

SYRINGOPORA VERTICILLATA, GOLDFUSS.

Large aggregations of parallel or diverging tubular stems, from two to three millimeters in diameter, keeping a distance of from two to five millimeters apart, across which they connect at various not very close intervals by narrow, transverse, branch tubules, of which two or three are always sent off at nearly the same height, but not in true verticillate position. The tubes are filled by invaginated, irregularly funnel-shaped diaphragms, attenuated at the lower ends into long siphons. The longitudinal rows of spinules are rarely well preserved in the tubes of the specimens which are all found in silicified condition. The colonies of stems are often large, several feet in diameter; their basal portions, composed of prostrate, irregularly reticulated expansions of stems, differ considerably from the erect parts, and among the specimens of colonies a great many variations occur as regards the size of the tubes or their mode of growth. In some the stems are distant, in others near; in some perfectly straight, in others flexuose or geniculated, with regular, verticillate side connections, or with dispersed side arms branching off at remote intervals or in closer proximity. These associated forms, sufficiently contrasting in the extreme, I have not attempted to divide into several species, but consider as variations of *Syringopora verticillata*, whose enumerated specific characters can not of course retain the limited form, applying only to a single variety which accidentally fell into the hands of Goldfuss, the first describer of this species. Found abundantly in the Niagara limestone of Drummond's Island, Point Detour, and in nearly all other fossiliferous outcrops of the formation in the western part of the Upper Peninsula.

Plate XXX.—Fig. 1 represents a silicified specimen from Drummond's Island, closely similar to the specimen figured by Goldfuss. Fig. 2 has somewhat smaller tubes, with less regularly disposed, transverse branch channels and more flexuose stems than the other. With the above-described specimens others are found, which seem to agree with *Syringopora cancellata* of Milne-Edwards. They are composed of flexuose tubes about one and a half millimeter wide,

in loose, irregularly reticulated colonies, with the curved stems alternately contiguous and diverging. Transverse connecting channels remote, short, and clumsy. Longitudinal rows of spinules and funnel-shaped diaphragms, quite plainly exhibited in some of the specimens. I have not figured this form for want of space.

SYRINGOPORA ANNULATA, N. SP.

Small colonies of closely approximated, tubular stems of jointed aspect, with sharply projecting rings of growth, and with numerous verticillate, transverse tubules connecting the stems at short intervals. Diameter of tubes about one and a half millimeter. Diaphragms of the elongated, funnel-shaped form peculiar to the genus. Found at Point Detour in the Niagara limestone, and in the drift deposits of the Lower Peninsula.

Plate XXXII., Lower tier.—The two left figures represent silicified specimens found in the drift of Ann Arbor.

SYRINGOPORA TENELLA, N. SP.

Irregularly reticulated colonies of tubules, one millimeter in width, or less. The tubules branch in the same manner as *Aulopora*, and directly connect with each other by approximation, without the intervention of narrower, transverse channels, as in other species of *Syringopora*. The tubules exhibit a faint longitudinal striation on the outside wall, and the cavity is lined by a cycle of twelve spinulose crests. Diaphragms funnel-shaped, but not always developed; the channels are often found open throughout.

Found in the Niagara group of Point Detour, Drummond's Island, and in the drift. Occurs also in Indiana and Kentucky.

Plate XXX.—Fig. 4 represents a small specimen found in the drift, seen from the basal side, with creeping, prostrate tubules. On the upper side of the specimen the tubules are bent into an erect position.

SYRINGOPORA FIBRATA, N. SP.

Large convex colonies, with closely approximated subparallel or diverging tubules half a millimeter in diameter, laterally connected by numerous short transverse channels, branching off at close intervals from the circumference of the thread-like stems. The distance separating the stems is variable—sometimes less, sometimes more than one tube diameter. Radial crests long, very distinct, twelve in number. Diaphragms direct transverse, not funnel-shaped. This species very frequently grows up in intimate connection with expansions of *Stromatopora*. The tissue of the *Stromatopora* fills out all the interstices left between the tubules, which in such specimens are usually further apart than in those growing solitary. Both hold in their growth an equal passus, and the addition of new layers to the *Stromatopora* coincides with the growth of the tubules. It resembles *Syringopora compacta*, Billings, found in the strata of Anticosti; but in that species the tubules are in almost perfect contiguity, and their diaphragms are distinctly funnel-shaped.

Common in the Niagara group of Point Detour, Drummond's Island, and frequently found in the drift. It occurs also in the Niagara group of Indiana, Kentucky, and Iowa.

Plate XXX.—Fig. 3 gives a surface view of a silicified specimen from Drummond's Island.

SYRINGOPORA PERELEGANS, BILLINGS.

Colonies of tubular stems, from one and a half to two millimeters in diameter, formed at the base of prostrate tubes, multiplying by bi- or tri-partite ramification, in the same manner as *Aulopora*, by production of one or two young tubes sprouting from the basal portion of their flanks, which creep on for some distance, while the mother-tube bends its orifice into an erect position, after having given off the branches. The spreading, prostrate, basal tubes, flattened on the lower side, come in multiple contact with their sides

and grow together into an open, reticulated expansion, or are so densely crowded as to form an uninterrupted basal leaf, from which the tubes singly ascend into a vertical, subparallel position, and then grow up with remarkably straight stems, if not disturbed by accidental impediments.

The stems in the erect growing parts of the colonies are remote from each other about the width of a tube diameter, or more, and are connected by slender, transverse tubules at intervals of from one half to one centimeter. The tubes are annulated by delicate wrinkles of growth, with periodical, sharper offsets, causing an articulated appearance. Internal structure longitudinally striate by spinulose crests, and intersected by funnel-shaped, irregular diaphragms prolonged with the lower apex into long siphons.

Occurs in the upper Helderberg limestones of Mackinac; frequently also in the drift, associated with corniferous limestone fossils, and in the corniferous limestones of Canada, New York, and of the Falls of the Ohio.

Plate XXXI.—Fig. 2. The small specimen attached to the lower left-hand corner of the other specimen represents a fragment of a laminar, basal expansion with erect, circular orifices, found in the drift. Figs. 3 and 4 are silicified specimens from the Falls of the Ohio—the one with larger sub-flexuose tubes, the other with more slender and straighter tubes.

SYRINGOPORA MACLUREI, BILLINGS.

Tubes about three millimeters wide, flexuose, occasionally touching each other, and then diverging again, or at other times of more regular, subparallel growth, with interstitial intervals usually larger than a tube diameter, and with remote, slender, transverse tubules of connection. This coral resembles the former species, differing from it only in having a larger tube size, and a more irregular mode of growth, but in many instances it becomes difficult to decide whether a specimen belongs to one or the other form.

Plate XXXI.—Fig. 1 represents a fragment found in the drift of Ann Arbor, exhibiting the terminal portion of a colony. In Fig. 2 the large specimen, also, from the drift, is seen from the basal

side, with the prostrate, creeping, reticulated tube portions. The basal expansions of the former species, represented in the same figure, do not always grow in uninterrupted leaves, as in the fragment represented, but often in an open network like that in the larger figure. In some specimens the tubules are more nearly approximated than they are seen to be in Fig. 1.

SYRINGOPORA TABULATA, MILNE-EDWARDS.

Synon., THECOSTEGITES BOUCHARDI, Milne-Edwards.

Large, convex colonies of diverging, subparallel, straight tubules, forming incrustations of other marine bodies with their creeping, Aulopora-like, basal ends, which subsequently continue to grow in an erect position. Tubules about one millimeter wide, closely approximated, with intervals narrower than a tube diameter; the transverse connecting tubules branch off in subregular, verticillate position, and correspond in all tubes in certain levels, by the lateral anchylosis of which almost uninterrupted laminar floors are formed; this is, however, not an invariable structure. The same specimens often exhibit portions in which the transverse branchlets are not verticillate, but in irregularly dispersed position, and in which no laminar floors intersecting the colonies are perceptible. The tubules are distinctly radiated by twelve spinulose crests, and on the surface of the tubules a dull, longitudinal striation is usually noticed. Diaphragms funnel-shaped, with tubular invaginated ends. The floors of connecting processes are in some specimens moderately distant, as in that represented on Plate XXXII., upper specimen to the right. These are the typical form of Milne-Edwards' *Syr. tabulata*. In other specimens, particularly those of smaller size, forming incrustations of shells, etc., these floors are in close approximation, and form a series of superimposed laminae, separated by small vesiculate interstices. Milne-Edwards, misapprehending their structure, described them as the type form of a new genus, *Thecostegites*; but a little more careful examination would necessarily have shown him the specific identity of his *Syringopora tabulata* with his *Thecostegites Bouchardi*, both described as occurring at the Falls of the Ohio, from

which locality the specimens represented on Plate XXXII. come. The upper convex specimen on the left side of the plate is the form corresponding with Milne-Edwards' *Thecostegites*. He has described similar other forms under the names of *Syringopora Vernuilli*, *Syr. Cleviana*, and Mr. Billings describes a form under the name of *Syringopora Hisingeri*, all of which are distinguished from one another by trifling modifications in their manner of growth. I consider them as mere varieties of one and the same species for which I retain Billings' name.

SYRINGOPORA HISINGERI.

It differs from *Syringopora tabulata* by its more distant, somewhat flexuose tubules, with side connections in dispersed position, and not in verticils. The tubules vary in size from half a millimeter to one millimeter. The three lower specimens in the upper tier of Plate XXXII. represent various fragments of this form, found in the drift. Other specimens are found in which the tubules are still further apart. The last-mentioned forms are all found associated in the corniferous limestone of Michigan, Canada, Ohio, New York, Indiana, Kentucky, etc.

SYRINGOPORA NOBILIS, BILLINGS.

Colonies of large tubes, from five to eight millimeters in diameter. In some the tubes are quite remote from each other, and connected by distant, transverse branch channels; others have the tubes more closely clustered and of smaller size. I am not positive of the specific identity of these forms, but provisionally arranged them under Billings' name, intended for the form with large, remote stems. Found in the corniferous limestone, and in the Hamilton group of Michigan and Canada; similar forms occur in the Hamilton group of Iowa.

On Plate XXXII., lower tier, right-side figure, is represented a specimen found in the drift of Ann Arbor, associated with corniferous limestone fossils; the adjoining central specimen is a young

specimen with closely clustered tubes, found in the Hamilton group of Alpena.

CANNAPORA, HALL.

(Compare FLETCHERIA, Milne-Edwards.)

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. Considerable affinity exists between Cannapora and Aulopora.

CANNAPORA JUNCIFORMIS, HALL.

Tubules from one to one and a half millimeter in diameter, forming large colonies of convex growth, with regular, subparallel stems in the larger masses; but in smaller specimens, representing incrusting basal portions, the tubes are sometimes agglomerated in irregular manner. Structure in conformity with the above given general generic description. Found in the Niagara group of Drummond's Island, and sometimes in the drift. In New York State it is found in somewhat lower position in calcareous layers of the Clinton group. The tubes of the New York specimens are somewhat smaller than those of the specimens from Drummond's Island.

Plate XXXIII., Fig. 4.—Lower specimen on left-hand side is a silicified young colony from Drummond's Island; the lower figure on the right-hand side is a fragment of a specimen from the Clinton group of Brockport, N. Y.

AULOPORA, GOLDFUSS.

Colonies of prostrate, stout-walled tubes, attached with their lower flattened side, multiplying by latero-basal gemmation. One or two young tubes sprout from the lateral edges of the base of the creeping tubes near the orifices, which then rise from the prostrate into an erect position, while the new branches creep on, until they again send off branches in the same manner, which latter, by coming in contact in their spreading growth, adhere together and form reticulated loops, or, if closely crowded, continuous laminar expansions. Other species grow, by union of their tubes, into compact, thicker masses. It is rarely the case that they compose ramified branches. The tubes nearly always exhibit a faint, longitudinal striation and longitudinal rows of spinules encircling the inner cavity in more or less rudimentary development. Remote, isolated diaphragms are sometimes observed, but usually the tube cavities are open throughout their entire length. Lateral pores connecting the contiguous tubes channels do not seem to exist. The orifices project with free circular margins; occasionally, through being closely crowded, the orifices of a limited spot may become polygonal from mutual pressure. Certain minute Bryozoa, in manner of growth resembling an Aulopora, have been confounded with this genus; one of them is *Aulopora arachnoides*, Hall; these have no affinity with Aulopora, their structure being the same as in the jurassic and cretaceous genera Proboscina, Berenicea, or Stomatopora, whose utriculous walls are perforated by numerous microscopical pores, comparable to the minute punctations of the shell of a Terebratula. These punctations can be distinctly seen in well-preserved specimens of *Aulopora arachnoidea*, collected at Richmond, Indiana.

AULOPORA SERPENS (?) GOLDFUSS.

Prostrate expansions of conical tubules, one sprouting in a linear row from the basal part of the orificial end of the other; or at times two of them fork off, and meeting others in the course of their

growth, unite laterally with them and inclose irregular loops. All the tube ends, after the departure of a branch tube, bend into an erect position and usually grow no further. The width of the tubes of different specimens varies from one to two millimeters. The identification of this species with the European form, described by Goldfuss, is made with some hesitation, and is intended rather to express their great resemblance than a full identity. Found in the Hamilton group of Thunder Bay and Little Traverse Bay, incrusting other corals.

Plate XXXIII.—Fig. 2 represents a specimen from Little Traverse Bay incrusting a *Stromatopora*.

AULOPORA CONFERTA, WINCHELL.

Incrusting, reticulated, or continuous laminar expansions formed of laterally anchylosed conical tubules, arranged in fan-like, spreading order by emanation from the prolific gemmation of a single mother-tube according to the bilateral, forking mode of growth exhibited in the generic description. The club-shaped tubules are about one millimeter wide across the thickest part; the channels of the erect, circular orifices measure about half of a millimeter. Found abundantly as incrustation of other corals in the blue fossiliferous shales of Little Traverse Bay.

Plate XXXIII.—Fig. 1 represents a solid incrustation of the surface of a *Stromatopora* by this species of *Aulopora*.

AULOPORA ERECTA, N. Sp.

Massive, incrusting expansions formed of very stout-walled tubes, about two or two and a half millimeters in diameter. On the basal side of the expansions, broke loose from the incrusting body, the prostrate, flattened tubes are noticeable, grown into a dense agglomeration by repeated rapid gemmation. From this basal sheet the tubules bend into a vertical position, and continue to grow in this direction for some length parallel with each other, and producing no more side branches at the rapid rate of the prostrate portions.

These erect tubes are circular, closely approximated, or sometimes in intimate, mutual contiguity, pressing each other into a sub-polygonal shape. The orifices exhibit a cycle of longitudinal furrows and intermediate rows of spinulose projections in rudimentary development. Diaphragms are generally not developed. Occurs in the Hamilton group at Stony Point, Thunder Bay.

Plate XXXIII.—Fig. 4, upper specimen.

COLUMNARIÆ.

CONSISTING OF THE SINGLE GENUS COLUMNARIA.

COLUMNARIA, GOLDFUSS.

Goldfuss at first included within this genus several corals which have a different structure; he acknowledges, in the appendix to his work, however, that the coral called by him *Columnaria sulcata* is only a weathered specimen of *Cyathophyllum quadrigeminum*. *Columnaria lævis* is also, in all probability, generically different from his *Columnaria alveolaris*, which alone is at present considered the typical representative of the genus. In Goldfuss's characteristics is expressly stated the absence of transverse diaphragms in the tubes, although in his figures the diaphragms of the tubes are so distinctly delineated that I can not conceive how they escaped his observation. I define the genus as follows:

Convex colonies of contiguous, polygonal, or rarely of free circular tubes, growing from a few attached mother-tubes by rapidly multiplying lateral gemmation. Tubes radiated by vertical lamellæ of alternately larger and smaller size, the larger ones in some species reaching to the centre, or not. Number of lamellæ from twenty to forty.

Transverse diaphragms simple, flat, moderately close in position. Walls not perforated by pores, thin, and inseparably united in the forms with polygonal tubes, appearing to be formed of simple laminae dividing the adjoining cavities, but in favorably preserved specimens the duplicity of the walls is positively observed.

COLUMNARIA ALVEOLATA, GOLDFUSS.

Convex, large colonies, sometimes attaining a diameter of several feet, composed of intimately connected tubes diverging from a basal centre. Lower side covered by a concentrically wrinkled epitheca; central part attached. Tubes quite unequal in the same specimens and in different specimens. In some they vary from two to five millimeters; in others, tubes one centimeter in width, and smaller ones of only two and three millimeters, are intermingled. Radial lamellæ from twenty to forty, according to the size of the tubes, not reaching to the centre. Transverse diaphragms flat, closely set, usually smooth in the centre, and only at the outer circumference intersected by the radial crests. It is rarely the case that the lamellæ extend as low carinations over the surface of the diaphragms to the centre. The figures of Goldfuss exhibit the radii as alternately reaching the centre; this is, as already stated, very unusual with specimens from the Trenton group, while it is regularly seen in the specimens from the Hudson River group and Niagara group. Milne-Edwards considers both forms as one species, but I think they differ sufficiently to be set down as two species. To the Trenton form Goldfuss's name, *Alveolata*, is applied by most of the palæontologists; for the Hudson River group species, Hall's name, *Columnaria* (*Favistella*) *stellata*, is adopted, although it is not perfectly certain whether Goldfuss had not also a Hudson River group specimen under consideration.

The Trenton strata of the Escanaba River and of St. Joseph Island, in Lake Huron, contain an abundance of this coral, but the specimens are not very well preserved, being transformed into dolomite spar, which is a very unfavorable material for the preservation of the finer structural details. This coral is also frequently found in the Trenton group of Illinois, at Dixon, and in the lead-bearing strata of Wisconsin and Iowa, where it is often found in silicified condition, and finely preserved.

Plate XXXIV.—Fig. 1 is the surface view of a specimen from the Trenton group of St. Joseph Island. Fig. 2 is a fractured surface exhibiting a vertical section of a specimen from Escanaba River. Fig. 4 is a specimen with very large and unequal tubes, found in the Trenton group, at Dixon, Illinois.

COLUMNARIA STELLATA, HALL.

Synon., *FAVISTELLA STELLATA*, Hall.

Convex masses of similar structure with the former species; the tubes are somewhat less unequal in the same specimens, varying in size between three and six millimeters. Radial lamellæ from twenty to thirty, alternately larger and smaller, the larger ones extending to the centre. Diaphragms flat, closely set, intersected by the radial lamellæ, which only in the peripheral circumference form continuous vertical leaves. The crests continued to the centre of the diaphragms are merely superficial. Found abundantly on the north side of Drummond's Island, in the shales of the Hudson River group. The equivalent exposures in Bay de Noquets, opposite Escanaba, do not contain any. It is likewise found in the upper part of the Hudson River, or Cincinnati group, near Madison, Indiana, and in other localities along the Ohio River.

During the progress of the survey, I found specimens which I consider as identical with this species in the Niagara group of Point Detour, in which formation it was not known to occur.

Plate XXXIV.—Fig. 3 gives a surface view of a specimen from Drummond's Island (Hudson River group).

Plate XXVIII.—Fig. 1 is a silicified specimen from the Niagara group of Point Detour.

COLUMNARIA HERZERI, N. SP.

Colonies of tubes, partially in close contiguity, of polygonal form, and intimately united with their walls; partially free, circular, laterally joining into chain-like rows, not unlike *Halysites*, or opening singly on the surface. Diameter of tubes three millimeters. Structure otherwise entirely corresponding with the associated form, *Columnaria stellata*. Is described by Nicholson under the name *Favistella calycina*.

The specimens were found by Rev. H. Herzer, of Louisville, in the Cincinnati group of Kentucky. It may only be a modification in the growth of the usual form *C. stellata*. Not figured. The specimens are too imperfect for photographic delineation.

ZOANTHARIA RUGOSA, MILNE-EDWARDS.

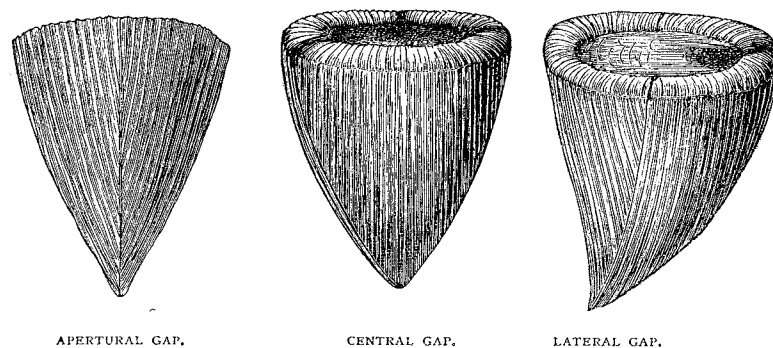
So called in allusion to the radial rugæ or plications of the stony, calcareous polyp cells, which are the only parts of these animals that have been preserved. The Zoantharia apora of a similar structure are distinguished from these by a difference in the arrangement of the radial plications. Milne-Edwards assumes four primary plications in the cycle of radii in the Zoantharia rugosa, and six primary plications in the Zoantharia apora, and deduces therefrom, in an elaborate essay, a law of symmetry, according to which the multiplication of the radii in the cycles takes place, and by which he endeavors to demonstrate that in case a new plication or lamella is formed in the interstice between two older plications of a certain value in the cyclical order, in all interstices, limited by plications of the same value, the intercalation of a new lamella takes place simultaneously, and this law he supposed to be governing the growth of Zoantharia rugosa, as well as of the Zoantharia apora. In the latter order this rule seems to be in force, but it does not apply to the growth of the Zoantharia rugosa.

The radial plications of the Zoantharia rugosa are arranged in four primary fascicles, separated from each other by more or less conspicuous gaps. These fascicles, apparently segments of a cycle of rays, are in reality bilaterally situated in symmetrical position on an axial line, dividing the apparent cycle in two halves. The two fascicles on one side are equivalent to those of the opposite side, but differ from one another. For better illustration, we may compare the circumference of a polyp cell to a horseshoe with narrow, almost closed aperture. Opposite this aperture, in the centre of the curve, two fascicles meet with their equivalent sides, leaving an obscure, narrow gap between them, the centre of which often exhibits a solitary, independent plication. This gap may, in distinction from the other gaps, be designated by the name of *central gap*. At the ends of these fascicles, remote from the central gap, and directed toward the aperture of the horseshoe, the plications become gradually shorter, and, seen from the peripheral surface of the polyp cells, do not extend to the apex of the conical polyparium, but terminate above, nearer the calycinal margins. Another gap

separates these shorter plications on each side from the joining fascicles of plications, which extend to the ends of the arms of the horseshoe. This pair of gaps are the *lateral gaps*. The further ends of this second pair of fascicles approach each other again, in the aperture of the horseshoe, leaving another larger gap between themselves than the other fascicles, which may be termed *apertural gap*; its centre is, like the opposite obscure gap, occupied by a solitary plication. The plications of this second pair of fascicles are longest and extend to the apex of the polyparium on their end joining the lateral gaps, and shortest at the apertural gap. This is the order in the structure of all the polyp cells of the Zoantharia rugosa. If, during the progress of growth, new plications are added to the cycle of existing ones, the new ones are only inserted at those ends of the four fascicles which are directed toward the apertural gap, while the already existing plications are never disturbed by interposition of new ones, excepting, as indicated at the four ends of the fascicles, directed to the apertural gap; furthermore, the addition of new plications at the four ends of the fascicles is not always contemporaneous in all, or in the opposite corresponding ones, for otherwise the lamellæ in each equivalent bundle should be equal in number, which is not always the case. This bilateral structure of the polyp cells of the Zoantharia rugosa has been observed by several palæontologists, and been mentioned by them as a peculiarity of certain species; but the late Dr. Kunth, of Berlin, was the first to demonstrate this bilaterality to be an essential character of all the Zoantharia rugosa, and to exhibit with clearness the peculiar mode of multiplication of the lamellæ in this order. If we examine a Streptelasma or a Zaphrentis, we find the outer surface of the polyp cells longitudinally striate, by broad, convex bands or ribs, and by intermediate, narrow, linear furrows. The furrows correspond to the crest-like plications on the inside of the calyces, the ribs to the interstitial spaces between them. Three of such longitudinal furrows are, on each of the polyp cells, more conspicuous than the others; they correspond to the gaps between the bundles of lamellæ. In the furrow corresponding to the apertural gap, the other furrows from both sides converge at acute angles, like the barbs of a plume, to its keel, gradually becoming shorter as they approach the margins of the calyx. The two other obvious furrows, corresponding with the lateral gaps, are, on the side nearest

to the apertural gap, joined by similar parallel furrows extending into the apex; on the other side the furrows abut against it at an acute angle, and decrease in length as they ascend. The central gap is not indicated on the outside, because the furrows on both its sides are parallel with it, as new plications are never intercalated in this place.

The annexed sketches will cause the descriptions to be understood at a glance. We perceive, by looking at the figures, that



in the apertural gap the striae must have a pinnate position, because on both of its sides new plications are constantly added to the ends of the fascicles; for the same reason we see them on the lateral gap on one side pinnate and on the other parallel, because no new plications are ever inserted there, and in the central they are all parallel because no implantation occurs on any of its sides.

All *Zoantharia rugosa* have this structure, but the four principal septal divisions do not present themselves in all with equal conspicuousness. In some the cycle of plications in the calyces is almost uninterrupted, and they appear as if of truly radial structure; in others the division lines between the fascicles are well marked by gaps, which on the bottom of the end-cells dilate into depressions called *septal foveæ*. The apertural fovea is always the largest, and an indication of it is noticeable in all forms of this order, while the two lateral gaps rarely become so distinct as to dilate into septal foveæ. The central gap is almost in every instance obscure, scarcely noticeable. Mr. Kunth, in speaking of the position and the

development of these foveæ, justly remarks that if only one of the four foveæ is well developed, it is always the apertural fovea which he calls *principal fovea*; but he is in error when he adds, "only in rare instances the opposite fovea is best developed." This case never happens; in symmetrically curved, horn-shaped polyp cells the apertural fovea is either in the median line of the convexity of the curve or on the concave side. Not unfrequently the largest fovea is found in a lateral position with respect to the curvature of the polyp cells. But even if we find the largest fovea in such lateral position, it does not follow that one of the lateral foveæ has been developed in preference to the others; on close examination, it will always be found that the septal striae on the surface converge from both sides toward the median line of that fovea, which unmistakably proves it to be the apertural fovea; if it were the lateral fovea the striae would converge toward it only from one side, or if the central, they would be all parallel, which is never observed.

Milne-Edwards divides the *Zoantharia rugosa* into four families: the *Stauridæ*, *Cyathaxonidæ*, *Cyathophyllidæ*, and *Cystiphyllidæ*. These sub-divisions, however, are artificial, not being based on important differences in the plan of structure.

Stauridæ are described as polyp cells with well-developed, radial lamellæ, which intersect the whole length of the corallum as uninterrupted, vertical leaves, which are at intervals connected by short, interstitial, transverse leaflets. The lamellæ are grouped in four fascicles, which have their limits marked by very obvious septal gaps visible within the cells under the form of a four-armed cross. The enumerated genera of *Stauridæ* are: *Stauria*, a Silurian coral; *Metriophyllum*, a Devonian form; *Polycœlia*, of Permian age. No coral which could be identified as belonging to one of these genera has been found in Michigan.

Cyathaxonidæ are described as single polyp cells, with well-developed radial lamellæ, extending as uninterrupted leaves through the whole length of the corallum, and uniting in the centre into a cristiform columella. The interstices between the lamellæ are said to be open throughout without diaphragms or transverse, interstitial leaflets. This family characteristic is based on imperfect observation. The lamellæ do not unite in the centre into a cristiform columella, and their interstices are not open all their length, but have transverse leaves intersecting them, the conically protrud-

ing centres of which leaves, one invaginated into the other, form the cristiform columella, and not the united central ends of the vertical lamellæ, which do not perfectly reach the centre under the form of uninterrupted vertical leaves; their inner termination is only a superficial carination on the conical centres of the diaphragms. This structure does not materially differ from the structure of many genera of the Cyathophylloids, particularly of some forms of *Zaphrentis* and *Trochophyllum*. The latter genus may be said to differ from *Cyathaxonia* only in the inverted direction of their invaginated diaphragms. In *Trochophyllum* the diaphragms form deep, funnel-shaped depressions in the centre of the cells, which, in their invaginated condition, likewise compose a solid central axis, turned inward instead of projecting. *Cyathaxonia* is not found in the strata of Michigan. The specimens described from the upper coal measures as *Lophophyllum proliferum*, McChesney, is a genuine form of *Cyathaxonia*, entirely corresponding in structure with the forms of *Cyathaxonia*, described by Milne-Edwards, from the sub-carboniferous strata of Kentucky. Palæontologists examining these well-preserved specimens observed at once the existence of transverse leaves across the radiated interstices of the calyces, and hesitated on that account to identify them with *Cyathaxonia*; had Milne-Edwards examined his type specimens somewhat more carefully, he would have noticed in them the same transversal leaves.

CYATHOPHYLLIDÆ.

Simple or compound polyparia formed of cell cups margined by a cycle of plications of an apparently radial position toward the centre of the cells, but actually disposed according to the bilateral plan peculiar to the whole order of the *Zoantharia rugosa*.

The polyparia are built up by a successive series of such cups, one invaginated into the other, with gradually increased size. In some forms the cups are clearly defined in their superposition by a more or less distinct lamination in the structure of the polyparia; in others the union of the cups is more intimate. The plications of the incased cups corresponding, and clasped over one another, grow together and form continuous vertical laminæ, while

the side walls of the cups unite into a common external wall of more massive structure; only the bottoms of the cups escape the general agglutination of the parts and remain free laminæ separated by an interstice from the adjacent cup bottoms. These laminar cup bottoms are, in the description of Cyathophylloid corals, considered under the name of diaphragms. In a portion of the Cyathophylloid family the interstices between the crest-like plications of the end cups are free and open; in other generic groups the interstices are up to the margins of the calyces traversed and filled with vesiculose plates, which divide them into small cell spaces.

The family of Cyathophylloids is represented by numerous modifications of its type, which will be specially considered in the generic descriptions. Milne-Edwards has adopted thirty-five genera of Cyathophylloids, and a large number of additional generic names, partly synonymous with the above, are used in the works of palæontologists. A careful study of the various forms has convinced me that a large proportion of the promulgated genera have been negligently established upon an examination of insufficient material and with incorrect appreciation of structural characters, individual peculiarities being often mistaken for important generic differences. In passing the genera in review, I will have frequent occasion for rectifications and changes in the arrangement, by which the number of the genera will be greatly reduced.

Cystiphyllidæ are pointed out as the fourth family of the *Zoantharia rugosa*, composed of the single genus *Cystiphyllum*. These corals differ from the true *Cyathophyllum* merely in having but a rudimentary development of the plications, which never compose continuous vertical leaves. The plications of *Cystiphyllum* are low crests much obscured by the blistered surface of the calycinal walls, which are entirely composed of vesiculose plates. In vertical sections the polyparia appear to be built up by a superimposed succession of layers of vesicles, disposed in accordance with the shape of the end cups.

An uninterrupted chain of transition forms between *Cystiphyllum* and the corals of the Cyathophylloid family exists, and the relations of *Cyathophyllum* proper and *Cystiphyllum* are so close that I think it unnatural to separate this genus from it as representing a different family type.

The formations of Michigan inclose a great many corals of the

Cyathophylloid family. The frequent fragmentary condition of the specimens and the altering effects of petrification prevent, in many instances, an exact identification of all the collected specimens, for which reason I have restricted myself to the description of those forms only of which I had satisfactory material for examination.

The genus *Cyathophyllum*, which gave the name to the entire large family, is not the primitive type form in which its first representatives appeared; the oldest forms of the *Cyathophyllides* were of the less complicated structure of *Streptelasma* and of *Zaphrentis*, which existed already in the lowest strata of the Trenton period. *Cyathophyllum* and many other diversifications of the type commence to appear in the upper Silurian beds. The Devonian period was the time of their greatest development, and after the carboniferous period we find the whole family exterminated, leaving no representative in the periods subsequent to the Permian strata.

CYATHOPHYLLUM, GOLDFUSS.

Simple or compound polyparia, each polyp cell surrounded by its own perfect wall. Vertical lamellæ well developed, forming continuous leaves through the whole length of the corallum, and extending to the centre, or near to it. The interstices between the lamellæ in the peripheral area (formed by the ascending walls of the calyces) are divided into small vesiculose cell spaces by short, transverse leaflets extending from one lamella to the other, and filling the calycinal interstices up to the outer margins. The central area (formed by the bottoms of the cell cups) is transversely septate by continuous simple diaphragms, or by compound plates formed of several convex, anchylosed pieces; these diaphragms are also intersected by the radial lamellæ reaching to the centre, or gradually vanishing in the middle. Surface of vertical lamellæ either smooth or granulose, with entire or with denticulated edges. Many species of *Cyathophyllum* have the side faces of their lamellæ decorated by low, equidistant carinæ, ascending in a curve from below and outward to the upper and inner edges, where they terminate as acute denticulations, or have the form of transverse trabeculæ, the carinæ of both sides of the leaves being coincident.

This carination is very obvious in a certain species first described in the geological reports of New York under the name of *Strombodes helianthoides*, which subsequently has been selected as the type form of the genus *Heliophyllum* (*Heliophyllum Hallii*), whose only distinguishing character from *Cyathophyllum* rests in the carinated surface of its lamellæ. If this distinction had been carried out strictly, and had all the forms agreeing in structure with *Cyathophyllum*, and at the same time having the surface of the lamellæ decorated by carinæ, been placed under the genus *Heliophyllum*, little objection could be urged against the arrangement, but no attempt has been made to do so. Milne-Edwards, the founder of the genus, while he describes one form as *Heliophyllum Hallii*, comes out with another equally characteristic *Heliophyllum* under the designation *Zaphrentis cornicula*, simply because that species has a somewhat large septal fovea, its only structural similarity to *Zaphrentis*. Other forms with the *Heliophyllum* character well developed he continues to consider as *Cyathophylla*, as, for instance, *Cyathophyllum helianthoides*, *Cyath hexagonum*, *Cyath. rugosum*, etc.

Carinated lamellæ are also regularly observed in the genera *Diphyphyllum*, *Acervularia*, *Phillipsastræa*, and in others. Another consideration depreciating the value of the carinations of the lamellæ as a generic mark is their frequent total obsolescence in specimens which by all other characters belong to a certain carinated species. Having the alternative before me then, either to adopt *Heliophyllum* and to substitute that name for a great many others well established, or to restore a few species now named so to their nearest relatives, the *Cyathophylla*, many of which participate in the same character of carination, I felt inclined to take the latter course as the simplest and most satisfactory.

CYATHOPHYLLUM HALLII, MILNE-EDWARDS.

Synon., *HELIOPHYLLUM HALLII*, Milne-Edwards.

Simple turbinate polyp cells, attached by the small basal apex, and frequently by additional root-like prolongations from a part of the side-walls. The conical shape of the cells varies considerably in

different specimens, and changes during the progress of growth. A specimen may begin with a narrow cylindrical base, and then suddenly spread its end cell into an expanded dish form, or another may very regularly and gradually dilate into curved, horn-shaped cells, or the conical calyces of the base, after attaining a certain diameter, may stop to dilate and continue to grow on, maintaining the same size, into long, cylindrical stems, straight, or curved, or geniculated by interruptions in the growth, with constrictions and deflexions. In regularly formed specimens the calyces are shallow, bell-shaped, with broadly spread margins; other specimens have deeper calyces, with nearly erect margins. The radial lamellæ are alternately shorter and longer, but equal in size near the calyx margins, forming a uniform, uninterrupted cycle, with exception always of a faintly indicated apertural gap and septal fovea. The longer lamellæ extend as somewhat flexuose crests to the centre. Often a lamella continues across the calyx from the centre of the apertural gap to the opposite side, and the other lamellæ abut against it from both sides in symmetrical order. The bottoms of the end cells are usually raised into obtusely rounded, monticulate protrusions, on which the lamellæ unite with interlaced, twisted ends; or sometimes the lamellar crests fade away before reaching the centre, which then is formed by a smooth, naked spot of narrow extent. The most obvious character of this species are the arched carinæ extending across the lateral faces of the lamellæ from the outer peripheral side and below, to the upper and inner edges of the lamellæ; the carinations correspond on both faces and project on the edges of the lamellæ as obtuse, transverse bars or as acute dentations. The carinæ of different specimens vary considerably in degree of approximation; in some about eight carinæ are in the space of one centimeter, while others may have as many as fifteen within the same space. The radial lamellæ are acute, linear, and the interstices between them are completely filled by vesiculate, transverse plates arranged in imbricated superposition, in arched rows, ascending from within and below, upward and outward, diagonally to the direction of the carinæ. In the central area the polyparia are intersected by diaphragmatic, transverse plates, usually compound, of several pieces, inclosing larger vesiculate, interstitial cavities, which, by intersection with the vertical lamellæ, are divided into cellulose spaces of a much coarser kind

than the interstitial cell spaces of the peripheral area. Associated with the specimens exhibiting plainly the carinated character of the lamellæ, others entirely similar to them are found with very obscure carinations. The calyces of the largest specimens attain a diameter of about six centimeters. The average number of lamellæ, in the circumference of calyces four centimeters wide, is from seventy-five to eighty-five. The external mode of growth is subject to a great many variations, from the short, broadly turbinate cell to long, cylindrical stems, with all sorts of irregularities by constrictions, flexions, etc. Occurs in the upper Helderberg group, and in the Hamilton group of Michigan, Canada, New York, Ohio, and in the Western States. The specimens of different localities and of different strata show some differences, but not in a degree to justify their separation into several species.

Plate XXXV., Upper tier.—The three left-hand figures are medium-sized specimens, found in the Hamilton group of Widder, C. W.; the two outer calyces are short, turbinate; the adjoining specimen exhibits an irregularly distorted cylindrical growth. The third upper figure from the left is found in the Hamilton group of Thunder Bay; the lamellæ on one side of the calyx are plainly carinated, while on the other side scarcely any traces of carination can be observed.

CYATHOPHYLLUM JUVENIS, N. Sp.

A very constant form found in association with the preceding species, resembling it in all particulars, but in all proportions smaller. The arched carinæ are closely approximated, twenty-four on the space of a centimeter. Number of lamellæ from sixty to seventy in the circumference of calyces two and one quarter centimeters wide, which is about the largest size observed. Found in the Hamilton group of Thunder Bay, Little Traverse Bay, at Widder, C. W.; also in the upper Helderberg strata of New York, Ohio, Kentucky, etc.

Plate XXXV., Upper tier.—The three smaller specimens on the right side of the plate; the longer cylindrical specimen is of larger size than usual.

CYATHOPHYLLUM CORNICULA.

ZAPHRENTIS CORNICULA, Milne-Edwards.

Single, conical, symmetrically curved polyparia, annulated by fine wrinkles of growth, and by distant, shallow, rounded constrictions; delicately striate in longitudinal direction by septal furrows; apex pointed; calyx deep, with suberect margins gently spreading near the edges. Bottom of calyces variable; there are specimens in which the calyx gradually narrows into an obtuse pit; in others the bottom is reflected into a moderately convex protrusion, on which the lamellar crests unite; or this protrusion of the reflected bottom is of annular form, with a depression in the centre, which is confluent with a well-developed septal fovea situated on the convex side of the curvature of the horn-shaped polyp cells. The lamellæ are alternately large and small, denticulated on the edges and carinated on the side faces; from sixteen to eighteen carinæ on the space of one centimeter's length. Number of lamellæ in calyces of two centimeters diameter, from seventy to eighty. Lamellar interstices of the peripheral area filled with vesiculose, transverse plates up to the margins of the end cups, but the edges of the lamellæ remain free to some extent, more so than in the former species. The central area is intersected by well-developed transverse diaphragms, of somewhat irregular compound structure, joining the outer vesiculose area with depressed margins. The largest sized specimens are about six centimeters long, by a diameter of four centimeters at the calycinal margins; but the majority of specimens are much smaller. It occurs in the upper Helderberg strata of Michigan, Ohio, Canada, New York, and in the Western States, as one of the most abundant and characteristic fossils of that horizon.

Plate XXXV., Lower tier.—The left-hand group of specimens represents different variations of the kind found in the drift of Ann Arbor, all in silicified condition, with exception of the upper largest specimen, which is calcified; the other specimens are from the Falls of the Ohio, and from Columbus, Ohio.

CYATHOPHYLLUM SCYPHUS, N. SP.

Conical polyp cells, symmetrically curved, or irregularly constricted and geniculated, pointed, or with a broad scar of attachment. Calyx deep, spacious, with erect margins; bottom narrowing into an obtuse point, or somewhat flattened. Lamellæ linear, equal near the margins, but unequal in length, the larger ones uniting in the centre. The two lateral and the apertural gaps always plainly indicated; particularly distinct is the apertural gap, which has no determined position with regard to the curvature of the polyp cells. The surface of the lamellæ is smooth; their interstices filled with vesiculose plates. The central area is transversely septate, by compound vesiculose diaphragms. Number of lamellæ in calyces three and a half centimeters wide, 125 to 130. Polyp cells of larger size, measuring about two inches across the calyx and about three inches in length. Surface longitudinally ribbed by septal furrows, and intermediate rounded carinæ. Found in great numbers in silicified condition in the lower beds of the Hamilton group, at Long Lake, north of Alpena.

Plate XXXV., Lower tier.—The two right-hand specimens. One exhibits a view of the calyx, with distinctly visible indication of the apertural and the two lateral gaps; the other gives a side view of a polyp cell.

CYATHOPHYLLUM GENICULATUM, N. SP.

Large conical polyp cells of much interrupted growth by smaller constrictions and by deeper abrupt truncations of the old calyces, and renewed growth from their centre of a new calyx in considerably deflected direction, often making a perfect right angle with the old cell, which interruptions, frequently repeated, result in the production of distorted, geniculated, conico-cylindrical polyp stems. The basal portion of these stems exhibits sometimes a small scar of attachment at the pointed end; at other times broad scars, extending some distance upward along the sides, are noticed on the lowest cell with truncate base. The latter more permanently attached stems are usually of a more regular, straight, conico-cylindrical form.

drical form; the others, feebly attached stems, by breaking loose and falling into any accidental position, were obliged to alter the direction of their calyces, and if by subsequent currents or other causes their position was changed, they had to accommodate themselves again to the new position, and this, I suppose, is the true reason of their distorted growth. The calyces of the polyp cells are deep, gradually tapering, with inclined suberect margins. Lamellæ delicate, linear, subequal near the margin, crenulated at the edges, and obtusely carinated on the side faces. Apertural gap well marked. Interlamellar interstices of the peripheral area filled with vesiculose plates. Central area traversed by compound vesiculose diaphragms, which are much intersected by the vertical lamellæ. Diameter of large calyces from five to six centimeters. Number of lamellæ in calyces four centimeters wide, 112. Found in the upper shaly strata of the Hamilton group, at Partridge Point, Thunder Bay.

Plate XXXVI.—Lower figure represents the peculiar mode of growth of the polyp cells. Some specimens found at Widder, C. W., in the Hamilton group, are of entirely similar growth, but these evidently are only a modified form of *Cyathophyllum Hallii*, with obscure lateral carinæ.

CYATHOPHYLLUM HOUGHTONI, N. Sp.

Erect, conico-cylindrical polyp cells, with a strong latero-basal attachment. Surface obtusely wrinkled, rarely interrupted by acute annulations. Calyx deep, with steep side walls, and erect, slightly dilating edges. Bottom of cells about one third as wide as their outer margin, subplane or gently convex, with depressed circumference, crossed by the lamellæ, of which three or four are always much stouter than the others and coalesce in the centre. Sometimes the centre of the cell bottoms is depressed, with a ring-like elevation surrounding the depression, of smooth surface. Lamellæ alternately larger and smaller, linear near the bottom of the calyces, roof-shaped on the ascending walls, and frequently explanate into a blistered plicated membrane near the margins. The surface and the

edges of the lamellæ within the calyces are covered with granulations and by short, interrupted, transverse carinations or rugosities. The transformation of the linear radial crests into roof-shaped plications on the ascending side walls of the calyces alters the structure of the peripheral area considerably. There are no small, vesiculose, interstitial plates developed in the interstices between the radial crests, as in the outer area of other *Cyathophylla*; the lamellæ themselves open in two diverging leaves, which join in the interstices into a continuous calycinal membrane of a blistered structure. The calycinal surface represents a complete laminar bag folded into plications, with the acute edges of the folds directed inward, and the rounded curve turned outward. The coral is formed by invagination of a series of such bags, which have elongated, blister-like intervals between them, but are in intimate connection by the edges of their crested plications, which correspond to each other and combine into vertical laminar dissepiments extending through the whole length of the corallum. In the marginal portions of the calyces, however, the crests are often interrupted in their vertical continuity by the extension of the blister-like interstices between the calycinal bags across several of the plications which have lost their edged crest form through spreading into a tent-shape. This structure frequently causes an exfoliation of the surface of the specimens, with exposure of the outer blistered surface of the bags, by which even small fragments can be identified as belonging to this species. The central area is septate by transverse diaphragmatic plates of much regularity. The vertical lamellæ intersect them as continuous leaves nearly to the centre. Occurs as the prevailing species in the Hamilton group of Thunder Bay and of Little Traverse Bay. A coral described by Hall under the name of *Chonophyllum ellipticum*, from the Hamilton group of Iowa, agrees in structure with the described form, but not with *Chonophyllum*. A similarly built species is found in the upper Helderberg strata of Kentucky, but both of these, according to their mode of growth, seem to differ specifically from our form.

Plate XXXVI.—In the upper tier of figures are views of different specimens found at Little Traverse Bay. The central larger specimen presents a polished section.

CYATHOPHYLLUM RUGOSUM, MILNE-EDWARDS.

Synon., *ASTRÆA RUGOSA*, Hall.

Astræiform colonies of polygonal, intimately united stems of a diameter from one to one and a half centimeter, which in some specimens of a certain state of preservation are separable, and present longitudinally ribbed polygonal stems, annulated by transverse wrinkles of growth. Calyces joining, with gradually ascending side walls, inclosing conical cell pits; or the end cells are formed by an abrupt, narrow, central pit, with horizontally expanded, discoid margins. The bottom of the cells is sometimes formed by diaphragms with a smooth central spot; usually the lamellæ reach to the centre and intermingle there, forming a twisted knot. Number of lamellæ in the circumference of the calyces from 35 to 45; their edges are crenulated, the side faces traversed by arched carinæ, which in some specimens are almost obsolete, in others very distinct. Interlamellar interstices traversed by small vesicles filling them to the margins of the calyces. The centre of the stems is transversely septate by diaphragms, intersected in their outer circumference by continuous vertical lamellæ; centrally their continuity is interrupted, and the ends are merely carinations on the upper face of the diaphragms.

Milne-Edwards describes paliform lobes and the development of a rudimentary columella in this species, but neither one nor the other structure can be recognized. The centre of the calyces in some weathered specimens protrudes with a degree of convexity exhibiting the twisted ends of the radial lamellæ, but no paliform lobes, much less a columella. Found in the Helderberg limestones of Mackinac Island, and in the drift of the Lower Peninsula. It is also common at the Falls of the Ohio, at Sandusky, and in many other localities.

Plate XXXVII.—The upper row represents a polished, horizontal section, and a lateral view of another specimen with stems separable from each other.

CYATHOPHYLLUM DAVIDSONI.

Synon., *ACERVULARIA DAVIDSONI*, Milne-Edwards.

ACERVULARIA PROFUNDA, Hall.

The corals described under the name *Acervularia Davidsoni* and *Acerv. profunda*, which latter I consider merely as a variety of the former, are in structure identical with *Cyathoph. rugosum*. The genus *Acervularia* is represented as having its central portion of the polyp cells surrounded by an internal wall, but neither the above-mentioned corals nor the typical forms of the genus *Acervularia* (*Cyath. pentagonum* and *Cyath. ananas* of Goldfuss) exhibit an internal wall. In the circumference of the abrupt inner cell-pits of all these forms a sort of annular demarkation is conspicuous in transverse sections, because the shorter ones of the alternately larger and smaller radial lamellæ terminate there with somewhat thickened edges, but they never combine into a closed, ring-like wall.

The specimens described by Milne-Edwards are from the Helderberg limestones of the Falls of the Ohio; the Michigan forms identified with it in the subsequent description are found in the Hamilton group.

Growth in large, convex masses, or in lenticular, discoid expansions, covered on the lower depressed, conical, and centrally attached side with a concentrically wrinkled epithecal crust. Stems multiplying by marginal and central gemmation from the calyces; sometimes single stems are free and circular; usually the growth is astræiform, with intimately connected polygonal calyces, surrounded by acute linear crested edges. The margins of the calyces are usually broadly explanate, discoid, rarely gradually descending into the more abrupt, bell-shaped, central excavation proper to all forms, on the rounded bottom of which the lamellæ unite, or which, in rarer instances, exhibits a narrow diaphragm sparsely intersected by lamellar crests. Diameter of calyces about one centimeter, but quite variable. Lamellæ long and short, in alternation, but equal in size near the calyx margins, crenulated at the

edges, and decorated by arched carinæ crossing their flanks; from thirty-six to forty lamellæ in the circumference of a calyx. Interlamellar interstices filled with delicate, transverse, vesiculose plates. The central area is distinctly septate by diaphragms, which are not much intersected by vertical crests; on the circumference of the central area, in polished transverse sections, a more compact ring is visible, formed by a thickening of the longer lamellæ, and by the abrupt termination of the alternating shorter ones within this circle, but not a trace of an actual inner wall is developed. By comparing specimens from different strata and different localities, a number of minor variations may be observed, but I do not consider them important enough to make specific distinctions. This form approaches also so near to *Cyathophyllum rugosum* of the upper Helderberg group, that a strict distinction between them is almost impossible.

Occurs abundantly in the Hamilton strata of Thunder Bay, and of Little Traverse Bay; is also a common form in the Hamilton strata of Iowa.

Plate XXXVII., Fig. 4.

CYATHOPHYLLUM CRISTATUM, N. SP.

Astræiform calyces, bell-shaped, joining with polygonal, suberect margins; diameter of cells about two centimeters; about thirty-six alternately large and small stout lamellæ in the circumference, with crenulated edges and lateral carinations; the larger lamellæ extend over the bottom of the cells to the centre; interlamellar interstices large, filled with coarse, transverse, vesiculose plates. Central area irregularly septate by vesiculose compound diaphragms. Occurs rarely in the Hamilton strata of Little Traverse Bay; its structure is much coarser than in *Cyathophyllum Davidsoni*, with which it is associated.

The specimens were not sufficiently perfect for photographic delineation.

CYATHOPHYLLUM COALITUM, N. SP.

Astræiform masses of very large, polygonal polyp cells measuring about four centimeters in diameter, each one surrounded by its

own complete wall. Surface of calyces expanded, discoid, with an abrupt but shallow central pit, the reversed bottom of which conically projects, covered by the central ends of the radial crests. Lamellæ linear, subequal, from sixty to seventy in the circumference of a calyx, crenulated by transverse trabeculæ (bars), which are the ends of lateral, arched carinæ decorating the side faces; about fourteen carinæ on the length of one centimeter. Interstitial spaces filled with vesicles arranged in arched rows running diagonally across the carinations. Central area traversed by transverse, larger plates, which are much intersected by the vertical lamellæ. The structure of this coral is identical with *Cyathophyllum Hallii*, from which it differs principally in its cespitose, compound growth. Found frequently in silicified condition in the drift, connected with fossils of the corniferous limestone.

Plate XXXVIII.—Fig. 4 represents a fragmentary specimen from the drift of Ann Arbor.

CYATHOPHYLLUM RADICULA, N. SP.

Small single polyp stems, about one centimeter in diameter, conical at the base, cylindrical in their prolongation, annulated by numerous sharp constrictions caused by periodical interruptions in the growth of the cells, which commences again with contracted base from the centre of the old cells. The bases of the stems are strongly attached to other bodies, and the attachment is often strengthened by excrescences from the sides of the stems. Calyces not as deep as wide, with erect, ascending sides, slightly expanded near the margins, and surrounded by about sixty alternately larger and smaller crenulated lamellæ. Bottom of cells flat, formed of a smooth or faintly carinated or granulose transverse diaphragm; in some other specimens the lamellæ extend to the centre, and the bottoms of the cells are more rounded, concave. A septal fovea is rarely indicated. Found in the Niagara group of Drummond's Island, at Point Detour, and in the Niagara group of Iowa.

Plate XXXIX., Fig. 3.—The left-hand, outer vertical row of specimens is from Point Detour; the central row represents specimens from Masonville, Iowa; the right-hand row may be a different species. It occurs in the Niagara group of Louisville, and of Charles-

ton, Indiana; the stems are of longer cylindrical growth, often curved and geniculated; their calyces rarely exhibit a naked diaphragm in the bottom, and the crenulated lamellæ generally reach to the centre. The surface of the stems is in both kinds longitudinally ribbed by septal striæ.

CLISIOPHYLLUM, DANA.

Simple conical polyp cells with the general structure of *Cyathophyllum*, differing from it in the shape of the calycinal bottom. Radial lamellæ linear, with prominent free edges within the end cells; the interstices between the lamellæ are traversed by transverse, vesiculose plates, but these do not fill the interstices up to the margins of the lamellæ, as is usual in *Cyathophyllum*, and the inclosed vesiculose spaces are somewhat larger. The broad central area of the polyp cells is formed of high, projecting, conical diaphragms, one incasing the other, and crested on the surface by the central ends of the radial lamellæ. The apertural septal fovea well developed.

CLISIOPHYLLUM ONEIDAENSE, BILLINGS.

Conico-cylindrical, sometimes elliptically compressed polyparia, annulated by numerous transverse wrinkles and intermediate linear constrictions. The stems are frequently flexuose; their width is from three to five centimeters, by a length of sometimes over one foot in cylindrical specimens; the conical cells are shorter, with a diameter equal to that of the former. The basal ends of the larger stems often, for some length, grow in the form of narrow cylindrical pedicles, the surface of which is ornamented with numerous stout spinulose projections, which also extend, but rarely, for some distance higher over the upper, more dilating portions of the stems. The calyces are spacious, with steep side walls, terminating with erect or only slightly exspatiated margins. Lamellæ near the calycinal margins of alternately larger and smaller size; further down the sides the lamellæ are all of one size; the smaller intercalated ones remain confined to the outer margin. A conspicuous septal fovea interrupts the cycle of the lamellar crests, causing a

deep, siphonal depression in the peripheral circumference of the cell bottoms, which are broad, rising into a strong cone carinated by the radial lamellæ uniting on its apex in somewhat twisted manner. Number of lamellæ in specimens of four centimeters calyx diameter, from 85 to 90, and at the margins of the calyces an equal number of small rudimentary folds are intercalated.

Found in the upper Helderberg strata of Mackinac, at the Falls of the Ohio, at Port Colborne, in Canada, and frequently in the drift deposits.

Plate XL.—The upper tier represents various silicified specimens found in the drift, left-hand and lower central specimen; the other two are from the Falls of the Ohio. The right-hand specimen exhibits the invaginated, conical diaphragms almost extending across the whole width of the stems, surrounded only by a narrow peripheral area.

LITHOSTROTION, FLEMMING.

Compound polyparia, formed of cylindrical stems, enveloped by a perfect epithelial wall, and either loosely approximated, with circular orifices, or intimately united, and joining under polygonal outlines by mutual pressure. Structure very similar to *Clisiophyllum*. The outer area is divided into small cellulose spaces by the interposition of vesiculose, transverse plates between the vertical lamellæ; the inner area, which is not defined from the outer area by an intervening wall, is formed by diaphragms reflected into large protruding cones, carinated by the radial crests uniting on them and invaginating into one another. The laterally compressed, crest-like apices of the invaginated cones grow together and form a continuous, thin axial lamina pervading the whole length of the corallum.

LITHOSTROTION MAMILLARE, EDWARDS & HAIME.

LITHOSTROTION PROLIFERUM, Hall.

Large colonies of remote, cylindrical stems, from one to two and a half centimeters in diameter, multiplying by gemmation from the margins of the calycinal disks, or astræiform masses of inti-

mately united, polygonal stems of similarly variable sizes, and unequal in the same specimens through the intermixture of frequent young cells. Calyces moderately deep, obliquely spreading in the margins, and more abruptly excavated in the inner circumference. Bottom of cups reflected into a large, conical protuberance, carinated on the sides by the converging ends of the radial lamellæ, and terminating with a laterally compressed cristiform edge. From thirty to forty lamellæ in the circumference of a calyx; and sometimes indications of rudimentary, intermediate plications are noticeable. The clusters of singly growing stems cover sometimes spaces of large extent, and not a specimen with astræiform, polygonal calyces is found among them; in other localities the astræiform colonies are the prevailing form; this seems to indicate a difference between the two forms, but specimens are found, and that not rarely, in which one part of the stems is free, circular, and another intimately united, pressing each other into the polygonal form. As no difference in the structure can be observed in the two forms, I am inclined to consider them modifications of one species, whose difference in mode of growth is perhaps only dependent upon local conditions existing at one and another place. Occurs in the carboniferous limestone of Wildfowl Bay, and at Bellevue and Grand Rapids, Michigan.

Plate LV.—The upper tier represents two specimens from the carboniferous limestone of Wildfowl Bay—one with astræiform, polygonal calyces, the other with partial free circular stems.

The specimen lying across the bottom of the lower tier in the same plate is a singly grown stem of the same species.

BLOTHROPHYLLUM, BILLINGS.

Conico-cylindrical polyparia, single, or in cespitose clusters, produced by prolific calycinal gemmation of a few parent cells. The structure of the stems, as being built of a series of invaginated cups, is particularly obvious. The bottom of these cups has the shape of transverse diaphragms, smooth in the centre, or superficially carinated by the central ends of the radial, crest-like folds, into which the side walls of the cups are plicated. These crests of the superimposed cups unite into continuous vertical laminæ within

a narrow circle intermediate between the central and the peripheral areas, but are interrupted in their continuity outside or inside of it. Inside, on the diaphragms, the plications fade away as superficial, low carinations; in the outer peripheral area their continuity is interrupted for other reasons; the margins of the incased plicated cell cups dissolve connection and begin to diverge; gradually widening gaps open between the laminar cup margins, which at first continue to repose on each other's crests, but finally also these become disjunct, and they remain so until at the peripheral surface the edges of the cup membranes join again into a common epithecal wall, which closes off from the outside the cavernous gaps between them. Some of the forms have a well-developed septal fovea; in others it is not very distinct.

BLOTHROPHYLLUM DECORTICATUM, BILLINGS.

Large polyp stems, conical at the base, cylindrical and flexuose above, attaining a diameter of over two inches and a length exceeding one foot. Surface, if perfect, covered by a continuous epithecal crust, longitudinally striate by septal furrows and annulated by deep wrinkles and constrictions. The conical basal part is decorated with strong nodular spinulosities, as the polyp cells of the associated Clisiophyllum, with which it stands in structural relationship. Calyces moderately deep, with steep sides, explanate margins, and broad bottoms, in the form of irregularly concave diaphragms, smooth in the centre, and on one side depressed into a deep septal fovea. The lamellæ are acute, very prominent linear crests on the ascending side walls of the calyces, but become lower and almost obsolete near the expanded peripheral margins; in the broad marginal interstices between them smaller plications are regularly intercalated.

The peripheral part of the polyparia formed by the expanded laminar cup margins, with large gaps between them, and supported only by their ends, united in an epithecal cuticle, is very fragile and rarely found in good preservation. The plurality of specimens have lost their epitheca, and the laminar margins stand out free, surrounding the stems like broad collars; or they have been destroyed, and only the central cores are found, presenting an ex-

foliated surface, and consisting of a cycle of stout vertical lamellæ, which incloses the central series of diaphragms. Occurs in the drift of Michigan, and is found in place at the Falls of the Ohio, and in the corniferous strata of Canada.

Plate XLI.—Silicified specimens from the Falls of the Ohio. The right-hand weathered specimen exhibits the centre of a polyp stem intersected by diaphragms. The left-hand specimen has at the conical base preserved its continuous epithecal wall; above it the surface is exfoliated and shows the coarse, blister-like cavities intermediate between the invaginated series of renewed cell cups.

BLOTHROPHYLLUM CÆSPITOSUM, N. SP.

Aggregated, conico-cylindrical polyp cells of a much interrupted, articulated growth, by constantly repeating constrictions and dilations of the cell cups. The constrictions of the stems are acute angular, without interruption of the continuity of the surface walls; in other instances the continuity is interrupted, and a more or less broad, expanded rim of the older cell cup projects with free edge at the places of constriction. The polyparia multiply by gemmation of many young cells at once from the end cups of the older stems. The clustered stems become attached to each other by their acute, annular edges; the joints of the obliquely diverging stems are generally oblique to each other in proportion to the inclination of the stems—one joint, so to say, being pushed sideways over the other in this direction. The calyces are shallow, with obliquely spreading side walls. Radial crests not very high, linear, and projecting most on the more vertical portions of the cup walls, dilating into tent form on the marginal, expanded portions of the calyces. Edges of the plications denticulate and surface granulose. At the margins of the calyces smaller, rudimentary plications are alternately interposed between the larger ones. Diaphragms forming the bottom of the cups flat, with several siphonal depressions in their circumference, but with no distinct septal fovea; their centre usually smooth, sometimes carinated by the ends of the lamellæ. By the united linear, crest-like portion of the plications a cycle of vertical lamellæ is formed around the central diaphragms; the area exterior to this cycle is formed by superimposed, plicate, sometimes blistered,

laminar cup-walls, partially connected by the edges of the lamellæ, otherwise separated by irregular, blister-like cavities, but uniting again in the peripheral wall. Diameter of stems from two to three centimeters. Found in the Niagara group of Drummond's Island, at Point Detour, etc., in silicified, generally much decayed and altered condition.

Plate XLII.—Surface view and lateral view of specimens from Point Detour.

CHONOPHYLLUM, MILNE-EDWARDS.

Single turbinate polyparia, composed of invaginated, radially plicated cell cups, which are intimately united within the central area, and form with their linear plications continuous vertical crests, extending through the whole length of the corallum, and uniting in the centre into a somewhat twisted fascicle, but without composing a solid central axis. The interlamellar interstices of this central fascicle or core are traversed by transverse vesiculose plates, but no larger transverse diaphragmatic septa are observable. In the peripheral area the structure is entirely different. The connection between the invaginated cups becomes more loose, the linear plications open themselves and spread horizontally, forming gradually widening and moderately convex, band-like folds of the expanded laminar cup walls, which are superimposed in well-defined, membraniform layers, one reposing on the granulose prominences of the surface of another, and more intimately connecting in the linear furrows between the plications, which correspond to the interlamellar spaces of other *Zoantharia rugosa*, but were confused by Billings with the lamellæ. In his description of *Chonophyllum magnificum*, Mr. Billings remarks: "The grooves on the floor of the cup indicate the position of the septa, and the ridges are the equivalent of the interseptal spaces." This is an evident error. It can be directly observed in the specimens how the linear vertical crests of the central area gradually open in two diverging leaves, spreading horizontally into flattened, band-like folds, and at the same time how the spacious interlamellar interstices of the central circle become outwardly angustated in the same measure as the plications widen. In the median line of these linear interstitial spaces, confounded with the lamellæ, the rows of vesiculose transverse plates,

characterizing them as true interstitial spaces, are, in all the well-preserved specimens, plainly demonstrable, anatomical facts.

CHONOPHYLLUM MAGNIFICUM, BILLINGS.

Conical polyparia, attaining a calyx diameter of nine inches in larger specimens; some grow in short, broadly expanded polypdoms, increasing but little in length; others proportionately elongate their stems with the widening of their calyces. The pointed ends of the polyparia are attached by a small scar. The outer wall is annulated by concentric wrinkles of growth and longitudinally ribbed by septal striæ. Calyces broad, explanate, dish-shaped. Plications equal, linear, crest-like in the central parts of the calyces, but changing into tent-shape on the spreading neck part, and opening into broad bands near their peripheral circumference. The surface of the plications is densely covered with decorative granulations or papilli, visible as well on the horizontal, band-like surface as on the side faces of the linear, crest-like portions. In calyces of three inches diameter about ninety plications are counted in the circumference. In the bottom of the calyces the lamellæ become very delicately linear and twisted, or irregularly interlacing into a central fascicle. No indication of a septal fovea. Occurs in the upper strata of Mackinac Island and in the drift of the Lower Peninsula, and is common at the Falls of the Ohio, at Charleston Landing, Indiana, and in other exposures of the upper Helderberg group.

Plate XLIII., Upper tier.—The right-hand specimen is a silicified fragment of a large calyx exhibiting the band-like form of the lamellæ toward the outer margin, and their crested linear form near the central cavity; the papillose surface is likewise well seen in the figure. The other specimen gives a side view of a specimen showing the general mode of growth, and the laminated structure of the polyparia. The right-hand figure in the lower row is a calyx seen from above. All the specimens represented are from the Falls of the Ohio; the Michigan specimens were not so well adapted for delineation.

CHONOPHYLLUM PONDEROSUM, N. Sp.

Patellate, depressed, conical polyparia of irregular, unsymmetrical, clumsy growth, with gemmation from the centre of the calyces, of single new cells, or, in rare instances, of from two to four confluent or imperfectly defined calyces. End cells shallow, explanate at the margins, more abruptly depressed in the centre, which is surrounded by a cycle of low linear crests uniting in it with twisted ends. Expanded marginal part radiated by flat, broad, band-like plications of papillose surface. The specimens are all formed of a heavy, compact mass of amorphous, white, ivory-like carbonate of lime, or partially silicified, and with scarcely a trace of the organic structure preserved; only in a few specimens could enough of it be seen by which to recognize the generic relations of the specimens and their correspondence with *Chonophyllum*. It does not seem to be the mode of petrification which obscures the structure, as we find this coral in many different localities associated with other corals exhibiting the finest details of structure, while they everywhere present the same massive, compact condition. The coral appears to have, during the progress of its growth, filled out all its cellulose cavities as soon as the fleshy parts of the animal abandoned them.

It occurs rarely in the upper Helderberg limestones, but is abundant in certain layers of the Hamilton group of Thunder Bay, and is also found in Little Traverse Bay.

Plate XLIII., Lower tier.—The left-hand figure is a specimen found in the lower limestones of Phelps' quarries, near Alpena.

OMPHYMA RAFINESQUE, PTYCHOPHYLLUM IN PARTE, MILNE-EDWARDS.

Single conical polyp cells of Cyathophylloid structure, composed of invaginated calycinal cups, the bottoms of which have the form of spacious diaphragms, either smooth or crested by the radial lamellæ uniting in the centre. The ascending side walls of the cups are encircled by linear, crest-like plications, which connect into uninterrupted vertical laminæ, within this intermediate area. At the peripheral cup margins the plications become tent-shaped, em-

bracing one another in their superposition, but not always combining with their edges into uninterrupted vertical leaves. The interlamellar interstices are traversed by transverse plates, and divided into cellulose spaces, but the dissepiments are not independent vesiculose leaflets; they make part of the tent-shaped folds of the invaginated series of cell cups, and represent the rounded, outwardly directed flexion of the plicated cup walls, while the inwardly turned folds are sharply crested. Root-like, cylindrical excrescences from the side walls of the polyparia, by which they are attached to other bodies, are a peculiarity of the different species of *Omphyma*, which, however, are not exclusively so to them, but are also noticed in other forms of the *Cyathophylloids* family. As another distinctive character of *Omphyma*, the development of four septal foveæ is mentioned by Milne-Edwards, but they are generally not all equally distinct, while very frequently only one of them is obvious, the others being almost obsolete. The genus *Ptychophyllum*, described by Milne-Edwards as being organized like *Chonophyllum*, differing from it in the twisted converging ends of the radial lamellæ, forming a central false columella, is likewise in close structural relationship with *Omphyma*, and in the special case of *Ptychophyllum Stockesii*, I found its affinity with *Omphyma verrucosa* so great that I altered the name of the first from *Ptychophyllum* to *Omphyma*.

OMPHYMA VERRUCOSA, MILNE-EDWARDS.

Conical polyparia, attaining in larger specimens the length of one decimeter by a calyx diameter of from seven to eight centimeters. Surface of the silicified specimens generally exfoliated; if perfect, it is covered by an epithelial wall with annular wrinkles of growth, and longitudinally striate by septal furrows. From the sides of the conical walls numerous cylindrical, root-like prolongations grow out, serving for attachment of the coral to other bodies; these appendices were not distributed equally over the surface, but seemed to form only on those sides where a chance for attachment was offered by close proximity of an object. Calyces spacious, with steeply ascending sides and a gently expanded margin; bottom broad, convex, with depressed circumference, flat or somewhat concave in the centre, which may be almost smooth, or

the lamellæ may extend over it as carinations, becoming twisted in the centre. On the ascending sides of the calyx the lamellæ have the form of acute linear laminae alternating in size, a smaller and a larger one near the bottom of the calyx always united into pairs. In the marginal portions of the calyces, the two plates forming the linear crests diverge at the base, and open into a tent-shape. The four septal foveæ are scarcely ever distinct—two of them, or it may be only one, being plainly developed.

The centre of the polyparia is, in vertical sections, seen regularly intersected by large transverse plates, and the continuity of the vertical crests is interrupted. Number of lamellæ in calyces of six or seven centimeters diameter from one hundred to one hundred and ten. Associated with the elongated type form already described, which is represented on Plate XLIV., lower tier, right- and left-hand specimens, are shorter conical specimens, with broad, expanded calyx margins, and generally with a very prominent bottom, covered by twisted radial crests, seeming to be a mere variety of the former kind. The central figure between the two represents one of them. Occurs in the Niagara group of Drummond's Island, etc.

OMPHYMA STOCKESII.

Synon., *PTYCHOPHYLLUM STOCKESII*, Milne-Edwards.

Conical polyp cells very similar to the former species, in structure and mode of growth. Calyces spacious, rather shallow, with expanded margins; bottom of cells always raised into a monticule, on which the lamellæ unite in twisted manner. Two of the septal foveæ distinct, the other two obscure. Lamellæ united into pairs of a larger and a smaller one; of more delicate structure than in the former kind, and with narrower interstices. Their vertical continuity is complete in an inner intermediate cycle; interrupted in the central part, occupied by transverse diaphragms, and in the marginal parts, in which the horizontally expanded cup membranes are bent into zigzag lines, and superimposed in layers. Number of lamellæ somewhat larger than in the former species in specimens of the same size. External surface covered with root-like excrescences as in the other. The description given by Edwards of

Ptychophyllum Stockesii says nothing about such excrescences, but otherwise it applies exactly to the specimens now considered, which were found in the same locality as his, at Drummond's Island, associated with the other form. Other forms of *Ptychophyllum*, found at Louisville, in the Niagara group, and resembling *Ptychophyllum patellatum* from Gothland, have these root-like appendices also well developed. It is sometimes difficult to draw a line of distinction between specimens of these two species.

Plate XLIV., upper tier, gives various silicified specimens from the Niagara group of Drummond's Island.

A very common species in the Niagara group of Iowa, described by D. Dale Owen, under the name of *Cyathophyllum undulatum et multiplicatum*, has a structure entirely conformable with the two species of *Omphyma* of Drummond's Island, and must therefore be arranged with them in the same generic group.

DIPHYPHYLLUM, LONSDALE.

Synon., ERIDOPHYLLUM, Milne-Edwards.

DIPLOPHYLLUM, Hall.

Colonies of aggregated cylindrical polyp cells, multiplying by calycinal gemmation, but not by fissiparous mode of propagation, as Lonsdale asserts. The stems are rarely in intimate contact so as to form astræiform masses; usually some interval remains between them, and they are mutually connected by rugose or radiciform lateral prolongations of the walls, or by floors formed by periodical horizontal expansions of the calyx margins until they join at their edges. Structure of cells biareal. The outer area is formed by the external epithecal wall with a cycle of stout vertical lamellæ having crenulated edges and arched carinæ decorating their flanks. The interlamellar interstices are filled with small transverse plates, dividing them into narrow cellulose spaces. These transverse plates are disposed in arched rows, crossing the arched carinæ diagonally from within and below, upwardly and outwardly. The inner area is principally composed of flat, transverse diaphragms, which are only in their circumference intersected by the radial lamellæ; their centre is free of the crests, or the crests extend only on their upper

surface to the centre. There are three different modifications in the structure. In one the demarkation of an inner and an outer area is very obscure; the vertical lamellæ reach to the centre of the diaphragms as superficial carinæ. These are exclusively Silurian forms, which might be distinguished as a peculiar generic type, but as their general mode of growth is so similar to the other biareal forms of *Diphyphyllum*, I prefer to leave them together. A second modification has a very broad central area, formed almost exclusively by transverse diaphragms, while the vertical lamellæ are confined to a narrow peripheral cycle; but the inner and outer cycle is not defined by an intermediate internal vertical wall. The third modification, which is generally of stouter growth than the second form, has the inner area defined from the outer by a distinct vertical wall of horseshoe shape, open on the side of the apertural fovea. The lamellæ in this latter form never transgress the inner wall, and the central part within is exclusively formed by a superimposed series of transverse diaphragmatic plates.

DIPHYPHYLLUM HURONICUM, N. Sp.

Aggregated, cylindrical, flexuose stems of a diameter of from one to two centimeters, annulated by delicate striæ of growth, and by deeper wrinkles and constrictions; longitudinally ribbed by septal furrows. The stems are laterally connected by stout rugose prolongations from their walls, which in all the stems of a colony are uniformly directed to one side. Calyces moderately deep, dish-shaped, with explanate margins, radiated by about sixty linear lamellæ, which unite in a central fascicle; their margins are faintly crenulated, or not so at all. Interstices filled with vesiculose plates, which in the central part are larger and inclose somewhat coarser cell spaces, but no distinct large plates, properly deserving the name of diaphragms, are developed, and the outer and inner area are not well defined. The stems multiply by gemmation from the centre and the margins of the end cells, the marginal gemmæ remaining for a good while of a more slender, smaller size than the contemporaneous new cells sprouting from the centre. Found in the Niagara group of Drummond's Island and Point Detour.

Plate XLV.—Fig. 1 represents a side view of a cluster of stems found at Point Detour.

DIPHYPHYLLUM RUGOSUM, MILNE-EDWARDS.

ERIDOPHYLLUM RUGOSUM, Milne-Edwards.

Of very similar structure to the former, but its stems are smaller, less than one centimeter in thickness; the gemmation from the calyces is very prolific; from four to six gemmæ grow at once from an end cup; the stems are tortuous, geniculated, annulated by sub-regularly repeating constrictions, and by delicate linear striæ of growth; the lateral processes, for mutual attachment of the stems, are acanthiform, quite numerous. Calyces forming rounded, moderately deep excavations with slanting sides and erect margins. Lamellæ crenulated, from forty to fifty in the circumference of a calyx, and extending nearly to its centre, which is generally formed by a very narrow diaphragm, not transgressed by the lamellæ, but not separated from the outer area by an internal wall.

This species is not found in Michigan, but is a very common form in the Niagara group of Indiana and Kentucky, and because of its close affinity to the former species, I have considered it of interest to describe and represent it in this place.

Plate XLV.—Fig. 2 gives a side view of a silicified specimen from the vicinity of Louisville; the stems are of somewhat larger size than the specimens usually have.

DIPHYPHYLLUM MULTICAULE, HALL.

SYRINGOPORA MULTICAULIS, Hall.

Flexuose cylindrical stems, from three to four millimeters in diameter, distant from each other about one tube diameter, connected by narrow, remote spurs resembling the transverse tubules of a Syringopora. Surface faintly ribbed by septal striæ, and encircled by wrinkles of growth. Calyces deep, with almost vertically erect walls, radiated by about thirty crenulated lamellæ, of which half the number are marginal; the others reach to the centre. Interstitial spaces filled with vesiculose plates. Diaphragms generally obscured by frequent intersection with the lamellæ; more rarely the central

area is occupied by a flat diaphragm free of crests. I was at first inclined to consider the latter form as a separate species, but I found later that these differences constitute only individual variations of the same form.

Found in the Niagara group of Point Detour, Seul Choix, on Lake Michigan, and in the drift boulders of the Lower Peninsula.

Plate XLV.—Fig. 3 is a specimen with plainly developed transverse diaphragms; in Fig. 4 the lamellæ extend to the centre, and the diaphragms are obscure. Both specimens are found in the drift of Ann Arbor.

DIPHYPHYLLUM SIMCOENSE, BILLINGS.

Synon., ERIDOPHYLLUM SIMCOENSE, Billings.

DIPHYPHYLLUM STRAMINEUM, Billings.

Colonies of cylindrical, subparallel, straight or flexuose stems, closely aggregated or more distant from each other, varying in different specimens, in diameter, from three to six millimeters. Surface longitudinally ribbed and annulated by wrinkles of growth. The stems laterally connect by slender transverse processes, similar to the transverse tubules of Syringopora—not, however, making communication between the visceral cavities, as in those, but merely fastening externally to the walls for mutual support, according to the necessity; in some places these are numerous and crowded, in others considerably distant. Calyces deep, with erect sides and slightly dilating margins, surrounded by about forty crenulated lamellæ of equal size near the margins, but alternately longer and shorter in the bottom part of the calyces. In some specimens these are almost totally restricted to a narrow marginal cycle, and the centre is occupied by flat, broad diaphragms with depressed circumference; in other specimens the larger lamellæ extend nearly or completely to the centre, and intersect the diaphragms as continuous vertical leaves. The same specimens often exhibit tubes with both variations of structure, plainly demonstrating how little importance can be placed in some cases on the degree in development and extension of the vertical

crests. The interlamellar interstices of the peripheral area are traversed by vesiculose plates; the central area, principally formed by transverse diaphragms, is not defined from the peripheral cycle by an internal wall. Gemmation calycinal, producing single forked branches or a number of young calyces sprouting at once from the end cells. Occurs in the upper Helderberg limestone of Mackinac, and in the corniferous strata of Canada, New York, Ohio, and in the Western States; likewise found frequently in the drift of the Lower Peninsula.

Plate XLVI., Upper tier.—The left-hand figure represents a specimen found in the drift, with tubes smaller than usual; it is in all probability identical with *Diphyphyllum stramineum*, Billings. The two lower figures are different views of one specimen with larger tubes, agreeing with the type form of *Eridophyllum Simcoense*, described by Billings. It was found in the corniferous limestone of Caledonia, N. Y.

DIPHYPHYLLUM RECTISEPTATUM, N. Sp.

Cylindrical, closely aggregated, subflexuose stems, from five to seven millimeters in diameter. Calyces with erect, vertically ascending side walls, and a broad bottom formed by flat diaphragms depressed in their circumference and smooth in the centre. Lamellæ stout, alternating in size, not crenulated, about thirty-six in the circumference of a calyx; the larger ones extend over the marginal parts of the diaphragms. Diaphragms remarkably regular, extending nearly across the entire width of the stems, meeting near the outer walls with a very narrow peripheral cycle of more minutely cellulose structure, formed by intersection of the interlamellar spaces with ascending rows of small, transverse, vesiculose plates. The species has much resemblance to *Diphyphyllum latiseptatum* of McCoy. Occurs in the lowest horizon of the Hamilton group, near Craford's quarry, at Middle Island, Presque Isle Lighthouse, etc. Not figured.

DIPHYPHYLLUM PANICUM.

Synon., *CYATHOPHYLLUM PANICUM*, Winchell.

Large colonies of diverging, partially contiguous cylindrical stems of about one centimeter in diameter, multiplying by prolific calycinal gemmation. Stems longitudinally striate and transversely wrinkled by lines of growth, and, periodically, by deeper inciding constrictions. Calyces deep, with steep side walls and slightly expanded margins. Bottom of calyces occupying about one third of the diameter of the stems, formed of vesiculose compound diaphragms, which are only in their peripheral circumference intersected by vertical lamellæ. Lamellæ crenulated at the edges and decorated on the sides with arched carinæ, from forty to fifty in the circumference of a calyx. Peripheral area filled with small interlamellar vesicles; the two areas are not defined from each other by an intervening wall. Found in the upper part of the Hamilton group, in the lime quarries near Petosky, and on Little Traverse Bay.

Plate XLVII., Fig. 3.—Two fragments, one exhibiting a vertical section through the stems, the other giving the exterior surface of the stems.

DIPHYPHYLLUM GIGAS, N. Sp.

Large cylindrical stems, sometimes over one inch in diameter, growing in cespitose colonies, and multiplying by prolific calycinal gemmation of the stems. Surface covered with annular wrinkles, by which the stems attach themselves to one another. Longitudinal septal striæ very distinct. Calyces deep, with steep side walls and gently expanded margins, surrounded by about eighty subequal lamellæ crenulated at the edges by the development of arched lateral carinæ. Interlamellar interstices of the outer area filled with small, transverse, vesiculose plates. Bottom of calyces formed by flat diaphragms, smooth in the centre, and intersected in the circumference by the vertical lamellæ; no defining walls between

the outer and inner area. Found in association with fossils of the corniferous limestone, in the drift deposits of Michigan.

Plate XLVI., Upper tier, right-hand figure.—*Diphyphyllum* (*Eridophyllum*) *Verneuilli*, a species with stems intermediate in size between this form and *Diphyphyllum Simcoense*, is likewise not uncommon in the drift boulders belonging to the corniferous limestone formation. Its central area, formed of smooth transverse diaphragms, is defined from the peripheral cycle by an internal wall, more or less distinctly developed. Not figured.

DIPHYPHYLLUM ARCHIACI, BILLINGS.

Synon., *ERIDOPHYLLUM STRICTUM* (?) Milne-Edwards.

Cylindrical stems, multiplying by calycinal gemmation, with a diameter of from one to two centimeters, transversely wrinkled by fine striæ of growth and longitudinally ribbed by septal rugæ; in some specimens the stems are articulated by abrupt constrictions, and moderately distant; in others the growth is more uniform and the stems are in closer approximation, partly touching with their sides. Calyces generally bell-shaped, with steep sides and gently dilating margins; sometimes more shallow and of expanded form. Lamellæ crenulated by the ends of the arched carinæ decorating their sides, fifty to sixty in the circumference of a calyx, subequal near the margins, but alternately longer and shorter; the longer ones abut against a narrow inner wall formed like a horseshoe, which incloses flat transverse diaphragms; the aperture of the horseshoe is coincident with the principal septal gap. The interstices of the peripheral cycle of lamellæ are divided into small cellulose spaces by transverse vesiculose plates. Occurs in the upper Helderberg limestones of Michigan and Ohio, and in the Hamilton group of Thunder Bay; likewise in Bosanquet township, Canada. The specimens from different localities vary somewhat, but agree in general so well that a specific distinction can not be made with propriety. The Helderberg form, which I have identified with this species, is probably the same with *Eridophyllum strictum*, Milne-Edwards.

Plate XLVII., Upper tier.—The left-hand figure is a polished

transverse section through a specimen from the upper Helderberg group, exhibiting the narrow horseshoe-shaped inner walls. The right-hand specimen, found in the same locality, exhibits a side view of the stems, interrupted by constrictions. The vertically intersected central stems have the narrow central area and the lateral carinations of the lamellæ well exposed. The right-hand figure in the lower tier of the same plate represents a cluster of stems found in the Hamilton group of Alpena, with well-preserved end cells.

DIPHYPHYLLUM COLLIGATUM.

HELIOPHYLLUM COLLIGATUM, Billings.

Colonies of subparallel stems of the structure of *Diphyphyllum*, with an internal narrow wall separating the outer finely cellulose from an inner transversely septate area. The growth of these colonies is entirely peculiar; the stems are regularly articulated by deep constrictions, in which constricted parts they are free. In alternation with these constrictions, the calyces become broadly expanded at certain levels, coincident in all the tubes of the colony, and join with their margins under polygonal outlines in a continuous floor of astræiform aspect. At a subsequent period the surface of the expanded calyces becomes covered up by an epithecal crust, and from the centre of each of the old calyces a new calyx grows with a contracted base, rapidly dilating above, in order to meet the others again in a common floor, which contractions and expansions follow each other in constant succession. The calyces are radiated by about fifty crenulated lamellæ, equal near the margins, but alternately longer and shorter on the sides of the calyces; the longer ones abut against the narrow inner wall. Found in the upper Helderberg limestones of Michigan, Canada, and at the Falls of the Ohio.

Plate XXXVIII.—Fig. 3 represents a side view of two silicified fragments from the drift of Ann Arbor.

PHILLIPSASTRÆA, D'ORBIGNY.

Synon., SMITHIA, Milne-Edwards.

Compound astræiform polyparia, with confluent calyces, destitute of intervening walls, but enveloped at the base of the colony by a common epithecal crust. Calyces horizontally expanded in their margins, excavated by an abrupt central pit, which is usually surrounded by an elevated monticulose rim. Radial lamellæ linear, carinated on the sides, and crenulated at the edges by the ends of the same carinations. Cycle of the lamellæ composed of alternately longer and shorter ones; the longer lamellæ unite in the centre, and form a pseudo-columellar, nodular protuberance, but do not connect into a continuous vertical axis. The shorter lamellæ terminate on the monticulose rim surrounding the central crateriform cell pit. Interlamellar interstices filled with transverse vesiculose plates, arranged in the peripheral area in arched rows crossing diagonally the direction of the lateral carinæ. The transverse septa of the centre are so much intersected by the centrally converging vertical lamellæ that the contrast in the structure of the outer area from that of the inner is very much weakened; the inclosed vesiculose interstitial cell spaces of the centre are somewhat coarser than the peripheral ones, but it is seldom that larger plates, comparable with continuous diaphragms, can be noticed. By the greater conspicuousness of these transverse plates in the centre, the genus *Pachyphyllum* is distinguished from *Phillipsastræa*; there are, however, so many gradations of transition between the two modifications of the otherwise perfectly identical types, that I consider their separation artificial and inappropriate.

PHILLIPSASTRÆA VERNEUILLI, MILNE-EDWARDS.

Size of corallites very different in various specimens. Distance from centre to centre of cell pits from one to one and a half centimeter. Diameter of the central pits varying from three to five millimeters. Number of lamellæ in the circumference of a cell from

thirty-six to forty. Lamellæ linear within the inner cycle, and tent-shaped on the expanded peripheral portions of the calycinal confluent disks. Such tent-form is evidently not caused by any divergence of the two leaves composing the crests, but by the oblique lateral attachment of the interstitial vesicles to them. The crenulations of the edges of the lamellæ have the form of linear crossbars. The centre of the calyx bottom is raised into a columellar knot, and in vertical sections of calcified specimens a central string of greater density can be observed, but it is not a solid axial column; in some specimens no indication of a columella is perceptible.

Grows in large discoid or convex masses, and is found frequently in the drift deposits of Michigan, associated with fossils of the corniferous limestone.

Plate XXXVIII.—Fig. 2 represents two silicified fragments found in the drift of Ann Arbor.

PHILLIPSASTRÆA GIGAS (?) OWEN.

PHILLIPSASTRÆA GIGAS, Billings.

Large lenticular masses covered by an epitheca on the lower side; upper side formed by large confluent star cells perfectly resembling the smaller form, *Phillipsastræa Verneuilli*. The polyp cells are unequal, owing to the frequent intercalation of young calyces. The cells are not perfectly confluent with their horizontally explanate margins; an obscure polygonal defining line indicates the extent of every individual calyx, but an intermediate wall is not developed. Diameter of the larger calyces over two centimeters; diameter of inner cell pit not quite one centimeter. The circumference of the inner cell pit is raised into a rounded monticulose rim. Bottom of inner cell pit reversed into a small central boss, on which the lamellæ unite with a spiral twist. Circumference of cells radiated by from fifty to sixty crenulated lamellæ.

Found in the upper strata of the Island of Mackinac.

Plate XXXVII., Lower tier.—The left-hand figure presents a surface view of a calcified specimen from Mackinac. This form is in all particulars, except in the size of the calyces, similar to

Phillipsastræa Verneuilli, but the two forms are not found associated on Mackinac Island. It is doubtful to me whether Owen's species is identical with this form; the figures and descriptions given by him are insufficient to determine the question positively. Another large form of Phillipsastræa, for which I propose the name of *Phillipsastræa Vandelli*, is found in the Helderberg limestones of the Falls of the Ohio, and in silicified condition, often loose, in the drift of that vicinity. It differs from the described form in having much more spacious central cell pits, not surrounded by a raised rim. The bottom of the cells is formed by a large convex protuberance on which the lamellæ unite; diameter of cells from three to four centimeters; inner cell pit one and a half to two millimeters wide; exterior outlines of calyces obscurely defined. Not represented for want of space.

STROMBODES, SCHWEIGGER.

Compound polyparia, formed of radiated polyp cells united, without defining walls. The cells are either confluent, without any peripheral demarkation, or they join under obtusely crested polygonal outlines, which inclose shallow calycinal depressions with an abrupt central pit. The surface impressed with these pits forms a continuous laminar expansion, and the growth of the polyparia consists in a constantly repeated production of such laminæ; wherefore we find them formed of a superimposed series of such layers. The walls of the abrupt central depressions of the calyces, which correspond in the layers, combine by invagination into cylindrical central cores, extending, without interruption, through the whole length of the corallum; the crest-like plications in the circumference of the inner cell pits form a cycle of vertical lamellæ, which intersect this central core. The horizontally spreading marginal portions of the superimposed calyces are not in immediate contiguity; between each layer an interstice exists, which is filled with unequally interlaced, blister-like vesicles. This indicates a periodicity in the growth of the polyparia by which at one time fully finished, radially plicated, continuous laminar calyces were formed, and in time for the abandonment of the old cells and pre-

paratory to the formation of a new layer, the old surface was covered by a coating of vesicles to serve as an under structure for the support of the new, carefully finished, calycinal floor. The radial plications of the calyces generally unite in the centre into a papillose projection; in rare cases they die out before reaching the centre and leave a small naked spot within. The arrangement of the lamellæ into four fascicles and the development of a small septal fovea are not unfrequently noticeable in the bottom of the cells; the steeply ascending sides of the inner pit are surrounded by crest-like plications, which grow stouter as they bend over upon the expanded marginal parts, and, in their course to the margin, repeatedly divide into narrow rounded rugæ, often five or six times more numerous than the crests of the cell pit from which they emanate. The division in this case is not conformable with the rule of intercalation of new lamellæ set forth in the introductory pages, but takes place apparently without any strict order. The plications of this expanded peripheral area are mere superficial rugæ, and do not combine into vertical lamellæ. In several species on each side of a radial ruga of the expanded calycinal surface, a row of punctiform, closely approximated pores opens, which are in alternating position on the two sides; in perfectly intact surfaces these pores seem to be closed; it is only in slightly worn specimens that they are open circular orifices.

STROMBODES PENTAGONUS, GOLDFUSS.

STROMBODES STRIATUS, D'Orbigny.

Large discoid expansions covered on the lower side with a concentrically wrinkled epitheca, and attached at the central apex. Surface of disks composed of irregularly polygonal, shallow calyces with an abrupt central depression. Diameter of the calyces very variable in different specimens, ranging from one to four centimeters. The steep walls of the inner cell pit are surrounded by about thirty stout, crest-like plications, which, reduced to a smaller number by coalescence, unite in the centre, and form there a styli-form protuberance; or the bottom of the cell remains even while

crossed by the carinae. On the expanded marginal portion of the calyces the plications lose their crest form and are reduced to rounded rugae, which, through division or through the implantation of new ones between them, multiply to three or four times their original number, and have then the form of equal, narrow, linear stripes. On both sides of each of these stripes a row of circular pores opens with closely crowded orifices alternating in position on the opposite sides. In some specimens the inner cell pits are surrounded by a monticulate raised rim; in others the surface of the calyces is roughened by blisters without a distinct radial striation; these conditions represent the different stages in the growth of the coral which it undergoes previous to the deposition of a new well-finished calycinal floor. The great difference in the size of the calyces of some specimens has induced D'Orbigny to distinguish the larger-celled form, as *Strombodes striatus*, from the smaller-celled *Strombodes pentagonus* of Goldfuss, but it is impossible to draw a dividing line between them; all gradations of sizes, from the large to the small forms, can be found associated in the same localities, and in structure not the least difference exists between them.

Occurs very abundantly in the Niagara group of Point Detour, Drummond's Island, etc., and frequently found in the drift.

Plate XLVIII.—Fig. 1 is a silicified specimen corresponding with *Strombodes striatus*, D'Orbigny. Fig. 2 represents the typical form of Goldfuss's species, *Strombodes pentagonus*.

The Niagara group of Kentucky and Indiana incloses an abundance of specimens, which appear to be in every respect identical with the above-described species, but I observe that the interstitial layers of vesicles in the specimens from Michigan are always of much coarser structure than in the specimens found at Louisville, etc.

STROMBODES PYGMÆUS, N. Sp.

Calyces not defined, composing laminar surfaces dotted with abrupt cell pits, about two millimeters in width, and distant from each other six or eight millimeters. The broad interstitial surface is striate by the diverging radial rugae of the cell cups, which meet

and intermingle with those of the adjoining cells. The radial striae are bordered on both sides by a row of circular pores as in the former species. In the centre of the pits the uniting radial crests form a small styliform projection.

Found in association with the other species in the Niagara group of Drummond's Island and of Point Detour.

Plate XLVIII.—Fig. 3, silicified specimen from Point Detour, Lake Huron.

STROMBODES MAMILLATUS, D. DALE OWEN.

Centre of calyces rising from a common interstitial surface as high, mamiform cones, excavated at the top by a crater-like, radiated pit. The radial rugae extend over the surface of the cones and across the interstitial surface from one cell into the other, as narrow, equal-sized bands of granulose surface. In the interstices between these bands distant depressions can be noticed, but nothing similar to the rows of circular pores bordering the rugae of the other species. The centre of the cell pits is formed by a small styliform projection. General structure as in the other species; composed of alternating layers of well-finished cup membranes, and of strata of vesicles. The size of the mamiform cones and their relative distance differ in various specimens. Width of cell pits from four to five millimeters. Distance from centre to centre from one to two centimeters. Found in the Niagara group of Drummond's Island; it is also common in the same formation in Iowa, Kentucky, Indiana, etc.

Plate XLVIII.—Fig. 4, silicified specimen from Point Detour.

STROMBODES ALPENENSIS, N. Sp.

Massive horizontal expansions, covered on the lower side by an epithelial crust. Surface formed of shallow calyces, deepening in the centre into a more abrupt pit. The calyces are confluent, or imperfectly defined from each other by tent-shaped, obtuse ridges

circumscribing irregularly polygonal spaces. Radial plications from thirty to forty, linear, crest-like in the circumference of the inner pits, and uniting in the centre into a twisted knot or without forming any protuberance. The crest-like plications, while diverging across the expanded peripheral cup margins, gradually widen into convex bands, separated by narrow linear furrows; their surface is ornamented with densely crowded granulations. The diameter of the calyces is very unequal in the same specimens; some of them are three centimeters wide, others only one. The internal structure of the specimens I could never distinctly observe; all the specimens are transformed into a solid white amorphous mass of carbonate of lime, resembling ivory or porcelain in a fracture, while other corals associated with them had their most delicate details of structure perfectly preserved, excepting one other heretofore described (*Chonophyllum ponderosum*), which is found in similarly solidified condition.

It is found in the light-colored limestones of the Hamilton group, forming the lowest beds in the quarries of Phelps' limekilns, near Alpena, and in a similar rock near Broadwell's mills, on Thunder Bay River.

Plate XXXVIII.—Fig. 1 is a calcified specimen from Broadwell's mills, in natural size.

In the Hamilton group of Rockford, Iowa, a coral is found which bears an almost perfect similarity to the form just described, exhibiting a well-preserved structure, consisting of membraniform layers of confluent radiated cell cups, interlaminated with strata of coarse, blister-like vesicles, entirely conformable with the structure of a *Strombodes* from the Niagara group. The lamellæ unite in the depressed central pits in a low obtuse boss. Mr. Hall has described this coral under the name of *Smithia Johnnai*, and another similarly built form as *Smithia multiradiata*, but they differ altogether in structure from the genus *Smithia*, or, what I consider as the same thing, from *Phillipsastræa*. The latter genus has the structure of the usual forms of the compound *Cyathophylla*, differing from them only by the absence of walls separating the single cell cups, while the specimens under consideration are built according to the plan of *Strombodes*; and, guided by perfect external similarity, I also identify the structureless specimens found in Michigan, with *Strombodes*.

VESICULARIA, N. GENUS.

Compound polyparia formed of a superimposed series of calycinal cups, of coarsely blistered surface, which in vertical sections appear as a uniform succession of layers of large, unequal, vesiculose plates, perfectly resembling a vertical section through a *Cystiphyllum*. These blistered calycinal membranous layers are radiated by plications, which are linear low crests in the circumference of an inner, broad, shallow cell pit, the bottom of which is occupied by a flat diaphragm, over which the crests converge toward the centre, gradually vanishing. The margins of the cells are broad, expanded, and confluent with each other, without demarkation. The radial plications lose, in their divergence across them, the crested form, and expand into flattened, gradually widening bands, as in *Chonophyllum*.

The crest-like portion of the plications in the circumference of the inner cell pit forms, by combination with the invaginated series of cups, a narrow cycle of vertical crests surrounding an inner core formed of diaphragms. In the outer area no trace of continuous vertical leaves is noticeable. *Vesicularia* is closely related with *Strombodes*; it differs from it in its broad calycinal bottoms having the shape of diaphragms, and in a prevailing disposition of all the calycinal layers to a vesiculose blistered structure, which in the other genus is only periodically so, and alternates with homogeneously formed laminar layers of more highly finished surface. From *Chonophyllum* it is likewise distinguished by the vesiculose structure of the superimposed cup walls; from *Cystiphyllum* it only differs in having a compound mode of growth with confluent cells.

VESICULARIA MAJOR, N. Sp.

Discoid expansions formed of large confluent polyp cells. Calyces shallow, explanate, with a broad, dish-shaped central pit, the bottom of which is formed by a flat diaphragm. Radial plications

linear, crest-shaped in the circumference of the inner pit, and extending over the surface of the diaphragms, gradually vanishing near the centre. In their divergence across the expanded marginal parts, the plications lose the crest form and dilate into low, rounded, gradually widening rugæ with intermediate linear furrows. The surface of the expanded parts of the calyces is raised into blisters, locally densely crowded, and obscuring the radial folds; in other parts singly dispersed. The central diaphragms are simple and not blistered. In vertical sections the polyparia fully resemble a *Cystiphyllum*, being composed of layers of coarse, unequal, interlaced vesicles. The calyces attain in some specimens a diameter of from three to four inches. Found in the Niagara group, at Point Detour, and on Drummond's Island.

Plate XLIX., right-hand figure, upper row.—In the Niagara group of Masonville, Iowa, another species of more minutely vesiculose structure occurs, which I have named *Vesicularia minor*, and represented, for sake of comparison, on the same plate with the other. The plications are very delicate, ornamented with spinulose projections; the cell pits, scarcely depressed, are only perceptible by the convergence of the plications toward certain centres. Under side of the expansions covered by a concentrically wrinkled epitheca, with radiciform excrescences for attachment to foreign bodies. Associated with these compound specimens are single polyp cells of the same vesiculose structure, which connect the compound forms so closely with *Cystiphyllum*, that it would have been more appropriate, perhaps, instead of establishing a new subgenus *Vesicularia*, to change Milne-Edwards' original definition of *Cystiphyllum* so as to include the compound forms with confluent cell cups.

VESICULARIA VARIOLOSA, N. Sp.

Confluent calyces forming mamiform monticules, truncate by abrupt but shallow cell pits, the bottoms of which are formed by flat diaphragms with marginal depressions indicating the principal septal fascicles. Distance from centre to centre of the monticulose calyces about two centimeters; diameter of terminal cell pits about five millimeters. Calyces surrounded by about thirty plications,

having the form of low crests in the inner circumference of the pits, but of rounded rugose form in their extension across the interstices, and on the sloping sides of the monticules. The surface of the polyparia is generally raised into irregular large blisters, which impair the distinctness and continuity of the radial plications. In vertical sections layers of interlaced coarse vesicles are found to constitute the whole polyparium.

Occurs in the Niagara group of Point Detour, and also in Iowa localities. This form is easily mistaken for *Strombodes mamillatus*, Owen, which occurs in its association. The well-developed flat diaphragms and entirely vesiculose structure distinguish it, however, from the latter.

Plate XLIX.—Fig. 4 represents a surface view of a silicified specimen from Point Detour.

CYSTIPHYLLUM, MILNE-EDWARDS.

Simple or loosely aggregated polyp cells, of conical or cylindrical form, enveloped by an epithecal wall, composed of an invaginated series of cell cups of compound vesiculose structure, and radiated by plications. The plications are either crest-like within the ascending part of the calyces, and dilating into flattened broader rugæ toward the peripheral margins, or are represented merely by superficial linear striæ or rows of spinules; they often become totally obsolete, and the surface of the calyces appears simply blistered, without any visible radiation; in no case do the plications combine into vertical laminæ pervading the whole length of the corallum. The arrangement of the plications into four principal fascicles is in some of the specimens very distinct. The inner area of the polyp cells is rarely intersected by transverse diaphragms; generally the central vesicles are somewhat coarser than the peripheral ones, but without demarkation between the bottom part of the calyces and the sides as in *Cyathophyllum*. The exterior epithecal wall is in many specimens longitudinally ribbed by well-pronounced septal striæ, while the vesiculose internal surface of the calyces may exhibit but very indistinct radial plications.

CYSTIPHYLLUM NIAGARENSE.

CONOPHYLLUM NIAGARENSE, Hall.

Conical polyp cells attached to other bodies at the base, and by additional root-like prolongations from the sides. Stems elongated, subcylindrical, or shorter turbinate, annulated by superficial constrictions with tortuous flexions, or by periodical total interruptions in the growth of a calyx, and the formation of a new cell from within. The calyces are moderately deep, uniformly spreading from an obtusely angustated bottom; margins erect; their surface is blistered, and is radially striate by spinulose crests, developed in some specimens with more distinctness than in others. The surface of the polyp stems in well-preserved condition is longitudinally ribbed by septal striæ, but it often happens that the outer walls are destroyed, and that the stems are of rough exfoliated aspect, exhibiting the concave side of the blisters composing the cell cups, and the free edges of the single invaginated cups composing the stems.

Found in the Niagara group of Drummond's Island, at Point Detour; likewise in the Niagara group of Kentucky, Iowa, and Indiana.

Plate XLIX.—Fig. 3 represents several silicified specimens of shorter turbinate and of more elongate tortuous form. The upper right-hand and the lower left-hand specimens are found at Drummond's Island; the other two at Masonville, Iowa.

CYSTIPHYLLUM AMERICANUM, MILNE-EDWARDS.

Single polyparia, surrounded by a perfect, concentrically wrinkled epithelial wall, of conical, or, in the progress of growth, of horn-shaped, curved, or straight cylindrical form. Dimensions of stems very variable, from one to two inches in diameter, and in specimens of cylindrical growth not unfrequently over one foot in length; other specimens have a much shorter turbinate form. Calyces moderately deep, with explanate margins, equally tapering toward the bottom, which is generally occupied by a few irregular blis-

ters. The ascending calyx walls are sometimes only slightly blistered, and folded into stout radial rugæ. In other specimens the rugæ are obsolete and the blisters principally obvious. A great many variations in mode of growth, in the relative size of the vesicles, and in distinctness of plications, can be observed among the numerous specimens found in the Helderberg group and in the Hamilton strata, which, upon closer investigation, may require to be separated into different species, but for the present I have not discovered any well-established characters upon which such a division could be based.

It occurs nearly in every stratum of the upper Helderberg group and of the Hamilton group in Michigan, Canada, New York, and in the Western States.

Plate L., Upper tier.—The outer left-hand specimen is from the Hamilton group near Broadwell's mills, on Thunder Bay River; the two other specimens are from the Hamilton group of Widder, C. W. The right-hand figure (Fig. 4) in the lower tier represents silicified specimens from the corniferous limestone found in the drift.

CYSTIPHYLLUM AGGREGATUM, BILLINGS.

Conico-cylindrical polyparia, closely aggregated, and attached to each other by the wrinkles of their surface, multiplying by calycinal gemmation. Diameter of stems from two to three centimeters. Structure conformable with *Cystiphyllum*; vesicles coarse; end cups moderately excavated, blistered, with faint, spinulose, radiating striæ. Epithelial walls likewise faintly ribbed by septal rugæ. Found in large clusters in the Hamilton group of Thunder Bay. Not figured.

CYSTIPHYLLUM SULCATUM, BILLINGS.

Symmetrically curved, conical polyparia with a pointed apex. Surface gently annulated by obtuse wrinkles of growth. Calyces spacious, oblique to the axis, with erect acute margins. The surface of the calyces generally forms a continuous laminar bag without a blistered surface; the marginal part of the cups is radiated by rounded rugæ, broadest near the edges of the cups, narrowing

and almost vanishing near the bottom. The arrangement of the plications into four fascicles with intermediate gaps is in this species particularly plain, and the apertural gap situated in the centre of the large curvature of the horn-shaped cells is the largest. In vertical sections the structure is found to be perfectly conformable with *Cystiphyllum*, composed of incased vesiculose cups. There are two varieties: in one the plications expand toward the margin of the cups into broad bands decorated with granulations; in the other form the plicæ split toward the margin into narrower fine striæ. The latter variety, which has also less obliquely erect cups, is found in the upper Helderberg limestones of the Falls of the Ohio; the other is found in the drift of Ann Arbor, on Mackinac Island, and in the corniferous limestone of Port Colborne, in Canada.

Plate L., Lower tier.—The left-hand figure (Fig. 3) represents silicified specimens from Port Colborne. Various other forms of the genus *Cystiphyllum* occur at the Falls of the Ohio, and at Columbus, Ohio, which I omit to describe, as not found in Michigan.

ZAPHRENTIS, RAFINESQUE.

Inclusive of STREPTELASMA, Hall, as a sub-generic form.

Simple conical polyparia, composed of a series of invaginated, radially plicated cell cups. The superimposed cell cups are with their side walls so intimately united, that no interstice is left between them, and all combine into one simple compact wall folded into laminar plications. The interstices between the plications are, within the terminal cups, free and open throughout. The plications of all the incased cups are connected into continuous, strong vertical leaves intersecting the whole length of the corallum. The bottom part of each cup remains free, and is separated from the subjacent one by a small interstice. It appears in vertical sections through the corallum as a transverse laminar diaphragm. These superimposed diaphragms extend from wall to wall; their peripheral margins are deflected and connect with the outer wall at an acute, downwardly directed angle. The interlamellar interstices, which are open in the end cell, become, below its bottom, in-

tersected by the diaphragms, and are divided into coarse cellulose chambers, which must not be confused with the smaller interstitial cell spaces of the outer area in a *Cyathophyllum*. The latter are formed by rows of small vesiculose plates traversing the interstices in arches, ascending from the inner circumference of the diaphragms to the outer walls of the polyparium, within the end cup as well as below it. The transverse interstitial plates which make part of the diaphragms invariably approach the outer walls in a downwardly instead of an upwardly directed curve. The arrangement of the lamellæ into four fascicles is, in *Zaphrentis*, generally well marked, and a largely developed septal fovea in the interstice between the two apertural fascicles is considered as the leading distinctive character of the genus *Zaphrentis*.

The importance of the development of a septal fovea in *Cyathophylloid* corals has been unreasonably overestimated by Milne-Edwards. In his work on palæozoic corals, he describes twenty-nine species of *Zaphrentis*, simply guided by the presence of a large septal fovea, in disregard of other structural peculiarities. Fully half of these forms, named *Zaphrentis*, have not the structure of *Zaphrentis*, and belong to the true *Cyathophylla*, by reason of the development of transverse vesiculose plates in the interlamellar interstices of the end cups, which, as has been stated before, never occur in the interstices of the lamellæ of a *Zaphrentis*. As examples of *Cyathophylla*, so misplaced, I mention *Zaphrentis* cornicula, *Zaphr. Guerangeri*, *Zaphr. excavata*, *Zaphr. Michelini*, etc. The genus *Streptelasma*, of Hall, and his *Polydilasma*, which I consider as the same thing, differ from *Zaphrentis* merely in having a less conspicuous, or, sometimes, almost obsolete development of a septal fovea, and in the irregular entanglement of its radial lamellæ in the centre, constituting, in combination with the intersected diaphragms, a spongioso-cellulose pseudo-columella; or, at least, the regularity of the diaphragms in the centre is obscured by their multiple labyrinthical intersection with the vertical leaves. A strict distinction of the two genera is not possible; some forms of this group could with the same propriety be placed in one as in the other.

The *Cyathophylloid* corals of the lower Silurian strata generally have the structure of *Streptelasma*, and, considering *Streptelasma*

as a subgenus of *Zaphrentis*, I begin with the description of its species first as being the oldest ones of the type, and let those of *Zaphrentis* follow them.

STREPTELASMA CORNICULUM, HALL.

The original specimens represented and described by Hall, from the Trenton strata of New York, are too imperfect to allow much more than recognition of the general structure. Similar and no better preserved specimens are found in the Trenton strata of Escanaba River, and on St. Joseph's Island and Sulphur Island, situated north of the other. I have represented them on Plate LI., the four left-hand figures in the upper row; the upper larger specimen is from the lower Trenton strata of Escanaba; the three lower specimens are from somewhat higher beds on Sulphur Island.

It is doubtful whether the specimens described under the same name by Milne-Edwards, from the Hudson River group, belong to the same species; they are found in much better preservation, and can therefore be more specifically described. Elongate conical, symmetrically curved, horn-shaped corals; middle-sized specimens have a diameter of about three centimeters at the calyx margin by a length of from seven to eight centimeters, but the proportion between length and width of the specimens differs; some are more elongated, others are shorter than the indicated proportions. The surface of the polyparia is covered by a perfect epithecal crust, with transverse fine wrinkles of growth, and longitudinally striate by septal rugæ and intermediate furrows. Milne-Edwards asserts the cells to be covered by an *imperfectly* developed epithecal crust, but this is an error. Calyces moderately deep, with erect acute margins, steeply inclined side walls, and a variably formed bottom, sometimes narrowed into a blunt end; at other times broader, rounded, convex in the middle. Lamellæ linear, stout, alternately larger and smaller, from 120 to 130 in the circumference of calyces, three centimeters wide. Their surface is decorated by minute granulose rugæ, crossing the side faces in an ascending direction from the inside toward the periphery. The radial crests become labyrinthically entangled in the centre of the cells, and usually form a broad convex protuberance. A small septal fovea is always

noticeable, and sometimes also the lateral septal gaps are well marked. In vertical sections the centre of the polyparia is found to be intersected by well-developed transverse diaphragms; the vertical crests intersecting them divide the interstices between them into irregular cell spaces. The apices of the polyparia are pointed, and rarely exhibit a small scar of attachment. Sometimes twin cells are found, but this is abnormal.

Plate LI., Upper tier.—The largest specimen is from the Hudson River group of Drummond's Island; the other six, smaller specimens, were found at Richmond, Indiana, and at Madison. The right-hand calyces have broad convex cup bottoms with irregularly entangled lamellæ; the two upper figures to the left of the larger have a well-developed septal fovea, and a narrow, styliform, central protuberance. The lower left-hand specimen is a twin-cell.

STREPTELASMA PATULA, N. Sp.

POLYDILASMA, Hall.

Short conical polyparia, about two centimeters wide at the expanded calyx margins, by a length of only one or one and a half centimeter. Calyx variable in depth in accordance with the more elongate or shortened external form of the polyp cells, surrounded by from twenty-five to thirty stout lamellar crests, with as many smaller intermediate ones, confined only to the marginal portions of the calyces. The sides of the lamellæ are transversely striate, and their edges crenulated. By the convergence of the lamellæ in the centre, a narrow columellar axis of spongiöse structure is formed, which on one side is deeply exsinuated by a septal fovea; in very young specimens this axis is a horseshoe-formed erect leaf, against the circumference of which the converging lamellæ abut; the centre of the horseshoe sinus is occupied by a strong lamella.

Found in the Niagara group of Drummond's Island and Point Detour; also in the Niagara limestones of Iowa, at Masonville.

Plate XXXIX.—Fig. 1 represents a number of silicified specimens found at Drummond's Island.

STREPTELASMA CONULUS, N. SP.

Straight, conical, small-sized polyparia; the larger ones attain a diameter of one centimeter by one and a half in length; surface faintly annulated by lines of growth, not ribbed longitudinally as in the similar form *Streptelasma calycula*. Calyces deep, with erect margins surrounded by from twenty to twenty-five denticulated lamellar crests of larger size, and by as many intermediate rudimentary ones with likewise dentate edges; the sides of the lamellæ are ornamented with transverse rugæ. The larger lamellæ unite in the centre, as in the former species, into a horseshoe-formed cycle which incloses a narrow core of lacunose, irregularly anastomosing cell spaces; the aperture of the horseshoe corresponds with the principal septal fovea.

Found associated with the former in the Niagara group of Drummond's Island, etc.

Plate XXXIX.—Fig. 4 represents a number of silicified specimens from the above-named locality.

STREPTELASMA SPONGAXIS, N. SP.

POLYDILASMA, Hall.

Small, conical, horn-shaped polyparia, about two centimeters wide by three in length in middle-sized specimens. Calyces moderately deep, with slanting sides and slightly expanding margins, surrounded by about thirty stout crests alternating with as many intermediate smaller ones. Surface of lamellæ decorated with granules and transverse rugæ. The lamellæ unite in the centre into a spongy axial core, resembling the tissue of a macerated porous bone. Septal fovea obscure. The apices of the cells exhibit generally a strong sublateral scar of attachment.

Found associated with the other forms in the Niagara group of Drummond's Island, and at Point Detour; also found at Masonville, Iowa.

Plate XXXIX., Fig. 2.—All the smaller specimens represent the usual form as it occurs at Point Detour. The larger specimen is from the Niagara group of Paul's Station, Indiana; it does not

seem to differ much from the smaller specimens except by a central compressed cristiform projection similar to the columella of *Cyathaxonia*, which is broken in the represented specimen, but is distinctly developed in other specimens found there and at Louisville. I hesitate therefore to identify the larger specimen with the smaller form. The subsequently described species have all a well-developed septal fovea, and are considered to represent the genus *Zaphrentis* proper.

ZAPHRENTIS STOCKESII, MILNE-EDWARDS.

Symmetrically curved conical polyparia, sometimes elliptical in outlines by a compression in a direction transverse to the curvature. Length of cones about twice the diameter of the calyces, which in middle-sized specimens is about four centimeters. Calyces moderately deep, with erect margins and a spacious subconvex bottom, on which the lamellæ unite in an irregularly twisted, interlacing manner as low carinæ. Lamellæ linear, stout; sixty to sixty-five larger ones alternating with as many small rudimentary crests may be counted in the circumference of calyces four centimeters wide. A large septal fovea is situated in the median line of the convex side of the curved polyparia. Transverse diaphragms well developed; the crests on the upper side do not connect into continuous vertical leaves with those of the succumbent cups; the lower side of the diaphragms is generally smooth, not crested. The external walls of the specimens are rarely preserved in the silicified condition, and the excoriated surface is longitudinally ribbed by the exposed vertical plications. In some specimens, however, the superficial epithelial crust is perfectly preserved. Found in the Niagara group of Drummond's Island, Point Detour, and in the same formation at Masonville, Iowa.

Plate LI., Lower tier—The two largest specimens. The upper one, on the left-hand side, is a side view of an excoriated specimen from Point Detour. The one on the right-hand side of the plate exhibits the bottom of a calyx and the position of the septal fovea; the erect marginal parts are broken off. The second figure from the left, in the lower tier, is also a young specimen of this kind.

ZAPHRENTIS UMBONATA, N. SP.

Conical, horn-shaped polyparia resembling *Zaphr. Stockesii*, attaining in some larger specimens a calyx diameter of eight centimeters by twice that in length; the usual size of the specimens found is smaller. Calyces spacious, with erect acute margins and a broad bottom, which is reversed into a large, laterally compressed, prominent cone. The circumference of the larger calyces is surrounded by about eighty large lamellæ, with as many intermediate smaller ones; the larger ones unite on the central cone, ascending its sides directly or with a spiral twist. A large septal fovea is developed in the median line of the larger curved side. In vertical sections the invaginated, reversed, conical cell bottoms are observed to have grown together with their apices and to form a cellulose, pseudo-columella. Found associated with *Zaphr. Stockesii* in the Niagara group of Point Detour and Drummond's Island. Casts of a similar species are common in the Niagara limestones of Milwaukee. At Louisville, also, this coral occurs.

Plate LI., Lower tier.—The upper figure in the centre is one of the smaller-sized specimens found on Drummond's Island; another small specimen is represented in the lower right-hand corner of the plate. The central cone is in some specimens much more prominent than in those given here. In the lower row of the same plate the first outer specimen on the left-hand side and the third one represent other calyces of a *Zaphrentis*, conformable in some respects with the heretofore described associated forms, but differing in the shape of the cell bottom, which in one is formed by a large rounded protuberance, exsinuated on one side by a septal fovea, while in the other, evidently only an individual modification of the former, it is a horseshoe-formed elevated ring with a deeply depressed, smooth, central excavation. This form seems to constitute a different species from the others, but I leave the question open for further decision.

ZAPHRENTIS GIGANTEA, LESUEUR.

Conico-cylindrical, horn-shaped polyparia, attaining in some specimens a size of two and a half feet in length, by a diameter of three

inches. Some enlarge their diameter rapidly to a certain thickness, and then grow on in a uniformly cylindrical shape; others are in the young state, slender, flexuose, and irregularly constricted stems, and grow gradually to larger diameters. The surface of the polyparia is covered by an epitheca with shallow annular wrinkles of growth and longitudinally ribbed by septal striæ, which, however, are not in all specimens equally distinct. Calyces spacious, with erect walls, and acute, wedge-like margins; bottom broad, marginally depressed and flat in the centre. In one place of the circumference the diaphragms are more deeply depressed by a septal fovea. Radial lamellæ stout, linear, alternately long and short, but appearing nearly equal on the margins of the calyces, where the sharp crested leaves of the inside expand into low rounded rugæ. The extension of the radial crests toward the centre is subject to variations; in some the central part of the diaphragms remains smooth, and the crests are confined to their peripheral circumference; in others the crests reach as low carinæ to the centre and become irregularly entangled in their convergence, but these central portions of the crests are merely superficial, and do not intersect the diaphragms to form continuous vertical leaves. The number of lamellæ in calyces of about two and a half inches diameter is 150 to 160, half of which are of the smaller size. Found in the upper Helderberg limestones of Michigan, Canada, Ohio, and in the Western States.

Plate LII. represents specimens of smaller size, found at the Falls of the Ohio.

ZAPHRENTIS PROLIFICA, BILLINGS.

Conical, irregularly curved polyp cells, obtusely wrinkled by annular rugæ. Middle-sized specimens about three or four centimeters wide at the calyx margin, by a length of from seven to eight centimeters. Calyces deep, spacious, with erect margins. Bottom of cells variable; most frequently its centre is reversed into a laterally compressed, more or less prominent cristiform projection, whose sides are carinated by the centrally uniting radial crests; in others the bottom is uniformly depressed convex, covered by the entangled converging ends of the lamellæ; sometimes also a flat smooth spot is left in the centre of the cell bottom, which merges

into a large septal fovea. The septal fovea is, in its position, independent from the curvature of the polyp cells, but always represents the apertural fovea, whether it be in the median line of the curved cells or in lateral position. Lamellæ about 120 in the circumference of calyces three or four centimeters wide, alternately large and small. Near the calyx margin the plications have the form of low rounded rugæ with granulose surface; further inside of the calyces the rugæ transform into acute, stout, linear crests. In vertical sections the superimposed bottoms of the incased cell cups appear as large transverse diaphragms joining the outer walls with deeply deflected margins. Occurs frequently in the upper Helderberg limestones of Michigan, and in the neighboring States to the east and west; is also common in the drift boulders belonging to the corniferous limestone formation.

Plate LIII.—The upper row represents various silicified specimens, partly found in the drift of Ann Arbor, partly from the corniferous limestone of Port Colborne, C. W.

ZAPHRENTIS NODULOSA, N. Sp.

Curved elongato-conical polyparia of somewhat flexuose growth, annulated by shallow constrictions and finer transverse wrinkles; vertically striate by septal furrows. The apical portion of the polyp cells is decorated by densely crowded, stout, spinulose projections, which gradually vanish on the upper parts of the cells. Calyces deep, with erect margins; bottom formed by a narrow, almost smooth diaphragm deflected on one side into a large septal fovea. The lamellæ are sharp linear crests within the calyx; near the margins they become low rounded rugæ; about seventy in the circumference of calyces one inch in diameter, alternately of larger and smaller size. The sides of the lamellæ are decorated by irregular transverse rugæ and granulations.

Not uncommon in the drift of Michigan, in association with corniferous limestone fossils; also found in the corniferous strata of Canada.

Plate LV.—The right-hand side small specimen, in the lower tier, represents a rather small calyx found in the drift of Ann Arbor; other larger specimens dilate more rapidly, and resemble in mode of growth *Zaphr. prolifica*.

ZAPHRENTIS GREGARIA, N. Sp.

Short turbinate, somewhat curved polyp cells, of about two inches calyx diameter by a length of from one and a half to two and a half inches. Surface annulated by sharp transverse wrinkles and distinctly ribbed by longitudinal septal furrows. Calyces spacious, with broad subplane bottoms, over which the lamellæ extend to the centres. A large septal fovea generally on the convex curved side. Side walls of calyces suberect with acute edges. Found in large numbers in the black shaly limestone strata of the lower part of the Hamilton group, on the shore of Lake Huron, north of Thunder Bay. Not represented.

Another form of *Zaphrentis* found in the Hamilton group of Arcona, C. W., may be mentioned here. Some of the specimens perfectly resemble *Zaphrentis prolifica* of the Helderberg group; other larger specimens, externally identical with them, have the bottoms of the calyces formed by broad, perfectly naked, flat, or somewhat concave diaphragms. They seem to be mere individual variations of one and the same type, first represented under the form of *Zaphr. prolifica*.

ZAPHRENTIS CONIGERA, N. Sp.

Compare *AULOPHYLLUM*, Milne-Edwards.

Long, horn-shaped, conico-cylindrical polyparia, with obtusely annulated rugose surface, attaining a size of one foot in length by a diameter of one and a half inch. Calyx deep, with erect side walls and acute margins, surrounded by about 120 alternately larger and smaller lamellæ; sharp linear crests in the inside of the calyces, lowered into rounded rugæ on the margins. The bottom of the calyces is reflected and forms a large pointed cone with broad base, on which the central ends of the radial crests ascend with a spiral twist. Septal fovea comparatively small, irregular in position regarding the curvature of the horn-shaped stems. The central cones are the analogon of the transverse diaphragms, which are invaginated into one another, and become superficially attached by their crests, but do not combine into a continuous axial column. From an observation of the figures of *Clisioph. prolapsum*,

McCoy, called *Aulophyllum* by Milne-Edwards, I would suggest that a great similarity exists between them and the species under consideration; but Milne-Edwards asserts the development of an internal wall separating the inner area from the outer, of which in our specimens not the least trace can be observed. Found in the upper Helderberg limestones of Mackinac Island, and at the Falls of the Ohio.

Plate XL., Lower tier.—The central, shorter, conical specimen is from Mackinac Island. The other specimens are from the Falls of the Ohio. The latter are silicified; the first is in calcified condition.

ZAPHRENTIS EXIGUA.

Synon., *HELIOPHYLLUM EXIGUUM*, Billings.

Small, conical, oblique polyp cells, encircled by linear constrictions and intermediate broader rugæ. The curved conules are flattened on the longer side and quite convex on the shorter side of the curvature. Diameter of calyces one and a half centimeter in medium-sized specimens, two and a half in the largest ones; their length is about equal to their width, or a little longer. Calyces moderately deep, surrounded by about seventy alternately large and small lamellæ, denticulated at the edges and transversely carinated on the sides by granulose ridges. The lamellæ are very stout, protruding with the convexity of their edges above the margin of the outer peripheral walls of the cells. In the median line of the flattened longer side of the cells a conspicuous septal gap is developed, which extends to the centre, dilating into a small horseshoe-formed sinus around which the lamellæ are grouped. The centre of the septal gap is occupied by a single lamella, which directly connects with another coming from the opposite side. The lamellæ on both sides of the septal gap unite at their central ends in semi-pennate fascicles.

The interlamellar interstices are all free and open, whereby this form proves itself positively distinct from *Cyathophyllum* or *Heliophyllum*, under which name it has been described by Billings.

Occurs in the upper Helderberg limestones of Mackinac, and in the drift, associated with corniferous limestone fossils; it is also

found in rare cases in the Hamilton group, at Broadwell's mills, on Thunder Bay River, while in the corniferous limestone of Canada, and at the Falls of the Ohio, it is quite common.

Plate LIII., Lower tier.—The six specimens in two vertical rows on the left side of the plate, and the lower one in the central row. The middle specimen in the second row is a calcified specimen from Mackinac; the next specimen below and the one in the central row are specimens from Crab Orchard, Kentucky. Of the remainder of the group, the two large specimens are found in the drift of Ann Arbor; the two smaller ones are from the Falls of the Ohio.

ZAPHRENTIS UNGULA, N. Sp.

Conical, transversely compressed, and, in the direction of the compression, curved polyp cells, more flattened on the convex side of the curvature than on the opposite. Surface annulated by linear constrictions, with intermediate, broad, rounded rugæ; apex of polyparia pointed. Calyces moderately deep, gently expanded near the margins, gradually narrowing into an obtuse, transverse, central pit, which is joined by a septal fovea, situated in the median line of the flattened broader side. Lamellæ stout, subequal near the margins, but alternately long and short; the longer ones extend nearly to the centre; the bottom of the small central pit is usually free of crests. Dimensions of polyparia from two to three centimeters in transverse calyx diameter by a little more than half that measure in the opposite direction, and in length exceeding the greater width by about one fourth. Number of lamellæ in medium-sized specimens, about 90; in larger ones, 100. Found in the upper Helderberg group, at the Falls of the Ohio, and rarely in the drift of Michigan in silicified condition.

Plate LIII., Lower tier.—The two right-hand specimens; the lower one is about the largest size found.

ZAPHRENTIS COMPRESSA, N. Sp.

Conical compressed polyp cells, straight, or curved in the direction of the narrow side. Large specimens have a calyx diameter of about eight centimeters in one direction, and four in the other,

by a length of one decimeter. Calyces of that size are surrounded by 170 or 180 alternately small and large lamellæ, which are, within the cups, sharp linear crests, but become lower rounded rugæ on the margins of the cup walls. End cups deep, with erect, acute margins, of the shape of elongated troughs, gradually diminishing into a narrow bottom, one side of which is deeply depressed by a septal fovea situated on the median line of the longer diameter of the compressed calyces. The degree of compression is not in all specimens equally strong; some are very nearly flattened on the compressed sides, while others have a convex oval circumference. The surface of the polyparia is annulated by irregular rounded rugæ.

Found in the upper Helderberg limestones of the Falls of the Ohio. It resembles the former species, but is much larger, and is easily distinguished by the position of its septal fovea, which is on the narrow side, while that of the previous form is in the centre of the broader side.

Plate LIII., Lower tier.—The upper second figure from the right-hand side. I consider it desirable to give a figure and description of this form, not found in Michigan up to the present date, but in all probability to be discovered some day by industrious collectors.

Various other species of *Zaphrentis*, partly already known and described (*Zaphrentis Rafinesqui*, Milne-Edwards), partly new forms, are omitted from this report, as not found within the boundaries of the State of Michigan.

ZAPHRENTIS SPINULOSA (?) MILNE-EDWARDS.

Symmetrically curved, conical polyp cells, attaining a length of six centimeters by a calyx diameter of three centimeters. Calyces deep, with erect margins, surrounded by about forty-five stout lamellæ, and as many rudimentary intermediate folds near the margins of the calyces. A large septal fovea is developed on the concave side of the horn-shaped cells, and besides the two lateral septal gaps, are generally well marked in the specimens. The surface of the polyp cells is annulated by rings of growth, and the basal portion is decorated by stout spinules similar to those of *Zaphr. spinulosa*, Milne-Edwards. I have not seen any of the Western specimens with sufficiently well-preserved open calyces to enable

me to establish their exact identification with the Michigan specimens.

Occurs in the carboniferous limestones of Saginaw Bay, on Point aux Grees, and on Charity Islands; likewise in the limestones of Bellevue, Eaton Co.

Plate LV., Lower tier.—The upper four central figures and the larger calyx to the left of them represent specimens found at Bellevue, Michigan.

AMPLEXUS, SOWERBY.

I can not find an appreciable difference between the genera *Amplexus* and *Zaphrentis*; both have the same general structure. The radial plications in *Amplexus* are said to be confined to the marginal parts of the polyp stems, and not to extend far across the central area, principally built up of transverse diaphragms. But it is not uncommon to see, in so-called specimens of *Amplexus*, the radial crests extending to the centre of the diaphragms, under the form of low superficial carinæ. On the other hand, it is equally common to notice genuine *Zaphrentis* forms in which the radial crests are confined to a peripheral cycle, and do not reach to the centre.

Amplexus generally grows in elongate cylindrical stems, while *Zaphrentis* has more of a conical mode of growth, but this is also a very vague difference; *Zaphrentis* frequently grows likewise in cylindrical stems, and among the associated forms of *Zaphrentis gigantea*, *Zaphr. Rafinesqui*, and *Amplexus Yandelli*, such a similarity in structure exists that fragments of stems of the three species are never distinguishable from each other with perfect security from mistakes. In some forms of *Amplexus* the septal fovea becomes obsolete, and in polyp stems where a septal fovea exists it is not as well marked in one part as in another. The genus *Calophyllum*, Dana, has been created to include these forms deprived of a septal fovea, but I consider such distinction superfluous.

AMPLEXUS SHUMARDI.

Synon., *CYATHOPH. SHUMARDI*, Milne-Edwards.

Articulated cylindrical polyp stems, composed of a succession of

subconical segments, formed by periodical interruptions in the growth of the calyces, resulting in the closure of the marginal parts of the old cells by a continuation of the epithecal wall, and a renewed growth of a cell, having a narrower basis, from the inner circumference of the old one, until after a while a new contraction occurs. The surface of the stems is delicately cancellated by the intersection of the longitudinal septal rugæ with annular striæ of growth. The basal joint of the stems is of conical growth and exhibits a strong scar for attachment at the apex. The stems are composed of a cycle of vertical crests projecting from the wall into the cavity, and of a series of superimposed diaphragms intersecting the cavity of the stems and extending from wall to wall, joining it with strongly deflected margins, and only intersected by the vertical crests in the outer circumference. The end cells, which are generally only preserved in small young specimens, are of a dilated funnel shape, surrounded by from sixty to seventy alternately large and small lamellæ, with granulose surface and denticulated edges. The bottom of the calyces is generally formed by a smooth diaphragm, but sometimes the crests of the circumference extend over their surface to the centre as low superficial carinæ. The lamellæ lose their linear crested form on the edges of the calyces, where they expand into low rounded rugæ. On one side of the calyx the diaphragms are deeply depressed by a septal fovea, but the latter is not in all parts of the stems equally distinct, and becomes not unfrequently obsolete for a while. The average diameter of the stems is from two to three centimeters; the length of the joints varies from one to two centimeters.

Found in the Niagara group of Point Detour and Drummond's Island; at Masonville, Iowa; in Perry Co., Tennessee, etc.

Plate LIV., Upper tier.—The outer figure on the right-hand side of the plate is a stem from the original locality from which the species was first described (Perry Co., Tennessee); the three next fragments to the left of it are from the Niagara group of Drummond's Island; the other figures on the left are specimens from Masonville, Iowa. I find it strange that Milne-Edwards should connect this form with the genus *Cyathophyllum*, which has the most characteristic structure of an *Amplexus*.

AMPLEXUS YANDELLI, MILNE-EDWARDS.

Conico-cylindrical flexuose stems, from two to four centimeters in diameter, annulated by fine wrinkles of growth with intermediate coarser rugæ, and frequently of a jointed structure through periodical constrictions of the calyces and continued growth of the stem without interruption of the continuity of the epithecal wall. Calyces deep, with erect margins, surrounded by about sixty alternately large and small vertical crests. The bottom of the calyces is formed by flat or warped diaphragms, depressed on one side by a deep septal fovea. The lamellæ are restricted to the outer circumference of the diaphragms, but sometimes they extend to the centre as superficial ridges.

Occurs in the corniferous limestone of Indiana, Kentucky, Canada, and is found in the drift deposits of Michigan. Some cylindrical stems, which evidently belong to the juvenile specimens of *Zaphrentis gigantea*, are so closely resembling *Ampl. Yandelli*, that I always find difficulty in distinguishing them.

Plate LIV., Lower tier.—The right-hand specimen is found in the drift of Ann Arbor; the others are from the Falls of the Ohio. The outer specimen on the left-hand side of the plate resembles considerably the basal portion of *Zaphrentis gigantea*. See Plate LII., base of large specimen.

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