rom.) The species is quoted by Milne-Edwards and Haime from the Caradoc sandstone of Britain (Mon. Brit. Foss. Cor., p. 257); but I have never seen any example from strata of Lower Silurian age. It is generally regarded as one of the most abundant and characteristic of the Upper Silurian Corals; but my own experience would, so far as it goes, be in favour of considering *F. Forbesi*, E. and H., as by far the commoner of the two in the Upper Silurian of Britain, while *F. Gothlandica* appears to attain its maximum in the Devonian.

Favosites Forbesi, Edwards and Haime.

(Pl. I., fig. 7; Pl. II., figs. 1-3; Pl. III., figs. 1, 2.)

Calamopora basaltica (pars), Goldfuss, Petref. Germ., vol. i. p. 78, tab. xxvi., figs. 4 *a*-4 *b*, 1829.

Favosites Gothlandica, Lonsdale, in Murchison's Silurian System, p. 682, Pl. XV., bis, figs. 3, 4, 1839.

" *Forbesi*, Milne-Edwards and Jules Haime, Pol. Foss. des Terr. Pal., p. 238, 1851.

[1] Under this heading I shall, as a rule, only give those localities from which I myself possess specimens. When this rule is departed from, the name of the author on whose authority the reference is given will be appended in brackets.

Favosites Forbesi, Milne-Edwards and Jules Haime, Brit. Foss. Cor., p. 258, Pl. LX., figs. 2 - 2 *g*, 1854.
,, *basaltica* (pars), Billings, Canadian Journ., new ser., vol. iv. p. 106, 1859.
,, *Forbesi*, Nicholson, Report on the Palæontology of Ontario, p. 48, Pl. VII., fig. 8, and Pl. VIII., fig. 4, 1874.
,, *tuberosus*, Rominger, Fossil Corals of Michigan, p. 30, Pl. IX., figs. 1, 2, 1876.
,, *Forbesi* (?), Hall, Twenty-eighth Ann. Rep. on the State Cabinet of N.Y., Pl. IV., figs. 6-15 (not described), 1876.

Spec. Char.—Corallum composite, forming globular, discoidal or clavate masses when young, and becoming when adult more or less irregularly spheroidal, hemispherical, or pyriform in shape, the diameter of the colony varying from less than half an inch up to two, three, or more inches. The colony may be attached to some foreign body by a limited portion of its base, having the whole of the rest of its surface covered by the calices; or the lower surface may be covered by a concentrically-striated epitheca, and the calices may be confined to the upper surface only. The corallites are prismatic, often approximating to a cylindrical form, comparatively thick-walled, of more or less conspicuously unequal sizes, the larger and more cylindrical corallites having a variable number of smaller and more angular tubes intercalated among them. The large tubes vary from one to two lines in diameter (being sometimes less than one line), and the small tubes have a diameter of from one-fiftieth of an inch to half or three-quarters of a line. Mural pores apparently in two or three alternating rows on each prismatic face of the corallites. Septa obsolete, or represented by longer or shorter radiating spines arranged in vertical rows. Tabulæ, typically, complete, but sometimes reduced to or accompanied by rudimentary horizontal laminæ.

Obs.—*F. Forbesi*, E. and H., like *F. Gothlandica*, Lam., is a comprehensive type-form, with well-marked characters, but giving rise to a series of varietal forms, which, from one point of view, may be regarded as distinct species. Regarded in a broad aspect, *F. Forbesi* is distinguishable from *F. Gothlandica*, Lam., and its immediate allies by the conspicuous inequality of the corallites in point of size, the less markedly prismatic and often nearly cylindrical form of the tubes, and the greater thickness of the walls. In the observations which I have to make upon the structural characters of *F. Forbesi*, I shall take the form which occurs in the Wenlock Limestone of Britain and Sweden as the type of the species, and I shall consider the variations of this type as constituting three distinct varieties—viz., var. *Waldronensis*, Nich., *Eifelensis*, Nich., and *tuberosa*, Rom. It is possible that *Calamopora Forbesi*, var. *discoidea*, Roemer (Sil. Fauna of Tenn., p. 19, Pl. II., figs. 10-10 *b*), is a fourth variety; but as I possess no examples of this form, I am unable to offer any opinion on this point.

The normal form of *F. Forbesi*, E. and H., occurs abundantly in the Wenlock Limestone of Britain, and has been very well illustrated by Milne-Edwards and Haime in their great work on the British Fossil Corals (Pl. LX., figs. 2 - 2 *g*). The most noticeable point about this form is the marked difference between young and old examples in the relative sizes of the corallites—supposing, as I think may safely be done, that the specimens in question really represent nothing more than different stages of growth. Young examples (Pl. II., fig. 1) are discoidal, with an inferior epitheca; or they form globular masses, which envelop parasitically the stem of a Crinoid or the branch of some dendroid coral, and have their entire free surface covered by the calices. The large-sized calices are both exceptionally numerous and exceptionally large, their diameter varying from a line up to close upon two lines, while the smaller calices are usually from a quarter to half a line in diameter, and are intercalated in comparatively scanty numbers in the limited spaces left between the large corallites. Transverse sections (Pl. II., fig. 1 *b*) of such specimens show precisely the same features. On the other hand, full-grown examples have the form of hemispherical, spheroidal, or clavate masses, generally two or three inches in diameter, and the inequality of the corallites is much less marked than in the young state (Pl. I., fig. 7). There is a greater proportionate number of *average* corallites; the small tubes are fewer in number and not so conspicuous; and the large tubes open on the surface by actually smaller apertures, the diameter of the larger calices being generally about one line, but sometimes rather less. Still it would be impossible to confound such examples with specimens of *F. Gothlandica*, since the observer has no difficulty in at once recognising the presence of a certain number of tubes, which catch the eye in consequence of their being larger than the others; while the prismatic form of the corallites so characteristic of the latter species is never regularly developed, and the bigger calices have a distinctly circular outline. As regards the internal structure of this form there is little of importance to note. The presence of septa in the form of short spines, vertical striæ, or tubercular ridges, can usually be made out by examining the surface with a lens; and thin transverse sections almost invariably confirm the existence of these structures (Pl. I., fig. 7, and Pl. II., fig. 1 *b*). These septal spines or ridges are, however, always short, and extend but a short distance inwards into the visceral chamber; nor would they usually be recognised at all by a mere naked-eye examination of the surface. Vertical sections (Pl. II., fig. 1 *a*) show the tabulæ to be complete, slender, and slightly flexuous, placed at variable distances apart, six or seven usually occupying the space of two lines. It is specially worthy of note in this connection that Milne-Edwards and Haime have figured an example of this species from the Wenlock Limestone of Wenlock (Brit. Foss. Corals, Pl. LX., fig. 2 *f*), in which the interior of the tubes is roughened by elevated points or ridges, which, though badly figured, entirely correspond in appearance to the "squamæ" which we shall see to be present in *F. Forbesi*, var. *tuberosa*, Rom., from the Devonian of North America, and which I believe to be unquestionably the same in their nature. Whether similar rudimentary tabulæ are present at all commonly in the Upper Silurian forms of *F. Forbesi*, I cannot say; for these structures very rarely reveal themselves in thin vertical sections, and the British examples of this species, so far as I have seen, very seldom exhibit the interior of the tubes. Finally, for the reason just given, I am not certain as to the arrangement of the mural pores in *F. Forbesi;* but in such vertical sections as show these apertures at all, they appear to be biserial or triserial, alternating in contiguous rows, and more closely set than in *F. Gothlandica* (Pl. II., fig. 1 *a*).

Favosites Forbesi, E. and H., var. WALDRONENSIS, Nich.
(Pl. II., figs. 2 - 2 *b*.)
Favosites Forbesi (?), Hall, Twenty-eighth Rep. on the State Cabinet of N.Y., Pl. IV., figs. 6-15.

Corallum forming globular or pyriform masses (Pl. II., 2), varying from half an inch up to two inches or more in diameter, and attached by a broad peduncle, the lower part of which may be covered by an epitheca. Large corallites, varying from one and a half to two lines in diameter, and proportionately very numerous, the small corallites occupying the angular spaces between the former, and varying from a fiftieth of an inch to more than half a line in diameter. Septa apparently obsolete (Pl. II., 2 *a*). Tabulæ numerous, thin, horizontal, usually about seven in the space of two lines (Pl. II., 2 *b*).

This well-marked form, from the Niagara Limestone of Waldron, Indiana, quite resembles the common *F. Forbesi* of the corresponding Wenlock Limestone of Europe in all essential features; and it would be difficult or impossible to mention any characters by which *young* specimens of these two forms (up to half an inch or rather more in diameter) could be separated from one another. The chief peculiarity of the present variety lies in the fact that it preserves in its *adult* condition the distinctions which characterise the young both of itself and of the normal form of *F. Forbesi.* Hence the fully-grown *F. Forbesi,* var. *Waldronensis,* is at once separated by its numerous and exceptionally large corallites, and the comparative paucity of the small tubes, from the adult *F. Forbesi* of the British Wenlock, in which the large tubes are much diminished in number, and there is much nearer approach to a general equality in the size of the corallites. This distinction will be at once evident on a comparison of transverse sections of these two forms (Pl. I., fig. 7, and Pl. II., fig. 2 *a*).

Favosites Forbesi, var. *Waldronensis*, has been beautifully figured by Professor Hall (*loc. cit.*), with a doubtful reference to *F. Forbesi*, E. and H.; but, so far as I know, no description of it has been published. In its internal structure there is no feature of special importance to note, save that there seem to be no traces of septal spines, and the tabulæ are perhaps more regularly distributed and less flexuous than in the normal form of the species. Professor Hall has figured the tubes with biserial mural pores—and so far as I have observed, this is the general arrangement; but there may be an additional row, and the pores seem to be close-set, and somewhat irregular in their distribution.

Favosites Forbesi, E. and H., var. Eifelensis, Nich.

(Pl. II., fig. 3, and Pl. III., figs. 1 - 1 *b*.)

Corallum forming spheroidal or pyriform colonies, from half an inch up to two inches in diameter, but generally an inch or rather more across. Corallites irregularly prismatic, or with rounded angles, and more uniform in size than in typical forms of the species, the larger ones being numerous, but mostly attaining a diameter of no more than a line or three-quarters of a line, while the small tubes are much reduced in numbers. Septa exceptionally well developed, and extending for a considerable distance into the interior of the visceral chamber, in the form of strong blunt spines. Tabulæ horizontal or slightly flexuous, about six or seven in the space of two lines. Mural pores numerous, close-set, apparently biserial or triserial.

I propose this name for a small *Favosites* which I have found to be tolerably plentiful at Gerolstein in the Eifel. Its general appearance (Pl. III., fig. 1) is so closely similar to that of medium-sized specimens of *F. Forbesi* from the Upper Silurian, that the near relationship of the two forms is beyond doubt. There is also the same general disposition of the calices, there being a marked difference in size between different corallites. In this respect, however, the condition of matters resembles that which obtains in *large-sized* colonies of the normal *F. Forbesi* from the Upper Silurian. That is to say, there is an approach to a general equality in size of the tubes, the larger ones not being exceptionally large (mostly from three-quarters of a line to a line in diameter), and being very numerous as compared with the small tubes (Pl. III., fig. 1 *a*). The distinguishing peculiarity of this form, however, is the quite unusual development of the *septa*, which are conspicuously visible even to the unassisted eye, and extend a considerable distance into the cavity of the tubes (Pl. II., fig. 3). In long sections (Pl. III., fig. 1 *b*), the septa are seen to have the form of strong spines, with a broad base, and with a distinct upward inclination. The tabulæ resemble those of the normal form of *F. Forbesi.* The mural pores, as revealed by thin vertical sections, appear to be numerous and close-set, being apparently in two or even in three rows; but I do not think that much stress can be laid upon this character, especially when only known by the, in this respect, partial and imperfect evidence afforded by transparent longitudinal slices.

Favosites Forbesi, E. and H., var. TUBEROSA, Rom.

(Pl. III., figs. 2 - 2 *e*.)

Favosites basaltica (pars), Goldfuss, Petref. Germ., Pl. XXVI., fig. 4 *a* (cæt. exclusis), 1829.
,, *basaltica* (pars), Billings, Canad. Journ., new ser., vol. iv. p. 106, 1859.
,, *Forbesi*, Nicholson, Report on the Palæontology of Ontario, p. 48, Pl. VII., fig. 8, and Pl. VIII., fig. 4, 1874.
,, *tuberosus*, Rominger, Fossil Corals of Michigan, p. 30, Pl. IX., figs. 1 and 2, 1876.

Corallum forming cylindrical or club-shaped, rarely hemispherical masses, varying from an inch up to half a foot or more in length, according to their age. Corallites conspicuously unequal in size, the larger ones being somewhat cylindrical, the prismatic angles of the tubes being obtusely rounded, and varying from a line and a half to a line and three-quarters in diameter. The small tubes are intercalated in the spaces between the smaller ones, and are usually from a quarter to half a line in diameter. Calices often in parts obliterated by an epitheca. Septa represented by blunt tubercular ridges on the inner faces of the walls of the tubes. Tabulæ complete, sometimes not developed in a perfect form, but always either represented or accompanied by numerous close-set transverse ridges or lamellæ ("squamæ"), which are to be regarded as rudimentary tabulæ, and which impart a peculiar rough aspect to the inner surfaces of the corallites.

This form is abundant in the Devonian deposits, and especially in the Corniferous Limestone, of Canada and the United States, and it has a historical interest, as it is unquestionably one of the forms figured by Goldfuss (*loc. cit.*) under the name of *F. basaltica.* The specimen figured by Goldfuss is stated in the text to come from Lake Erie; and the accuracy of the drawing places it beyond a shadow of doubt that it was a silicified example of this form derived from the Corniferous Limestone. Mr Billings, who clearly recognised this fact, appropriated the *name* of *F. basaltica*, Goldf., for the form now under consideration, upon the belief that the other forms included by Goldfuss under the same title were really referable to *F. Gothlandica*, Lam. I have before expressed the opinion that we have not at present sufficient evidence to support this course (Rep. on the Palæontology of Ontario, p. 48). Those forms included by Goldfuss under *F. basaltica*, which have prismatic tubes and uniserial mural pores, *may* turn out ultimately to be a variety of *F. Gothlandica;* but there is not at present any definite proof of this. I preferred, therefore, and still prefer, to retain the name of *F. basaltica*, Goldf.—if it is to be retained at all—for forms which essentially belong to the type of *F. Gothlandica*, but have the mural pores uniserially arranged. The present form, on the other hand, is clearly of the type of *F. Forbesi*, E. and H., with conspicuously unequal corallites, and biserial or triserial mural pores; and the only question, to my mind, is as to whether it should be regarded as a variety of this, or as a distinct species. That it belongs to the same *type-form* cannot be questioned, and I formerly referred it unconditionally to *F. Forbesi*, E. and H., which was to all practical intents and purposes the course followed by Mr Billings, with this difference, that he regarded *F. Forbesi* as a mere synonym of *F. basaltica*, and therefore employed the latter name. Having now made a careful microscopic examination by means of thin sections of both the present form and of typical examples of *F. Forbesi*, E. and H., from the Upper Silurian, I still think that the two are substantially identical; but the former presents so many peculiarities, that it may reasonably stand as a distinct variety. For this I have adopted the specific name given to it by Dr Rominger (*loc. cit.*), who describes it as a distinct species—a view for which I am inclined to think there is as yet hardly sufficient evidence.

In general shape, the corallum of the present form only differs from that of the typical *F. Forbesi*, E. and H., in the general predominance of a cylindrical or clavate, rather than a spheroidal figure. I have given a drawing of the youngest and smallest specimen I have seen (Pl. III., fig. 2), which gives a very good idea of the general form of the corallum, though adult examples may be six inches or more in length. The characters of the corallites are, also, those distinctive of *F. Forbesi* (Pl. III., fig. 2 *a*), there being a very marked inequality in the sizes of the tubes, and the larger ones being more or less strikingly cylindrical, rather than strictly prismatic. The large tubes, however, are of comparatively great size, and are comparatively numerous, while the small tubes are reduced proportionately both in size and numbers—the condition of things thus rather resembling what we see in the *young* of the typical Upper Silurian *F. Forbesi* than in the adult of the same. In calcareous examples from the Hamilton formation of Canada (Pl. III., fig. 2 *b*), the largest tubes are not so numerous, while the small tubes are increased both in numbers and in size; though I entertain no doubt as to the identity between these and the silicified specimens from the Corniferous Limestone of the same region. As regards internal structure, the walls of the corallites are comparatively thick, and the *septa* are represented by a number (ten, twelve, or more) of blunt tubercular ridges on the inner faces of the tubes (Pl. III., fig. 2 *c*). In silicified specimens, the tabulæ generally appear to be wanting (in their ordinary form), or are, at most, present as incomplete transverse partitions; but vertical sections of calcareous examples (Pl. III., fig. 2 *d*) exhibit complete horizontal or slightly flexuous tabulæ of the ordinary type. All the examples of this form, however, have the peculiarity that the interior of the tubes is roughened by a series of close-set projecting transverse ridges or lamellæ, which are best seen in silicified examples, in which the corallites are empty (Pl. III., fig. 2 *c*), but which can be recognised in thin vertical sections of calcareous examples as short uneven lines occupying the interspaces between the regular tabulæ (Pl. III., fig. 2 *d*). These singular and characteristic structures are clearly represented in the specimen of this form from Lake Erie figured by Goldfuss under the name of *F. basaltica* (Petref. Germ., Pl. XXVI., fig. 4 *a*). Mr Billings (*loc. cit.*), while recognising the existence of these lamellæ, regards them as possibly merely the result of a peculiar method of fossilisation, but I hardly think that there is any evidence to support this view. Dr Rominger, if I rightly understand his views, regards these projecting lamellæ (or "squamæ") as being an abnormal form, or representative of the spiniform septa of so many of the species of *Favosites*. In this view, for reasons previously given in speaking of the genus, I cannot coincide. The transverse position, and the often complete extension of these lamellæ across the whole diameter of a tube, are, in my opinion, fatal to the idea that these structures are in any way of a septal nature; and I can only regard them as being essentially of the nature of rudimentary *tabulæ*. The presence, then, of these imperfect tabulæ, is characteristic of the present form; but I must again draw attention to the fact that Messrs Milne-Edwards and Haime have figured (Brit. Foss. Cor., Pl. LX., fig. 2 *f*) a specimen of *F. Forbesi* from the *Upper Silurian*, in which structures of apparently precisely the same nature seem to be present. Upon the whole, therefore, I do not think that the structures in question can be regarded as of specific value, though they constitute a very striking feature in the Devonian variety now under consideration.

Of the other characters of the present form, it is only necessary to allude to two. In the first place, the mural pores have the character, which seems to be the general rule in the less aberrant types of *F. Forbesi,* that they are usually biserial, though sometimes triserial. They are more closely set than in *F. Gothlandica,* and are stated by Dr Rominger to be surrounded by a depression instead of an elevated ring. In the second place, many of the calices in the lower part of the corallum become covered and completely sealed up by an epithecal or opercular membrane, which can hardly be regarded as the result of mere age, since it seems to be present in extremely young examples (Pl. III., fig. 2). It is, however, most conspicuous in the old specimens, in which a variable number of the corallites are always, or almost always, closed in this way (Pl. III., fig. 2 *a*), those at the summit of the colony remaining open. It must be admitted that this peculiarity has not been observed in any of the Silurian examples of *F. Forbesi;* but as it occurs in several of the other species of *Favosites* in the same deposits, I do not think that it can well be regarded as a character of specific importance, being rather the result of local conditions and of environment.

Formation and Locality.—(1.) The typical form of *F. Forbesi* —Wenlock Limestone, Longhope, Dudley, Benthall Edge, and Stoke-Edith; Wenlock Limestone, Gotland.

(2.) *F. Forbesi*, var. *Waldronensis* — Niagara Limestone, Waldron, Indiana, U.S.

(3.) *F. Forbesi*, var. *Eifelensis* — Devonian (Eifler-kalk), Gerolstein, Eifel.

(4.) *F. Forbesi*, var. *tuberosa*—Corniferous Limestone, Port Colborne, and other localities in Ontario; Hamilton group, Arkona, Ontario.

Favosites (Emmonsia) hemispherica, Yandell and Shumard.

(Pl. III., figs. 3 - 3 *b*.)

Favosites alveolaris, Hall, Geol. of New York, p. 157, No. 13, figs. 1 and 1 *a*, 1843.

" *hemispherica*, Yandell and Shumard, Contrib. to the Geology of Kentucky, p. 7, 1847.

Emmonsia hemispherica, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 247, 1851.

Favosites hemispherica, Billings, Canad. Journ., new ser., vol. iv. p. 107, figs. 5-7, 1859.

" *hemispherica*, Nicholson, Rep. on the Palæontology of Ontario, p. 49, Pl. VIII., fig. 3, 1874.

" *Emmonsii*, Rominger, Foss. Corals of Michigan, p. 26, Pl. VII., figs. 1 and 2. (Non *Favosites hemisphericus*, Rominger, ibid., p. 24.)

(It has been pointed out to me by my friend Mr George Jennings Hinde, that Mr S. A. Miller, in his 'Catalogue of the American Palæozoic Fossils,' p. 52, states that this species was described by Troost in the 5th Geol. Rep. of Tennessee, in 1840, under the name of *Calamopora hemispherica*. I have not included this reference in the above list, as I have not access to Troost's work, and have therefore no means of verifying it. Milne-Edwards and Haime do not include Troost in their list of references. If, however, Mr Miller's reference be correct, then Troost's name should follow the species in place of the names of Yandell and Shumard.)

Spec. Char.—Corallum generally hemispherical or irregularly spherical in shape, massive, often several inches in diameter. Corallites prismatic, often with rounded angles, thick-walled, generally about one line or rather less in diameter, but varying from half a line to a line and a quarter. Calices subpolygonal, irregular in size and form, with thick margins. Septa in the form of longer or shorter spines, but often not recognisable. Tabulæ most generally in the form of thin, flexuous, close-set

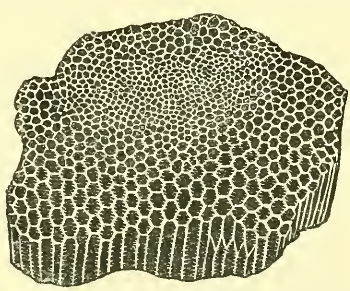


Fig. 15.—Fragment of *Favosites hemispherica*, of the natural size. Devonian (Corniferous Limestone), Ontario, Canada. (After Billings.)

laminæ, which for the most part only extend across about a third or a half of the total diameter of the tube. At other times the tabulæ are complete, and they are occasionally quite regular and horizontal. Mural pores usually biserial, very closely set, opposite or alternating.

Obs.—This species was taken by Milne-Edwards and Haime (*loc. cit.*) as the type of the separate genus *Emmonsia*, distinguished from *Favosites* by the peculiar condition of the tabulæ. I agree, however, with Mr Billings in thinking that the occurrence of single examples of this species in which the tabulæ are in parts complete, renders the establishment of a distinct genus for its reception unnecessary. Moreover, incomplete, leaf-like, or squamose tabulæ are known to occur in undoubted species of *Favosites* (*e.g.*, in *F. Forbesi* and in its variety *tuberosa*).

Recently, Dr Rominger (*loc. cit.*) has applied the name of *Favosites hemisphericus*, Yand. and Shum., to the entirely different *F. turbinata* of Billings; while he has established a new species, under the name of *F. Emmonsii*, for the form now under consideration. The only ground given for this change is, that "all the original specimens of Fav. hemisph. kept in Mr Yandell's collection are identical with *Favosites turbinatus* of Billings." I regret that, after a careful consideration of the circumstances, and with all deference to this high authority, I am unable to acquiesce in the propriety of this change, whereby two species thoroughly familiar to all palæontologists are made to change places, one of them receiving an entirely new name. This course deprives Milne-Edwards and Haime on the one hand, and Mr Billings on the other, of their just connection with two species which they for the first time described in an excellent and thoroughly recognisable manner; and it does not appear to be sufficiently justified by the fact that the specimens labelled *F. hemispherica* in Mr Yandell's cabinet are really referable to *F. turbinata*, Billings. On the contrary, it appears to me that the just course in such a case as this, is, not to make any alteration in generally accepted and long current names, unless it can be shown by clear evidence that such an alteration is warranted by the *published description* of the original author, since this is obviously all of which other observers can, as a rule, avail themselves. Taking this view of the question, I quote the entire description of the species given by Yandell and Shumard (Contrib. to the Geol. of Kentucky, p. 7) :—

"*Favosites hemispherica.*—This fossil, the most characteristic of the shell-beds, to which it is limited, is abundant on the Falls, and is found in masses of a hemispherical figure, which vary from one to ten inches in diameter. It is most commonly calcareous, though sometimes it is siliceous."

Passing over the obvious fact that the above description—unaccompanied by any figure—is wholly worthless as characterising *any* species of *Favosites*, and that its vagueness would have altogether justified Milne-Edwards and Haime in giving a new specific title to the form which they were describing, it may be simply remarked that the only two tangible points alluded to by Yandell and Shumard are the *shape* and the *size* of the corallum; and in both these points their description agrees with the *Emmonsia hemispherica* of Edwards and Haime, and differs from the description of *F. turbinata* given by Billings. The form of *F. turbinata*, Billings, though not absolutely uniform, is almost always that of a bent cone, rendering the name *turbinata* a very apt one; while of the many examples I have seen, none could be properly said to be "hemispherical," and none exceeds some five or six inches in diameter. On the other hand, *Emmonsia hemispherica*, E. and H., is typically "hemispherical" in form, and is often eight or ten inches in diameter (Billings gives two or three feet as the maximum diameter of specimens observed by him). Upon the whole, then, I cannot but conclude that the names of *F. hemispherica*, E. and H., and *F. turbinata*, Bill., ought to be retained for the forms described by their respective authors under these titles, and that these names should not be invalidated by any evidence which is not based exclusively upon, or directly supported by, published *descriptions* or *figures* of older date — these being, in the majority of cases, the only data available to the worker. I have discussed this point at some length, because it seems to me a matter of importance that every observer should receive due credit for his labour, and that the principle involved is one of some concern to all palæontologists and zoologists; and I am happy to know that in this special case I have the entire concurrence of my friend Mr George J. Hinde, whose wide acquaintance with the American Palæozoic Corals generally, and with these forms in particular, renders his opinion on such a question of peculiar value. I need hardly add that I do not suppose for one moment that Dr Rominger has intentionally done an injustice to his predecessors, and I trust that a reconsideration of all the facts of the case will induce him to alter his decision on this point.

In its general form and habit, *F. hemispherica*, Yand. and Shum., is of the *type* of *F. Gothlandica*, Lam., its corallum being massive, and its corallites essentially polygonal. The prismatic shape of the tubes is, however, not so conspicuous as in the latter species, partly because the angles of the prisms really are often obtusely rounded, and partly because the walls of the corallites are much thicker (Pl. III., fig. 3). Without having the obvious intermixture of large and small tubes which characterises *F. Forbesi*, E. and H., there is a considerable want of uniformity in the size of the corallites, and it is not unusual for particular parts of the corallum to be occupied by tubes of less than the average dimensions, while in other parts the average diameter is maintained or exceeded. Upon the whole, the majority of the corallites are from three-quarters of a line to a line in diameter, the latter measurement being only rarely exceeded. I formerly included under this name (*loc. cit.*) colonies in which the tubes have an average diameter of from half a line to three-quarters of a line; but I feel doubt as to whether these really belong to this species, as I have not been able to examine their internal structure fully. Septa are present in the form of irregular spines, which can be observed in specimens in which the tubes are empty, or in transverse sections (Pl. III., fig. 3), but which can be with difficulty separated from the imperfect tabulæ. The mural pores are most generally biserial, sometimes triserial, and are remarkable for their close arrangement. In the best-preserved calcareous examples which have come under my notice, they form a double row, running down the centre of each prismatic face (Pl. III., fig. 3 *à*), sometimes alternately, sometimes oppositely placed, contiguous pores in each row being separated by their own diameter or less. The most remarkable feature about the present species, however, is presented by the *tabulæ*, which can be admirably studied by means of specimens from the Corniferous Limestone of Wainfleet, Ontario, in which the corallum is in the exceptional condition of not only being calcareous, but of being entirely empty and free from foreign matter, thus quite resembling the skeleton of a recent coral. In such specimens it is not unusual to find that the condition of parts is twofold. In some of the tubes, sometimes in the greater number, the corallites are traversed by horizontal and complete tabulæ, about five of which occupy the space of two lines, the state of matters in these corallites thus resembling what we see in *F. Gothlandica*, Lam. In other tubes, again, there are few or no *complete* tabulæ, but the visceral chamber is crossed by a series of incomplete tabulæ, in the form of thin foliaceous, irregularly flexuous laminæ (Pl. III., fig. 3 *b*), which only extend to a certain distance inwards towards the axis of the tube, and are often so closely packed as to cause a regular interlocking of their free ends, or even an actual anastomosis or confluence. When viewed from above, these incomplete tabulæ often have a regularly radiate arrangement, and thus simulate septa; but their true nature is rendered obvious by their broad, leaf-like, or tongue-like form, and by their *transverse* extension as regards the axis of the visceral chamber. While many specimens, as just remarked, show a development of complete tabulæ in some tubes and of incomplete ones in others, it should be remarked that in other examples, often of very large size, *all* the tubes exhibit the characteristic incomplete and inosculating tabulæ of this species.

Formation and Locality.—Common in the Corniferous Limestone (Devonian) of Rama's Farm, Port Colborne, and other localities in the same formation in Ontario. The species occurs at many points in the United States, where the Corniferous Limestone is exposed; and it is quoted by Milne-Edwards and Haime from the Upper Silurian of the same area.

Favosites Bowerbanki, Milne-Edwards and Haime, sp.

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

Favosites spongites (pars), Lonsdale, in Murchison's Silurian System, p. 683, Pl. XV., bis, figs. 8 *c*-8 *e* (cæt. exclusis), 1839.
Chætetes (?) *Bowerbanki*, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 272, 1851.
Monticulipora (?) *Bowerbanki*, Milne-Edwards and Haime, Brit. Foss. Cor., p. 268, Pl. LXIII., figs. 1-1 *c*, 1854.

Spec. Char.—Corallum exceedingly variable in form and size, but generally in the shape of thick lobate and branched masses. Corallites irregularly polygonal in shape, mostly about one-fiftieth of an inch in diameter, but sometimes less or more; the walls thin, and perforated by irregularly-distributed mural pores, which vary in number in different examples, and may be uniserial, biserial, or triserial. Calices irregularly polygonal, occasionally diamond-shaped in parts of the corallum, often divided by incomplete vertical partitions arising from both sides of the wall, and indicating unfinished fission of the tube. Septa entirely obsolete. Tabulæ very few in number, usually curved, remote, from three-quarters of a line to a line apart.

Obs.—I have not thought it necessary to figure a specimen of this species, as it has been very well illustrated by Milne-Edwards and Haime (Brit. Foss. Cor., Pl. LXIII.) The principal figure given by these authors is, however, that of a quite exceptionally complex and dendroid example of this form. So far as I have seen, the corallum is generally in the form of lobate pyriform masses, which, when young, are from an inch to two inches in height, with a diameter of half an inch to an inch. Sometimes they terminate above in a simply dilated and undivided upper surface, which may be slightly convex or nearly flat; but at other times they split up superiorly into two or more lobate divisions. Older examples, with or without proportionate increase in height, may become massive, till we get coralla, of variable, but most generally of obconical shape, which may be three or four inches in diameter at their summit. While branching of the corallum is quite common, I have not personally met with so completely dendroid a specimen as one of those figured by Edwards and Haime (Brit. Foss. Corals, Pl. LXIII., fig. 1). The lower and outer surface of the corallum does not appear to be covered with a regular epitheca—at least I have not observed such a structure; but the long irregularly prismatic corallites pass upwards from the base of attachment, diverging as they go in such a manner that a side view exhibits the walls of the corallites, broken at tolerably regular intervals by recurrent spaces or ledges occupied by open calices. This feature is one very characteristic of the pyriform examples of this species, but in all forms alike the uppermost surface is occupied by the calices.

Milne-Edwards and Haime referred this species with doubt to *Chætetes* or *Monticulipora*, and of its close resemblance to these genera there can be no question. Vertical sections, suitable for microscopic examination, bring into view, however, a well-developed series of mural pores, and thus prove conclusively that the species is truly referable to *Favosites* (Pl. III., fig. 4 *b*). The pores are irregularly distributed, and seem to be generally in two or three series, their size always being small. They are very abundant and conspicuous in Swedish examples, and, for some reason, appear to be much fewer in number in British specimens, though still quite determinable with a little care. It is worthy of note, in this connection, that though the existence of mural pores can usually be recognised in thin sections without any difficulty, I have never succeeded in detecting the smallest sign of these apertures by an examination of the outsides of the tube with a hand-lens, though I have for this purpose carefully gone over an extensive series of excellently preserved specimens. This shows that the mere fact that mural pores cannot be detected with a magnifying-glass, even in calcareous examples, is not proof positive that such openings are absolutely wanting.

The corallites of *F. Bowerbanki* are long and slender, of variable size, but usually from one-sixth to one-quarter of a line in diameter. Their cross-sections (as the calices also) are irregularly polygonal (Pl. III., fig. 4), and in their general aspect they closely resemble the corallites of *Chætetes radians*, Fischer, and its allies. They show a peculiarity, also, which is very characteristic of the forms just alluded to (such as *Chætetes septosus*, Flem.)—viz., that the larger tubes are not uncommonly partially subdivided by vertical partitions, which spring from the wall, and extend a certain distance inwards into the interior of the visceral chamber (Pl. III., figs. 4, 4 *a*). These incomplete partitions are usually placed in pairs, one opposite the other, and they appear ultimately to become complete by the union of their inner ends. Though they might be taken at first sight as irregular *septa*, they really are not of this nature, and they truly indicate different stages in the multiplication of the older corallites by means of fission. Genuine septa, in the form of vertical ridges, tubercles, or spines, such as are so commonly present in other species of *Favosites*, seem here to be entirely absent. Lastly, the tabulæ are present in the form of slender curved plates, which are exceptionally few in number and remote in position (Pl. III., fig. 4 *b*), not more than two or three of these structures usually occupying the space of two lines.

Formation and Locality.—Abundant in the Wenlock Limestone of Benthall Edge, Stoke-Edith, and Longhope. Also in the Wenlock Limestone of Gotland.

Favosites clausa, Rominger.

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

Favosites clausus, Rominger, Fossil Corals of Michigan, p. 36, Pl. XIV., 1876.

Spec. Char.—Corallum dendroid, of branching or anastomosing, cylindrical or oval stems, from two to five lines in diameter, attached by its base, but having its whole free surface covered by the calices. Calices open only in parts of the surface, and especially towards the ends of the branches, but elsewhere closed by flat or convex opercula. Corallites unequal in size, the larger ones being conspicuously circular or oval in shape, and about half a line in diameter, while the smaller ones are more or less angular in form, and vary from a fifth to a third of a line in diameter. Surface commonly marked by raised encircling ridges, which usually have a spiral direction, and are placed parallel with one another at intervals of from half a line to a line or more. These are simply formed by the elevation of the lips of a number of the calices along a given line, and they appear to mark successive stages of growth. Septa obsolete; tabulæ complete, horizontal, or slightly bent, from three to four in the space of one line, sometimes with a few incomplete tabulæ interspersed among the others. Mural pores uniserial.

Obs.—This pretty little species may be regarded as a good example of a true *Favosites* (as distinguished from *Pachypora*, Lindst.), growing in a branching and dendroid form. The inequality of the calices and the markedly circular shape of the larger tubes (Pl. IV., fig. 1 *b*) are characters in which the species makes a distinct approach to *Fistulipora*, M'Coy; but *F. Forbesi*, E. and H., exhibits the same feature to a less marked extent; and the presence of mural pores sufficiently separates the present form from the species of the latter genus. It is also separated from *Pachypora* by the fact that the walls of the corallites show none of that thickening in the neighbourhood of their mouths which is so characteristic of the latter. The existence of an operculum in the form of a flat or convex calcareous plate in a large number of the calices is a peculiar feature in the species (Pl. IV., fig. 1 *a*) ; but the same character occurs generally in *F. Forbesi*, var. *tuberosa*, Rom., and constantly in *F. turbinata*, Bill. In all these forms the actual characters of the operculum are the same, but in the last-mentioned species they become more or less continuous, so as to constitute a regular epithecal membrane, clothing the entire under surface of the corallum. Thin tangential sections exhibit no traces of septal ridges or tubercles. Similar vertical sections show that the walls of the corallites are not thickened as they approach the surface, and that the visceral chamber of each tube is crossed by delicate horizontal tabulæ, which are usually complete, though occasionally incomplete ones exist as well. Rominger says that the mural pores are "numerous." So far as I have observed them in thin sections, they are uniserial, and moderately close to one another.

Formation and Locality. — Hamilton Group (Devonian), Arkona, Ontario, and Erie County, N.Y. (Dr Rominger states that it occurs also in the Corniferous Limestone.)

CHAPTER IV.

GENERA OF FAVOSITIDÆ—(*continued*).

Genus Pachypora, Lindström, 1873.

(Öfversigt af K. Vetensk. Akad. Förhandl.)

Gen. Char.—Corallum dendroid or frondescent, of polygonal or subcylindrical corallites, the walls of which are greatly thickened towards their mouths by the deposition of concentric layers of sclerenchyma. Calices sometimes annular, sometimes oblique and semi-lunar. Septa in the form of minute spiniform projections, or obsolete. Tabulæ complete, remote. Mural pores few in number, irregular, often of large size.

This genus was founded by Lindström for the reception of the single species *Pachypora lamellicornis*, Lindst., from the Upper Silurian deposits of Gotland, which will be shortly described immediately. So far as my investigations have gone, the genus will be found to include a considerable number of types, some of which have been referred to *Favosites*, while others have been placed in *Alveolites*. Thus it has been already pointed out by Mr R. Etheridge, jun., and myself (Journ. Linn. Soc., vol. xiii. p. 362), that the so-called *Alveolites Fischeri*, Bill., and *Alveolites frondosa*, Nich., of the Devonian deposits of North America, are really referable to *Pachypora;* and I have now determined that the well-known *Favosites cristata*, E. and H., of the Upper Silurian, and *F. cervicornis*, De Blainv., of the Devonian, must be placed in the same genus. It is probable, in fact, that all the *thick-walled* species which have been regarded as dendroid forms of *Favosites* will more appropriately find a place in *Pachypora;* and the same may be considered as likely as regards the majority of the thick-walled types which have been referred to *Alveolites.*

The mere thickening of the walls would not of itself afford a sufficient ground for the separation of *Pachypora* as a generic division, since it is present in other groups; but there are other distinctive characters to be taken into account as well. Little stress can be laid upon the external *form* of the corallum, but all the known species are dendroid or frondescent. *P. lamellicornis*, Lindst., the type-species, forms flattened branches, which are often coalescent; *P. Fischeri*, Bill., and *P. frondosa*, Nich., grow as broad undulating expansions or fronds; *P. cristata*, E. and H., and *P. cervicornis*, De Blainv., are essentially ramose, usually with cylindrical branches, but sometimes sublobate. In all these cases the corallum is fixed to some foreign body by its base; and there is no epitheca, the whole of the free surface being covered by the open mouths of the corallites. The calices are sometimes circular, sometimes polygonal, sometimes markedly triangular; so that the genus includes forms which would, in this respect, fall on the one hand under *Favosites*, and on the other hand under *Alveolites.* The calices are in all instances more or less remote from one another, and thin sections show that the cause of this remoteness is to be found in the thickening of the walls of the corallites by a secondary deposit of sclerenchyma. This thickening affects the corallites throughout their entire length, but it is least developed in the central and interior portion of the corallum, and becomes much more conspicuous as the mouths of the tubes are approached. Hence in tangential sections taken close to the surface the visceral chamber is seen to be surrounded by a dense calcareous envelope composed of numerous delicate concentric laminæ, and surrounded externally by a clearly distinguishable proper "wall" (see Pl. IV., figs. 2 *a* and 3 *c*). The tabulæ are poorly developed, being few in number, remote, and in general complete. *P. cristata*, E. and H., however, sometimes exhibits structures which may possibly be incomplete tabulæ. Septa are usually recognisable, as minute tubercles or spines, but may be wholly obsolete. Lastly, the mural pores differ from those of the typical forms of *Favosites* in being comparatively few in number, apparently arranged in no regular series, and usually of large size.

From *Favosites* proper, *Pachypora* is to be distinguished principally by the thickening of the walls of the corallites, the characters of the mural pores and tabulæ, just alluded to, affording secondary points of difference. From *Alveolites*, as I shall here define it, the genus must likewise be separated chiefly by its incrassated walls. *Striatopora*, Hall, is very nearly allied to *Pachypora*, but may be separated by the fact that the cup of the calice is constricted at its base, and the walls below this point are excessively thickened. *Trachypora* E. and H., is another allied type; but in it the thickening of the walls of the corallites attains its maximum, and tabulæ are greatly reduced or wanting.

The only other point which need be noticed is the relation between *Pachypora*, Lindst., and *Cladopora*, Hall. The latter genus was originally founded by Hall (Pal. N.Y., vol. ii. p. 137), for branching or reticulate corals from the Niagara Group, "composed of a series of tubes or cells radiating equally on all sides from the axis, and opening upon the surface in rounded or subangular expanded mouths." The corallites are stated to be more or less closely arranged, but not always contiguous, and both tabulæ and septa are said to be apparently absent. On the other hand, in the latest definition of *Cladopora*, Hall, as given by Rominger (Foss. Cor. of Michigan, p. 45), the genus is placed among the *Favositidæ*, and is stated to possess mural pores, with "occasionally" tabulæ. There can, further, be no doubt but that the Corals placed by Dr Rominger under this head are in great part referable to *Pachypora*, Lindst.; and as *Cladopora*, Hall, is of course a much older name, it might seem proper to suppress the former in favour of the latter. It is not clear, however, that any of the forms originally included by Hall (*loc. cit.*) under the name *Cladopora* are really congeneric with *Pachypora lamellicornis*, Lindst.; while it is certain that many of the forms which have subsequently been placed under *Cladopora* by American palæontologists are of very diverse affinities. Moreover, Dr Rominger states that septa are not developed in the forms which he calls *Cladopora*, these structures being undoubtedly present in the typical forms of *Pachypora*, Lindst. Under these circumstances, therefore, I have not thought it advisable to resuscitate the genus *Cladopora*, though it is quite possible that one or more of the forms originally described under this name by Hall are really identical in their characters and structure with the more recently described *Pachypora* of Lindström.

So far as certainly known, the species of *Pachypora* are confined to the Upper Silurian and Devonian deposits.

Pachypora lamellicornis, Lindström.

(Pl. IV., figs 2-2 *c*.)

Pachypora lamellicornis, Lindström, Några anteckningar om Anthozoa Tabulata. Öfversigt af Kongl. Vetensk. Akad. Förhandl., 1873.
„ *lamellicornis*, Nicholson and R. Etheridge, jun., Journ. Linn. Soc., vol. xiii. p. 361, Pl. XX., figs. 15-17.

Spec. Char.—Corallum composed of broad flattened branches having a width of from four to seven lines or more, with a thickness of from two to three lines, often coalescing to form flat reticulate or palmate expansions (Pl. IV., fig. 2). Corallites essentially polygonal in shape, tolerably equal in size, from one-third of a line to two-fifths of a line or rather more in diameter. Walls of the corallites greatly thickened by a secondary deposit of sclerenchyma, which is laid down in delicate concentric laminæ in the interior of the tubes, and increases considerably in amount as the mouth is approached (Pl. IV., figs. 2 *a* and 2 *b*). Calices covering the entire free surface of the corallum, subpolygonal, rounded, or sometimes distinctly oblique and semicircular, the margins being thick, and the lower lip not specially prominent. Septa represented by minute tubercles or spines, arranged in vertical rows (Pl. IV., fig. 2 *a*). Tabulæ delicate, few in number, remote, and complete (Pl. IV., fig. 2 *b*). Mural pores few, irregular, of comparatively large size.

Obs.—Dr Lindström has kindly furnished me with specimens of this, the type-species of the genus *Pachypora*, from which I have been enabled to draw up the above description. As the structure and affinities of the genus have already been discussed at some length, it is unnecessary here to enter into further details as to the characters of this interesting form. In its general appearance it resembles most nearly a palmate or dendroid *Favosites;* but the conspicuous thickening of the mouths of the calices, and the consequent remoteness of these apertures, is sufficient to separate it from the typical forms of the latter. Sometimes the calices resemble those of *Favosites* in being polygonal or rounded, sometimes they are like those of *Alveolites* in being markedly oblique and semi-lunar; and both these conditions are commonly present in the same specimen, calices of the latter shape occurring principally towards the ends of the branches. The lower lip of the calice is, however, never markedly prominent, nor thinner than the rest of the calicine margin. The nearest ally to *P. lamellicornis* is the *P.* (*Alveolites*) *Fischeri*, Bill., of the Devonian of North America; but the corallum of the latter is invariably in the form of thin lamellar or palmate expansions, never partially or completely ramose, while the calices are commonly oblique and subtriangular over the whole surface. There is also a close resemblance between the present species and *P.* (*Favosites*) *cristata*, E. and H., from the Upper Silurian of Britain; but the latter is always distinctly ramose, of more or less cylindrical branches, while its tabulæ are much more largely developed, and the septa appear to be nearly obsolete.

Formation and Locality.—Upper Silurian (Wenlock Limestone), Wisby, Gotland. (*Coll.* Dr Gustav Lindström.)

Pachypora cervicornis, De Blainville, sp.

(Pl. IV., figs. 3-3 *d.*)

Calamopora polymorpha, var. *ramoso-divaricata*, Goldfuss, Petref. Germ. t. i. Pl. XXVII., figs. 3 *a*, 4 *a*, 4 *b*, 4 *c* (cæt. exclusis), 1826.
„ *spongites*, var. *ramosa*, Goldfuss, ibid., Pl. XXVIII., figs. 2 *a*-2 *g* (cæt. exclusis), 1826.
Alveolites cervicornis, De Blainville, Dict. Sci. Nat., t. lx. p. 369, 1830.
„ *reticulata*, De Blainville, ibid., p. 369, 1830.
Favosites cronigera, *Alveolites celleporatus*, and *Alveolites spongites*, D'Orbigny, Prodr. de Paléont., t. i. pp. 107, 108, 1850.
„ *cervicornis*, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 243, 1851; and Brit. Foss. Cor., p. 215, Pl. XLVIII., fig. 2 (?), 1853.
„ *reticulata*, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 241, and Brit. Foss. Cor., p. 215, Pl. XLVIII., figs. 1-1 *b*, 1853.
„ *polymorpha*, Billings (pars), Canad. Journ., new ser., vol. iv. p. 111, fig. 11, 1859. (Non Goldfuss.)
„ *reticulata*, Nicholson, Rep. on the Pal. of Ontario, p. 51, Pl. VII., fig. 2, 1874.
„ *dubia*, Nicholson (pars), ibid., p. 51, Pl. VII., fig. 5, 1874. (Non *Favosites cervicornis*, Nicholson, ibid., p. 52.)
„ *limitaris*, Rominger (?), Foss. Cor. of Michigan, p. 35, Pl. XIII.

Spec. Char.—Corallum of branching cylindrical stems, which vary in diameter from two up to ten lines, and which sometimes inosculate so as to form reticulated expansions. Corallites essentially polygonal, but having the visceral chamber greatly narrowed by a secondary deposit of sclerenchyma, which increases in amount towards the mouth. Calices subpolygonal, with thickened lips surrounding a subcircular aperture, tolerably equal in point of size, and usually about half a line in diameter, more or less. Septa obsolete, or represented only by very minute spiniform tubercles. Tabulæ comparatively few in number (in some cases apparently numerous), complete, horizontal or slightly flexuous. Mural pores few, large-sized, irregularly distributed.

Obs.—The dendroid Favositoid Corals constitute a group particularly difficult to study and to separate satisfactorily into species, and with the space at my command it would be useless to attempt to discuss and illustrate more than one or two types. Some forms, as has been seen, have the thin walls of *Favosites* proper, and are clearly generically inseparable from the more typical massive examples of this group. The forms now under consideration, however, have the thickened walls and general structural characters of *Pachypora*, Lindström, under which head they ought clearly to be placed. The species which I have here selected is one highly characteristic of the Devonian, and I have made a careful macroscopic and microscopic study of a large number of specimens which I have personally collected from rocks of this age in Devonshire, in the Eifel, and in Canada. Nevertheless I do not feel certain as to the limits of the species, nor am I sure that all the forms given in the foregoing list of synonyms are really only variations of a common specific type, though I am disposed at present to take this view.

The figures which I have given (Pl. IV., figs. 3 - 3 *c*) are all taken from a single form, which I found to be very abundant at Gerolstein, in the Eifel, and which I consider as certainly identical with those figured from the same region by Goldfuss under the name of *Calamopora polymorpha*, var. *ramoso-digitata* —these being identified by the high authority of MM. Milne-Edwards and Haime with the *Alveolites cervicornis* of De Blainville. Nor can I doubt the substantial identity of this form with the *Favosites reticulata* of De Blainville,—the only tangible difference between them being the unimportant feature that the branches of the latter inosculate with one another. On the other hand, Milne-Edwards and Haime, in the 'Polypiers Fossiles,' state that the larger calices of *F. cervicornis* have a diameter of nearly two millimeters, and that the walls are only "un peu épaisses;" whereas they give one millimeter as the diameter of the calices in *F. reticulata*, and speak more decisively as to the thickness of the walls of its corallites. Goldfuss's figures, however, which are usually very reliable, show hardly any appreciable difference in the size of the corallites in these two forms, both having the majority of the calices about one millimeter in diameter, and thus agreeing with the examples which I have seen from the Eifel. The statements on this head made by Milne-Edwards and Haime would much more closely apply to the form which they have described and figured from the Devonian rocks of Devonshire under the name of *F. cervicornis* (Brit. Foss. Cor., Pl. XLVIII., fig. 2), and which is so common in the limestones of Newton-Bushell and Torquay. This form has large calices which are often nearly two millimeters in diameter, and the thickening of its walls (though present) is not strikingly marked. I am, however, very much disposed to doubt if this be specifically identical with the form figured by Goldfuss from the Eifel, and my opinion is based both upon actual specimens and upon thin sections. The Devonshire form is rather sublobate than strictly dendroid; its walls are not nearly so thick as those of the typical examples from the Eifel; its calices are on an average larger; and its tabulæ are much more numerous and more closely set. Upon these grounds, though I have doubtfully placed it under this species, I am inclined to think that it is entitled to at least varietal if not specific distinction. The form figured by Billings, from the Corniferous Limestone of Canada, as *F. cervicornis* (Canad. Journ., new ser., vol. iv. p. 110, fig. 9), and subsequently described by me under the same name (Rep. on the Pal. of Ontario, p. 52, 1874), is apparently identical with, or closely allied to, the Devonshire form, and differs from the Eifel specimens in the characters above alluded to as distinctive of the British examples.

Favosites polymorpha, Goldfuss, has often been regarded as comprising dendroid forms, probably in part identical with the present type. It seems clear, however, that this name, if it be retained at all, can only be with propriety kept for examples of a submassive or completely massive form, with uniserial pores, and with the thin walls characteristic of *Favosites* proper.

Favosites dubia, De Blainv., again, comprises dendroid species which are obviously of the *Pachypora* type, and it is a question whether the species can be maintained as distinct from *Pachy-*

pora (*Favosites*) *cervicornis*. The presence of very minute calices scattered among the larger ones is of itself, perhaps, hardly of more than varietal value; but if Goldfuss's figure can be trusted (*Calamopora polymorpha*, var. *gracilis*, Petref. Germ., Pl. XXVII., fig. 5), then *Pachypora* (*Favosites*) *dubia* is sufficiently distinguished from *P. cervicornis* by the comparatively large size and the obliquity of its calices.

Lastly, it seems very probable that some of the forms figured by Rominger (Fossil Corals of Michigan) are really inseparable from the present species; and this is specially the case with *F. limitaris*, Rom., in part or in whole. From an examination of numerous specimens of this form from the Corniferous Limestone of Ontario, I can assert its very close resemblance to examples of *P. cervicornis* from the Eifel—this resemblance in some cases amounting to absolute identity of external characters. Other specimens, again, have larger and more distinctly circular or annular calices, thus closely approximating to the type of *Pachypora* (*Favosites*) *dubia*, De Blainv. Unfortunately, the highly silicified state of the Canadian specimens, accompanied with a more or less completely hollow condition of the tubes of the corallites, renders it impossible to prepare satisfactory microscopic sections; and in the absence of these, I hesitate to pronounce as to their absolute identity with the European type, though I cannot doubt their very close alliance.

Taking the Eifel specimens as the type of *Pachypora cervicornis*, De Blainv., the corallum is generally in the form of cylindrical or subcylindrical, often irregularly swollen branches, from two to ten lines in diameter (Pl. IV., fig. 3), dividing at variable intervals, but usually not anastomosing. Where inosculation of the branches occurs, it may perhaps be convenient to use De Blainville's name of *reticulata* as a varietal designation, though forms so characterised certainly differ in no other particular from those which divide without anastomosis. The corallites radiate from the axis of the branch, curving gently outwards till they open on the surface, and their true form is essentially polygonal. This is clearly shown by sections at right angles to their course, and especially by those which cut perpendicularly across their axial portions (Pl. IV., fig. 3 *c*). The walls of the corallites, under all circumstances, remain quite distinctly recognisable in thin sections, but the visceral chamber becomes more and more contracted as we approach the mouths of the tubes, by a dense secondary deposit of sclerenchyma (Pl. IV., figs. 3 *b*, 3 *c*). As the result of this thickening of the walls, the calices assume the form of rounded apertures encircled by a prominent thickened margin (Pl. IV., fig. 3 *a*), the true wall being still discernible as a raised thread-like line describing a polygon round the central opening. In transverse or tangential sections (Pl. IV., figs. 3 *b*, 3 *c*), the visceral chamber is seen to be reduced to a comparatively small circular or oval tube; and in longitudinal sections (Pl. IV., fig. 3 *d*) the same feature is shown, while it is seen that the secondary deposit of sclerenchyma is laid down irregularly, so as to constrict the visceral chamber unequally at different points, but always most markedly towards the mouth. Vertical sections also show that the tubes are crossed by a few comparatively remote, complete, and approximately horizontal tabulæ, and that the walls are pierced by a few larged-sized and irregularly placed mural pores. In many instances, transverse or tangential sections coincide in places with the plane of a mural pore, and then the visceral chambers of contiguous corallites are shown as laterally continuous (Pl. IV., fig. 3 *b*). Septa are sometimes not recognisable at all; but in other instances their presence can be detected in the form of very rudimentary spiniform or tubercular projections into the interior of the visceral chamber.

One of the nearest allies of the form here selected as the type of *Pachypora cervicornis*, De Blainv., is the *P.* (*Favosites*) *cristata*, E. and H., of the Upper Silurian. The latter, however, is distinguished by the constant presence of minute calices interspersed among the larger annular apertures, by the smaller size of average examples of the corallum, and by the possession of more numerous tabulæ, while the septa are often long and spiniform, and the mural pores are much smaller. (The only variety of *P. cervicornis* in which I have observed comparatively numerous tabulæ is that from the Devonian rocks of Devonshire, and I have already given reasons for thinking this to be probably at least varietally distinct from the Eifel form, if not a good species.)

Formation and Locality.—Abundant in the Devonian Limestone of Gerolstein in the Eifel. Also not uncommon in the Corniferous Limestone of Wainfleet, Ontario. [Quoted by Milne-Edwards and Haime as occurring in the Devonian of France, Belgium, Germany, Spain, Turkey in Europe, and Britain.]

Pachypora cristata, Edwards and Haime, sp.

(Pl. IV., figs. 4-4 *b*, and Pl. V., figs. 1-1 *b*.)

(?) *Madreporites cristatus*, Blumenbach, Comment. Soc. Scient. Gött., t. xv. p. 154, Pl. III., fig. 12, 1803.
Favosites polymorpha, Lonsdale, in Murchison's Silurian Syst., p. 684, Pl. XV., fig. 2, 1839.
„ *Lonsdalei*, D'Orbigny, Prodr. de Paléont., t. i. p. 49, 1850.
„ *cristata*, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 342, 1851; and Brit. Foss. Cor., p. 260, Pl. LXI., figs. 3 and 4, 1854.
Calamopora cristata, Fr. Schmidt, Sil. Form. von Ehstland, p. 239, 1858.
„ *cristata*, Ferd. Roemer, Sil. Fauna des West. Tennessee, p. 20, Pl. II., fig. 12, 1860.
Favosites Lonsdalei, Lindström, Öfversigt af Kongl. Vetensk. Akad. Förhandl., 1873, p. 22.

Spec. Char.—Corallum dendroid, or sometimes sublobate; the branches generally cylindrical, often irregularly swollen, from two to four or five lines in diameter, dividing at frequent intervals, and terminating in rounded ends. Corallites radiating from the axis of the corallum, and diverging outwards to open on all parts of the free surface; their walls thickened by sclerenchyma, especially in the neighbourhood of their mouths. Mural pores few in number, apparently uniserial or irregular. Calices rounded, encircled by greatly thickened margins, and usually of two principal sizes,—the larger ones often nearly or quite circular, and from half to two-thirds of a line in diameter; while the smaller ones are intercalated among the preceding, are often subpolygonal or angular, and vary from a quarter to a third of a line in diameter. Septa represented by radiately arranged spinules, or nearly obsolete. Tabulæ numerous, complete, usually curved with their convexity downwards, or flexuous.

Obs.—The present species was identified by Milne-Edwards and Haime with the *Madreporites cristatus* of Blumenbach; and if this identification be correct, it ought to stand as *Pachypora cristata*, Blum. sp. Lindström has, however, expressed the opinion (*loc. jam cit.*), that the form described under the above title by Blumenbach was really the Devonian *P.* (*Favosites*) *cervicornis*, De Blainv., and he therefore revives for the form now under consideration D'Orbigny's name of *F. Lonsdalei*. Not having it in my power to decide whether or not the identification of Milne-Edwards and Haime is well founded, I have preferred to keep the species in the meanwhile under the name by which all British palæontologists know it, and by which it is described in the two classical treatises of the French authors.

Pachypora cristata, E. and H., usually presents itself in the form of small branching fragments, which may be cylindrical, or which may be so far dilated as to be almost sublobate. I have never seen any fragments even as large as those figured by Edwards and Haime (Brit. Foss. Cor., Pl. LXI., figs. 3, 4), and I should imagine the perfect corallum to have attained no great size. The diameter of the branches is most commonly from two to four lines; and an examination of its internal structure at once shows it to belong to *Pachypora*, Lindst., and not to *Favosites* proper. Transverse sections (Pl. V., fig. 1) show that the corallites are essentially polygonal, and that their proper walls are distinctly recognisable; but the interior of the tubes is narrowed by a dense deposit of sclerenchyma, which increases in quantity as the aperture is approached, and which leaves only a small oval or circular central space. Longitudinal sections (Pl. V., figs. 1 *a* and 1 *b*) show precisely the same features. The calices also (Pl. IV., figs. 4 *a* and 4 *b*) exhibit the thickened lips so characteristic of *Pachypora*, the proper wall being still marked by a raised line which forms the crest of the calicine margin. The characters of the calices differ to a considerable extent in two different groups of examples. In one of these groups—which at the same time comprises the smaller forms, with the most regularly cylindrical branches—the calices (Pl. IV., figs. 4 and 4 *a*) are markedly circular or annular, opening flush with the surface, and having a diameter for the most part of about half a line. Mixed up with these larger calices are smaller ones, which are also more or less circular, and vary from a quarter to a third of a line in diameter. On the other hand, in another great group of specimens—in which the corallum is usually irregularly swollen, or even sublobate—the calices (Pl. IV., fig. 4 *b*) are more disproportioned in their dimensions, the larger ones being from two-thirds to even three-fourths of a line in diameter, while the small ones are wedged in among the bigger openings, and are mostly polygonal or angular. The large calices, also, are not always markedly circular, but are often oval, and they have a decided obliquity to the surface, which varies in amount in different specimens. (I have never seen any example with an obliquity so great as that figured by Milne-Edwards and Haime, Brit. Foss. Cor., Pl. LXI., fig. 4 *a*, where the front wall of each corallite is free and exposed for a considerable distance; but I have seen an approach to this condition. Possibly this was a weathered specimen.) Marked examples of these two conditions may easily be selected, which are so different in appearance that they might quite well be regarded as distinct species. After an examination, however, of a large number of specimens, I find the two groups to shade into one another so imperceptibly, that I cannot regard them as specifically separable. I agree, therefore, with Milne-Edwards and Haime, who recognised the two conditions of the species to which I have just referred, and who regarded the smaller form, with the rounded calices, as the type of the species; while they figured the form with the larger and more oblique calices under the name of *varietas major* (Brit. Foss. Cor., Pl. LXI., fig. 4 *a*). I thus regret to find myself unable to adopt the opinion of my friend Dr Lindström on this point, who regards the latter form (viz., var. *major*) as the type of *P. cristata*, while he considers the examples with the annular calices as specifically distinct.

In a few instances, I have noticed the existence of an operculum closing the mouth of a tube, but this seems to be unusual. The condition of the septa varies. In some examples they cannot be recognised at all, whereas in others (certainly not so commonly) the mouths of the corallites are seen to be clearly marked by radiating ridges. Thin transverse and tangential sections (Pl. V., fig. 1) show the same differences. Usually such sections exhibit no traces of septa, or only a few rudimentary tubercles, but sometimes there proceed tolerably long spines into the interior of the tube. Similar spines are present in most longitudinal sections, but in very varying numbers. Sometimes (Pl. V., fig. 1 *a*) there are very few of them; but in other instances (Pl. V., fig. 1 *b*) there are numerous pointed spines which spring from the walls, and are directed upwards into the visceral chamber. It seems almost certain that these spines are truly septa, though some of them may perhaps be of the nature of incomplete tabulæ. The tabulæ are well developed, about five or six in the space of two lines, complete, usually curved, with their convexities turned towards the base of the corallum, sometimes irregularly flexuous. I have only been able to investigate the mural pores by means of thin vertical sections, in which these openings may be often partially detected. They are of no great size, and appear to be either uniserial or irregular.

P. cristata, E. and H., is distinguished from *P. lamellicornis*, Lindst., by the different form of the corallum, the presence of small calices interspersed among the larger ones, and the much greater development of the tabulæ. From the *P. cervicornis*, De Blainv., of the Devonian, the present species is separated by slight but upon the whole readily recognisable differences in external appearance: while its calices are more conspicuously annular, and more obviously of two sizes, its tabulæ are more numerous (as compared with typical examples of the former), and its mural pores are markedly smaller and apparently more numerous.

Formation and Locality.—Common in the Wenlock Limestone of Benthall Edge, and Dormington Quarry, near Stoke-Edith. (Milne-Edwards and Haime and Lindström quote it from a corresponding horizon in Gotland. It is also very probable that some of the so-called *Cladoporæ* of the Niagara and Lower Helderberg groups of North America really belong to this species; but there are at present no means of verifying this conjecture.)

Pachypora Fischeri, Billings.

(Fig. 16.)

Alveolites Fischeri, Billings, Canad. Journ., new ser., vol. v. p. 256, fig. 6, 1860.

,, *Fischeri*, Nicholson, Report on the Palæontology of Ontario, 1874, p. 57.

Cladopora Fischeri, Rominger, Foss. Cor. of Michigan, p. 47., Pl. XIX., figs. 1 and 4, 1876.

Pachypora Fischeri, Nicholson and R. Etheridge, jun., Journ. Linn. Soc., vol. xiii. p. 362, Pl. XX., figs. 18-20, 1877.

Spec. Char. — Corallum forming flattened expansions or fronds, of a palmate form, and from one to four lines in thickness, and often of considerable size. Corallites disposed obliquely to the surfaces, diverging in opposite directions from a central plane, and opening by distinct calices over the whole free surface of the corallum on both sides of the frond. The corallites are subpolygonal in shape, but their interior is thickened by a secondary deposit of sclerenchyma, arranged in concentric laminæ, so as to leave only a comparatively small oval or circular central tube. Calices sometimes rounded or oval, sometimes markedly oblique and subtriangular — both conditions sometimes prevailing in different parts of the same specimen. About three, or sometimes four, calices in the space of two lines, measured transversely as regards the axis of the frond. Calicine margins much thickened. Septa obsolete; tabulæ few, remote, and complete. Mural pores few, large-sized, irregularly distributed.

Obs.—The above diagnosis gives all the principal characters of this species. Originally described by Mr Billings, and subsequently by myself, as an *Alveolites*, it was referred by Dr Rominger to Hall's genus *Cladopora*. I have, however, already given my reasons for thinking that this generic name cannot be advantageously retained; and the present form, at any rate, differs from those to which Professor Hall originally gave this title, in the possession of well-developed tabulæ. At a still later date it was referred by Mr R. Etheridge, jun., and myself to *Pachypora*, Lindst.; and its very close alliance with *P. lamellicornis*, Lindst., renders the propriety of this reference undeniable. The specific differences between these two forms are, however, numerous; and though it possesses the internal structure of *Pachypora*, the present form in external characters very nearly approaches *Alveolites*, Lam., and thus forms a connecting-link between these two generic types. The corallum in *P. Fischeri*, Bill. (fig. 16, A), is a palmate, flattened, and undulated expansion, which doubtless attained considerable dimensions though the larger examples (three inches or more in length) are always broken; while the thickness varies from one to three or four lines. At its base, the corallum was fixed to some foreign body, but its entire free surface is occupied by the calices, the corallites diverging regularly from an imaginary plane midway between the two flat surfaces of the frond (fig. 16, B). The corallites thus open obliquely on the surface, but the apparent obliquity of the calices varies greatly. In some examples (fig. 16, C) the calices are very slightly oblique, oval or circular, and in these there are about three calices in the space of two lines, in whatever direction the measurement be taken as regards the frond. In other cases (fig. 16, D) the calices are oblique, oval, or subtriangular, or lozenge-shaped, sometimes with the thin lower lip characteristic of *Alveolites*, and in these there are generally four calices in the space of two lines measured across the frond, and five of these apertures on the same space measured vertically. These differences,

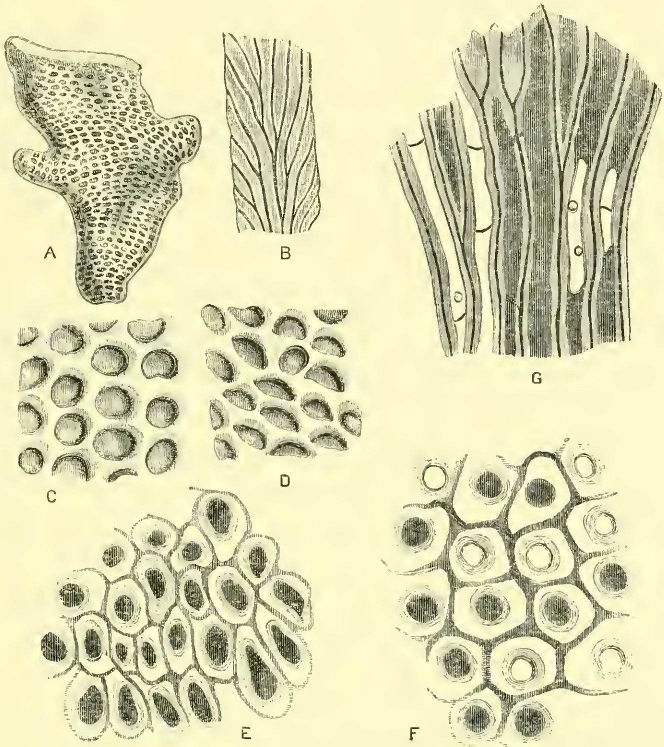


Fig. 16.—A, A young but imperfect specimen of *Pachypora Fischeri*, Bill., from the Hamilton group of Ontario, of the natural size, showing the general form and characters of the corallum; B, Vertical section of the corallum, at right angles to its flat surfaces, enlarged three times, showing the divergence of the corallites from a central plane; C, Portion of the surface of a specimen with rounded calices, enlarged five times; D, Portion of the surface of a specimen with oblique calices, enlarged five times; E, Tangential section of a specimen with oblique calices, enlarged six times; F, Tangential section of a specimen with rounded calices, enlarged six times; G, Vertical section of a specimen with oblique calices, parallel with its flat surfaces, enlarged six times, showing tabulæ and mural pores.

however, are not of specific value, since intermediate conditions are common, and different parts of the same specimen may exhibit both of these states. In both cases, also, thin sections taken in a plane tangential to the surface and just below it, show that the walls of the calices have the characteristic thickening of *Pachypora* (fig. 16, E and F), this being due to the deposition of delicate concentric laminæ of sclerenchyma within the interior of the corallites. The same thickening is shown by the comparative remoteness of the openings of the calices on the surface; but this feature is much more conspicuous in specimens in which the calices are rounded than in those in which they are oblique and more closely crowded together. Sections taken along the median plane of the frond (fig. 16, G), and cutting the tubes longitudinally, also exhibit much-thickened walls and correspondingly contracted visceral chambers. Sections of this kind further show that complete and delicate tabulæ are always present, though few in number, and placed wide apart, while the mural pores are few in number, large in size, and quite irregular in position. Lastly, there are no traces of septa to be detected, even in a rudimentary form, either in tangential or in longitudinal sections.

Formation and Locality.—Common in the Hamilton formation (Devonian) of Arkona, Ontario; also, rarely, in the Corniferous Limestone (Devonian) of Port Colborne, Ontario.

Pachypora frondosa, Nicholson.

(Fig. 17.)

Alveolites frondosa, Nicholson, Geol. Mag., new ser., Dec. II., vol. i. p. 15, Pl. II., fig. 2, 1874; and Rep. on the Palæontology of Ontario, 1874, p. 57.

Pachypora frondosa, Nicholson and Etheridge, jun., Journ. Linn. Soc., vol. xiii. p. 362, 1877.

Cladopora Canadensis, Rominger, Foss. Cor. of Michigan, p. 48, Pl. XIX., fig. 3, 1877.

Spec. Char.—Corallum forming elongated palmate flattened expansions, which grew in an erect position from a rooted base, and which have their entire free surfaces covered with the open mouths of the corallites. In size, the corallum is usually from half an inch to an inch and a half in width, with a height of two inches or more, and a thickness of generally two lines or less. The corallites diverge from an imaginary plane midway between the two flat surfaces of the expansion, and open obliquely on the surface. Walls thickened, and completely amalgamated in contiguous tubes. Calices subtriangular, oval, semilunar, or sometimes fissure-like, with thickened margins, but generally with a sharp lower lip which may be indented with one or more emarginations. The arrangement of the calices is very irregular, but they are often disposed in diagonal lines running across the frond, and there are usually five or six of them in the space of two lines. One or two inward projections of the wall of the corallites on one side may represent septa; or these structures may be wholly wanting. Tabulæ obsolete, or few, remote, and complete. Mural pores apparently very few and remote.

Obs.—In its general habit and form this species (fig. 17) closely resembles *P. Fischeri*, Bill., both constituting thin flat-

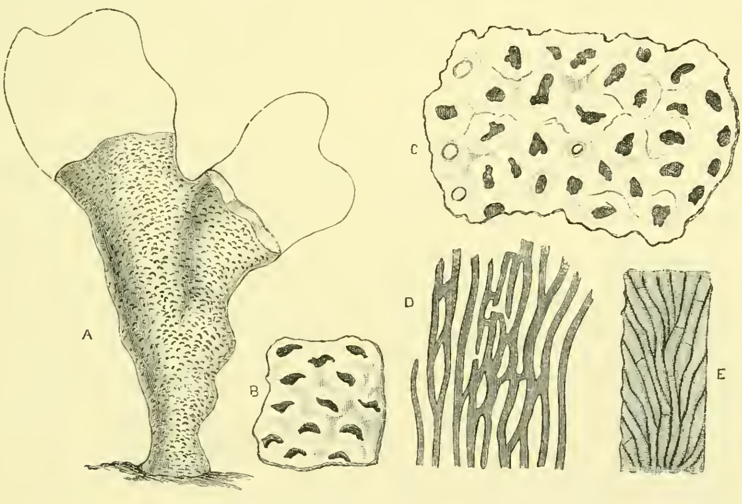


Fig. 17.—A, A fragment of *Pachypora frondosa*, Nich., of the natural size, shown as if attached to some foreign body, and with the extremities of the frond restored in outline; B, A small portion of the surface of the same, enlarged five times; C, Tangential section of the same, enlarged seven times; D, Vertical section of the same, similarly enlarged; E, Section at right angles to the flat surfaces of the frond, enlarged twice, showing the divergence of the corallites from a central plane, together with a few tabulæ. From the Hamilton group of Arkona.

tened fronds, attached basally to some foreign object, and having the corallites so arranged in reference to the median plane of the expansion as to open over the whole of both of the flat surfaces as well as on the edges of the corallum. In spite, however, of this close general resemblance, I do not yet feel absolutely satisfied that the present species is rightly referred to the genus *Pachypora*, Lindst.; and it will require more extended investigations than I have hitherto been able to carry out before this point can be finally settled. In fact, *P. frondosa* exhibits a union of the features which characterise *Pachypora* proper with those distinctive of *Cœnites*, and I am not sure that it will not be ultimately necessary to remove it to the latter genus. This point is especially shown by the calices. These openings, though never actually rounded or polygonal, are often oval, and they are seen in sections parallel with the surface (fig. 17, C) to be surrounded by a dense deposit of sclerenchyma, as in *Pachypora*. On the other hand, the calices are commonly subtriangular, and in parts of the frond they are generally quite crescentic or even fissure-like, while the lower lip is sharp and thin, and may project inwards as a single or double tooth, as in *Cœnites*. Moreover, though the walls of the corallites are thickened, and the calices thus rendered remote, I have failed to detect the delicate concentric laminæ of sclerenchyma so characteristic of *Pachypora*; and the walls of contiguous tubes are completely incorporated, and exhibit no clear line indicating their original separateness. The comparatively numerous septal spines of *P. lamellicornis*, Lindst., are here wanting, but one or two ridges on the interior of one of the walls of the corallites may represent septa. In other cases, however, the tubes appear in transverse section (fig. 17, C) to be oval or rounded, and there may be no traces of septal ridges or tubercles. Thin sections taken along the median plane of the expansion, and cutting the tubes longitudinally (fig. 17, D), show no signs of tabulæ, or but unsatisfactory ones; but sections taken at right angles to the flat surfaces of the frond (fig. 17, E) show that these structures are at any rate occasionally present, when they are few, remote, and complete. I have not been able to discover mural pores otherwise than by the presence of lateral communications between the visceral chambers of contiguous tubes, as seen in long sections (fig. 17, D); and the presence of a few remote and large-sized pores may be regarded as thus sufficiently established. Taking all its known characters into consideration, I am disposed to regard the present species as congeneric with *P. Fischeri*, Bill., though with affinities to *Cœnites*.

There cannot be any question as to the identity of *P. frondosa*, Nich., with the form more recently described by Dr Rominger from the Devonian rocks of North America under the name of *Cladopora Canadensis* (*loc. cit.*) I have also a number of specimens from the Devonian limestones of the Eifel, which appear to be undistinguishable from *P. frondosa;* but as my collections from this region are as yet imperfectly examined, I shall leave this point open in the meanwhile.

Formation and Locality.—Common in the Hamilton formation (Devonian) at Arkona, Ontario.

Genus STRIATOPORA, Hall, 1852.

(Pal. N. York, vol. ii. p. 156.)

Gen. Char.—Corallum dendroid, of simply-dividing cylindrical stems. Corallites essentially polygonal, diverging from an imaginary central axis, their walls greatly thickened by a secondary deposit of sclerenchyma, which increases in amount as their mouths are approached. Calices in the form of circular apertures surrounded by a cup-shaped thickened margin, the floor of which is striated by rudimentary septal ridges. Septal spines in vertical rows occasionally present. Tabulæ few, remote, complete. Mural pores comparatively numerous, circular, irregularly distributed.

Obs.—The first species of this genus which was described or figured is the *Striatopora Iowensis* of Dale Owen (= *S. rugosa*, Hall), of which its author gave a brief description under the name of *Cyathopora Iowensis* (Rep. Geol. Expl. Iowa, Wisconsin, and Illinois, p. 69, 1844). It is not necessary here to enter into the discussion raised by Meek and Worthen (Geol. Survey of Illinois, vol. iii. p. 368, 1868), as to whether Dr Dale Owen is entitled to priority, in the sense that Hall's name of *Striatopora* should give way to *Cyathopora*. There is no doubt at all that *Cyathopora Iowensis*, Dale Owen, is a genuine *Striatopora*; but the fact that Dr Owen gave no separate description of the genus *Cyathopora*, coupled with the close similarity of this name to the entirely different *Cyathopora* of Michelin, would render it highly undesirable to supplant the well-recognised title of *Striatopora*, even if it were demonstrable that strict justice would require this change.

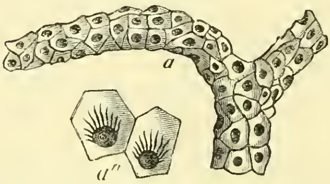


Fig. 18.—Fragment of *Striatopora flexuosa*, Hall, of the natural size. Niagara formation. After Hall.

The genus *Striatopora* was very briefly defined by Hall (*loc. cit.*), and its zoological relations are left undecided; but Dr Rominger (Foss. Cor. of Michigan, p. 57) has correctly seized its true affinities, and has placed it in the family of the *Favositidæ*, a position to which I had independently and simultaneously assigned it (Art. "Corals," Encyclopædia Brit., 9th ed., vol. vi. p. 377). Microscopic examination, in fact, by means of thin sections, places it beyond a doubt that *Striatopora*, Hall, is an immediate relative of *Favosites* itself, and that it agrees so closely with *Pachypora*, Lindst., that the two may be safely regarded as mere offshoots of a common stem. All the known species of *Striatopora* possess a ramose corallum, composed of cylindrical stems, which divide in a dichotomous manner, but are not known to inosculate. The corallites diverge in an obliquely-curved manner from a central axial line, and open by large irregularly-sized polygonal calices on all parts of the free surface. The general form and structure of the corallum are thus precisely those of any dendroid species of *Favosites;* and the close relationship of the two genera is shown by the existence in *Striatopora* of numerous circular mural pores, of well-developed though sparse tabulæ, and, sometimes at any rate, of spiniform septa. On the other hand, the corallites exhibit, in an even more extreme degree, the thickening of their walls by a secondary concentrically-laminated deposit of sclerenchyma, which is so characteristic of *Pachypora*, Lindst. There is, indeed, no feature in the way of internal construction which could be brought forward as separating *Striatopora* from *Pachypora;* and in distinguishing these two types we have to fall back upon a well-marked external character. In all the forms of *Pachypora*, Lindst., namely, the actual orifices of the corallites are but slightly sunk beneath the general surface, and they are surrounded by thick and but faintly-crested margins. On the other hand, in all the species of *Striatopora*, Hall, the circular apertures of the corallites are more or less deeply sunk below the general surface, and open at the bottom of an expanded polygonal cup (fig. 18), the actual margins of which are as thin as the lips of the calices in a species of *Favosites.* This feature is quite sufficient to distinguish *Striatopora* from either *Favosites* or *Pachypora*, between which it is in this respect an intermediate link; though it must be admitted that the filling up of the cup-like terminations of the corallites by the matrix to the level of their free margins, sometimes renders it difficult to apply this distinction in practice. Moreover, the floor of the cup-shaped calices of *Striatopora* is seen in perfect specimens to be generally striated in a radiating manner, with delicate ridges or rows of tubercles, representing septa (fig. 18); though this character also cannot be constantly recognised, and is present in a minor degree in some forms of *Pachypora* (*e.g.*, *P. cristata*, E. and H.)

The geological range of *Striatopora*, so far as known, is a limited one, all the described species being either Upper Silurian or Devonian in age. I have made a careful microscopic examination of *S. Linneana*, Bill., from the Hamilton group of Ontario, and also of *S. Halli*, Lindst., from the Wenlock Limestone of Gotland, but I shall merely give a brief description of the former of these. So far as I am aware, the genus has not yet been recognised as British, though it will doubtless yet be found to be represented in our area.

Striatopora Linneana, Billings.

(Pl. V., figs. 2 - 2 *d.*)

Striatopora Linneana, Billings, Canad. Journ., new ser., vol. v. p. 253, fig. 1, 1860.
,, *Linneana*, Nicholson, Rep. on the Palæontology of Ontario, 1874, p. 59.
,, *Linneana*, Rominger, Foss. Cor. of Michigan, p. 59, Pl. XXIII., figs. 5 and 6, 1877.

Spec. Char.—Corallum dendroid, of dichotomously-branched cylindrical stems, which have a diameter of from two to five lines. Corallites polygonal, diverging from the central line of the branches in gentle curves to open on all points of the free surface, their walls greatly thickened by the growth of a deposit of sclerenchyma, which increases in amount towards their expanded mouths. Calices of very unequal dimensions, the larger ones mostly about one line in diameter, the younger ones of all sizes, intercalated uniformly among those of full growth. The margins of the calices are polygonal and thin, and surround a funnel-shaped or cup-shaped cavity which opens below by a contracted circular orifice into the proper tube-cavity. The thickened neck of the tube exhibits radiating septal ridges or spines, which are continued throughout the length of the tube, but the outer cup appears to be smooth. Tabulæ few, remote, complete. Mural pores moderately numerous, irregularly distributed.

Obs.—There is little need to add any remarks to the above description, all the essential characters of the species being further shown in Plate V., figs. 2 - 2 *d.* All the specimens I have seen are fragmentary, and are in the form of cylindrical or slightly-compressed stems (Pl. V., fig. 2), which evidently subdivide only at considerable intervals, as often no branch can be observed. When not filled up with adherent matrix, the calices (Pl. V., fig. 2 *a*) at once show the characters of *Striato-*

pora, being in the form of deep cups, surrounded by thin polygonal margins, with a much smaller rounded or oval aperture at the bottom, leading into the visceral chamber. Tangential sections taken close below the surface (Pl. V., fig. 2 *c*) show that the throat of the tube is beset with a variable number of radiating spines, representing the septa ; and similar structures may often be detected within the tube-cavity itself. Transverse sections (Pl. V., 2 *b*) show (like the preceding) that the walls of the corallites are immensely thickened by numerous delicate concentric laminæ of sclerenchyma deposited in their interior ; and they are specially instructive as exhibiting the variation of the amount of this secondary deposit in different parts of the corallites. Thus, in the centre of such a section the vertically-placed tubes in the axis of the branch are cut across at right angles, and here their diameter is comparatively small, and the extent to which they are filled up is less. On the contrary, the outer portion of such a section cuts obliquely through the corallites in the terminal part of their course, just as they curve outwards to open on the surface. At this point, therefore, the tubes are seen to be considerably expanded, and a proportionately large amount—generally about two-thirds—of the actual space comprised within the proper walls of the corallites is here filled up with sclerenchyma. Vertical sections (Pl. V., fig. 2 *d*) show the general course of the tubes, and also the same progressive thickening of the walls as the mouth is approached. They show at the same time that the proper walls of the corallites never become obliterated ; that the visceral chamber is crossed by remote, delicate, horizontal, and complete tabulæ ; and that contiguous tubes are placed in communication by comparatively abundant circular mural pores, which in all respects appear to resemble those of *Favosites* itself, except that they appear to have a quite irregular distribution.

Formation and Locality. — Rare in the Hamilton group (Devonian) of Arkona, Ontario.

Genus TRACHYPORA, Edwards and Haime, 1851.

(Pol. Foss. des Terr. Pal., p. 305.)

Gen. Char.—Corallum dendroid, of compact cylindrical stems, attached basally to foreign bodies, and composed of conical corallites which diverge with an increasing curvature from an imaginary axial line to open on all parts of the free surface. Corallites essentially polygonal, in close contact, their proper walls usually not obliterated, and in no case separated by the intervention of a true cœnenchyma. Interior of the tubes contracted by the deposition of numerous concentric layers of sclerenchyma, which increase in amount as the surface is approached. Calices superficially widely distant from one another, arranged in irregular longitudinal rows, the interspaces between them, formed by their enormously-thickened lips, being ornamented with grooves or ridges. Septa represented by radiately-placed spines or tubercles, or obsolete. Tabulæ few, remote, complete. Mural pores generally well marked, but few and irregular.

Obs. — The genus *Trachypora* was founded by Milne-Edwards and Haime for the reception of the single species *T. Davidsoni*, from the Devonian formation of France; and it was placed by these eminent zoophytologists (*loc. cit.*) in the family of the *Seriatoporidæ*, in the immediate neighbourhood of *Dendropora*, Mich., and *Rhabdopora*, E. and H., both also founded upon single species. These three types, in fact, if really capable of generic separation at all, are apparently most closely allied to one another; and as I do not possess any specimens of the two latter, and as their microscopic structure is wholly unknown, I shall make the few remarks concerning them which may be necessary in connection with the present genus, with the anatomy of which I am better acquainted.

My knowledge of the genus *Trachypora* is based upon a minute examination of *T. ornata*, Rom., and *T. elegantula*, Bill., both of which are, in my opinion, unmistakably congeneric with the type-species, *T. Davidsoni*, E. and H., and were so regarded by their respective founders. The investigation of thin sections of these two species has led me to entirely coincide in all points of substantial importance with the account given of the genus by Dr Rominger, who unites it with *Dendropora*, Mich. (Foss. Corals of Michigan, p. 60, 1877). It becomes quite clear, then, that there is no real affinity between *Trachypora*, E. and H., and *Seriatopora*, Lam. Not only is the columella of the latter genus totally wanting in the former, but thin sections place it beyond a doubt that there exists in *Trachypora* absolutely nothing of the nature of a *cœnenchyma*. It is true that the apertures of the calices are widely removed from one another, and that the dense calcareous tissue which separates them is superficially sculptured in various ways; but tangential sections (such as fig. 3 *c*, Pl. V.) show that the appearance thus produced—and mistaken, very naturally, by Milne-Edwards and Haime as indicating the presence of an abundant cœnenchyma—is really due to quite a different cause. In reality there is no cœnenchyma at all, and the essentially polygonal corallites are in close contact by their walls throughout. The wide interspaces which separate the openings of the calices are truly formed by the extraordinary thickening of the walls caused by the deposition of numerous concentric layers of sclerenchyma *in the interior of the tubes*. The actual structure is, therefore, precisely that of *Pachypora*, Lindst., and *Striatopora*, Hall, so far as this point is concerned—with the difference, that the thickening of the immediate periphery of the calices is carried to a much more extreme extent, and that the free surface separating the openings of the calices exhibits the peculiarity of being ornamented with grooves or ridges. This last-mentioned feature is, indeed, the only definite character by which such species of the genus as *T. ornata*, Rom., can be separated from *Pachypora*, while other species (such as *T. Davidsoni*, E. and H., and *T. elegantula*, Bill.) exhibit the additional peculiarity that the remote calices are upon the whole distributed in a small number of vertical rows. Not only is there no true cœnenchyma in *Trachypora*, but the propriety of the step taken by Dr Rominger in placing the genus among the *Favositidæ* is further shown conclusively by the fact that the cavities of contiguous tubes are placed in communication by means of a system of mural pores—the importance of this fact not being diminished by the comparatively small number of these openings. It should be added that in some forms (including the type-species, *T. Davidsoni*) such apertures in the walls of the corallites have not yet been recognised; but it may be confidently expected that these structures will yet be brought to light by a sufficiently minute examination. Lastly, Milne-Edwards and Haime state that, in *T. Davidsoni*, "on ne distingue pas de cloisons;" and the same statement will apply to *T. elegantula*, Bill. In other cases, however, and especially in *T. ornata*, Rom., the septa are quite recognisable as a well-developed series of spines arranged in vertical rows.

While I am unable at present to recognise any true relationship between *Seriatopora* and *Trachypora*, I ought to add that I have had no opportunity of examining microscopic sections of the former, and that my conclusions are therefore based upon the published descriptions and figures of *Seriatopora*. There is a close *general* resemblance between such forms of *Trachypora* as *T. elegantula*, Bill., on the one hand, and certain forms of *Seriatopora* (*e. g.*, *Seriatopora elegans*, Hist. Nat. des Coralliaires, Pl. F 4, figs. 3 *a*, 3 *b*) on the other hand; and it is possible that a microscopic examination of the latter may show that this resemblance is based upon a real identity of structure. All that I can affirm is, that the species of *Trachypora* assuredly do not possess either a proper cœnenchyma or a columella, organs which are said to be present in *Seriatopora*, and that there is thus established a wide difference in systematic position. In the same way there is a striking resemblance between *Trachypora ornata*, Rom., and the living *Pocil-*

lopora acuta, Lam. (see Hist. Nat. des Cor., Pl. F 4, fig. 2); but I have no means of knowing how far this resemblance may express an actual agreement in anatomical structure, and the former assuredly does not possess the cœnenchyma stated to exist in the latter coral.

As distinguished by Milne-Edwards and Haime (Pol. Foss. des Terr. Pal., pp. 304, 305), *Trachypora* is separated from *Dendropora*, Mich., by the fact that the "cœnenchyma" (that is, the thickened margin of the calices) is smooth, or almost so, in the latter, whereas in the former it is adorned by irregular vermiculate or sub-echinulate striæ. The genus *Rhabdopora* E. and H., again, is said to be characterised by having four-sided branches, with an echinulate "cœnenchyma," and calices arranged in simple longitudinal series, the septa being very distinct and slightly exsert. Professor Martin Duncan, in his masterly "Third Report on the British Fossil Corals" (Rep. Brit. Assoc., 1872), concludes—as I think, rightly—that the maintenance of a generic distinction between *Dendropora*, Mich. (1845), and *Rhabdopora*, E. and H. (1851), is quite untenable; but I am unable to follow this distinguished authority in his further conclusion that both of these genera are identical with *Seriatopora*, Lam., which, in turn, is said to be inseparable from *Pocillopora*, Lam., the name of *Acropora*, Oken, being rehabilitated for the reception of all of these. *Trachypora*, E. and H., is, on the other hand, doubtfully referred to the *Alcyonaria*. The researches of Verrill (Trans. Conn. Acad., vol. i., 1868) have, however, shown that *Pocillopora* is closely related to the *Oculinidæ*; and it is highly probable that *Seriatopora*, whether generically separable or not, will ultimately be found to occupy a similar zoological position. Dr Rominger, on the contrary, merges *Trachypora* under *Dendropora*, Michelin, holding that the surface-ornamentation is a character of merely superficial importance. In this view I should be quite prepared to concur, if it were once shown that *Dendropora explicita*, Mich., the type of the genus, possessed the internal structure of *Trachypora*; but in the absence of any information as to the intimate characters of the former, I think it safer to retain *Trachypora* in the meanwhile as a distinct genus. This genus, as will be abundantly evident from what has been said already, is incontrovertibly referable to the *Favositidæ*, and is very nearly related to *Pachypora*, Lindst. If, as is very probable, an examination of the minute structure of *Dendropora explicita*, Mich., should show that this too is a Favositoid, then the genus *Dendropora*, Mich. (including *Rhabdopora*, E. and H.), will have to take the place of *Trachypora*, E. and H., and the classification and arrangement of this difficult group will have been materially improved.

All the known species of *Trachypora*, E. and H., are Devonian; but its union with *Rhabdopora* would extend the range of the type into the Carboniferous, and I possess a specimen from the Wenlock Limestone of Longhope, which appears to be undistinguishable from *Dendropora*. It is probable, therefore, that the genus will ultimately be shown to range from the Upper Silurian to the Carboniferous; but its exact limits must remain at present uncertain.

Trachypora ornata, Rominger, sp.

(Pl. V., figs. 3-3 *c*.)

Dendropora ornata, Rominger, Foss. Corals of Michigan, p. 61, Pl. XXIII., fig. 1, and Pl. XXIV., fig. 2.

Spec. Char. — Corallum composed of cylindrical stems, generally about two or three lines in diameter, branching dichotomously at intervals of half an inch or more. The openings of the tubes on the surface are oval or circular, variable in size, the larger ones mostly about two-thirds of a line in diameter, and either raised above the general surface by a projecting rim, or apparently level with it. Openings of the tubes separated by dense calcareous tissue, which is really formed by the thickening of the walls of the corallites, and which may separate the actual orifices to their own diameter or more. The proper walls may or may not be superficially recognisable as subpolygonal lines surrounding each orifice, and the thickened margins are adorned with tubercles or ridges arranged in a more or less conspicuously radiate manner round the calices. Septa represented by rows of spinules arranged radiately in vertical rows. Tabulæ few, remote, complete. Mural pores few, large-sized, irregularly distributed.

Obs.—This pretty species is readily distinguished from the forms most nearly allied to it by the peculiar ornamentation of the incrassated margins of the calices, which are ornamented with rows of granules or discontinuous ridges invariably having a more or less clearly recognisable radiate arrangement (Pl. V., fig. 3 *a*). Vertical sections show that the walls of the corallites are greatly thickened (Pl. V., fig. 3 *b*), and that this thickening is rapidly augmented in amount towards the openings of the tubes; but considerable differences obtain in the extent to which this process is carried. In some instances, the thickening is so great that the actual openings of the corallites appear to be separated by dense calcareous tissue to their own diameter or even more; but in others they are much more closely approximated, owing to the comparative thinness of the walls. Vertical sections (Pl. V., fig. 3 *b*) further show that the walls of the corallites are always distinctly recognisable and closely contiguous, no cœnenchymal tissue being present; that the visceral chambers remain open throughout their entire length, though greatly contracted in diameter by the thickening of the walls; that there are a few, remote, horizontal tabulæ; that the septa are represented by rows of spinules; and that the cavities of the tubes are placed in communication by a few large pores, of the same character as those of *Favosites*, but quite irregular in their distribution. Tangential sections (Pl. V., fig. 3 *c*) show the same thickening of the walls of the corallites as do vertical slices, and show distinctly that this thickening is due to the deposition of successive thin concentrically-disposed laminæ of sclerenchyma within the interior of the tubes. They further show that the actual polygonal walls of the corallites remain quite distinct and unobliterated, in spite of the thickening to which they are subjected. In some instances, if the plane of the section is just below the actual surface, the dense tissue surrounding the cavity of the visceral chamber may exhibit small discontinuous cavities; but these are clearly merely spaces in the interior of the superficial tubercles and ridges surrounding the opening of the calices (as seen in the lower part of the section figured in fig. 3 *c*, Pl. V.) Lastly, tangential sections show that the cavities of the tubes are surrounded by short, blunt, septal spines. Transverse sections taken at right angles to the axis of the corallum show no features of special importance.

Formation and Locality.—In shales belonging to the Hamilton formation, at Canandaigua, New York. (Dr Rominger's specimens are also from the Hamilton group.)

Trachypora elegantula, Billings.

(Pl. V., figs. 4-4 *c*.)

Trachypora elegantula, Billings, Canadian Journ., new ser., vol. v. p. 254, figs. 2-4.
,, *elegantula*, Nicholson, Report on the Palæontology of Ontario, 1874, p. 59.
Dendropora elegantula, Rominger, Report on the Foss. Cor. of Michigan, p. 63, Pl. XXIII., fig. 2.

Spec. Char.—Corallum ramose, of slender, cylindrical stems, which have generally a diameter of from one to two lines, and branch dichotomously at angles of about 75°. Corallites conical, nearly or quite vertical in the centre of the branches, and curving gently outwards to open obliquely on the surface in generally four longitudinal rows of calices, sometimes with supplementary and irregularly-distributed apertures in addition. The central tubes of the corallites are greatly thickened by the deposition of concentric layers of sclerenchyma, which more or less obliterate the proper walls as distinct structures, though the boundaries of contiguous tubes still remain separate. The orifices of the calices are oval, their long axes parallel with that of the stems, two-thirds or three-fourths of a line in their long diameter, and about half a line across, surrounded wholly or for their lower two-thirds by a slightly-elevated rim, which is sometimes marked with radiating striæ. The thickened margins of the calices separate contiguous apertures to a width about equal to the long diameter of the latter, and form by their union dense interstitial spaces, which are marked by slightly flexuous broken striæ. Septa apparently obsolete. Tabulæ few in number or seemingly absent. Mural pores not recognised.

Obs.—The external characters of this species, as given in the above diagnosis (Pl. V., figs. 4 and 4 *a*), sufficiently separate it from all the known forms belonging to the genus. The internal structure, however, presents various points which are as yet not sufficiently elucidated, the remarkable density of the corallum rendering the preparation of satisfactory microscopic sections a matter of exceptional difficulty. In most of its structural features, *T. elegantula*, Bill., does not differ greatly from such forms as *T. ornata*, Rom., with which it is undoubtedly congeneric; but the thickening of the corallites by a secondary deposit of sclerenchyma is carried in the present form to an extreme extent. This is seen particularly in the fact (as shown both by transverse and vertical sections) that the actual walls of the corallites are more or less obliterated (Pl. V., figs. 4 *b* and 4 *c*), and are not present as distinct partitions definitely circumscribing the individual tubes. In the centre of the stem, where the thickening has not been excessive, the walls are still distinctly recognisable (Pl. V., fig. 4 *b*); but as the thickening increases in approaching the surface, the definite lines indicating the proper walls disappear, and the boundaries of contiguous corallites are now only marked by an obscure but still quite unmistakable band of thickened tissue, occupying the place of the wall (Pl. V., fig. 4 *c*). On the surface, the polygonal margins of the calices—which are quite recognisable in *T. ornata*, as ridges surrounding the actual orifices of the tubes at some little distance—are no longer to be detected at all; and the calices now appear as if sunk in a dense cœnenchyma, superficially adorned with discontinuous striæ (Pl. V., fig. 4 *a*). Moreover, a careful microscopic examination shows that this dense interstitial tissue is, in parts at any rate, rendered minutely porous by the presence of numerous excessively small cavities.

The general appearances presented by this species — as apparently also by the type-species *T. Davidsoni*, E. and H.—are entirely such as would support the view entertained by Milne-Edwards and Haime—namely, that we have to deal in *Trachypora* with composite corals, the corallites of which are sunk in a general cœnenchyma. Thin sections, however, render it abundantly clear that this is not the case, but that the thickened interstitial tissue between the actual tubes of the corallites is only due to the deposition of delicate concentric laminæ of sclerenchyma round the visceral chambers, thus more or less extensively obliterating the true walls. The corallites are therefore really in close contact, and a true cœnenchyma is wanting. It may further be noted that there exists in the present species a kind of undulating median partition (Pl. V., fig. 4 *c*), which seems to separate the corallites on opposite sides of the frond, or to mark the line along which the four longitudinal rows of corallites meet centrally.

As regards other points of structural importance, tabulæ are very sparsely developed, and are not always detectable; though there can be no doubt of their general existence. Septa appear to be wanting, so far as my observations go. Lastly, I have not succeeded in demonstrating the existence of mural pores to my own satisfaction; but they are asserted to be present by Dr Rominger, and I entertain no doubt as to the correctness of his observations on this point.

Formation and Locality.—Rare in the Hamilton formation (Devonian) of Arkona, Ontario.

Genus VERMIPORA, Hall, 1874.

(Twenty-sixth Annual Report on the State Cabinet of New York, p. 109.)

Professor Hall defines this genus as follows: "Bryozoum growing in ramose branches, which are composed of small cell-tubes growing upon one another side by side, without inter-tubular or cellular substance, and destitute of rays or transverse partitions within the tubes. Tubes diverging from the centre of the branch, gradually diverging, and opening upwards on the exterior surface; each tube forming the apex of the branch at the time of its origin, and giving place to succeeding cells in its diverging outwards."

More recently, Dr Rominger has published the following definition of *Vermipora*, Hall, (Rep. Foss. Cor. of Michigan, p. 68, 1876):—

"Ramified twigs, composed of contiguous, sub-parallel, cylindrical tubules, multiplying by lateral gemmation, slowly diverging in their parallel ascending course from a central imaginary axis, and becoming disjunct near their peripheral ends, which project on the surface as single proboscidal siphuncules. Tubes intersected by remote transverse diaphragms, and connected by lateral pores. Vertical radiating crests not observed."

To the above generic diagnosis Dr Rominger adds the following remarks: "Mr Hall places these forms with the *Bryozoa*, and gives of their structure a description different from mine. He has overlooked the principal Favositoid characters of the tubes, *diaphragms* and *lateral pores;* but I think these organs can be found in his specimens as well as in those I have under consideration."

Obs.—Not having had the opportunity of personally examining any unquestionable examples of this genus, and having no knowledge of its microscopic structure, it is impossible for me to supply any data which might serve to clear up the discrepancies between the generic diagnoses given by Hall and

Rominger, as above quoted. Judging, however, from Dr Rominger's figures (*loc. cit.*, Pl. XXIV.), and accepting the general accuracy of his observations as regards the presence of tabulæ and mural pores, it appears impossible to doubt that we have to deal in *Vermipora*, Hall, with a true Favositoid coral, and not with a Polyzoan. In fact, *Vermipora* would not appear to be structurally separable from *Favosites*, except by the disjunct condition of the tubes towards their superficial terminations—the limited development of the tabulæ and the irregular distribution of the mural pores being features of minor importance, and being, perhaps, not always present.

Though I have not had access to any American specimens which I could unhesitatingly refer to the present genus, my friend Dr Lindström has kindly sent me some examples of a small coral from the Upper Silurian of Gotland, with the label *Favosites clausus*, n. sp., which appear to me to be unquestionably congeneric with *Vermipora*, Hall. I shall therefore proceed to briefly describe the structure of these under the name of *Vermipora clausa*, Lindst., sp.; and I will only add here, that I am inclined to think it very probable that in reality the genus *Vermipora*, Hall, is identical with the previously-described *Fletcheria* of Edwards and Haime. The latter genus is, however, stated to increase by calicinal gemmation, and to be destitute of mural pores; and as I have had no opportunity of examining any specimens of the type-species (*F. tubifera*, E. and H.), I shall at present leave it in the position to which it was assigned by the distinguished French palæontologists, and also by Professor Martin Duncan—viz., in the immediate neighbourhood of *Syringopora*.[1]

[1] It may be observed that there is some resemblance in external appearance between *Vermipora* and some of the corals which have been referred to *Aulopora*; and it does not seem impossible that such species of the latter as the *A. spicata* of Goldfuss (Petref. Germ., p. 83, Pl. XXIX., fig. 3), may prove on microscopic examination to belong to the *Favositidæ*, and to be referable to *Vermipora*, Hall.

Vermipora clausa, Lindström, sp.

(Pl. VI., figs. 1-1 *b*.)

Spec. Char.—Corallum forming small sublobate or subramose masses, composed of nearly cylindrical corallites, which diverge from an imaginary central axis. Centrally the corallites are in close contact, and are rendered subpolygonal by mutual compression; but as they diverge outwards, they become, as a general rule, more or less completely free, each being enclosed by its proper wall. Diameter of the corallites about half a line, the intercalated younger tubes of all sizes below this. Walls thick, perforated at all points where the corallites are in contact, by numerous irregularly-distributed, circular mural pores. Septa well developed, in the form of radiating spines. Tabulæ well developed, complete, mostly horizontal, or curved with their convexities downwards.

Obs.—As before said, I am indebted to Dr Lindström for examples of this species, with the label of *Favosites clausus;* and I presume that it is a portion of a specimen of this form which he has figured in a paper on certain Zoantharia Rugosa in the 'Öfversigt Vetenskaps-Akademiens Förhandlingar' for 1856, Pl. XXXI., fig. 14, under the name of *Fletcheria clausa.* I have not access, however, to the original of this paper, and do not know if Dr Lindström has published any full description of the species.

In general appearance the corallum of *Vermipora clausa* might well be taken for a small dendroid *Favosites,* which has a tendency to assume rather a lobed than a truly branched character. The largest specimen I have is about ten lines in length and five lines in its greatest width. The internal structure is also precisely that of *Favosites* proper; and the only point which justifies generic separation is to be found in the fact that the tubes invariably become more or less cylindrical and more or less completely free as their mouths are approached (Pl. VI., fig. 1). In the amount of this freedom, however, there is considerable difference in different specimens. In some examples the corallites, though still retaining their cylindrical form, are very nearly in contact to their calices; whereas in others the tubes become completely disjunct long before their mouths are reached. In all cases, however, the corallites are in close contiguity in all the central portions of the skeleton; and here their walls are always perforated by irregularly distributed mural pores, the condition of parts being, therefore, precisely the same as in *Favosites*. The walls of the corallites, though moderately stout, are not thickened by a conspicuous deposit of sclerenchyma, as in *Pachypora;* while the calices are rounded, and often slightly oblique, smaller ones being intercalated among those of average dimensions. Dr Lindström has noticed the fact that the calices are occasionally closed by an opercular growth; and the exterior of the wall in the free portions of the tubes exhibits numerous fine encircling striæ. Transverse sections (Pl. VI., fig. 1 *a*) show that the tubes in the centre of the corallum are subpolygonal, with moderately thick walls, the lines of division between them always remaining quite distinct. At the same time, well-developed spiniform septa are brought into view. Longitudinal sections (Pl. VI., fig. 1 *b*) precisely resemble those of a *Favosites*, exhibiting septa and mural pores, along with well-developed complete tabulæ, which may be horizontal, or may be curved with their convexity downwards.

Formation and Locality.—Upper Silurian, Gotland, *Coll.*, Dr Gustav Lindström.

Genus ROMINGERIA, Nicholson.

Quenstedtia, Rominger, Fossil Corals of Michigan, p. 70, 1876.
[Non *Quenstedtia*, Morris and Lycett, 1854.]

Gen. Char.—Corallum lax, spreading; resembling *Aulopora* in its general appearance, but only attached basally, and free throughout the greater part of its extent. Corallites cylindrical, annulated, multiplying by lateral gemmation, and typically producing new tubes in umbellate whorls or verticils, which are placed at short intervals. Where their walls are in contact, their visceral chambers are placed in communication by means of mural pores. Tabulæ complete, remote, apparently not distinctly infundibuliform. Septa represented by vertical rows of spinules.

Obs.—The type of this genus is the singular coral described by Billings under the name of *Aulopora umbellifera* (fig. 19), from the Corniferous Limestone of North America. It was provisionally left by Billings, and subsequently by myself, in the genus *Aulopora*, upon the ground that its internal structure was imperfectly known, but both of us stated that it would probably prove to be the type of a new genus. At a later date Dr Rominger succeeded in establishing the important fact that mural pores are present in this species, and he therefore properly removed it to the family of the *Favositidæ*, and raised it to the rank of a genus under the name of *Quenstedtia*. This designation would of course have been retained by me but for the fact that it has, unfortunately, been employed as early as 1854, by Morris and Lycett, for a genus of Lamellibranchiate Molluscs. Under these circumstances, I have great pleasure in proposing for the genus the title *Romingeria*, in honour of one who has so largely contributed to the elucidation of the fossil corals of North America.

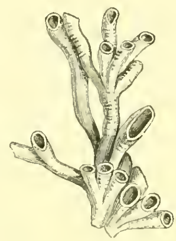


Fig. 19. — Portion of the corallum of *Romingeria umbellifera*, Bill. sp., from the Corniferous Limestone of Canada, of the natural size.

In many respects *Romingeria* is a type of special interest, as affording us a transitional link between the families of the *Favositidæ* and the *Syringoporidæ*. It differs from *Aulopora*, to which it was originally referred, by its erect mode of growth, in the disposition of the branches (as a rule) in successive verticils, and more especially in its perforate walls. In general habit it does not differ much from some species of *Syringopora*; and if we imagine its mural pores to be converted into hollow connecting processes, it would be difficult or impossible to separate it from this genus. The existence, however, of mural pores, as first demonstrated by Rominger, proves that it is properly referable to the *Favositidæ*, among which its true place would seem to be in the neighbourhood of *Vermipora*, Hall. It differs from the latter, in fact, principally by the lax spreading mode of growth of the corallum, and by the much greater extent to which the corallites are disconnected from one another.

Dr Rominger has described a species from the Niagara Group of North America (*loc. cit.*, p. 71); but I am only acquainted personally with the type-species, *R. umbellifera*, Bill., of which I subjoin a short description. I regret, however, that the state of preservation of my specimens is such—owing to silicification—that I have been unable to procure satisfactory microscopic sections, and that I can therefore merely give such characters as can be learned by the ordinary methods of examination.

Romingeria umbellifera, Billings, sp.

(Fig. 19.)

Aulopora umbellifera, Billings, Canad. Journ., new ser., vol. iv. p. 119, fig. 21.
,, *umbellifera*, Nicholson, Report on the Palæontology of Ontario, p. 43, Pl. VI., fig. 4 (poor figure).
Quenstedtia umbellifera, Rominger, Rep. Foss. Cor. Michigan, p. 70, Pl. XXXIII., fig. 3.

Spec. Char.—Corallum erect, lax, spreading, of cylindrical corallites, with a thick annulated wall, adorned with fine encircling striæ. Diameter of the corallites about one line. The primary stems remain undivided for a distance of a quarter of an inch or more, and then give origin to a cluster of corallites in an umbellate manner, one or more of these proceeding to proliferate in a similar manner, and at a similar interval, and the process being repeated till a loosely fasciculate corallum is produced. The number of corallites in a single verticil varies from five or six to as many as ten or twelve, and they are at first closely in contact with one another, the union of their walls often extending to a distance of two or three lines from the point of origin from the parent tube. Ultimately, they become more or less completely free—radiating outwards, like the spokes of a wheel—and one or more are continued beyond the general circle of the whorl to give rise to a new umbel. Walls thick, the visceral chambers of the corallites, where the latter are in contact, being placed in connection by distinct mural pores (Rominger). Tabulæ remote, complete, so far as observed horizontal. Septa represented by from six to ten vertical rows of strong spinules.

Obs.—I have little to add to the above specific diagnosis, which embodies all the important characters which I can gather from an examination of the specimens in my possession. The existence of mural pores cannot be determined from any of my examples, but Dr Rominger's figures (heliotypes) prove their presence beyond all question. I think it quite likely that Dr Rominger is correct in regarding *Aulopora cornuta*, Bill. (Can. Journ., new ser., vol. iv. p. 118, fig. 20), as really founded upon fragments of the present species. I have, however, various specimens which seem to belong to *Aulopora cornuta* as regards their general characters, but which agree with *Aulopora* proper in being parasitic; so that I must at present leave the identity of this form with *Romingeria umbellifera* an open question.

Formation and Locality.—Rare in the Corniferous Limestone (Devonian) of Port Colborne, Ontario.

Genus ALVEOLITES, Lamarck, 1801.

(Syst. des Anim. sans Vert., p. 375.)

Gen. Char.—Corallum massive, incrusting, or ramose, composed of contiguous compressed corallites, which possess *thin walls*, and open obliquely upon the surface by subtriangular or semilunar calices. Septa sometimes obsolete, but often present in the form of longitudinal rows of spinules, which may be equally developed, or may be reduced to a single, double, or treble row by the suppression of the others. Tabulæ well developed, complete. Mural pores generally few in number, of large size, and irregular in their distribution.

Obs.—There is no genus in the entire series of the *Favositidæ* which presents greater difficulty than the present one, as regards its satisfactory definition and separation from allied types. So much so is this the case, that a strong disposition has been shown by some of our most distinguished palæontologists to reject the genus *Alveolites* altogether, and not without reason, since it is certain that the forms which have at various times been included under this name are of very different affinities. The difficulties which environ this subject have been elsewhere discussed at some length by Mr R. Etheridge, jun., and myself (Journ. Linn. Soc., vol. xiii. p. 353, 1877); and I shall avail myself largely of the memoir just referred to in what follows. Since this paper was written, however, I have been able to obtain much additional material throwing light upon the genus, and am therefore able to speak more decidedly upon some points which at that time appeared doubtful, as well as to modify in some particulars the opinions therein expressed.

The genus *Alveolites* was originally founded by Lamarck in the first edition of the 'Système des Animaux sans Vertèbres' (published in 1801), p. 375, for the reception of a single Devonian species which he described under the names of *A. suborbicularis* and *A. escharoides*, and for which the former title has been subsequently retained. The original definition is, "Polypary stony, thick, globular, or hemispherical, formed of numerous concentric layers, which are superimposed one upon the other, each layer formed by the union of alveolar, subtubular, prismatic, contiguous cellules [or tubes], forming a network on the surface." In the Hist. Nat. des Anim. sans Vertèb. (published in 1816), vol. ii. p. 184, the same definition is given with very slight alterations, the principal change being that the genus is now made to include incrusting forms. In the second edition of Lamarck's Hist. Nat. des Anim. sans Vertéb. (published in 1836), the portion relating to the corals was revised by Milne-

Edwards, and the genus *Alveolites* is defined as follows (vol. ii. p. 285):—

"Corallum stony, sometimes incrusting, sometimes free and massive, formed of numerous layers which are concentrically superimposed upon one another, each layer composed of tubular, alveolar, prismatic cellules, which are somewhat short, and form a network on the surface." Four species of the genus were recognised by Lamarck, of which *A. suborbicularis* and *A. escharoides* have been subsequently united with one another. *A. madreporacea* is stated by Milne-Edwards to be a *Pocillopora*, and *A. incrustans* appears to be a Polyzoön. To the above four species Milne-Edwards added, in the work just quoted, four others, of which *A. tubiporacea* and *A. milleporacea* appear to be referable to *Favosites; A. clavata* may perhaps be a *Chætetes;* and *A. infundibulifera* was afterwards placed by Edwards and Haime in a new genus under the name of *Rœmeria*.

Without taking up time by discussing the views entertained as to the characters of the genus *Alveolites*, and the different forms referable to it, by Goldfuss, De Blainville, Michelin, Steininger, D'Orbigny, and other well-known palæontologists, we may pass on to consider the opinions expressed by Milne-Edwards and Jules Haime in their great works on the fossil corals. In the Introduction to the 'Monograph of the British Fossil Corals' (Palæontographical Society, 1850, p. lx), these distinguished authorities place the genus *Alveolites* in the group of the Favositidæ proper, characterised by the presence of well-developed tabulæ, the existence of mural pores, and the rudimentary condition of the septa. They define the genus as possessing a "corallum composed of superposed strata of corallites very similar to those of *Favosites*, but much shorter, and terminated by an oblique semicircular or subtriangular calice, the edge of which projects on one side." The type-species of the genus is *A. spongites*, Steininger (= *A. suborbicularis*, Lamarck). In their 'Polypiers Fossiles des Terrains Paléozoiques' (p. 254), the same authors in the succeeding year redefine *Alveolites* as follows: "Corallum forming a convex or dendroid mass. Calices oblique, subtriangular, or semicircular, presenting interiorly a longitudinal protuberance which is opposed to two other smaller protuberances. These eminences appear to represent the primary septa, and no other traces of the septal apparatus can be detected. The walls are simple, well developed, pierced with a small number of mural pores. The tabulæ are complete and horizontal." After giving a history of the genus, the authors just quoted remark that the elongated teeth or eminences above alluded to constitute the most remarkable feature of the genus *Alveolites*, and that they are to be regarded as so many primary septa, the other three which form the normal cycle of six being aborted. They further add that one of these three septal teeth is always more pronounced than the other two, and that these latter may be wholly wanting.

In the 'Histoire Naturelle des Coralliaires' (vol. iii. p. 263, 1860), Milne-Edwards makes the following remarks as to *Alveolites*: "The most striking character of *Alveolites* is furnished by the *septal system*, which is represented by three teeth or vertical projections—one situated on the inside face of the outer lip of the calice, the others opposite the preceding, upon the inner lip of the corallite, and sometimes rudimentary. The calices are *oblique*, subtriangular, or subhemispherical. Walls simple, well developed, and pierced by a small number of pores. Tabulæ complete and horizontal. . . . The elongated teeth or vertical projections which we see in the interior of the visceral chambers of the corallites *form the most peculiar character of Alveolites*, and recall the three principal septa which characterise the genus *Heterocœnia* amongst the Astræidæ. . . . It is also worthy of note that one of the septal projections is more developed than the other two, and often it alone may exist."

In briefly analysing the above, it will be obvious, in the first place, that Lamarck's definition of the genus *Alveolites* does not contain a single character which would at the present day be regarded as of generic importance at all; so that the ultimate existence of the genus will depend upon whether the type-species, *A. suborbicularis*, Lam., can be shown to possess characters which separate it generically from allied forms. In the second place, the various definitions given by Milne-Edwards and Haime yield, upon collation, the following characters as essentially distinctive of the genus *Alveolites* as understood by them: (1.) The corallites are furnished with lamellar walls, and are not united by any cœnenchyma. (2.) The visceral chamber is traversed by well-developed horizontal tabulæ. (3.) Mural pores, comparatively large and few in number, are present. (4.) The corallites are oblique, shorter than in *Favosites*, and terminated by *oblique*, *semilunar*, or *subtriangular calices*. (5.) There exist in the interior of each corallite three elongated teeth, which represent the primary septa, and of which one is always larger than the others, and may be the only one present. (6.) The corallites are arranged in the massive and incrusting forms in superimposed layers.

Alveolites suborbicularis, Lam., the type-species, possesses all the above-mentioned characters, and is therefore, to begin with, clearly a member of the Favositidæ proper. In order, however, to establish the validity of the genus *Alveolites*, it is further necessary to prove that *A. suborbicularis* is generically separable from *Favosites;* and there are only two of the above-mentioned characters—namely, the obliquity of the calices and the presence of septal teeth—which require special consideration in this connection. Moreover, even if the generic distinctness of *A. suborbicularis* and immediate allies be satisfactorily established, there still remain various forms more or less resembling this, which nevertheless differ considerably from it in minute structure, and which must therefore be referred to different groups.

To the above remarks, taken from the paper already referred to, was added a brief account of the principal types of structure which are recognisable in the various forms which have been at different times included under *Alveolites* by different palæontologists, and which externally resemble this genus more or less closely. In most of the views therein expressed, I am still quite willing to concur, but the further observations which I have made enable me to state these views in a more definite form than was at that time possible, and also to make some modifications in them. The results, then, of my inquiries, combined with those formerly arrived at by my colleague and myself, are briefly as follows:—

1. Taking *Alveolites suborbicularis*, Lam., as the type of *Alveolites*, the genus may be usefully retained, but the presence of septal teeth must be abandoned altogether as a generic distinction, and we must include under the same head forms such as *A. Labechei*, E. and H., and *A. Goldfussi*, Bill., which have numerous septa, or in which the septa are obsolete. On this view, *Alveolites* will include forms which agree with *Favosites* in all essential characters, save only the possession of oblique calices and narrow compressed or triangular corallites. I fully admit that the characters just mentioned, when standing alone, cannot be strictly regarded as of generic value, and that the most rigidly scientific course would be to merge *Alveolites* in *Favosites*. This course, however, would render the genus *Favosites* an extremely unmanageable one, and upon the ground of practical convenience I prefer separating *Alveolites* by means of the readily recognisable character of the reclined corallites and oblique calices. All the species thus placed in *Alveolites* agree with one another and with *Favosites* proper in having *thin-walled corallites*, without any excessive thickening of the terminations of the tubes, and they are thus distinguished both from *Pachypora* and from *Cœnites*, with which they are otherwise closely allied. I include in this group *Alveolites suborbicularis*, Lam., *A. Labechei*, E. and H., *A. Goldfussi*, Bill., *A. Indianensis*, Rom., and all forms related to these.

2. Some of the forms which have been referred to *Alveolites* are properly placed under the genus *Pachypora*, Lindst., as shown by the thickening of the interior of the tubes by a dense

secondary deposit of sclerenchyma. As has previously been pointed out, this is the case with the so-called *Alveolites Fischeri*, Bill., and *A. frondosa*, Nich.; and I have no doubt that other forms, both of the expanded and ramose type, will ultimately prove to be referable to *Pachypora*, rather than to *Alveolites* as here defined.

3. The forms grouped under *Cœnites*, Eichw., so far as properly placed under this head, may be distinguished from *Alveolites* by the form of the calices, but more especially by the great thickening of the interior of the tubes in the neighbourhood of their mouths. As will subsequently be seen, therefore, *Cœnites* bears the same relation to *Alveolites* that *Pachypora* does to *Favosites*, while it has some special features in addition.

4. The forms which have been described as *Alveolites septosa*, Flem., and *A. depressa*, Flem., are closely allied to *Chætetes radians*, Fischer, and must be removed to the genus *Chætetes*.

Returning now to the genus *Alveolites* as here defined, the *form* of the corallum appears to be very variable. *Alveolites suborbicularis*, Lam., the type of the genus, appears really to be almost always in the form of irregular masses which are formed of concentrically disposed layers which have grown parasitically round some foreign body. In other forms, however, such as *A. Labechei*, E. and H., and *A. Goldfussi*, Bill., the form of the corallum is that of a flattened, sometimes gibbous expansion, which is covered below by a wrinkled epitheca, and only exhibits calices upon its upper surface. Other forms, again, such as *A. Rœmeri*, Bill., are dendroid; but the various ramose corals which have been included under *Alveolites* will require to be subjected to a careful microscopic examination before their true affinities can be positively asserted. Lastly, so far as I have seen, no true *Alveolites*, in the sense here understood, has the form of an erect frondose expansion, attached basally, and having its free surfaces entirely covered with calices.

In the most typical species of *Alveolites*, the corallites are excessively oblique to the principal plane of the corallum, those which open on the circumference of the mass most so, and those in its centre least. *A. suborbicularis*, Lam., offers the extreme type of this condition, while *A. Indianensis*, Rom., though an unquestionable *Alveolites*, presents the minimum amount of obliquity of its tubes. It has been pointed out by Lindström that *A. Fougtii*, E. and H., primitively possesses erect corallites, which only become reclined in the course of growth; and upon this ground this high authority has placed the species in *Favosites*. Upon the whole, however, though formerly disposed to adopt the same view, I think it safer to go by the adult characters of the corallum, which would seem to place this curious transitional form in *Alveolites*.

Owing, also, to the obliquity of the corallites, the *calices* in *Alveolites* open obliquely upon the surface, one lip being shorter than the other, and the aperture being more or less transversely elongated, its shape being in general subtriangular, semilunar, or subrhomboidal.

The *walls* of the corallites in *Alveolites* are invariably thin, as conclusively shown by thin sections; there is no marked thickening due to the deposition of concentric lamellæ of sclerenchyma in their interior, nor are the tubes notably, or as a rule at all, expanded towards their mouths. All forms resembling *Alveolites* in appearance, but with abnormally thickened walls, must find a place either in *Pachypora*, Lindst., or in *Cœnites*, Eichw.

The *mural pores* are usually few in number, and of comparatively large size; but it is certain that this character cannot be used as one of generic value, precisely the same feature occurring in *Pachypora*.

The *septal system* varies much in its development in *Alveolites*. As has been seen, Milne-Edwards and Haime regarded the presence in the interior of each corallite of three elongated teeth or septal ridges, which may be reduced to one, and which represent the septa, as the leading character of the genus. I am, however, quite satisfied that this view is untenable, and that the condition of the septa is too variable to allow of its being used as a generic character. *A. suborbicularis*, Lam., seems often to possess such a single septal ridge in the interior of each corallite (see fig. 20, and Pl. VI., fig. 2); but an examination of a number of well-preserved specimens from the Eifel has convinced me that it is excessively difficult to detect this feature even in the most perfect examples, and that it is seemingly really not invariably present, since it is only occasionally that such a structure can be made out by thin sections, so far as I have seen. It may be freely conceded, however, that certain species have the septa reduced to one or three longitudinal ridges, though no more than a specific value can be assigned to this. On the other hand, *A. Labechei*, E. and H., though stated by Edwards and Haime to possess a "slightly developed" or "very indistinct" septal ridge, like that of *A. suborbicularis*, can be conclusively shown by microscopic sections to possess numerous vertical rows of septal spines (Pl. VI., figs. 3 and 3 *a*) precisely similar in their characters to those of *F. Hisingeri*, E. and H., and other species of *Favosites*. The same feature is equally observable in some other species. In certain types, again, such as *A. Goldfussi*, Bill. (Pl. VI., fig. 4), the septa appear to be entirely obsolete, no traces of their existence being observed in thin slices. Upon the whole, then, we must regard the development of the septa in *Alveolites* as quite variable, and as affording characters of no more than specific importance.

Lastly, the tabulæ in *Alveolites* are always well developed, and are complete and essentially horizontal. These structures, however, present no features of special importance.

The known species of *Alveolites*, as here defined, are confined to the Upper Silurian and Devonian periods; and the two species which I shall select for brief description as illustrating more fully the characters of the genus are *A. suborbicularis*, Lam., and *A. Labechei*, E. and H.

Alveolites suborbicularis, Lamarck.

(Pl. VI., figs. 2 - 2 *b*.)

Alveolites suborbicularis, Lamarck, Hist. des An. sans Vert., vol. ii. p. 186, 1816.

„ *escharoides*, Lamarck, ibid., p. 186.

Calamopora spongites, var. *tuberosa*, Goldfuss, Petref. Germ., p. 80, Pl. XXVIII., figs. 1 *a* - 1 *e* (cæt. exclusis), 1829.

Favosites spongites (?), Phillips, Pal. Foss., p. 16, Pl. VIII., fig. 23, 1841.

Alveolites suborbicularis, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 255, 1851, and Brit. Foss. Cor., p. 219, Pl. XLIX., figs. 1 and 1 *a*, 1853.

Spec. Char.—Corallum forming masses of considerable size and variable form, consisting of concentrically superposed layers, attached parasitically to some foreign body, and having an irregularly elevated surface. Corallites very oblique, compressed, mostly subtriangular, with a long convex and two short concave sides, but very variable in form, though never regularly polygonal or cylindrical. Long diameter of the tubes about one-third of a line, transverse diameter about one-sixth of a line. Walls moderately but not excessively thick, not incrassated towards the terminations of the tubes, and pierced by few remote mural pores. Septa represented only by a single longitudinal ridge, which does not appear to be constantly present. Tabulæ numerous, close-set, horizontal, complete.

Obs.—The specimens from which the above description is taken were collected by myself in the Eifel, and agree in all respects with the figures given by Goldfuss (Petref. Germ., Pl. XXIX., figs. 1 *a* - 1 *e*; Milne-Edwards and Haime add figs 1 *f* - 1 *h* of the same plate, but I think these belong to a different species). These figures give an excellent idea of the general form and appearance of this species; and I have not, therefore, thought it necessary to give an illustration of one of my own specimens. So far as I can judge at present, I think that the name of *A. suborbicularis* will have to be restricted to the specimens which have the habit of forming irregularly gibbous masses, composed of successive concentric strata enveloping some central foreign body. It is not that any particular stress can be laid upon the mode of growth *per se*; but so far as my observations have gone as regards this species, this peculiar habit is only found in specimens which have a special internal structure; and, under these circumstances, it becomes a character of specific value. On the other hand, there occur along with the preceding many specimens which form flattened or sub-hemispherical expansions, having their under surface covered by a wrinkled epitheca, attached to some foreign object by a pedunculate base, having the calices confined to the upper surface only, and not exhibiting any composition of the corallum out of concentric layers. Specimens of this type in other respects nearly resemble *A. suborbicularis*, Lam., and they might be easily, and I believe sometimes have been, confounded with the latter. So far as I have yet examined such specimens, however, I find them to differ from the encrusting and laminated specimens which constitute the true *A. suborbicularis*, Lam., in various points of their internal structure, and especially in the possession of numerous unusually strong spinose septa.

The only points in the anatomy of *A. suborbicularis* to which I need draw attention are the condition of the septa and the tabulæ. According to Milne-Edwards and Haime, the outer or under side of each of the calices "bears interiorly a small elongated ridge, which appears to represent a septum, and is placed opposite to a small notch" (Brit. Foss. Cor., p. 219). Such septal ridges have been well figured by Goldfuss, and I have reproduced his drawing in order to show their character (fig. 20). I am not able to assert, however, that I have succeeded in detecting their presence by an examination with a lens of any of the specimens in my possession, and I think that little specific value can be attached to a character

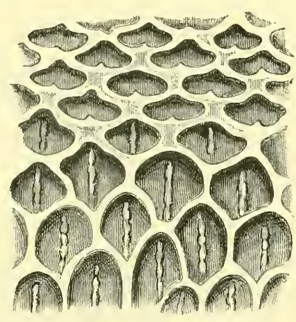


Fig. 20.—Calices of *Alveolites suborbicularis*, Lam., greatly enlarged, showing the single septal ridge. Devonian, Eifel. (After Goldfuss.)

so uncertain and so difficult of recognition. This opinion is strongly supported by the appearances presented by tangential sections (Pl. VI., fig. 2 *a*). In these, the characteristic compressed form and the moderately thick walls of the corallites can be admirably observed; but the single septal ridge above alluded to can only be made out occasionally, and never, so far as I have seen, in more than quite a small proportion of the tubes. It does not seem, therefore, to be of constant occurrence, and no other traces of septa can be detected.

In longitudinal sections (Pl. VI., fig. 2 *b*) the chief feature observable is the abundance of the horizontal and complete tabulæ, no traces of septa being recognisable.

Formation and Locality.—Abundant in the Devonian Limestone of Gerolstein and Bensburg in the Eifel. I do not yet feel certain if any of the specimens which I possess from the Devonian limestones of Devonshire are really identical with this species, though some certainly present a close resemblance to it. None of the species of *Alveolites* from the Devonian of North America that I have examined, or that have been figured or described by other observers, seem to be referable to this species.

Alveolites Labechei, Edwards and Haime.

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

Favosites spongites (pars), Lonsdale, in Murchison, Silurian Syst., Pl. XV., figs. 8-8 *b* (cæt. exclusis), 1839.

Alveolites Labechei, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 257, 1851.

„ *Labechei*, Milne-Edwards and Haime, Brit. Foss. Cor., p. 262, Pl. LXI., figs. 6-6 *b*, 1854.

„ *Grayi*, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 258, 1851, and Brit. Foss. Cor., p. 262, Pl. LXI., figs. 2-2 *a*.

Spec. Char.—Corallum massive, attached to foreign bodies by one point of its base, and forming a flattened expansion with a slightly convex or irregularly elevated surface, the upper surface being occupied by calices, while the lower surface may be in large part similarly occupied, or may be covered with a concentrically-wrinkled epitheca. Average size of the corallum from an inch or less up to three inches in diameter, with a height of from five to fourteen lines. Corallites extremely oblique, compressed, from one-third to one-half of a line in their long diameter, and less than this in their short diameter. Calices upon the upper surface very oblique, subtriangular, or somewhat lozenge-shaped, usually bounded by one long and two short curved margins; upon the lower surface, where present, usually less oblique, and often irregularly polygonal. Septa numerous, in the form of pointed spines, which have a marked upward direction, and extend into the visceral chamber to about one-third of its diameter. Tabulæ numerous, complete, horizontal. Mural pores apparently comparatively numerous and of no large size.

Obs.—This is one of the most abundant of the corals of the Wenlock Limestone of Britain. If the Devonian *A. suborbicularis*, Lam., be considered, as has here been done, to include only forms which grow into irregular masses composed of superposed concentric strata of corallites, then the present species is easily distinguished from it by the difference of its ordinary habit. It forms flattened expansions, attached by a pedunculate base, and usually having part of the lower (as well as the upper) surface covered by calices. Sometimes almost the whole lower surface is so occupied, but generally a portion seems to have been protected by an epitheca. In general form, therefore, *A. Labechei*, E. and H., resembles the *A. Goldfussi*, Bill., of the Devonian of North America; but the latter is readily distinguished by the much larger size of the calices and the total absence of septa (Pl. VI., fig. 4). Milne-Edwards and Haime have separated *Alveolites Grayi* from *Alveolites Labechei*, upon the ground that "its calices are always larger, and are limited by walls that are thicker in proportion to the size of the corallites." After a careful examination, however, of both of these forms, I am forced to come to the conclusion that they are not specifically separable, the more especially as single specimens are not uncommon in which the calices have in parts the long diameter of those assigned to *A. Labechei* ("somewhat more than one-third of a line"), while in other parts the long diameter of these openings is that of *A. Grayi* ("about half a line"). Moreover, thin sections show that they agree with one another in their internal structure, this exhibiting a feature unusual in the genus *Alveolites*—namely, a well-developed system of septa. These septa are excellently seen by means of thin tangential and vertical sections (Pl. VI., figs. 3-3 *a*), and have the form of a circle of radiating spines, of variable number (often ten or twelve), extending into the interior of the tubes, and sometimes reaching nearly to the centre of the visceral chamber. In longitudinal sections (Pl. VI., fig. 3 *a*) these septal spines are seen to form vertical rows, and to be generally markedly directed upwards, or towards the mouths of the tubes. Owing to this latter fact, they often look, when seen in transverse sections (Pl. VI., fig. 3), as if they were not actually connected with the wall of the tube. Longitudinal sections show the presence of numerous complete tabulæ, and occasionally of mural pores, the latter seemingly more numerous and smaller than is usual in *Alveolites*. Both kinds of sections show that the walls of the corallites are in no wise abnormally thickened, and *A. Labechei*, E. and H., is thus shown to belong properly to *Alveolites* as here understood.

Formation and Locality.—Abundant in the Wenlock Limestone of Benthall Edge, and Dormington Quarry near Stoke-Edith. Also in the Wenlock Limestone of Gotland. It has not been hitherto detected in the corresponding formation of the Niagara Limestone of North America, but species of the same general *type* are abundant in the Devonian of Europe and North America.

Genus Cœnites, Eichwald, 1829.

(Zool. Spec., t. i. p. 179.)

Limaria, Steininger, Mem. Soc. Géol. de France, t. i. p. 339, 1831.

Gen. Char.—Corallum usually dendroid or frondescent, rarely submassive. Corallites compressed, thin-walled in the centre of the corallum, but immensely thickened in the neighbourhood of their mouths by means of a dense secondary deposit of sclerenchyma, the proper walls nevertheless always remaining distinct. Visceral chamber reduced to a fissure in the vicinity of its termination, and opening upon the surface by a narrow transversely-elongated slit-like calice, one lip of which carries two tooth-like projections, which face a single similar tooth springing from the opposite lip. Septa represented only by the calicine teeth just spoken of. Tabulæ well developed, complete, horizontal. Mural pores moderately numerous, large-sized, irregularly distributed.

Obs.—The genus *Cœnites* was originally founded by Eichwald (*loc. cit.*), and was subsequently described by him (Lethæa Rossica, vol. i. p. 457) as comprising dendroid or lamellar and encrusting corals, with semicircular or triangular calices, provided with a single rudimentary septal ridge upon their lower lips, the corallites being united by an abundant "cœnenchyma." Milne-Edwards and Haime (Pol. Foss. des Terr. Pal., p. 301) also suppose that a "cœnenchyma" is present, and they describe the septal system as consisting typically of three teeth, two on one margin of the calice and one on the other. The same authors include the genus among the *Pocilloporidæ*, though they subsequently express a doubt whether it should not rather be removed from the *Actinozoa* and placed among the *Polyzoa* (Brit. Foss. Cor., p. 276). Professor Martin Duncan (Third Rep. on Brit. Foss. Cor.; Rep. Brit. Ass., 1871, p. 130) also assumes the existence of a "cœnenchyma" in *Cœnites*. Dr Lindström (Några Anteckningar om *Anthozoa Tabulata*, Öfversigt af Vetensk. Akad. Förhandl., 1873) considers that *Cœnites* may possibly be referable to the *Polyzoa*; but, somewhat inexplicably, he regards *Alveolites suborbicularis*, Lam., and its allies as belonging to this genus. Mr R. Etheridge, jun., and myself pointed out (Journ. Linn. Soc., vol. xiii. p. 361), from an examination of *Cœnites orientalis*, Eichw., that probably there existed no true cœnenchyma in *Cœnites*, and indicated that this generic name might need to be suppressed in favour of *Alveolites*, Lam. Lastly, Dr Rominger (Foss. Corals of Michigan, p. 43) placed the genus in the *Favositidæ*, in the immediate neighbourhood of *Alveolites*, from which he regards it as differing only by "more conical stout-walled tubes of less compressed and more rounded form in the central or basal parts of the polyparia."

The true structure and affinities of *Cœnites*, Eichw., can be determined with the greatest certainty by means of thin microscopic sections; and these show that the genus is not only not Polyzoan in its relationships, but that it is in all respects properly referable to the *Favositidæ*, standing upon the whole nearer to *Pachypora* than to *Alveolites*. Thus, thin sections show that the tubes are not only tabulate, but that they have the more important feature of being placed in communication with one another by means of a well-developed system of "mural pores," which are precisely similar in all points of importance to the pores of *Favosites*, and which only differ from these in being irregularly distributed. Moreover, there is no "*cœnenchyma*" present in the corals of this genus, as has been generally supposed. On the contrary, the corallites (Pl. VI., fig. 5 *a*) are in close contact throughout their entire length, and their walls are also everywhere quite distinct. In the centre of the corallum the tubes have quite thin walls, and present no feature by which they could be distinguished from the corallites of a ramose *Favosites*. Just before reaching the surface, however, each tube bends abruptly, often dividing at the same time, and the wall for the rest of its course is immensely thickened by a dense secondary deposit of sclerenchyma. In this constriction of the visceral chamber near its mouth, the species of *Cœnites* agree with those of *Pachypora*, Lindst.; but in the former the thickening is rigidly confined to a narrow external band, and does not affect the internal parts of the corallum at all; whereas in *Pachypora* the thickening affects the tubes throughout their entire length, and merely attains its maximum as the mouth is approached. Furthermore, the corallites in *Pachypora* are not markedly compressed or oblique, and are equally thickened all round, so as to have their calices surrounded by tumid margins of equal thickness, and mostly rounded or subpolygonal in form. On the other hand, in *Cœnites* the thickening affects principally the upper aspects of the tubes; and hence the calices assume the form of long narrow slits or fissures, the length of which greatly exceeds the width (Pl. VI., fig. 5). Lastly, in *Pachypora* there are usually numerous short radiating septa, in the form of tubercles or spines. No structures, however, can be recognised in *Cœnites* as representing the septa in the actual visceral chamber itself below the thickened portions of the tubes; and the only traces of these organs are to be found in the tooth-like projections of the margins of the calices. These projections are generally three in number —two on one margin, and a single unpaired tooth opposite the notch between these on the opposite margin; but there may be five of these teeth—three on one margin, and two on the other. The tabulæ present no specially noticeable features, being well developed and complete, though not very numerous, throughout the central unthickened portion of the tubes. The different species of *Cœnites* will require careful revision, by the light of microscopic sections, before they can be regarded as fully established.

In its geological range, the genus is principally Upper Silurian; but species supposed to belong to it have been also described from the Devonian formation. In the Upper Silurian rocks the genus is found in Britain, Europe, and North America. The species which I have selected as illustrative of the genus are *Cœnites juniperinus*, Eichw., and a form which I believe to be the *Cœnites linearis* of Edwards and Haime.

Cœnites juniperinus, Eichwald.

(Pl. VI., figs. 5, 5 *b*).

Cœnites juniperinus, Eichwald, Zool. Spec., vol. i. p. 179, 1829.
Limaria clathrata, Lonsdale, in Murchison's Sil. Syst., p. 692, Pl. XVI., bis, figs. 7, 7 *a*, 1839.
Cœnites juniperinus, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 301, 1851; and Brit. Foss. Corals, p. 276, Pl. LXV., figs. 4 and 4 *a*.
(Compare *Limaria ramulosa*, Hall, Pal. N.Y., vol. ii. p. 142, Pl. XXXIX., fig. 4, 1852.)

Spec. Char.—Corallum dendroid, of cylindrical dichotomously-dividing branches, the diameter of which is generally about two lines. Corallites nearly vertical in the centre of the branches, with thin walls, and about one-sixth of a line in diameter; gradually diverging in their upward course till they reach a point from one quarter to half a line from the surface, when they suddenly bend outwards, their walls being now greatly thickened, and the visceral chamber reduced to a mere slit. Calices fissure-like and elongated in the direction of the transverse diameter of the branches, their long diameter about one-third of a line; the lower margin adorned with two prominent teeth, while the upper margin carries a single tooth corresponding in position to the notch between the lower teeth. Tabulæ not very numerous, but well developed and complete. Mural pores moderately numerous, circular, not excessively large, irregularly distributed.

Obs.—This well-known Upper Silurian form is readily distinguished by the external characters of the cylindrical branches, and the long, transversely-disposed toothed calices (Pl. VI., fig. 5), which are not elevated above the general surface. The fissure-like calices are generally separated from one another, in a vertical direction, by interspaces varying from about one-fifth to one-third of a line; and they thus appear as if sunk in a compact smooth cœnenchyma. In longitudinal sections (Pl. VI., fig. 5 *a*) this apparent cœnenchyma is shown to be due to a deposit of sclerenchyma within the tube of each corallite in the neighbourhood of its mouth, this portion of the corallite being in reality rather dilated than narrowed. The deposit of secondary sclerenchyma seems, further, to be laid down almost entirely on the upper aspect of each corallite in its interior, so that the visceral chamber is reduced to a mere slit occupying the lower side of the corallite. In the interior portions of the branches the corallites are not thickened, but possess patulous tube-cavities (Pl. VI., fig. 5 *a*), which are intersected by remote and complete tabulæ, and are placed in communication by distinct mural pores. Transverse sections (Pl. VI., fig. 5 *b*) not only show the absence of secondary thickening in the walls of the corallites in the interior of the corallum, but likewise the compressed and subpolygonal form of the tubes in this region.

Formation and Locality.—Abundant in the Wenlock Limestone of Dormington Quarry, Stoke-Edith.

Cœnites linearis, Edwards and Haime.

(Pl. VII., figs. 1-1 *e*.)

Cœnites linearis, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 302, 1851; and Brit. Foss. Cor., p. 277, Pl. LXV., fig. 3, 1854.

Spec. Char.—Corallum usually in the form of a lamellar expansion, sometimes sublobate, rarely massive. Corallites from a fifth to a fourth of a line in diameter, compressed, and possessing thin walls throughout the interior of the corallum. On approaching the surface they bend more or less abruptly outwards, their upper walls being now greatly thickened by an adventitious deposit of sclerenchyma, and their tube-cavities reduced to a mere fissure. Calices in the form of long linear slits, sometimes nearly straight, sometimes arcuate, which have a length of about half a line, or rather less, with a width of not more than about one-twelfth of a line. Tabulæ remote, horizontal, complete. Mural pores circular, of tolerably large size, moderately numerous, irregularly distributed. Septa represented by from three to five longitudinal ridges, which appear to be confined to the thickened outer portions of the tubes, and which form a corresponding number of teeth projecting into the calice. Ordinarily there are two of these teeth on one lip of the calice, and one on the other ; but there may be three teeth on one lip and two on the other, or even more of these projections may be present.

Obs.—I have some doubt as to the propriety of identifying my specimens with *Cœnites linearis*, E. and H., which is defined as follows (Brit. Foss. Cor., p. 277) :—

" Corallum massive, convex, or subgibbose, and composed of thin superposed layers. Calices closely set, not prominent, or but very slightly so, linear, with their margin very obscurely denticulated, about half a line broad, and one-twelfth in the contrary direction."

My specimens agree with the above description in the linear form of the calices, and in the dimensions of these apertures ; but the calicine teeth are very well marked (in well-preserved examples), and the corallum, though sometimes sublobate, could certainly not be properly said to be " massive." The great majority of the specimens which I refer here have the form of thin lamellar or palmate expansions (Pl. VII., fig. 1), two inches or more in width, with a thickness of a line and a half to two lines. The corallites in the centre of the frond are nearly or quite parallel with the flat surfaces of the latter, and they diverge outwards to open either on one surface only, or apparently more generally upon both surfaces. Sometimes, by the superposition of several laminæ, the corallum may attain a thickness of four or five lines ; and the same dimensions are sometimes reached when the corallum has the form of a broad flattened or palmate stem. I have never seen any truly massive example. Upon the whole, however, considering the points of likeness between the two, I think it safest to refer my specimens to *C. linearis*, E. and H., and to regard the specimen described by Edwards and Haime as probably exceptional, or as owing its apparently massive form merely to the coalescence of a succession of crusts.

The calices of *C. linearis*, E. and H., are very characteristic. They appear as long linear slits (Pl. VII., figs. 1-1 *b*), which may be nearly straight, but are more commonly strongly curved, and which have their margins toothed by a variable number of septa (most generally two on one margin, and one on the other), while they have the *appearance* of being embedded in a dense compact cœnenchyma. The form of the calices accurately expresses the form of the visceral chamber to a certain depth (half a line to nearly one line) below the surface, and tangential sections taken within this depth (Pl. VII., fig. 1 *c*) show that the tubes are still curved linear fissures, with denticulate margins, and surrounded by dense calcareous tissue. In the interior of the corallum, on the other hand, the corallites appear as thin-walled, subpolygonal, compressed tubes, with freely open cavities. The internal structure, in fact, is precisely the same as that already described as characterising *C. juniperinus*, Eichw. Thus, sections taken at right angles to the flat surfaces of the frond (Pl. VII., fig. 1 *d*) show that the gently-diverging and thin-walled tubes of the central area, on approaching a point situated a line or less below the actual surface, suddenly bend outwards, nearly at right angles to their former course. They now dilate, but their central cavity, instead of undergoing a corresponding expansion, becomes now still further restricted, and is reduced to a narrow linear chamber, which occupies one side of the corallite, the whole of the remaining space within the walls of the latter being occupied by a dense secondary deposit of sclerenchyma. There is, however, no true "cœnenchyma;" and the appearance of such a structure is only due to the deposition of this sclerenchyma in the interior of the tubes, and its coalescence in contiguous corallites, to the more or less complete obliteration of the walls of the latter as recognisable structures. Lastly, sections taken through the median plane of the frond, and parallel with its flat surfaces (Pl. VII., fig. 1 *e*), show the visceral chambers of the (here) thin-walled tubes to be crossed by remote and complete tabulæ, and to be connected by a well-developed system of circular mural pores.

Formation and Locality.—Not uncommon in the Wenlock Limestone of Benthall Edge, Longhope, Dudley, and Stoke-Edith.

CHAPTER V.

GENERA OF FAVOSITIDÆ—(*continued*).

Genus MICHELINIA, De Koninck, 1842.

(An. foss. des terr. Carb. de le Belgique, p. 29.)

Gen. Char.—Corallum forming hemispherical, depressed, or pyriform masses, often of considerable size, composed of prismatic or subcylindrical corallites, in close contact throughout their entire length. Walls not thickened to any unusual extent, perforated by numerous mural pores, which are often multiserial, and have no definite arrangement. Calices polygonal or subcylindrical, not surrounded by thickened margins. Tabulæ numerous, generally more or less curved with their convexities upwards; usually anastomosing with one another to a greater or less extent, so as to give rise to a loose and open vesicular tissue; and often carrying numerous vertically-directed spinules. Septa represented by numerous radiately-arranged longitudinal striæ, ridges, or vertical rows of tubercles, varying in number from twenty-five to forty. Under surface covered by a concentrically-striated epitheca, which may or may not be provided with hollow radiciform prolongations.

Obs.—This well-known genus comprises a number of Devonian and Carboniferous corals, which present a close general resemblance to the larger forms of *Favosites*. The corallum (fig. 21) is massive, usually more or less hemispherical, or in the form of a flattened expansion, the under surface of which is covered with a wrinkled epitheca. The corallum is attached to some foreign body by the centre of its base, and in some instances the epitheca gives off root-like prolongations in addition. In all the typical forms the corallites are polygonal, of larger size than in the ordinary species of *Favosites*, and in close contact throughout their entire length; and they radiate from the centre of the base, those occupying the circumference of the mass being so highly inclined as to be nearly parallel with the epitheca, while those in the middle are more or less nearly vertical. The visceral chamber, like the corallite itself, is usually polygonal; but in some cases (*e.g.*, *M. cylindrica*, E. and H.), the tube-cavity is constricted at intervals by ring-like ridges, which give it a cylindrical appearance. The walls, though moderately stout, have none of the secondary thickening of the interior so characteristic of *Pachypora*, Lindst., and its allies. The mural pores are numerous, circular, of variable size, and quite irregular in their distribution. The chief noticeable feature about the tabulæ is their marked curvature, their convexities being directed upwards. Moreover, the tabulæ seldom extend quite across the visceral tube, but in approaching the margin, they usually unite with other smaller tabulæ, so as to give rise to the formation of numerous large-sized lenticular vesicles, which are most abundantly developed near the sides of the tubes. The extent, also, to which the tabulæ thus become

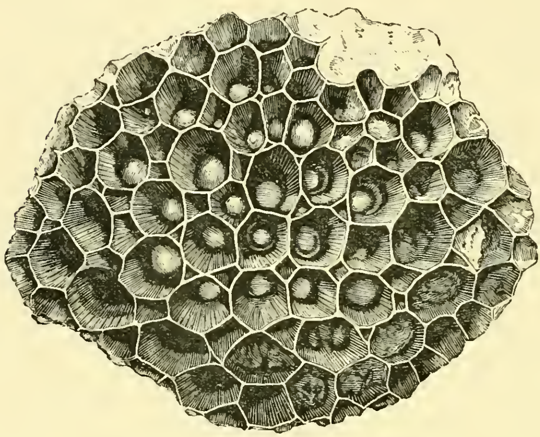


Fig. 21.—*Michelinia convexa*, D'Orb., viewed from above, of the natural size, from the Corniferous Limestone of Ontario. (After Billings.)

vesicular varies in different species of the genus; and the condition of these structures is in any case very different to that which obtains in *Favosites* (*Emmonsia*) *hemispherica*, Yand. and Shum., where the tabulæ are mostly actually "incomplete," and do not become united with contiguous plates. The tabulæ often carry on their upper surface vertically-directed spinules, which may be regarded as a continuation towards the centre of the marginal septa. These latter are in the form of vertical striæ, or ridges, or rows of tubercles; and their number varies from twenty-five to fifty.

It will be evident from the above description that *Michelinia* is a true Favositoid coral, very nearly allied to *Favosites* itself, near which it has been almost uniformly placed by palæontologists. It does not, in fact, differ from *Favosites* proper in any characters except that the tabulæ usually subdivide and become more or less united among themselves, while the septa are more numerous, and are not spiniform, and the mural pores are irregularly distributed. Of these peculiarities the subvesicular character of the tabulæ is the only one of generic importance, and even this is not equally noticeable in all the species. The occasional presence (as in *M. favosa*, Goldf.) of radiciform prolongations from the lower surface—apart from the fact of the total absence of these structures in most of the species—cannot, in my opinion, be regarded as sufficient to overbalance the many and weighty resemblances between this genus and *Favosites*. I am therefore altogether unable to agree with my friend Dr Lindström in thinking that *Michelinia* should be removed from the *Favositidæ* and placed in the family of the *Cystiphyllidæ* (On the Affinities of the *Anthozoa Tabulata*, Ann. and Mag. Nat. Hist., ser. 4, vol. xviii. p. 12).

I shall in the meanwhile, for reasons to be stated immediately, retain *Pleurodictyum*, Goldf., and *Chonostegites*, E. and H. (= *Haimeophyllum*, Bill.), as generically distinct from *Michelinia*, though I think that the first of these, at any rate, will ultimately have to be united with the present genus. If this course be followed, then the genus *Michelinia* is only known with certainty from the Devonian and Carboniferous rocks; since the forms which have been noted as occurring in the Upper Silurian deposits of North America appear to be small discoid examples of the type of *Pleurodictyum.* My own collection includes excellently-preserved specimens of *M. convexa*, D'Orb., *M. favosoidea*, Bill., and *M.* (*Emmonsia*) *cylindrica*, E. and H.; but as these are not only silicified, but have their tubes entirely empty, they do not admit of being satisfactorily sectioned for the microscope. Through the kindness of Mr Etheridge, I have also had the opportunity of examining specimens of *M. megastoma*, Phill., *M. tenuisepta*, Phill., and *M. favosa*, Goldf., from the Museum of Practical Geology. As, however, I am not in the position of being able to give any details as to the microscopic structure of any of the above, it will be unnecessary to select any species for description.

Genus PLEURODICTYUM, Goldfuss, 1829.

(Petref. Germ., t. i. p. 113.)

Gen. Char.—Corallum discoidal, with a slightly convex upper surface, attached to foreign bodies by the centre of its base, and having its lower surface covered by a well-developed, concentrically-striated epitheca. Corallites diverging from the centre of the base, those on the circumference being nearly horizontal, while the median ones are more or less nearly perpendicular; their general shape polygonal or subcylindrical. Walls of considerable thickness, pierced from side to side by mural pores, which have no regular arrangement. Tabulæ not very numerous, nor markedly arched; often inosculating to some extent, but not giving rise to a vesicular or subvesicular tissue. Septa rudimentary, in the form of marginal ridges or rows of vertically-disposed spines.

Obs.—This genus was founded for the reception of the curious *P. problematicum* of the Devonian deposits, which is still only known by means of casts of the tubes in sandstone.

The structure of these casts was well described by Edwards and Haime (Pol. Foss. des Terr. Pal., p. 209), and the true significance of the most singular of the features presented by the genus was fully recognised by them. They placed the genus, however, in the Perforate Zoantharia, in the immediate neighbourhood of *Protaræa* and *Litharæa*, and thus failed to appreciate its relationships with the *Favositidæ*. Dr Rominger was, I believe, the first to point out (Amer. Journ. Sci. and Arts, vol. xxxv. p. 82, 1863) that *Pleurodictyum* was really founded upon casts of a coral allied to *Favosites* or *Michelinia*; and he has recently united it with the latter genus (Foss. Corals of Michigan, p. 72, 1876). At present, we are acquainted with the actual corallum itself in more than one species of *Pleurodictyum*; and I shall defer any further remarks upon the genus till I have described the only one of these which I have had the opportunity of examining with proper fulness.

Pleurodictyum stylophorum, Eaton.

(Fig. 22, and Pl. VIII., figs. 1 - 1 *b*.)

Astræa stylophora, Eaton (?), Geological Text-Book, 1832.
Pleurodictyum Americanum, Ferd. Roemer, Lethæa Palæozoica, Pl. XXIII, figs. 2 *a* and 2 *b*, 1876.
Michelinia trochiscus, Rominger, Fossil Corals of Michigan, p. 75, 1876.

Spec. Char.—Corallum discoidal, with a slightly convex upper surface, generally from an inch to an inch and a half in diameter, and about half an inch or rather more in height; attached by the centre of the base to some foreign body such as the stem of a Crinoid. Lower surface covered by a well-developed epitheca, with strong concentric wrinkles, and also with finer radiating striæ. Corallites subpolygonal, very unequal in size, the larger ones from nearly two lines to about three lines in diameter. Walls thick, perforated by irregularly-placed mural pores. Septa in the form of from twenty-five to thirty-five or more marginal ridges or vertical rows of blunt spines. Tabulæ few in number, slightly convex or horizontal, sometimes uniting with one another, but not subvesicular in character. The "vermiform body" of *Pleurodictyum problematicum*, Goldf., is sometimes (always?) present in the interior of the corallum.

Obs.—This pretty little species seems to have been first named *Astræa stylophora* by Eaton, I presume in his 'Geological Text-Book' (published in 1832); though I am unable to consult this work, and cannot speak positively upon this point. Dr Rominger (*loc. cit.*), in describing his *Michelinia trochiscus*, gives the above as its synonym; and assuming the correctness of this, it would seem that Eaton's specific name has the clear right to be retained, as no other species of *Michelinia* or *Pleurodictyum* has been similarly entitled. Should it be found necessary, for any reason, to abandon Eaton's name, then it would be a question whether the present species should not stand as *Pleurodictyum Americanum*, under which name it was well figured and briefly described by Professor Ferd. Roemer in 1876 (Leth. Pal., Pl. XXIII., figs. 2 *a*, 2 *b*). Through the kindness of my friend Mr George Jennings Hinde, I possess a few specimens of this remarkable form, which is of special interest as presenting us with the actual corallum of a form unquestionably congeneric with *Pleurodictyum problematicum*, Goldf., though apparently specifically distinct. These I have submitted to a careful examination by means of thin sections, and I shall now give the principal results of this, along with some remarks upon the genus *Pleurodictyum*, and upon *P. problematicum*, Goldf.

As before remarked, *P. problematicum* is only known by casts in sandstone, which are of not very rare occurrence in the Devonian deposits of Europe and of Devonshire. Precisely similar casts—though probably specifically distinct—occur in the Onondaga sandstones of North America, and have been well described and figured by Meek and Worthen, with a somewhat doubtful reference of them to the European species (Geol. of Illinois, vol. iii. p. 405, Pl. IX., figs. 1 *a*-1 *c*, 1868). In both these cases the fossil (fig. 22, A and B) consists of a series of prismatic or subcylindrical columns radiating from a common base, in such a manner that those nearest the periphery are horizontal or even reclined, and those in the centre are vertical, while intermediate columns have correspondingly intermediate grades of inclination. These columns are sometimes markedly striated with longitudinal ridges, as well as marked with small rounded elevations (fig. 22, B); while each is

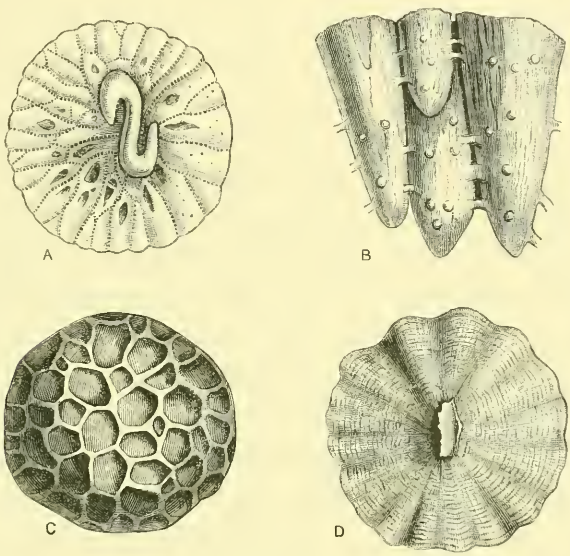


Fig. 22.—A, Lower surface of the cast of *Pleurodictyum problematicum*, Goldf., from the Lower Devonian of Germany, of the natural size (after Roemer), showing the vermiform body in the centre; B, A few of the separate casts of the tubes of *Pleurodictyum problematicum*, Goldf., from the Devonian of the Eifel, showing the casts of the mural pores and interseptal grooves, enlarged (after Milne-Edwards and Haime); C, Upper surface of the corallum of *Pleurodictyum stylophorum*, Eaton, from the Hamilton group of North America, of the natural size, showing the form of the calices (original); D, Lower surface of another example of the same, of the natural size, showing the striated epitheca, and the point where the corallum was attached to the stem of a Crinoid (original).

connected with its neighbours by a number of cylindrical rods. The above appearances are now readily intelligible, as, indeed, they were to all intents and purposes even to the authors of the 'Polypiers fossiles,' though these distinguished observers had never seen any actual coral capable of giving rise to a similar cast. The prismatic columns of *P. problematicum* are, then, casts of the polygonal corallites of a Favositoid corallum, of a discoidal form; the rounded tubercles which they carry upon their surface, as well as the rods which connect contiguous columns, are casts of the mural pores, left by the solution of the thick walls; and the vertical ridges (not always present) are casts of the grooves between the septal ridges or striæ. Moreover, perfect examples of *P. problematicum* show that the corallum was concavo-convex, its under surface being concave (probably a character of specific value), and covered by a concentrically-striated epithecal membrane. So far there is no difficulty in interpreting the peculiarities of the *P. problematicum* of the European Devonian by the light afforded by the well-preserved coralla of allied forms in the corresponding formation in North America; but there remain two points of difficult interpretation. One of these points consists in the occasional existence of numerous small pits—much more numerous than the corallites themselves—on the *upper* surface of the cast of the epitheca (see Pol. Foss. des Terr. Pal., Pl. XVIII., figs. 4 and 4 *a*). Messrs Meek and Worthen have not only noticed the same phenomenon in the American specimens, which they provisionally refer to *P. problematicum*, Goldf.; but they notice, in addition, that the corallites which rest directly upon the epitheca are connected with the latter by rods precisely similar to those which unite the different corallites with one another. They suggest that this indicates the occurrence of "pores" passing through the base; but it may be offered as a probable explanation that these really indicate the existence in this particular species of numerous radiciform and hollow prolongations of the lower surface of the epitheca, such as are known to occur in *Michelinia favosa*, Goldf., and which, after all, are essentially of the same nature as the "mural pores."

The other point of difficulty consists in the presence in many (but apparently not in all) specimens of *P. problematicum*, Goldf., of the curious structure known as the "vermiform body." This body (fig. 22, A) has the form of a cylindrical, crooked, often S-shaped rod, occupying the centre of the base of the corallum, and having the corallites radiating from it on all sides. None of the American examples referred to this species by Meek and Worthen (*loc. cit.*) show any traces of this structure. The nature of this curious body has been much disputed, but it has generally been regarded as being one of two things—viz., either the cast of the burrow of some boring Annelide which mined the coral after the latter had attained its full growth, or else the calcareous tube of some Annelidous genus like the existing *Serpula*, to which the coral attached itself when young, and which it subsequently enveloped in the process of development. This latter view, which would make the phenomenon an instance of "commensalism," is the one which was adopted by Edwards and Haime, and in which they have been followed by most subsequent writers. It is a noteworthy fact, however, that a tube of precisely the same nature has been found by me to exist in the only specimens of *P. stylophorum*, Eaton, which I have been able to section for the microscope; and though I do not pretend to offer any satisfactory explanation as to its true significance, I have been able to satisfy myself of the following points, which have a considerable bearing upon any view which may be framed upon this subject:—

1. The mere fact of the occurrence of this peculiar structure in two different species of the same genus, in regions as widely remote as Europe and North America, is *primâ facie*, though by no means conclusive, evidence against the view that the "vermiform body" is merely the work of a parasite, or is the tube of an Annelide upon which the corallum grew.

2. The "vermiform body" in *P. stylophorum*, Eaton, either existed before the coral, or grew simultaneously with it. This is shown incontrovertibly by the fact that, in sections, the corallites are seen to *accommodate their shape to that of the tube*, and to be fixed to it in places by their bases. In no instance observed by me does the tube cut across the corallites (see Pl. VIII., figs. 1 - 1 *b*, where the tube is shown in section). This observation is sufficient to conclusively negative the view

that the tube can be the work of some parasitic animal which bored into the coral *after the latter was formed.*

3. The tube was by no means confined to the mere base of the coral, nor did it lie like the letter S in a single plane. On the contrary, it traversed the corallum in a loose and open spiral, so that both vertical and horizontal sections cut it at various points (see Pl. VIII., figs. 1-1 *b*).

4. The tube (in adult specimens, at any rate) was completely concealed within the corallum, and was, to all appearance, altogether superior to the epitheca. Whether or not it had any opening upon the *upper* surface of the corallum, I cannot say.[1]

5. The *walls* of the tube are extremely thin, calcareous, and apparently destitute of any definite structure. The interior is usually filled with transparent calcite, but occasionally there are seen inside it numerous spheroidal or ovoid opaque bodies, as to the nature of which I can offer no opinion whatever (Pl. VIII., fig. 1 *a*). It will be seen from the above that this peculiar structure is one well worthy of further examination by those who may have calcareous specimens suitable for the preparation of microscopic sections. My own observations are much too limited to enable me to come to any definite conclusions as to its true nature; but they are at the same time sufficient to make me dubious as to the received explanations upon this subject.

Returning now to *P. stylophorum*, Eaton, I may give a brief account of its structure, as shown by microscopic sections, it being the only species of *Pleurodictyum* which, to my knowledge, has ever been examined by this method. The general form of the corallum, as seen in fig. 22, C and D, is that of a small discoid expansion, the upper surface of which carries the calices, and is more or less convex; while the lower surface is generally flat or slightly convex, and is covered by a strong

[1] Dr Rominger (Amer. Journ. Sci. and Arts, vol. xxxv. p. 82), however, states that he has observed specimens in which the vermiform tube opens upon the upper surface of the corallum by a round mouth. His further statement that the tube traverses the substance of the corallum irrespective of the direction of the corallites through which it seems to cut, is not borne out by my specimens.

epitheca, marked with concentric and radiating striæ. All my specimens show a distinct cicatrix of attachment, the foreign body upon which the coral grew being in one instance unquestionably the column of a Crinoid (fig. 22, D). I can also detect no traces of perforations nor of radiciform prolongations of the epitheca. The upper surface (fig. 22, C) shows the apertures of the polygonal, irregularly-sized corallites. Tangential sections, taken just below the upper surface (Pl. VIII., fig. 1 *a*), cut across the corallites at right angles, and show that the polygonal tubes are surrounded by thick walls, those of contiguous corallites remaining so far distinct as to be always separated from one another by a marked and definite line of demarcation. The same feature is shown by sections which cut the corallites longitudinally (Pl. VIII., figs. 1 and 1 *b*). Both these kinds of sections exhibit, further, the well-developed but irregularly-distributed "mural pores," together with certain other openings of a seemingly different nature, the structure of which I shall endeavour to elucidate by the help of the annexed diagram. Remembering that the mural pores are apertures which pass through the walls of the corallites from side to side, it is easy to see how and under what forms they may present themselves in thin sections of the corallum of any of the *Favositidæ*. In transverse sections (fig. 23, A and C) the pores are usually not to be detected, or only here and there, and they present

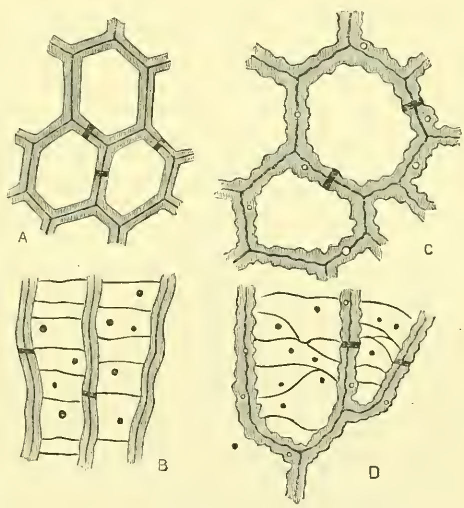


Fig. 23. — Semi-diagrammatic representations of sections of the corallum of *Favosites* and *Pleurodictyum*, showing "mural pores" and "intramural canals," the former shaded black, the latter left unshaded. A and B, Transverse and vertical sections of *Favosites*, showing mural pores only; C and D, Transverse and vertical sections of *Pleurodictyum*, showing mural pores and intramural canals.

themselves as canals which run right across the walls of two contiguous corallites, and place their visceral chambers in direct communication. In vertical sections (fig. 23, B and D), on the other hand, the mural pores may present themselves under one or other of two forms, or under both of these. Thus they may appear *either* as canals running directly across the wall between two contiguous tubes, *or* (if the section happen to coincide more or less nearly with the plane of one of the walls) as scattered circular pores situated within the space bounded by the lateral walls of the corallites. All the *Favositidæ* may show the phenomena just described; but in *Pleurodictyum* and some other types thin sections show the existence of another set of canals, which appear to run entirely within the substance of the walls, and to have a course parallel with the flat surfaces of the latter. The canals in question are best seen in transverse sections (fig. 23, C), where they are shown as distinctly circumscribed circular openings, placed at the point of union of the walls of two contiguous corallites, or situated within the actual substance of the wall. Similar openings are seen in long sections (fig. 23, D), but the evidence is here not so satisfactory as in the preceding case, since we *might* be dealing with mural pores passing through the *angles* of the prismatic corallites. What these canals are, it is difficult to say, but they are certainly distinct from the "mural pores;" and as it is convenient to have a distinct name for them, I shall call them the "intramural canals." Possibly they may only be due to imperfect calcification or coalescence of the walls of the corallites; but that they are distinct from the mural pores is shown by the fact of their occurrence in forms like *Lyopora*, Nich. and Eth. jun., in which these latter openings are not known to occur. In *Pleurodictyum* the "intramural canals," as just defined, are neither numerous nor very conspicuous. They are, however, present in a marked form in *Columnopora*, Nich., and in *Lyopora*, Nich. and Eth. jun., in both of which they appear to have been regarded as "cœnenchymal tubules;" though their sparse and scattered arrangement, and their total absence in parts of the corallum, together with the fact that they traverse the walls in different directions, would entirely negative this view.

The only remaining points in the anatomy of *Pleurodictyum stylophorum* which need notice, concern the condition of the septa and tabulæ. Returning again to transverse or tangential sections of this species (Pl. VIII., fig. 1 *a*), we find the septa represented by short spines arranged in vertical rows, quite resembling the same structures in various species of *Favosites*. The tabulæ are seen in long sections (Pl. VIII., figs. 1 and 1 *b*) to be always well developed, and to have the form of strong horizontal flexuous plates, which are not strongly convex, and which do not give rise to anything that could be appropriately called "vesicular tissue," though they not uncommonly unite with one another to a limited extent. Owing to the shortness of the corallites, there are usually not more than four or five tabulæ in a single tube.

Upon the whole, it will be seen by the preceding description that there is a close relationship between *Pleurodictyum*, Goldf., and *Michelinia*, De Kon., and it is a matter of question if the two genera can be kept apart. Should it be found necessary to merge these two genera, it is *Michelinia* which will have to give way to the older *Pleurodictyum*, and not, as some writers assume, the latter to the former. In the meanwhile, however, I think it safest to keep the two distinct until, at any rate, the structure of *Pleurodictyum* has been fully worked out. If this course be followed, *Pleurodictyum*, Goldf., will contain corals in most respects quite similar to *Michelinia*, De Kon., but distinguished by their small size and discoid form, and by the fact that the tabulæ are not markedly convex, and do not subdivide or inosculate to any notable degree. It is possible (though not likely) that the "intramural canals" which I have described as occurring in *Pleurodictyum* may be found to distinguish the genus further from *Michelinia*. I need only add that it is certain that Dr Ferd. Roemer must have been misled by appearances when he asserts (Leth. Pal., Explanation of Pl.

XXIII., 1876) that there are no tabulæ in *Pleurodictyum*, these structures being quite as well developed as could be expected in such short tubes.

Formation and Locality. — Hamilton group (Devonian), Hamburg, State of New York, *Coll.* George J. Hinde. (Judging from the figures, it would seem not improbable that the coral described by Prof. Ferd. Roemer in the 'Silurian Fauna of West Tennessee,' p. 19, 1860, under the name of *Calamopora Forbesi*, var. *discoidea*, may be really a species of *Pleurodictyum* allied to *P. stylophorum*, Eaton. It is probable, also, that the nummiform species of *Michelinia* alluded to by Dr Rominger in the 'Foss. Corals of Michigan,' p. 72, as occurring in the Upper Silurian strata of North America, are referable to *Pleurodictyum*, if the latter genus is to be kept distinct.)

Genus CHONOSTEGITES, Edwards and Haime, 1851.

(Pol. Foss. des Terr. Pal., p. 299.)

Haimeophyllum, Billings, Canad. Journ., new ser., vol. iv. p. 139, 1859.

Gen. Char.—Corallum forming large subhemispherical, subfasciculate masses, composed of cylindrical corallites, which grow side by side, and are annulated by numerous close-set, hollow, periodic expansions, which alternate with as many circular constrictions. For the most part the corallites are separate, except that they are united by the periodic expansions above spoken of, which thus form a succession of concentric floors, connecting the tubes with one another. In the parts between these periodic floors the corallites are enclosed each by a distinct epitheca, and the walls are imperforate. There are, however, often parts of the corallum in which the walls of contiguous corallites are in close contact, and then numerous "mural pores" are developed. Tabulæ numerous, arched, often uniting with one another in such a way as to give rise to a loose and open subvesicular tissue, which is continued into the hollow periodic expansions of the corallites. Septa in the form of short spines in the interior of the tubes. New corallites produced by gemmation from the hollow periodic expansions in the intervals between the old cups.

Obs.—It is perhaps impossible for any one who has not access to the original examples of *Chonostegites Clappi*, E. and H., and *Michelinia intermittens*, Bill., to entirely and finally unravel the confusion in which the present genus is enveloped. I shall, however, briefly state the conclusions at which I have arrived upon this subject, and some of which I regard as quite certain.

The genus *Chonostegites* was founded by Milne-Edwards and Haime for the reception of a coral unquestionably possessing the general characters given in the above generic diagnosis, which is based upon specimens of the coral described by Billings under the name of *Haimeophyllum inordinatum*. They state that their specimens are of Devonian age, and that they were found in the drift of Dayton in Ohio. Under these circumstances it cannot be doubted but that the original specimens of *Chonostegites Clappi*, E. and H., were derived from the Corniferous Limestone, the silicified corals of this formation being abundantly distributed in the drift of various parts of the Northern United States.

At a later date, in 1859, Mr Billings described two corals from the Corniferous Limestone of Canada, under the names of *Michelinia intermittens* and *Haimeophyllum inordinatum*, the latter being made the type of a new genus. With regard to *Michelinia intermittens*, Mr Billings himself expresses a doubt if it be truly separable from *Chonostegites Clappi*, E. and H., adding that in this case the species should stand as *Michelinia Clappi*. This opinion on the part of Mr Billings was based upon the observation that in those portions of the corallum of *M. intermittens* in which the corallites are in contact they are prismatic in shape, and that they possess mural pores. On the other hand, *Haimeophyllum* is founded for a coral which is said to differ from *Michelinia* only in the fact that the corallites are not in close contact, are subparallel, and are united by the coalescence of periodic expansions of the margins of the calices, while mural pores are alleged to be absent.

At a still later date, in 1876, Dr Rominger (Foss. Cor. of Michigan) placed *Chonostegites Clappi*, E. and H., in *Michelinia*, and referred *Michelinia intermittens*, Bill., in part to the same species; while he considered *M. intermittens* as also in part synonymous with *M.* (*Emmonsia*) *cylindrica*, E. and H.

Having carefully examined an excellently-preserved series of specimens of *Haimeophyllum inordinatum*, Bill., I have failed to discover any character by which it could be specifically separated from *Chonostegites Clappi*, E. and H. Mr Billings was undoubtedly in error in supposing that "mural pores" are absent in *Haimeophyllum*, these openings being present in all parts of the corallum where the tubes come into actual contact. I regard *Haimeophyllum*, Bill., therefore, as a synonym of *Chonostegites*, E. and H., and shall discuss the relations of the latter to *Michelinia*, De Kon., later on.

In the second place, I think *Michelinia intermittens*, Bill., to be merely a variety of *Haimeophyllum ordinatum*, Bill., with the tubes more extensively in contact than is usual in this variable species. As the latter species is in my opinion the same as *Chonostegites Clappi*, E. and H., it follows that *M. intermittens*, Bill., is a synonym of *C. Clappi*, as it is in part made to be by Dr Rominger. I need only add that there cannot be the slightest hesitation in rejecting Dr Rominger's further view that *M. intermittens*, Bill., is *in part* identical with *M. cylindrica*, E. and H., since Billings expressly states that his species was founded *upon a single specimen*; and it cannot, therefore, possibly be partly referable to one species and partly to another.

Before discussing the relations between *Chonostegites* and *Michelinia*, and the possible propriety of uniting them with one another, it will be well to briefly describe the structure of *C. Clappi*, the type and the only satisfactorily differentiated species of the former genus.

Chonostegites Clappi, Edwards and Haime.

(Pl. VIII., figs. 2-2 *c.*)

Chonostegites Clappi, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 299, 1851.
Michelinia intermittens, Billings, Canad. Journ., new ser., vol. iv. p. 113, 1859.
Haimeophyllum inordinatum, Billings, Canad. Journ., new ser., vol. iv. p. 139, fig. 29, 1859.
Michelinia Clappi, Rominger, Foss. Cor. of Michigan, p. 75, Pl. XXVIII., figs. 3 and 4, 1876.

Spec. Char.—Corallum often of considerable size, composed of subparallel, essentially circular, tubular corallites, which are for the most part free, though sometimes partially in contact, in which latter case they become more or less polygonal by mutual pressure. In parts where they are in contact the walls of the corallites are perforated by numerous irregularly-distributed mural pores, which place the visceral chambers of contiguous tubes in direct communication. When they are not in contact, the corallites are individually enclosed in a distinct epitheca, which is not perforated, and which is marked with numerous fine encircling striæ. Where not in contact, also, the corallites are annulated by numerous alternate constrictions and dilatations, giving to each the appearance of a succession of funnels vertically superimposed upon one another. The dilatations of contiguous tubes are placed more or less at the same levels, and unite with one another, so as to form a succession of concentrically superposed floors, which can be shown to be hollow, and thus to place the visceral chambers of neighbouring tubes in actual communication. Viewed from above, the calices are seen to be circular, and to be surrounded at a little distance by faintly-marked polygons inscribed on the upper surface of the connecting-floors. Tabulæ numerous, arched, inosculating to a greater or less extent, and forming large lenticular cells, which are continued into the hollow horizontal connecting-floors. Septa in the form of short spines arranged in vertical rows. The upper surfaces of the tabulæ are also often serrated with erect spinules, which appear to represent continuations of the septa towards the axis of the visceral chamber. New corallites budded forth between the old calices from the hollow connecting-floors.

The dimensions of the corallites, the degree to which they are in contact, and the closeness of the periodical expansions, vary in different examples. In the most typical forms, the tubes themselves are about two lines in diameter, but the diameters of the polygons inscribed round these upon the upper surfaces of the horizontal floors (where recognisable) are three lines or more. In other examples the tubes themselves may reach three lines or over in diameter. The periodical expansions which give rise to the horizontal floors by their union are mostly from one line to a line and a half distant from one another, but they may be two or even three lines apart. The corallites are often only from half a line to a line apart in their constricted portions, but they may be distant two, three, four, or even five lines, and, on the other hand, they generally approach one another in parts of a large colony, so as to become closely contiguous or coalescent.

Obs.—It is not necessary to add anything to the above description of the general characters of this singular species (Pl. VIII., figs. 2 - 2 *c*). I may, however, shortly describe the appearances presented by thin sections, by which alone the internal anatomy can be satisfactorily studied. The most instructive sections are vertical ones (Pl. VIII., fig. 2 *c*), which admirably exhibit the alternately and rapidly constricted and dilated tubes of the corallites, each of which looks like a series of wide and shallow funnels arranged in vertical order. These sections also show the important fact that the periodic expansions of the tubes are really hollow prolongations of the visceral cavities of the corallites, so that by the union of these to form the horizontal connecting-floors all the polypes of the colony are placed in actual organic connection. The tubes are traversed by well-developed, arched, flexuous, or nearly horizontal tabulæ, the upper surfaces of which commonly carry short erect spines, and which more or less extensively anastomose with one another, precisely as in the genus *Michelinia*, De Kon. The tabulæ are continued into the hollow horizontal expansions of the tubes, where they continue to present the same characters of irregular anastomosis as in the cavities of the corallites themselves. Transverse sections (Pl. VIII., fig. 2 *b*) exhibit the corallites themselves, cut across at right angles to their long axis, together with irregular moieties of the hollow connecting-floors, which come into view in consequence of their not lying in a single horizontal plane. The only special features exhibited by sections of this nature are that the corallites are provided with distinct and separate walls, and that the septa are represented by radially-disposed spinules.

From the preceding description it will be clear that we have to deal in *Chonostegites Clappi*, E. and H., with a coral in many respects closely allied to *Michelinia*. If we take typical examples of this species, in which the corallites stand wide apart, each enclosed in its own epitheca, and united with its fellows by hollow horizontal expansions derived from the visceral chamber, then, it is true, we should feel no hesitation in separating *Chonostegites* from *Michelinia* as a distinct genus. Even in such examples, however, the hollow periodic expansions of the tubes may be properly regarded as homologous with the "mural pores" of *Michelinia*. If, on the other hand, we examine a portion of the colony of *Chonostegites Clappi*, in which the corallites are in actual contact and have their walls perforated by numerous mural pores, then we feel at a loss to produce a single character by which the species could be generically separated from *Michelinia*. Moreover, the curious *M.* (*Emmonsia*) *cylindrica* of Edwards and Haime is a distinct connecting-link between the present species and the typical forms of *Michelinia*, since it exhibits slight periodic constrictions of its tubes, and the mural pores are generally confined to the dilated portions of the corallites.

Upon the whole, however, I prefer keeping *Chonostegites* distinct from *Michelinia*, in the meanwhile at any rate. It may be added that the reference of the genus by Milne-Edwards and Haime to the *Halysitidæ*, in the vicinity of *Syringopora*, is based upon a solid foundation of structural likeness, since the connecting-floors of *Chonostegites* are the homologues of the hollow connecting-tubes in *Syringopora*, and the genus thus forms a true link between *Michelinia* and *Syringopora*.

Formation and Locality.—Not uncommon in the Corniferous Limestone of Walpole, Ontario.

CHAPTER VI.

GENERA OF FAVOSITIDÆ—(*continued*).

Genus COLUMNOPORA, Nicholson, 1874.

(Geol. Mag., new ser., vol. i. p. 253, fig. 1.)

Houghtonia, Rominger, Foss. Cor. of Michigan, p. 17, 1876.

Gen. Char. — Corallum massive, forming subhemispherical or pyriform masses, often of considerable size, composed of subpolygonal or subcircular corallites, which radiate from the base, and are for the most part in contact and firmly united by their walls. Septa in the form of marginal ridges, generally about twenty in each corallite. Walls thick, perforated by numerous large, close-set, oval mural pores, arranged in rows between the septal ridges. Tabulæ numerous, generally more or less flexuous, often uniting with one another, complete. No columella and no true cœnenchyma.

Obs.—The corallum in this genus is massive, and in general aspect very similar to that of any of the larger species of *Favosites*, though distinguished from the latter even by a very cursory examination. The corallites are in reality subpolygonal, but the angles of the tubes are more or less rounded off, and they thus become subcircular in form (Pl. VII., fig. 2). The real structure of the corallum can be best investigated by means of transparent sections, though many of its most important features can be studied in the actual specimens. The corallites are essentially in contact with one another—if not invariably, certainly as a general rule—throughout their entire length; though occasionally limited tubular spaces are left at the point of junction of three or four of the corallites.[1] Moreover, thin transverse sections (Pl. VII., fig. 2 *a*) prove incontrovertibly that the walls of the corallites are firmly amalgamated with one another, the junction between contiguous tubes being marked by a wavy dark line. Occasionally, as just remarked, the sections show a tubular space at the angles of junction of the corallites, and these spaces are definitely circular or oval, and are accompanied by smaller rounded and definite vacuities (Pl. VII., fig. 2 *b*), which are situated in the substance of the walls themselves. These spaces I regard as being cross-sections of tubes which pass through the thick walls longitudinally, and as being, therefore, of the same nature as the canals which I have described in *Pleurodictyum* under the name of "intramural canals." Similar tubes occur in the walls of *Lyopora*, Nich. and Eth. jun.; and though I am uncertain as to their true nature, they are clearly endothecal, and cannot be of the nature of "cœnenchymal tubes." They are, further, very minute, and only the largest of them would be recognised by the use of a hand-lens upon actual specimens. Vertical sections (Pl. VII., fig. 2 *c*) entirely confirm the evidence derivable from transverse slices as to the absence of anything which could properly be called cœnenchymal. The walls, as before, are firmly united, and the boundary between contiguous tubes is marked by a sinuous dark line, occasionally interrupted by an irregular or oval space. The septa are best studied in transverse sections (Pl. VII., figs. 2 *a* and 2 *b*), though excellently seen in the actual

[1] Occasional and partial absence of complete contact between the tubes is by no means an unusual phenomenon in genera in which the corallites are normally and regularly polygonal and accurately contiguous. Thus, in *Columnaria* (*Favistella*) *alveolata*, Goldf., it is not uncommon for the tubes close to their mouths to become, in parts of the corallum, slightly separate, in which case they are also subcircular, though the corallites are ordinarily prismatic and in close contact. In *Columnaria* (*Favistella*) *calicina*, Nich., again, some of the corallites are always more or less disjunct and subcircular, while others are always polygonal and firmly united by their walls.

specimens themselves. They have the form of from fifteen to twenty or more longitudinal ridges, which have broad bases, and extend only a very limited distance inwards towards the centre of the visceral chamber. The tabulæ are seen in vertical sections (Pl. VII., fig. 2 *c*) to be complete and numerous, more or less flexuous, and often uniting to a limited extent with one another. They do not, however, carry this process of anastomosis so far as to give rise to anything like the "sub-vesicular" tabular tissue of *Michelinia.* Lastly, the mural pores are seen both in transverse and longitudinal sections, though best in the latter. In transverse sections (Pl. VII., fig. 2 *a*) they appear as transverse channels crossing the walls, and allowing contiguous tube-cavities to communicate. In vertical sections they are only seen where the plane of the section may happen to coincide with that of one of the walls of the tubes, and then they are seen to have the form and arrangement observable by the ordinary methods of examination in the actual specimens. They appear, namely (Pl. VII., figs. 2 *c* and 2 *d*), in the form of numerous longitudinally-placed oval pores of large size, which occupy the interseptal spaces, and place the visceral cavities in direct and free communication. The number of these pores in a given space is not absolutely uniform in all parts of a given specimen; but they are usually placed at much less than their own diameter apart, measured both vertically and laterally, so that the walls become completely cribriform.

In his excellent work upon the Fossil Corals of Michigan, Dr Rominger, in 1876, founded the new genus *Houghtonia,* to include certain corals from the Cincinnati group of North America, which I cannot doubt to be really congeneric with the previously described *Columnopora.* Indeed, Dr Rominger has himself admitted this identity in a note appended to a later edition of the same work (1877). In his description of the genus *Houghtonia,* as originally published, and in the note just alluded to, in which he admits that this name must be abandoned in favour of *Columnopora,* Dr Rominger states that the corallites are often separated from one another by an irregular cellular cœnenchyma, and that the walls of the tubes when contiguous are not perforated by mural pores, though he gives no drawings of the structure of the corallum which would support either of these statements. I cannot, of course, offer any opinion as to the phenomena presented by Dr Rominger's specimens, as I have not had any opportunity of examining them, and I should not wish to dogmatise as to examples which have not come under my direct observation. It must be borne in mind, however, that the specimens in my possession are *the ones upon which the genus was founded*, and that they are therefore the *types* of the genus. These specimens have been subjected to a careful macroscopic and microscopic examination, and I can confidently affirm that they possess walls of an exaggeratedly perforate type (as compared with *Favosites*); that their corallites are for the most part indubitably in contact, with their walls absolutely fused with one another; and that any interspaces which may here and there exist between the corallites admit of being explained upon a different supposition than that they are of the nature of "cœnenchymal tubes." The drawings which I have given, being taken by the camera lucida from microscopic slides, will sufficiently prove the accuracy of these statements.

A more difficult point to settle concerns the relations of *Columnopora* to *Calapœcia*, Billings; and as I have no specimens of the latter, I shall here say the little that is necessary concerning the curious types included by the eminent Canadian palæontologist under the above name :—

The genus *Calapœcia* was defined by Mr Billings in the 'Canadian Naturalist' (2d ser., vol. ii. p. 425, 1857) as follows :—

"Corallum composite, forming hemispherical or subspherical colonies. Corallites slender, tubular, perforated as in *Favosites*, and with their outside striated by imperfectly-developed costæ. Radiating septa (in the species at present known) about twenty-four. Tabulæ thin, and apparently in some instances not complete. When the corallites are not in contact, the space between them is filled with a variously-formed vesicular tissue. This genus resembles *Heliolites*, but differs therefrom in having double the number of septa and the walls perforated."

Two species were described by Mr Billings as belonging to this genus—viz., *C. Canadensis*, from the Black River Limestone, and *C. Huronensis*, from the Hudson River formation. The former is stated to have corallites about one line in diameter, and generally in contact, although still remaining circular; while the mural pores are arranged in horizontal rows running all round the tube, one row between each pair of tabulæ. The latter was separated specifically from *C. Canadensis*, principally upon the ground of the greater slenderness of its tubes. Neither of these forms was figured. From the above description it would appear that *Calapœcia Canadensis* and *C. Huronensis* are corals nearly allied to the form which I have described as *Columnopora cribriformis;* but such a conclusion has been rendered very hazardous by the publication by Mr Billings, at a later date, of a third species of *Calapœcia*, which was both described and figured (Cat. Sil. Foss. of Anticosti, p. 32, fig. 15, 1866). The species in question (viz., *C. Anticostiensis*) is stated to have a hemispheric corallum, the corallites sometimes in contact, but usually distant from one another by a quarter or half a line. The shape of the corallites is circular, and they are surrounded on the exterior by a fringe of well-developed *costæ*, while the spaces between them are subdivided by horizontal and close-set exothecal plates. The septa have the form of longitudinal striæ, and tabulæ were only obscurely seen. In a note Mr Billings adds that this species would seem to be congeneric with *Syringophyllum organum.*

Whether or not Mr Billings be correct in the suggestion just alluded to, the above description and the figures which accompany it leave no doubt whatever as to the entire distinctness of *Calapœcia Anticostiensis*, Bill., and *Columnopora cribriformis*, Nich. If, therefore, the originally-described species—viz., *Calapœcia Canadensis* and *C. Huronensis*—are to be regarded as congeneric with *C. Anticostiensis*, then it is clear that the genus *Columnopora* has no relationships with *Calapœcia*. This, at any rate, seems to be the only conclusion that can safely be arrived at, until the original specimens of *Calapœcia* shall have been more fully examined and described.

The geological range of *Columnopora*, so far as known, is a very limited one, the type-species being confined to the Lower Silurian (Cincinnati group) of North America. The type of the genus is *C. cribriformis*, Nich., of which I append the following brief description. Judging from the figures given, I should imagine *C.* (*Houghtonia*) *Huronica*, Rom., to be at most a variety of *C. cribriformis;* but as the corallites are apparently to a considerable extent disjunct, it may prove to be a separate species when it shall have been examined by means of thin sections.

Columnopora cribriformis, Nicholson.

(Pl. VII., figs. 2 - 2 *d*.)

Columnopora cribriformis, Nicholson, Geol. Mag., new ser., vol. i. p. 253, fig. 1, 1874; Pal. Ohio, vol. ii. p. 186, Pl. II., figs. 8 - 8 *b*, 1875; Second Rep. Pal. Ont., p. 25, 1875.

Spec. Char. — Corallum forming hemispheric or pyriform masses, which vary in diameter from ten lines to half a foot or more, and in height from eight lines to three or more inches. Corallites spreading from the base of attachment, essentially polygonal, and for the most part in close contact, their walls thick and fused together; occasionally becoming subcircular, and partially separated by narrow interspaces as their mouths are approached. Calices rounded or distinctly polygonal, averaging one line and a half in diameter, smaller ones being often intercalated here and there among those of ordinary dimensions, their margins thick and crenulated by the septa. Septa about twenty in number, more or less, in the form of strong longitudinal ridges, which pass but a short distance inwards towards the axis of the visceral chamber. Mural pores large, oval, arranged in longitudinal rows between the septa, and separated by intervals as a rule much less than their own diameter. Tabulæ numerous, complete, flexuous, often uniting with one another, generally about eight in the space of two lines.

Obs.—The above description is based upon specimens from the Cincinnati group of Ohio, as regards its essential features; though, as regards one or two characters, I have had in view examples from the corresponding formation in Canada, which I believe to belong to the same species. Thus, in the Canadian examples, the tubes are more liable to show a circular form, and to be at times partially separated near their mouths, than is the case with those from Ohio. On the other hand, the latter usually show polygonal and closely-contiguous tubes. Having fully discussed the structure of this species in dealing with the genus, I need only add that it would seem probable that the *Columnopora* (*Houghtonia*) *Huronica* of Rominger (Foss. Cor. of Michigan, p. 17, Pl. III., figs. 3 and 4) is really identical with *Columnopora cribriformis*, Nich. As, however, Dr Rominger's description differs in some important respects from that of the type-species as here given, and as I have not had the opportunity of examining the specimens upon which his account is based, I shall in the meanwhile consider it as a separate species.

Formation and Locality.—In the Cincinnati formation, South-western Ohio. Rare in the corresponding formation (Hudson River group) of the Credit River, Ontario.

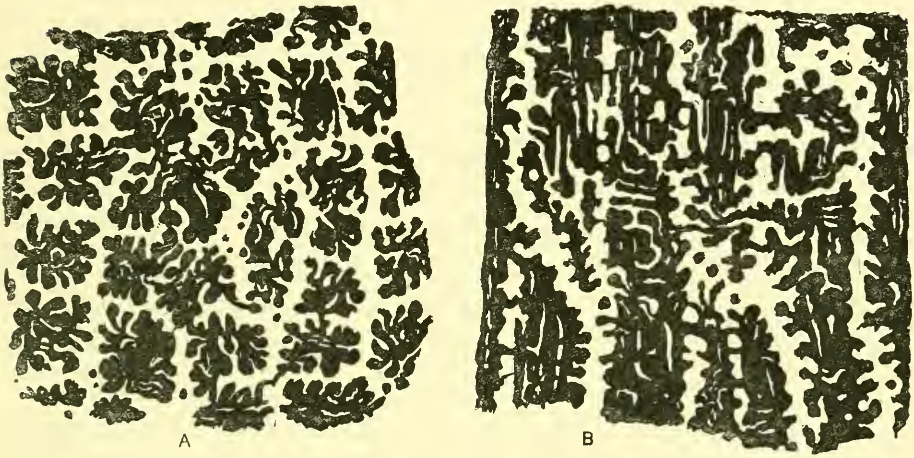
Genus ARÆOPORA, Nich. and Eth. jun., 1879.

(Fig. 24.)

Gen. Char.—Corallum massive, Favositiform, of polygonal corallites, which radiate outwards from an imaginary axis to open upon the free surface of the colony. Under surface covered by an epitheca (?). The corallites are firmly united by their walls, which are extensively perforated by apertures which place the visceral chambers of contiguous tubes in direct communication. Septa trabecular, often irregularly divided, or anastomosing at their free ends. Tabulæ rudimentary, represented only by occasional horizontal trabeculæ. No columella, nor cœnenchyma.

Obs.—This genus is founded upon a remarkable specimen belonging to the "Daintree Collection" of corals, from the Devonian or Carboniferous deposits of Queensland, descriptions of which will shortly be published by Mr R. Etheridge, jun., and myself. Pending the publication of our joint memoir, I shall simply avail myself here of the permission of my colleague to briefly discuss the characters and affinities of the genus *Aræopora*, as deduced from the only species with which we are as yet acquainted, and which we propose to name *A. Australis*.

The corallum in our specimen of *Aræopora Australis* might at first sight be taken for that of any of the larger and more massive species of *Favosites* (such as *F. hemispherica*, Yand. and Shum.); though even to the naked eye the absence of distinct tabulæ and the cribriform or porous condition of the walls are striking features. The height of the specimen (which is an imperfect one, and is not only silicified, but is likewise thoroughly infiltrated with silica) is rather more than three inches, and its greatest width something over four inches. Its form is pyriform, the narrow base having evidently been attached to some foreign body, while the under surface was almost certainly covered with an epitheca, of which no traces now remain. The calices must have opened over the whole of the convex upper surface, but none of them are preserved in the example before us. The corallites radiate with a graduated divergence from the imaginary axis of the colony, and their form is regularly prismatic or polygonal, as in *Favosites*. This character is much more perceptible to the eye, or when the surface is examined with a lens, than it is when thin sections are investigated under the microscope, as it is to some extent masked in the latter case by the broken and cribriform character of the walls. The average diameter of the corallites is about two-thirds or three-fourths of a line. The tubes are completely in contact, and the walls of contiguous corallites are undistinguishably amalgamated (fig. 24, A and B). Thin sections, whether



A B

Fig. 24.—A, Part of a transverse section of *Aræopora Australis*, Nich. and Eth. jun., enlarged eight times, showing the trabecular septa and porous walls; B, Part of a vertical section of the same similarly enlarged, showing the cribriform character of the walls, the septa, and the rudimentary tabulæ. Devonian (?), Queensland. (Daintree Collection). In these figures the matrix, which is really transparent, is represented as if opaque.

transverse or vertical, show that the walls of the tubes are extensively porous and cribriform (fig. 24, A and B), being pierced by numerous apertures, which place the visceral chambers in direct communication. Transverse sections, further, serve admirably to show the character of the irregular trabecular septa, some of which are short and spiniform, while others divide at their ends, or even unite with their neighbours. Vertical sections show that the septa are upon the whole placed in longitudinal rows, and they exhibit in addition occasional horizontal trabeculæ (fig. 24, B), which may be regarded as of the nature of rudimentary tabulæ.

From a consideration of the above characters, it cannot be doubted that we have to deal in *Aræopora* with a genuine

"Perforate" coral, which, however, is closely allied to the *Favositidæ*, and may be best placed in this family rather than in any of the more regular groups of the *Perforata*. By the characters of its walls and septa the genus presents certain alliances with the *Poritidæ*, but its general form and aspect are those of a *Favosites*, and the presence of rudimentary tabulæ would still further confirm the view here taken. Among the genera of the *Favositidæ*, *Aræopora* finds its nearest ally in the Lower Silurian genus *Columnopora*, Nich., which it nearly resembles in form and habit. It is distinguished from the latter, however, by the less regularly perforate character of its walls, by the rudimentary condition of its tabulæ, and by the irregularly-dividing and trabecular septa. I am unable to institute any comparison between *Aræopora* and the Cretaceous *Koninckia*, E. and H., but the septa of the latter seem to be merely spiniform (six in number), and the tabulæ are said to be well developed and complete.

The geological horizon of *Aræopora Australis*, Nich. and Eth. jun., is not quite certain, but it occurs in deposits of Devonian or Carboniferous age (the former most probably) in Queensland.

Genus STENOPORA, Lonsdale, 1844.

(Appendix to Darwin's Volcanic Islands, p. 161, 1844, and in Strzelecki's Phys. Hist. of New South Wales, p. 262, Pl. VIII., 1845.)

Tubuliclidia, Lonsdale, in Murchison's Geol. of Russia, p. 601 (note), 1845. (Non *Stenopora*, M'Coy, Brit. Pal. Foss. p. 24, 1851.)

Gen. Char.—Corallum ramose, or sublobate, rooted below, and 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. Corallites in the centre of the branches, polygonal, thin-walled, and more or less completely in contact; but in the outer curved portion of their course, more or less cylindrical, and annulated by periodical ring-shaped thickenings, which are placed at corresponding levels in contiguous tubes, in such a manner as to leave vacant spaces between the intervening unthickened portions. Visceral chamber in the outer portion of the tubes alternately contracted and dilated in correspondence with the periodical thickening of the walls of the corallites just spoken of; but open and subpolygonal in the axial portion of the corallum. Septa obsolete. Tabulæ remote, usually placed at corresponding levels in contiguous tubes. Mural pores of small size, not numerous, and irregularly distributed.

History.—The genus *Stenopora*, Lonsdale, was first described by its author in a note in Darwin's 'Volcanic Islands,' but was more fully defined in Strzelecki's 'Physical History of New South Wales' as follows: "A ramose spherical or amorphous tubular polypidom; tubes polygonal or cylindrical, radiated from a centre or an imaginary axis, contracted at irregular distances, but in planes parallel to the surface of the specimen; tubular mouths closed at final (?) period of growth; ridges bounding the mouths granulated or tuberculated; additional tubes interpolated."

It is quite clear, as properly pointed out by Dana (U.S. Expl. Exped. Zoophytes, p. 537, 1848), that the above generic diagnosis is insufficiently characterised;[1] and to this must be ascribed the great confusion in which the genus has subsequently become involved. Professor Dana, in the work just quoted, defines the genus as follows:—

"Internal structure of corallum fine prismatic; cells of surface minute, subangular, contiguous; zoophytes glomerate or ramose; surface often small-verrucose."

This definition, also, really adds nothing to our knowledge of the actual structure of the genus; and it is therefore no matter

[1] In the original description of *Stenopora* in Darwin's 'Volcanic Islands,' Mr Lonsdale does give a character of generic value—viz., the gradual closure of the mouths of the tubes by the deposition of calcareous matter on the interior of the wall, giving rise to what he regarded as periodical "constrictions" of the tubes; though these are really periodical "thickenings" of the wall, it being only the visceral chamber that is "constricted."

of surprise to find that Milne-Edwards and Haime at first accept the genus in part (Brit. Foss. Cor. Intr., p. lxi, 1850), with the clearly insufficient definition that the corallum is "very similar to *Chætetes*," but has "small styliform processes at the angles of the calices;" and then immediately afterwards (Pol. Foss. des Terr. Pal., p. 261, 1851) merge the genus with *Chætetes*, Fischer.

Mr Lonsdale's definition of *Stenopora* was founded (as also Professor Dana's) upon specimens derived from Australia and Van Diemen's Land; and, so far as known, all the examples in the hands of these observers were of Devonian or Carboniferous age. At this point, however, the history of the genus—which need not here be followed out in detail—became complicated by the reference to it by Professor M'Coy of a number of Silurian Corals (Brit. Pal. Foss., p. 24, 1851). The definition of *Stenopora* given by M'Coy is as follows:—

"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 only species unhesitatingly referred to the genus by M'Coy is one which he identifies specifically with the *Calamopora fibrosa* of Goldfuss (Petref. Germ., Pl. XXVIII., figs. 3 *a*, 3 *b*, 1829). The examples upon which Goldfuss founded this species were derived from North America; and as I have not had the opportunity of examining the originals, I can only say that the figures of the German palæontologist would pass very well as figures of such a species of *Stenopora* as *S. ovata*, Lonsd. *Calamopora fibrosa*, Goldf., was, however, subsequently referred by Milne-Edwards and Haime to *Favosites*, under the name of *F. fibrosa* (Pol. Foss. des Terr. Pal., p. 244), and the species was stated to occur in the Lower and Upper Silurian, and also in the Devonian, in Britain, Europe, and North

America. I have never myself been so fortunate as to meet with any specimens which I could refer without doubt to *Favosites fibrosa*, Goldf. sp., as defined by the eminent French authors above referred to; and I am therefore quite unable to express any opinion as to its affinities. It seems, however, quite certain that the corals described by Professor M'Coy under the name of *Stenopora fibrosa*, Goldf. sp., have in reality no relations whatever with the true *Stenopora* of Lonsdale. On the contrary, it is almost certain that they belong to the genus *Chætetes*, Fischer, or to *Monticulipora*, D'Orb., as ordinarily understood; and the same may be pretty confidently asserted of all the examples of *Stenopora* which have subsequently been quoted by various writers as occurring in the Silurian deposits of various parts of the world. At the same time, though I think that we have at present no actual evidence of the existence of any species of *Stenopora* in the Silurian rocks, it is quite possible that a more extended investigation may yet show some of the so-called *Monticuliporæ* of the Silurian to be really referable to the former genus. We shall subsequently see, indeed, that there are certain of the Silurian *Monticuliporæ* which, except in the apparent absence of "mural pores," make a very close approach in structure to *Stenopora*.

It is quite clear, further, that with the available information as to the structure of the genus *Stenopora*, Lonsd., it was impossible to establish any satisfactory generic distinction between this type and *Chætetes* or *Monticulipora;* and this view was the one finally adopted by Milne-Edwards and Haime, and subsequently followed by myself (Quart. Journ. Geol. Soc., vol. xxx. p. 499, 1874). To this opinion I should have been still inclined to adhere; but Professor De Koninck has shown that one of the species described by Lonsdale (viz., *S. ovata*) possesses perforated walls, and is therefore fundamentally separated from the entire family of the *Chætetidæ*. Indeed he refers the species just mentioned to the genus *Favosites* itself. I have, moreover, recently had the opportunity of examining a tolerably extensive series of examples of *Stenopora*, mostly collected by

Mr R. L. Jack, F.G.S., in Queensland; and having made a careful microscopical examination of the genus by means of thin sections, I am able not only to confirm De Koninck's reference of the genus to the *Favositidæ*, but to show further that its characters are entirely peculiar, and such as to separate it generically from all the other members of the family. The specimens in question formed part of a collection of Australian corals which will shortly be described by Mr Robert Etheridge, jun., and myself; and it is to the kindness of my colleague that I owe the permission to use here the previously given generic diagnosis, as well as the following observations upon the structure of *Stenopora*. Pending the publication of our joint memoir, however, I shall not add in this place any descriptions of the species, merely remarking that the forms which we have examined appear to be referable to three species, one of which is identical with *S. ovata*, Lonsd., while a second seems to be new (*S. Jackii*, Nich. and Eth. jun.), and the third is not in a condition to admit of definite specific identification.

Obs.—Taking *S. ovata*, Lonsd., as the basis of the following remarks, the corallum in *Stenopora* is usually more or less branched; but the branches may be so thick, and may so extensively coalesce, that its general form becomes that of a lobate mass. The corallites (fig. 25, A) radiate in all directions from an imaginary axis, and present very different appearances in the central and circumferential portions of the corallum respectively. In the axial portion of the branches the tubes are nearly vertical, have thin walls, are essentially polygonal or prismatic in shape, and are nearly or quite in contact with one another throughout. As they pass upwards, the tubes gradually diverge, coming at last to be nearly horizontal, and continuing in this direction for some distance, till they at last open upon the surface. There is thus an outer zone of the corallum in which the corallites are nearly transverse to the axis of the branches, and within this zone they present all their peculiar features. In this region, namely, the corallites (fig. 25, B) assume a generally cylindrical appearance, owing to the fact that their walls are thickened at very short intervals by annular accretions of growth, the portions of the tube between these retaining their normal diameter. As these thickened portions of the corallites are placed at cor-

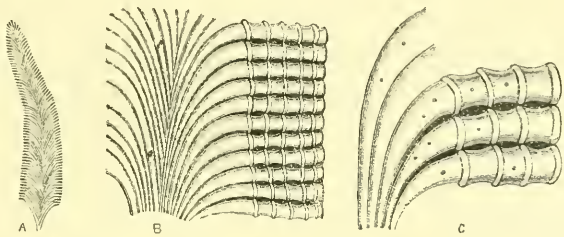


Fig. 25.—A, Portion of a branch of *Stenopora Jackii*, Nich. and Eth. jun., split open, of the natural size ; B, Portion of the same enlarged, showing the annulations of the tubes in their outer portions ; C, A few of the tubes of the same still further enlarged, showing the mural pores. Permo-Carboniferous formation, Queensland.

responding levels in all the corallites, it follows that the tubes are actually in contact with one another at these points only, and that they are separated by ring-like spaces corresponding to all the unthickened segments of the tubes.

Thin sections of the corallum bring to light the peculiarities just mentioned, along with others, the true significance of which cannot at present be ascertained. Thus, if we take a transverse section of a branch, and examine its central portion, where the nearly vertical tubes are cut across approximately at right angles to their course, we find that the corallites (fig. 26, B) differ in no essential respect from those of *Favosites* as regards their general structure. Each possesses its own wall, which is not excessively or abnormally thickened, and the boundary between contiguous tubes is clearly marked by a dark line. The tubes in this portion of the corallum are, moreover, regularly polygonal, and are, as a rule certainly, in close contact. If, on the other hand, we take a section tangential to the branch, and just below its surface, we have the corallites cut transversely across in the horizontal and annulated portion of their course, and the appearances presented are very different to the above. The tubes still appear to be in close contact and to be polygonal, each being bounded externally by a well-defined dark line; but the appearances of the area within this boundary-line vary according as the section cuts the tubes at the level of their thickened portions, or at that of the unthick-

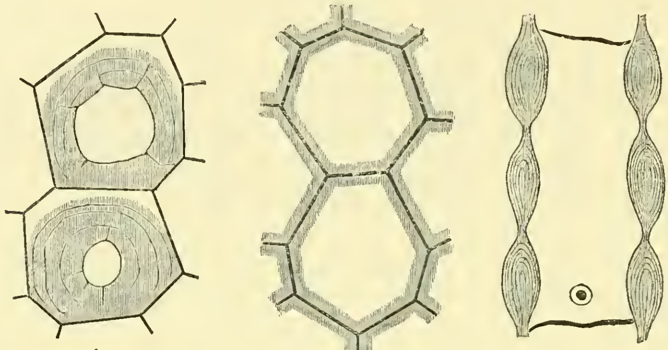


Fig. 26.—A, Two tubes of *Stenopora ovata*, Lonsd., cut transversely across their thickened portions, and showing the contraction of the visceral chamber by an annular deposit of sclerenchyma, which is not in contact with the wall on one side; B, Two tubes of the same from the axis of a branch, cut transversely, showing their thin walls and polygonal form; C, Portion of a tube of the same cut longitudinally, showing the thickening of the wall, the tabulæ, and one of the mural pores. Enlarged twenty-five times. Permo-Carboniferous, Queensland.

ened intervals between the latter. In the former case, the visceral chamber (fig. 26, A, and Pl. IX., fig. 1 *a*) is seen to be greatly contracted, and to be reduced to a comparatively small rounded or subpolygonal central tube, which is in turn surrounded by a thickened ring of sclerenchyma, which usually shows distinct traces of its being composed of successively-deposited concentric laminæ. In the latter case there is still a ring of sclerenchyma within the dark outer polygonal boundary, but this ring is of small thickness comparatively, and the central tube is wide and open—the general appearances being on the whole like those presented by cross-sections of the tubes in the axial portion of the corallum. In both the above cases, however, whether the section cut the corallites across their thickened or their unthickened portions, there are two phenomena observable which I am at present quite unable to explain. One of these consists in the fact that the ring of sclerenchyma within the corallites is never in contact with the outer polygonal wall for more than one half or two-thirds of its circumference, being separated from the latter throughout the remaining part of the tube by a distinct and conspicuous interspace, which is filled in the fossil with transparent calcite. Not only is this partial interspace between the inner ring and the outer wall (Pl. IX., fig. 1 *a*, and fig. 26, A) apparently always present, but it seems to be always situated upon the same side of all the corallites in any particular section. The other point that is difficult to understand is how the outer dark walls of the corallites should appear in tangential sections to be always in close contact, seeing that an examination of the exterior of the tubes with a lens shows that they are only in contact along the thickened planes in which rings are developed, and are separated by distinct intervals in the spaces between these. Moreover, in many parts of tangential sections the corallites exhibit few features that would satisfactorily separate them from similar sections of the tubes of certain *Monticuliporæ*, though they usually have exceptionally thick walls, and also often exhibit a thin dark ring a little within the true wall, and concentric with the latter. There are also some other phenomena occasionally observable which it is extremely difficult to explain; and it seems clear that the precise structure of this curious type must remain to some extent unelucidated until a large series of specimens can be microscopically investigated.

Longitudinal sections of the tubes (fig. 26, C, and Pl. VIII., fig. 1) show the periodical annular thickenings of the tubes in a very instructive manner, and show that these are really *thickenings of the wall*, projecting both externally and internally, and that it is therefore incorrect to regard the tubes as being "periodically *constricted*"—this phrase applying only to the visceral chamber. In fact, the longitudinal section of the wall has a regularly moniliform appearance, due to its successively traversing thickened and unthickened segments of the tube. Sections of this kind also show that there exist remote and complete tabulæ, which are usually placed at approximately corresponding levels in all the corallites of a single colony.

Lastly, these sections occasionally show mural pores, though these structures can be best made out by a microscopic examination of the exterior of the tubes, when they are found to be present in the form of small, circular, irregularly-distributed apertures. It may be added that long sections show the same curiously puzzling feature as do tangential slices—namely, that the corallites are apparently in contact throughout their length, whereas macroscopic examination shows them to be clearly free over the unthickened segments of the tube.[1]

So far as can be at present ascertained, the species properly belonging to *Stenopora*, Lonsd., as now worked out, are all confined to the Carboniferous or Permo-Carboniferous periods, there being some uncertainty as to the precise horizon of some of the deposits which have yielded specimens of this type. So far as known, also, the species of the genus are confined to Australia and Van Diemen's Land. It cannot be said that any species of the genus has been certainly identified in the Silurian rocks, and all the Silurian corals which have been at various times referred here must in the meanwhile be placed under *Monticulipora* or *Chætetes* pending their complete examination by microscopic methods. The internal structure of *Stenopora*, as I have here described it, is such as to fundamentally separate the genus from either *Chætetes* or *Monticulipora;* but I am unable to say how far a mere examination of the surface with a lens would enable an observer to separate a specimen of the first from one belonging properly to either of the latter genera. None of my examples, in fact, show the surface-characters in a satisfactory manner; but so far as I can judge, the general

[1] Since the foregoing has been written, examples of *Stenopora Tasmaniensis*, Lonsd., *S. crinita*, Lonsd., and of a third form apparently referable to *S. informis*, Lonsd., have been carefully examined by Mr R. Etheridge, jun., and myself. The phenomena which these present will be elsewhere recorded by us, and it will be sufficient here to say that all the above species are true *Stenoporæ*, though the two last are massive, and in many respects widely unlike *S. ovata* in general appearance. All of them, however, possess the peculiar fibrous thickenings of the walls of the tubes in parts, and must therefore be regarded as congeneric with *S. ovata*. They show, nevertheless, many very singular features, the two last in particular not only differing considerably from *S. ovata*, but also differing in important characters from one another.

aspect of the calices is very similar to that of some *Monticuliporæ*, and I should therefore doubt if simple inspection of the exterior would enable one to identify a specimen of *Stenopora*. Certainly the presence of spines or tubercles on the lips of the calices—even if a constant character—cannot be supposed to have anything beyond a mere specific significance. I shall, however, have occasion to show hereafter that the spines and calicine tubercles of certain *Stenoporæ* and *Monticuliporæ* are not mere surface-ornaments, but that they in reality are produced by the metamorphosis of a peculiar and special series of corallites.

Genus RŒMERIA, Milne-Edwards and Haime, 1851.

(Pol. Foss. des Terr. Pal., p. 253.)

The genus *Rœmeria* was founded by Milne-Edwards and Haime for the reception of the single species *R. infundibulifera*, the *Calamopora infundibulifera* of Goldfuss (Petref. Germ., t. i. p. 78, Pl. XXVII., fig. 1, 1826). I reproduce here the description given by these authorities both of the genus and species :—

Genus RŒMERIA.—" Corallum forming a rounded mass, the corallites united by their walls, the tabulæ infundibuliform."

Species, Rœmeria infundibulifera, Goldf.—" Corallum massive, sublobate ; the corallites unequal, intimately united by their walls at certain places, although free near their summits; calices in general polygonal, of a diameter of two or three millimetres. There are traces of thin and equal-sized rudimentary septa. A vertical section shows that there are tolerably regular and numerous tabulæ, in the form of funnels let one into the other. We do not know if mural pores are actually present."

The brevity of the above diagnosis is sufficient to show that Milne-Edwards and Haime possessed but a partial knowledge of the structure of the above species and of the genus which they founded upon it ; nor is any additional light to be derived from an examination of the figure given by Goldfuss, except that this indicates a coral in many respects very unlike the normal forms of *Favosites*. I am unable personally to give any fresh information as to the structure or affinities of this coral; but Mr George J. Hinde, who has lately examined the original specimen in the Bonn Museum, permits me to say that in his opinion the relationships of this peculiar type, so far as they can be determined without actual sections, are rather with *Syringopora* than with *Favosites*. The walls of the corallites are very thick, and the tubes (as noted by Milne-Edwards and Haime) are actually not in contact near their mouths, while there is no positive evidence as to the existence of mural pores. The tabulæ also are simply invaginated, without being so bent downwards in the centre as to give rise to a median tube; so that, on the whole, the corallum may "be compared with that of a *Syringopora*, in which the connecting-processes are absent and the corallites are in close contact." On the other hand, my friend Mr Hinde has had the great kindness to allow me access to his specimens of a most remarkable Favositiform coral, which he has collected in the Niagara Limestone of Canada, and which in some respects agrees with the published description of *Rœmeria*, E. and H.; and I am further indebted to him for the permission to make use here of the following condensation of its characters, drawn from the MS. of a paper which he is about to publish on the subject.

Genus SYRINGOLITES, Hinde, 1879.

(Fig. 27.)

Gen. Char.—Corallum composite, forming flattened expansions, with a basal epitheca, in general appearance resembling *Favosites Gothlandica*, Lam. Corallites in close contact throughout, prismatic, thin-walled, with one or more vertical rows of mural pores on each prismatic face. Tabulæ annular, curved so as to be concave upwards, and depressed centrally so as to give rise to a vertical median tube, which may be continuous or may be crossed by an occasional partition, and which runs down the centre of the visceral chamber of each corallite, and possesses non-perforate walls. Septa represented by crenulations of the walls of the corallite, which are continued over the upper surfaces of the tabulæ in the form of a series of short spines or tubercles, arranged in radiating rows, till they ultimately disappear in the depths of the central tube (fig. 27).

This extraordinary genus is only known by a number of silicified specimens, in a state of beautiful preservation, collected by Mr George J. Hinde in the Niagara Limestone of Manitoulin Island, Canada, and about to be fully described by him under the name of *Syringolites Huronensis*.[1] Under these

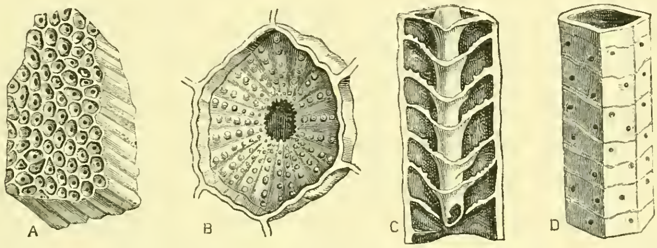


Fig. 27.—A, A fragment of a colony of *Syringolites Huronensis*, Hinde, of the natural size; B, A single calice of the same, enlarged eight times, showing the central tube, and radiating lines of septal tubercles; C, Part of a corallite of the same, split open, and enlarged six times, showing the composition of the central tube out of invaginated tabulæ; D, Part of a corallite of the same, viewed from the exterior and enlarged six times, showing the mural pores. Niagara Limestone, Manitoulin Island, Ontario. Coll. George J. Hinde.

circumstances, it would not be proper for me to do more than to say that, after a careful examination of the specimens collected by this indefatigable observer, I am able to entirely corroborate his views as to the structure of the genus, while I may justifiably add a few general remarks bearing upon the connection between this new type and those which have been previously considered.

In the first place, then, it is clear that in *Syringolites*, Hinde, we are presented with a coral closely allied to *Favosites* proper, as shown by its general form, its prismatic corallites, intimately

[1] Since the above was written, Mr Hinde has published his description of *S. Huronensis* (*see* Geol. Mag., Dec. ii., vol. vi. p. 244, June 1879).

united by their walls, and its possession of rudimentary spiniform septa, of tabulæ, and of *mural pores*. In the second place, we have here a coral which really fulfils Goldfuss's ideal of *Calamopora*—"diaphragmatibus transversis, e siphone prolifero;" if it were at all possible to revive this name with justice or advantage. It is, however, quite certain that not one of the forms included by Goldfuss under the name of *Calamopora*—not even his *Calamopora* (*Rœmeria*) *infundibulifera*—really possesses a central siphonal tube, formed by the junction of a vertical series of funnel-shaped depressions of the tabulæ in the middle line. Mr Hinde's specimens, however, place it beyond a doubt that, in his *Syringolites Huronensis*, we have precisely such a form; and we are thus presented with a true member of the *Favositidæ*, which, in one of the most striking points of its organisation, offers a distinct approximation to certain of the forms included under the genus *Syringopora*. It need only be added here that the present form is generically distinguished from all those ordinarily ranged under *Syringopora*, not only by the close union of the polygonal corallites and the total absence of connecting-processes, but also by the possession of mural pores in all respects resembling those found in the type-species of the genus *Favosites*.

Genus LACERIPORA, Eichwald, 1860.

(Lethæa Rossica, p. 490.)

Gen. Char.—"Corallum thick, elongated, curved, ramose, of almost cylindrical branches; the calices angular, unequally-sized, united with one another [by their walls], and provided with two, three, or more rudimentary vertical lamellæ. The corallites radiate regularly from a cellular or porous central axis, and are intersected by thick tabulæ, which are placed at the same level in different tubes, so as to form a succession of superimposed layers. The margins of the calices are crenulated or uneven; they may or may not be provided with rudimentary vertical lamellæ. The corallites differ from one another in size and shape, and are so amalgamated by their walls that no distinct lines of demarcation can be distinguished between them" ["elles se soudent ensemble et forment des murs confluents, de sorte qu'on ne peut pas les distinguer les unes des autres"].

Obs.—I am not acquainted with any example of this genus, and can do nothing more than give the above translation of M. Eichwald's description of it. For the clearer understanding of its characters I have likewise reproduced Eichwald's figures (Pl. VII., figs. 3 - 3 *b*), which, if reliable, would seem to indicate a distinct generic type. These figures present us with a ramose corallum, with a general resemblance to the dendroid forms of *Pachypora* or *Favosites;* with very thick-walled corallites, which are furnished with a small number of strong marginal septa (Pl. VII., fig. 3 *a*). The drawing given on Pl. VII., fig. 3 *b*, is said by Eichwald to be the "coupe transversale," and it doubtless is the transverse section; but it represents the outermost portion of such a section, where the tubes, as they diverge outwards, become nearly horizontal, so that we really see the corallites cut *longitudinally*. In this section we see that the tubes—in accordance with the description given by Eichwald—are intersected by thick tabulæ, placed at corresponding levels in contiguous tubes.

There is nothing in Eichwald's description or figures which would lead to any safe conclusion as to the systematic position of *Laceripora;* and no allusion whatever is made to the existence of mural pores. I have therefore provisionally included the genus in the *Favositidæ*, simply in deference to the opinion of Dr Lindström, who is probably acquainted with actual examples of the genus, and who states that it is "nothing more than a highly-perforated *Favosites*" (Ann. Nat. Hist., ser. 4, vol. xviii. p. 12, 1876).

The only known species of the genus is the *Laceripora cribrosa* of Eichwald, which is stated to occur in the "grauwacke" (Upper Silurian), and also in the Carboniferous formation.

Genus Nyctopora, Nicholson.

Gen. Char. — Corallum composite, massive, of polygonal corallites, which radiate from the base of the spheroidal corallum, to open on its upper surface, and are in complete contact throughout their entire extent. Walls of the corallites thin, and so completely amalgamated that no trace whatever of the original lines of division between the tubes can be detected. Mural pores numerous, small, in more than one series, occupying the sulci between the septa. Septa in the form of marginal vertical ridges, which extend along the whole length of the tubes, from ten to fifteen in number in each corallite, not divisible into an alternating series of longer and shorter lamellæ. Tabulæ numerous, complete, horizontal.

Obs.—I have been obliged to establish this genus for the reception of a coral from the Trenton Limestone of Canada, which I have previously regarded as probably identical with *Columnaria Goldfussi*, Bill. In its general form and aspect this coral, in fact, is entirely similar to *Columnaria Halli*, mihi (*C. alveolata*, Bill.); and it does not differ in any superficially obvious character from the typical species of *Columnaria* (*C. alveolata*, Goldf., and *C. calicina*, Nich.), except in the marginal and comparatively rudimentary condition of the septa. Thin sections, however, place it beyond a doubt that the walls of the present form are perforated by mural pores, and that the coral in question must be placed in the *Favositidæ*. Whether or not the walls of *Columnaria* (?) *Halli* are likewise perforate is a point which at present I cannot determine, though I am inclined to think that in this form also mural pores are present. If this conjecture should be ultimately established, then this well-known form (the *Columnaria alveolata* of American palæontologists) will also have to be removed to the genus now under consideration.

The corallum in the only certainly ascertained species of *Nyctopora* is in the form of spheroidal or pyriform masses, composed of polygonal and closely-contiguous corallites, the walls of which are not only in contact, but are undistinguishably amalgamated with one another (Pl. IX., figs. 3 - 3 *c*). The corallites radiate from the base of attachment, the lower surface being probably covered with an epitheca, and the calices opening upon the convex upper surface (Pl. IX., fig. 3). The calices are polygonal, with moderately thick margins, which are crenulated by the rudimentary septa (Pl. IX., fig. 3 *c*). Transverse sections (Pl. IX., fig. 3 *a*) show that the walls of contiguous corallites are completely fused with one another, no trace whatever of the original line of demarcation between neighbouring tubes being recognisable under the microscope. Sections of this kind also show the short marginal septa, to the number of from eight to twelve or more in each tube; while occasionally a mural pore is laid open, connecting the cavities of contiguous corallites directly with one another. Vertical sections (Pl. IX., fig. 3 *b*) show that there are numerous thin, horizontal, and complete tabulæ; and in parts where the section more or less nearly coincides with the plane of the walls of any of the tubes, we observe numerous unmistakable mural pores. These apertures differ in no respect from the mural pores of *Favosites*, except that they are perhaps proportionately smaller, and do not seem to obey any regular law of distribution.

So far as known, this genus is confined to the Trenton Limestone in North America, and it affords a very interesting link between the *Favositidæ* and the *Columnariadæ*. It differs from *Favosites* in the lamellar condition of the septa, which, though rudimentary, are never spiniform; and in the more minute size and apparently irregular distribution of the mural pores. On the other hand, though agreeing with *Columnaria*, Goldf., in its general structure and appearance, and especially in the character of its septal apparatus, it is fundamentally distinguished from the latter (as our present knowledge stands) by the perforated condition of its walls.

Nyctopora Billingsii, Nicholson.

(Pl. IX., figs. 3 - 3 *c*.)

Columnaria Goldfussi, Nicholson, Sec. Rep. Pal. Ont., p. 9, 1875.

Spec. Char.—Corallum forming small spheroidal or pyriform masses, varying from seven lines in diameter and four lines in height, to rather more than an inch and a half in diameter and an inch in height. Corallites prismatic or polygonal, subequal, about three-quarters of a line or rather less in diameter, their walls everywhere contiguous and closely amalgamated. Septa in the form of from eight to twelve or more strong marginal ridges, which run the entire length of the tubes, and project to a very limited extent into the interior of the visceral chamber. Mural pores numerous, minute, circular, apparently not arranged in any definite order. Tabulæ horizontal, complete, about six in the space of two lines.

Obs.—As I have discussed the structure of this coral in dealing with the genus *Nyctopora*, of which it is the only known representative, I have little to add here. The specimens in my possession are all from the Trenton Limestone of Canada, and they were identified by me, from an external examination only (Sec. Rep. Pal. Ont., p. 9), as young examples of *Columnaria Goldfussi*, Bill. They agree, indeed, with the description of this species (Geol. Surv. Can. Report of Progress for 1857, p. 166, 1858) in most respects, but the latter is said to form " large amorphous or subglobose masses," with from four to six tabulæ in the space of one line, the septa " rudimentary, but distinctly striating the interior walls ;" whereas the present form is always quite small, its tabulæ are wider apart, and its septa, though rudimentary, have the form of strong vertical ridges. As it is not known whether or not mural pores are present in *Columnaria Goldfussi*, Bill., no stress can be laid upon this character ; but their undoubted presence in *Nyctopora Billingsii*, taken along with the differences above noted, and the fact that *Columnaria Goldfussi* is believed to belong to the Hudson River formation, would seem to point to the at least specific distinctness of the present coral. If a further examination of *C. Goldfussi*, Bill., should show it to be possessed of mural pores, then it also must be removed to the genus *Nyctopora*. Lastly, there is a close general resemblance between the present form and *Columnaria* (?) *Halli*, mihi (the *Columnaria alveolata* of American writers), and it is not at all impossible that the latter may be shown to have perforate walls, and thus to truly belong to the present genus.

Formation and Locality.—Not uncommon in the Trenton Limestone of Peterboro', Ontario.

Genus BILLINGSIA, De Koninck, 1876.

(Rech. sur les Foss. Pal. de la Nouv. Galles du Sud., p. 75, Pl. II., fig. 4.)

Gen. Char.—"Corallum composed of compressed corallites, united by their walls, and communicating freely with one another by means of lateral openings. Calices small, ovate, and furnished with a few septal striæ. Tabulæ apparently absent."

Obs.—This genus was founded by Professor De Koninck (*loc. cit.*) for a single species of coral (*B. alveolaris*), from strata of Devonian age, near Zass, on the Murrumbidgee River, in Australia. Not having seen any examples of the form in question, I can simply reproduce the above generic diagnosis and one of the figures (Pl. IX., fig. 4) given by De Koninck. Assuming the correctness of the description given—as to which the great experience of this distinguished observer leaves little room to doubt—we have to deal in *Billingsia* with a perforate coral, belonging to the *Favositidæ*, but distinguished from the other members of this family by the suppression of the tabulæ. The mural pores are apparently numerous and of large size, but they do not seem to have any serial arrangement. Professor De Koninck expresses the opinion that the genus is intermediate between *Aulopora* and *Syringopora*; but it seems hardly possible, with our present knowledge, to arrive at any certain conclusions as to its true systematic position.

Genus NODULIPORA, Lindström, 1873.

(Öfversigt af Kongl. Vetensk. Akad. Förhandl., No. 4, p. 14, note, 1873.)

Gen. Char. — "Polyparium turbinatum, totum e nodulis minimis contextum, ceterum et forma et septis *Favositarum*. Epitheca tenuis, longitudinaliter rugosa. Superficies calycigera lata, plana. Calyces inæquales, sæpe in radios crescentes, obovati, angusti vel circulares, polygonii et curvi. Muri incompleti, perforati. Noduli corpore rotundo, processibus tenuibus inter se conjuncti. Partes inferiores vel primariæ polyparii materia calcarea consolidatæ. Superficies calycigera processus radiciformes emittit." "Species unica *N. acuminata*, m. in Dalhem, Gotlandia, reperta."

Obs.—I am not aware that Dr Lindström has ever published any further description or any figures of this remarkable form; and as I am altogether unacquainted with actual specimens, I can add nothing to the above generic diagnosis. Judging from this alone, *Nodulipora*, Lindst., must be regarded as an aberrant member of the *Favositidæ*, with no marked affinities to any other member of this varied family.

CHAPTER VII.

COLUMNARIADÆ (LYOPORA AND COLUMNARIA).

Genus LYOPORA, Nich. and Eth. jun., 1878.

(Mon. Sil. Foss. of Girvan, Fasc. i. p. 25.)

Gen. Char.—Corallum composite, massive, forming irregularly spherical or pyriform masses, composed of tubular, subcylindrical, or subpolygonal corallites, which are more or less completely fused with one another. Walls of the corallites extraordinarily thick and dense, apparently destitute of mural pores. Septa rudimentary, marginal, few in number, having the form of irregular obtuse ridges on the interior of the wall. Tabulæ strong and complete. No columella nor cœnenchyma.

Obs.—The corallum in this genus is chiefly remarkable for the great density of the walls of the corallites, contiguous tubes being separated by partitions which may equal half or more of diameter of the former (Pl. IX., figs. 2 and 2 *a*). Moreover, the walls of neighbouring tubes are completely amalgamated with one another, so that the original boundaries of the corallites are either quite irrecognisable, or can only be made out more or less obscurely. Rough fractures, also, invariably expose the interior of the tubes. The corallites are subpolygonal or subcircular in shape, and are essentially in contact throughout their entire length. The dense intertubular sclerenchyma, however, exhibits very commonly small irregularly-distributed and irregularly-shaped vacuities, which vary much in number in different specimens, or even in different parts of the same specimen. Sometimes they are almost wholly absent, sometimes they are so far abundant that one may count five or six in the wall surrounding one corallite; while they may be circular, oval, crescentic, or quite irregular in outline. They are seen both in transverse and vertical sections (Pl. IX., figs. 2 and 2 *a*), and they can often be detected on the surface in the form of pits in the thick margins of the calices. It would appear to have been the above structures which induced M'Coy to place *Lyopora favosa* in the genus *Heliolites* (*Palæopora*); but microscopic sections prove, beyond the shadow of a doubt, that they are certainly not "cœnenchymal" in their nature. They are either placed at the angles of junction of the original corallites (when these can be detected at all), or they run in the substance of the wall itself. It is clear, therefore, that they cannot be "cœnenchymal tubules;" but it is at the same time difficult to say precisely what they are. Probably they are (as suggested by Mr R. Etheridge, jun., and myself, *loc. cit.*, p. 28) mere vacuities due to imperfect deposition of sclerenchyma; but the more regularly-shaped ones are possibly of the nature of the "intramural canals" of *Columnopora*, whatever these may be.

As regards the other features in the anatomy of *Lyopora*, I have failed to find any evidence of the existence of "mural pores," after a careful examination of a large number of specimens and of microscopic sections. I am not, however, prepared to assert that mural pores may not ultimately be proved to be present. The septa are entirely rudimentary, and have the form of broad, obtuse, and somewhat irregular marginal ridges, which project to an extremely limited extent into the visceral chamber (Pl. IX., fig. 2). The tabulæ are strong and complete, and, in the only species known, are usually remote and horizontal (Pl. IX., fig. 2 *a*).

The apparent absence of mural pores renders it impossible to refer *Lyopora* to the *Favositidæ;* and the undoubted absence of "cœnenchymal tubules" entirely precludes any comparison between it and the *Helioporidæ.* Under these circumstances it is very difficult to state anything definite as to the systematic place which the genus ought to occupy. Its general characters are in many respects such as to approximate it to *Columnaria,* Goldfuss, which will be discussed immediately; but this can hardly be said to make matters any clearer, for the precise zoological relationships of the latter are still very uncertain. Moreover, a close comparison of specimens and thin sections of these two genera has convinced me that the points of resemblance between them are largely counterbalanced by points of structural dissimilarity. Thus the typical forms of *Columnaria* not only want the extraordinarily thickened walls of *Lyopora,* but possess a septal system, which, even in its most rudimentary condition, is a marked advance upon that of the latter; while the amalgamation of the walls of the corallites is never carried to the extent of in any way obliterating or obscuring the line of demarcation between contiguous tubes. The typical species of *Columnaria,* indeed, present many features which would induce us to place them among the Rugose Corals, whereas *Lyopora* exhibits no characters save such as were supposed to be distinctive of the old group of the "Tabulata." Upon the whole, therefore, I must at present leave the position and zoological relationships of *Lyopora* entirely open questions.

So far as known, the geological range of the genus *Lyopora* is an extremely limited one, the only recorded species being the *L. favosa,* M'Coy, sp., of the Lower Silurian rocks of Ayrshire. I subjoin a brief diagnosis of this singular species, extracted from the 'Monograph on the Silurian Fossils of Girvan,' by Mr R. Etheridge, jun., and myself.

Lyopora favosa, M'Coy, sp.

(Pl. VIII., figs. 3, 3 *a*, and Pl. IX., figs. 2, 2 *a*.)

Palæopora (?) *favosa*, M'Coy, Ann. and Mag. Nat. Hist., ser. 2, vol. vi. p. 285, 1850.

,, *favosa*, M'Coy, Brit. Pal. Foss., p. 15, Pl. I. C, fig. B, 1851.

Heliolites (*Palæopora*) *favosus*, Salter, Quart. Journ. Geol. Soc., vol. vii. p. 170, 1851.

Lyopora favosa, Nicholson and R. Etheridge, jun., Mon. Sil. Foss. Girvan, p. 26, Pl. II., figs. 1 - 1 *e*, 1878.

Spec. Char.—Corallum composite, massive, spheroidal, hemispherical, pyriform, or irregular in shape; the corallites subcylindrical, elliptical, hexagonal, or irregular in outline, firmly united with one another. Calices usually circular or hexagonal, averaging a line and a half in diameter, the lip coarsely granular. Walls imperforate, extraordinarily thick, the interspaces between any two contiguous tubes being occupied by dense calcareous tissue, of from three-quarters of a line to more than a line in thickness, sometimes with minute and irregular vacuities. Septa rudimentary, often wanting in individual calices, varying in number from two or three up to ten or twelve or more, always abortive, and represented only by rough and blunt ridges on the interior of the wall. Visceral chamber crossed by strong, solid, complete tabulæ, distant from a line to a line and a quarter from one another.

Obs.—Having discussed the characters of the genus *Lyopora*, of which this is the only recorded species, at some length, it is unnecessary to dilate upon the above specific diagnosis. The reference of this curious form by Milne-Edwards and Jules Haime to *Heliolites interstinctus*, Wahl. (Brit. Foss. Corals, p. 250), has been shown by Mr R. Etheridge, jun., and myself (*loc. cit. supra*), to have been caused by the erroneous figures given by M'Coy of its internal structure. The form of the corallum is very variable, but it was rooted at its base to some foreign body, and the diverging corallites seem to have opened over the whole of the free surface, no traces of an epitheca having come under my observation. The size of ordinary specimens varies from an inch or less in height and breadth up to half a foot or more.

Formation and Locality.—Abundant in the Lower Silurian Limestone of Craighead, Girvan, Ayrshire.

Genus Columnaria, Goldfuss, 1826.

(Petref. Germ., t. i. p. 72.)

Columnaria (pars), Goldfuss, Petref. Germ., t. i. p. 72, 1826.
Favistella,[1] Hall, Pal. N.Y., vol. i. p. 275, 1847.
Favistella, Nicholson, Sec. Rep. Pal. Ont., p. 21, 1875.

Gen. Char.—Corallum composite, massive, composed of polygonal, closely-compacted and contiguous corallites, which are united by their walls, but do not possess mural pores. Walls of the corallites not excessively thickened. Septa well developed, typically extending nearly to the centre of the visceral chamber, and alternately large and small. Tabulæ extremely well developed, complete, and horizontal. No columella or cœnenchyma.

Obs.—This genus was founded by Goldfuss to include certain massive aggregate corals, which closely resemble *Favosites* in general appearance, but differ in having lamellar septa and imperforate walls. Of the three forms included by Goldfuss under this name, two appear to be compound Rugose corals, as shown by Milne-Edwards and Haime (Pol. Foss. des Terr. Pal., p. 308, 1851); and the title *Columnaria* can therefore only be retained for the third of these—viz., *C. alveolata*, which occupies the first place in the original description, and must therefore be strictly regarded as the *type-species*. Nor can any doubt be

[1] The name of *Favistella* was proposed in 1846 (U.S. Expl. Exped. Zooph., p. 538) by Dana for "a part of the true *Favosites*, in which the cells are stellate with twelve distinct rays." There is, however, no sufficient evidence that Dana had in view the true *Columnariæ*, rather than the similar-looking forms of *Favosites* with well-developed septa; and it is quite clear that Hall introduced the name *Favistella* quite independently.

entertained as to the identity of the coral which Goldfuss described and figured under the name of *C. alveolata*, with that of the coral subsequently described and figured by Hall under the designation of *Favistella stellata* (Pal. N.Y., vol. i. p. 275, Pl. LXXV., fig. 1). Indeed, the original specimens described by Goldfuss were derived from North America.

It is certain, then, that the genus *Columnaria*, if kept at all, can only be retained for corals having the characters of *C. alveolata*, Goldf. (=*Favistella stellata*, Hall); and there is also no doubt that the strict law of priority demands that this course should be followed, and that the ill-characterised genus of Goldfuss should take precedence over the properly-defined *Favistella* of Hall. I have elsewhere pointed out (Sec. Rep. Pal. Ont., p. 21) that this course is attended with grave inconvenience, in consequence of the fact that the *name* of *Columnaria alveolata* has been used generally, as by Hall, Billings, and others, for an entirely different species to that so designated by Goldfuss. In deference, however, to the opinion of authorities whom I respect, I shall consider *Favistella*, Hall, as a synonym of *Columnaria*, and I shall subsequently discuss the characters of the coral which has been generally, but erroneously, described as *Columnaria alveolata*, Goldf.

Taking, then, the true *C. alveolata* of Goldfuss (the *Favistella stellata* of American palæontologists) as the type of the genus *Columnaria*, we find that the genus includes massive corals, of a hemispheric, pyriform, or irregularly spheroidal shape, and often of large size, composed of prismatic or polygonal corallites, which radiate outwards from the base of attachment. The walls of the corallites are not excessively thickened, and contiguous tubes are usually in contact throughout their entire length. An occasional and partial separation of the corallites close to their mouths can, however, be sometimes observed; and in an allied species (*C. calicina*, Nich.) the tubes become to a large extent disjunct, though never wholly so, in the upper portion of the corallum. The boundary-lines between contiguous corallites are never completely obliterated (Pl. X., figs. 1

and 2), and weathered or roughly-fractured surfaces sometimes exhibit the exterior of the tubes. No evidence has been obtained by thin sections, or otherwise, as to the existence of "mural pores," and it must therefore be presumed that the walls are imperforate.

The septa (Pl. X., figs. 1 and 2) are well developed and lamellar, extending from the top to the bottom of the visceral chamber, and reaching more or less nearly to the centre of the tube, which they do not quite reach. There is sometimes a curious irregularity of the septa, one or more being predominantly developed, and there are also two distinct sets of these structures, a long and a short series, alternating regularly with one another. Lastly, the tabulæ are very numerous and well developed, being complete and more or less horizontal, and not placed at corresponding levels in contiguous tubes.

The affinities of the genus *Columnaria* are still very obscure. If a more extended examination of specimens by means of thin sections, with special reference to this point, should show the walls to be really imperforate, as we must at present conclude them to be, and as they probably really are, then we cannot place the genus in the *Favositidæ*. Nor is there any other group among the old "Tabulate Corals" of Milne-Edwards and Haime to which they could be referred with any greater propriety. The genus, indeed, is much more like one of the *Rugosa* than one of the "*Tabulata*." It possesses well-developed and lamellar septa (in its type-forms at any rate), and its tabulæ are hardly better developed than in several undoubted Rugose corals (such as *Amplexus*, *Diphyphyllum*, &c.) In fact, it might be at once, and without any violence, placed in the *Stauridæ*, close to *Stauria*, except that there is no predominant development of four of the septa. On the other hand, the genus has many points of likeness with *Lyopora*, which has no Rugose affinities to speak of. Upon the whole, therefore, it seems impossible at present to assign any definite systematic place to *Columnaria*, and we must regard it as the type of a special family, to which the name of *Columnariadæ* may be applied.

Professor Verrill (Amer. Journ. Sci. and Arts, ser. 3, vol. iii. p. 191, 1872) has drawn attention to the resemblance between *Columnaria* and certain of the Astræans (such as *Cœlastræa*), and he has expressed the opinion that the genus, "if not actually a member of the *Astræidæ*, should at least be referred to a family very near that group." There is much to be said for this view, but considering the less regular development of the septal apparatus in *Columnaria*, and its apparent want of any endothecal dissepiments (apart from the "tabulæ," if these structures are regarded as dissepimental), I think it safer in the meanwhile to leave the position of the genus an open question.

The typical species of the genus *Columnaria* are *C. alveolata*, Gold. (*non* M'Coy and Hall), *C. Gothlandica*, E. and H., and *C. calicina*, Nich., all of which are Silurian in their distribution. The first and last of these are principally Lower Silurian, and the Upper Silurian *C. Gothlandica*, E. and H. (Pol. Foss. des Terr. Pal., p. 309, Pl. XIV., figs. 2 and 2 *a*), would appear to be hardly separable specifically from *C. alveolata*, Goldf.

There remains the Silurian coral which has been described by Hall, M'Coy, and other observers under the name of *Columnaria alveolata*, Goldf., with which we may possibly associate certain other forms (*e. g.*, *C. erratica*, Billings). This form I shall briefly consider under the name of *Columnaria* (?) *Halli*, mihi, though I very greatly doubt if it be really referable to the genus *Columnaria* of Goldfuss. As to the other forms which have been included by various writers under the genus *Columnaria*, I can say nothing, as I have not had the opportunity of examining actual specimens.

Columnaria alveolata, Goldfuss.

(Pl. X., figs. 1, 1 *a*.)

Columnaria alveolata, Goldfuss, Petref. Germ., t. i. p. 72, Pl. XXIV., fig. 7, 1826.

" *multiradiata*, Castelnau, Sil. Syst. de l'Amér. sept., p. 44, Pl. XIX., fig. 1, 1843.

Favistella stellata, Hall, Pal. N.Y., vol. i. p. 275, Pl. LXXV., fig. 1, 1847. (Non *Columnaria alveolata*, Hall, ibid., p. 47.)

Columnaria alveolata (pars), Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 309, 1851.

" *Gothlandica*, Milne-Edwards and Haime, ibid., p. 309, Pl. XIV., figs. 2, 2 *a*, 1851.

Favistella stellata, Nicholson, Sec. Rep. Pal. Ont., p. 23, 1875, and Pal. Ohio, vol. ii. p. 185, 1875.

Columnaria stellata, Rominger, Foss. Cor. of Michigan, p. 90, Pl. XXXIV., fig. 3, and Pl. XXVIII., fig. 1, 1876. (Non *Columnaria alveolata*, M'Coy, Hall, Billings, Rominger, &c.)

Spec. Char.—Corallum massive, subhemispheric, or pyriform, often attaining a very considerable size. Corallites prismatic, hexagonal or pentagonal, but often more or less drawn out along one axis, the larger ones being from rather less than two to over three lines in their long diameter, and having numerous much smaller tubes interspersed amongst them. Walls of the corallites more or less amalgamated, the line of division between contiguous tubes still remaining quite distinct. Mural pores apparently wanting. Septa unequally developed, alternately large and small, the latter quite rudimentary, and the former extending usually across two-thirds of the distance between the wall and the axis of the visceral chamber, or even reaching the last-mentioned point. The septa are thin and flexuous but completely lamellar, and the number of each series varies from about twelve to fifteen or more. Tabulæ complete, horizontal, or somewhat flexuous, about six in the space of two lines. Calices polygonal, unequally-sized, moderately deep, with thin margins, usually closely contiguous, but sometimes separated by slight interspaces; the floor formed by the uppermost tabula, the surface of which is striated by the radiating septa.

Obs.—Having given an account of this species in describing the structure of the genus *Columnaria*, I have little to add to the above specific diagnosis. I entertain no doubt at all that the specimens described and figured by Goldfuss (Petref. Germ., Pl. XXIV., fig. 7) are really the present form—so well known to American palæontologists under the name of *Favistella stellata*, Hall — and that they are quite different to the species described by Hall, M'Coy, and others under the name of *C. alveolata*. Not only do Goldfuss's figures show the extension of the septa to near the axis of the visceral chamber in the clearest possible manner, but his examples were actually collected on the shores of Seneca Lake, in the State of New York, where the Lower Silurian Rocks do not occur in place, so that they were doubtless derived from a travelled boulder originally belonging to the Hudson River formation.

I should be inclined to think that a re-examination of the specimens upon which Mr Billings founded his *Columnaria rigida* (Geol. Surv. of Canada, Rep. of Prog. for 1857, p. 167, 1858) would show that these are really the same as *C. alveolata*. Mr Billings himself states that the principal distinction between the two is, that in *C. rigida* the septa do not quite reach the centre of the visceral chamber, whereas in *C. alveolata* (which he calls *Favistella stellata*, Hall) the septa not only reach the centre, but are often "so strongly developed there as to produce by their junction the appearance of a pseudo-columella." This last-mentioned appearance is one that I have never seen, while it is quite common for the septa of *C. alveolata* to fall short of the centre of the visceral chamber, as indeed the most of them almost always do; so that I hardly think *C. rigida*, Bill., can be retained as a distinct species.

Formation and Locality.—Abundant in the Cincinnati group (Hudson River Group) of Canada and the United States. Dr Rominger (Foss. Cor. of Michigan, p. 90) quotes it also from the Niagara Group (Upper Silurian).

Columnaria calicina, Nicholson.

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

Favistella calicina, Nicholson, Rep. Brit. Ass., 1874, and Second Rep. Pal. Ont., p. 24, fig. 9, 1875.
Columnaria Hertzeri, Rominger, Foss. Cor. of Michigan, p. 90, 1876.

Spec. Char. — Corallum subhemispheric or pyriform, of moderate but not very large dimensions. Corallites partially in contact and partially more or less completely separate from one another, averaging about two lines in diameter, but varying from less than a line up to three lines. Where the corallites are more or less uniformly contiguous (as always towards the base of the colony), they are prismatic or polygonal. In diverging from the base, however, the tubes separate from one another to a greater or less extent, so as to leave more or less conspicuous intervals between them. In these portions of their course each corallite is surrounded by a distinct and separate wall, which is marked exteriorly by strong vertical ridges and intervening grooves, about five of which occupy the space of one line, together with fine encircling striæ. Septa alternately large and small, twenty-eight in number altogether, the primary ones being continued over the upper surfaces of the tabulæ to near the centre of the corallites, whilst the secondary ones are marginal and rudimentary. Tabulæ well developed and complete, about three in the space of one line. Increase by calicular gemmation, combined with parietal budding.

Obs.—This pretty little species is very distinct from *C. alveolata*, Goldf., from which it may be readily separated by the following characters: 1. It is much more diminutive in average size than *C. alveolata*, its colonies rarely exceeding three inches in diameter and two inches in height, and being often much smaller than this. 2. The corallites are comparatively lax and discrete in their mode of growth. Rarely they may be more or less contiguous and prismatic in form throughout the greater part of their course. More usually, they are cylindrical or subcylindrical, and as they radiate from the base, become more or less widely separated towards their terminations. Hence the surface of a mass of *C. calicina* (fig. 28)

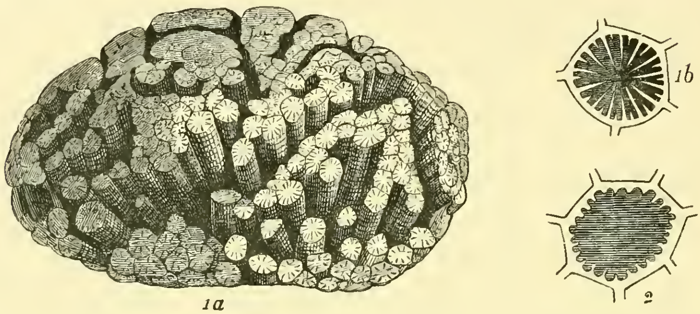


Fig. 28.—1 *a*, A colony of *Columnaria calicina*, Nich., from the Hudson River Group of Canada, of the natural size; 1 *b*, A single calice of the same enlarged; 2, A calice of *Columnaria* (?) *Halli*, Nich., (*C. alveolata*, auctt. non Goldf.), enlarged.

often presents an appearance similar to the convolutions of the human cerebrum or to a colony of *Fascicularia*. 3. It is only where the corallites are in actual contact that their walls are united, and in the remaining portions of their course each is enclosed in a distinct and separate wall, marked with conspicuous vertical ridges and fine encircling striæ. 4. The increase of the corallum is effected by calicular gemmation, and apparently also to some extent by lateral budding, the former mode of growth not seeming to occur in *C. alveolata*.

When we come to consider the internal structure of *C. calicina*, we find that the differences which separate it from *C. alveolata*, Goldf., depend principally upon the peculiar mode of growth of the former, the anatomical characters of the two species being very much the same. Transverse sections (Pl. X., fig. 2 *a*) show that though the tubes in the contiguous portions of their course are practically amalgamated by their walls, the real duplicity of their walls is never lost, the actual line of division between neighbouring corallites being still conspicuously recognisable under the microscope. In this respect, therefore, *C. calicina* entirely agrees with *C. alveolata*. These sections, further, show a highly "Rugose" condition of the septa, these structures being divisible into a double series of alternately long and short septa, of which the latter are quite rudimentary and marginal, while the former vary greatly in their development. Sometimes they fall short of the centre by a considerable interval—as is also usually the case in *C. alveolata* —but in other tubes they nearly or quite reach the axis of the visceral chamber. Moreover, the phenomena which the septa exhibit are precisely such as every student of the Rugose corals is familiar with. The longer septa, namely, are not of uniform length, but exhibit clear differences in their development, almost amounting to that produced by the existence of regular "cycles." Some of them quite reach the centre, others fall a little short of it; and there is even a tendency to the production of a single predominant septum, or of two such, towards the sides of which the remaining septa bend. Lastly, it is quite common for the longer septa to be more or less united with one another by their inner ends in a series of fascicles, though at other times each may be quite free.

Vertical sections of the corallum show no features of special structural importance (Pl. X., fig. 2 *a*). When they pass accurately through the centre of the visceral chamber, the principal or only structures observable are the tabulæ, which are complete, essentially horizontal, though flexuous, and about six in number in the space of two lines. On the other hand, when the section passes at all out of the central line of the tubes, the tabulæ are cancellated by vertical lines representing the cut edges of the septa. No mural pores have been detected.

Formation and Locality.—Abundant in the Cincinnati Group (Hudson River formation) of the Credit River, Ontario. Dr Rominger quotes the same species (under the name of *C. Hertzeri*, Rom.) from the Cincinnati Formation of Kentucky.

Columnaria (?) Halli, Nicholson.

(Pl. X., figs. 3, 3 *a*.)

Columnaria alveolata, Hall, Pal. N.Y., vol. i. p. 47, Pl. XII., figs. 1 *a* - *c*.
,, *alveolata*, Billings, Geol. Can., fig. 70, p. 139, 1863.
,, *alveolata*, Nicholson, Sec. Rep. Pal. Ont., p. 8, 1875.
,, *alveolata*, Rominger, Foss. Cor. of Michigan, p. 89, Pl. XXXIV., figs. 1, 2, and 4, 1876.
(Non *Columnaria alveolata*, Goldfuss.)

Spec. Char.—Corallum forming large massive colonies, which vary from a few inches to several feet in diameter, and which are composed of variously-sized polygonal corallites, in close contact with one another throughout their entire length. The walls of the corallites are not excessively thickened, and they are so completely amalgamated in contiguous tubes that even under the microscope the original line of demarcation between the tubes can be made out with difficulty or not at all. The large tubes are usually from two to three lines in diameter, though occasionally considerably more than this; and the smaller corallites are of all sizes. Septa marginal, in the form of obtuse longitudinal ridges, which vary in number from twenty to forty, do not extend to any distance into the visceral chamber, and are not divisible into an alternating longer and shorter series. Tabulæ strong, horizontal, and complete, about half a line apart or sometimes closer. Mural pores not recognised with certainty.

Obs.—I have come to the conclusion, after full consideration, that the best course to adopt with regard to this species is to give it a distinct specific name, though it has so long been known to palæontologists as *C. alveolata*, Goldf., that this course is attended with much inconvenience, and I have myself elsewhere opposed it (Sec. Rep. Pal. Ont., p. 8). Dr Rominger has evaded the difficulty, as I tried to do, by reserving the name of *C. alveolata* for the form now under consideration, and by retaining Hall's *Favistella stellata.* It is, however, quite certain that the latter is really the *Columnaria alveolata* of Goldfuss, and it is therefore best to give the present species a distinct title rather than to perpetuate a source of endless confusion. I am the more inclined to take this course, as I am disposed to doubt very strongly if the present form can be referred to *Columnaria* at all, and whether it is not truly a perforate coral, congeneric with *Nyctopora*, Nich. The material in my hands is, however, not sufficient to settle this point finally. All that I can affirm is that *Columnaria* (?) *Halli* agrees with *Nyctopora Billingsii*, Nich., precisely in its general form and aspect, in the complete amalgamation of the walls of the corallites, and in the fact that the septa have the form of blunt marginal ridges, not divisible into a double series. In all these points *C.* (?) *Halli* differs from the true *C. alveolata*, Goldf., and from the allied *C. calicina*, Nich. I am disposed also to think that I can detect in thin vertical sections of *C.* (?) *Halli* small mural pores, such as are so abundant in *Nyctopora Billingsii*. On the existence, however, of this crucial character, I must at present speak with much reserve, for the state of preservation of my specimens is such that I have not succeeded in obtaining from them any microscopic sections that could be confidently relied upon as deciding a point of such delicacy and importance.

Leaving the existence of mural pores an open question, I have little to add to the above specific diagnosis of *C.* (?) *Halli*. The general form of the corallum (fig. 29) is very similar to that of *C. alveolata*, Goldf., though the colonies mostly tend to assume a flattened and laterally expanded form. The corallites are always polygonal and prismatic, of very unequal sizes, but invariably in close contact throughout, and with

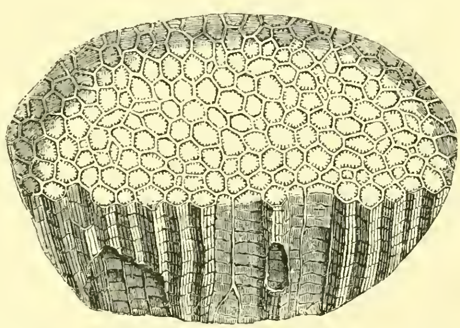


Fig. 29.—A small colony of *Columnaria* (?) *Halli*, Nich., from the Trenton Limestone of Canada, of the natural size. (After Billings.)

walls of no more than average thickness. Transverse sections (Pl. X., fig. 3) show that the walls are so entirely amalgamated in contiguous corallites that it is difficult to detect the original boundaries of the tubes. The same sections show that the septa are in the form of strong vertical ridges, which vary in number in tubes of different dimensions, but are invariably marginal, and never extend beyond a very limited distance into the interior of the visceral chamber. There is also no trace of that division of the septa into an alternately-disposed long and short series, such as has been seen to be so characteristic of *C. alveolata*, Goldf., and *C. calicina*, Nich.

Vertical sections (Pl. X., fig. 3 *a*) exhibit principally the strong, remote, and complete tabulæ; but when the plane of the section comes to coincide more or less closely with the plane of one of the walls of the tube, we observe also a series of vertical ridges or bands, which represent the broad edges of the septa as seen in section. In such parts of vertical sections, I think I can detect, as before said, small mural pores, but I cannot affirm this positively.

Formation and Locality.—Abundant in the Trenton Limestone of Canada and the United States. Professor Hall's specimens seem to be exclusively from the Black River Limestone, which forms an inferior division of the Trenton Limestone in the State of New York. It has not hitherto been detected in the Cincinnati formation (Hudson River Group); and this of itself is to some extent evidence of its distinctness, considering that *Columnaria alveolata*, Goldf. (*Favistella stellata*, Hall), is such a common coral in the latter formation.

CHAPTER VIII.

SYRINGOPORIDÆ.

In the family of the *Syringoporidæ*, as typified by *Syringopora* itself, there is a fasciculate corallum, commencing in the form of a reticulated tubular expansion, which sends up at intervals vertical, more or less cylindrical corallites, enclosed in strong compact walls. The corallites are either completely free, as regards absolute contact, or only touch each other occasionally at limited points, and their visceral chambers communicate directly by means of hollow connecting-processes, into which the tabulæ are prolonged. Delicate spiniform septa are usually present. The tabulæ are well developed, more or less funnel-shaped, and often forming an axial tube in the median line of the visceral chamber.

The type of this family is *Syringopora*, Goldf., which was placed by Milne-Edwards and Haime (Brit. Foss. Cor. Intr., p. lxii, 1850) with *Halysites* and *Thecostegites* in the tribe *Halysitinæ* of the family *Chætetidæ*. Subsequently, the same authors, while retaining *Syringopora* in the same systematic position, associated with it the additional genera *Fletcheria*, E. and H., and *Chonostegites*, E. and H. (Pol. Foss. des Terr. Pal., p. 280, 1851). The only other genera that subsequent authors have shown a disposition to associate with *Syringopora* are *Cannapora*, Hall, and *Aulopora*, Goldf.

Of the above genera, *Halysites*, Fischer, is shown conclusively, by its minute structure, to have no genuine affinities with *Syringopora*, and must therefore be retained in the meanwhile as the single representative of the family of the *Halysitidæ*, while *Syringopora* must be considered as the type of a new family, for which the name of *Syringoporidæ* may be appropriately chosen. The only other form which can, in the meanwhile, be at all definitely placed in the *Syringoporidæ* is *Cannapora*, Hall. The few specimens which I possess of this singular genus—which, so far as is known, is confined to the Upper Silurian deposits of North America—are so poorly preserved that I have been unable to make microscopic sections of them, and can give no details as to their minute internal structure. Dr Rominger (Foss. Cor. of Michigan, p. 85, 1876) has, however, examined good specimens of *Cannapora junciformis*, Hall, the type-species of the genus, and the following generic diagnosis is given by him :—

"Colonies of closely-approximated erect tubules, with stout walls, sprouting from an incrusting basal expansion, formed of prostrate tubules, growing and multiplying in the same manner as an *Aulopora*. The erect ends of the tubules are annulated by wrinkles of growth and by sharp-edged periodical offsets marking an interruption and renewed growth from the inner circumference of the old orifices. The sides of the tubes are partly connected by horizontal expansions of the walls, partly in direct contiguity, in which latter case the otherwise circular tubes are pressed into a polygonal shape, and connect in the contiguous parts by lateral pores. The orifices are slightly dilated at the margins, radiated by twelve spinulose projections, rows of which extend through the whole length of the tubes. Diaphragms are not often developed, direct, transverse, and not funnel-shaped as in *Syringopora*."

From the above description it will be evident that *Cannapora* supplies us with a very interesting link between *Syringopora* and *Favosites*, though upon the whole most closely allied to the former. *Cannapora* closely resembles *Syringopora* in its habit and general form, and the periodically-produced horizontal expansions which connect contiguous corallites have been shown by Rominger to be sometimes developed in *Syringopora tabu-*

lata, Van Cleve. The chief distinction between *Cannapora* and *Syringopora* would, in fact, seem to consist in the possession by the former of horizontal instead of infundibuliform tabulæ. On the other hand, *Cannapora*, Hall, approaches *Favosites* in the possession of "mural pores" in those parts of the corallum in which the corallites are in actual contact; and it may be directly compared with such members of the *Favositidæ* as *Vermipora*, Hall, in which a partially disjunct condition of the tubes exists.

Chonostegites, E. and H., has been shown (see *supra*) to be a true member of the *Favositidæ* closely allied to *Michelinia*, De Kon., and it cannot, therefore, be associated with *Syringopora*.

Thecostegites, E. and H., again, is defined as having an incrusting submassive corallum, composed of short cylindrical corallites, which are united by strong mural expansions in the form of more or less distinct horizontal platforms. The walls of the corallites are well developed, and are only free in the intervals between the periodic expansions just spoken of. The calices are circular; imperfect septa to the number of twelve are present; and the tabulæ are distinctly horizontal (Pol. Foss. des Terr. Pal., p. 297). The type of this genus is *T. Bouchardi*, Mich., from the Devonian of Ferques in France; and Milne-Edwards and Haime mention that they have seen specimens from the Falls of the Ohio, and possibly from the Eifel. They further point out that the genus has a decided affinity to *Syringopora*, and that it has special relations with *S. tabulata*, Van Cleve. They give a short and very insufficient description of a second species (*T. auloporoides*) from the Devonian of Spain. Recently Dr Rominger (Foss. Cor. of Michigan, p. 83) has made out a strong case in favour of the view that *Thecostegites Bouchardi* is really nothing more than a peculiar condition of growth of *Syringopora tabulata*, Van Cleve. Dr Rominger, however, seems to consider that the original specimens of *T. Bouchardi* were derived from the Falls of the Ohio, which is certainly not the case; and until these specimens are re-examined, it cannot be said that absolutely final evidence has been brought forward in favour of the complete suppression of *Thecostegites*.

It need only be added that if *Thecostegites* should prove finally to be nothing more than a mode of growth of *Syringopora*, then the curious little coral from the Lower Silurian of Ayrshire described by Mr R. Etheridge, jun., and myself (Mon. Sil. Foss. Girvan, p. 50, 1878), under the name of *T.* (?) *Scoticus*, will have to be removed from the genus *Thecostegites*, with which it will have no affinity. The coral in question, however, though resembling the figures given of *T. Bouchardi*, E. and H., in general appearance, is only known from limited material, and it throws no light on the validity or the reverse of the genus *Thecostegites.*

The genus *Fletcheria* was founded by Milne-Edwards and Haime (Pol. Foss. des Terr. Pal., p. 300) for the single species *F. tubifera*, of the Upper Silurian of Sweden. The genus is defined as having a corallum composed of cylindrical corallites, which increase by calicular gemmation, and are not united laterally either by transverse connecting-processes or by horizontal mural expansions. The walls are strong, with a complete epitheca; the septa are rudimentary; and the tabulæ are highly developed and horizontal. As in the case of *Thecostegites*, it seems impossible to determine finally the true position of *Fletcheria* without a re-examination of the original specimens, upon which Milne-Edwards and Haime founded the genus. Dr Lindström (Ann. and Mag. Nat. Hist., ser. 4, vol. xviii. p. 13) says that *Fletcheria tubifera*, E. and H., "seems to be a Cystiphylloid of very variable characters;" but I do not know the evidence in support of this view. Dr Rominger is disposed to think that *Fletcheria*, E. and H., and *Cannapora*, Hall, may be identical and closely allied; but there seems little decided ground for accepting this view, or indeed for in any way associating *Fletcheria* with *Syringopora* or *Cannapora*. As just remarked, it appears hopeless to try and settle the affinities of the genus without access to the type-specimens; but judging merely from the description and figures of *Fletcheria tubifera* given by Milne-Edwards and Haime (*loc. cit.*), I should be rather disposed to think that *Fletcheria* will be found to be a member of the *Favositidæ*, and that *Vermipora*, Hall, if not an actual synonym, is most nearly allied to it. The calicinal gemmation of *F. tubifera* is, however, an almost unique feature.

Lastly, the genus *Aulopora*, Goldf., has been by various palæontologists associated with *Syringopora*, or even merged with the latter. This view, for reasons which have been previously stated in brief, and which I shall subsequently discuss at greater length, appears to me to be untenable; and *Aulopora* must, with our present knowledge, be regarded as the type of a special group.

From the above remarks it will be seen that no other forms can in the meanwhile, with any definiteness, be placed in the *Syringoporidæ*, except only *Syringopora* and *Cannapora*. It is only in the case of the former of these that I have had the opportunity of making myself thoroughly acquainted with the minute characters of the corallum, and I shall therefore not only take this genus as the type of the group, but I shall defer any remarks as to the affinities of the family till I have given a brief description of the peculiarities in its structure. Both the above genera are strictly Palæozoic, *Cannapora* being exclusively an Upper Silurian form, and *Syringopora* being confined to the Upper Silurian, Devonian, and Carboniferous periods.

Genus SYRINGOPORA, Goldfuss.

(Petref. Germ., t. i. p. 75, 1826.)

Harmodites, Fischer, Notice sur les Tubipores fossiles, p. 19, 1828.

Gen. Char.—Corallum commencing as a prostrate network of tubes, which in process of growth sends up numerous vertical corallites. The corallites are cylindrical, arranged with varying degrees of closeness, and each enclosed in a distinct wall. The visceral cavities of contiguous polypes communicate directly by means of a greater or smaller number of hollow horizontal connecting-processes, which in some cases may be nearly or quite obsolete. Tabulæ well developed, usually more or less regularly funnel-shaped, and often giving rise to a more or less continuous tube occupying the axis of the visceral chamber. Septa usually slightly developed, spiniform, never lamellar.

Obs.—Few genera of Palæozoic corals are more clearly marked out than *Syringopora* by the general form and mode of growth of the corallum. The corallum commences as a stoloniferous prostrate network of anastomosing tubes, which closely resemble an *Aulopora* in general appearance, and have given rise to the opinion that *Aulopora* is founded simply upon young colonies of *Syringopora*. The chief grounds for rejecting this view will be briefly discussed hereafter, but there is one consideration to which attention may here be drawn. The prostrate network which forms the base of a colony of *Syringopora* can be admirably studied in forms like *S. fascicularis*, Linn., of the Upper Silurian; and in these cases we find that there is presented to our observation the *under surface* of the basal reticulation, as figured by Edwards and Haime in the British Fossil Corals, Pl. LXV., fig. 1 *c*. Now this under surface of the network would, if the coral were an *Aulopora*, be cemented firmly to some foreign object throughout the whole of its extent, and it would not therefore be exposed to view at all. On the other hand, there is the clearest possible evidence that the basal reticulation of *Syringopora* was not parasitic at all, and that its under surface was quite free as a general rule, except at one or more circumscribed points of attachment. Whether or not the *upper surface* of the basal reticulation of a *Syringopora*, *prior to the formation of the ascending corallites*, has ever been so much as actually observed, is a matter quite open to question. Cases in which the upper surface of such a reticulation have been described or figured (*e.g.*, by Edwards and Haime, Brit. Foss. Cor., Pl. LXV., fig. 1) may admit of the explanation that the observer was in reality dealing with the colony of a true *Aulopora*. It seems, indeed, in the highest degree probable that the formation of the vertically ascending corallites is commenced in the very earliest stages of the formation of the basal network, in which case there is little likelihood of our ever seeing the upper surface of the latter. Even if this were not the case, and if the basal reticulation were really formed as a whole before the ascending tubes began to be thrown up (as seems to have been generally assumed), it may be stated with confidence that nothing short of a microscopic examination of the internal structure would suffice to show whether any given specimen were a young *Syringopora* or an adult *Aulopora*, seeing that the macroscopic characters would in either case be precisely the same. Upon the whole, therefore, I cannot regard it as established that *Aulopora* is founded upon the early stages of *Syringopora*; nor can I accept the view propounded by Dr Lindström (Ann. Nat. Hist., ser. 4, vol. xviii. p. 14), that the connecting-tubes which unite the neighbouring corallites of *Syringopora* are " morphologically nothing but the stolons, no longer creeping or attached, but suspended freely between the corallites."

In its fully-grown condition, the great bulk of the corallum of *Syringopora* is composed of essentially cylindrical erect corallites, which are placed at variable but slight intervals, and usually diverge more or less markedly as the surface is approached, owing to the intercalation of new tubes. The new corallites are produced either by budding from the sides of the old tubes or as offshoots from the transverse connecting-processes. The walls of the corallites are thick and compact, surrounded superficially by a delicately-wrinkled epitheca, and sometimes strengthened internally by a secondary deposit of finely-laminated sclerenchyma (often in *S. geniculata*, Phill.) Whether the corallites are near or comparatively remote from one another, their visceral chambers are placed in direct communication by means of hollow, usually cylindrical, horizontal connecting-processes. These connecting-processes (fig. 30, A) are tubular, and the anastomosing lamellæ of the tabulæ from the visceral cavity are prolonged into them. They are therefore to be regarded as direct outward prolongations of the visceral chambers of the polypes, and they correspond precisely with the hollow transverse floors which connect the corallites in *Chonostegites Clappi*, and into which the subvesicular tabulæ are similarly extended. The number of the connecting-processes in the different species of *Syringopora* is very variable. Usually they are placed at tolerably distant and to some extent regular intervals; sometimes they are arranged in whorls (*S. verticillata*, Goldf.); sometimes they are greatly reduced in number (*S. serpens*, Linn.); and sometimes they are given off in verticils at corresponding levels, and coalesce so as to form almost uninterrupted horizontal floors (*S. tabulata*, Van Cleve). In *S. nobilis*, Bill., and *S. intermedia*, Nich., both from the Devonian of North America, the erect tubes throw out lateral buds at short intervals, but the corallites are very rarely connected by horizontal processes; and it is possibly the case that these forms should be regarded as a distinct subgeneric type. Lastly, in the singular *S. laxata*, Billings, also from the Devonian of North America, the connecting-processes are totally wanting, and the corallites are for the most part quite free. In places, however, the flexuous and closely-set tubes come into partial contact, and at these points they become coalescent by their walls. That their visceral chambers communicate directly at these points of partial coalescence, I think hardly doubtful, though the preservation of my specimens will not allow me to verify this conjecture.

How far the arrangement and form of the connecting-tubes, and the distances by which the various corallites in a colony are separated from one another, can be employed as characters of specific value, remains for future consideration. All that can safely be said at present is, that too much stress has probably been laid by the older observers upon these characters, and that they must in reality be admitted to enjoy a considerable variability within the limits of the same species, though they exhibit at the same time a certain average condition, which is by no means without its value, in each specific type.

As regards the internal structure of the corallites of *Syringopora*, we have only to notice the condition of the tabulæ and the septa. The tabulæ (fig. 30) are typically, if not always, more or less conspicuously infundibuliform, and they become connected with one another in such a manner as to give rise to a central cylindrical tube, occupying the axis of the visceral chamber. Whether or not this tube is present in all the species of the genus is a point for future determination; but its existence is clearly recognised by Goldfuss (Petref. Germ., Pl. XXV., figs. 6 *b*, 7 *b*), and I have recognised its existence in all the forms which I have as yet examined microscopically. In its general form and structure it is precisely similar to the axial tube which is formed by the tabulæ in the corallites of *Syringolites*, Hinde; and the continuity of its internal cavity seems to be interrupted (as in *Syringolites*) by the occasional extension of a tabula across it. Some forms of *Syringopora* are stated to possess horizontal tabulæ, but the true structure and position of these will require to be more fully worked out before this can be finally admitted.[1]

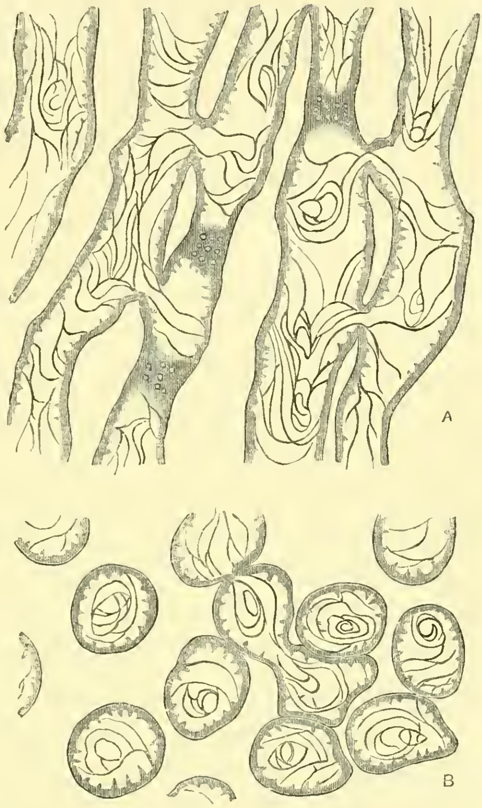


Fig. 30.—A, Part of a longitudinal section of *Syringopora reticulata*, Goldf., from the Carboniferous Limestone of Kendal, Westmorland, enlarged five times, showing the spiniform septa and the funnel-shaped tabulæ with their central tube. Owing to the flexures of the corallites, the section cuts the tubes in different parts, sometimes passing close to the wall and showing the cut ends of the spiniform septa, sometimes passing through the axis of the visceral chamber and bisecting the axial tube, and sometimes cutting the axial tube and its enveloping tabulæ in an oblique manner. B, Part of a transverse section of the same specimen, enlarged five times, showing the spiniform septa, and the cut edges of the tabulæ surrounding the central tube.

[1] Ludwig (Pal. des Urals, p. 10, 1862) has endeavoured to revive the genus *Harmodites*, Fisch., as distinct from *Syringopora*, Goldf., upon the ground that

The septa in *Syringopora* are usually, if not always, detected without difficulty in thin sections, whether vertical or transverse; and their most striking feature is, that they are thoroughly "Favositoid" in character, having the form of slender spinules arranged in vertical rows (fig. 30). They never extend more than a limited distance into the interior of the visceral cavity, and they vary much in length. Not uncommonly, also, the descending tabulæ carry on their inner faces slender spines (as in the Favositoid genus *Chonostegites*, E. and H.), which seem to represent inward prolongations of the septa. They are also variable in number, not unfrequently exceeding twenty in a single cycle. Lastly, they are composed of a sclerenchyma which is conspicuously lighter in tint than that of the walls of the corallites (see Pl. X., fig. 5). As the result of this, long sections in parts where they happen to coincide with the wall of a corallite (fig. 30, A) exhibit vertical rows of rounded spaces of lighter colour than the surrounding tissues, these being really the cut ends of the spiniform septa divided near their bases, though they might at first sight be readily mistaken for mural pores.

With regard to the affinities and zoological position of *Syringopora*, a consideration of the foregoing account of its minute structure will, I think, render it clear that the genus cannot be referred to the *Halysitidæ*, to the *Tubiporidæ*, or to the *Rugosa*, one or other of these courses having been generally followed by palæontologists. From *Halysites*, the genus *Syringopora* is fundamentally separated by the general form of the corallum, the entirely different construction of the tabulæ, the total absence of a set of small zoöids coexisting with one of larger dimensions, and the presence of hollow connecting-processes placing the visceral chambers of contiguous corallites

some forms from the Carboniferous Limestone of Russia appear to have the funnel-shaped tabulæ open inferiorly, whereas they are closed in *Syringopora*. So far as I understand the ambiguous language which he uses on this point, the differences alluded to by Ludwig are of no moment whatever; and at any rate, the forms which he describes as *Harmodites* are shown by his figures to be typical species of *Syringopora*.

in direct communication. As to the recent genus *Tubipora*, it seems unnecessary to enter into any detailed discussion, as the known facts as to the internal structure of *Syringopora* render any direct affinity between the two genera wholly out of the question. More, on the other hand, may be said for the view so ably advanced by Dr Lindström (Ann. and Mag. Nat. Hist., ser. 4, vol. xviii. p. 13), that *Syringopora* is truly a Rugose Coral, allied to *Lithostrotion* and *Diphyphyllum*. Even here, however, I think that the distinguished Scandinavian palæontologist has allowed himself to be misled by resemblances which are truly analogical and not fundamental. I am not prepared to allow that there is any true relation of homology between the hollow connecting-tubes of *Syringopora* and the also hollow radicular processes or connecting-processes of many Rugose Corals. Dr Lindström's argument on this point, if carried to a logical conclusion, would necessitate the removal of unquestionable Favositoid and Perforate Corals (such as *Michelinia*, *Nodulipora*, &c.) to the *Rugosa*, since these also possess hollow radiciform prolongations. On the other hand, the totally different nature of the tabulæ and septa in *Syringopora*, as compared with these structures in *Lithostrotion* and *Diphyphyllum*—to say nothing of the connecting-tubes of the former—entirely forbids, in my opinion, any taxonomic union of forms so diverse.

For my own part, after a careful study of the minute structure of both groups, I am satisfied that the *Syringoporidæ* are properly to be regarded as an aberrant group of the *Perforata*, having genuine relationships with the *Favositidæ*, though distinct from these. Upon this view, the hollow connecting-tubes of *Syringopora* are homologically nothing more than "mural pores," as existing in corallites which are not in absolute contact. In support of this view, I would simply draw attention to the absolute identity in the internal structure of the connecting-tubes of *Syringopora* and the hollow connecting-floors of *Chonostegites*. Yet *Chonostegites* is a true *Favositoid*, with the closest possible relations to *Michelinia*, De Kon.; and wherever we find its corallites actually in contact, there we find true "mural pores" developed, of the precise type of these structures in *Favosites* itself. Nor have I much doubt that at any points in the corallum of a *Syringopora* at which the corallites come into actual contact, openings in the wall placing the body-cavities of the polypes in direct communication will be found to exist, though I have as yet had no opportunity of verifying this conjecture. Indeed, Rominger states that such a condition of parts actually does exist in *Cannapora*, Hall, which seems to be a close ally of *Syringopora*. Lastly, as supporting the relationship between the present genus and the *Favositidæ*, it may be pointed out that the singular funnel-shaped tabulæ and axial tube of *Syringopora* are found to exist in an almost precisely similar form in *Syringolites*, Hinde, a "Favositoid" genus which possesses prismatic contiguous corallites and serially-placed "mural pores" of a form exactly similar to those of *Favosites*.

So far as is known, the genus *Syringopora* ranges from the Silurian to the Carboniferous inclusive, but it attains its maximum in Devonian and Carboniferous strata. The species which I have at present been able to examine by means of a proper series of microscopic sections are *S. reticulata*, Goldf., *S. geniculata*, Phill., *S. intermedia*, Nich., *S. laxata*, Bill., *S. fascicularis*, Linn., and *S. bifurcata*, Lonsd.; but as I have given a tolerably detailed account of the genus, it will be sufficient to add merely very brief descriptions of the specific characters and minute structure of the first two of these.

Syringopora reticulata, Goldfuss.

(Fig. 30, and Pl. X., fig. 5.)

Syringopora reticulata, Goldfuss, Petref. Germ., vol. i. p. 76, Pl. XXV., fig. 8, 1826.
,, *reticulata*, Phillips, Geol. of Yorkshire, vol. ii. p. 201, 1836.
,, *reticulata*, Edwards and Haime, Pol. Foss. des Terr. Pal., p. 290, 1851; and Brit. Foss. Corals, p. 162, Pl. XLVI., figs. 1, 1 *a*, 1852.
,, *reticulata*, M'Coy, Pal. Foss., p. 84, 1851.
,, *reticulata*, De Koninck, Nouv. Rech. sur les An. Foss., Part I., p. 123, Pl. XI., figs. 7 - 7 *b*, 1872.

Spec. Char.—Corallum fasciculate, of long cylindrical corallites, the usual diameter of which is about one line. The distance at which the corallites stand apart varies very much in different colonies, and even in different parts of the same corallum, some tubes being in partial contact, while others may be separated by intervals of two lines or more. Ordinarily they are from half a line to a line apart. The tubes are slightly flexuous, but not abruptly geniculated; and the irregularly-distributed connecting-tubes are about two lines apart, or rather less than this. Well-developed spiniform septa are present, the wall is not thickened by secondary deposit, and the tabulæ are infundibuliform, and give rise to the formation of an axial tube.

Obs.—This is one of the most characteristic of the species of *Syringopora* in the Carboniferous Limestone of Britain, and the above diagnosis embodies its most noticeable structural features. As regards its internal structure, cross-sections (fig. 30, B, and Pl. X., fig. 5) show that the walls of the corallites, though of tolerable thickness, have no secondary deposit of sclerenchyma in their interior; while the spiniform septa are well developed, and are arranged in about twenty or twenty-four rows. The cut edges of the infundibuliform tabulæ are exhibited in sections of this kind as so many concentrically-disposed or spirally-arranged lines surrounding the transversely-divided axial tube. In long sections (fig. 30, A) the septa present different appearances in different parts of the slide (precisely as in *Favosites*), according to the inclination of the plane of the section as regards the axial plane of the corallite. Where the section cuts through the axis of the visceral chamber, the septa are only seen as lateral spines directed inwards from the bounding walls of the tube; where the section is to any extent excentric, the cut ends of the spiniform septa come into view as rows of circular spots; and where the section coincides with the wall of the corallite, the cut bases of the septa look like rows of light spots in the darker-tinted sclerenchyma which surrounds them (see fig. 30, A). The most striking feature in long sections, however, is that of the infundibuliform tabulæ arranged in a succession of invaginating cones, which give rise centrally to a distinct axial tube. This axial tube seems to be intersected by occasional prolongations of the tabulæ inwards; and owing to the flexuous condition of the tubes, it is never laid open continuously for any distance. On the contrary, any long section, as a rule, cuts the axial tube over and over again with varying degrees of inclination, so that we are presented with repetitions of the obliquely-divided tube, surrounded by the cut edges of the concentrically-disposed ensheathing tabulæ. Lastly, both long and cross sections show that the connecting-processes afford a direct communication between the visceral chambers of contiguous tubes, and that the progressive walling off of the visceral cavities of the polypes by the production of tabulæ is accompanied by an extension of these structures into the connecting-processes, as these are successively rendered useless. It only remains to add that Milne-Edwards and Haime speak of this species as being remarkable (Brit. Foss. Cor., p. 163) "for the existence of a delicate transverse lamina which passes through the concentric infundibula, and is shown by a transverse section of the corallum;" but I can find no traces of such a structure, and do not feel sure if I rightly understand what structure they refer to.

Formation and Locality.—Abundant in the Carboniferous Limestone of Kendal, Shap, Cross-Fell, Red-Hills, and other localities in Westmorland and Cumberland.

Syringopora geniculata, Phillips.

(Pl. X., figs. 4-4 *b*.)

Syringopora geniculata, Phillips, Geol. of Yorkshire, vol. ii. p. 201, Pl. II., fig. 1, 1836.

,, *geniculata*, M'Coy, Syn. Carb. Foss. of Ireland, p. 190, 1844; and Brit. Pal. Foss., p. 83, 1851.

,, *geniculata*, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 291, 1851; and Brit. Foss. Cor., p. 163, Pl. XLVI., figs. 2, 2 *a*, and 4, 1852.

,, *geniculata*, De Koninck, Nouv. Rech. sur les An. Foss., Pl. XI., fig. 8, and XII., fig. 2, 1872.

Spec. Char.—Corallum fasciculate, of long, diverging, close-set, cylindrical, thick-walled tubes, which are enclosed in a thick wrinkled epitheca, and are usually rather less than one line in diameter. Connecting-tubes numerous, having no regular distribution, and usually placed at distances apart of one line or less, though sometimes more remote. Wall often thickened by a dense laminated secondary deposit of sclerenchyma. Septa short and spiniform. Tabulæ numerous, infundibuliform, and giving rise to an axial tube. Distance between the corallites variable, but mostly half a line or less.

Obs.—This species is commonly associated with the preceding in the Carboniferous Limestone, and is usually easily to be distinguished from it by the more marked divergence of the corallites from the base of the colony, their closer approximation to one another, their more conspicuously round tubes, their thicker walls, and the greater abundance of the connecting-processes, together with the rather smaller diameter of the corallites. The specific name would indicate that the tubes were markedly geniculate; but this is by no means the case, and the corallites resemble those of *S. reticulata*, Goldf., in being simply flexuous. In all the principal features of its internal structure, *S. geniculata*, Phill., agrees entirely with *S. reticulata*, and it is unnecessary to dwell upon the phenomena exhibited by thin sections. There is, however, one curious character, of very common though apparently not universal occurrence, in which *S. geniculata* is quite peculiar. One of the most striking features, namely, in *S. geniculata*, is the apparent thickness of the walls of the tubes; and thin transverse sections show that this is really due to the fact that the proper wall is liable to become lined by a dense, finely-laminated secondary deposit of sclerenchyma (see Pl. X., figs. 4 *a* and 4 *b*). This secondary deposit is of a markedly darker colour than the true wall, which, along with the short spiniform septa, can be thus easily recognised. In this peculiarity, *S. geniculata*, Phill., bears to the ordinary forms of *Syringopora* the same relation that *Pachypora* and its allies bear to *Favosites*. This same thickening can often be recognised in long sections (Pl. X., fig. 4), but I have not been able invariably to recognise its existence, and I am disposed to think that it is probably present only in certain parts of the tubes (as is the case in *Pachypora* and in some related forms), or that it depends upon age.

Formation and Locality.—Common in the Carboniferous Limestone of Shap, Kendal, Asby, Ravenstonedale, and other localities in Westmorland.

CHAPTER IX.

AULOPORIDÆ.

THIS family can only be treated very briefly, partly because the materials at present in my possession are insufficient for its complete elucidation, partly because these materials have not yet been fully examined, and partly because the small size and parasitic habit of the type-forms give rise to special difficulties in the way of their satisfactory examination by means of thin sections. The genus *Aulopora*, Goldfuss, with its ally *Cladochonus*, M'Coy (= *Pyrgia*, E. and H.), was originally referred by Edwards and Haime to a special division of *Zoantharia*, to which the name of *Z. Tubulosa* was given. This division was stated to be characterised (Pol. Foss. des Terr. Pal., p. 310, 1851) by the fact that the corallites are pyriform and destitute of "tabulæ," and the septa are represented only by vertical striæ, while the walls of the thecæ are wholly imperforate; but the undoubted presence of tabulæ in typical forms of *Aulopora* removes the only ground for the retention of the *Tubulosa* as a distinct division of *Zoantharia*. The corallum in *Aulopora* (fig. 31, D) has the form of a creeping, branched or reticulate, system of tubes, attached by the whole of the lower surface to the exterior of a shell, coral, or other foreign body. The basal and prostrate stolons send up tubular or trumpet-shaped corallites at longer or shorter intervals; but though the terminal portions of these are free, the length of the tubes is always very limited, and the reclined corallites never grow up into a fasciculate mass. The walls of the corallites are quite compact, and the tubes are for the most part not in contact with one another in any part of their extent. In cases, however, where the tubes come into contact to any extent, it may

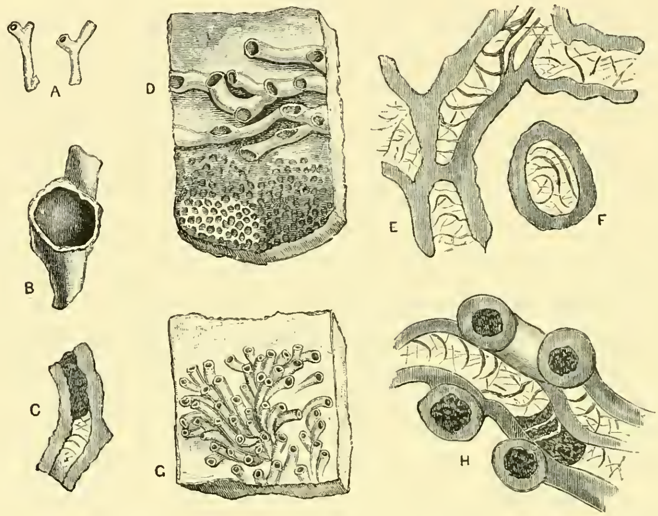


Fig. 31.—A, Two examples of *Cladochonus Michelini*, E. and H., from the Lower Carboniferous of Dunbar, of the natural size; B, A small example of the same, enlarged five times; C, A longitudinal section of the same species, enlarged five times; D, Portion of a colony of *Aulopora*, sp., from the Devonian (Hamilton Group) of Ontario, of the natural size; E, Longitudinal section of part of the same, enlarged five times; F, Cross-section of a corallite of the same, enlarged five times, showing the tabulæ; G, Portion of a colony of *Aulopora repens*, E. and H., from the Devonian of the Eifel, of the natural size; H, Longitudinal section of part of the same, enlarged seven times, showing curved tabulæ.

not impossibly be found that "mural pores" exist at the points of union. The septa are always quite rudimentary, in the form of marginal striæ or vertical rows of tubercles. Lastly, the continuity of the visceral chamber is interfered with (in certain species at any rate) by complete transverse tabulæ (fig. 31, E, F, and H), which are usually more or less curved, or even funnel-shaped, but which do not appear to give rise to anything resembling the axial tube of *Syringopora*.

The resemblance between the colonies of *Aulopora* and the basal portions of a *Syringopora*, as regards general aspect, has been already pointed out; but there is, nevertheless, no sufficient reason, in my opinion, for uniting the two. The reasons for this belief have been already given, but may be briefly summarised as follows: 1. The colonies of *Aulopora* are parasitic, the whole of their lower surface being attached to foreign bodies; whereas the similar-looking basal reticulation of *Syringopora* was clearly attached only at one or two limited points, the greater part of its under surface being free. 2. The curved and reclined corallites of *Aulopora* are free only at their terminations, and they do not give origin to erect branches; whereas the basal network of *Syringopora* throws up numerous erect corallites from its upper surface, and it has not been shown that the network has any existence apart from the erect tubes to which it gives origin. 3. The connecting-tubes of *Syringopora* are not known to be represented by any corresponding structures in *Aulopora*. 4. The tabulæ of *Aulopora* are simply curved, or, if infundibuliform, do not appear to give rise to any structure comparable with the axial tube of *Syringopora*. 5. Species of *Syringopora* abound in formations where the genus *Aulopora* is hardly or not at all represented, while colonies of the latter are common in deposits in which *Syringoporæ* are nearly or quite unknown.

For the above reasons, I am at present unable to accept the union of *Aulopora* with *Syringopora*, as advocated by some high authorities. At the same time, there are one or two species now referred to *Syringopora* (such as *S. serpens*, Linn., of the Upper Silurian) which have marked "Auloporoid" characters, and which may prove on minute examination to be really referable to the *Auloporidæ*.

To *Romingeria*, Nich. (= *Quenstedtia*, Rom.), the present genus bears considerable external resemblance; and if Rominger is right in regarding *Aulopora cornuta*, Bill., as only the young of *Romingeria*, this resemblance would seem to be based upon real affinity. As far as our present knowledge goes, however, we are constrained to separate *Romingeria* from the *Auloporidæ*, as it possesses "mural pores" in parts, while it further differs from *Aulopora* proper in having an erect corallum.

As regards its geological range, the genus *Aulopora* seems to appear for the first time in the Lower Silurian period, and is well represented in the Upper Silurian. In the Devonian period it attains its maximum of development, and a few Carboniferous species are known; but the latter are rare and local in their distribution, and the genus is not known to have survived into the Permian period.

The genus *Cladochonus*, M'Coy, was proposed in 1847 (Ann. and Mag. Nat. Hist., ser. 1, vol. xx. p. 227) for some Australian Palæozoic corals, having "some relations to *Aulopora*," but differing "in their curious erect habit, regular angular mode of branching, slender, equal, stemlike tubes, and abruptly-dilated terminal cups bent in nearly opposite directions." He further states that the curious little Carboniferous corals which he had formerly referred to Lamoroux's genus *Jania* (Syn. Carb. Foss. of Ireland, 1844) are really to be placed in the genus *Cladochonus*. There seems, further, to be no reasonable doubt that the genus *Pyrgia*, Edwards and Haime (Pol. Foss. des Terr. Pal., p. 310, 1851), is really founded upon forms of *Cladochonus*, M'Coy, and that it must therefore be withdrawn in favour of the latter. My friend Mr R. Etheridge, jun., and myself have prepared a paper[1] dealing with the structure and relations of some of the forms of *Cladochonus*, and we find that besides species which may be retained in *Cladochonus*, the genus contains at least one very peculiar type (viz., *C. crassus*, M'Coy), which must be considered as generically distinct, and to which we have given the name of *Monilopora crassa*, M'Coy, sp. In a typical species of *Cladochonus*, such as the Carboniferous *C.* (*Pyrgia*) *Michelini*, E. and H., the corallum has the form of a slender erect branching colony, composed of long conical corallites (fig. 31, A and B), which are produced from one another by lateral budding, the entire growth being fixed basally to some foreign object by one or more isolated points of attachment. An excellent description of this singular coral is given by De Koninck (Nouv. Rech. sur les An. Foss., p. 153, Pl. XV., fig.

[1] Since the above was written this paper has been published (*see* Geol. Mag., Dec. ii. vol. vi., July 1879).

6, 1872), and this accurate observer states that the visceral chambers of the corallites are entirely hollow, and that they communicate freely with one another by their bases. This latter point is doubtless correct; but Mr R. Etheridge, jun., and myself have made thin sections of specimens from the Carboniferous of Scotland which we are unable to distinguish from *C. Michelini*, E. and H., and we find that in these the visceral cavities of the corallites are intersected by a few remote, delicate, complete tabulæ, which are either straight or slightly curved (fig. 31, c). It would appear, then, that so far as at present known there is nothing in the internal structure of *Cladochonus*, M'Coy (= *Pyrgia*, Edw. and H.), which would separate it from *Aulopora*, Goldf., and the generic distinctness of the two can only rest upon the feature that the corallum of the former is erect, whereas in the latter it is creeping and parasitic. So far as known, the species of *Cladochonus* appear to be exclusively Carboniferous.

Lastly, it remains to say a few words upon the singular genus *Monilopora*, Nich. and Eth. jun., which includes only the curious *M.* (*Cladochonus*) *crassa*, M'Coy, sp., of the Carboniferous rocks. In this singular form the corallum (fig. 32, A) is decidedly "Auloporoid" in its general appearance, consisting of a creeping tubular basis, which at intervals throws up curved conical corallites, which are of much larger size than is usual in *Aulopora*, and are free throughout the whole or the greater part of their height. As a rule, the corallum commences in the form of a ring of such corallites, with their connecting basal stolons, encircling the column of a Crinoid like a necklace; and by the continued growth of the latter the colony often becomes entirely buried within the stem of the Crinoid, only the calices appearing on the surface. Adult examples, again, often lose a good deal of this ring-like arrangement, and present themselves as a confused aggregation of corallites quite resembling a magnified *Aulopora*. The minute structure of *Monilopora*, as elucidated by means of thin sections, has been shown by Mr Rofe (Geol. Mag., vol. vi. p. 352, 1869), and subsequently more fully by Mr R. Etheridge, jun., and myself, to be of a most remarkable character. The entire visceral cavity of each polype is open from top to bottom, and we have been unable to

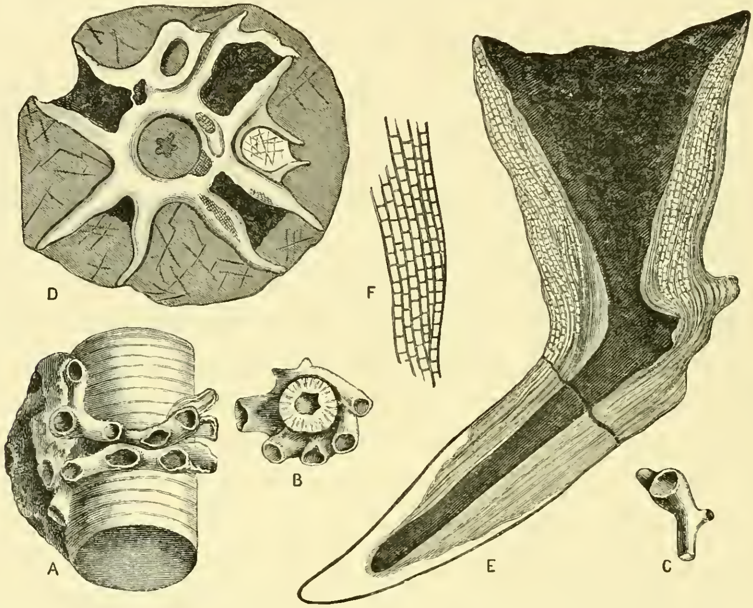


Fig. 32.—A, A full-grown colony of *Monilopora crassa*, M'Coy, sp., growing upon the stem of a Crinoid, of the natural size. B, A younger colony of the same, encircling a Crinoidal column, viewed from above, of the natural size. C, A detached fragment of the corallum of the same, of the natural size. D, Transverse section of a young colony of the same growing upon a Crinoidal column, enlarged two and a half diameters. (The visceral chambers of the corallites are largely filled with matrix, and the peculiar reticulated tissue of the skeleton is here and there visible in the wall, while the whole has been finally enveloped by the growth of the stem of the Crinoid.) E, Longitudinal section of a single corallite of the same, enlarged five diameters, showing the open visceral chamber, the fibrous wall, and the reticulated structure of the wall of the calice. F, A portion of the reticulated tissue still further enlarged. Carboniferous Limestone of Lancashire (British Museum.)

detect any traces of tabulæ (fig. 32, D and E). The wall of the theca is exceedingly thick, and throughout the greater part of its extent it seems to consist wholly of delicate concentric layers of sclerenchyma firmly united with one another. In parts of the corallite, however, and especially as the calice is approached, the concentric lamellæ of the wall become separated from one another, so as to include a series of distinct interspaces or cavities, which are approximately parallel to the axis of the visceral chamber, diverging slightly outwards, and which are crossed at right angles by numerous delicate cross-bars or trabeculæ of sclerenchyma (fig. 32, E and F). This extraordinary reticulate tissue is present in the calicine wall of all specimens of *Monilopora crassa* which have hitherto been examined, but no similar structure is known to occur in any other coral, nor does it seem possible to offer any probable suggestion as to its functions or homologies. Apart from this unprecedented feature, *Monilopora* can only be separated from *Aulopora* by the total absence of tabulæ, such as exist in, at any rate, some of the latter, if not in all.

As to the affinities of the *Auloporidæ*, it appears hazardous at present to give any definite opinion. If I am right in referring *Syringopora* to the Perforate Corals, then it would not appear that the present group can have any *real* alliance with the *Syringoporidæ;* and its relationship with any other division of "Tabulate Corals" would seem to be even more remote. Perhaps the most probable conjecture is that which would look upon the *Auloporidæ* as a peculiar group of the *Alcyonaria.*

CHAPTER X.

HALYSITIDÆ AND TETRADIIDÆ.

HALYSITIDÆ.

THE group of the *Halysitidæ* constituted, in the system of Milne-Edwards and Haime, a sub-family (*Halysitinæ*) of the family *Chætetidæ*, and it contained the five genera *Halysites*, *Syringopora*, *Thecostegites*, *Chonostegites*, and *Fletcheria*. The last four of these have been already treated of; and there remains, therefore, only the genus *Halysites* itself as the type and sole representative of the family, which may be defined as comprising coralla composed of long cylindroidal tabulate corallites, which are always more or less extensively united with one another, but have imperforate walls, and exhibit neither mural pores nor connecting-tubes. Spiniform septa may or may not be present, and there may or may not be two diverse sets of corallites. As the family comprises only the single genus *Halysites*, any remarks as to its systematic position will be best deferred until the characters of the genus have been discussed.

Genus HALYSITES, Fischer, 1813.

(Zoognosia, 3d ed., t. i. p. 387.)

Catenipora, Lamarck, Hist. des An. sans Vert., t. ii. p. 206, 1816.

Gen. Char.—Corallum fasciculate and reticulate, composed of long tubular cylindroidal corallites, which are placed side by side in intersecting and anastomosing laminæ or lines, any given corallite being united along its whole length with its neighbours to the right and left, and each lamina of the corallum consisting of no more than a single linear series of tubes. Each tube is enclosed in a strong imperforate wall surrounded on its free sides by a thick epitheca, and there is usually a distinct division of the corallites into two series of different sizes, in which case a single small tube is placed between each pair of the larger tubes. Septa may be obsolete, and, when present, have the form of vertically-disposed rows of spines in cycles of twelve. The tabulæ are well developed, complete, not infundibuliform nor vesicular, the smaller tubes (when present) being more closely tabulate than the larger ones.

Obs.—The general form of the corallum in *Halysites* is constant in all the known species of the genus, and is too well known to need special description. Every corallite in the corallum, except those which form the actual circumference, is united along its whole length, along opposite sides, to two other corallites, those which form the centre of three of the constituent laminæ of the mass being similarly united to three of their neighbours. This union is, moreover, not one of mere contact, but is absolute, the epitheca and wall of any given tube being directly continuous with the corresponding structures in the tubes which stand to the right and left of it (Pl. XI., fig. 1). The most extraordinary feature in the organisation of *Halysites*, however, concerns the mode by which the lateral union of the ordinary corallites of *Halysites* is effected. If we make a thin transverse section of the form usually known as *H. escharoides*, Lam. (Pl. X., fig. 6), we find, as just remarked, that the epitheca and walls of neighbouring tubes are absolutely continuous; but we observe, further, that the epitheca does not take any part in the formation of the partition which actually divides any tube from its neighbour on either side. On the contrary, the partition in question is formed solely by the coalescent *walls* of the two contiguous corallites, and it is always of a lighter colour and apparently less compact texture than the rest of the tube. We have, therefore, here the singular fact that each tube is enclosed by the epitheca only on its two free sides. In the form known as *H. escharoides*, Lam., all the tubes are of approximately equal size; but if, on the other hand, we make a thin transverse section of an example of the typical *H. catenularia*, Linn., we shall find a still more interesting and curious condition of parts (Pl. X., fig. 7, and Pl. XI., fig. 1). In these cases the epitheca and proper walls of the corallites are directly continuous (as in *H. escharoides*), but there is now the additional feature that between each pair of the normal corallites there is intercalated a much smaller sub-quadrate tube, which forms the medium of union between the former. This interstitial tube, moreover, does not seem to be bounded laterally by an inward prolongation of the walls of the large tubes (as one would expect it to be), but it appears to be enclosed by a proper and peculiar wall of its own on the two sides where the large tubes on either side come against it; and this proper wall is at once distinguished under the microscope from the wall of the large tubes by its much darker colour and seemingly different texture (see Pl. XI., fig. 1). There are thus shown to exist *two* distinct sets of corallites in *H. catenularia*, Linn., which occupy fixed and invariable relations to one another, and can be proved by long sections to possess a marked difference in internal structure. Thus the large or normal corallites of this species (Pl. X., fig. 8, and Pl. XI., 1 *a*) have curved or nearly straight complete tabulæ, regularly and comparatively remotely disposed. On the other hand, the small interstitial tubes are intersected by much more numerous and more closely-set tabulæ, which are sometimes straight and sometimes sub-vesicular, the condition of parts thus closely resembling what is observed in the large and small corallites of *Heliolites* and its allies.[1] In *Halysites escharoides*, as we have seen, the small

[1] So far as I know, Hall first noticed the occurrence of the small closely tabulate tubes between the larger ones, as he says, in his description of *H. agglomerata*, that the "spaces between the tubes" are "cellular" (Pal. N.Y., vol. ii. p. 129, 1852), and he clearly figures the closely tabulate intermediate tubes. The first clear and at all complete account of this subject appears to have been given by Fischer-Benzon in a paper, "Ueber Halysites," to which I have unfortunately been unable to obtain

interstitial tubes—so far as my observations go—seem to be wanting; but I have never failed to recognise their existence in *H. catenularia*, Linn.; and they are especially well developed in all specimens of *H. agglomerata*, Hall, which I have examined.

With regard to the septa of *Halysites*, the condition of parts varies greatly in different forms of the group. In those forms, namely, which are usually referred to *H. catenularia*, Linn., I have never succeeded in recognising in microscopic sections any traces whatever of septa, except that the lateral walls of the intermediate or small corallites often carry small projections apparently of a septal nature (Pl. XI., fig. 1). On the other hand, in the forms which are usually known as *H. escharoides*, Lam., there are always well-developed spiniform septa, of exactly the same type as in the *Favositidæ* and *Syringoporidæ*. These septa are arranged in vertical rows, the number of which seems to be constantly twelve in each corallite.

I do not intend here to give any description of any of the species of *Halysites*, especially as I am unable to make up my mind as to the true relations of *H. catenularia* and *H. escharoides* to one another. Till now I have ventured to differ from such distinguished authorities as Milne-Edwards and Haime, and have always considered these as mere varietal forms, since I have looked upon the sole alleged differential characters—viz., the size of the tubes and the dimensions of the meshes of the corallum—as purely varietal characters. By means of microscopic sections, I have satisfied myself—so far as my material goes—that the form known as *H. escharoides*, Lam., is distinguished from the typical *H. catenularia*, Linn., not only by the superficial characters just mentioned, but also by the constant possession of spiniform septa, and the apparently constant absence of small tubes between the larger one. As these dif-

access, but this observer does not seem to have recognised the true nature of the interstitial tubes. To Dr Lindström, therefore, is due the credit of having pointed out that the corallum of *Halysites*, as of *Heliolites*, consists of two distinct sets of zoöids (Öfversigt af Kongl. Vetenskaps Akad. Förhandl., 1873).

ferential characters are fundamental ones, it may seem ridiculous to doubt any longer the specific distinctness of *H. escharoides* and *H. catenularia*. The two forms, however, are so remarkably similar in most respects, are so variable in external characters, and are so constantly associated together, that I am still almost disposed to conjecture that they are the different conditions of a dimorphic species, and that their differences are due to something else than specific distinctness.

As regards the affinities and zoological position of *Halysites*, the above account of its structure leaves little doubt that the genus is more nearly allied to the *Heliolitidæ* than to any other. *Halysites* agrees with *Heliolites* and the recent *Heliopora* in possessing (usually) two distinct sets of corallites, large and small, the two being distinguished further by the arrangement of their tabulæ; and there can be no reasonable doubt that this indicates that each colony of the typical *H. catenularia*, Linn., consisted of two structurally and functionally distinct sets of zoöids. On the other hand, I cannot accept the view of Dr Lindström (Ann. Nat. Hist., ser. iv., vol. xviii. p. 13), who actually places *Halysites* among the *Heliolitidæ*. It appears to me, on the contrary, to form a quite special group, distinguished from *Heliolites* and its allies, not only by the unique form of the corallum, but also by the great reduction, or, it may be, total absence, of the smaller zoöids, by the frequent absence of septa, and by the fact that the septa (when present) are *spiniform*, and present no resemblance to the "pseudo-septa" of the *Helioporidæ*. If the view that *Halysites* is nearly allied to the *Helioporidæ* be accepted, then it follows that the family of the *Halysitidæ* will have to be considered as a distinct and ancient group of the *Alcyonaria;* but it will still remain certain that no true relationships have been shown to exist between *Halysites* and the *Tubiporidæ*, with which family the genus has often been associated.

The geological range of *Halysites*, so far as known, is an extremely limited one, the first representatives of the genus appearing in the later portion of the Lower Silurian period, while the maximum development of the genus is attained in the Upper Silurian, and no Devonian species has been as yet detected.

TETRADIIDÆ.

This group includes only the Silurian genus *Tetradium*, Dana, and its probable systematic place will be best discussed after some description of the genus has been given. The fullest account of the genus which has yet been published is one which was given by Mr R. Etheridge, jun., and myself (Ann. and Mag. Nat. Hist., ser. iv., vol. xx. p. 162, 1877); and the following brief analysis of the chief characters of *Tetradium* is for the most part extracted from the memoir just referred to.

Genus TETRADIUM, Dana, 1846.

(Wilkes's Expl. Exped. Zoophytes, p. 701.)

Gen. Char.—Corallum massive, composed of long prismatic and closely contiguous corallites, the walls of which are not pierced by mural pores or other foramina. The septa are distinct, few in number, most typically four, short, not reaching the centre of the visceral chamber, and seeming as if formed by inflections of the wall. Calices generally petaloid, as are the corallites in transverse section. Tabulæ numerous, complete. Increase apparently by fission of the old tubes.

Obs.—The genus *Tetradium* was founded by Professor Dana for the reception of a fossil of uncertain locality in the collection of Yale College, New Haven; and the following characters were ascribed to it: "Coralla massive, consisting of four-sided tubes and cells, with very thin septa or parietes; cells stellate, with four narrow laminæ."

At a subsequent date, Professor J. M. Safford described four species of corals from the Lower Silurian Rocks, which he referred to this genus (Amer. Journ. Sci. and Arts, ser. 2, vol. xxii. p. 236); and he supplemented Dana's description with the following remarks: "The tubes in the different species vary from one quarter of a line to nearly one line in breadth; they are very long, and are most frequently united throughout laterally, forming massive coralla, resembling more or less those of *Favosites* and *Chætetes;* sometimes, however, they are united in single intersecting series, as in *Halysites catenulata*, Linn.; not unfrequently, too, the tubes are isolated, or only united at irregular intervals, thus forming loose fasciculated coralla, resembling certain forms of *Syringopora*."

Professor Safford further states that the *isolated* tubes are nearly quadrangular, with more or less rounded angles, and with a slight external longitudinal depression opposite to each of the four septa; the walls are more or less rugose; and increase is by fission of the old tubes. Only one specimen was seen in which tabulæ could be detected; and in this they were confined to one end of the mass, and were distant from one another about twice the width of the tubes.

The genus *Tetradium* is regarded by Safford as intermediate between the *Favositidæ* and the *Rugosa*, the quadripartite character of the corallites placing it in the latter group.

Taking such a well-known species as the *T. minus*, Saff., of the Cincinnati Group, as the type of the genus *Tetradium*, we find that the corallum (fig. 33, A) is massive, hemispherical, or irregular in shape, and composed of closely amalgamated, slender, prismatic corallites, which diverge from the base or from an imaginary axis, and are not arranged in superimposed layers. No general epitheca seems to be present. The corallites are in close contact throughout their length, and their walls appear to be entirely imperforate. Some doubt, however, must in the meanwhile remain upon this point, owing to the fact that all the microscopic sections I have made (of specimens derived partly from Ohio and partly from Canada) show the walls to have undergone a very peculiar change. The walls of the corallites, namely — though the specimens appear otherwise to be quite unaltered—have the normal granular carbonate of lime which composes the Cœlenterate skeleton replaced by *crystalline cal-*

cite. Hence we could hardly hope to detect mural pores, even if such structures had at one time existed. For the same reason it must remain doubtful whether or not the walls of contiguous corallites are actually amalgamated with one another. Mr Etheridge and myself arrived at the conclusion that the walls were really double (as in *Favosites*); but we based this opinion chiefly upon the apparent exposure of the exterior of the tubes in some fractured specimens, and I have subsequently seen reason to think that the appearances in question are not constant. I still think that the walls are really double; but as the microscopic evidence is not conclusive, I can only leave the point an open one.

The most characteristic feature in the corallum of *Tetradium*, which separates it, even to superficial inspection, from that of a massive *Chætetes*, is the conspicuously cruciform or petaloid form of the calices or of transverse sections of the corallites (fig. 33, B). This petaloid form is due to the presence of four delicate lamellar septa, which look as if formed by inward fold-

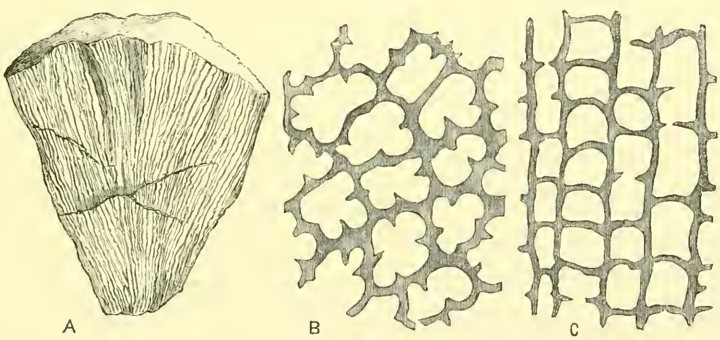


Fig. 33.—A, Fragment of a large corallum of *Tetradium minus*, Safford, from the Cincinnati Group of North America, of the natural size; B, Transverse section of the same, enlarged ten times, showing the petaloid form of the tubes and the short septa; C, Vertical section of the same similarly enlarged, showing the tabulæ.

ings of the wall, and which extend for a short distance only towards the centre of the visceral chamber. Normally, and most generally, four of these septal laminæ are present, but their number is not constant, and varies from one to five. The only other special point brought out by sections is, that the visceral cavities of the polypes are intersected by numerous complete tabulæ, which are straight and horizontal, and entirely independent of each other (fig. 33, c).

As regards the systematic position of *Tetradium*, the known peculiarities in its structure seem to render three conclusions more or less certain: (1) That Safford's conjecture as to the Rugose affinities of the genus is entirely untenable; (2) that the genus has no strong points of relationship with *Chætetes*, which it most nearly resembles in general form and habit; and (3) that its true alliances are with *Halysites* and *Heliolites*. As regards *Halysites*, the chief points of likeness are to be found in the fact that both genera possess remarkably long tubular imperforate corallites, and in the fact that both Safford and Billings have indicated that specimens of *Tetradium* sometimes assume the otherwise unique habit of *Halysites*, the corallites being united by their lateral margins in single intersecting series. I have never myself been so fortunate as to meet with any specimens exhibiting the peculiar mode of growth just alluded to, but it is evident that whatever may be the relationship between *Tetradium* and *Halysites*—and I do not doubt that there *is* a relationship—the former genus is widely separated by its lamellar, not spiniform septa, by the cruciform arrangement of these structures, and by the total absence of any set of small zoöids coexisting with those of normal size. On the other hand, *Tetradium* presents a very striking resemblance to *Heliolites* in the *form* of the delicate lamellar septa, which have every appearance of being "pseudo-septa" produced by inflection of the wall. The absence, however, of small zoöids, would of itself be quite sufficient to prevent any actual reference of *Tetradium* to the *Helioporidæ*, even if other differences (such as in the number of the septa) did not exist as well. Upon the whole, therefore, it seems best to regard *Tetradium*, Dana, as the type of a special group of the *Alcyonaria*, allied to the *Halysitidæ* and the *Helioporidæ*, and yet distinct from both of these.

CHAPTER XI.

THECIDÆ AND HELIOPORIDÆ.

THECIDÆ.

The group of the *Thecidæ*, E. and H., comprises only the anomalous Silurian genus *Thecia*, E. and H., the type of which is the *Thecia Swindernana* of Goldfuss. It is important to bear this fact in mind, as I shall found the following description of the group entirely upon a most careful macroscopic and microscopic investigation into the structure of the type-species of the genus, of which I possess a large number of authentic examples, derived from the Wenlock Limestone of both Britain and Sweden. I mention this the more particularly here, because it is needless to say that the diagnosis of a genus must in all cases be ultimately decided by the structural characters of the original type of that genus, and cannot be based upon forms which any given observer may believe, perhaps upon insufficient grounds, to be congeneric with that type. The genus now under consideration illustrates this point in an especial manner, for the last, and in all respects the most circumstantial, account of the genus *Thecia*, E. and H., which has yet been published (Foss. Cor. of Michigan, p. 65, 1876), ascribes to the genus characters such as do not exist in the type-species, and ignores other fundamental features which are really present in the latter; and I do not think that so accomplished an observer as Dr Rominger could have arrived at some of his conclusions, unless it were that some of the forms which he refers to *Thecia* are really of a different nature.

The affinities of the family of the *Thecidæ* will be best considered after I have given a short account of the structural characters of the genus *Thecia;* and the group may be in the meanwhile defined as including coralla formed of tubular corallites of two distinct sizes, the larger disposed with considerable regularity among the smaller ones. The large corallites are tabulate, with indistinctly differentiated walls, provided with obtusely triangular and irregular septa, and having their visceral cavities more or less freely connected with one another by lateral horizontal channels, which penetrate the interstitial tubular tissue. The smaller interstitial tubes are doubtfully tabulate, and their cavities are liable to be largely filled up by a secondary deposit of sclerenchyma.

Genus THECIA, Edwards and Haime, 1849.

Comptes Rend., t. xxix. p. 263.

Gen. Char.—Corallum rarely ramose, usually in the form of a laminar expansion, covered below by a concentrically wrinkled epitheca, and having the calices placed upon its upper surface. Corallites in the main erect and perpendicular to the horizontal axis of the corallum (sometimes slightly curved inferiorly), of two sizes, large and small. The large corallites are placed at regular intervals, and though their visceral chambers are clearly circumscribed, they cannot be said to be bounded by distinctly differentiated walls; but they are, on the contrary, embedded in a dense tissue composed of the smaller tubular corallites, which may open on the surface by means of irregular, often stelliform apertures, or may be to a large extent closed by a secondary deposit of sclerenchyma. The smaller corallites are primitively bounded by distinct polygonal walls, and it is not certain if they are tabulate. On the other hand, the large corallites are distinctly tabulate, are provided with irregular and obtuse lamellar septa, and communicate directly with one another by means of tortuous horizontal channels passing from one to another. No columella is present.

Obs.—Owing to the great density of its tissues, the difficulties in the way of making a thorough examination of the structure of *Thecia* by means of the microscope [1] are unusually great, and it has been only by means of a large series of thin sections that I have been enabled to come to any satisfactory conclusions as to its minute anatomy, while there still remain some points of importance which I have found it impossible to clear up. The corallum in the type-species, *T. Swindernana*, Goldf. sp., has the form of a laminar, usually discoid expansion, attached by the centre of its base to some foreign body, and having the whole of the lower surface covered by a concentrically striated and wrinkled epitheca. The upper surface carries the calices, and when examined macroscopically, even by means of a lens, usually shows nothing but the stellate apertures of the larger corallites, which are from a third of a line to half a line in diameter, and are separated by what appears to be an equal width of dense interstitial tissue. This interstitial tissue is marked superficially by numerous minute, radiating, often vermicular grooves, which extend from each calice to the neighbouring ones (Pl. XI., fig. 2), and it was regarded by Milne-Edwards and Haime as being of the nature of a "spurious cœnenchyma, resulting from the intimate union of the costæ" (Brit. Foss. Corals, p. 278). As there are no costæ in *Thecia*, Milne-Edwards and Haime were, of course, in error in supposing this interstitial tissue to be formed by the coalescence of structures of this nature; but in the sense in which they used the term "cœnenchyma," they were undoubtedly right in supposing that they were dealing here with a "cœnenchymal" tissue. In other words, there can be no doubt as to the identity of the interstitial tissue of *Thecia* with the so-called "cœnen-

[1] Though in the habit of preparing all my own sections for the microscope, I was compelled in this instance to have resort to the skill of Mr F. G. Cuttell; and I have therefore had the advantage of probably the most beautiful sections of this difficult form which could be prepared at the present day.

chymal tubuli" of *Heliolites* and its allies, which we only know by the quite recent researches of Moseley to be not truly of a cœnenchymal nature. When, in fact, we examine exceedingly thin sections of *Thecia*, whether these be either transverse or longitudinal, we find that the apparently dense and compact tissue which seems to separate the large corallites is in truth composed of vertical tubules, which we must now regard—from what we know of the *Helioporidæ*—as being properly small corallites, tenanted by a special set of zoöids. So far, then, the structure of *Thecia* is essentially identical with that of *Heliolites*, but there are some very important differences to be observed in these types respectively. In *Heliolites* and its relatives, both the larger and the smaller corallites are enclosed by thin but perfectly distinct walls, the former having well-developed septa and remote tabulæ, the latter having no septa and crowded tabulæ; while there is no sufficient evidence of any lateral communication between the visceral cavities of the larger corallites. In *Thecia*, on the other hand, the large corallites cannot be proved, even in the thinnest sections, to possess any proper wall, their boundaries not being clearly separable from the dense tubes of the interstitial tissue; the septa which they possess are not at all similar to the thin inflections of the wall which constitute the "pseudo-septa" of *Heliolites* and its allies, but are thick and irregular ridges; while the interstitial tubuli—so far as can be certainly ascertained—are destitute of tabulæ. There is, moreover, the curious feature that the larger corallites are placed in direct communication by means of distinct, often tortuous, horizontal channels, which traverse the interstitial tubuli.

If we examine a thin transverse section of *Thecia Swindernana* under the microscope (Pl. XI., figs. 2 *a*, 2 *b*), we observe that the visceral chambers of the large corallites are quite distinctly marked out, though nothing of the nature of a differentiated bounding-wall can be detected. Here and there the visceral cavities of two contiguous polypes may be seen to be directly connected by a horizontal canal, which happens to have been placed in the plane traversed by the section. The septa appear simply as blunt, triangular, irregular lateral ridges, with ill-defined margins, having deep sulci at their bases, but always leaving a considerable central area into which they do not penetrate. The interstitial tissue presents different appearances in different parts, or under different conditions of preservation. Sometimes—though by no means always—the interstitial tissue can be recognised as divided into a number of small polygonal areas by a network of dark lines, which represent the primitive walls of the interstitial tubuli. Often these walls can only be recognised by the slightly thickened nodes at their angles of junction, or they may not be capable of detection at all. In the same way, the minute central cavities of the interstitial tubuli may appear in cross-sections as so many minute, irregular, sometimes stelliform apertures, or they may be filled with granular sclerenchyma, when the interstitial tissue appears to be wholly solid.

In longitudinal sections (Pl. XI., figs. 2 *c*, 2 *d*), the visceral cavities of the larger corallites are distinctly marked out, as before, without any clearly-defined wall, and are seen to be intersected by well-developed complete tabulæ, which are slightly flexuous, and sometimes anastomose to some extent with each other; while occasionally the section exhibits a portion or the whole of one of the horizontal canals placing contiguous tubes in communication. In sections of this nature, the composition of the apparently dense interstitial tissue out of numerous closely-approximated vertical tubuli can always be recognised without the slightest difficulty. Moreover, these tubuli, in sections of sufficient thinness, can always be recognised as being bounded by perfectly distinct, apparently double walls; but their cavities appear to be more or less extensively obliterated by a deposit of granular, not laminated sclerenchyma, which seems, however, to be very irregularly distributed. No tabulæ can be detected, though it is possible that such structures really existed.

From a consideration of the above characters, it will be evident that Dr Lindström had much ground for his suggestion (Ann. Nat. Hist., ser. 4, vol. xviii. p. 13) that *Thecia* is closely allied to the *Heliolitidæ*. As has been already pointed out, however, there exist certain very important differences between *Thecia* and *Heliolites*, which are of too fundamental a nature to permit of our associating these genera in a single family. Of these differences, the most important is the presence in the former genus of distinct and well-developed horizontal canals, which traverse the interstitial tissue, and place the visceral cavities of neighbouring polypes in direct communication This feature is one in which the genus approaches the Perforate corals in general, and the *Favositidæ* in particular; but the latter are fundamentally distinguished by the total absence of anything analogous to the interstitial tubuli of *Thecia*. Upon the whole, therefore, the best course to follow is to place *Thecia* in a distinct family—*Thecidæ*, E. and H.—which will occupy a position in the *Alcyonaria* close to the *Helioporidæ;* and in so doing we may remember that though the horizontal canals above spoken of recall to our minds the "mural pores" of the *Favositidæ* and the hollow "connecting-processes" of the *Syringoporidæ*, the existence of a direct connection between the visceral cavities of neighbouring polypes is a common feature in the Alcyonarian Zoophytes. Before leaving the subject of the affinities of the genus *Thecia*, a few words may be said as to the views which Dr Rominger has expressed upon the same point (Foss. Cor. of Michigan, p. 65). According to this observer, *Thecia* has "the general structure of *Favosites;*" the walls of the corallites are thick, and are bounded by "defined polygonal outlines," but occasionally "the walls do not exceed in thickness those of an ordinary *Favosites;*" the septa are spiniform, and extend nearly to the centre of the visceral chamber; and "large and abundant" lateral pores (*i.e.*, mural pores) are present. The figures given by Dr Rominger, beautiful as they are, being heliotypes, present the specimens of the natural size, and give one no clue as to their real internal structure. Not having seen Dr Rominger's specimens, it would be useless to criticise his diagnosis of the genus in detail. I can only say, therefore, that the structure of the type-species, *T. Swindernana*, Goldf. sp., as above described, is such as to render it apparently impossible that the forms ascribed to *Thecia* by Dr Rominger can really be congeneric with it. In fact, *Thecia Swindernana* does not agree in any important respect with *Thecia* as defined by Dr Rominger, and especially differs in the characters which I have above enumerated. If Dr Rominger, therefore, has not been misled by the examination of specimens greatly altered by fossilisation, it is clear that the species described by him under the name of *Thecia* must belong to some other generic type. Lastly, Dr Rominger asserts that *Protaræa*, E. and H., possesses corallites which have mural pores, and are provided with convex tabulæ, and that it is a near ally of *Thecia*. On this point, I can only say that I have failed to discover any traces of tabulæ in *Protaræa*, either in actual specimens or in thin vertical sections; that though the walls are porous, there are no "mural pores," properly so called, in any examples I have seen; and that I am unable, therefore, to accept the view that any alliance exists between this genus and *Thecia*.

So far as at present known, the genus *Thecia* is confined in its geological range to the Upper Silurian rocks, the type-species, *T. Swindernana*, Goldf., being an abundant and characteristic fossil of the Wenlock Limestone of Britain and Sweden.

Helioporidæ (Moseley).

This well-defined and distinctly circumscribed group of corals is characterised by the possession of a corallum composed of two distinct sets of corallites, tenanted in life by two distinct sets of zoöids. The larger tubes are uniformly distributed among a very much larger number of much smaller ones, and are provided with delicate lamellar septa ("pseudo-septa"), which are formed by infoldings of the wall, are typically twelve in number, and are occasionally rudimentary or even obsolete.

The visceral cavities of the polypes are also crossed by complete, more or less horizontal tabulæ. The smaller corallites are typically provided with distinct walls, which may, however, be rudimentary; and they have their internal cavities intersected by horizontal or strongly convex tabulæ, while septa are entirely wanting. No lateral channels exist in any of the fossil forms (so far as known), by which the visceral cavities of the larger corallites are placed in communication with one another, or with the cavities of the smaller corallites.

From the researches of Mr Moseley (Phil. Trans., vol. clxvi p. 92, 1876), we know that *Heliolites* and its allies are essentially similar as regards the structure of the corallum to the living *Heliopora*, and we have therefore the right to conclude that this resemblance extended to the soft parts as well. We have therefore every right to conclude that *Heliolites* and its relations were Alcyonarian Zoophytes, with polypes of two different kinds, the fully-developed zoöids inhabiting the larger tubes of the skeleton, and having eight mesenteries and eight pinnately-fringed tentacles; while the septa do not correspond in number with the mesenteries, and are consequently to be regarded as "pseudo-septa." The only important point in which *Heliolites* and the forms related to it appear to differ from *Heliopora* is that the cavities of the small sexless zoöids of the latter genus are stated by Mr Moseley to communicate directly with the body-cavities of the larger corallites; but we have in the meanwhile no evidence of the existence in the extinct genera of any apertures in the walls of the larger corallites by which such a communication could be effected. This difference, if ultimately established, will be one of great importance; but a further examination of the fossil forms will be required to prove conclusively that the large zoöids possessed no direct communication with the smaller ones.

The genera included in this family are the Palæozoic[1] *Helio-*

[1] The Devonian genus *Battersbyia*, E. and H. (Pol. Foss. des Terr. Pal., p. 227), originally placed by its founders in the neighbourhood of *Heliolites*, has been shown by Professor Martin Duncan (Phil. Trans., vol. clvii., 1867) to be a member of the special family of the *Palastræaceæ*, an extinct group of the *Zoantharia Aporosa*.

lites, Dana, *Plasmopora*, E. and H., *Propora*, E. and H., *Pinacopora*, Nich. and Eth. jun., and *Lyellia*, E. and H., the Cretaceous *Polytremacis*, D'Orb., and the recent *Heliopora*, De Blainv., of which only the first five concern us here. *Fistulipora*, M'Coy, which has often been included among the *Heliolitidæ*, appears to me, for reasons which will subsequently be given, to belong rather to the *Chætetidæ* (or to the *Monticuliporidæ*, if such a family be ultimately established), and I shall consider it in association with *Constellaria* and *Monticulipora*. The Palæozoic genera of the *Helioporidæ* are exclusively Silurian and Devonian, and there is such a close similarity in their general structure that they require but comparatively brief notice.

Genus HELIOLITES, Dana, 1846.

(Wilkes's Expl. Exped. Zooph., p. 541.)

(Pl. XII., figs. 2 - 2 *a*.)

Gen. Char.—Corallum spheroidal, pyriform, hemispherical, or rarely ramose, composed of numerous closely contiguous corallites, which are divisible into two distinct series. The larger corallites are cylindrical, comparatively few in number, and furnished with twelve lamellar infoldings of the wall, of the nature of pseudo-septa, which fall short of the axis of the visceral chamber. Small corallites completely investing the larger ones, more or less regularly polygonal in form, provided with distinct walls, which are completely amalgamated with one another and with the walls of the larger tubes, and which are not known to be provided with any apertures allowing lateral communication. The small tubes have no septa, but have numerous straight and complete tabulæ, similar but somewhat less numerous structures existing in the large tubes. No columella.

Obs.—The corallum in *Heliolites* is usually more or less hemispherical or spheroidal in shape, the under surface covered with a concentrically-striated epitheca, and having the calices opening over the whole upper surface. In other cases (*e.g.*, *H. Grayi*, E. and H.) the corallum is ramose or lobate, fixed by its base, and having the calices covering the whole of the free surface. The internal structure of the corallum can be readily studied in actual specimens or in polished sections, and little fresh information is afforded by thin slices. The most important points to notice, as differentiating the genus from its immediate allies, or as otherwise of interest, are the following :—

The corallites are universally and throughout in complete contact, their walls being so entirely amalgamated that no traces of their originally duplex constitution can be detected. No apertures of the nature of "mural pores" are known to exist in the walls.

The walls of the larger corallites are folded so as to give rise to twelve septal ridges, which are continuous from the top to the bottom of the visceral chamber, and are not spiniform. In some cases (*e.g.*, *H. megastoma*, M'Coy) the septa are marginal and rudimentary (Pl. XII., fig. 2) ; in other cases they extend inwards for a considerable distance; but in no case do they actually meet in the centre of the visceral chamber. No septa exist in the smaller corallites.

The number of the smaller corallites varies much in different species, but there is always enough of them to completely isolate the larger tubes. Usually there are several layers of small tubes between any given pair of the larger tubes, but there are only from two to five rows in *H. megastoma*, M'Coy ; and there are usually no more than two rows, or only a single one, separating the larger corallites in *H. dubia*, Fr. Schmidt, and in *H. plasmoporoides*, Nich. and Eth., jun.

The smaller corallites of *Heliolites* are principally distinguished from the corresponding tubes in *Propora* and *Plasmopora* by their regularly polygonal shape, and by the fact that their walls are never obsolete, but are completely developed (Pl. XII., fig. 2 *a*). In long sections, therefore, no difficulty is experienced in recognising the walls of the smaller tubes.

The tabulæ are well developed in both the larger and smaller corallites (Pl. XII., fig. 2 *a*), and in thin sections appear to be of a much darker colour than the actual walls of the tubes. In the small corallites the tabulæ are numerous, complete, more or less horizontal, and often placed at corresponding levels in contiguous tubes. In the larger corallites the tabulæ are also complete, and essentially horizontal, but they are placed at somewhat greater distances apart, and they occasionally unite with one another.

I have made an examination by means of thin sections of *H. interstincta*, Linn., *H. Murchisoni*, E. and H., *H. megastoma*, M'Coy, *H. porosa*, E. and H., and *H. Grayi*, E. and H.; but none of these depart in any noticeable feature from the normal type of the genus, or exhibit peculiarities of such importance as to justify special description. The most aberrant species of the genus which I have examined is a form from the Devonian of Australia, which will be subsequently described by Mr R. Etheridge, jun., and myself under the name of *H. plasmoporoides*, and which nearly approaches the genus *Plasmopora* by its comparatively irregular and comparatively few interstitial tubes. It shows itself, however, to be a true *Heliolites* by the complete walls of the smaller corallites, and by the fact that the tabulæ of these tubes are not curved or vesicular. Another curious type is the Upper Silurian *H. dubia*, Fr. Schmidt, but I have had no opportunity of investigating this species microscopically.

So far as at present known, all the species of *Heliolites* are confined to the Lower and Upper Silurian rocks, and to the Devonian.

Genus PLASMOPORA, Edwards and Haime, 1849.

(Compt. Rend., t. xxix. p. 262.)

(Pl. XI., fig. 5, and Pl. XII., fig. 1.)

Gen. Char.—Corallum discoidal when young, but becoming hemispherical or spheroidal when adult, its lower surface covered by a concentrically-striated epitheca, while the upper surface carries the calices. Corallites in complete contact throughout, divisible into two distinct series. The larger tubes are comparatively few in number, and possess twelve lamellar septa, formed by infoldings of the wall, and extending but a short distance into the visceral chamber; while they are crossed by horizontal, complete, and comparatively remote tabulæ. The smaller tubes are devoid of septa, are comparatively irregular in form, and only possess distinctly differentiated walls when young. In their adult state their walls become amalgamated with the convex and anastomosing tabulæ by which their cavities are intersected, in such a manner that they can no longer be recognised as distinct structures, and the interspaces between the larger corallites become filled up with a loose tissue composed of irregular lenticular vesicles.

Obs.—In almost all the essential features of its anatomy, *Plasmopora* entirely resembles *Heliolites*, and it is only necessary here to make a few remarks on the sole character by which the two genera can be separated—namely, the peculiar structure of the smaller tubes. In *Heliolites*, as we have seen, the smaller corallites are polygonal in shape, have perfectly distinct walls, and are crossed by essentially horizontal tabulæ, which, though often placed at the same level in neighbouring tubes, do not actually coalesce with one another laterally. In very young specimens of *Plasmopora petaliformis*, E. and H.,—the only species of the genus that I have examined by means of thin sections—the condition of parts is so far like that of *Heliolites* that the walls of the smaller corallites are perfectly recognisable (Pl. XII., fig. 1) in long sections; but there is this difference, that the tabulæ are now very highly convex, and are either continued into one another, or are joined with the walls of the tubes in such a manner as to give rise to an apparently continuous vesicular tissue, which fills all the spaces between the larger corallites. In older coralla this amalgamation of the curved and inosculating tabulæ with the walls of the tubes has gone so far, that the latter almost or quite disappear. Hence, when we examine tangential sections of the corallum (Pl. XI., fig. 5), we find that the polygonal and comparatively regular tubes of *Heliolites* are replaced by quite irregular spaces, of very variable size, surrounded for the most part by curved boundaries, which represent the cut edges of the component vesicles of the interstitial tissue.

With the exception of the imperfectly characterised *Plasmopora micropora* (Goldfuss), E. and H., which is believed to be from the Devonian of the Eifel, all the species of this genus are Silurian in their range.

Genus Propora, Edwards and Haime, 1849.

(Compt. Rend., t. xxix. p. 262.)

(Pl. XI., figs. 3-3 *b*.)

Gen. Char.—Corallum discoidal, hemispherical, or irregularly spheroidal, the lower surface covered with a concentrically-striated epitheca. Corallites of two sizes: the larger ones with distinct walls, which are infolded so as to form twelve short septal ridges, the visceral chamber being intersected by comparatively remote, complete, approximately horizontal tabulæ. Smaller corallites with altogether obsolete walls, these structures being undistinguishably amalgamated with the convex tabulæ, so that the narrow interspaces between the larger tubes become filled up with a vesicular tissue formed of lenticular cells. Calices slightly exsert.

Obs.—I am quite disposed to agree with Dr Lindström (Ann. Nat. Hist., ser. 4, vol. xviii. p. 16) in thinking that *Propora* can hardly be kept generically distinct from *Plasmopora.* The mere fact that the larger corallites are slightly exsert can hardly be regarded as of generic importance; and an examination of thin sections of *Propora tubulata*, E. and H., has led me to take a different view of the condition of the septa to that propounded by Edwards and Haime. These high authorities believed that the twelve short septa of the larger corallites were prolonged exteriorly into "costæ" (Pol. Foss. des Terr. Pal., p. 223); but I do not think that any structures to which this name could be properly applied are really present. On the contrary, I believe that the apparent "costæ" are in reality—as also in *Plasmopora*—nothing more than the imperfectly-developed walls of the smaller interstitial corallites. In the structure of the large corallites, *Propora* differs in no respect from either *Heliolites* or *Plasmopora;* and as regards the smaller corallites, the condition of parts is very similar to that which we have seen to exist in the latter genus. I have not had the opportunity of examining very young specimens of *Propora tubulata;* but if we look at a thin longitudinal section of an adult example (Pl. XI., fig. 3 *b*), we see that the interspaces between the larger corallites are occupied by a vesicular tissue, composed of lenticular vesicles of different sizes, closely resembling the vesicular tissue of a *Cystiphyllum* in general aspect. This tissue resembles that of *Plasmopora*, except that the vesicles are more regular in form; and I entertain no doubt but that it is similarly formed by the lateral anastomosis and confluence of the convex tabulæ of the interstitial tubes or small corallites, with the resulting obliteration of their walls. The walls of the small corallites, in fact, can occasionally be very partially detected, though more usually they have entirely disappeared as distinct structures. Similarly, when we come to examine thin tangential sections of *Propora* (Pl. XI., figs. 3 and 3 *a*), we see that the narrow interspaces between the comparatively close-set large corallites are occupied by rows of irregular spaces, bounded by dark lines. These lines, however, are not "costæ," but are the cut edges of the lenticular vesicles formed by the coalescence of the curved tabulæ with the walls of the small corallites. Ordinarily there is but a single row of small corallites between each pair of large ones, though sometimes two rows are present. (In long sections, as in Pl. XI., fig. 3 *b*, there commonly appears to be quite a wide tract of vesicular tissue between two contiguous large tubes; but this, of course, is only due to the fact that the section has happened here to traverse a line lying between several of the larger corallites.)

Accepting the above views as to the true structure of the corallum of *Propora*, it seems clear that the genus agrees in substantial characters with *Plasmopora*, with which therefore it should be united. The species which have been referred here are Upper Silurian in their range. (The supposed Carboniferous species is a *Palæacis*.)

Genus Lyellia, Edwards and Haime, 1851.

(Pol. Foss. des Terr. Pal., p. 226.)

(Pl. XI., figs. 4, 4 *a*.)

Gen. Char.—" Corallum massive; corallites cylindrical, with thick and costulated walls, free towards their terminations, and united throughout the remainder of their length by a very abundant vesicular cœnenchyma; visceral chambers traversed by somewhat irregular tabulæ; septa twelve in number, well developed " (Edwards and Haime, *loc. cit.*)

Obs.—The genus *Lyellia* was founded by Edwards and Haime to include two species of corals (*L. Americana* and *L. glabra*) from the Upper Silurian of North America. Other species of the genus have been described by Dr Rominger (Foss. Cor. of Michigan, p. 14), from deposits of the same age; and it is probable that some of the forms of *Heliolites* (*e.g.*, *H. affinis* and *H. speciosus*) described by Mr Billings from the Lower and Upper Silurian deposits of Anticosti, are really referable to *Lyellia* (Cat. Sil. Foss. of Anticosti, pp. 5 and 30). I have not myself been so fortunate as to meet with any examples of this genus, and am therefore able to say nothing as to its minute internal structure. Judging from the descriptions and figures of the above-mentioned authors, *Lyellia* would seem to be nearly allied to *Plasmopora*, and especially to those forms of the genus which have been usually separated under the name of *Pro-*

pora. The conversion of the smaller corallites into a mass of lenticular vesicles, and the round form of the larger corallites (Pl. XI., fig. 4 *a*), render this resemblance especially noticeable. The large corallites, however, appear to be more markedly free towards their upper ends, and the openings of the smaller tubes upon the surface do not appear to be conspicuous or even recognisable (Pl. XI., fig. 4).

Dr Rominger, in his diagnosis of the genus, adds the further character that the septa are composed of "vertical rows of spinules." This of itself would go far to separate the genus from *Plasmopora* and *Heliolites*, in which the septa appear to be always lamellar.

Genus PINACOPORA, Nich. and Eth., jun., 1878.

(Mon. Sil. Foss. of Girvan, Fasc. i., p. 52.)

(Pl. XII., figs. 3 - 3 *e*.)

Gen. Char.—"Corallum composite, coin-shaped, of extremely short corallites supported upon the upper convex surface of a free, discoidal, concavo-convex, concentrically striated epitheca. Corallites of two sizes, regularly alternating with one another. Large-sized corallites disposed in obliquely decussating rows, each completely surrounded by a circle of very much smaller corallites ('cœnenchymal tubes'), rarely more than a single row of these latter, however, intervening between any given pair of the larger tubes. Large tubes furnished with twelve short septa, in the form of blunt spiniform projections; small tubes without septa. Large tubes furnished with one or two tabulæ, or rarely more, situated close to their base, the upper portion of the tube being open. Small tubes furnished with from two to four strong and complete tabulæ, which extend to close to their summits. Large tubes circular or oval in shape; small tubes irregular in shape. No mural pores. No columella."

Obs.—The above generic diagnosis is taken from the Monograph of the Silurian Fossils of Girvan (Fasc. I.), by Mr R. Etheridge, jun., and myself, in which the only known species of the genus—viz., *P. Grayi*, of the Upper Silurian rocks of Ayrshire—is fully described. As I have no further material of this species in my hands, I shall content myself on the present occasion with the following brief remarks, most of which are taken from the work just alluded to.

The corallum in *Pinacopora* is free, and has the form of a thin circular expansion, the under surface of which is covered with a concentrically-striated epitheca (Pl. XII., fig. 3). The epitheca is always symmetrically concave, and its upper convex surface (Pl. XII., fig. 3 *a*) carries the corallites, which are remarkable for their extreme shortness, when we take into account their comparatively large size. Thus in a specimen one inch in diameter the height of the corallites is only about half a line, while the diameter of the larger tubes is equal to their height. The corallites are divided into two groups, the relations of which to each other are remarkably uniform. The larger corallites are arranged upon the upper surface of the epitheca with great regularity in obliquely intersecting rows, each individual tube being isolated and separated from its fellows by a zone of the smaller tubes (Pl. XII., fig. 3 *b*). Usually but one single row of the small corallites intervenes between any given pair of the larger tubes, but occasionally and here and there a few extra interstitial tubes may be developed. The large corallites, except in their extreme shortness, are constructed upon the type of the corresponding tubes in *Heliolites* and its allies, the resemblance between the two being especially manifest in the presence in each of twelve short septa (Pl. XII., fig. 3 *d*). As in *Heliolites*, the smaller corallites are wholly destitute of septa. Considering the very limited vertical development of the corallites, the tabulæ may be said to be well developed, and they differ in their arrangement in the large and small tubes respectively. In the former, the tabulæ (Pl. XII., figs. 3 *c* and 3 *e*) are confined to the bottom of the visceral chamber, and there is generally but one of these structures present, though two or three may be developed, in which case they are very closely approximated. In the smaller corallites the tabulæ are more numerous (Pl. XII., fig. 3 *e*), and they extend to close upon the summit of the tubes. No traces, lastly, of mural pores, or of any other apertures, in the well-developed walls of either the larger or smaller corallites have hitherto been detected.

As regards the systematic position of *Pinacopora*, there can be no doubt that it belongs to the family of the *Helioporidæ*, and that its nearest relationships are with *Heliolites* itself. It agrees with *Heliolites* in the essential structure of the large corallites, and also in the more important features exhibited by the small tubes. The latter, it is true, in their comparatively limited development, remind us of *Plasmopora* (*Propora*) *tubulata*, E. and H., the regular distribution of the large corallites being another feature of resemblance between the type just mentioned and the present form. On the other hand, there is the fundamental difference that the walls of the small corallites in *Pinacopora* are completely differentiated, while their tabulæ do not become vesicular. In these features, *Pinacopora* agrees with *Heliolites*, from which it differs in the fact that the corallum constitutes a thin, concavo-convex, leaf-like plate, not attached to foreign bodies; in the extraordinary shortness of the corallites; in the comparatively rudimentary condition of the septa; in the very regular arrangement of the large corallites; and in the peculiar arrangement of the tabulæ in the large and small tubes respectively. As before remarked, the only described species of this genus is found in deposits of the age of the Upper Silurian, in Ayrshire.

CHAPTER XII.

CHÆTETIDÆ AND MONTICULIPORIDÆ.

Using the name *Chætetidæ* in the wide and general sense in which it has been usually employed, and temporarily including under this title the genus *Monticulipora* and its allies, we find that the group now under discussion comprises massive, ramose, laminar, or encrusting corals composed of contiguous tubular corallites, which are intersected by complete tabulæ, and are destitute of mural pores. There are either no structures of the nature of septa, or, at most, mere rudiments of such. All the corallites may be like one another, or the corallum may be composed of two distinct and differing sets of tubes.

The *Chætetidæ* were regarded by Milne-Edwards and Haime as a "tribe" of the *Favositidæ*, and the genera *Chætetes*, Fischer, *Dania*, E. and H., *Stenopora*, Lonsd., and *Constellaria*, Dana, were regarded as constituting this division (Brit. Foss. Cor. Introduction, p. lxi, 1850). *Monticulipora*, D'Orb., was originally included by Edwards and Haime under *Chætetes*, but they subsequently admitted its generic distinctness (Brit. Foss. Cor., p. 264, Note, 1854). The genus *Fistulipora*, M'Coy, on the other hand, was placed by the French observers in the family of the *Milleporidæ*, in the immediate neighbourhood of *Heliolites*. In their great work, the 'Polypiers Fossiles des Terrains Palæozoiques,' Milne-Edwards and Haime established the three additional genera *Beaumontia*, *Dekayia*, and *Labechia*, which they placed in the *Chætetinæ*;

and in his last important work upon the corals (Hist. Nat. des Cor., 1860), M. Milne-Edwards adhered substantially to the above arrangement, except that *Stenopora*, Lonsd., is now not regarded as a well-characterised type.

In the sense in which it is here employed, the family *Chætetidæ* corresponds in the main with the "tribe" *Chætetinæ* of Edwards and Haime. *Stenopora*, Lonsd., is, however, now placed among the *Favositidæ; Labechia*, E. and H., is regarded as the type of a special group; and *Fistulipora*, M'Coy, and *Prasopora*, Nich. and Eth., jun., are temporarily added to the family, to take their proper place beside *Monticulipora.* Thus constituted, it must be at once admitted that the family is an artificial and unnatural assemblage, the retention of which, as a single group, can only be defended upon the ground of our at present imperfect knowledge of the structure and real relations of many of the forms included in it. It is clear, indeed, that the forms here provisionally associated under the family *Chætetidæ* agree with one another only in the general fact that they possess coralla composed of closely contiguous corallites, which are without septa, are traversed by tabulæ, and have imperforate walls. This last character, however, cannot be regarded as sufficiently established for all the forms now under consideration. Some of them almost certainly possess nothing of the nature of the "mural pores" of the *Favositidæ*, and none of them have been actually *proved* to possess openings of a similar nature to the above. It is not impossible, however, that some of the genera at present placed in the *Chætetidæ* may yet be demonstrated to possess "mural pores;" and I have myself examined a coral from the Wenlock Limestone of Dudley, which is closely similar to *Monticulipora*, D'Orb., in form and general appearance, but in which the walls are indubitably porous. Moreover, an examination of the minute structure of the forms here included under the *Chætetidæ* renders it clear that they admit of separation into two groups, of very different size, and perhaps of a very different nature. In the one group—which we may speak of as the *Chætetidæ* proper—we have only the forms which properly constitute the genus *Chætetes*, Fischer (as typified by *C. radians*, Fisch., and exclusive of the *Monticuliporæ*). These forms possess corallites of one kind only, which are completely amalgamated by their walls, and which possess comparatively few and remote tabulæ. In the other group we have all the forms included under the genera *Monticulipora*, D'Orb., *Fistulipora*, M'Coy, *Dekayia*, E. and H., *Constellaria*, Dana, and *Prasopora*, Nich. and Eth., jun., in all of which the walls of the corallites are not fused with one another, and there is mostly the important feature that the corallum is composed of two distinct classes of corallites, indicating the existence during life of two distinct kinds of zoöids. The corals of this latter group I shall speak of collectively as the *Monticuliporidæ*, though I do not at present feel justified in finally removing them from the vicinity of the *Chætetidæ* proper, as there are a few forms generally referred to *Monticulipora* in which the corallites are *homomorphic*, and in which the corallum only differs from that of *Chætetes*, in its most restricted sense, in the fact that the corallites are not united by their walls.

As regards the affinities of the *Chætetidæ* and *Monticuliporidæ* anything that can be said at the present moment can be regarded as, at best, little more than conjecture. So far as *Chætetes* proper is concerned, I do not at present see that we have any sufficient ground for supposing that we have to deal in it with anything but a group of genuine *Actinozoa*. The association of *Chætetes* with the true *Favositidæ*, as proposed by Milne-Edwards and Haime, must certainly be rejected, as there is no evidence to hand of the existence of perforations in the walls of the former, and there are other important differences as well. At the same time, the general structure of *Chætetes* is entirely that of the Corals rather than of the *Polyzoa*, and there is a very close resemblance to such forms as *Tetradium*, Saff., the only essential difference between these two types being the possession by the latter of definite septa. When, however, we come to ask more particularly as to the precise place of

Chætetes among the *Actinozoa*, it becomes abundantly clear that we have no sufficient data upon which to found a final conclusion. All that can be said is that the genus seems to have nearer relationships with the *Halysitidæ* and *Tetradiidæ* among the Palæozoic "Tabulata" than with any others, and that we may therefore suppose, with some probability, that it is really an ancient type of the *Alcyonaria.*

Still greater difficulties surround the attempt to definitely fix the place of the *Monticuliporidæ* in the zoological system. Within late years there has been a strong tendency among palæontologists to relegate the fossils in question to the *Polyzoa*, and a good deal of evidence—some of which will be referred to subsequently—has been brought forward in support of this view (see especially the admirable paper by Dr Lindström on the affinities of the Anthozoa Tabulata in the 'Annals of Natural History,' 1876). The chief ground for the proposal to refer *Monticulipora* and its allies to the *Polyzoa* is found in the resemblance between the ramose *Monticuliporæ* and the Polyzoan genus *Heteropora*, De Blainv., and it must be admitted that the mere *general likeness* between these two types is extremely close. External similarity, however, is an unsafe guide in dealing with questions of zoological affinity, and such evidence as I have at present in my hands leads me to believe that there is in reality no relationship beween *Monticulipora* and *Heteropora.* The latter of these types is best known as occurring in the Tertiary deposits as a fossil, but I possess a large and well-marked recent form from New Zealand, nearly allied to *H. pustulosa*, Busk, and *H. tortilis*, Lonsd., which I have submitted to Mr Busk, and which this eminent authority has pronounced to be new. In this interesting species, as in the extinct forms of the genus, the polyzoary is ramose and calcareous (fig. 34), and consists of long, tubular, thin-walled cells, which radiate from the imaginary axis of the branches to open on the surface by round apertures. The walls of the cells appear to be imperforate, though in some forms of the genus (*H. lævigata*, D'Orb.) they are pierced by minute foramina;

nor are any traces of transverse partitions or "tabulæ" to be detected. Between the true cells, and more or less completely separating them from one another, are numerous smaller "interstitial tubes," which in this particular form appear to have their mouths unrestricted by any partial diaphragm, and which nearly equal the true cells in point of size. It is the presence of these interstitial tubes which gives to *Heteropora* its very close superficial resemblance to the ramose species of *Monticulipora* and *Fistulipora*. Not only is the nature of these tubuli still obscure, but they present the curious feature that they exhibit (in some cases at any rate) structures which, to say the least of it, admit of comparison with the "tabulæ" of *Monticulipora*. Many or all, namely, of the mouths of the "interstitial tubes" of some species of *Heteropora* are closed by a delicate transverse partition or lid, which is perforated in its centre by a small aperture, and is placed a little below the lip of the opening. Sometimes these "hymen-like lids," as shown by Prof. Busk, are periodically produced at successive stages of growth, and thus come to simulate "tabulæ." In *Heteropora clavata*, Goldf., the same distinguished observer has also shown that the mouths of the interstitial tubes commonly exhibit a stellate appearance, owing to the projection into their interior of delicate vertical lamellæ, which simulate the "septa" of the true corals.

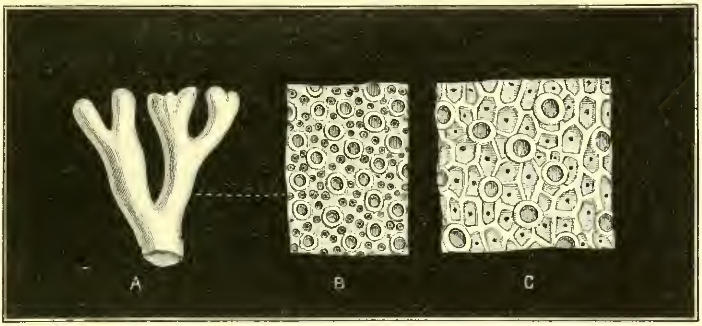


Fig. 34.—A, Fragment of an undescribed living species of *Heteropora*, from New Zealand, of the natural size; and B, Surface of the same, enlarged (original); C, Surface of a branch of *Heteropora subreticulata*, from the Tertiary, enlarged (after Reuss).

When we consider the structural characters of *Heteropora*, as above briefly indicated, it cannot be denied that there is a general resemblance between this type and the ancient *Monticulipora* and *Fistulipora*. Dr Lindström, in the memoir already referred to, has further brought forward a considerable body of evidence, which I shall more fully allude to hereafter, to prove that the developmental history of *Monticulipora* shows it to be a *Polyzoön*. In the meanwhile, however, I am unable to admit that we have sufficient evidence for the removal of *Monticulipora* and its allies from the *Actinozoa*, and their transference to the *Polyzoa*. So far as *Heteropora* is concerned, the genus seems to be sufficiently separated from *Monticulipora* by its total absence of genuine tabulæ in the cells themselves and its (occasionally) perforated walls, together with the occurrence in some forms of radiating septa in the interstitial tubes. On the other hand, *Monticulipora* presents the closest possible resemblance in most of its structural features to the ramose *Favositidæ*, from which it can only be separated by the general possession of two sets of corallites and the apparent absence of mural pores. That the latter are true *Actinozoa* does not, in my opinion, admit of doubt, and I think we must in the meanwhile come to the same conclusion as regards *Monticulipora* itself and the closely-allied *Fistulipora*, *Constellaria*, and *Prasopora*. The three last of these types, and the great majority of the forms usually included under the first name, possess a corallum which is composed of two distinct sets of corallites, a feature which at once reminds us of the *Helioporidæ*, and would lead us to suppose that the *Monticuliporidæ* are to be regarded as an ancient group of *Alcyonaria*. Moreover, the different sets of corallites in these forms are not only unlike in point of size, but the smaller tubes are almost invariably more closely tabulate than the larger tubes, this being another feature in which they unmistakably approach the *Helioporidæ*. In no known forms of *Polyzoa*, not even in *Heteropora*, can a similar condition of parts be shown to exist, and I am therefore of opinion that we are not justified, with the evidence now before us, in removing the *Monticuliporidæ* from the *Actinozoa*, and that we may provisionally regard them as a special group of *Alcyonaria*. It should also be borne in mind in this connection that we are at present quite unacquainted with the *animal* of *Heteropora*, and that it is just possible that an examination of the soft parts of this type—admittedly a very aberrant form of the *Polyzoa*—might show it to be a Cœlenterate. At the same time, I do not at all mean to deny but that some of the fossils which have been described by various palæontologists under the names of *Monticulipora*, *Fistulipora*, or *Callopora*, are probably really *Polyzoa*. Erroneous determinations of this kind, especially where microscopic examination has not been resorted to, are almost inevitable; but they do not affect the systematic position of the forms which are recognised as the *types* of *Monticulipora* and of the genera related to this.

CHAPTER XIII.

GENERA OF CHÆTETIDÆ AND MONTICULIPORIDÆ.

CHÆTETIDÆ.

Genus CHÆTETES, Fischer, 1837.

(Oryct. de Gouv. de Moscou, p. 159.)

Gen. Char.—Corallum massive, composed of long irregularly prismatic erect corallites, which are closely contiguous, and are completely amalgamated by means of their walls. Corallites of one kind only, opening upon the surface by means of irregularly polygonal, non-oblique calices, and destitute of true septa. Walls imperforate. Tabulæ complete, comparatively remote, often placed at corresponding levels in contiguous tubes. Visceral chamber often partially divided by an imperfect longitudinal septum (or by two such septa) resulting from the uncompleted fission of the tube into two young corallites.

Obs.—It is not necessary to enter here into a detailed account of the genus *Chætetes*, except in so far as concerns its relations with the genera *Stenopora*, Lonsd., and *Monticulipora*, D'Orb., and even on this point little need be said. The *type* of the genus *Chætetes* is unquestionably the great *C. radians*, Fischer, of the Carboniferous Limestone of Russia, and the characters of the genus must, therefore, necessarily be based upon this species. This form was for the first time adequately described by Mr Lonsdale (Geol. of Russ., vol. i. p. 595, 1845), who drew special attention to the fact that the walls of the corallites are inseparably united, so that fractures expose the *interior* of the tubes, this structure depending upon the fissiparous mode of increase of the coral. M'Coy (Brit. Pal. Foss., p. 82, 1851) may be considered as entirely accepting Mr Lonsdale's views as to the characters of the genus *Chætetes*. Milne-Edwards and Haime (Brit. Foss. Cor. Intr., p. 61, 1850), while accepting the genus, ignore the feature just alluded to as so strongly emphasised by Mr Lonsdale, and add no character which could be accepted as in any way of generic value. In the "Polypiers Fossiles" (p. 261, 1851) the same authors give a fuller account of *Chætetes*, and they now unite with it the genus *Stenopora*, Lonsd., and also the ill-characterised type which D'Orbigny had named *Monticulipora* (Prodr. de Paléont., t. i. p. 25, 1850). At a still later period (Brit. Foss. Cor., p. 264, 1854), the two distinguished French observers so far altered their views that they accepted *Monticulipora*, D'Orb., as distinct from *Chætetes*, Fischer, the ground of distinction being that in the former the corallum increases by gemmation, whereas in the latter the mode of growth is by fission. Most subsequent writers have followed the course ultimately adopted by Milne-Edwards and Haime, so far as concerns the generic distinctness of *Chætetes* and *Monticulipora*, and the grounds of this distinction. In a paper, however, upon the species of *Chætetes* in the Lower Silurian rocks of North America (Quart. Journ. Geol. Soc., vol. xxx. p. 499, 1874), I formerly expressed the opinion that the genera *Chætetes* and *Monticulipora* were not sufficiently differentiated, and that the mere mode of growth, even if admitted to be of generic value, was a character so difficult, in many instances, of determination, that it should not be regarded as of itself sufficient to separate two types otherwise closely allied. At the same time I stated that I thought *Stenopora*, Lonsdale, to be insufficiently characterised, and pointed out that different observers had defined this genus by means of very different and in some cases comparatively trivial features. To the opinions expressed in the paper just referred to I still adhere—in the sense, that is, that I still think the conclusion which I had then reached the only one justified by the information at that time published. Since that time, however, I have had the opportunity of making a careful microscopic examination of authentic Russian specimens of *C. radians*, Fischer, the type of its genus, and I am now quite satisfied as to its generic distinctness; while a similarly minute investigation of *Monticulipora* and its allies has convinced me that here also we have to deal with a distinct generic type. Lastly, as has been previously shown, I have had now the opportunity, in association with my friend Mr R. Etheridge, jun., of examining authentic Australian specimens of *Stenopora*, Lonsd., and have thus been able to show that this genus is one quite distinct from either *Chætetes* or *Monticulipora*, and, in reality, referable to the Perforate group of the *Favositidæ*.

The type, then, of the genus *Chætetes*, as here restricted, is the *C. radians*, Fischer, of the Carboniferous of Russia, and the generic diagnosis previously given is founded upon an examination of the structural characters of this form. It has, however, been pointed out by Mr R. Etheridge, jun., and myself (Journ. Linn. Soc., vol. xiii. p. 365, 1877) that the corals known as *Alveolites septosa*, Flem., and *A. depressa*, Flem., are generically inseparable from *Chætetes radians*, Fischer; and we have further described another species (*Chætetes hyperboreus*), from the Carboniferous rocks of Scotland, as possessing similar generic characters. All the forms just mentioned are of Carboniferous age, and there are no published species of corals from either older or younger deposits which can, in the meanwhile, be certainly asserted to belong to the same genus. I may say, however, that I have collected in the Devonian Limestone of Gerolstein, in the Eifel, specimens of a coral which would appear to be congeneric with *C. radians*, Fischer.

If we take the corals just mentioned as the only satisfactorily identified species of *Chætetes*, we find that the corallum is massive and usually irregularly hemispherical or pyriform in shape, rarely (*C. hyperboreus*, Nich. and Eth., jun.) forming thin flattened expansions, with a concentrically-striated epitheca below. The corallites are irregularly polygonal, and are in complete contact throughout their entire length. Rough fractures (generally, but not always) expose the interior of the tubes; and thin sections, whether transverse or longitudinal (Pl. XII., figs. 4, 4 *a*, 4 *d*), show that the walls of contiguous corallites are entirely and undistinguishably amalgamated or fused with one another, the originally duplex character of the partition between neighbouring corallites being in no case recognisable. Though somewhat variable in shape and size, the corallites are indubitably of one kind only, and there is no reason for believing that the corallum consisted of two distinct sets of zoöids. The corallites, further, are not reclined, as in the typical species of *Alveolites*, Lam., but are *erect*, in precisely the sense that this term is employed in speaking of the massive coralla of species of *Favosites*, such as *F. Gothlandica*, Lam., and its allies. The calices, therefore, though wanting the regularly polygonal form of those of *Favosites*, are never *oblique* or semilunar, with one lip more prominent than the other, as is so characteristically the case in *Alveolites* and its allies. The walls of the corallites seem to be wholly imperforate, and as this conclusion is based upon a minute examination of thin sections as well as of actual specimens, its correctness may be accepted as tolerably certain. This character, therefore, alone is sufficient to separate *Chætetes* from all the externally similar genera of the *Favositidæ*. No traces whatever either of lamellar or of spiniform *septa* can be detected in thin sections or in the specimens themselves (except some obscure longitudinal striæ in *C. septosus*), and these structures must therefore be considered as wholly wanting. There exists, however, in a certain number of the corallites a curious inward projection of the wall (Pl. XII., figs. 4, 4 *b*), which is seen both in typical specimens of *C. radians*, Fischer, and also in *C. hyperboreus*, Nich. and Eth., jun., *C.* (*Alveolites*) *septosus*, Flem., and *C.* (*Alveolites*) *depressus*, Flem. In the two last-mentioned species this inward process was noticed and figured by Edwards and Haime, and they regarded it as being a "septal tooth," similar to the unpaired septal ridge of certain species of *Alveolites*. As pointed out by Mr R. Etheridge, jun., and myself, however (Journ. Linn. Soc., vol. xiii. p. 366), this supposed septal tooth was more correctly interpreted by Mr Lonsdale (Geol. Russ. and Ural, vol. i. p. 95), who regarded it as being an inflection of the wall of the corallite, due to its undergoing the process of division by fission into two tubes. That this view is the correct one is shown by the fact that this inwardly-projecting ridge is of variable length and of equally variable occurrence. It is never present in more than a quite limited number of the tubes, and it varies in size from a hardly perceptible protuberance up to a vertical lamina extending half-way or more across the tube, while it is not uncommonly faced by a corresponding ridge upon the opposite side of the visceral chamber. Lastly, the *tabulæ* in *Chætetes* are always well developed, and are invariably complete and horizontal. Mr Lonsdale considered that the tabulæ of *Chætetes* were placed at corresponding and remote levels, and separated by zones in which no tabulæ were developed, but Milne-Edwards and Haime explicitly deny this (Pol. Foss. des Terr. Pal., p. 261). So far as *Chætetes radians*, Fischer, is concerned, the truth seems to lie between these two extremes, for the tabulæ are certainly developed throughout the entire course of the corallites at comparatively remote intervals (Pl. XII., fig. 4 *a*); but they are, at the same time, periodically developed at corresponding levels at certain horizons, so that the corallum as a whole readily splits into a series of concentric layers. In the other species here included in the genus the tabulæ appear to be developed more irregularly, though they are always present.

As regards the zoological affinities of *Chætetes*, it is not possible at present to reach any final conclusion. In spite of the resemblance of the corallum of *Chætetes* to that of some forms of *Favosites* (such as *F. Bowerbanki*, E. and H., sp.), it is quite clear that there is no direct relationship between these two types, if we admit that the former possesses imperforate walls, as seems all but absolutely certain. At the same time, I see no reason whatever for accepting the view, advocated at the present day by high authorities, that *Chætetes* is not truly a Cœlenterate. I am quite unable to recognise in the structure of the fossils referred to this genus anything which would justify us in referring them to the *Polyzoa* (as advocated by Lindström and others), and I think the general details of their structure to be such as are only compatible with their being members of the *Cœlenterata*. The precise position which they should occupy among the *Actinozoa* is a point upon which it is far more difficult to arrive at any positive conviction. Upon this point, while confessing the absence of positive evidence, I can only say that I am disposed to agree with Professor Martin Duncan (Third Rep. on Brit. Foss. Cor.; Brit. Ass. Reports, 1871, p. 128) in thinking that *Chætetes* is probably an Alcyonarian.

As to the relations of *Chætetes* to allied genera, it can only be said at present that there is nothing save close external resemblance to unite the genus with any other, and especially with the group of which *Monticulipora* is the central type. For reasons previously given, I have not thought myself justified in definitely separating the species of the latter from *Chætetes*, with which they often agree in general form and habit, as well as in the imperforate walls of their corallites; but I entertain at the same time a strong conviction that there is little or no true affinity between the two. Most of the so-called *Monticuliporæ*, apart from other peculiarities, have heteromorphic coralla, composed of two distinct sets of zoöids, and in all of them the walls of the corallites are not amalgamated with one another. These distinctions alone are quite sufficient to fundamentally separate the typical forms of *Monticulipora* from *Chætetes*. The type with which *Chætetes* shows the strongest affinity is the Silurian *Tetradium*; but in this genus we have well-developed and definitely-disposed lamellar septa, and we can therefore hardly suppose that the two genera are closely related.

The species of *Chætetes*, as here defined, are not known to occur out of the Carboniferous (and possibly the Devonian) rocks; and I shall give a brief description of the type-species, *C. radians*, Fischer, founded upon an examination of specimens derived from the Carboniferous Limestone of Russia and the north of England.

Chætetes radians, Fischer.

(Pl. XII., figs. 4, 4 *d.*)

Chætetes radians, Fischer, Oryct. de Moscou, p. 160, Pl. XXXVI., fig. 3, 1830.
„ *radians*, Lonsdale, Russ. and Ural, vol. i. p. 595, Pl. A, fig. 9, 1845.
„ *radians*, Milne-Edwards and Haime, Pol. Foss. des Terr. Pal., p. 263, Pl. XX., figs. 4, 4 *a*, 1851.
„ *radians*, Milne-Edwards and Haime, Brit. Foss. Cor., p. 158, 1852.

Spec. Char.—Corallum massive, of large size, composed of long basaltiform, closely contiguous corallites, which are intimately united by their walls. Calices irregularly polygonal, often elongated, being in the former case about a fourth of a line in diameter on an average, whereas in the latter case they are about one-fifth of a line or less in their short diameter, and one-third of a line in their long diameter. Walls imperforate. Septa wanting. Visceral chamber commonly partially divided by an imperfect longitudinal partition on one side, which appears in the calice as a tooth-like process, and which is sometimes confronted by a similar process proceeding from the opposite wall of the tube. The tabulæ are complete, well developed, variable in number, sometimes about a quarter of a line apart, sometimes much more remote, and often specially developed along planes concentric with the surface, so that the corallum splits into a succession of concentric layers or zones.

Obs.—The Russian examples of this species which I have had the opportunity of examining form large masses of a pyriform shape, six inches or more in height, and composed of long basaltiform tubes which are in complete contact throughout, and which, though somewhat unequal in point of size, are not divisible into a series of larger and smaller corallites. Transverse and longitudinal microscopic sections (Pl. XII., figs. 4 and 4 *a*) show that the walls of contiguous corallites are absolutely and uniformly amalgamated, so that no traces whatever can be detected of the original divisional lines between them. The walls are thick, and the most careful examination both of actual specimens and of thin sections has failed to produce any evidence of the existence of mural pores; so that we must accept the view held by all the older observers of this species as to the imperforate condition of the walls of the corallites. The calices, like the corallites, are unequal in point of size, though in no uniform manner, and commonly exhibit an inward tooth-like projection (Pl. XII., fig. 4 *b*) on one side, sometimes with a similar but smaller corresponding process on the opposite side of the tube. These tooth-like projections are never present in more than a quite limited number of the tubes, and they vary much in length; while transverse sections (Pl. XII., fig. 4) show them to be produced by the existence of a vertical lamella or longitudinal inflection of the wall of the corallite. Their true nature was pointed out by Lonsdale (*loc. cit.*), who maintained that they were due to the uncompleted fission of the old tubes, the fissiparous mode of development being characteristic of the species. The correctness of the views of Mr Lonsdale upon this point has subsequently been upheld by Mr R. Etheridge, jun., and myself (Journ. Linn. Soc., vol. xiii. p. 366). The tabulæ (Pl. XII., fig. 4 *a*) are always numerous, and are invariably complete and horizontal; and Milne-Edwards and Haime are perfectly right in asserting (in their description of the genus *Chætetes*) that they are not uniformly placed at corresponding levels in contiguous tubes. At the same time Mr Lonsdale is correct in his assertion that the species possesses "diaphragms in parallel bands;" for the tabulæ are specially developed periodically, at the same level in all the tubes, so that the corallum is conspicuously composed of a succession of concentrically disposed strata, which generally have a thickness of from half an inch to three-quarters of an inch.

In addition to specimens from the Carboniferous Limestone of Moscow, I have examined a number of examples which I have collected from the Carboniferous Limestone of the north of England—a formation from which *C. radians* is quoted by Milne-Edwards and Haime. The British specimens entirely resemble the Russian ones in their shape and general configuration, in their long basaltiform corallites, and in the composition of the corallum out of concentrically disposed strata formed by a periodic development of tabulæ at corresponding levels. At the same time there are some differences between the two sets of specimens. The English examples (Pl. XII., figs. 4 *c* and 4 *d*) have rather smaller tubes, which are more regularly polygonal, and more uniform in shape, and which are slightly more thin-walled than is the case in Russian specimens. The tabulæ also are not nearly so numerous, and few of these structures are developed between the concentric zones of these diaphragms, by which the whole colony is divided into superimposed strata. At the same time, there is the same total amalgamation of the walls of the corallites, and in certain of the tubes we always see the same tooth-like projection indicating the approaching division of the corallite into two. Upon the whole, therefore, in spite of the differences just noted, I am not disposed to regard the British specimens as more than a mere variety of the typical *C. radians* of Russia.

As has been already pointed out, *C. radians*, Fischer, is closely allied to *C.* (*Alveolites*) *septosus*, Flem., *C.* (*Alveolites*) *depressus*, Flem., and *C. hyperboreus*, Nich. and Eth., jun., with which it forms a most natural group; and all of these forms are characteristic of the Carboniferous Limestone. The last mentioned of these species is easily separated from *C. radians* by the lamellar and expanded form of the corallum, as well as by other characters, and *C. depressus*, Flem., is similarly separable by the very small size of its tubes. On the other hand, *C.* (*Alveolites*) *septosus*, Flem., so nearly approaches *C. radians* in its leading characters, that the specific distinctness of the two may well be called in question, but I am unable to offer any definite opinion upon this subject till I may have been able to examine the original specimens of the former species. All that I can say now is, that such specimens as I have seen of the British Carboniferous coral ordinarily called by the name of *C. septosus*, or *Alveolites septosa*, seem to be very similar in appearance and structure to *C. radians*, Fischer, though a microscopic examination may yet show that they are distinct.

Formation and Locality.—Carboniferous Limestone of Moscow, Russia. Not uncommon in the Carboniferous Limestone ("Orton Scar Limestone") of Hardendale Nab, near Shap, Westmorland, and in the same limestone at Penruddock, Cumberland. (Quoted by Milne-Edward and Haime from the same horizon at Kendal, Westmorland.)

MONTICULIPORIDÆ.

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.

Gen. Char. — Corallum very variable in shape, massive, ramose, laminar, frondescent, or encrusting, composed of numerous tubular closely-approximated corallites, the walls of which are not amalgamated with one another. Walls imperforate (so far as certainly known, though one or two forms otherwise undistinguishable from the genus unquestionably possess "mural pores"). Septa entirely wanting. Tabulæ always well developed, complete. Corallites usually distinctly divisible into two series, one of large and the other of small tubes, the latter usually more closely tabulate than the larger ones, or otherwise differing from these in structure. Surface commonly exhibiting at regular intervals definite areas occupied by corallites which are larger or smaller than the average. These areas are commonly elevated above the general surface, and are then known as "monticules."

Obs.—The corals which are usually known by the name of *Monticulipora*, together with the forms allied to this, constitute perhaps the most intricate and difficult assemblage of Palæozoic fossils with which the zoophytologist is called upon to deal. I had originally intended to devote considerable space to this group; but I find that the limits of this work will not allow of my carrying out this intention, and I have decided rather to publish an entirely separate memoir upon the *Monticuliporidæ*. Here, therefore, I shall merely give a brief outline of the general results of the investigations which I have been carrying out as to the internal structure of the corals usually referred to *Monticulipora* and allied types.

[It may not be out of place if I add a few remarks here as to the proper method of making thin sections of the *Monticuliporidæ;* for the results which I have obtained will certainly not be reached by other investigators, unless they follow the plan of procedure which I have adopted. In any massive or ramose *Monticulipora* (and, I may add, in *any* coral similarly composed of tubular corallites radiating from an imaginary axis), the true structure can only be understood by making *three* distinct sections. Two of these sections are perfectly obvious and natural ones—one being *transverse*, or at right angles to the long axis of the corallum, while the other is *vertical*, and is taken *in the median plane of the corallum and parallel with its long axis.* I used myself to consider these two sections sufficient, and probably others have entertained a similar opinion. Owing, however, to the fact that the diverging corallites often very materially alter their character just before they open on the surface, and owing also to the generally very limited inward extension of the interstitial small corallites (the so-called "cœnenchymal tubules"), as also of the curious intertubular spines which are commonly present, it is absolutely necessary to make a *third* series of sections which should run *just below the calices of the corallites and at right angles to the long axis of the latter.* The direction in which it will be necessary to cut any given coral to obtain sections of this nature will always vary with the form of the corallum; but these sections may be termed *tangential*, as they must in all cases be taken in a direction tangential to the calicular surface and just below that surface. Sections of this kind are most instructive and important; and from my ignorance of their value and consequent neglect to prepare them, I have fallen into grave errors, or failed to seize the true structure, in the case of certain forms of this group, of which I have on former occasions described the minute characters.]

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 well-known *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. 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* seem to be 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.

As regards the later history of *Monticulipora*, it is sufficient to add here that Milne-Edwards and Haime at first placed all the forms referred to this genus under *Chætetes* (Pol. Foss. des Terr. Pal., p. 261, 1851), but that they subsequently accepted the genus as distinct (Brit. Foss. Cor., p. 264, 1854). In this course—whatever differences of opinion as to the affinities of the genus may have been expressed—Milne-Edwards and Haime have been followed by almost all palæontologists. For my own part, as previously mentioned in speaking of *Chætetes*, I have been disposed to consider that no sufficient characters had been indicated whereby *Monticulipora*, D'Orb., could be separated generically from *Chætetes*, Fischer; and I have described a number of species of the former genus under the latter title. Having now, however, had the opportunity of examining authentic specimens of the type-species of *Chætetes* (the *C. radians*, Fischer, of Russia), I am quite satisfied as to the complete distinctness of this genus, and, consequently, as to the necessity for retaining the genus *Monticulipora*.

The genus *Monticulipora*—using this term in the meanwhile in a wide general sense—includes Palæozoic coralla of the most variable form. In many cases the corallum is massive, consisting of a variably-shaped aggregation of diverging corallites based upon an inferior epitheca, and having the calices placed exclusively upon the upper surface. In other cases, including, perhaps, the majority of species, the corallum is ramose, or dendroid, fixed by its base, and having the calices opening over the whole of the free surface. In another group the corallum is fixed by its base, but has the form of a flattened, palmate, and variously-divided frond, the corallites diverging from the imaginary median plane of the expansion and opening on the two flat surfaces. In still another group, the corallum forms a thin crust, growing parasitically upon foreign bodies; but though some undoubted species of the genus have this habit, it is probable that a considerable number of the so-called encrusting *Monticuliporæ* will prove, upon adequate examination, to be truly of a Polyzoan nature. Be this as it may, it is quite certain that the mere *form* of the corallum, though affording a useful guide to the collector, is usually of no value whatever in determining the structure and affinities of a given specimen of *Monticulipora*. As an illustration of this fact, I may mention that among the corals which, from their general form and superficial characters, would unhesitatingly be placed under the well-known species *M. petropolitana*, Pand., I find at least three well-marked types to be included, which differ so widely from one another in minute structure, that they might well be regarded as at least distinct sub-genera. At the same time, certain species, and especially those which have a laminar or frondescent corallum, are very constant in their mode of growth, so that in these cases the form of the corallum really is of value in the determination of species; while the ramose species, however variable, never appear to form crusts on foreign bodies, as some of the massive species occasionally do.

The corallites in *Monticulipora* may be distinctly prismatic or polygonal, or they may be rounded and nearly cylindrical, but in either case they are always in close contact, and they never really exhibit the condition of parts characteristic of *Chætetes* proper, in which, as has been shown, the walls of contiguous corallites are so completely amalgamated that the original lines of demarcation between neighbouring tubes cannot be in any way detected. In some cases (*e.g.*, in the typical *M. petropolitana*, Pand.) the walls are so thin that the partitions between the visceral chambers of contiguous corallites appear to be absolutely indivisible, and present themselves in thin sections merely as delicate dark lines (fig. 35, A). This is, however, a state of parts very different to what occurs in *Chætetes* proper (fig. 35, D), and is much more nearly comparable to what we observe in many species of *Favosites*. In other cases, the condition of things is very like that observable in *Favosites* generally, in which the walls of contiguous tubes are distinct, and the line of demarcation between them remains clearly marked out in cross-sections of the corallites (fig. 35, C). This occurs, for example, in typical specimens of *M. pulchella*, E.

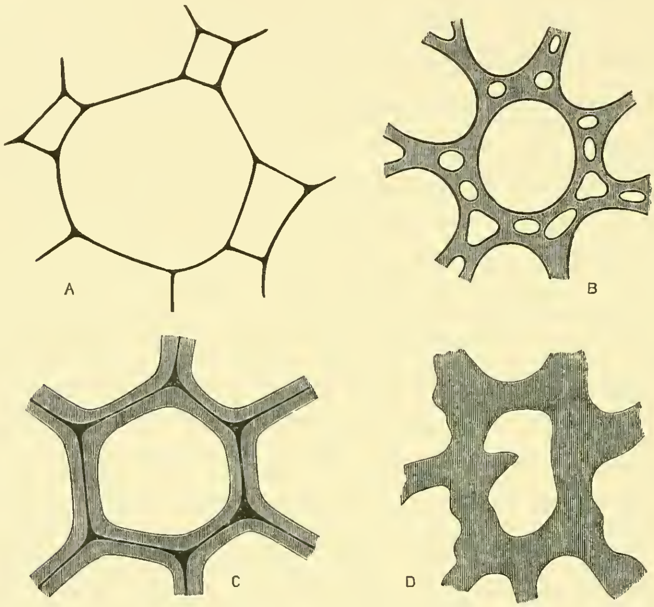


Fig. 35.—A, Tangential section of a few corallites of the typical *Monticulipora petropolitana*, Pand., from the Lower Silurian of Sweden; B, Tangential section of a corallite of a typical example of *Monticulipora ramosa*, E. and H., from the Cincinnati group of Ohio; C, Tangential section of a corallite of *Monticulipora pulchella*, E. and H., a typical example 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.

and H., from the Wenlock Limestone of England. In still another group of cases, embracing many typical species of the genus (*e.g.*, *M. mammulata*, D'Orb.), 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 (fig. 35, B), the state of matters really differs widely from that which exists in *Chætetes* proper, since each visceral chamber is enclosed by a distinct dark line, 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.

Apart from the evidence of microscopic sections, into which I cannot fully enter here, the permanent non-amalgamation of the walls of the corallites in *Monticulipora* is shown by the fact that fractured surfaces 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).

There is at present no evidence as to the existence of "mural pores" in *Monticulipora* or its allies. Considering the minute size of the tubes, and the great difficulties which commonly attend the detection of these apertures in microscopic sections, the non-recognition of pores does not absolutely imply their non-existence. We know that pores are present in the similar-looking *Stenopora*, Lonsd.; I have previously shown that similar apertures exist in the *Favosites Bowerbanki*, E. and H. sp. of the Upper Silurian, which has hitherto been regarded as a *Monticulipora;* and, as before remarked, I have recently examined a specimen from the Upper Silurian of Dudley, in which the general characters of *Monticulipora* are present, but the walls are minutely porous. Moreover, the microscopic examination of weathered or fractured surfaces often brings to light deficiencies in the walls of the tubes, though whether these are accidental, or are really of the nature of "mural pores," is a point upon which I have hitherto been unable to satisfy myself. In the want of direct and positive evidence, we must at present assume the walls in *Monticulipora* and its allies to be imperforate. At the same time I should not be surprised if future and more extended investigations should show that mural pores really exist; though it may be safely assumed that any structures of this kind that may be detected will prove to be proportionately more minute, and more irregular in their size and distribution, than is the case with these openings in the typical *Favositidæ*.

Whatever may be the condition of the walls in *Monticulipora*, microscopic examination brings out very clearly the important fact that in the vast majority of cases, and probably invariably, the corallum is truly *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 in 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." 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 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 almost always be demonstrated; and the importance of this fact, from a theoretical point of view, can hardly be over-estimated. The relations of the two sets of tubes to one another vary extremely in different forms of *Monticulipora*, and I shall employ these variations as the basis of a provisional classification of the multitudinous forms included under this head. I shall, therefore, postpone a further consideration of this subject till I come to speak of the different groups which may be comprehended under the general name of *Monticulipora*.

I must, however, briefly notice here certain peculiar superficial features in different species of *Monticulipora*, which are in reality due to the dimorphic condition of the corallum just spoken of. 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 the 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. Those forms, moreover, in which the walls are thickened towards the surface are particularly liable to exhibit a feature, sometimes seen in the thin-walled species, and common to most or all of the species of *Stenopora*, Lonsd., which demands a little consideration here, though its true significance is still somewhat dubious. I allude to the occurrence 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 various 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. (figs. 36, 37), *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 perforated by any apical apertures. When examined by means of thin sections, however, 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 (fig. 37) 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, therefore, 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

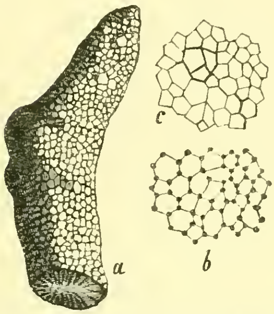


Fig. 36.—*a*, Fragment of *Monticulipora moniliformis*, Nich., from the Hamilton Group of Ontario, enlarged; *b*, Portion of surface of same enlarged further; *c*, Portion of surface of *M. Barrandi*, Nich., enlarged.

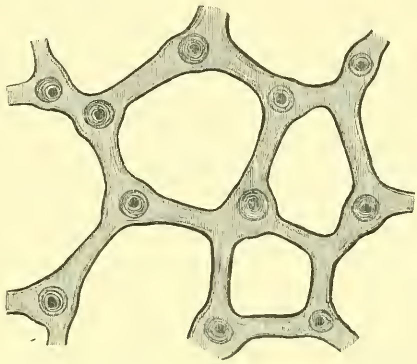
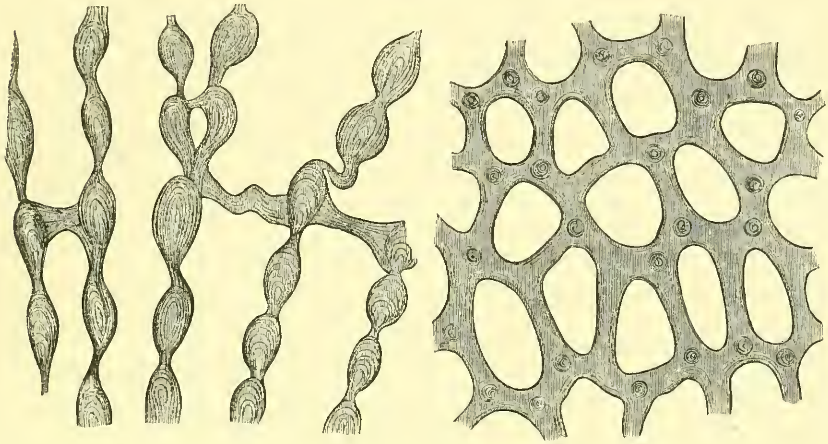


Fig. 37.—Portion of a tangential section of *Monticulipora moniliformis*, Nich., taken just below the surface, showing the intracalicine spines, enlarged fifty times. From the Hamilton Group of Ontario.

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. The correctness of this view is most readily recognised when we come to examine thin sections of those forms which have usually been separated from *Monticulipora* under the generic title of *Dekayia*, E. and H. In these cases (Pl. XV., figs. 1 *b*, 1 *c*) 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 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. (figs. 36, 37), *M. Jamesi*, Nich., *M. tumida*, Phill., *M. gracilis*, James, and others, are similarly peculiarly modified corallites, the mouths of which 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 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 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). 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. 38), we see that the surface-spines are continued inwards precisely as they are in *Monticulipora moniliformis* and allied types, while they are similarly composed of concentrically-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. 38, A) 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.

More conspicuous, more generally familiar, and more uniformly present than the spines, are those structures in the *Monticuliporæ*, which are known as "monticules" and "maculæ." The "monticules" or "mamelons" are circumscribed areas on the surface of the corallum, which are, typically, elevated so as to form a series of rounded, oval, or elongated



A B

Fig. 38.—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.

projections, but which may be nearly or quite level with the general surface. Sometimes the "monticules" are composed of corallites which differ in no conspicuous feature from those which form the rest of the coral (*e.g.*, in *M. ramosa*, D'Orb.); in other cases (*e.g.*, *M. pulchella*, E. and H.) the corallites which form the "monticules" are of a markedly larger size than the average; while in still other forms (*e.g.*, *M. frondosa*, D'Orb.) the "monticules"—in this case flat—are occupied by corallites much more minute in their size than those which form the bulk of the colony. The so-called "maculæ" are simply "monticules," in which the mouths of the tubes have become closed by a calcareous membrane.

The only other point as regards the structure of the *Monticuliporæ* which need specially be noticed here concerns the disposition of the *tabulæ*. These structures are invariably present in the typical *Monticuliporæ*, and are almost invariably "complete." The only exception to the latter part of this statement with which I am acquainted is the curious *M. frondosa*, D'Orb., in which the tabulæ seem to have the form of crescentic diaphragms, with an excentric aperture or perforation on one side. As a rule, the tabulæ are very sparsely developed in the axial and deeper portions of the corallum, and become much more numerous as the tubes approach the surface. As a rule, also, the tabulæ are conspicuously more numerous and more closely set in the smaller corallites of the two sets of tubes of which the corallum is normally composed. In a few forms, lastly, the tabulæ may become curved, so as to assume a subvesicular or vesicular aspect; but this is quite an exceptional feature.

With regard to "septa" in the *Monticuliporæ*, it need only be said that no traces of these structures have hitherto been detected in any Monticuliporoid. Occasionally one may see in thin transverse or tangential sections a single azygous septum projecting for some distance into the interior of a tube, but this seems to be really the result of fission of a corallite, as we have seen to be the case in *Chætetes*.

As regards the *development* of the *Monticuliporæ* I have little to say from actual observation, and that little will be best said after I have given some account of the views held upon this subject by Dr Gustav Lindström (Ann. Nat. Hist., ser. 4, vol. xviii. p. 5 *et seq.*) 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. 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 the *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 hemisphericus* of Ferd. Roemer (Sil. Faun. of 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*."[1] From this "*Fistulipora* stage" the colony is stated to pass next into what Dr Lindström calls the "*Thecostegites* stage," in which the interstitial tubes become covered with "a thin smooth calcareous membrane," leaving the larger tubes open, and causing

[1] 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., are just as "complete" as they are in the typical members of the *Favositidæ*.

their mouths to assume a circular or oval shape, and to project above the general surface. Lastly, the fossil 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 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 very 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 crescentic mouths, and, so far as I have observed, wholly devoid of tabulæ. (Dr Lindström states that tabulæ exist in *Ceramopora*, but I have been unable to detect these structures in thin sections; though I have found tabulæ in some specimens of a *Monticulipora* from the Wenlock Limestone of Dudley, which may perhaps be the *M. papillata* of M'Coy, and which certainly has more of the look of a Polyzoön than is usual in species of *Monticulipora*.) 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 genetic 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 *Lichenalia* 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, 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 I hope to show that in one sense 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, at most, mere subgeneric forms of *Monticulipora*. I shall show, namely, that the possession of a dimorphic corallum is a common feature in all 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, I shall endeavour to show 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.

As regards the zoological position of the *Monticuliporidæ*, there has been of late, as is well known, a strong tendency on the part of palæontologists to remove them from the *Cœlenterata*, and to relegate them to the *Polyzoa*. Some of the grounds upon which this step has been proposed merely concern the general resemblance in external characters between the Monticuliporoids and certain of the *Polyzoa* (such as *Heteropora*); and I have already expressed my opinion of the value of this resemblance in speaking of the systematic position of *Chætetes*, Fischer. The only positive and direct evidence in favour of the removal of the *Monticuliporæ* to the *Polyzoa* is to be found in the account of the development of the former as given by Lindström, and I have given the reasons which prevent me from accepting that account. Without, then, going into this question in detail, I may simply say that I see at present no sufficient ground for removing the Monticuliporoids to the *Polyzoa*. I do not think any weight can be attached to external appearance 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 almost always (I expect, always) 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*.

As for the relations of *Monticulipora* to other types of the so-called "Tabulate Corals," the genus is separated from all the *Favositidæ*, including the similar-looking *Stenopora*, Lonsd., by the possession of imperforate walls to the corallites.[1] Admitting the absence of mural pores, in the want of direct evidence to the contrary, we have only to compare *Monticulipora* with a very limited number of types, of which the most important is *Chætetes* of Fischer. From this latter the present genus is sufficiently distinguished by the non-amalgamation of the walls of contiguous corallites, by the want of the curious vertical ridge which is found in the interior of many of the corallites of *Chætetes*, and by the possession of two sets of corallites in the corallum, one set of tubes being commonly disposed in special groups. From *Tetradium*, Dana, *Monticulipora* is sufficiently distinguished by its total want of septa and by the dimorphic structure of the corallum. To *Heliolites* and its allies the various types included under the general name of *Monticulipora* present a considerable alliance, especially if we compare the structure of such a form as *Fistulipora* (*Callopora*) *incrassata*, Nich., with that of a form like *Propora tubulata*, E. and H. The absence of septa is, however, sufficient to distinguish *Monticulipora* from the *Helioporidæ*.

[1] As before remarked, it is not impossible that "mural pores" may yet be demonstrated to exist in *Monticulipora*. This is the more likely, if we remember that these openings have as yet been absolutely demonstrated in only two species of *Stenopora*; so that some exceptionally well preserved specimen, or some lucky section, may bring them to light in the Monticuliporoids at any time.

From *Prasopora*, Nich. and Eth., jun., *Monticulipora* is distinguishable only by the very peculiar structure of the tabulæ of the former. Lastly, I need not attempt to differentiate from *Monticulipora* the types known by the names of *Dekayia*, E. and H., *Constellaria*, Dana, and *Fistulipora*, M'Coy (= *Callopora*, Hall), as I shall include all these under the former genus, retaining their titles as of subgeneric value, and shall, therefore, speak of them at greater length hereafter.

The number of forms included under the comprehensive title of *Monticulipora*, D'Orb., is so large, and the variations in the minute structure of these are so important, that the genus must of necessity be split up into sections, which may be distinguished by separate names. It is impossible here for me to give anything like a full account of my researches into this subject, and I shall, therefore, content myself with simply giving a brief summary of the general conclusions at which I have arrived, together with short descriptions of some illustrative species of the genus. Taking the intimate structure of the corallum as the sole reliable basis for the subdivision of the genus, I propose to include under the general name of *Monticulipora*, D'Orb., the following six subgeneric groups, which will be best designated by special titles, and some of which have been previously described as distinct genera.

I. Heterotrypa, Nich.—Corallites of two or sometimes of three kinds; the larger ones subpolygonal, partially separated by the development of numerous smaller circular or irregularly-shaped tubes, of which there is no more than a single row. Walls thickened towards the mouths of the tubes. Tabulæ conspicuously more numerous in the smaller tubes than in the larger ones. Type of the group the *Monticulipora mammulata*, D'Orb. (which is also the type of the whole genus).

II. Dekayia, Edwards and Haime.—Corallites of two kinds, the larger tubes with thin walls, polygonal in shape, and provided with well-developed tabulæ. The smaller tubes isolated by the larger corallites, apparently destitute of tabulæ, their walls greatly thickened, and appearing on the surface as so many detached spiniform processes placed at the angles of junction of the larger tubes. Type of the group, *Dekayia aspera*, E. and H.

III. Constellaria, Dana. — Corallites of two kinds, the larger ones circular or oval, with well-developed walls, which become somewhat thickened as the calices are approached, the tabulæ being few in number and developed chiefly in the outer portions of the corallum. Small corallites developed at the angles of junction of the larger tubes, and more especially in the depressed centres of closely-disposed stellate areas, which project above the general surface as conspicuous star-shaped elevations. Walls of the small corallites imperfectly developed, their shape being angular, or subangular, and their tabulæ being numerous and sometimes subvesicular. Type of the group, *Constellaria antheloidea*, Hall.

IV. Fistulipora, M'Coy (= Callopora, Hall).—Corallites of two kinds, the larger ones circular or oval, with few and remote tabulæ, but with well-developed walls, which are not thickened towards the mouths. Small corallites completely isolating the larger tubes, round which they are developed in one or more rows, with numerous tabulæ, which sometimes become vesicular by imperfection of the walls of neighbouring corallites. The shape of the smaller tubes is markedly angular (sometimes round ?); and though they may be specially developed in star-like areas, these areas never project as stellate elevations above the general surface. Type of the group, *Fistulipora minor*, M'Coy.

V. Diplotrypa, Nich.—Corallites of two kinds, the larger ones thin-walled throughout, conspicuously polygonal, with comparatively few and remote tabulæ, which occasionally are developed in a peculiar bilateral manner, so that the two halves of the tube are provided with tabulæ of a different kind and form. The large corallites are usually or always 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 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. Type of the group, *Monticulipora petropolitana*, Pander.

VI. MONOTRYPA, Nich.—Corallites of two kinds, which are not conspicuously different from one another. The larger tubes aggregated into clusters or "monticules," and very slightly differing in size from the smaller ones. The smaller tubes occupying all the spaces between the monticules. All the corallites, of both kinds, uniformly thin-walled, regularly polygonal, and similarly tabulate, the tabulæ being remote and few in number, and not uncommonly disposed at corresponding levels in contiguous tubes. Type of the group, *Monticulipora* (*Chætetes*) *undulata*, Nich.

Sub-genus HETEROTRYPA, Nich., 1879.

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. (Pl. XIII., figs. 2-2 *a*), *M. rugosa*, E. and H., *M. frondosa*, D'Orb., *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 (sometimes trimorphic), and consists of two sets of corallites of different sizes. The larger tubes are subpolygonal 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 subpolygonal or rounded, and more or less thickened towards their mouths. Sometimes (as in *M. frondosa*, D'Orb., *M. tumida*, Phill., &c.) many of the smaller corallites become abnormally thickened, so as to constitute a third series, in which tabulæ do not appear to be developed, and which present themselves on the surface as a series of blunt spines. In other cases—whether or not spiniform corallites are present—the small corallites are more closely tabulate than the larger ones, and are thus easily recognised in longitudinal sections (Pl. XIII., figs. 1 *b* and 2 *a*). The general characters of the *Monticuliporæ* of this section will be best understood from the following very brief descriptions of *M. mammulata*, D'Orb., and *M. ramosa*, D'Orb.

Monticulipora (Heterotrypa) mammulata, D'Orb.

(Pl. XIII., figs. 1 - 1 *b*.)

Monticulipora mammulata, D'Orbigny, Prodr. de Paléont., t. 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; and Pal. of Ohio, vol. ii. p. 207, 1875.

Spec. Char.—Corallum in the form of thin undulated expansions, from two to four lines in thickness, consisting of two layers of corallites, which diverge from an imaginary central plane, to open on both sides of the frond. Surface covered with well-marked "mamelons" placed at intervals of from half a line to a line, and composed of corallites, which may be slightly larger than the average, and which sometimes have their calices closed by a calcareous membrane. Large or average corallites polygonal, their walls but slightly thickened towards their mouths, from eight to ten occupying the space of one line. Small tubes not very numerous, wedged in among the larger corallites, and generally subpolygonal or angular in shape. Large corallites with few and remote tabulæ; small corallites closely tabulate.

Obs.—This species is so well known that I need only make a few remarks upon its minute structure, as elucidated by thin sections. Both tangential and vertical sections (the latter taken at right angles to the plane of the frond) show that the corallum is really dimorphic; though the mere examination of the surface with a lens, except in occasional specimens, would lead one to conclude that small tubes are almost wanting. Tangential sections (Pl. XIII., figs. 1 and 1 *a*) show, however, that there exists really a fair number of small tubes scattered among the larger corallites in an indiscriminate manner; and vertical sections (Pl. XIII., fig. 1 *b*) prove that these are really special corallites, as they are much more closely tabulate than the ordinary corallites. There seems also generally to exist a very small number of thickened spiniform tubes, easily recognised in tangential sections by their circular outline and thick dark margins; though I have not been able to detect spines on the surface. The corallites which occupy the "mamelons" certainly *look* a little larger, as a rule, than the average; but as they cannot be recognised in thin sections, I suspect this is an illusory appearance, due to their greater nearness to the eye of the observer. Their calices may be open, or may be closed by a thin calcareous membrane, and they often have minute tubes intercalated among them. The walls of the corallites, both large and small, are slightly but unmistakably thickened by a deposit of light-coloured sclerenchyma, which increases in amount as the calices are approached (Pl. XIII., fig. 1 *a*); but in the limited extent of thickening, as well as in the comparatively small number of the smaller corallites, *M. mammulata* shows itself to be not nearly such a characteristic member of the section *Heterotrypa* as *M. ramosa*, D'Orb., *M. frondosa*, D'Orb., *M. Jamesi*, Nich., or *M. tumida*, Phill.

Formation and Locality.—Abundant in the Cincinnati group, Cincinnati, Ohio.

Monticulipora (Heterotrypa) ramosa, Edwards and Haime.

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

Monticulipora ramosa, D'Orbigny, Prodr. de Paléont., t. i. p. 25, 1850.
Chætetes ramosus, Edwards and Haime, Pol. Foss. des Terr. Pal., p. 266, Pl. XIX., figs. 2, 2 *a*, 1851.
Monticulipora ramosa, Edwards and Haime, Brit. Foss. Cor., p. 265, 1854.
Chætetes Dalei, 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.

Spec. Char.—Corallum dendroid, of cylindrical or elliptical branches which divide dichotomously, and vary from one to three or four lines in diameter. Corallites markedly divided into two series, the larger ones being rounded or elliptical, about a seventh or an eighth of a line in their long diameter, and opening on the surface by subpolygonal calices, which have somewhat thickened margins. The small corallites are excessively numerous, surrounding the larger tubes in a single row, and often completely isolating them, their shape and size being very variable. In internal structure, both sets of corallites are traversed by complete horizontal tabulæ, which are much more numerous in the small tubes than in the large ones. Walls thickened towards the mouth. Surface covered with conical or somewhat elongated "mamelons," placed at intervals of from half a line to a line, and not occupied by corallites of specially large or small dimensions.

Obs.—The external characters of this species are too well known to require further remark here; but we may note the following features in the intimate structure of the corallum, as shown in thin sections. In thin tangential sections (Pl. XIII., fig. 2) the most striking appearance is 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*) *Jamesi*, Nich., *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. Vertical sections (Pl. XIII., fig. 2 *a*) 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. 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 the two are probably but varietal forms of a single species. The only difference between the two, in fact, is to be found in the marked transverse elongation of the "monticules" of the former.

Formation and Locality.—Common in the Cincinnati group, Cincinnati, Ohio.

Sub-genus DEKAYIA, Edwards and Haime, 1851.

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

This section of the genus *Monticulipora* includes only one or two types, which were separated by Edwards and Haime as a distinct genus under the name of *Dekayia*, but which I regard as forming a group 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* (*Heterotrypa*) 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. The more minute characters of the sub-genus will appear from the following very brief description of *Dekayia attrita*, Nich., the only species with which I am acquainted, and which is very probably identical with the type-species *D. aspera*, E. and H.

Dekayia attrita, Nich.

(Pl. XV., figs. 1 - 1 *c*.)

Chætetes attritus, Nicholson, Quart. Journ. Geol. Soc., vol. xxx. p. 503, Pl. XXIX., figs. 4, 4 *a*, 1874; Pal. of Ohio, vol. ii. p. 194, Pl. XXI., fig. 4, 1875.

Dekayia attrita, Nicholson, Ann. Nat. Hist., ser. 4, vol. xviii. p. 93, figs. 12, 12 *a*, 1876.

Spec. Char.—Corallum dendroid, of subcylindrical branches, varying from four to seven lines in diameter, and dividing at short intervals. Corallites for the most part polygonal, thin-walled, and sub-equal, from eight to ten in the space of one line. Interspersed between the large corallites, generally at the junction of four or six of the latter, are conical or sub-quadrangular eminences or tubercles (Pl. XV., fig. 1 *a*), placed at intervals of from a fifth of a line to half a line. These eminences are the upper ends of curved and thick-walled tubes, which appear to be closed above, and which are not traversed by tabulæ, but which are to be regarded as specially modified corallites. The normal corallites are crossed by horizontal, complete, and remote tabulæ.

Obs.—This species seems to be distinct from *D. aspera*, E. and H., its size apparently being less, and its form more strictly dendroid; but the latter is insufficiently described, and it is quite possible that *D. attrita* is merely a variety of it. In internal structure, tangential sections of *D. attrita* (Pl. XV., fig. 1 *b*) show that the bulk of the corallites are thin-walled, polygonal, and approximately equal in size, while interspersed among these and completely isolated by them are the thick-walled tubes, which give rise to the surface-columns. The apices of these columns (Pl. XV., fig. 1 *a*) certainly seem to be solid and imperforate; but when divided transversely a little below the surface, they are seen to be composed of dense and dark-coloured sclerenchyma, deposited in successive concentric lamellæ in the interior of the originally angular tube, and almost always exhibiting a small circular central canal. Tangential sections also show occasional small angular corallites intercalated among the larger ones, and we may regard these as spiniform corallites in which the walls are still unthickened. Vertical sections (Pl. XV., fig. 1 *c*) show that the corallum is mainly made up of the normal corallites, which in the axis of the branches are provided with very delicate and undulated walls, and are free from tabulæ. As the corallites curve outwards towards the surface, their walls become slightly thickened, and a few remote and complete tabulæ are developed in their interior. The spines only extend inwards from the surface to the point where the corallites bend downwards to the axis of the branch, and they are seen to consist of a central non-tabulate tube, bounded by very thick dense walls. In some cases, also, the central tube of the spines seems to be continued to the actual surface, though I have failed to detect openings in the surface-columns. I have, however, no doubt but that the surface-columns are primitively perforated, and that the spines are, therefore, genuine corallites, though of a peculiar kind. The forms to which *Dekayia* shows the greatest affinity are those like *Monticulipora* (*Heterotrypa*) *moniliformis*, Nich., but in these the spiniform corallites are much more extensively developed. I must, however, defer further consideration of this subject till I am able to separately discuss the very remarkable features exhibited by the spines of various of the Monticuliporoids, as well as of certain species of *Stenopora.*

Formation and Locality.—Rare in the Cincinnati group, Cincinnati, Ohio.

Sub-genus 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 sub-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 (Pl. XIV., fig. 5). 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 subvesicular, while their walls become obsolete. The above characters will be more fully brought out by a brief description of the type-species, the *Constellaria antheloidea*, Hall, of the Lower Silurian of America.

Constellaria antheloidea, Hall.

(Pl. XIV., figs. 5, 5 *b*.)

Stellipora antheloidea, Hall, Pal. N.Y., vol. i. p. 79, Pl. XXVI., figs. 10 *a*, 10 *c*, 1847.
,, *antheloidea*, D'Orbigny, Prodr. de Paléont., t. i. p. 22, 1850.
Constellaria antheloidea, Edwards and Haime, Pol. Foss. des Terr. Pal., p. 279, Pl. XX., figs. 7 - 7 *b*, 1851.
,, *antheloidea*, Nicholson, Pal. of Ohio, vol. ii. p. 214, 1875.
,, *antheloidea*, Nicholson, Ann. Nat. Hist., ser. 4, vol. xviii. p. 92, Pl. V., fig. 10, 1876.

Spec. Char.—Corallum in the form of palmate, or sublobate, flattened expansions, two or more inches in height, with a thickness of from one and a half to two lines, and composed of corallites which radiate from an imaginary central plane to open on all unattached parts of the skeleton. Surface (Pl. XIV., fig. 5) with numerous stellate areas, a line or less in diameter, and placed about half a line or rather more apart, each consisting of a depressed central space, surrounded by from six to eight prominent and radiately-placed elevated ridges. Corallites of two kinds, large and small. Large corallites oval or circular, about one-tenth of a line in diameter, with strong bounding-walls, occupying the general surface of the corallum, and specially aggregated on the elevated ridges of the star-shaped monticules, in the central depressed areas of which they are wanting. Small tubes, apparently really subangular, occupying all the interspaces between the larger oval tubes, and especially aggregated in the central depressed areas of the monticules, and in the star-like prolongations which run out from these; their walls thin and apparently often wanting. Large corallites with few remote tabulæ; small corallites with very numerous close-set tabulæ, which often anastomose with those of neighbouring tubes.

Obs.—Passing over the obvious and well-known external features of the corallum in *Constellaria antheloidea*, I may make a few remarks upon the appearances presented by thin sections. Tangential sections (Pl. XIV., fig. 5 *a*) present some peculiar difficulties of preparation, owing to the irregularity of the surface due to the monticules, but when properly made, they are very instructive. They exhibit both sets of corallites, the larger being conspicuous both by their size and their circular or oval form, and by the fact that each is bounded by a thick and apparently double wall. It is only in the stellate ridges of the monticules that the large corallites are at all extensively in contact; but in the intervals between the monticules they are only partially contiguous, and are separated by more or less extensive interspaces. These interspaces, as well as the central areas of the monticules and the branching diverticula therefrom, are occupied by the smaller corallites. The appearances presented by these vary under different circumstances, and in different parts of the section; and I am not at present able to explain some of the appearances which they exhibit. They are best studied in the central depressed areas of the monticules, and in their most perfect condition they are seen to be angular in shape, and to be bounded by thin and delicate walls, which, however, are often partially imperfect, thus allowing neighbouring tubes to communicate. In other cases, the divisional walls between the small corallites seem wholly wanting, and the central areas of the monticules exhibit simply minute rounded and remote pores, together with other peculiarities which I must leave for future examination. In the interspaces between the large tubes, also, the smaller tubes only rarely seem to possess complete bounding walls, and here, as in the monticules, there is the curious feature that the cavities of the smaller corallites seem to be very commonly obliterated by a secondary deposit of light-coloured sclerenchyma. Vertical sections (Pl. XIV., fig. 5 *b*) render it certain, however, that whether or not their walls are developed in a complete form, the interspaces between the larger tubes and the central areas of the monticules are alike uniformly occupied by the smaller corallites. In sections of this kind, we see that the large corallites exclusively occupy the central part of the corallum, in which region they are thin-walled, and possess few or sometimes no tabulæ. As they bend outwards, in approaching the surface, their walls become thicker, and the tabulæ, though still very few and widely remote, become somewhat more numerous. The small corallites are only developed in the interspaces between the larger tubes in the outer portion of the course of the latter, so that they occupy only a superficial zone of the corallum; and they are at once recognised not only by their small size, but also by their very numerous and close-set tabulæ. Sections of this kind further demonstrate that the walls of the smaller tubes are really often wanting, though at other times clearly recognisable; their tabulæ, in the former case, becoming laterally coalescent and often more or less extensively vesicular. This latter feature is particularly observable in the aggregations of the smaller corallites which constitute the central depressed areas of the monticules.

The affinities of *Constellaria* seem to be clearly with *Fistulipora*, M'Coy, in which, likewise, the bounding-walls of the smaller tubes may in some forms become so far obsolete as to allow of the tabulæ assuming a completely vesicular structure. The sub-genus is, however, sufficiently separated from *Fistulipora* by the much less complete development of the small tubes, which in the latter type always completely encircle and isolate the larger tubes; while the star-shaped form of the monticules is another well-marked distinguishing character.

Formation and Locality.—Rare in the Cincinnati group, Cincinnati, Ohio.

Sub-genus 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."

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* have infundibuliform tabulæ, while Hall describes radiating 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 intimate structure of the genus is also so nearly allied to that of certain *Monticuliporæ*, as well as to *Constellaria*, that I think it is best to regard *Fistulipora* as only a sub-genus of *Monticulipora*.

The species of *Fistulipora* agree in the possession of a dimorphic corallum, composed of two sets of corallites of conspicuously different sizes, and bearing definite relations to one another. 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, 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; 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, as has been previously mentioned, 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*, is provided with perforate 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*.

The genus *Fistulipora* ranges from the Silurian to the Carboniferous, and I shall briefly describe the following three species as illustrating its more characteristic features.

Fistulipora minor, M'Coy.

Fistulipora minor, M'Coy, Ann. Nat. Hist., ser. 2, vol. iii. p. 130, 1849; and Brit. Pal. Foss., p. 79, 1851.

Spec. Char.—Corallum in the form of thin, irregular crusts, attached parasitically at one point or over the whole lower surface, attaining a thickness of two or three lines. Large corallites oval or circular, about a fifth of a line in their long diameter; separated by interspaces of about their own width, less or more; and with few or no tabulæ, these structures, when present, being horizontal. Small tubes angular, of variable shape, generally about a tenth of a line in diameter, each of the larger tubes being surrounded by a single circle of the smaller corallites, so that there exist two rows of the latter between any given pair of the former. The small tubes are closely tabulate, but by the imperfect development of their walls the tabulæ coalesce to a larger or smaller extent, and thus give rise to a vesicular tissue, composed of lenticular vesicles, which have their convexities directed upwards.

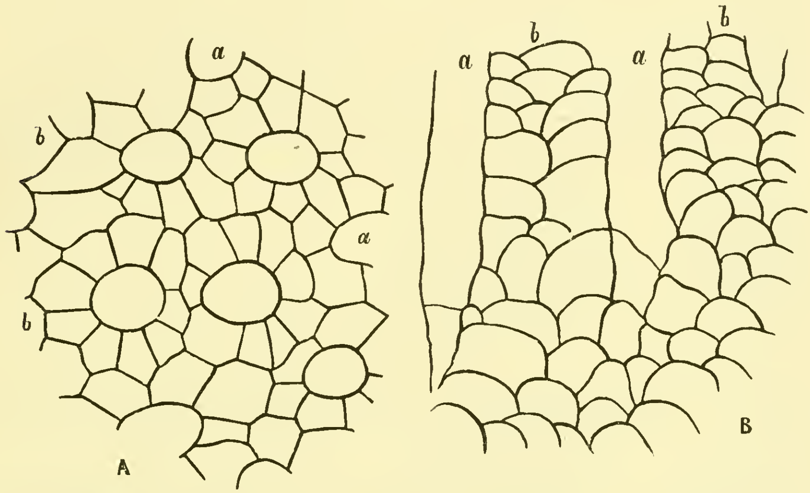


Fig. 39.—*Fistulipora minor*, M'Coy. A, Portion of a tangential section, showing the rounded large tubes (*a*, *a*) and the angular interstitial tubes (*b*, *b*); B, Portion of a vertical section, showing two of the large tubes, almost free from tabulæ (*a*, *a*), and the interstitial vesicular tissue formed by the tabulæ of the smaller tubes (*b*, *b*). The sections are enlarged twenty-five times.

Obs.—I am indebted to my friend Dr Ramsay H. Traquair for a specimen from the Carboniferous rocks of Scotland which he had previously, and unquestionably correctly, identified with the *Fistulipora minor* of M'Coy. The surface of this specimen is poorly preserved, the prominent round mouths of the larger tubes being alone shown; and I am unable to determine whether or not "maculæ" are present, though I see no traces of these in thin sections. The internal structure is fully shown by thin tangential and vertical sections (fig. 39, A and B); but I need add nothing further to the description given in the specific diagnosis.

In its minute characters, *F. minor* is nearly related to *F. incrassata*, Nich., from the Devonian of North America. This is especially shown by the fact that the tabulæ of the angular corallites in both species give rise to a series of convex lenticular vesicles (*compare* fig. 39, B, and Pl. XV., fig. 3 *b*). The large round corallites of *F. incrassata* are, however, nearly twice as large as those of *F. minor*, and are only separated by a single row of angular tubes, while they are provided with more numerous tabulæ, these features alone being sufficient to establish the specific distinctness of the two forms.

Formation and Locality.—In the Lower Carboniferous Limestone of Cousland, near Edinburgh. Collected by Dr R. H. Traquair.

Fistulipora incrassata, Nich.

(Pl. XV., figs. 3 - 3 *b*.)

Callopora incrassata, Nicholson, Geol. Mag., Dec. ii. vol. i. p. 13, Pl. II., fig. 1, 1874; Rep. Pal. of Ontario, p. 61, fig. 19, 1875.

Spec. Char.—Corallum sometimes forming thin crusts, attached parasitically to foreign bodies, or partially epithecate below, or at other times constituting irregular masses of considerable size. Large corallites, oval or pyriform in section, one end being wider than the other, and the junction between the two commonly being marked by two small laminar inflections of the wall of the tube on opposite sides. The large tubes are about a third of a line in their long diameter, and their calices project slightly above the general surface, while they are completely separated from one another by the intermediate "small" corallites. These latter are angular in form, and there is never more than a single row of them between any given pair of the large corallites. Their mouths are seldom distinctly shown, and are often closed by a thin calcareous membrane. At intervals the surface shows star-shaped depressed "maculæ," which are entirely occupied by the angular corallites, and which are often covered by a superficial calcareous pellicle. Owing to the variable shape of the angular corallites, their size is correspondingly variable; but they are generally of smaller diameter than the round tubes. The large corallites are intersected by a few, remote, horizontal tabulæ; while the tabulæ of the angular interstitial corallites are much more closely set, and become amalgamated in contiguous tubes, so as to give rise to a vesicular tissue, the lenticular vesicles of which have their convexities directed upwards.

Obs.—I have reproduced here the original figures of this species (fig. 40), though they are in some respects incorrect. The real structure of the corallum is, however, shown in Pl. XV., figs. 3 - 3 *b*, from which it will be seen that its minute characters are in the main similar to those of *Fistulipora minor*, M'Coy. It differs from this form, however, in the larger size of the round corallites, and in the fact that any given two of these are separated by no more than one row of the smaller tubes. Not only are these latter markedly angular in shape, but they, thus, necessarily abut on their opposite sides against the larger corallites. The large tubes are not only oval, but they are wider at one end than the other, and they usually exhibit the peculiar feature that there exist two small inward inflections of the wall of the tube, which are placed, one on each side, at a point situated about one-third of the long diameter of the tube from its pointed end (Pl. XV., fig. 3 *a*). Thin vertical sections (Pl. XV., fig. 3 *b*) show that the large corallites are intersected by a few complete horizontal tabulæ; while the walls of the smaller tubes are imperfectly developed, and their tabulæ coalesce to constitute a series of

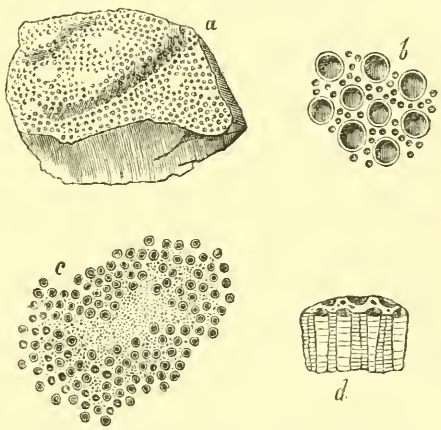


Fig. 40.—*Fistulipora incrassata*, Nich. *a*, A fragment, of the natural size; *b*, A portion of the surface enlarged, showing the mouths of the two sets of corallites; *c*, A portion of the surface less highly magnified, showing one of the star-shaped "maculæ;" *d*, Vertical section enlarged.

strongly convex vesicles. From the nearly allied *F. proporoides*, Nich., the present species is distinguished by its generally more massive form, the inflections of the walls of the large corallites above spoken of, and the fact that the tabulæ of the smaller tubes coalesce to form a vesicular tissue.

Formation and Locality.—Common in the Hamilton Group of Arkona, Ontario. I originally included under the name of *Callopora incrassata* certain large and massive specimens from the Corniferous Limestone of Ontario. Not having had, however, the opportunity of examining these microscopically, I do not feel sure they are specifically identical with the Hamilton examples, upon the characters of which the foregoing description is based.

Fistulipora proporoides, Nich.

(Fig. 41, and Pl. XV., figs. 2, 2 *a.*)

Spec. Char.—Corallum in the form of thin and extended, often much contorted expansions, which have an average thickness of about one line, and have the under surface covered by a concentrically-striated epitheca, the corallites being nearly vertical, and opening upon the upper surface. The large corallites are oval or nearly circular, about one-fifth or one-sixth of a line in diameter, and separated by interspaces of about the same width. The "small" corallites are markedly angular, only one row ever existing between contiguous round tubes, and their size being often equal to, or even larger than, that of the latter. On the surface the calices of the round tubes appear as marked projecting apertures, while the calices of the angular tubes appear to be usually closed in the adult condition by a thin calcareous membrane. Maculæ present or absent. In internal structure the round tubes have very few or no tabulæ, and, when present, these structures are always complete and horizontal. The "small" tubes are always bounded by complete walls, and are intersected by comparatively numerous horizontal, not vesicular tabulæ.

Obs.—This beautiful species, in the essential features of its organisation, is clearly nearly allied to the two forms previously described, and especially to *F. incrassata*. It agrees more particularly with this last in the comparatively large size and markedly angular form of the interstitial corallites, and in the fact that there is but one single series of these separating the round tubes. In both species also the surface exhibits, alone or principally, the projecting apertures of the round corallites (Pl. XV., figs. 2 and 2 *a*), the mouths of the angular interstitial tubes seeming to be often closed by a thin calcareous membrane. The form of the corallum, however, is in the present species always that of a thin, often contorted expansion, the under surface of which is clothed by a striated and plicated

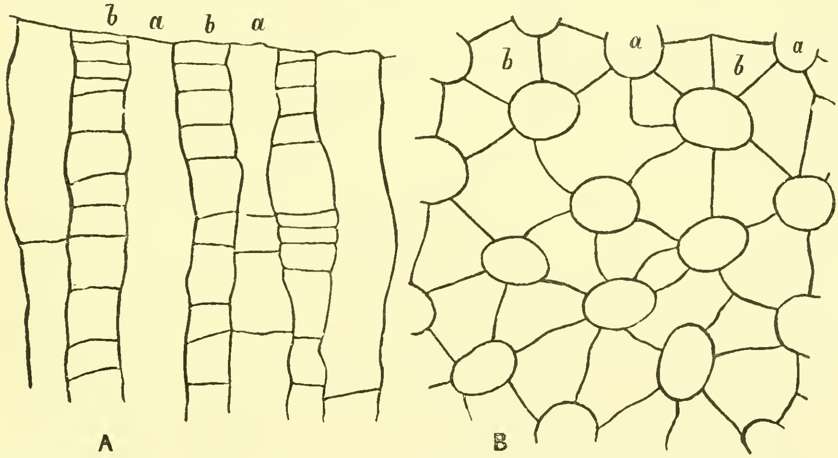


Fig. 41.—*Fistulipora proporoides*, Nich. A, Part of a vertical section, enlarged twenty times, showing the different tabulation of the two sets of corallites. B, Part of a tangential section, showing the round and the angular corallites, enlarged twenty times: *a*, *a*, Round or "large" corallites; *b*, *b*, Angular or "small" corallites.

epitheca; the round corallites are strictly round or oval, and are not contracted at one point; the "maculæ" are sometimes obsolete; and there is the striking internal difference that the angular interstitial corallites are always limited by complete walls, and are intersected by numerous horizontal tabulæ, which never assume a vesicular character (Fig. 41, A). This last-mentioned feature, among other points of distinction, sufficiently separates the species from *F. minor*, M'Coy, this latter likewise having a much greater development of the interstitial corallites.

Formation and Locality.—Common in the Hamilton Group, Canandaigua, State of New York.

Sub-genus DIPLOTRYPA, Nich., 1879.

I propose this name as a subgeneric designation for a group of *Monticuliporæ*, of which *M. petropolitana*, Pand., is the type. The corallum in the forms in question is like that of the sub-genus *Heterotrypa* in being conspicuously dimorphic; but *all* the corallites are markedly *angular or prismatic*, while their walls are remarkably *thin* and delicate, and their general appearance resembles that of the corallites of *Favosites*. The large corallites have few and remote tabulæ, and are usually or always aggregated at special points into clusters or "monticules;" but they are also scattered throughout the entire colony, the bulk of which they compose. In the "monticules" the large tubes are usually alone present, but in the other parts of the corallum the larger corallites are partially separated by the development of a larger or smaller number of small corallites, which agree with the large ones in being angular in shape, but differ in being provided with much more numerous and close-set tabulæ. The characters of the group will be best elucidated by a brief consideration of the internal structure of *M.* (*Diplotrypa*) *petropolitana*, Pand.

Monticulipora (Diplotrypa) petropolitana, Pander.

(Pl. XIII., figs. 3-3 *c.*)

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

(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, 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 one-quarter of a line 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 a twelfth to an eighth of a line or more. 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

[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.

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 of the species have never been, so far as I am aware, either described or figured. Even now it can hardly be said that the position of our knowledge is absolutely satisfactory, seeing that Pander's type-specimens have not been subjected to minute examination. I am, however, indebted to the kindness of my friend Dr Lindström for specimens from the Lower Silurian of Sweden, the identity of which with the original *Favosites petropolitanus* of Pander hardly admits of doubt, seeing that they are derived from a corresponding geological horizon and from a neighbouring geographical area. These specimens I have subjected to a careful microscopic examination, and the characters which they afford I regard as those specifically diagnostic of *M. petropolitana*, Pand. Starting with this basis, it is at once clear that the mere external form and surface-characters of the corallum are of no use at all in the determination of this species. Thus all, or almost all, of the corals which I have myself examined and described from the Lower Silurian rocks of North America, and which I have identified with *M. petropolitana* on account of their general form and appearance, turn out to be widely different from the similar-looking Russian species in their internal structure. I shall also describe specimens from the Devonian which on merely external examination would unhesitatingly be referred to *M. petropolitana*, but which, tested by the facts of their minute structure, are specifically or even sub-generically different. 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 (Pl. XIII., figs. 3, 3 *a*). In thin sections (Pl. XIII., figs. 3 *b* and 3 *c*) no feature is more 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 (Pl. XIII., fig. 3 *b*) 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 (Pl. XIII., fig. 3 *c*) 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 more closely tabulate than is the case with the large tubes.

The nearest ally of *M.* (*Diplotrypa*) *petropolitana* with which I am acquainted is one of the forms which I previously described as *Chætetes petropolitanus*, from the Lower Silurian rocks of North America. Now, however, that I know the internal structure of the Russian species, I find that the American specimens are specifically distinct, and I shall describe them under the name of *M.* (*Diplotrypa*) *Whiteavesii*. They are distinguished from *M. petropolitana*, Pand., by the much closer tabulation of the small corallites, the peculiar double tabulation of many of the large corallites, and the form and size of the latter tubes. From the forms which I shall here describe under the names of *M.* (*Monotrypa*) *undulata*, and *M.* (*Monotrypa*) *Winteri*, the present species is easily distinguished on minute examination; for both the former types are destitute of a series of small corallites interspersed among the ordinary tubes of the colony, while all the corallites are similarly and uniformly tabulate.

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

Monticulipora (Diplotrypa) Whiteavesii, Nich.

(Pl. XIII., figs. 4 - 4 *b*, and Pl. XIV., fig. 1.)

Chætetes petropolitanus, Nicholson, Quart. Journ. Geol Soc., vol. xxx. p. 510, Pl. XXX., figs. 5 - 8, 1875.

„ *petropolitanus* (pars), Nicholson, Pal. of Ohio, vol. ii. p. 204, Pl. XXI., figs. 14, 14 *b*, 1875.

„ *petropolitanus*, Nicholson, Ann. Nat. Hist., ser. 4, vol. xviii. p. 88, Pl. V., figs. 6, 6 *a*, 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.

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 kinds, large and small, the tubes of both series intermingled throughout the entire corallum. Large tubes, mostly from a sixth to a fifth of a line in diameter, more or less thin-walled, 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. In internal structure the large tubes may be simply crossed by remote, delicate, complete tabulæ; but many of them are divided by a vertical flexuous partition into two compartments, the tabulæ on the one side of this partition being strongly curved, with their convexities directed upwards, while on the other side they are simply horizontal. In the small tubes the tabulæ are always very numerous, close-set, and horizontal.

Obs.—In general form, the corallum of the present species (fig. 42, and Pl. XIII., figs. 4, 4 *a*) is generally quite like that

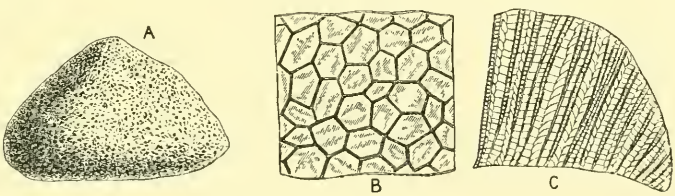


Fig. 42.—*Monticulipora* (*Diplotrypa*) *Whiteavesii*. A, Side view of the corallum, of the natural size; B, *Transverse* section of the corallum near its base, showing the thin-walled hexagonal corallites, enlarged. (This section cuts across the *axial* corallites close above their origin, showing none of the small tubes, the appearances presented being thus quite unlike those exhibited by a *tangential* section taken just below the surface, as in Pl. XIII., fig. 4 *b*); C, Part of a vertical section, greatly enlarged.

of the typical *M. petropolitana*, Pand., with which it has generally been confounded by myself and others. When young it is a concavo-convex disc; but it usually becomes elevated and hemispherical when fully grown. The lateral margins of the corallum are, however, very often extended and comparatively thin, the chief elevation of the corallum being central, and there is often a curious funnel-shaped depression at the summit of the colony, the nature of which I do not understand. Adult coralla reach a diameter of from one and a half to three inches, with a height of three-quarters of an inch to an inch. The characters of the surface are very like those of the typical *M. petropolitana*, Pand., especially in the presence of low elevations or monticules, composed of corallites which seem to be slightly larger than the average. Thin sections show that the corallum also, as in *M. petropolitana*, is composed of very thin-walled corallites, the walls of which are undistinguishably united, and are not thickened towards the surface; while two distinct sets of tubes, of different sizes, form by their intermixture the entire colony. Tangential sections (Pl. XIII., fig. 4 *b*) clearly exhibit both groups of corallites, both being angular in shape, and the small tubes being situated at all the angles left between the larger ones. The latter are seldom completely surrounded by small tubes, though this does sometimes occur. Very characteristically the large tubes are arranged in stellate groups or rosettes, consisting of four or five tubes; and the central point where these meet is marked by a thickened rounded or quadrate body, which exhibits commonly a median tube. Similar structures are often developed at the points where the small corallites abut against the larger ones, and their appearance is precisely similar to that of the "columns" of *Dekayia*, or the spines of certain of the *Monticuliporæ* as seen in transverse section. I cannot say, however, that I have ever detected spines on the surface in this species, though I cannot doubt that the structures to which I have just referred are peculiarly modified corallites. Vertical sections (Pl. XIV., fig. 1) show that the corallites, instead of being reclined towards the margin of the colony, are everywhere nearly perpendicular to the epithecal plate; and they further show very striking differences in the structure of the large and small tubes. The former are not uniformly similar in structure. In some cases they are simply crossed by a few remote tabulæ, as is usual among the *Monticuliporæ.* In other cases, and more commonly, however, they exhibit throughout or in part of their course a very singular double arrangement of the tabulæ, the explanation of the phenomena in question being still unknown to me. In these cases the visceral chamber of the corallite may be considered as divided into two lateral halves or compartments. In one half of the tube the tabulæ are not only remote, but are strongly convex, with their convexities directed upwards, or towards the centre of the visceral chamber, thus forming a series of large lenticular vesicles, the internal margins of which unite so as to form an apparent median septum to the tube. In the other half of the corallite the tabulæ are simply remote, complete, and horizontal, extending from the lateral wall of the corallite on the one hand to the inner margin of the lenticular vesicles just mentioned on the other hand. Lastly, the smaller corallites are uniformly provided with very numerous crowded and complete horizontal tabulæ.

The features which separate *M.* (*Diplotrypa*) *Whiteavesii*, Nich., from the typical *M. petropolitana*, Pand., have been alluded to in speaking of the latter, and need not be further insisted on here. The internal structure of the corallum, and especially the remarkable form of tabulation displayed by the greater number of the large corallites, will serve to differentiate the species from all other types which resemble it in general shape and aspect.

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

Formation and Locality.—Abundant in the Trenton Limestone of Peterboro', and of other localities in Ontario. Specimens of a rounded form attached by a broad base to foreign bodies occur also in the Cincinnati group of Waynesville, Ohio.

Sub-genus MONOTRYPA, Nicholson, 1879.

I propose the name of *Monotrypa* for a few forms of *Monticulipora* which agree with those that I have called *Diplotrypa* in the fact that the corallites are thin-walled throughout their entire extent, and are so amalgamated in contiguous tubes that their originally double structure is not recognisable. On the other hand, they differ from *Diplotrypa* in the fact that the closely-tabulate small corallites of the latter are now totally absent, the colony consisting of subequal tubes which are uniformly and throughout provided with remote and complete tabulæ. The only sign of dimorphism, in fact, which can be detected in the corallum of *Monotrypa* is the constant existence of special clusters ("monticules") of corallites, which are decidedly larger than the average tubes, though quite like these in internal structure.

There are several respects in which this section of the genus *Monticulipora* must be considered as not wholly satisfactory, at the same time that the composition of the corallum out of tubes which are identical in internal structure, and which differ very little in point of size, precludes our associating the forms in question with any of those we have been previously considering. In some points *Monotrypa* makes an approach to *Chætetes* proper, but the much greater thinness of the walls of the corallites, and the constant presence of clusters of large tubes, sufficiently distinguish the species of the former from those of the latter. The only two forms which I at present know as combining all the features here ascribed to *Monotrypa* are those which I shall describe immediately under the name of *M. undulata* and *M. Winteri*. Typical examples of the *M. pulchella*, E. and H., from the Upper Silurian of Britain, show, however, all the general characters of *Monotrypa* (see Pl. XIV., figs. 6, 6 *a*), except that the walls of the corallites become decidedly thickened in approaching the surface, and the boundary-lines between contiguous tubes are usually clearly marked. (I have not yet submitted to microscopic examination the forms from the Lower Silurian rocks of North America which have usually been known to American palæontologists as *M. pulchella* or *Chætetes pulchellus;* but I suspect they will prove to be distinct from the British Upper Silurian examples, which are the true type of the species).

Monticulipora (Monotrypa) undulata, Nich.

(Pl. XIV., figs. 3 - 3 *b*, and 4 - 4 *a*.)

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.

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, 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. 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 formation 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 not yet had the opportunity of examining these latter forms microscopically, but I imagine that I shall find I was in error in associating these with the

Trenton Limestone 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 reality entirely identical in internal structure with the *M. undulata* of the Trenton Limestone, from which they only differ in their smaller size and hemispherical or spheroidal shape (Pl. XIV., fig. 3). I have figured thin sections of both for comparison.

Tangential sections of both the Trenton Limestone and Hudson River group examples of *M. undulata* (Pl. XIV., fig. 4 and fig. 3 *a*) 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. Here and there, of course, small corallites will occur, but these are simply young tubes, such as would be seen in any tangential section of a *Favosites*, and they do not form part of a regular series of special corallites. That this view is correct is shown by their very occasional occurrence, but is still more conclusively proved by vertical sections (Pl. XIV., figs. 3 *b* and 4 *a*). 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 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.

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.

(Pl. XIII., figs. 5, 5 *a*; Pl. XIV., figs. 2, 2 *a*.)

Spec. Char.—Corallum when young, discoid and concavo-convex; when adult, hemispherical or subglobular. 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 subequal 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 (Pl. XIII., figs. 5, 5 *a*) to the Lower Silurian *M. petropolitana*, 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 (Pl. XIV., fig. 2) 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 (Pl. XIV., fig. 2 *a*) 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.

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.

Genus PRASOPORA, Nich. and R. Eth., jun., 1877.

(Ann. Nat. Hist., ser. 4, vol. xx. p. 38.)

Gen. Char.—Corallum compound, concavo-convex or hemispheric in form, composed of numerous prismatic corallites radiating from a wrinkled basal epitheca. Corallites of two kinds, large and small,[1] regularly and uniformly intermingled throughout the entire colony. No "monticules" or clusters of large tubes. All the corallites thin-walled, and prismatic or angular in shape; the large tubes furnished with an exterior zone of vesicular tabulæ surrounding a vacant central tube, which may be crossed by an occasional tabula. Small corallites arranged in a zone (rarely or never quite complete) round the large tubes, and crossed by numerous close-set, complete, and horizontal tabulæ.

[1] In our original description of *Prasopora* (*loc. cit.*), as well as in our "Monograph of the Silurian Fossils of Girvan," Fasc. I., p. 44, Mr Etheridge and I employed the term of "cœnenchymal tubuli" for the small corallites. We did so, however, simply in conformity with the nomenclature employed by Milne-Edwards and Haime, and we expressed the opinion that the small tubes are "really of the nature of rudimentary corallites, which contained in the living state a series of small and specially modified zoöids."

Obs.—This singular genus was founded by Mr R. Etheridge, jun., and myself for the reception of a small coral from the Lower Silurian deposits of Girvan, Ayrshire, to which we gave

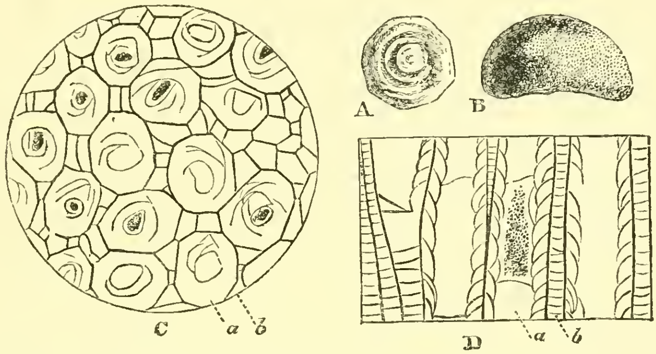


Fig. 43.—*Prasopora Grayæ*, Nich. and Eth., jun. A, Under side of a small example, showing the epitheca, of the natural size. B, Side view of a larger specimen, of the natural size. C, Tangential section enlarged twenty times. D, Vertical section similarly enlarged: *a*, One of the large corallites ; *b*, One of the small corallites. The dark shading in the microscopic sections indicates the presence of the matrix.

the name of *Prasopora Grayæ*. The characters of the genus and species have been so fully treated of by us (*loc. cit.* and Monograph of the Sil. Foss. of Girvan, Fasc. I., pp. 44-48), that it is unnecessary for me to do more than briefly allude to the most striking features of the structure of the corallum.

In general form and size the corallum of *Prasopora Grayæ* (fig. 43, A and B) precisely resembles that of moderately young examples of *Monticulipora 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 aspect. The corallum is conspicuously and very remarkably dimorphic, the large and small corallites being uniformerly 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, D, *a*), 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 series of large circumferential vesicles, the convexities of which are directed upwards and towards the centre of the corallite. 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, C, *a*), the large corallites are seen to be hexagonal, prismatic, or subpolygonal, 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, C) 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, D, *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.

As regards its affinities, there cannot be any doubt but that *Prasopora* is a genuine Monticuliporoid, and that it is most nearly allied to that section of *Monticulipora* which I have named *Diplotrypa*, and of which *M. petropolitana*, Pander, is the type. There is, indeed, a distant approach to the peculiar structure of the large corallites of *Prasopora* in the large vesicular tabulæ which are commonly found on one side of the visceral chamber in the corresponding corallites of *M.* (*Diplotrypa*) *Whiteavesii*, Nich. (see Pl. XIV., fig. 1). The existence, however, of a complete peripheral zone of vesicular tabulæ, enclosing a central tube, is a feature of an entirely unique nature, and fully entitles *Prasopora* to take rank as a distinct genus.

The only known species of *Prasopora* occurs commonly in the "Craighead Limestone" (Lower Silurian) of Craighead, near Girvan, Ayrshire, whence it was collected by Mrs Robert Gray.

Genus DANIA, Milne-Edwards and Haime, 1849.

(Comptes Rend., t. xxix. p. 261.)

The genus *Dania* was proposed by Milne-Edwards and Haime for the reception of a single species (*D. Huronica*) from the Upper Silurian of Drummond Island, Lake Huron; and they give the following as the characters of the genus (Pol. Foss. des Terr. Pal., p. 275) :—

"Corallum massive, composed of prismatic corallites, which are intimately united by their well-developed walls. Tabulæ completely horizontal, and continued across contiguous corallites in such a manner as to give rise to continuous lamellæ, which divide the entire mass into a series of superposed strata. Calices subpolygonal. No traces of septa."

Not having seen the original specimens upon which Milne-Edwards and Haime founded the genus *Dania*, I am unable to give any final opinion as to the validity or the reverse of the genus. It is clear from their description, and still more from their figures, that *Dania Huronica* is a Chætetoid or Monticuliporoid Coral; and it is also clear that the single character emphasised by Milne-Edwards and Haime—namely, the presence of tabulæ placed at corresponding levels in contiguous tubes—is not of itself sufficient for generic characterisation. This is amply proved by the fact that a like periodic production of tabulæ, giving rise to a similar division of the corallum into superimposed concentric layers, occurs in such different forms as *Stenopora crinita*, Lonsd., from the Carboniferous, and *Monticulipora undulata*, Nich., from the Lower Silurian, as well as in the familiar *Chætetes radians*, Fischer, of the Carboniferous. Professor Martin Duncan (Third Rep. on the Brit. Foss. Cor.; Rep. Brit. Ass. 1871, p. 128) is of opinion that *Dania*, E. and H., is inseparable from *Chætetes*, Fischer, and in this view he is very probably correct, though I do not know what positive evidence exists upon the point.

The only other coral that I am acquainted with as having been referred to the genus *Dania* is the *Thecia multiseptosa*, A. Römer (Beiträge III., p. 2, Pl. 2, f. 1, 1855), from the Lower Devonian of Germany. This form was doubtfully referred by Römer to *Thecia*, but Giebel assigned it to *Dania* (Sil. Fauna Unterharz, p. 59, Pl. 6, f. 3 and 4, 1858), and this view is also taken by Kayser (Fauna d. Ält. Devon. Ablager. des Harzes, p. 223, 1878). Judging from the figures given by Kayser, the close-set tabulæ are certainly placed at corresponding levels in contiguous corallites; but there is nothing definite brought forward except this character to justify its being placed in *Dania*. It appears to be either a member of the genus *Chætetes* or *Favosites*.

Genus Beaumontia, Milne-Edwards and Haime, 1851.

(Pol. Foss. des Terr. Pal., p. 276.)

The genus *Beaumontia* was founded by Milne-Edwards and Haime (*loc. cit. supra*) for the reception of certain Carboniferous and Devonian Corals, to which they ascribed the following common characters :—

"Corallum generally massive ; the corallites usually prismatic and amalgamated by their walls, but occasionally partially free. The walls thin, provided with an epitheca. The tabulæ vesicular, or, at any rate, irregular, occasionally exhibiting upon their surface septal striæ."

The distinguished French observers just quoted regard *Beaumontia* as corresponding in the series of the *Chætetidæ* to *Michelinia*, De Kon., in the series of the *Favositidæ ;* and they assert that the walls of the corallites are destitute of mural pores. If this last character be certainly established, then the genus may be regarded as undoubtedly distinct ; but the general resemblance of the corallum in the species of *Beaumontia* to *Michelinia* would rather lead one to suspect that mural pores may really exist, and that the genus is truly referable to the *Favositidæ*. Not, however, having had any opportunity of examining specimens of *Beaumontia*, I am necessarily unable to pronounce any opinion on this point. I may add, however, that Dr Lindström (Ann. Nat. Hist., ser. 4, vol. xviii. p. 16) refers *Beaumontia* to the *Favositidæ ;* while Prof. Martin Duncan (Third Rep. on the Brit. Foss. Corals ; Rep. Brit. Ass., 1871, p. 135) regards the genus as being properly referable to the *Halysitidæ*. I am not aware, however, of any published evidence which would positively decide between these opposing views.

CHAPTER XIV.

LABECHIDÆ.

The extraordinary Upper Silurian genus *Labechia*, E. and H., alone constitutes this group, and its characters are so abnormal that we must in the meanwhile regard it as the type of a special family, to which the name of *Labechidæ* may be applied. As we have, however, to deal in this family with only a single genus, comprising only a single species, the characters of the group will be sufficiently elucidated by a consideration of the structure of the genus. As a definition of the group it will be sufficient to say that it comprises calcareous corals (?), composed of laminar or submassive expansions, which are fixed by the centre of the base, and have the rest of the lower surface covered with an epitheca; the skeleton being composed of a series of calcareous, primitively tubular, but finally more or less completely solid columns, which project above the surface as so many rounded or elongated imperforate tubercles; the spaces between the columns filled with a cellular tissue of lenticular vesicles, and the intervals between the surface-tubercles covered by a continuous and imperforate calcareous membrane.

Genus Labechia, Edwards and Haime, 1851.

(Pol. Foss. des Terr. Pal., p. 279.)

Gen. Char.—Corallum usually having the form of a larger or smaller laminar expansion, which is attached by a portion of its base to some foreign object, the remainder of the lower surface being covered by a concentrically-striated epitheca. Upper surface covered with rounded or elongated, sometimes partially confluent, tubercles, which are quite solid, and are separated by an imperforate calcareous membrane. In internal structure, the corallum consists of a great number of cylindrical calcareous columns, which are directed vertically upwards from the basal epitheca, and the upper ends of which constitute the surface-tubercles above mentioned. The columns sometimes appear to be solid throughout; sometimes they exhibit more or less distinct traces of a minute central tube; so far as certainly observed, they are apparently solid at their upper ends. The interspaces between the columns are occupied by a series of lenticular vesicles, the convexities of which are directed upwards, and the uppermost layer of which gives rise to the seemingly imperforate membrane which forms the whole of the upper surface between the tubercles.

Obs.—The genus *Labechia* was originally founded by Milne-Edwards and Haime for the reception of the singular *L. con-*

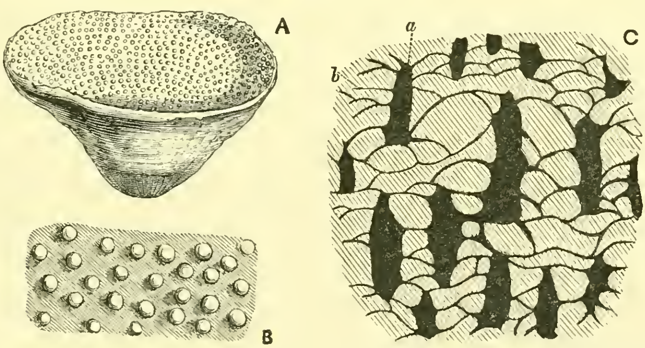


Fig. 44.—*Labechia conferta*, E. and H. A, A small specimen from the Upper Silurian of Gotland, of the natural size. B, Portion of the upper surface of the same enlarged, showing the surface-tubercles. C, Part of a vertical section of the same, enlarged: *a*, the calcareous columns represented as opaque; *b*, the lenticular vesicles, filled with calcite.

ferta of the Upper Silurian rocks, which is still the only described species of the genus. As to the structure and affinities of *Labechia*, the French authors regarded it as referable to the *Chætetinæ*, and they describe it as having a corallum with confluent and not distinct calices, the "visceral chambers filled up with complete, horizontal, closely-set tabulæ, and presenting quite rudimentary septa;" while they regard the surface-tubercles as processes springing from the edge of the walls (Brit. Foss. Cor., p. 269). Professor Martin Duncan (Third Rep. on Brit. Foss. Corals; Rep. Brit. Ass., 1871, p. 128) appears to take nearly the same view of the affinities of *Labechia* as that put forward by Edwards and Haime; but he considers that it should be regarded as simply a sub-genus of *Monticulipora*. No evidence, however, in support of this view is actually adduced, so that I can merely mention the opinion held by this distinguished authority. On the other hand, Dr Lindström (Ann. Nat. Hist., ser. 4, vol. xviii. p. 4) correctly pointed out that there is not in *Labechia* "the least trace of any wall circumscribing any calicle, or of any septa;" and he adopts the view—which will be more fully noticed at a later period—that the genus is not Actinozoan at all, but truly Hydrozoan in its affinities. Lastly, the internal structure of *Labechia*, as elucidated by means of microscopic sections, was, so far as I am aware, first pointed out by Dr Murie and myself in a memoir upon the Stromatoporoids (Journ. Linn. Soc., vol. xiv. p. 232).

The skeleton of *Labechia* is calcareous, and entirely resembles that of many of the composite Corals in its general *form* (fig. 44, A), constituting, as it does, a laminar expansion, attached by a basal peduncle, and having its lower surface covered by a concentrically-striated epitheca. On looking at the upper surface of the colony (fig. 44, B, and Pl. XV., fig. 4 *a*), the most striking feature is the apparent total absence, even in the best-preserved examples, of any of the apertures or "calices" that one would expect to find in any normal compound corallum. On the contrary, the whole of the upper surface is covered by a thin imperforate calcareous membrane, which is studded closely and throughout with blunt, elevated, conical, or elongated solid tubercles, which sometimes run into one another and give rise to vermicular ridges. No other features than the above can be recognised by a mere examination of the exterior of the perfect corallum. As regards the internal structure, thin vertical sections (fig. 44, c) at once show that the surface-tubercles are the summits of a series of vertical columns which spring from the epitheca below, and are separated by intervals, which are in general equal to their own width. As viewed in sections of this kind, the columns appear to be composed of homogeneous granular carbonate of lime, which often shows no differentiation into parts. In many cases, however, a central darker or lighter portion may be distinguished from the margins. In tangential sections (Pl. XV., fig. 4), on the other hand, the transversely-divided columns appear as so many oval or rounded bodies, separated by small intervals, and their real structure can now be more satisfactorily studied than in long sections. It was originally believed by Dr Murie and myself that the columns were absolutely and throughout solid and homogeneous, and in many instances they certainly appear to be so, while their *upper ends* seem to be generally solid. In the examination, however, of a series of thin tangential sections, I find that in many cases the columns really show a distinct differentiation of their tissues. I find, namely, that the columns exhibit in cross-section a more or less distinct composition out of delicate concentric lamellæ (Pl. XV., fig. 4), the outermost of which are occasionally denser than the others, and form a distinct marginal line ; while there exists centrally a larger or smaller axial area, which may be either darker or lighter than the rest of the column, and may be surrounded by a definite dark marginal ring. This central area appears really to be a central tube, which is sometimes persistent, but in other cases becomes filled up, in process of growth, with dense sclerenchyma. There is thus reason to believe that the columns of *Labechia* are primitively tubular, but that the median tube is finally largely or entirely obliterated ; while I have at present no positive evidence which would go to show that the axial canal is ever absolutely continued to the summit of the column, so as to open on the surface by a distinct aperture. As a rule, the surface-tubercles appear to be absolutely solid and imperforate ; but I have been occasionally able to detect a minute central depression at their apices, which would appear to show that the central tubes of the columns are really sometimes open above. In specimens which have been slightly weathered, also, one may often recognise under the microscope the existence of an unmistakable central tube in the columns, though I certainly cannot affirm that I have ever been able to detect any openings to which the name of "calices" could be applied.

The interspaces between the columns in the skeleton of *Labechia* are entirely filled (fig. 44, c) with a cellular tissue formed by curved calcareous lamellæ, which have their convexities directed upwards, and give rise to a series of lenticular vesicles which extend from the epitheca below to the surface above, and appear to be bounded superiorly and superficially by a delicate calcareous membrane. In tangential sections (Pl. XV., fig. 4) the cut edges of the curved lamellæ which form the lenticular vesicles appear as irregular curved lines extending between the transversely-divided columns, and subdividing the intervening space into irregular compartments. Both in vertical and in tangential sections, the appearances presented by the interstitial tissue present some curious resemblances to those exhibited by species of *Fistulipora* (such as *F. minor*, M'Coy, and *F. incrassata*, Nich.), in which the tabulæ of the small corallites coalesce and give rise to vesicular tissue.

Having now briefly discussed the intimate structure of *Labechia*, it remains to make a few remarks upon its possible affinities and systematic position. The most recent and most widely adopted theory upon this subject is that put forward by Dr Lindström (Ann. Nat. Hist., ser. 4, vol. xviii. p. 4). According to this acute observer, the skeleton of *Labechia* in its earliest stages of growth consists of "a very thin circular disc, with concentric lines of growth beneath, and having the superior surface studded with blunt spines, which radiate from the centre, and also coalesce and form continuous ridges. In this state it reminds one of nothing more than the sclerobasis of the Hydrozoan genus *Hydractinia;* and the only difference seems to be that *Labechia* is entirely calcareous, whilst *Hydractinia* is corneous. During the course of growth the primitive disc of *Labechia* is increased in thickness by the addition of successive thin strata, which closely conform to the subjacent fundamental crust, being elevated where the spines are situated. As these successive layers leave a small space between them, and are in themselves very thin, they give rise to a false appearance of tabulæ."

Apart from the fact that our present knowledge of the minute structure of *Labechia* will not allow us to accept the above account of the development of the skeleton as entirely correct, there are certain general considerations which preclude an unhesitating acceptance of the Hydractinian affinities of the genus. The most important of these considerations are, in the first place, that the skeleton of Hydractinia is *encrusting*, whereas that of *Labechia* is entirely like that of many corals, and is provided with a basal "epitheca;" while, secondly, the columns of *Labechia* are not certainly known to be perforated at their summits, and there is at present no evidence of the existence of any superficial cells or openings which may be supposed to have given exit to the zoöids.

As we have previously seen, the genus *Labechia* was referred by Milne-Edwards and Haime to the *Chætetinæ*, and has been more recently regarded by Professor Martin Duncan as a sub-genus of *Monticulipora*. It is, indeed, quite clear that if *Labechia* be a coral at all, then it will find its nearest ally in the *Monticuliporidæ*, and especially in *Fistulipora*, M'Coy. From this point of view, it is worth while to glance for a moment at the resemblances presented by *Labechia conferta*, E. and H., and *Fistulipora incrassata*, Nich., as regards their internal structure. Thus, if we compare the vertical section of these two types (see fig. 44 C, and Pl. XV., 3 *b*) we see that in both the basis or general tissue of the skeleton is made up of a series of lenticular vesicles, traversed at regular intervals by the vertical columns in *Labechia*, and by the tabulate tubes of the large corallites in the *Fistulipora*. Similarly in tangential sections (Pl. XV., 4, and Pl. XV., fig. 3 *a*), we have the transversely-divided columns of *Labechia* connected by irregular lines representing the cut edges of the lenticular vesicles; while in the *Fistulipora* we have the cut sections of the large tubes united by lines, which are also the cut edges of the lenticular vesicles, but which in this case are regular in form and mark off the boundaries of the small corallites. When we consider the above resemblances, we are very much tempted to conclude that *Labechia* is a coral similar to *Fistulipora* (or to *Propora* in the series of the *Helioporidæ*), but having the visceral chambers of the large corallites largely or totally obliterated in process of growth. The conversion of some of the corallites into spines or columns is a phenomenon which we have seen to occur in some of the *Monticuliporidæ* (*e.g.*, in *Dekayia*), and would not, therefore, be an absolutely unexampled occurrence. If, however, we were to accept this view, we should have to believe that in *Labechia* it is the *large* corallites of the colony which have their cavities obliterated, and thus become columnar, no such thing having been noticed among other types of corals. Moreover, in the case of corals like *Fistulipora* and *Propora*, we know exactly what is the nature of the interstitial vesicular tissue. We know, namely, that this tissue is formed simply by the coalescence and anastomosis of the tabulæ of a series of small interstitial corallites, the walls of which are imperfectly developed; and we know that the calices of these small corallites can often be detected on the surface in the intervals between the large tubes. (In this connection it should be remembered that the mouths of the small corallites of *Fistulipora* are commonly closed by a calcareous membrane, so that only the calices of the large tubes can be recognised at the surface). On the other hand, there is no distinct evidence that the vesicular tissue of *Labechia* is formed in a manner similar to the above, by the confluence of the tabulæ of a series of small corallites; and, upon any view, we are confronted with the inexplicable circumstance that no apertures or "calices" have ever been certainly detected on the surface of the skeleton. Till openings of some kind have been detected, or till some sort of explanation can be given as to their absence, it appears impossible to come to any definite conclusion as to the affinities and zoological position of *Labechia*, since surface-openings are as essential to our conception of a coralligenous Hydrozoön as to that of an Actinozoön. At the same time, the resemblances which I have pointed out between *Labechia* and certain of the *Fistuliporæ* should not be lost sight of, and, pending more complete investigations, I am disposed at present to consider that we have in these points of likeness the real clue to the true relationships of the former.

As to its geological range, the only described species of *Labechia* is the *L. conferta*, E. and H., of the Upper Silurian, which is a familiar fossil in the Wenlock Limestone of Britain and the Continent of Europe. I have never seen any example of the genus in the corresponding formation (Niagara Limestone) in North America; but I possess a specimen of *Labechia* from the Cincinnati group of Ohio, thus extending the range of the genus to the Lower Silurian; though I have not yet determined whether or not this ancient form is specifically identical with the *L. conferta* of Europe.

INDEX.

The names of genera and species which are 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.

THE END.

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PLATE I.

Fig. 1. Transverse section of a typical example of *Favosites Gothlandica*, Lam., from the Wenlock Limestone of Gotland, showing the regular, polygonal, thin-walled corallites, enlarged five times.

Fig. 1 *a*. A vertical section of the same, similarly enlarged. A mural pore is seen here and there.

Fig. 2. Transverse section of a specimen of *Favosites Gothlandica*, var. *favosa*, Gold., from the Hamilton Group (Devonian) of Erie Co., New York, enlarged five times. Some of the corallites show the marginal foldings of the tabulæ as so many dark spaces.

Fig. 3. Upper and under surfaces of an exceedingly young specimen of *Favosites Gothlandica*, Lam., from the Wenlock Limestone of Dudley, of the natural size.

Fig. 4. Outline of part of the upper surface of the corallum of a specimen of *F. Gothlandica*, var. *favosa*, Gold., from the Niagara Limestone of Manitoulin Island, of the natural size; and a single corallite enlarged four times to show the marginal depressions or plications of the tabulæ.

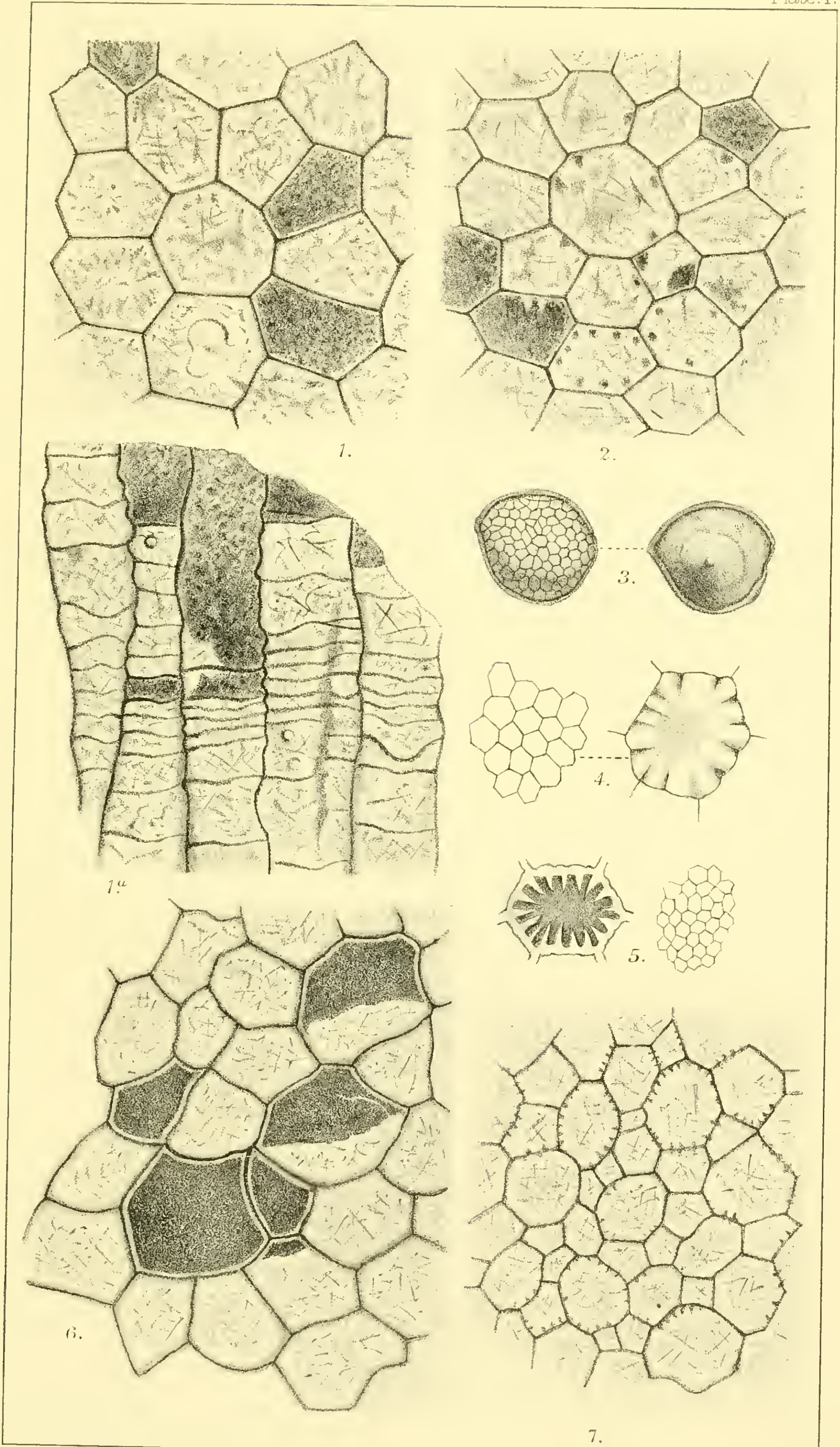
Fig. 5. A few corallites of a specimen of *F. Gothlandica*, from the Niagara Group of Manitoulin Island, with well-developed septal spines (*Astrocerium* of Hall), of the natural size, and one corallite enlarged four times.

Fig. 6. Transverse section of *Favosites Gothlandica*, var. *Billingsii*, Rom., from the Hamilton Group of Arkona, Ontario, enlarged five times.

Fig. 7. Transverse section of an adult example of *Favosites Forbesi*, E. and H., from the Wenlock Limestone of Stoke-Edith, enlarged five times.

H. Alleyne Nicholson del.

Plate. 1.



C. Berjeau lith.

Mintern Bros imp.

PLATE II.

Fig. 1. A young and nearly globular specimen of *Favosites Forbesi*, E. and H., from the Wenlock Limestone of Dudley, of the natural size.

Fig. 1 *a*. Upper portion of the vertical section of a similar specimen of the same species, from the Wenlock Limestone of Benthall Edge, enlarged five times.

Fig. 1 *b*. Transverse section of another young example of the same species, from the Wenlock Limestone of Dudley, enlarged five times.

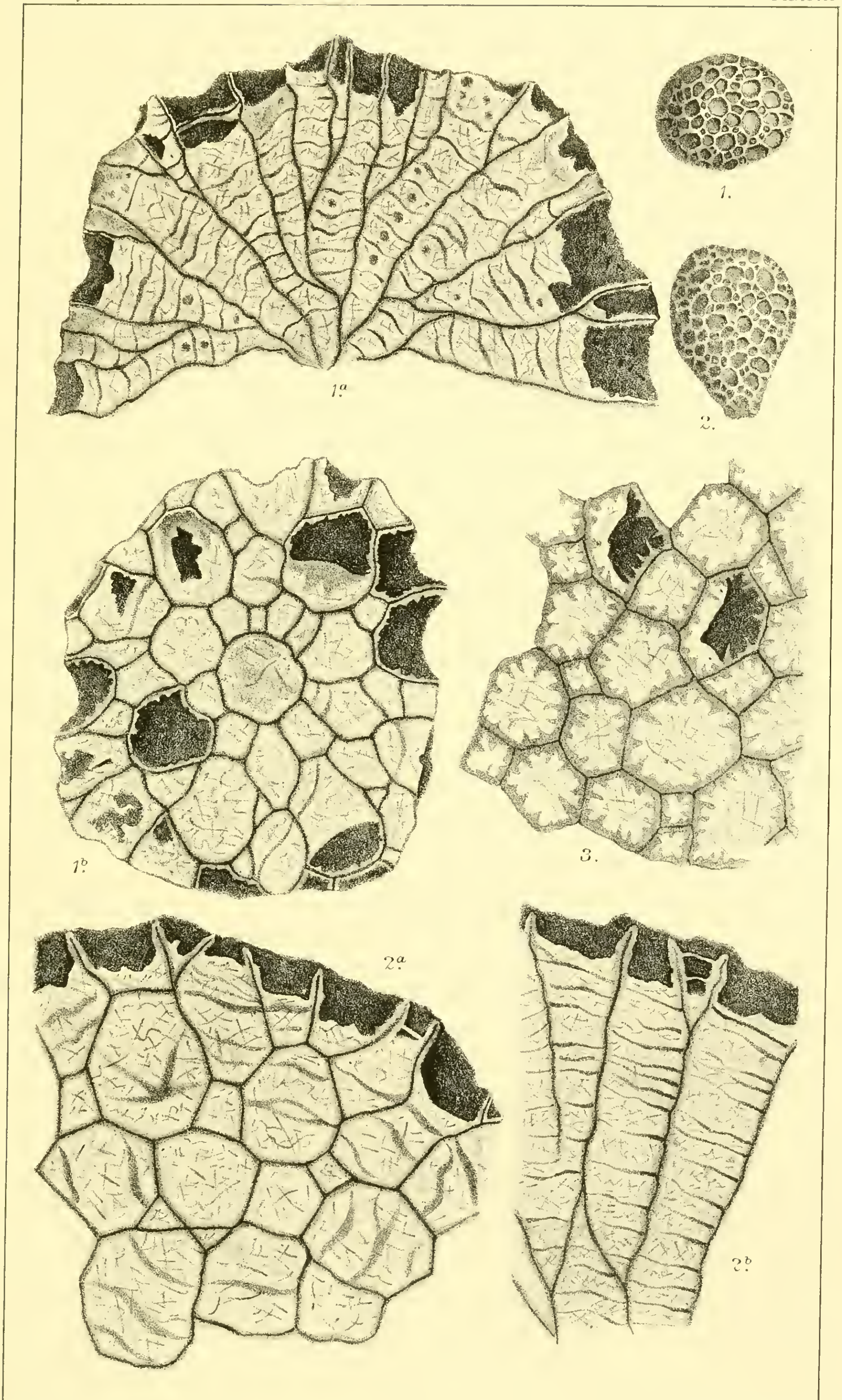
Fig. 2. A young specimen of *Favosites Forbesi*, E. and H., var. *Waldronensis*, Nich., from the Niagara Group of Waldron, Indiana, of the natural size.

Fig. 2 *a*. Part of a tangential section of another young example of the same, from the same locality, enlarged five times.

Fig. 2 *b*. Vertical section of the same species, enlarged five times.

Fig. 3. Transverse section of *Favosites Forbesi*, E. and H., var. *Eifelensis*, Nich., enlarged five times, showing the well-developed septa.

H. Alleyne Nicholson del. Plate. II.



C. Berjeau lith.

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PLATE III.

Fig. 1. An example of *Favosites Forbesi*, E. and H., var. *Eifelensis*, Nich., from the Devonian of Gerolstein in the Eifel, of the natural size.

Fig. 1 *a*. Portion of the surface of the same, enlarged twice.

Fig. 1 *b*. Vertical section of the same, enlarged five times, showing the septal spines, seen laterally and in cross-section, as well as the tabulæ.

Fig. 2. A very young example of *Favosites Forbesi*, E. and H., var. *tuberosa*, Rom., from the Corniferous Limestone of Port Colborne, Ontario, of the natural size. The calices in the lower part of the corallum are closed by an epithecal or opercular growth.

Fig. 2 *a*. Portion of the surface of a large and fully-grown example of the same, from the same locality, of the natural size. The lower calices have undergone closure by the epitheca.

Fig. 2 *b*. Portion of the surface of a large specimen of the same, from the Hamilton formation of Arkona, Ontario, of the natural size.

Fig. 2 *c*. Transverse section of a specimen of the same, from the Hamilton formation of Arkona, Ontario, enlarged five times.

Fig. 2 *d*. Part of a vertical section of the same specimen as the last, enlarged five times. Besides the tabulæ proper, the section shows some of the peculiar transverse squamæ, or incomplete tabulæ, characteristic of this peculiar form.

Fig. 2 *e*. Portion of two corallites of a silicified example of the same, from the Corniferous Limestone of Port Colborne, Ontario, enlarged three times. The interior of the tubes exhibits the peculiar transverse squamæ above alluded to, and the mural pores are also seen.

Fig. 3. Transverse section of *Favosites* (*Emmonsia*) *hemisphærica*, Yand. and Shumard., enlarged five times, from the Corniferous Limestone of Port Colborne, Ontario.

Fig. 3 *a*. Portion of one of the tubes of the same specimen, similarly enlarged, showing the close-set biserial mural pores.

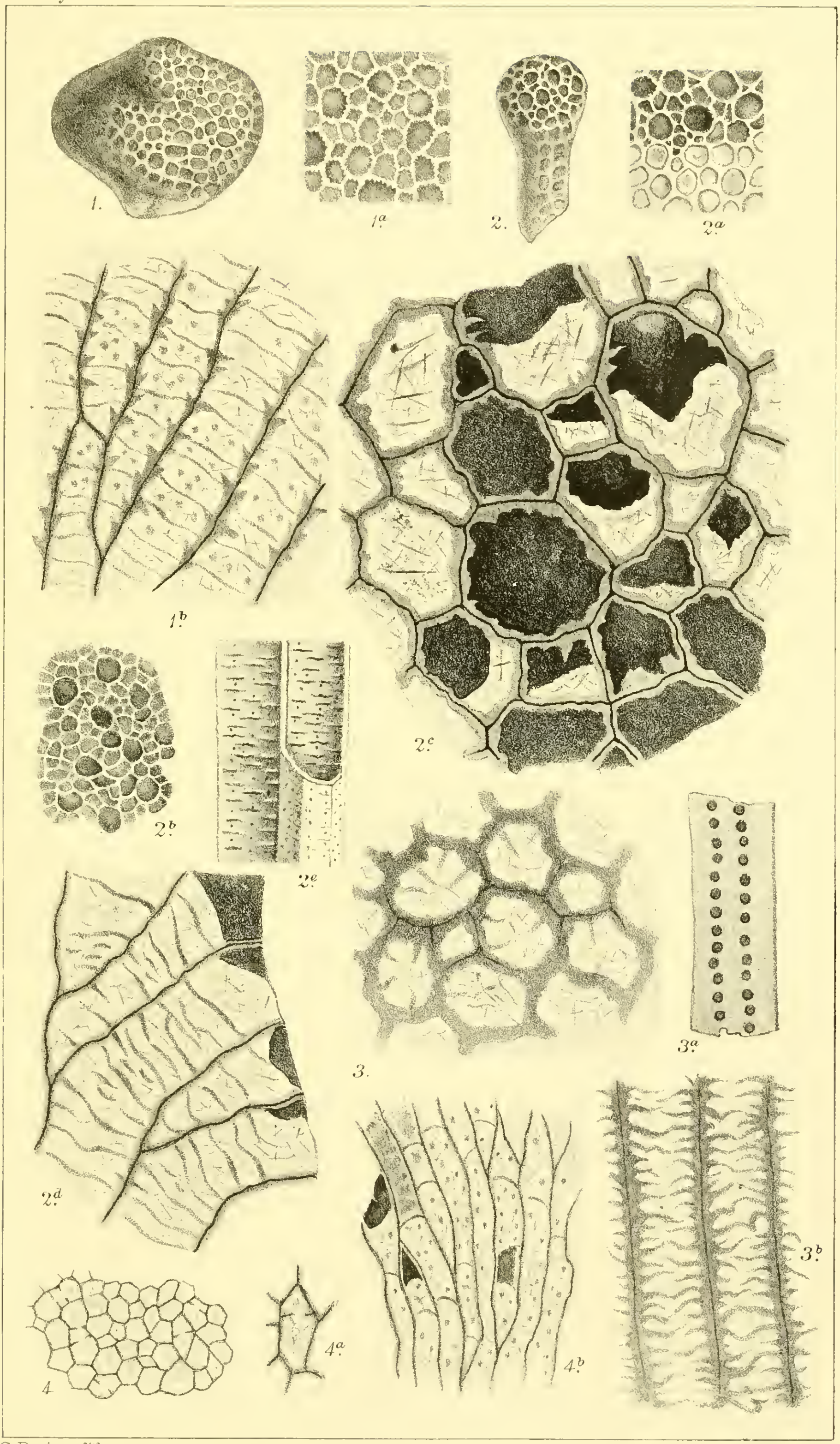
Fig. 3 *b*. Portion of a vertical section of the same specimen, in which the tubes are quite empty, enlarged five times, showing the incomplete and flexuous tabulæ.

Fig. 4. Portion of a transverse section of *Favosites Bowerbanki*, E. and H., from the Wenlock Limestone of Benthall Edge, enlarged five times. Several of the corallites show an incomplete division of their tubes by means of laminæ directed inwards.

Fig. 4 *a*. Transverse section of a single corallite of the same specimen, showing incompleted fission, enlarged ten times.

Fig. 4 *b*. Part of a vertical section of the same species, from the Wenlock Limestone of Gotland, enlarged five times, showing the tabulæ and mural pores.

H. Alleyne Nicholson. del. Plate. III.



C. Berjeau lith. Mintern Bros imp.

PLATE IV.

Fig. 1. Portion of the corallum of *Favosites clausus*, Rom., from the Hamilton formation (Devonian) of Arkona, Ontario, of the natural size. In the upper portion of the specimen the calices are open.

Fig. 1 *a*. A few of the calices of the same, closed with an operculum, enlarged five times.

Fig. 1 *b*. Tangential section of the same, enlarged five times.

Fig. 1 *c*. Vertical section of the same, enlarged five times.

Fig. 2. *Pachypora lamellicornis*, Lindst., from the Upper Silurian of Gotland, of the natural size.

Fig. 2 *a*. Portion of a tangential section of the same, showing the dense secondary deposit of sclerenchyma in the interior of the tubes, enlarged seven times, with a single corallite enlarged still further, to show the rudimentary septa.

Fig. 2 *b*. Portion of a longitudinal section of the same, similarly enlarged, showing the thick walls, remote tabulæ, and mural pores.

Fig. 2 *c*. Portion of the surface of the same, enlarged five times.

Fig. 3. Portion of the corallum of *Pachypora* (*Favosites*) *cervicornis*, De Blainv., from the Devonian of Gerolstein in the Eifel, of the natural size. The calices are omitted over the greater portion of the surface.

Fig. 3 *a*. Portion of the surface of the same, enlarged about six times.

Fig. 3 *b*. Portion of a tangential section of a specimen of the same, in which the cavities of the fossil are filled with oxide of iron, enlarged seven times. The thickening of the walls of the corallites is shown, as well as the lateral communication of the visceral chambers of some of the corallites.

Fig. 3 *c*. Portion of a transverse section of the same, taken in the axis of a branch, similarly enlarged, showing how greatly the tubes are narrowed by secondary deposits of sclerenchyma, the original walls still remaining quite distinct.

Fig. 3 *d*. Portion of a longitudinal section of the same, enlarged seven times, showing the great and irregular thickening of the corallites near their mouths, together with remote tabulæ, and large-sized mural pores. The specimen is partially infiltrated with oxide of iron.

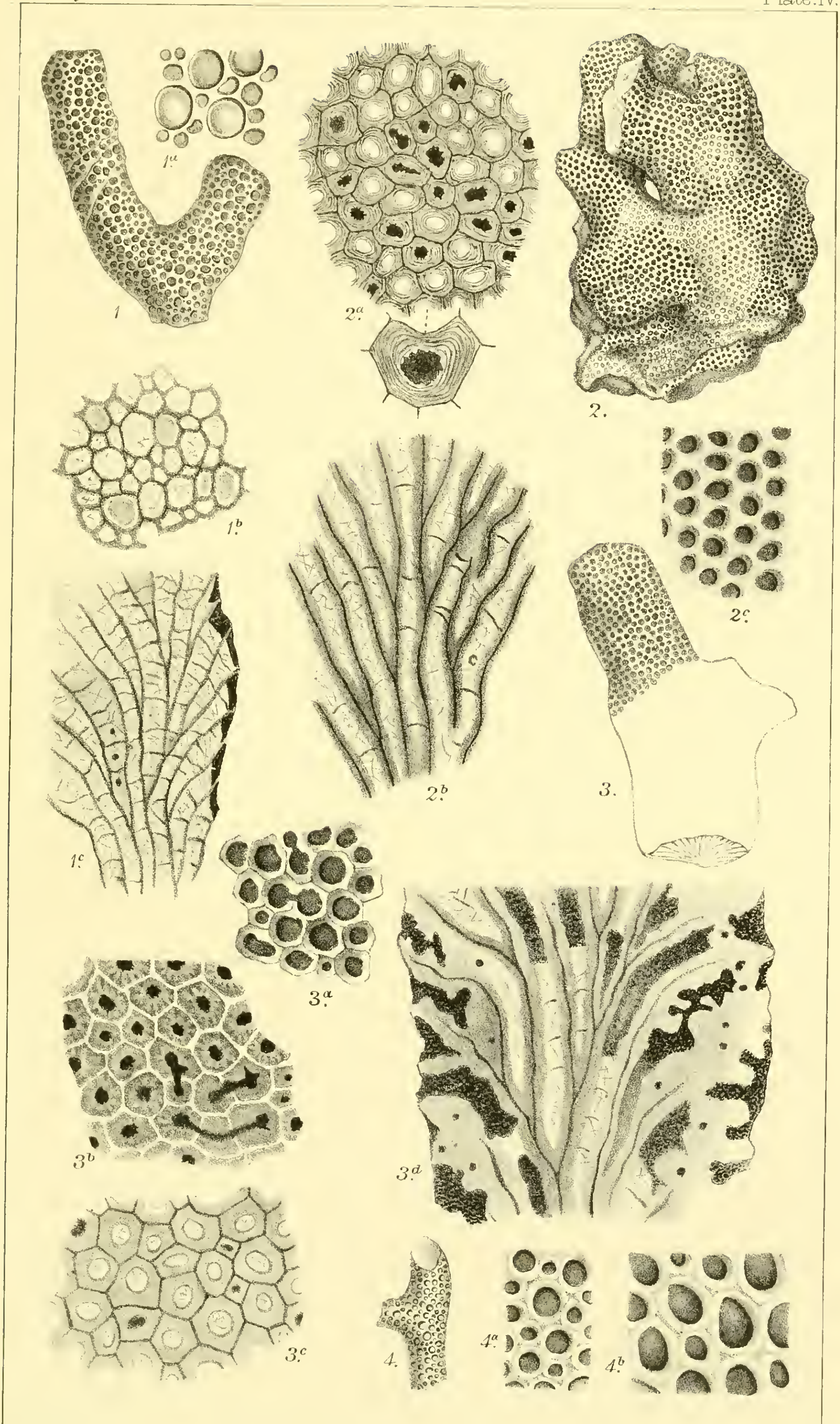
Fig. 4. Small and imperfect specimen of *Pachypora* (*Favosites*) *cristata*, E. and H., from the Wenlock Limestone of Dormington, near Stoke-Edith, of the natural size.

Fig. 4 *a*. Portion of the surface of the same, enlarged five times.

Fig. 4 *b*. Portion of the surface of a specimen of *Pachypora* (*Favosites*) *cristata*, var. *major*, E. and H., from the same locality, similarly enlarged.

H. Alleyne Nicholson del.

Plate. IV.



C. Berjeau. lith.

Mintern Bros imp.

PLATE V.

Fig. 1. Transverse section of *Pachypora* (*Favosites*) *cristata*, E. and H., enlarged seven times, showing the thickening of the tubes by a secondary deposit of sclerenchyma. From the Wenlock Limestone of Dormington, near Stoke-Edith.

Fig. 1 *a*. Vertical section of the same, showing the thickened walls, tabulæ, and mural pores, enlarged seven times.

Fig. 1 *b*. Vertical section of another specimen of the same, from Benthall Edge, showing the tabulæ, together with numerous septal spines; enlarged seven times.

Fig. 2. Fragment of *Striatopora Linneana*, Billings, from the Hamilton formation of Ontario, of the natural size.

Fig. 2 *a*. A small portion of the surface of the same, enlarged five times.

Fig. 2 *b*. Transverse section of a branch of the same, enlarged seven times.

Fig. 2 *c*. Portion of a tangential section of the same, enlarged seven times, showing the thickened walls, and spine-like septa.

Fig. 2 *d*. Part of a vertical section of the same, enlarged seven times, showing the thickened walls, the occasional tabulæ, and the mural pores.

Fig. 3. Fragment of *Trachypora ornata*, Rom., from the Hamilton formation of Erie County, New York, of the natural size.

Fig. 3 *a*. Small portion of the surface of the same, enlarged five times, showing the ornamentation.

Fig. 3 *b*. Vertical section of the same, enlarged seven times, showing the thickened walls, the occasional tabulæ, the numerous spiniform septa, and the few mural pores.

Fig. 3 *c*. Tangential section of the same, enlarged seven times, showing the thickening of the walls by concentric lamellæ of sclerenchyma and the rudimentary septa.

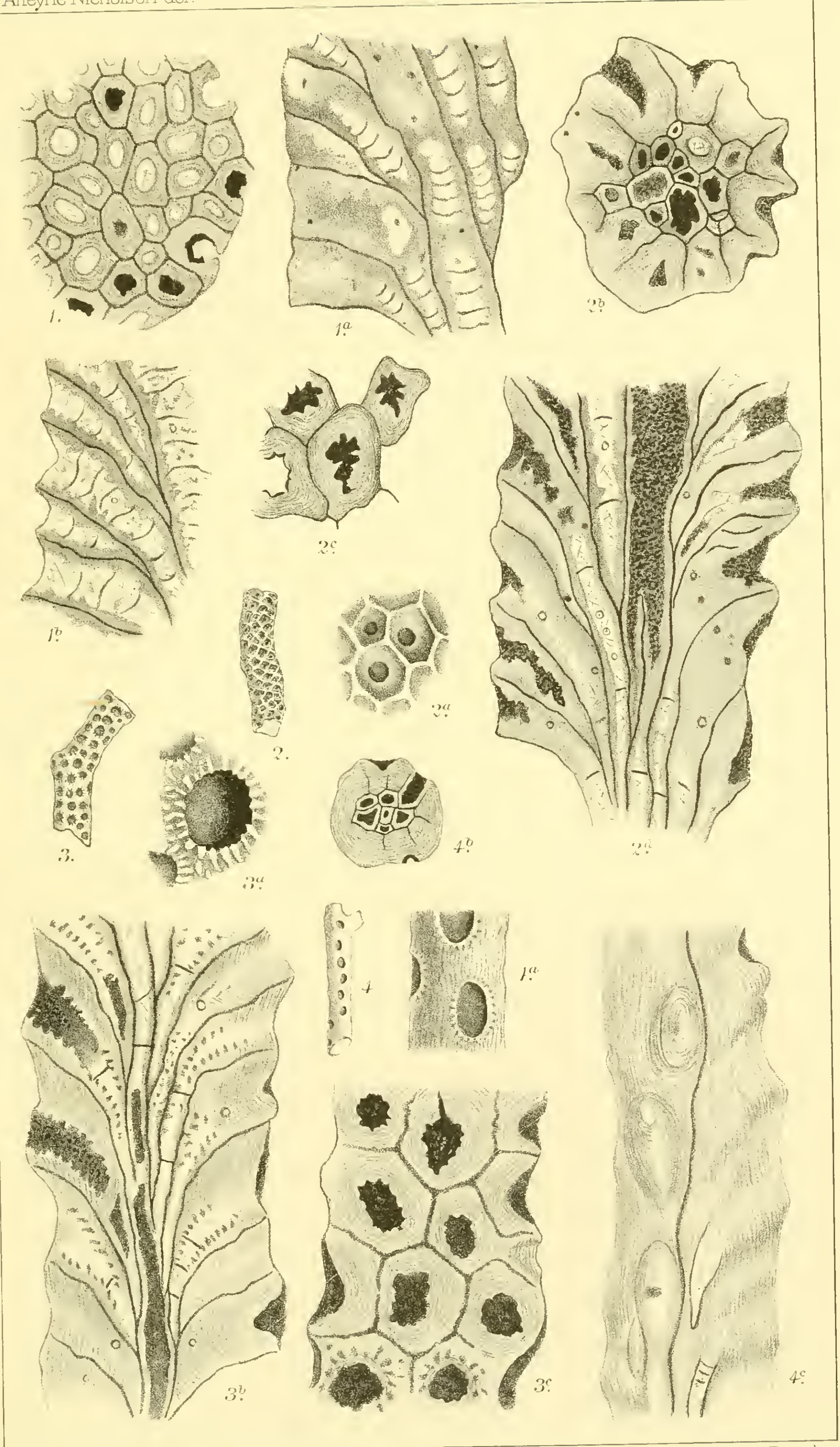
Fig. 4. Fragment of *Trachypora elegantula*, Bill., from the Hamilton Group of Arkona, Ontario, of the natural size.

Fig. 4 *a*. Small portion of the surface of the same, enlarged five times, showing the peculiar ornamentation.

Fig. 4 *b*. Transverse section of a branch of the same, enlarged five times.

Fig. 4 *c*. Vertical section of a branch of the same, enlarged seven times, showing the immense thickening of the corallites by the deposition in their interior of successive laminæ of sclerenchyma.

H. Alleyne Nicholson del.



C. Berjeau lith.

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PLATE VI.

Fig. 1. A colony of *Vermipora clausa*, Lindst., from the Upper Silurian of Gotland, enlarged twice.

Fig. 1 *a*. Transverse section of the same, enlarged seven times, showing spiniform septa.

Fig. 1 *b*. Vertical section of the same, enlarged seven times, showing tabulæ and mural pores.

Fig. 2. Portion of the surface of the corallum of *Alveolites suborbicularis*, Lam., from the Eifel, enlarged seven times, showing no apparent traces of the single septal ridge.

Fig. 2 *a*. Portion of a tangential section of the same, also from the Eifel, showing the form of the corallites. A few of the tubes show a single septal tooth. Enlarged twelve times.

Fig. 2 *b*. Vertical section of the same, enlarged twelve times, showing tabulæ. The section cuts the tubes at right angles to their long diameters.

Fig. 3. Tangential section of *Alveolites Labechei*, E. and H., from the Upper Silurian of Benthall Edge, enlarged twelve times, showing the compressed tubes and well-developed spiniform septa.

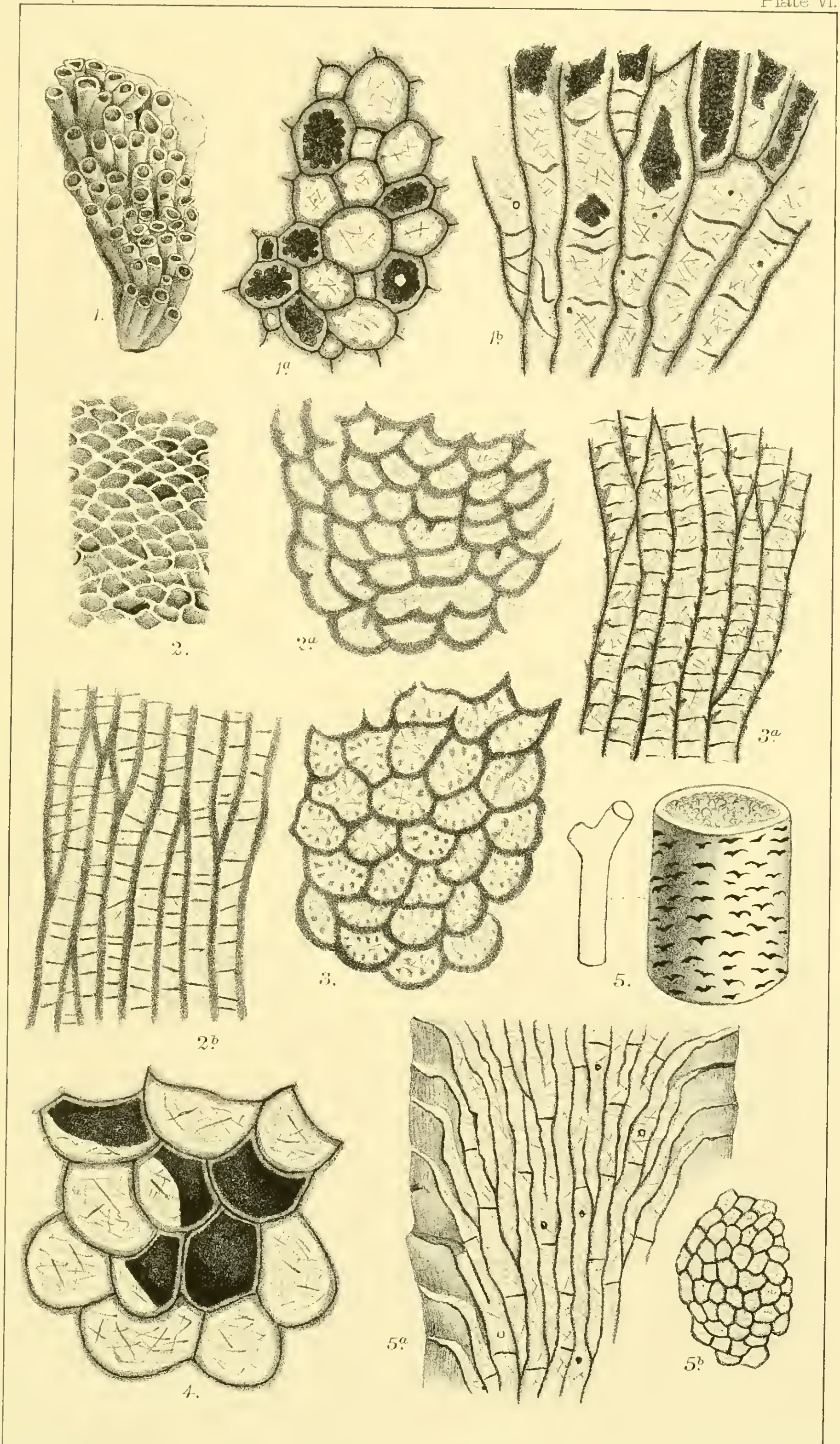
Fig. 3 *a*. Vertical section of the same, enlarged twelve times, showing the spiniform septa, and the tabulæ. The section cuts the corallites parallel with their short diameters.

Fig. 4. Portion of a tangential section of *Alveolites Goldfussi*, Bill., from the Hamilton Group (Devonian) of Canada, enlarged twelve times, showing the thin-walled compressed tubes, and the absence of septal spines or ridges.

Fig. 5. A fragment of *Cœnites juniperinus*, Eichw., of the natural size, and enlarged five times. From the Wenlock Limestone of Stoke-Edith.

Fig. 5 *a*. Part of a vertical section of the same, enlarged twelve times, showing the thickening of the tubes close to the mouths, the tabulæ, and the mural pores.

Fig. 5 *b*. Portion of a transverse section of a branch of the same, enlarged twelve times, showing the compressed corallites in the axis of the stem, with unthickened walls.



C. Berjeau lith.

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PLATE VII.

Fig. 1. Fragment of a laminar specimen of *Cœnites linearis*, E. and H., of the natural size, from the Wenlock Limestone of Benthall Edge.

Figs. 1´*a* and 1 *b*. Different forms of the calices of the same, enlarged eight times.

Fig. 1 *c*. Tangential section of the same, enlarged twelve times.

Fig. 1 *d*. Portion of a section of the same, taken at right angles to the flat surfaces of the expansion, enlarged twelve times, showing the great thickening of the tubes as they bend outwards to the surface.

Fig. 1 *e*. Portion of a longitudinal section of the same, taken through the median plane of the corallum, enlarged twelve times, showing tabulæ and mural pores.

Fig. 2. A small specimen of *Columnopora cribriformis*, Nich., from the Cincinnati Group of Ohio, of the natural size, viewed from above.

Fig. 2 *a*. Portion of a tangential section of a specimen of the same, from the Cincinnati Group of Ohio, enlarged five times, showing the rudimentary septa, the mural pores, and the "intramural canals." The visceral cavities are filled with the matrix.

Fig. 2 *b*. Cross-section of a single corallite of the same, enlarged ten times, showing the "intramural canals."

Fig. 2 *c*. Part of a vertical section of another specimen of the same, from the Cincinnati Group (Hudson River Group) of the Credit River, Ontario, enlarged five times. In parts the section cuts through the centre of the tubes, and shows the inosculating tabulæ; but in other parts it more or less nearly coincides with the plane of the walls of the corallites, and shows the large and numerous mural pores.

Fig. 2 *d*. Part of the preceding section, enlarged ten times, showing the cribriform wall.

Fig. 3. Fragment of *Laceripora cribrosa*, Eichw., of the natural size. (After Eichwald.)

Fig. 3 *a*. Surface of the same, enlarged. (After Eichwald.)

Fig. 3 *b*. Longitudinal section of the tubes of the same, enlarged. (After Eichwald.)

H. Alleyne Nicholson del. Plate VII.

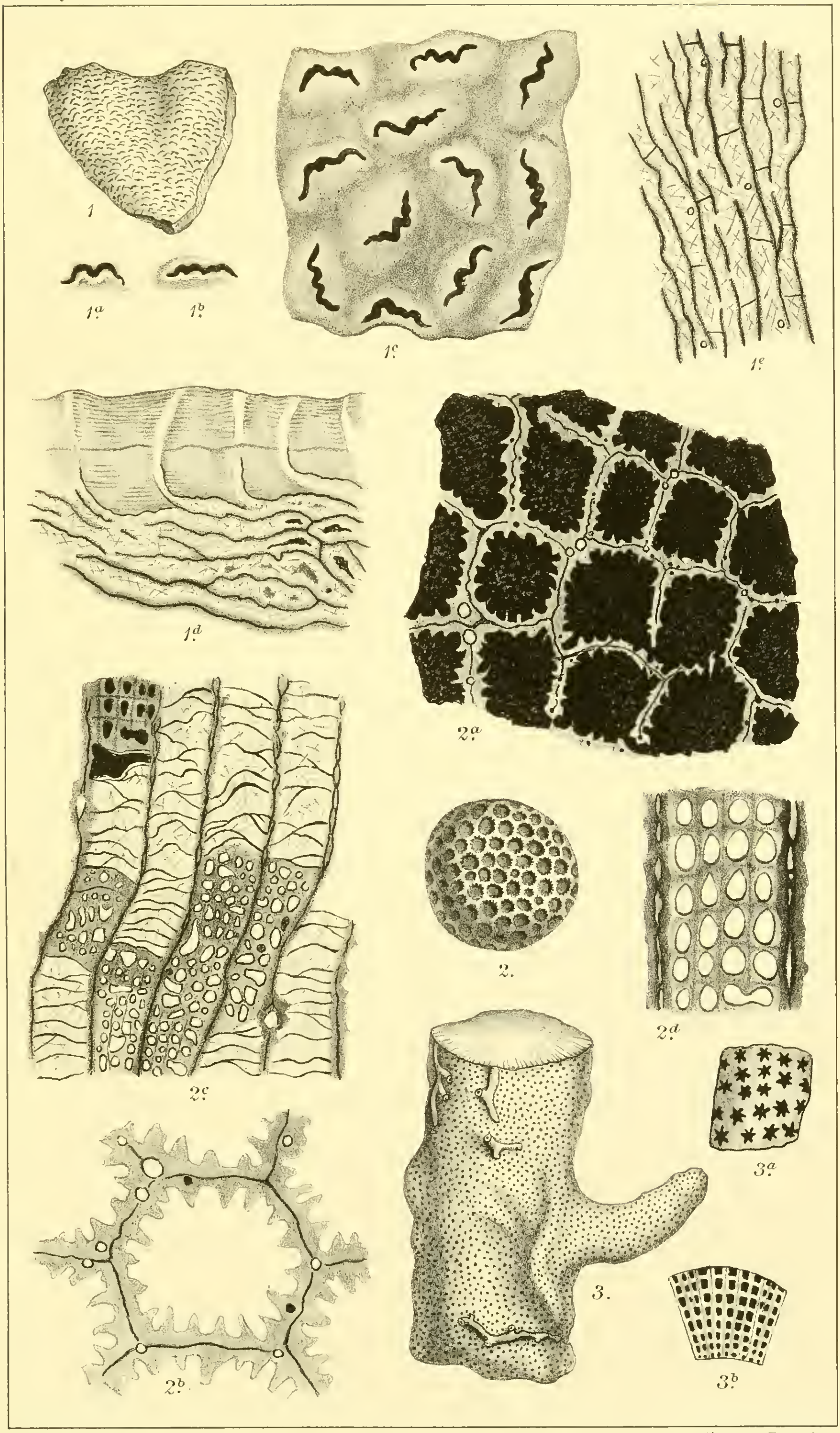

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PLATE VIII.

Fig. 1. Section of the corallum of *Pleurodictyum stylophorum*, Eaton., taken parallel with and just above the flat base, enlarged two and a half times, showing the tabulæ, pores, and rudimentary septa. The sections of the "vermiform body" are left white, for clearness' sake. From the Hamilton Group (Devonian) of the State of New York.

Fig. 1 *a*. Part of a tangential section of the same, similarly enlarged. A few mural pores are seen in section; and the sections of the "vermiform body" are, as before, left white, except in one place where some dark ovoid bodies occur within its cavity.

Fig. 1 *b*. Vertical section of a specimen of the same, similarly enlarged, showing the inosculating tabulæ and mural pores. The visceral chambers of all the corallites, except one, are filled with the matrix, and the sections of the "vermiform body" are, as before, left unshaded.

Fig. 2. Portion of the corallum of *Chonostegites Clappi*, E. and H. (= *Haimeophyllum ordinatum*, Bill.), of the natural size, viewed laterally. Corniferous Limestone (Devonian), Walpole, Ontario.

Fig. 2 *a*. Portion of the upper surface of a broken corallum of the same, of the natural size, showing the convex tabulæ, and the upper surfaces of the lateral connecting-floors.

Fig. 2 *b*. Part of a transverse section of the same, enlarged twice. The actual corallites are cut across transversely, but the lateral connecting-floors are only seen where their undulations happen to bring them into the plane of the section.

Fig. 2 *c*. Part of a vertical section of the same, enlarged twice, showing the form and mode of increase of the corallites, their hollow and vesicular lateral connecting-floors, and the inosculating and subvesicular tabulæ, the upper surfaces of which are serrated with spiniform projections. Both this and the preceding drawing (fig. 2 *b*) are taken from sections of a specimen in which the tubes are exceptionally wide apart.

Fig. 3. Small specimen of *Lyopora favosa*, M'Coy, sp., from the Lower Silurian of Craighead, Girvan, of the natural size. (After Nicholson and R. Etheridge, jun.)

Fig. 3 *a*. A few calices of the same enlarged.

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Plate VIII.

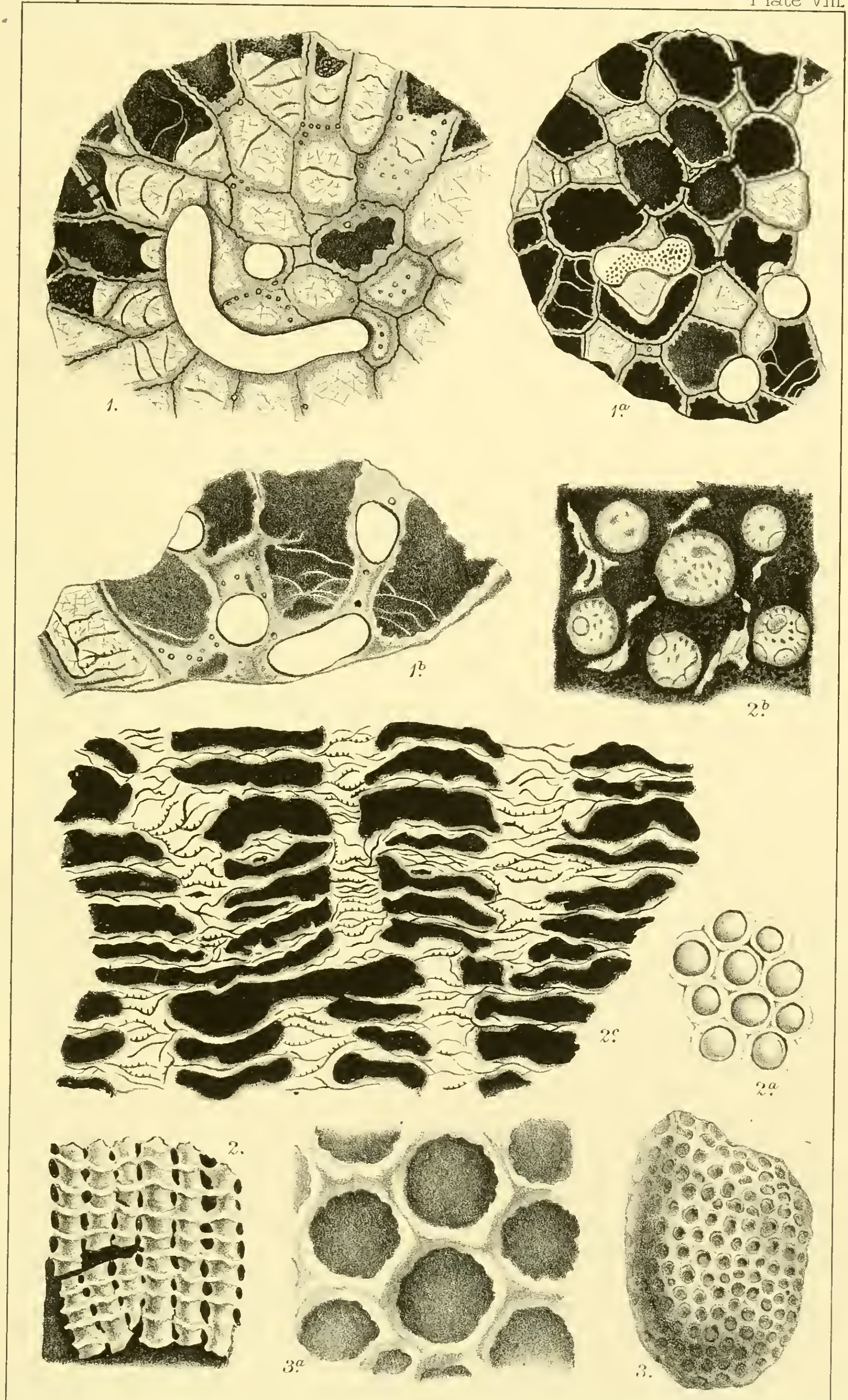

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PLATE IX.

Fig. 1. Part of a vertical section of *Stenopora ovata*, Lonsd., from the Carboniferous rocks of Queensland, enlarged about twenty-five times, showing the periodical annular thickenings of the corallites, the remote tabulæ, placed at corresponding levels in contiguous tubes, and the mural pores.

Fig. 1 *a*. Part of a tangential section of the same specimen, taken just below the surface, and similarly enlarged, showing the hexagonal form of the tubes and the peculiar appearances which they present when the section cuts them across their unthickened or thickened portions.

Fig. 2. Part of a tangential section of *Lyopora favosa*, M'Coy, sp., from the Lower Silurian of Craighead, Girvan, enlarged eight times, showing the rudimentary septa, and the thickened walls, in which a few small vacuities are visible.

Fig. 2 *a*. Part of a vertical section of another specimen of the same, similarly enlarged, showing the thick walls and the remote complete tabulæ. As in the preceding section, a few minute irregular vacuities are seen here and there in the substance of the wall.

Fig. 3. A specimen of *Nyctopora Billingsii*, Nich., from the Trenton Limestone of Canada, of the natural size; viewed from above.

Fig. 3 *a*. Part of a transverse section of the same, enlarged eight times, showing the complete fusion of the walls of the corallites, and the marginal septa, together with an occasional mural pore.

Fig. 3 *b*. Part of a vertical section of the same, enlarged eight times, showing the tabulæ and mural pores. Where the section cuts through the centre of the tubes, the tabulæ are alone seen; where the section passes nearly along the plane of the wall of a tube, the marginal septa and mural pores are brought into view.

Fig. 3 *c*. Small part of the surface of the same, enlarged ten times, showing the calices.

Fig. 4. A small specimen of *Billingsia alveolaris*, De Koninck, from the Devonian of New South Wales, of the natural size (after De Koninck). The corallum is split, and shows the large mural pores connecting contiguous tubes.

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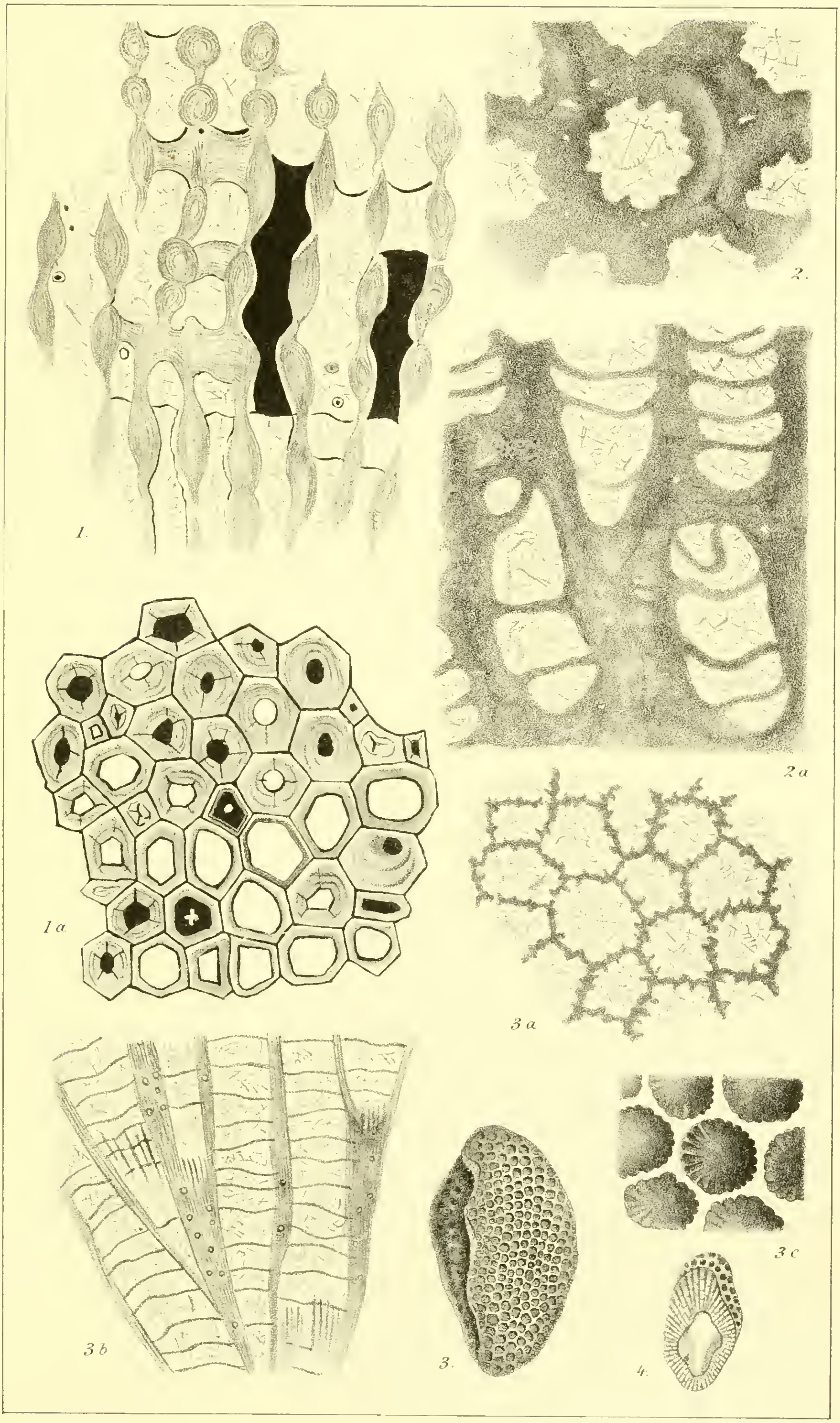

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PLATE X.

Fig. 1. Part of a transverse section of *Columnaria alveolata*, Goldf. (= *Favistella stellata*, Hall), enlarged five times, showing the characters of the septa. From the Cincinnati Group of Ohio.

Fig. 1 *a*. Longitudinal section of a single tube of the same, similarly enlarged. Owing to the curvature of the tube, the cut edges of the septa appear in parts of the section.

Fig. 2. Part of a transverse section of *Columnaria calicina*, Nich., from the Hudson River Group of Canada, enlarged five times, showing the structure of the wall and the characters of the septa.

Fig. 2 *a*. A single tube of the same, in longitudinal section, similarly enlarged, showing tabulæ, and part of the cut edges of the septa.

Fig. 3. Part of a transverse section of *Columnaria* (?) *Halli*, Nich. (= *Columnaria alveolata*, of Hall, Billings, &c.), enlarged five times, showing the amalgamation of the walls of the corallites and the marginal septa.

Fig. 3 *a*. Part of a vertical section of the same, similarly enlarged, showing the tabulæ. In part of the section the cut edges of the septa are seen.

Fig. 4. Part of a vertical section of *Syringopora geniculata*, Phill., enlarged five times. From the Carboniferous Limestone of Shap, Westmorland.

Fig. 4 *a*. Part of a transverse section of the same specimen, enlarged five times, showing the thickened tubes.

Fig. 4 *b*. Transverse section of a corallite of the same, enlarged about twenty-five times, showing the contraction of the visceral chamber by a secondary deposit of sclerenchyma within the true wall.

Fig. 5. Transverse section of a single corallite of *Syringopora reticulata*, Goldf., from the Carboniferous Limestone of Kendal, Westmorland, enlarged about fifteen times, showing the spiniform septa, and the cut edges of the tabulæ.

Fig. 6. Transverse section of a few of the tubes of *Halysites escharoides*, Lam., from the Upper Silurian of Gotland, enlarged ten times, showing the spiniform septa, and the apparent absence of any small zoöids.

Fig. 7. Transverse section of a few of the tubes of *Halysites catenularia*, Linn., from the Wenlock Limestone of Dudley, enlarged five times, showing the presence of small zoöids and the absence of septa.

Fig. 7 *a*. Vertical section of another specimen of the same, enlarged five times, showing the tabulæ of the larger and smaller zoöids.

H. Alleyne Nicholson, del. Plate X

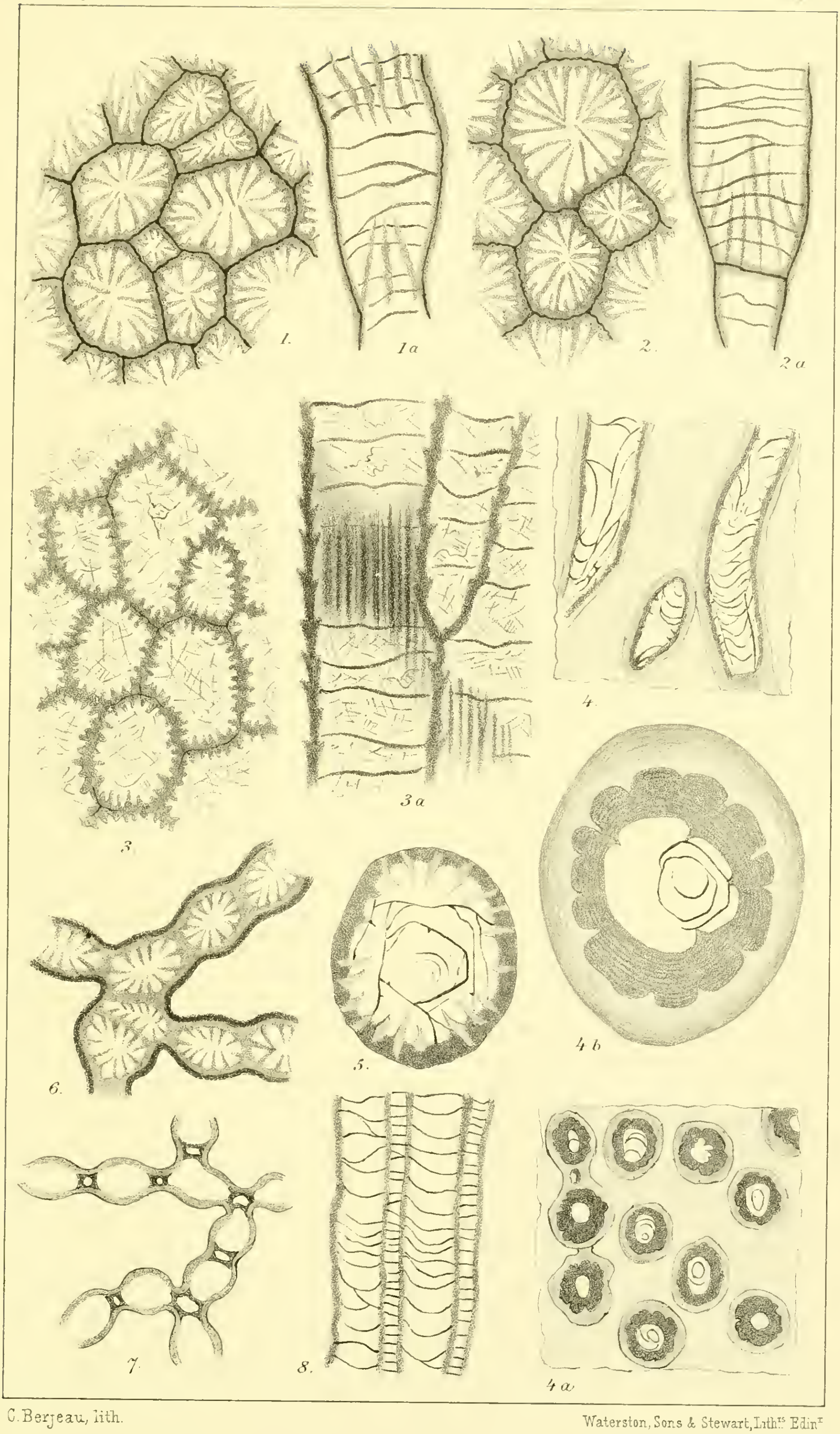

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PLATE XI.

Fig. 1. Transverse section of a few of the tubes of *Halysites catenularia*, Linn., from the Wenlock Limestone of Dormington, Stoke-Edith, enlarged ten times, showing the absence of septa in the large tubes, and the structure of the intermediate tubes. The epitheca is left unshaded.

Fig. 1 *a*. Part of a vertical section of another specimen of the same, from the same locality, enlarged five times. The specimen is one in which the tubes are of unusually large size, and the tabulæ of the intermediate tubes are subvesicular.

Fig. 2. Portion of the surface of *Thecia Swindernana*, Goldf., enlarged about ten times. Wenlock Limestone, Dormington Quarry, Stoke-Edith.

Fig. 2 *a*. Part of a transverse section of the same, enlarged ten times, showing the obtuse septal ridges, the communication of the cavities of the polypes by horizontal channels, and the filled-up tubuli of the interstitial tissue.

Fig. 2 *b*. A small part of the same transverse section, enlarged twenty times, showing the filled-up interstitial tubuli.

Fig. 2 *c*. Part of a vertical section of the same, enlarged ten times, showing the tabulate larger corallites, the horizontal canals uniting the visceral chambers of these, and the small tubules of the interstitial tissue.

Fig. 2 *d*. Small portion of the same section, enlarged twenty times, showing the interstitial tubuli.

Fig. 3. Part of a transverse section of *Propora tubulata*, E. and H., enlarged five times, from the Wenlock Limestone of Dudley. The specimen is one in which the septa are unusually small and short.

Fig. 3 *a*. Part of the same section, enlarged ten times.

Fig. 3 *b*. Part of a vertical section of the same specimen, enlarged ten times.

Fig. 4. Portion of the surface of an altered specimen of *Lyellia glabra*, E. and H., from the Upper Silurian of Iowa, of the natural size (copied from Edwards and Haime).

Fig. 4 *a*. Portion of a specimen of *Lyellia glabra*, E. and H., seen from one side, enlarged (copied from Edwards and Haime).

Fig. 5. Part of a tangential section of *Plasmopora petaliformis*, E. and H., from the Wenlock Limestone of Gotland, enlarged five times.

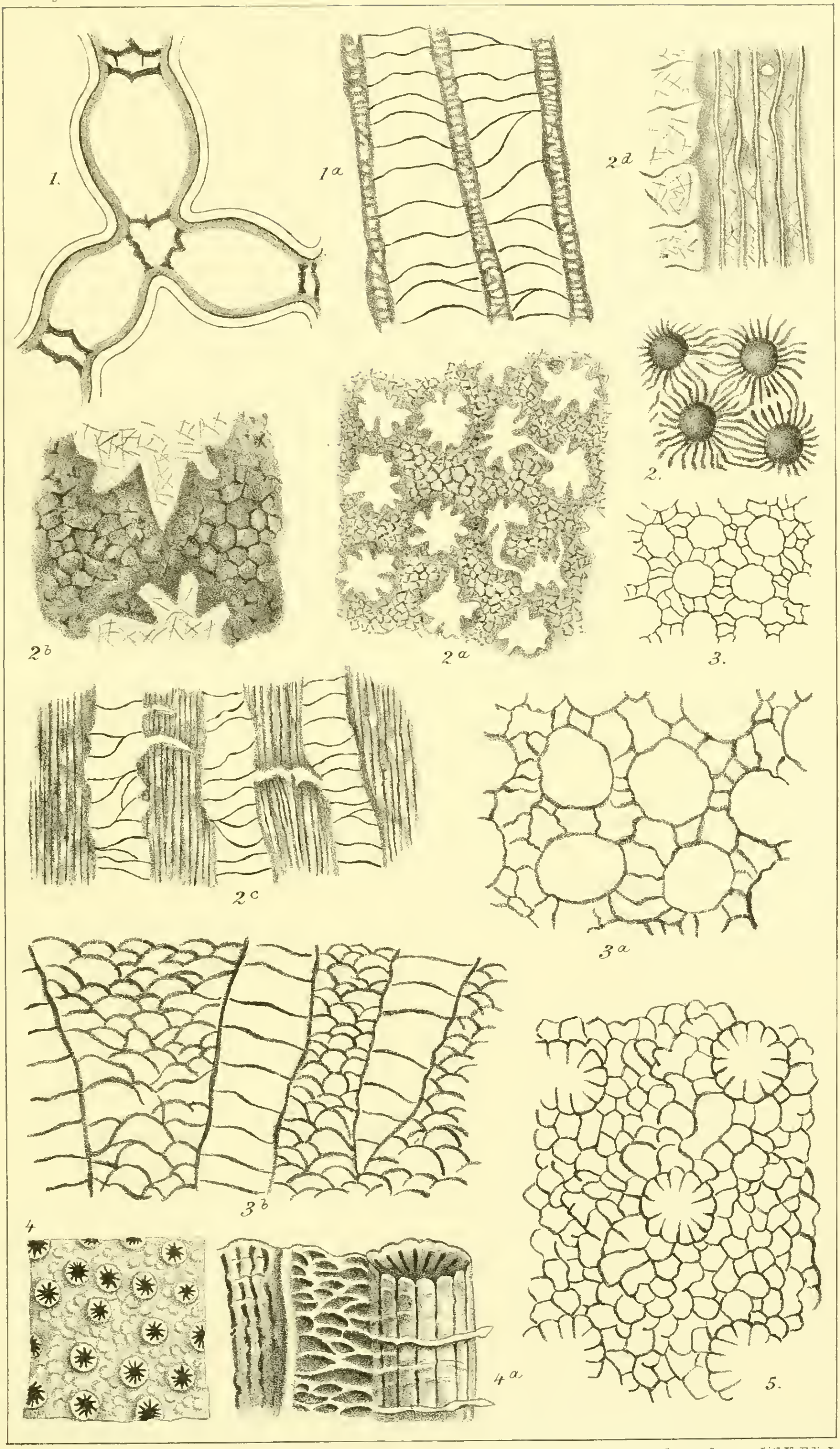
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PLATE XII.

Fig. 1. Part of a vertical section of a young specimen of *Plasmopora petaliformis*, E. and H., from the Wenlock Limestone of Dudley, enlarged five times, showing the faintly-marked walls of the smaller corallites, and their convex tabulæ.

Fig. 2. Portion of a tangential section of *Heliolites megastoma*, M'Coy, from the Wenlock Limestone of Dudley, enlarged five times.

Fig. 2 *a*. Part of a vertical section of the same specimen, enlarged five times, showing the comparatively well-marked walls of the smaller corallites and their strong horizontal tabulæ.

Fig. 3. Under surface of a small specimen of *Pinacopora Grayi*, Nich. and Eth. jun., from the Lower Silurian of Girvan, Ayrshire, of the natural size, showing the concave base, with its concentrically-striated epitheca.

Fig. 3 *a*. Upper surface of another specimen of the same, from which all the short corallites except a few on one margin have been denuded, leaving the superior aspect of the epithecal plate to view, of the natural size.

Fig. 3 *b*. Portion of the corallum of the same, as naturally split along a horizontal plane, showing the large and small corallites, with their visceral chambers filled with dark matrix,—enlarged five times.

Fig. 3 *c*. Part of a vertical section of the corallum of the same, embedded in an opaque matrix,—enlarged five times.

Fig. 3 *d*. Tangential section of another specimen of the same, infiltrated with calcite, showing the large and small corallites (*p*, *p* and *t*, *t*),—enlarged twenty times.

Fig. 3 *e*. Vertical section of another example of the same, enlarged twenty times, showing the large corallites (*p*, *p*), and the smaller and more closely tabulate tubes (*t*, *t*). [Figs. 3-3 *e* are copied from the "Monograph of the Silurian Fossils of Girvan," by R. Etheridge, jun., and the author.]

Fig. 4. Tangential section of a specimen of *Chætetes radians*, Fischer, from the Carboniferous Limestone of Russia, showing the thick and completely confluent walls of the corallites, with an occasional inward projection indicative of commencing fission,—enlarged ten times.

Fig. 4 *a*. Vertical section of the same, enlarged ten times, showing the remote and regularly placed tabulæ.

Fig. 4 *b*. Portion of surface of the same, enlarged ten times, showing the form of the calices.

Fig. 4 *c*. Portion of a tangential section of a specimen of the same, from the Carboniferous Limestone of Shap, Westmorland, enlarged ten times.

Fig. 4 *d*. A small portion of the same section as the last, enlarged twenty times, showing the complete amalgamation of the walls of the tubes, and the presence in some of the tubes of the inward projections produced in the process of fission of the old corallites.

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Plate XII.

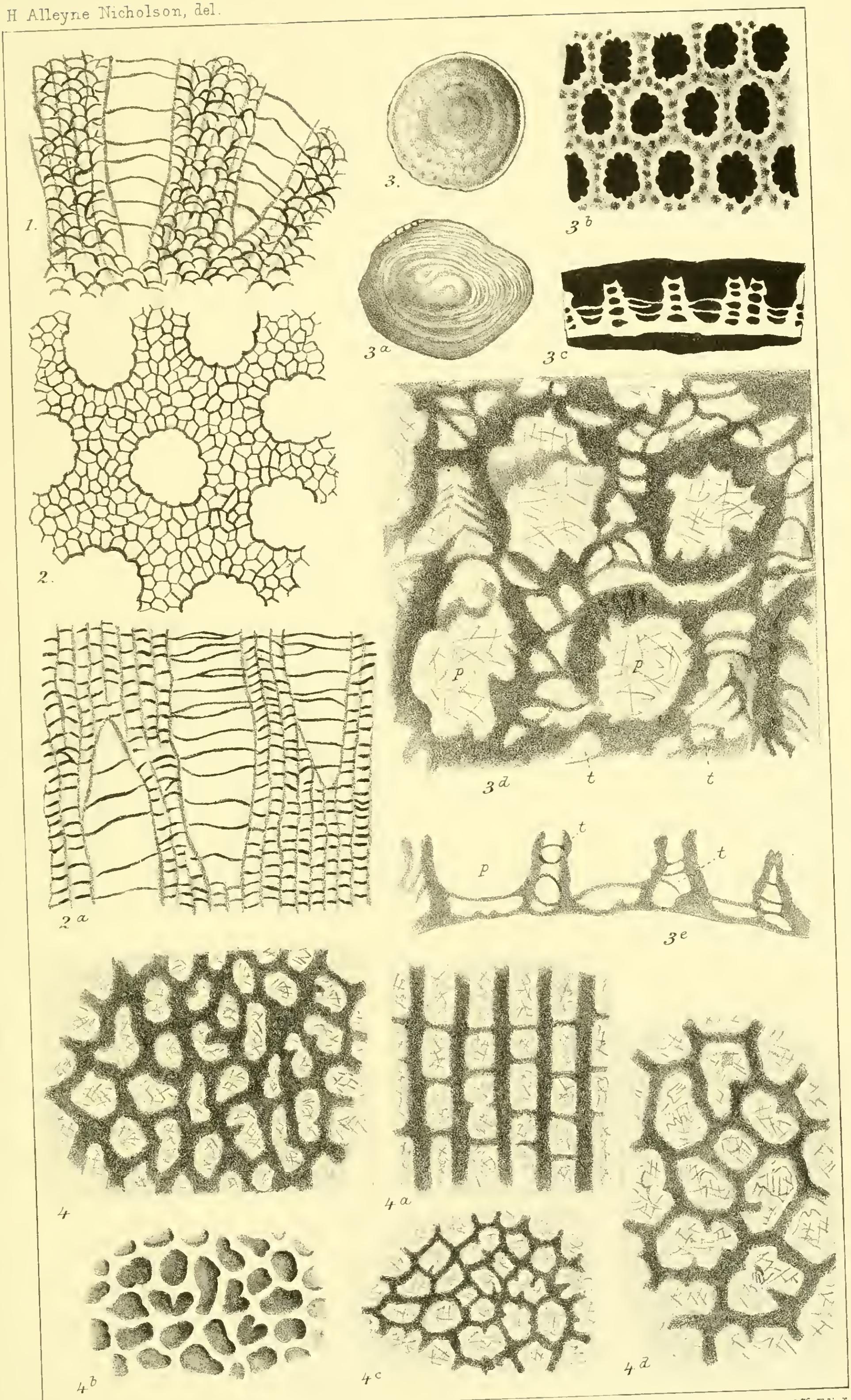

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PLATE XIII.

Fig. 1. Part of a tangential section of *Monticulipora* (*Heterotrypa*) *mammulata*, D'Orb., from the Cincinnati Group of Cincinnati, Ohio, enlarged twenty times, showing the two sets of corallites.

Fig. 1 *a*. Small portion of the preceding section, enlarged fifty times, showing the structure of the walls, and the occasional presence of spines (modified corallites).

Fig. 1 *b*. Part of a vertical section of the same species, enlarged twenty times, showing the different disposition of the tabulæ in the two sets of corallites respectively.

Fig. 2. Part of a tangential section of *Monticulipora* (*Heterotrypa*) *ramosa*, E. and H., from the Cincinnati Group of Cincinnati, Ohio, enlarged twenty times, showing the two sets of corallites.

Fig. 2 *a*. Part of a vertical section of the same species, enlarged twenty times, showing the different disposition of the tabulæ in the two sets of tubes.

Fig. 3. Under surface of a specimen of *Monticulipora* (*Diplotrypa*) *petropolitana*, Pand., from the Lower Silurian rocks of Sweden, of the natural size, showing the epithecal plate.

Fig. 3 *a*. The same specimen, viewed in profile, of the natural size.

Fig. 3 *b*. Part of a tangential section of the same, enlarged twenty times, showing the uniformly thin walls of the corallites, and the small angular tubes wedged in at the angles of junction of the larger ones.

Fig. 3 *c*. Part of a vertical section of the same, showing the two sets of tubes, and the increase in the number of the tabulæ as the exterior is approached, —enlarged twenty times.

Fig. 4. Under surface of *Monticulipora* (*Diplotrypa*) *Whiteavesii*, Nich., of the natural size, showing the concave base and epithecal plate. From the Trenton Limestone of Peterboro', Ontario.

Fig. 4 *a*. The same specimen viewed in profile.

Fig. 4 *b*. Part of a tangential section of the same, enlarged twenty times, showing the different groups of corallites.

Fig. 5. Side view of a specimen of *Monticulipora* (*Monotrypa*) *Winteri*, Nich., of the natural size, from the Devonian Limestone of Gerolstein in the Eifel.

Fig. 5 *a*. Under surface of the same, of the natural size, showing the epithecal plate partially removed by weathering.

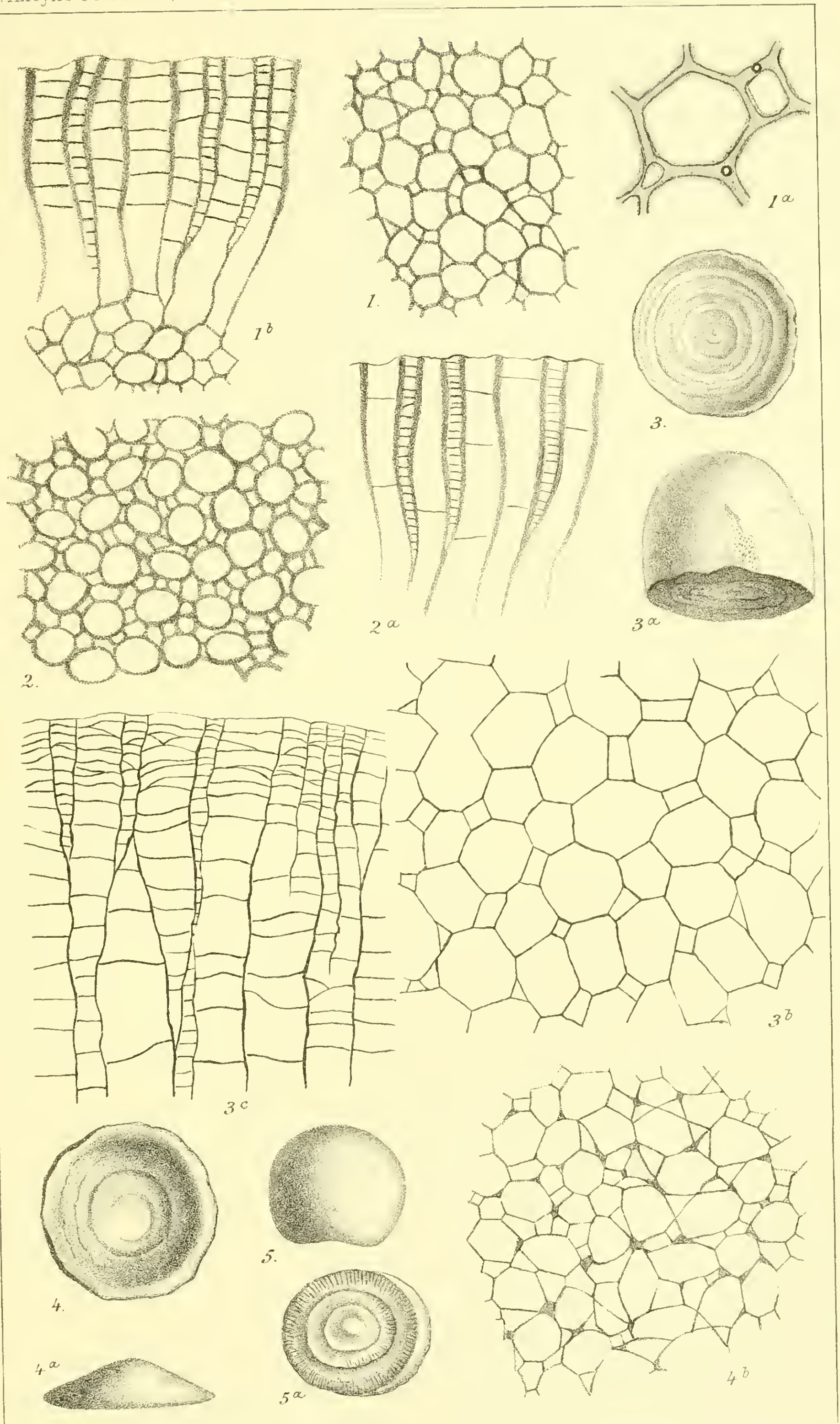
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PLATE XIV.

Fig. 1. Portion of a vertical section of *Monticulipora* (*Diplotrypa*) *Whiteavesii*, Nich., from the Trenton Limestone of Peterboro', Ontario, enlarged twenty times, showing the closely-tabulate small corallites, and the twofold constitution of the tabulæ of the large corallites.

Fig. 2. Part of a tangential section of *Monticulipora* (*Monotrypa*) *Winteri*, Nich., from the Devonian Limestone of Gerolstein in the Eifel, enlarged twenty times, showing the thin-walled polygonal corallites, with an occasional young tube intercalated.

Fig. 2 *a*. Part of a vertical section of the same, showing the thin walls, and the uniform development of the tabulæ of all the corallites.

Fig. 3. A medium-sized specimen of *Monticulipora* (*Monotrypa*) *undulata*, Nich., from the Hudson River Group of Toronto, Ontario, of the natural size. The specimen is broken on one side.

Fig. 3 *a*. Part of a tangential section of the same, enlarged twenty times, showing the thin-walled, and nearly equal-sized corallites.

Fig. 3 *b*. Part of a vertical section of the same, enlarged twenty times, showing the thin and undulated walls, and the uniform development of the remote tabulæ.

Fig. 4. Part of a tangential section of *Monticulipora* (*Monotrypa*) *undulata*, Nich., from the Trenton Limestone of Peterboro', Ontario, enlarged twenty times.

Fig. 4 *a*. Part of a vertical section of the same, enlarged twenty times, showing the thin undulated walls, and the remote tabulæ placed at corresponding levels.

Fig. 5. One of the star-like elevations of the surface of *Constellaria antheloidea*, Hall, from the Cincinnati Group of Ohio, enlarged.

Fig. 5 *a*. Part of a tangential section of the same, taken just below the surface, enlarged twenty times. The upper part of the portion figured traverses one of the stellate areas or "maculæ," while the lower part cuts across a portion of the general surface.

Fig. 5 *b*. Part of a vertical section of the same, showing the two sets of corallites, enlarged twenty times.

Fig. 6. Part of a tangential section of a typical example of *Monticulipora pulchella*, E. and H., from the Wenlock Limestone of Dudley, enlarged twenty times. The section cuts across one of the clusters of large corallites.

Fig. 6 *a*. Small portion of a longitudinal section of the same specimen, showing the characters of the corallites just before they open on the surface, enlarged twenty times.

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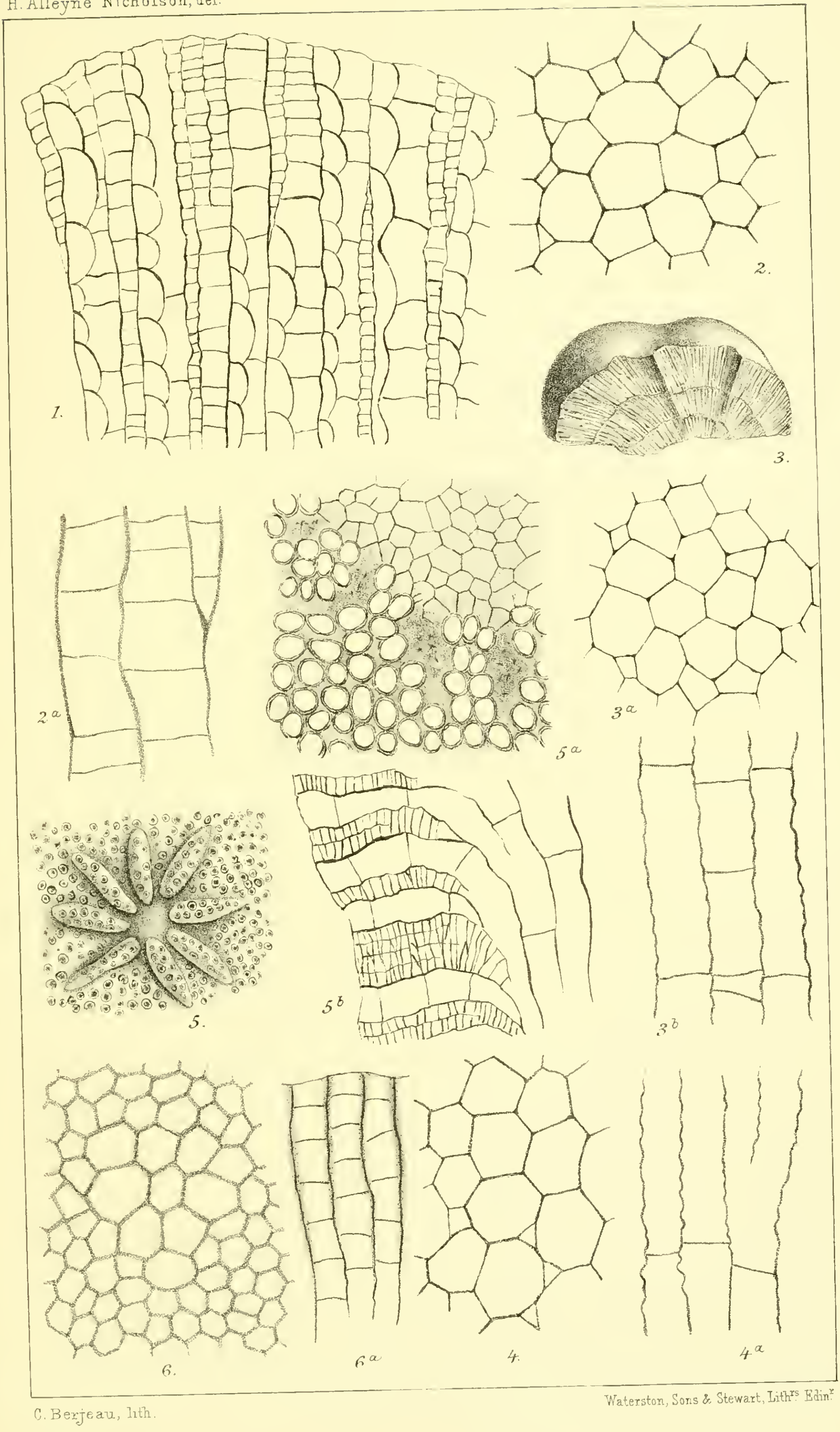

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PLATE XV.

Fig. 1. Fragment of *Dekayia attrita*, Nich., from the Cincinnati Group of Ohio, of the natural size.

Fig. 1 *a*. Portion of the surface of the same, enlarged.

Fig. 1 *b*. Tangential section of the same, enlarged twenty times, showing the spiniform corallites scattered among the ordinary tubes.

Fig. 1 *c*. Vertical section of the same, enlarged twenty times, showing the characters of the two sets of corallites just before they open on the surface.

Fig. 2. A small specimen of *Fistulipora* (*Callopora*) *proporoides*, Nich., from the Hamilton Group of Canandaigua, State of New York, of the natural size.

Fig. 2 *a*. Part of the surface of the same, enlarged. The large circular tubes have projecting and open calices, but the mouths of the interstitial angular tubes are mostly closed by a calcareous membrane, and the lines of division between them are only faintly indicated.

Fig. 3. Part of the surface of *Fistulipora* (*Callopora*) *incrassata*, Nich., from the Hamilton Group of Arkona, Ontario, enlarged. The mouths of the interstitial corallites are seen in the specimen figured; but they are often concealed from view by a calcareous membrane.

Fig. 3 *a*. Part of a tangential section of the same, enlarged twenty times, showing the oval corallites with a slight constriction on one side, surrounded by a series of angular corallites.

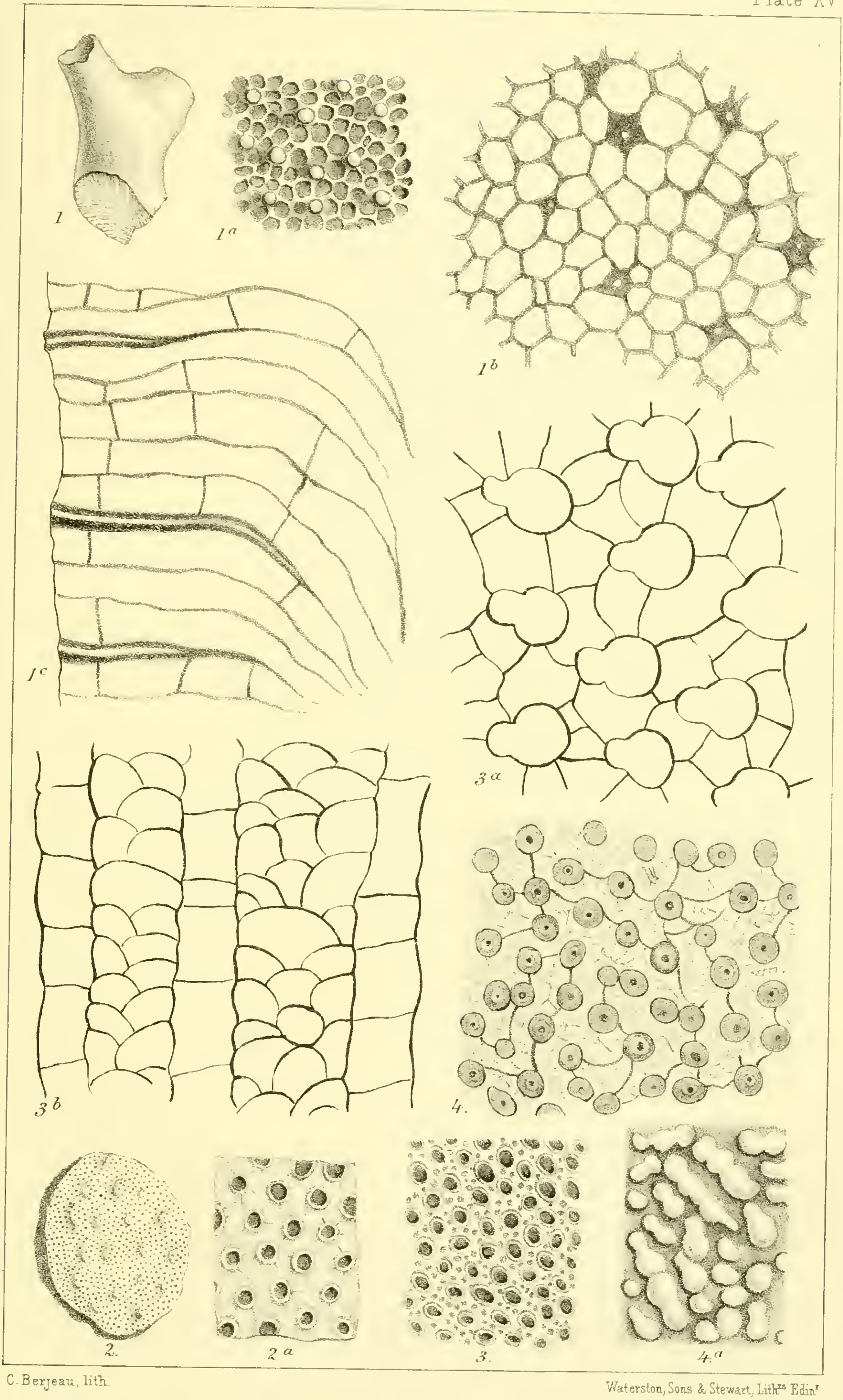
Fig. 3 *b*. Part of a vertical section of the same, enlarged twenty times, showing the remotely-tabulate oval tubes, and the vesicular tabulæ of the angular corallites.

Fig. 4. Part of a tangential section of *Labechia conferta*, E. and H., from the Wenlock Limestone of Benthall Edge, enlarged ten times, showing the primitively tubular condition of the pillars, and the transversely-divided edges of some of the vesicular tabulæ.

Fig. 4 *a*. Part of the upper surface of another specimen of the same, from the same locality, enlarged. The surface-tubercles in the specimen figured are more extensively confluent than is usually the case.

A.H Nicholson, del.

Plate XV



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