

III.—*On the Corals and Coralliform Types of Palaeozoic Strata.*

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Among the fossil forms of post-palaeozoic date referred to the Anthozoa or Corals proper, very few, if any, occupy a debatable position. Many of the commonly admitted palaeozoic corals, on the other hand, are of more or less doubtful character, and have thus been placed by some authorities under other subdivisions. Whilst admitting their uncertain affinities, however, it seems impossible to separate these doubtful types on any really satisfactory grounds from the more distinctly coralloidal forms, into which, indeed, they appear to merge by almost insensible transitions. In this paper, therefore, the term "coral" will include all the generally recognized coralloidal types of palaeozoic occurrence.

The great division of the COELENTERATA, to which the corals belong, is usually subdivided into three leading classes:—Hydrozoa, Anthozoa, and Ctenophora. The latter class, represented by a small number of pelagic, ciliated types, is an entirely aberrant group, and is without any known fossil representatives. Living Hydrozoa are distinguished from existing Anthozoa by no very certain characters—many of the supposed distinctions, at one time regarded as characteristic, having been shown of late years to be more or less indefinite; and it is extremely probable, as suggested by the late Professor Agassiz, that the so-called "tabulated corals" should be referred, really, to this class—the Hydrozoic Millepores forming the connecting link. These tabulated corals, again, offer in many cases a complete transition into the tabulated Rugosa,¹ the assumed tetramerous character of the latter being in many instances, as shown farther on, either without foundation or entirely unrecognizable. It would seem advisable, therefore, in place of *three*, to adopt *five* leading subdivisions in the classification of the Coelenterates generally, as in the annexed tabular synopsis:

A.—Without natatory cilia.

A.¹—Stomach cavity completely identical with body cavity:

(i).—Without stony corallum:

CLASS I. *Hydrozoa.*

(ii).—With calcareous (typically tabulated) corallum:

¹ As exemplified, for example, by the following series:—*Favosites*—*Columnaria*—*Ampplexus*—*Zaphrentis*—*Cyathophyllum*.

CLASS II. *Hydrocoralla*.

A.—Stomach partially separated from body-cavity.

(i)—Oro-anal orifice with eight fringed tentacles :

CLASS III. *Alcyonaria* or *Crossocoralla*.

(ii)—Oro-anal orifice with numerous simple tentacles. Corallum essentially non-tabulated, but with distinct septa :

CLASS IV. *Zoantharia* or *Anthocoralla*.

B.—With natatory cilia :

CLASS V. *Ctenophora*.

The present communication refers essentially to the second of the above named classes—that of the HYDROCORALLA. This includes the *Hydro-Coralline* of Moseley, together with the so-called *Tabulata* and *Rugosa* of other classifications. In the present state of our knowledge it is necessarily to some extent a group of convenience, connecting the *Hydrozoa* with the typical corals. The *Tabulata* in many classifications are widely separated from the *Rugosa*, and placed with the ordinary "Hexamerous Corals:" although, from the absence or rudimentary character of septa in many of these forms it is not possible to tell whether the tentacles of the living animal were hexamerous or otherwise. The *Rugosa* are also for the greater part essentially tabulated forms; and although, commonly separated from the *Tabulata* under the name of Tetracoralla, the actual number of septa in many cases is either indeterminable or exceedingly variable. As examples of variation in the number of septa in both the *Tabulata* and *Rugosa*, the genera *Stylina*, Lamarck, *Stylocania*, Edwards and Haime; *Heterophyllia*, McCoy; *Duncanella*, Nicholson, and many others, may be cited. The descriptions of many Canadian species by the late Mr. Billings, a most minute and trustworthy observer, also substantiate this point, and prove that, although very convenient on paper, the distinction (except in certain well marked cases) is virtually of impossible application. And again, we have no certainty that the number of septa or septal markings really indicate the number of the tentacles possessed by the living animal. In the living *Millepora*, for example, the researches of Moseley have shown the presence of eight tentacles, as in the Alcyonarians. If therefore, as commonly assumed, the fossil *Heliolites* be regarded as a closely related type, its twelve septa or "pseudo-septa" are entirely misleading.

Many of the forms placed under this subdivision in the present synopsis—especially those of the three first sections given below—may very probably belong to the *Alcyonaria* or to the *Bryozoa*; but this view is entirely conjectural, and cannot at present be either proved or disproved. On the other hand, the strikingly tabulated structure, so characteristic of the great majority of these forms, serves to unite them conveniently, and, in the absence of negative evidence, naturally also, into a common group.

The class HYDROCORALLA, as here adopted, may therefore be defined as follows:—*Hydrozoa* or closely allied types with calcareous corallum. The cells of the latter either

entirely destitute of internal structures, or containing in the great majority of cases : (1) well developed tabulæ, with or without radiating septa ; or (2), vesicular tissue with or without tabulæ and septa ; or (3) a distinctly hexamerous or tetramerous system of septa ; or (4) indications of bilateral symmetry.

The class, as thus defined, may be subdivided provisionally, and especially for determinative purposes, into eight leading sections, as in the following scheme :

Corallite cell entirely empty, *i.e.*, without any internal structures :

§ 1. VACUATA (Type form, *Autopora*.)

Septa absent or quite rudimentary ; tabulæ well developed :

§ 2. TABULATA (Type form, *Favosites*.)

Corallites united by a tubular or cellular coenenchyme.

§ 3. CELLULATA (Type form, *Fistulipora*.)

Tabulæ and septa both present.

§ 4. TABULO-STELLATA (Type forms, *Amplexus*, *Zaphrentis*.)

Tabulæ central only, surrounded by area of vesicular tissue. Septa well developed :

§ 5. VESICULO-STELLATA (Type forms, *Cyathophyllum*, *Lousdalia*.)

Tabulæ entirely replaced by irregular vesicular tissue :

§ 6. VESICULOSA (Type form, *Cystiphyllum*.)

Cell provided with an operculum composed of a single valve or of several valves :

§ 7. OPERCULATA (Type form, *Calceola*.)

Cup or cell containing septa only ; tabulæ absent :

§ 8. INTEGRI-STELLATA (Type form, *Petraia*.)

§ 1. VACUATA :—The representatives of this section, distinguished essentially by their tubular cells being entirely destitute of internal structures, are of very doubtful position. Very probably, they should be referred to the Alcyonaria or placed near the Sertularians under the Hydro-medusæ ; but nothing definite, it is obvious, can be determined on this point, and as the forms in question are of not uncommon occurrence in palæozoic strata, it has been thought advisable to retain them here, at least provisionally. They form but one family, that of the *Autoporidæ*, containing the following genera :

Fam. *Autoporidæ* :—Corallum composed of short, tubular or funnel-shaped empty cells, united in branching groups :

Aulopora, Goldf., Sil., Dev., Carb.

Reptella, Rolle, Sil., Dev.

Cladoconus, McCoy, Carb.

§ 2. TABULATA.

The corals of this section are distinguished by the presence of numerous transverse tabulæ in their component cells, coupled with the absence of radiating septa, or the rudimentary, imperfect character of these when indistinctly present. They have been separated widely in many systems, and have been allotted partly to the *Aleyonaria*, partly to the *Bryozoa*, and in part also to the *Rugosa* generally. Whilst thus manifestly occupying an uncertain position, the two fundamental characters given above—namely, the presence of tabulæ, with absence or merely indications of septa—are sufficiently definite to warrant their retention in a common group, and to show at the same time their relations to the coral forms of section 3, in which both tabulæ and well developed septa are present. The more typical representatives, including all the better known genera, may be arranged under six families, as in the following synopsis:

Fam. 1. *Chactetide* :—No cœnenchyme. Corallites, capilliform, or of small diameter.

Chactetes, Fisch. (including *Monticulipora* and *Stenopora*), Lr.
Sil. to Trias.

Tetradium, Safford, Lr. Sil.

Fam. 2. *Beaumontide* :—No cœnenchyme. Corallites comparatively large, polygonal, with imperforate walls.

Beaumontia, E. & H., Carb.

Fam. 3. *Favositide* :—No cœnenchyme. Corallites, polygonal, round or crescented at surface, with perforated walls.

Group A. *Plani*.—Tabulæ horizontal or inclined :

Favosites, Lmk., Sil., Dev., Carb.

Columnipora, Nich., Lr., Sil.

Atveotites, Lmk., Sil., Dev.

Pachypora, Linds., Sil.

Nodulipora, Linds., Sil.

Group B. *Tumidi*.—Tabulæ convex or more or less vesicular :

Emmonsia, E. & H., Sil., Dev., Carb.

Michelinia, de Kon., Dev., Carb.

Fam. 4. *Halysitide* :—Corallites tubular, imperforate, connected only at opposite sides, typically in chain-like aggregations. Tabulæ, horizontal :

Halysites, Fisch., Sil.

Thecostegites, E. & H., Dev.

Fam. 5. *Syringoporidae* :—Corallites tubular, imperforate, connected by short transverse processes or by lateral expansions. Tabulæ, funnel-shaped :

Syringopora, Gold., Dev., Carb.

Haimenophyllum, Bill., Dev.

§ 3. CELLULATA.

This section, like the last, comprises a series of coralloidal forms of very doubtful position, but connected with the Hydro-Coralla generally by the presence of numerous tabulæ; and in one of the two families, into which they are subdivided, by distinct septa, or "pseudo-septa." They are made up of capilliform or narrow tubular corallites, traversed by septa, and connected by cœnenchyme, in itself composed of minute, tabulated tubes, the whole somewhat resembling the surface of a sponge in which the corallites represent the oscula. Some have been given to the *Bryozoa*. Others, from their supposed relations to the modern *Heliopora*, have been referred to the *Alcyonaria*; but it seems better to leave them among the HYDRO-CORALLA until more certain evidence is obtained of their true affinities. They may be subdivided into two families, with genera as follows :

Fam. 1. *Fistuliporidae* :—Corallum compound, composed of minute corallites with surrounding capilliform cœnenchyme; both tabulated, but without septa.

Fistulipora, McCoy, Sil., Dev.

Callopora, Hall (scarcely differing from *Fistulipora*), Sil., Dev.

Fam. 2. *Heliolitidae* :—Corallum compound, composed of small corallites separated by a cellular or finely tubular cœnenchyme; both tabulated; the corallites showing twelve short septa or pseudo-septa around their inner margin.

Heliolites, Dana, Sil., Dev.

Lyellia, E. & H., Sil.

Plasmopora, E. & H., Sil.

Thecia, E. & H., Sil.

§ 4. TABULO-STELLATA.

The corals of this section are characterized by the presence of both tabulæ and septa. The tabulæ extend in typical examples entirely across the corallite-cell, but indications of an outer area of vesicular tissue are occasionally observable. The septa are marginal or short in some cases, although always distinctly developed. In other cases they extend into the centre of the cell, and form by their union a twisted pseudo-columella. The typical representatives form three families, as in the annexed tabular distribution :

Fam. 1. *Favistellidae* :—Corallum compound, with hexagonal or polygonal corallites in close juxtaposition, much resembling *Favosites*; but walls imperforate, and distinct septa (short or long) always present.

Columnaria, Goldf., Lr. Sil.

Favistella, Dana, Sil.

Fam. 2. *Amplexidae* :—Corallites tubular or reed-like, typically with short or marginal septa and extended tabulæ.

Amplexus, Sowerby, Sil., Dev., Carb.

Calophyllum, Dana (including *Cyathophylloides*), Sil.

Chonophyllum, E. & H., Sil., Dev.

Fam. 3. *Zaphrentide* :—Corallum simple, turbinate or horn-like, with well developed tabulæ and septa.

Group A.—*Corniculati* (simple, horn-like forms) :

Zaphrentis, Raf. (including *Anisophyllum* and *Pentaphyllum*), Up. Sil., Dev., Carb.

Ptycophyllum, E. & H., Sil., Dev.

Streptelasma, Hall. Under this genus, the forms of *Zaphrentis* with marked pseudo-columella may be appropriately placed. Sil.

Group B.—*Columniferi* (with distinct columella) :

Lophophyllum, E. & H., Dev., Carb.

Group C.—*Cruciferi* (primary septa forming a distinct rectangular cross) :

Phryganophyllum, de Kon., Carb.

Group D.—*Bi-formes* (septa showing a twofold mode of arrangement) :

Menophyllum E. & H., Carb.

§ 5. VESICULO-STELLATA.

This section is more or less closely connected with section 4, but is distinguished especially by the contracted dimensions of the tabulæ, and the replacement of the outer portion of these by an area of vesicular tissue. Hitherto, many genera of these corals have been made to include both simple and compound forms, as well as types of very dissimilar configuration; but in the present distribution I have ventured upon an innovation in this respect—believing, from the examination of numerous examples, that a generic separation of the compound tessellated forms on the one hand, and the sub-aggregated, reed-like and cylindrical types on the other, from the essentially simple forms, is warranted on natural grounds, and is conducive to a more ready determination of genera, as well as to clearer and sharper definitions.

In the present distribution these vesiculo-stellate corals are arranged under four families, comprising : (1.) *Cyathophyllidae*, distinguished by the absence of a columella and by the absence of a distinctly cruciform arrangement of septa; (2.) *Lonsdalidae*, in which a distinct columella is present; (3.) *Stauridae*, characterized by the primary septa forming a distinct rectangular cross; and (4.) *Halliade*, with distinctly twofold arrangement of septa.

Fam. 1. *Cyathophyllidæ*.

Group A.—*Tesselati*: Compound vesiculo-stellate *Cyathophyllidæ* composed of closely united corallites, forming mosaic-like, tessellated or asteroidal groups.

- Cynthogonium*, E. J. C. (= tessellated forms of *Cyathophyllum*; also *Str. abodes* and *Acerularia*), Sil., Dev., Carb.
Heliogonium, E. J. C. (= tessellated forms of *Heliophyllum*), Sil., Dev.
Phillipsastræa, E. & H. (including *Pachyphyllum*), Dev., Carb.

Group B.—*Arundinacei*: Vesiculo-stellate *Cyathophyllidæ*, composed of reed-like or tubular corallites, either simple or in partially connected groups.

- Cannophyllum*, E. J. C. (= reed-like forms of *Cyathophyllum*), Dev., Carb.
Diphyphyllum, Lonsd. (including *Stylastræa*), Sil., Carb.
Eridophyllum, E. & H., Sil., Dev.

Group C.—*Corniculati*: Simple vesiculo-stellate *Cyathophyllidæ* of more or less conical or horn-like form.

- Cyathophyllum*, Goldf. (including *Dicophyllum* and *Campophyllum*), Sil., Dev., Carb.
Heliophyllum (including *Acanthophyllum*), Sil., Dev.
Blotrophyllum, Sil., Dev.
Clisiophyllum, Dana, Sil., Dev., Carb.
(*Pycnophyllum*, Linds., Sil. ?)
Strephodes, McCoy, Sil., Dev., Carb.

Fam. 2. *Lonsdalidæ*.

Group A.—*Aggregati*: Compound forms of *Lonsdalidæ*.

- Lonsdalia*, McCoy (including *Stylidophyllum*), Carb.
Lithostrotion (including *Koninckophyllum* in part, *Petalaxis*, *Stylaxis*, etc.), Carb.

Group B.—*Turbinati*: Simple, more or less turbinated or horn-like forms of *Lonsdalidæ*:

- Azophyllum*, E. & H., Carb.
Koninckophyllum (?) Nich. (= simple forms of *Lithostrotion*), Carb.

Fam. 3. *Stauridæ*:—Primary septa forming a rectangular cross:

Group A.—*Tesselati*: Compound tessellated forms of *Stauridæ*:

- Stauria*, E. & H., Sil.

Group B.—*Turbinati*: Simple forms of *Stauridæ*:

- Omphyma*, Raf., Sil.

Fam. 4. *Hallüite*:—Septa distinctly twofold in their arrangement :

Hallia, E. & H. (including *Aulacophyllum*), Sil., Dev.

§ 6. VESICULOSA.

This section includes but one family, that of the *Cystiphyllida*, distinguished by the corallite cell being entirely filled with vesicular tissue. Radiating septa absent or quite rudimentary :

Group A.—*Aggregati* : Septa absent or quite rudimentary.

Cystiphylloides (=aggregated forms of *Cystiphyllum*, typified by *C. aggregatum*, Billings), Dev.

Group B.—*Corniculati* : Septa absent or rudimentary.

Cystiphyllum, Lons., Sil., Dev.

§ 7. OPERCULATA.

The forms of this section comprise a small number of peculiar types in which the corallite cell is furnished with a cover or operculum composed either of a single valve or of several valves. Radiating septa are mostly rudimentary, but are well developed in one genus. Provisionally, the representatives of the section may be classed in a single family, with subdivisions as shown below :

Fam. *Calceolida*.

Group A.—*Arundinucei* : Corallum made up of cylindrical or reed-like corallites. Septa rudimentary.

Fletcheria, E. & H., Sil.

Rhizopora, de Kon., Carb.

Group B.—*Univalvati* : Operculum composed of a single valve. Septa rudimentary.

Calceola, Lam., Dev

Rhizophyllum, Linds., Sil.

Group C.—*Tetravalvati* : Operculum composed of four valves. Septa well developed.

Goniophyllum, E. & H., Sil.

§ 8. INTEGRI-STELLATA.

In the representatives of this section, the internal tabulæ, so characteristic of paleozoic corals generally, and the vesicular tissues which frequently accompany or replace the tabulæ, are practically unknown. Radiated septa, on the other hand, are well developed. The known genera present collectively, two distinct types of configuration—a disciform, and a coniform type, respectively. A central columella is present in some representatives of the coniform type, and is absent in others. Hence the *Integri-Stellata* admit of a separation into three well characterized families, as in the following distribution :

Fam. 1. *Cyctinide* :—Corallum simple, disciform.

Group A.—*Spiniferi*: Septa represented by longitudinal rows of short spines.

Acanthocyclus, Dyb., Sil.

Group B.—*Alternati*: Septa, alternating in length, regularly arranged.

Palæocyclus, E. & H., Sil.

Group C.—*Sulcati*: Cup with one or more septal furrows, towards which some of the septa commonly incline.

Microcylus, Meek, Dev.

Campophyllum, E. & H., Dev.

Baryphyllum, E. & H., Dev.

Hadrophyllum, E. & H., Dev.

Fam. 2. *Petraide* :—Corallum simple, conical, straight or curved, without columella.

Petraia, Munst., Sil., Dev., Carb.

Polycælia, King., Palæozoic.

Kenophyllum, Dyb., Sil.

Fam. 3. *Cyathaxonide* :—Corallum coniform, simple, a central columella present.

Cyathaxonia, Mich., Sil., Dev., Carb.

Duncanella, Nichol., Sil.

Duncania, de Kon., Carb.

RETROSPECT.

A. Subdivisions of the CELENERATA :

- I. Hydrozoa.
- II. Hydrocoralla.
- III. Crosscoralla.
- IV. Anthocoralla.
- V. Ctenophora.

B. Subdivisions of the HYDROCORALLA :

- ‡ 1. VACUATA :
 - Fam. *Auloporidæ* (e. g. Aulopora, Reptella, etc.)
 - ‡ 2. TABULATA :
 - Fam. *Chaetidae* (e. g. Chaetetes, Tetradiuni).
 - Fam. *Beaumontidae* (e. g. Beaumontia).
 - Fam. *Favositidae* :
 - Group 1. *Plani* (e. g. Favosites, Alveolites, etc.)
 - Group 2. *Tumidi* (e. g. Michelinia, Emmonsia).
 - Fam. *Halysitidae* (e. g. Halysites, etc.)
 - Fam. *Syringoporidæ* (e. g. Syringopora, Haimeo-
phyllum).
 - ‡ 3. CELLULATA :
 - Fam. *Fistuliporidæ* (e. g. Fistulipora, Callopora).
 - Fam. *Heliolitidae* (e. g. Heliolites, Thecia, etc.)
 - ‡ 4. TABULO-STELLATA :
 - Fam. *Favistellidae* (e. g. Columnaria, Favistella).
 - Fam. *Amplexidae* (e. g. Amplexus, Calophyllum, etc.)
 - Fam. *Zaphrentidae* :
 - Group 1. *Corniculati* (e. g. Zaphrentis, Streptelas-
ma).
 - Group 2. *Columniferi* (e. g. Lophophyllum).
 - Group 3. *Cruciferi* (e. g. Phryganophyllum)
 - Group 4. *Bitformes* (e. g. Menophyllum).
 - ‡ 5. VESICULO-STELLATA :
 - Fam. *Cyathophylloidæ* :

- Group 1. *Tessellati* (e. g. Cyathogonium, Phillips-
astrea, Heligonium).
- Group 2. *Arundinacei* (e. g. Cannophyllum, Di-
phyphyllum, Eridophyllum).
- Group 3. *Corniculati* (e. g. Cyathophyllum, He-
liophyllum, Clisiophyllum, etc.).

Fam. *Lonsdalidae* :

- Group 1. *Aggregati* (e. g. Lonsdalia, Lithostro-
tion).

- Group 2. *Turbinati* (e. g. Axophyllum, etc.)

Fam. *Stauridae* :

- Group 1. *Tessellati* (e. g. Stauria).
- Group 2. *Turbinati* (e. g. Omphyma).

Fam. *Halliidae* (e. g. Hallia).

‡ 6. VESICULOSA :

Fam. *Cystiphyllidae* :

- Group 1. *Aggregati* (e. g. Cystiphyllodes, etc.)
- Group 2. *Corniculati* (e. g. Cystiphyllum).

‡ 7. OPERCULATA :

Fam. *Calceolidae* :

- Group 1. *Arundinacei* (e. g. Fletcheria, Rhizo-
pora).
- Group 2. *Univalvati* (e. g. Calceola, Rhizophyl-
lum).
- Group 3. *Tetravalvati* (e. g. Goniophyllum).

‡ 8. INTEGR-STELLATA :

Fam. *Cyclinidae* :

- Group 1. *Spiniferi* (e. g. Acanthocyclus).
- Group 2. *Alternati* (e. g. Palaeocyclus).
- Group 3. *Sulcati* (e. g. Microcylus, Campophyl-
lum, etc.)

Fam. *Petraidae* (e. g. Petraia, Polycælia, etc.)Fam. *Cyathaxonidae* (e. g. Cyathaxonia, Duncan-
ella, Duncania.)