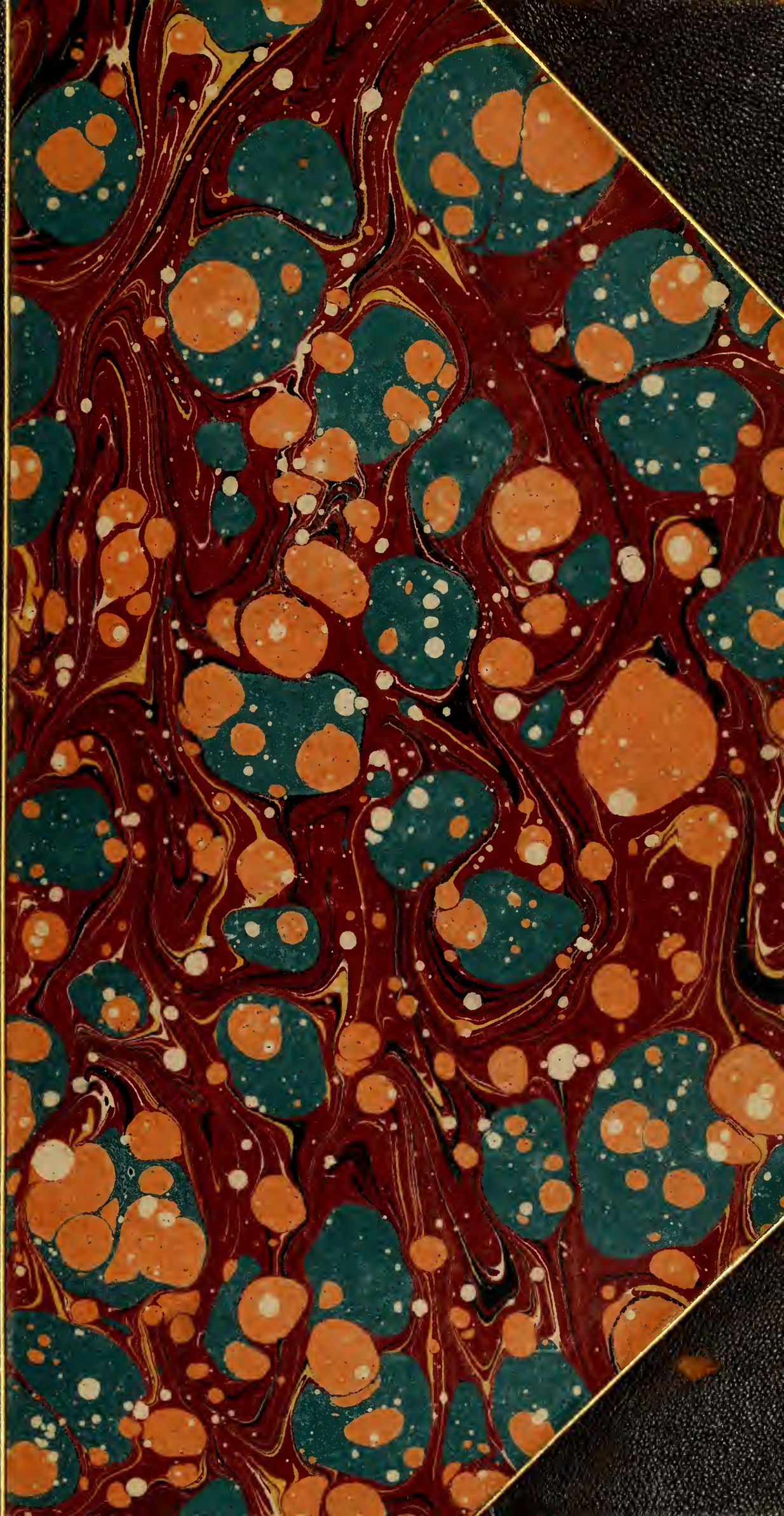
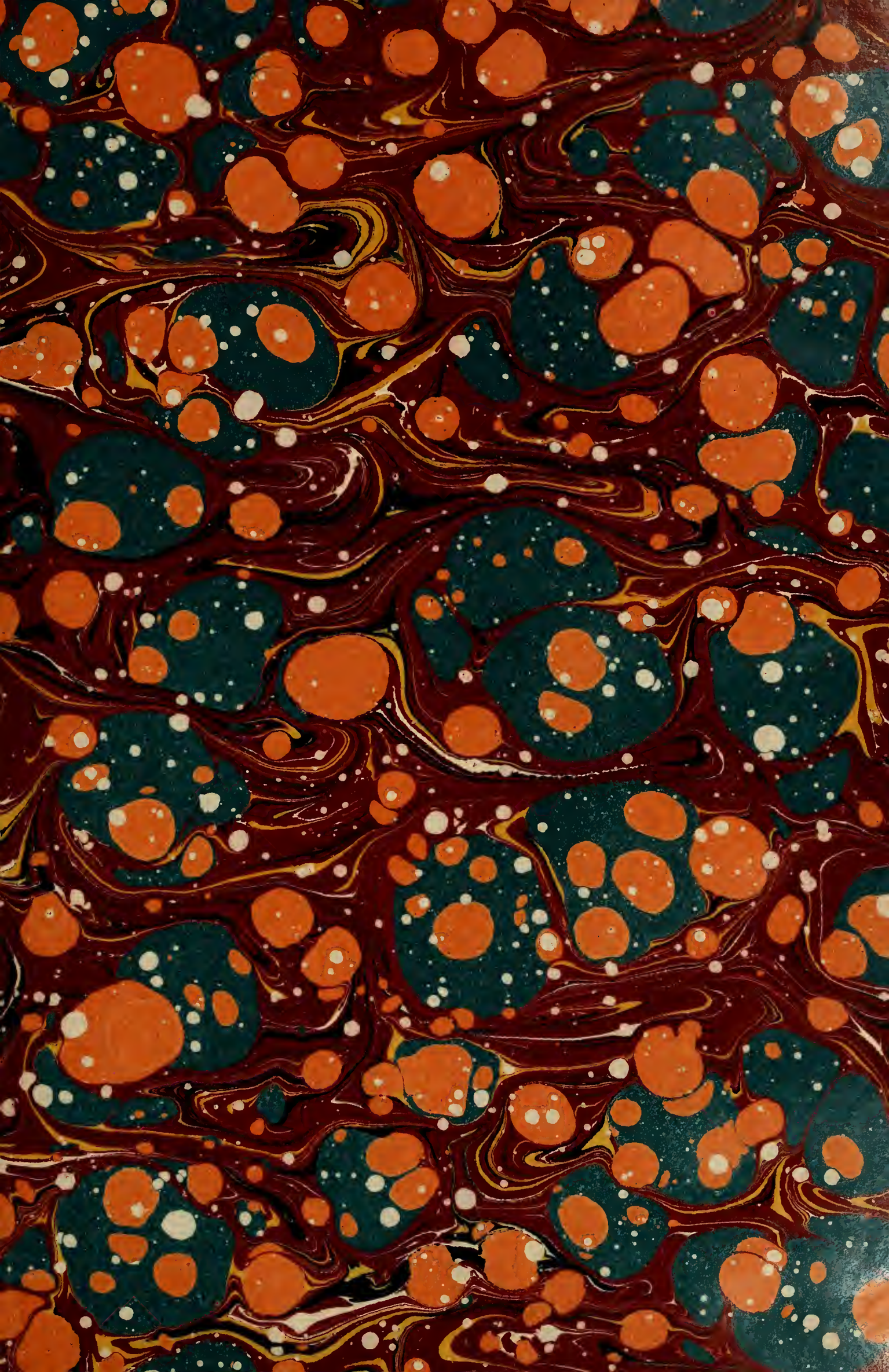




with reg
from the author.

GEOLOGICAL SURVEY OF MICHIGAN

LOWER PENINSULA

PALÆONTOLOGY

FOSSIL CORALS

BY

DR. Carl ROMINGER

STATE GEOLOGIST

(ADVANCE COPY, UNREVISED BY THE AUTHOR)

NEW YORK

JULIUS BIEN

1876

PALÆONTOLOGY.

GEOLOGICAL SURVEY OF MICHIGAN

LOWER PENINSULA

PALÆONTOLOGY

FOSSIL CORALS

BY

DR. C. ROMINGER

STATE GEOLOGIST

(ADVANCE COPY, UNREVISED BY THE AUTHOR)

NEW YORK

JULIUS BIEN

1876

PALÆONTOLOGY.

THE stratified rocks forming the surface crust of our globe are very frequently found to contain petrified corals, shells of mollusks, bones of vertebrates, vegetable remains, or impressions thereof.

The ancients were already well acquainted with this fact, but up to the eighteenth century naturalists and philosophers were greatly troubled in seeking for a satisfactory explanation of the origin of these peculiar forms, so similar to living organisms, yet made of stone.

One of the first theories on the subject was, that fossils were a *lusus naturæ*, or play of nature—that is, an effort of nature to produce organic forms, a moulding of life shape from inanimate material, without fully accomplishing the task to the final act of the inspiration of life. The Mosaic account of creation is in full accord with such views, and it is not at all improbable that Moses, or whoever was the writer of the biblical accounts of creation, derived his first thoughts upon the process of creation from the observation of fossils and meditation concerning their origin. It no doubt appeared to him more reasonable to accept them rather as half-finished work than as the remains of once living bodies, whose position within the rock was inexplicable to him ; and in analogy with this conception, he imagines man created by the double process, first, of moulding his form from earth, and then of the divine inspiration of life.

During the fourteenth century the hypothesis of the origin of fossils by *lusus naturæ* began to lose credit, and it became generally recognized that they were the veritable remains of once living organisms. This being acknowledged, the thought of ascribing the origin of fossils to the scriptural deluge recommended itself as plausible, and they were at once, without critical examination of

the correctness of this view, universally believed to be the remains of the animals which perished during this catastrophe, which belief was obstinately held up to the end of the eighteenth century. At that time, with the progress made in natural history, so many facts contradicting this theory had accumulated, that it could no longer be held. It was clearly recognized that the deluge could not account for fossils generally; that there existed an immense difference in the age of fossils, and that a large number of animal and vegetable creations came and disappeared again, in long-continued succession, involving the lapse of spaces of time far exceeding former conceptions of the age of the globe.

The study of the fossils and of the conditions under which they were found threw an entirely new light on the earth's history. Formerly the fossils were mere objects of curiosity; now they became important witnesses to a long series of progressive changes which the earth must have undergone ages and ages before man was created, and before the scriptural deluge could have occurred; of changes which were rarely sudden reversals of the existing conditions, but which were from the beginning and are now in constant quiet action—an endless, shifting motion; destroying here and building up there, with a slowness almost imperceptible, but, in the long lapse of time, astounding in its effects. The attentive study of fossils led to the discovery that, in the series of rock beds composing the earth's crust, certain animal forms were confined to a certain definite group of strata, which, in ascending to higher beds, disappeared gradually or abruptly, and were replaced by new forms; the same changes were noticed to occur frequently in ascending higher and higher. It was further ascertained, on examination of far remote localities, but built up by an equivalent succession of rock beds, that, in the distribution of fossils throughout the strata, the same order is found to exist—that is to say, the equivalent strata contain in different places the same, or at least very similar fossils. By deduction from this rule, we may infer that strata containing the same fossils have the same relative age; we have in the fossils a standard criterion for the determination of a certain geological horizon, irrespective of the character of the rock, which may be widely different in remote equivalent beds, and independent of direct observation of the succession of the beds, which may be hidden from view, or be complicated by irregularities, either through

the absence of certain layers, or through the intercalation of new ones not observed in other localities under comparison. In the fossils we have always an infallible guide, in cases where lithological and stratigraphical characters would leave us in an inextricable perplexity, regarding the position of certain strata.

The value of palæontology, as fundamental to all our geological knowledge, is at present generally understood. Such of the States as have instituted a geological survey of their territory have shown their appreciation of its importance by making liberal provisions by law for a careful collection of fossils, and for the subsequent description and delineation in their report of all new and interesting forms.

During the progress of the geological survey of Michigan, a rich harvest of fossils has been made, the class of corals in particular being well represented in the collections. Our law provides that due attention shall be paid to the description and figuring of new or imperfectly known specimens. The number falling within this category is so great that the limited compass allowed for the present report will not admit of their being all described.

Being compelled, therefore, to make a selection out of the mass of material, I proposed to the Geological Board to give a more elaborate treatise on the indigenous fossil corals, omitting all description of mollusks and other fossil remains treated of and so amply illustrated in the reports of other States, while the corals have received comparatively little attention, notwithstanding that they belong to the forms most significant of the age of strata. The Board consented to this plan, and I hope the general reader as well as the scientist will not be displeased at being offered a carefully elaborated monograph of this class, instead of a superficial description of a great variety of species from all classes. These were the alternatives, as the fixed limits of the volume, as already stated, would not permit my entering upon a critical examination of the whole field of palæontology.

The species descriptions are illustrated by photographic figures, printed by the new Albertotype process. The figures are necessarily somewhat imperfect, because their convexity would not allow their entire surface to be within the proper focus of the instrument. Their absolute correctness in other respects, however, compensates fully for these unavoidable imperfections.

The figures of the plates could not be numbered without great inconvenience to the printer, on which account I have adopted a rule applying to all, which I think will serve the purpose.

In all the text references the upper right-hand figure is 1; the upper left-hand figure is 2; the lower left-hand figure is 3, and the lower right-hand, 4. Some plates have several figures on each of their two or four principal divisions. In these cases, to save the reader from mistakes and confusion, I have been very explicit in my descriptions, in indicating the particular figure referred to.

CORALS.

CORALS are sea animals of low organization. The general structure of their body, in the simpler forms, is that of a membranaceous bag, frequently plicated into radially arranged folds. This bag has only one central opening, which serves both as mouth and anus, and is surrounded by a variable number of retractile hollow tentacles. In the compound forms the individuals are frequently so intimately united, that the exact demarkation of one body from the other is lost.

Circulation imperfect, not propelled by a heart. Nervous system very rudimentary; no special organs of senses. Propagation partly by eggs, forming in the plications within the bag, and ejected at maturity through the central opening, partly by buds sprouting from the surface, or by division and individualization of single parts of the body. Some corals are entirely soft and fleshy; others secrete a horny or stony basal skeleton or domicil, into which the fleshy parts can be partially retracted. All the fossil corals belong to this latter tribe, and this stony Polyparium is the only portion of them preserved. Soft corals, not capable of preservation, have left no traces within the rocks, although, from analogy of present conditions with former, we have a right to assume that they were not missing in the ancient fauna.

The systematic arrangements under which corals have been described by various naturalists are very different.

Milne-Edwards is one of the writers who has paid special attention to the fossil forms of corals. I consider it, therefore, for the

present purpose, most appropriate to adopt his system as a basis. It requires, however, important rectifications, which I will make as I proceed with my descriptions.

CLASSIFICATION OF POLYPES.

BY MILNE-EDWARDS.

I. *Corallia.*

II. *Hydroida:* soft, not represented in fossil condition.

The Corallia are divided into three orders:

1. *Zoantharia.*
2. *Alcyonaria.*
3. *Podactinaria.*

Of these, the first order includes the principal part of all the fossil corals; the second is only represented by Graptolites, and the third has no palæozoic representative.

The Zoantharia are divided into seven sub-orders:

1. *Malacoderma:* soft, not fossil.
2. *Apora:* recent coralline forms.

Milne-Edwards placed the genus *Palæocyclus* with this sub-order, but its affinities are decidedly nearer to forms placed in another sub-order, the Z. rugosa.

3. *Perforata.*—Abundantly represented in the mesozoic and recent coralline fauna, but not in the palæozoic. The genus Protaræa, placed here by Milne-Edwards, belongs to the next following order, the *tabulata*, and the genus *Pleurodictium*, likewise enumerated among the Zoanth. perforata, is created by simply mistaking the casts of a Michelinia for a particular type of organization, very appropriately connected with the specific by-name of "*problematicum.*"

4. *Tabulata.*
5. *Rugosa.*

These last two orders comprise nearly all palæozoic corals, and will form the special object of consideration in subsequent pages.

6. *Tubulosa.*—An order formed to include the genus *Aulopora* and *Pyrgia*, both of which genera are in intimate relationship with certain types placed under the Zoanth. tabulata, with which I am going to describe them.

7. *Zoanth. caulicula.*—These have no representatives of palæozoic date.

Zoantharia tabulata.—The corals comprehended under this sub-order are composed of tubular polyp cells, septate by transverse diaphragms, and radiated by vertical crests, which in some forms are very well developed, in others remain in rudimentary condition, or are entirely obsolete in individuals. Two principal groups of tabulata are distinguished:

I. *Milleporidæ.*—Compound polyparia built up by two structural elements; of larger radiated tubes, forming the visceral cavities for the animal, and of a cœnenchymatose tissue surrounding the tubes, likewise either of tubular structure, or of a cellulose vesiculous nature.

II. *Favositidæ.*—Compound polyparia formed of aggregated tubules of equal structure, without intervention of any other tissue element between the tube walls. The radiation of the tubes by vertical crests is often more rudimentary in its development than in the former order of Milleporidæ.

The palæozoic forms of the *Milleporidæ* are represented by the genera: Heliolites, Lyellia, and Plasmopora, to which Milne-Edwards adds Propora, Battersbyia, and Fistulipora. The latter genus has only an external resemblance to the Milleporidæ. It belongs to the Bryozoa, as I have already demonstrated in an essay published in 1866, in the proceedings of the Academy of Natural Sciences, of Philadelphia.

The genera Propora and Battersbyia, I was not able to recognize among the American fossils, unless a form which I have provisionally named *Houghtonia* should be identical with the Propora.

The second order of Zoanth. tab., the *Favositidæ*, is grouped by Milne-Edwards into six sub-orders:

1. Favositinæ. 2. Chætetinæ. 3. Halysitinæ. 4. Pocilloporinæ. 5. Seriatoporinæ. 6. Thecideæ. From these the Chætetinæ have to be eliminated as a type belonging to the Bryozoa.

The genera arranged under the Pocilloporinæ, Seriatoporinæ, and Thecideæ are in perfect conformity of structure with the Favositinæ, and I see no reason for their separation from them—with one exception, that of the genus *Columnaria*, which is a form of peculiar type, exhibiting no great affinity with the genus Thecia, which has been placed by Milne-Edwards in the same sub-order with it.

The sub-order Halysitinæ includes the genera Halysites, Syringopora, Fletcheria, Thecostegites, and Chonostegites. The latter two genera I place under the Favositinæ as a form intimately related in structure to Michelinia. The genus Thecostegites is only created through mistaking compact, short-jointed specimens of Syringopora tabulata for the type for a new genus, which assertion I shall prove farther on by giving a detailed description of the species. I have, in view of the above statements, reduced the six sub-orders of Favositidæ to three, namely, *Favositinæ*, *Halysitinæ*, and *Columnariæ*, under which headings I will describe the genera and species found in the State of Michigan, taking the liberty sometimes of drawing into the descriptions specimens found in the foreign territory of the neighboring States, when I find it necessary for a full illustration of a certain group of organisms, of which the material found in the State is too imperfect. In the production of photographic figures specially, I had frequently to resort to specimens not found in Michigan localities—not that I am without indigenous ones of the same order, but because these are in a less perfect condition.

MILLEPORIDÆ.

Genus HELIOLITES, Guettard.

Large visceral tubes, circular, scarcely or not at all projecting above the general surface, radiated by twelve longitudinal crests, not reaching the centre, and often being only low, spinulose carinæ. Numerous transverse diaphragms intersect their channels. Cœnenchym abundant, formed of much smaller, not radiated, polygonal tubules, which, divided by regularly disposed, transverse diaphragms, represent vertical rows of subquadratic cell spaces filling the interstitial space between the larger circular tubes. No lateral anastomosis between tubes or cell spaces.

Several species of Heliolites occur in the Niagara group of Michigan. The specimens are all found in silicified condition, and the more delicate surface characters have suffered partial obliteration by the process of petrification.

HELIOLITES MEGASTOMA, McCoy.

Visceral tubes about two millimeters wide. Orifices crenulated by a cycle of twelve low vertical crests. Diaphragms flat, closely set. Cœnenchym tubules about half a millimeter wide. Interstitial spaces filled by them, subject to many variations in different specimens; in some the distance between the larger circular tubes is smaller than their own diameter, in others it is larger. External mode of growth convex, or in subplane expansions, covered by a concentrically wrinkled epitheca on the impressed lower concave side. It is a common species in the Niagara group of Drummond's Island, Point Detour, and many other localities; in the drift deposits of the Lower Peninsula it also frequently occurs. The Niagara group of Indiana, Iowa, Kentucky, etc., and the Silurian strata of Bohemia inclose forms perfectly identical with those of Michigan.

Plate I.—Fig. 3 represents a silicified specimen from Point Detour, natural size, the structural details of which will all be seen more distinctly by using a weak magnifier, when looking at the figure.

HELIOLITES PYRIFORMIS, Hall.

Tubes about one millimeter wide, radiated by a cycle of twelve spinulose, vertical crests. Diaphragms flat, simple, or anchylosed with the spinulose, vertical crests into an irregularly cellulose mass, filling the tube cavities. Cœnenchym of minutely tubular structure, divided by transverse septa. Interstitial spaces between the larger tubes equal to or larger than one tube diameter. External growth, subglobular.

The mode by which the specimens are preserved alters their appearance considerably. Some of the specimens, with simple transverse diaphragms exposed to weathering, are apt to have the diaphragms of the larger tubes destroyed, and the channels of the larger tubes are seen all open, surrounded by the well-preserved mass of the smaller cœnenchym tubules. In other specimens where the vertical crests, intermingling with the diaphragms, give the larger tubes more strength, the cœnenchym is found destroyed and the larger tubes are preserved, and present themselves as free cylindrical, longitudinally carinated columns. Still other specimens are

found, in which, by incrustation of the wall substance, the tube channels are narrowed, and the contrast between the larger and smaller tubes is diminished; these have a spongious aspect, and appear at first glance to be a fossil of totally different structure from the more regularly formed specimens. It is sometimes difficult to distinguish this species from the next described species, *Heliolites interstinctus.* This species is found in association with the former kind at Drummond's Island, and in the other mentioned localities in Michigan; it is likewise common in the drift. The Niagara group of Iowa and Wisconsin incloses the same form.

Plate I.—Fig. 2 represents two specimens from Drummond's Island, in natural size.

HELIOLITES INTERSTINCTUS, Linn.

Visceral tubes from one to one and a half millimeter in width. Vertical crests quite prominent, almost reaching the centre, and composed of rows of spinules pointing obliquely upward with their apices. Cœnenchym composed of minute, polygonal, transversely septate tubules. Interstitial spaces between the larger tubes usually much exceeding one tube diameter. Diaphragms rarely flat, and simple, generally complicated into a cellulose network with the spinulose, vertical crests, with a nodular projection in the centre, formed by the converging apices of the spinules. No central columella. In vertical sections the channels of the larger tubes are scarcely distinguishable from the surrounding septate cœnenchym, because the intersection of the spinules with the diaphragms divides the interior of the larger tubes into small cell spaces similar to the surrounding cœnenchym tissue. The visceral tubes always resist decay better than the cœnenchym, and are preserved as slender, longitudinally carinated columns, held together by a portion of undestroyed cœnenchym. The mode of growth is in discoid, subplane expansions, with a concentrically wrinkled epithecal crust on the lower side.

It is of rare occurrence in Michigan; occasionally specimens are found in the drift of the Lower Peninsula, but it is a very common species in the Niagara group of Indiana, Kentucky, Tennessee, etc.

Plate I.—Fig. 1 is a specimen from Louisville, Ky., in calcified

condition. Specimens from the Silurian strata of Bohemia perfectly correspond with the American form.

HELIOLITES SUBTUBULATUS (?) McCoy.

Visceral tubes only half a millimeter wide, with twelve delicate marginal crenulations around the orifices. Cœnenchym tubular, very minute. Interstitial spaces between the larger tubes broad. Transverse diaphragms simple, regular, disposed at close distances.

External growth in convex, rounded masses. I have identified this form with McCoy's species on account of a general resemblance to his figures, but had no opportunity to compare specimens. It occurs in the Niagara group of Point Detour, Drummond's Island, etc.; also in Iowa, at Masonville.

Plate I.—Fig. 4, lower specimen found at Marblehead, of Drummond's Island, natural size; upper specimen from Masonville, Iowa.

PLASMOPORA.

Milne-Edwards.

Visceral tubes circular, not projecting above the general surface, radiated by twelve well-developed vertical rows of spinulose projections. Cœnenchym formed of stout vertical laminæ, which partly appear as the extraneous continuation of the radial crests of the tubes. They intersect each other in irregular manner, inclosing tubular spaces between, which are transversely septate, like the tubules of the cœnenchym of Heliolites; but while in the latter they are actually closed tube channels, in the cœnenchym of Plasmopora no closed tube walls seem to exist, but only lacunæ (intersecting each other) between the vertical plates, Diaphragms of visceral tubes numerous, flat, but usually complicated by intersection with the vertical rows of spinules almost reaching to the centre.

read plates intersecting each other

The cœnenchym usually resists weathering better than the tubes—large, open channels being found to occupy the places of the latter in such specimens.

Plasmopora and Heliolites are in structure so similar that it often becomes difficult to make a distinction between the two forms.

PLASMOPORA FOLLIS, Milne-Edwards.

Tubes from one to one and a half millimeter in diameter, separated with their circular crenulated orifices by interstitial spaces equal to a tube diameter or smaller. Vertical laminæ of the cœnenchym often holding a position toward the tubes as of external radii, and inclosing, by mutual junction and intersection by transverse dissepiments, vertical rows of cell spaces very similar to the cœnenchym of Heliolites; but the vertical walls of these septate pseudo tubules are much stouter than the tubular walls in Heliolites, and comparatively much stouter than the transverse septal laminæ dividing them. Grows in pyriform or subcylindrical, club-shaped masses of moderate size, not often exceeding that of a man's fist; the conical base is attached and exhibits a rudimentary epithecal crust; in the subcylindrical specimens, the cœnenchym cells and orifices on the side faces of the stems are usually closed, and only those of the convex terminal disk apert. Rarely found in the Niagara group of Point Detour, and sometimes in the drift of Michigan. It is a very common species, however, in the Niagara group of Indiana, Kentucky, and Tennessee.

Plate III.—Fig. 2 represents two species of Plasmopora, arranged in a group to economize space. The two upper figures are small silicified specimens of Plasmopora follis; the elongated one was found at Paul's Station, Indiana; the other, of rounded form, is from Charleston Landing, Indiana.

PLASMOPORA ELEGANS, Hall.

Synon., Heliolites elegans, Hall.

Heliol. spinipora, Hall.

Plasmopora scita (?) Milne-Edwards.

Tubes a little over half a millimeter wide, radiated by twelve prominent longitudinal rows of spinules obliquely directed upward, and nearly reaching the centre. Diaphragms complicated and anchy-

losed with the spinulose projections. Cœnenchym composed of very stout vertical lamels, with delicate transverse leaflets intersecting them. Intervals between the tubes about as large or larger than a tube diameter. Growth pyriform or globular. Found in the drift deposits of Michigan. Common in the Niagara group of New York, Indiana, and Kentucky.

Plate III., Fig. 2.—The two lower specimens, both silicified, are from Paul's Station, Indiana.

LYELLIA.

MILNE EDWARDS.

Visceral tubes circular, with orifices projecting above the general surface, radiated by twelve conspicuous vertical rows of spinules, and transversely septate by subplane diaphragms.

Cœnenchym abundant, formed of convex, vesiculous, horizontal plates of unequal size, extending in interlacing layers across the intertubular interstices, and inclosing blister-like cavities much resembling the vesiculous tissue of a Cystiphyllum.

LYELLIA AMERICANA, MILNE-EDWARDS.

Synon., HELIOLITES MACROSTYLUS, Hall.

Tubes 1½ to 2 millimeters wide, radial crests almost extending to the centre, and decurrent on the outer projecting part of the orifices, but not prolongated across the interstices, which are divided into a network of irregular angular cell spaces, or are, in weathered specimens, of blistered aspect. Transverse diaphragms subplane, often warped, closely set. Interstices between the tubes larger than one tube diameter. Vesiculous plates of cœnenchym of irregular, coarser, or smaller size, frequently found partially destroyed by decay, in which cases the tubes present themselves as free, longitudinally carinated columns, held together by such of the cœnenchym as escaped destruction. Some of the specimens of Sarcinula represented by Goldfuss are doubtless weathered specimens of Lyellia. (*Vide* Sarcinula costata, Goldf. Tb. 24 f. 11.)

Growth in large convex expansions, with an epithecal crust on the lower, often concave side, or of lenticular or pyriform shape, with conical basal side. Found abundantly on Drummond's Island, Point Detour, and in other localities of Niagara exposures in Michigan ; of frequent occurrence also in the drift of the Lower Peninsula, and common in the Niagara group of Iowa.

Plate II.—Fig. 1. Surface view of a silicified specimen from Point Detour, Lake Huron. Fig. 2. Side view of a weathered specimen presenting the tubes as partially free columns connected by the remains of the cœnenchym vesicles.

LYELLIA PAPILLATA, Nov. Spec.

Tubes circular, not projecting above the general surface, crenulated at the margins by twelve spinulose vertical crests. Diameter of tubes about $1\frac{1}{2}$ millimeter. Interstitial spaces as wide as a tube diameter, or narrower, obscurely radiated on the surface by arrangement of the cœnenchym vesicles in conformity with the radial crests of the inside. Diaphragms convex, with deeply depressed margin, projecting within the orifices as rounded monticules, decorated with granules. In weathered specimens the tubes stand out as free, longitudinally carinated columns, as in the former species. Mode of growth convex hemispherical above, flat or concave at the lower side, which is covered by a concentrically wrinkled epitheca, or sometimes incrusting other bodies. Found abundantly in the Niagara group of Point Detour and at Drummond's Island.

Plate II.—Fig. 3 is a silicified specimen from Point Detour, Lake Huron.

LYELLIA DECIPIENS, Nov. Spec.

Flat, undose expansions of laminated structure. Tubes one millimeter wide, orifices not projecting, crenulated by twelve marginal crests. Diaphragms slightly convex. Interstitial spaces usually larger than one tube diameter, their surface delicately reticulated by circumscribed cell spaces, as in Heliolites, but in vertical sections exhibiting a distinctly interlacing vesiculose structure, and not a tubular cœnenchym. Found in the Niagara

group of Point Detour and Drummond's Island. Exteriorly it fully resembles Heliolites interstinctus.

Plate III.—Fig. 1 represents a silicified specimen from Point Detour, Lake Huron.

LYELLIA PARVITUBA, Nov. Spec.

Tubes one millimeter wide, with projecting orificial rims, radiated within by prominent spinulose crests, and on the surface of the interstices by the converging arrangement of the cœnenchym vesicles. Interstitial spaces about equal to a tube diameter, vesicles rather coarse. Diaphragms subplane, granulose. Growth explanate, discoid, with a concentrically wrinkled epitheca on the lower side. Rarely found in the Niagara group of Drummond's Island. In the Niagara group of Indiana and Kentucky this species is very common, and is partly found silicified, partly in calcified specimens with finely preserved structure.

Plate II.—Fig. 4 is a calcified specimen from Louisville, Ky.

Various other forms described by Billings under the name of Heliolites are by structure true Lyellias, as *Heliolites affinis*, Billings; *Heliolites speciosus*, Billings; *Heliolites exiguus*, Billings: all found at Anticosti Island.

HOUGHTONIA.

N. Gen.

Tubes circular, with projecting rims; cavity lined by twenty or more longitudinal crests, and transversely septate by subplane diaphragms. Cœnenchym formed of irregularly lacunose cell spaces anastomosing amongst themselves, and frequently by pores with the tube channels. Intertubular interstices narrow—the tubes are often in immediate contiguity, so that the intertubular cœnenchym becomes restricted to the corners left between the joining tubes. No pore communication between the contiguous tube walls.

HOUGHTONIA HURONICA, Nov. Spec.

Globular masses, from the size of a man's fist to that of a foot in diameter, with a basal scar of attachment. Tubes from two to three millimeters in diameter. Interstitial spaces narrow, or tubes in partial immediate contiguity without intervention of cœnenchym cells. Vertical crests spinulose. Diaphragms numerous, slightly concave, and usually coincident with linear constrictions of the tubes. By intersection of the vertical crests with these constricted annular rims, the inner surface of the tubes becomes cancellated by regular, square-shaped conical pits, the bottom of which is often, but not always, perforated, and communicates with the cell spaces of the surrounding cœnenchym.

Occurs in the Hudson River group of Drummond's Island, associated with Columnaria stellata. It is likewise found abundantly in the upper part of the Cincinnati group at Madison, Indiana; more rarely in the lower strata of the same locality.

Plate III.—Fig. 3 is a lateral view of a specimen from Drummond's Island, split open. Fig. 4 is a surface view of the same.

FAVOSITIDÆ.

Sub-order, FAVOSITINÆ.

Compound polyparia, formed of intimately connected elongato-conical tubes, diverging from an imaginary axis, and frequently originating from a single mother-tube by prolific lateral gemmation, constantly repeating.

In some forms the tubes are in close connection in their whole length; in others the tubes become free at their ends. In contiguity the tube channels are anastomosing by lateral pores. Transverse diaphragms generally intersect the tube channels, but are sometimes absent, either from being destroyed, or from non-development, which latter is usually found to be the case in forms with very stout thickened tube walls. The inner tube cavity is, in the majority of Favositinæ, radiated by a cycle of longitudinal crests, or rows of spinules or squamiform horizontal leaflets projecting from the walls, which are separated by deep intervening furrows. In other forms the crests are obsolete, the radial structure being indicated only by shallow longitudinal furrows, and in others still the tube cavity is entirely destitute of crests or longitudinal furrows.

The following genera are representing this sub-order: 1. Favosites; 2. Alveolites; 3. Limaria; 4. Cladopora; 5. Striatopora; 6. Dendropora; 7. Thecia; 8. Vermipora; 9. Quenstedtia; 10. Michelinia.

FAVOSITES.

Massive or dendroid polyparia, with polygonal or circular orifices, not or rarely projecting above the general surface, and opening almost rectangularly to it. Tubes intersected by transverse dia-

phragms, either simple, or compound through the anchylosis of several plates meeting at angles, or rendered imperfect by partial plates not anchylosed. Tube cavity exhibiting twelve longitudinal furrows, and having the band-like intermediate spaces frequently decorated with one or several vertical rows of spinules, or with a row of horizontal, squamiform leaflets. These characters of radiation are, however, not in all species equally distinct, becoming in some specimens nearly obsolete, while in others of the same kind they may be exhibited in obvious development. The rows of squamose projections, peculiar to certain Devonian forms, by coming in contact and adhering together at their joined edges, form compound, perfect, or incomplete diaphragms, interposed between the regularly formed simple diaphragms, and in some specimens these prevail to such an extent as to altogether exclude the regular diaphragms.

Milne-Edwards proposed for Favosites of the above indicated structure the name *Emmonsia*, but the character of the diaphragms in the forms in question is so variable and inconstant, that one and the same specimen, or even the same identical tube channels, may at a certain period of growth be intersected by compound complicated diaphragms, exhibiting at another only simple, straight diaphragms like other forms of Favosites, while in the prolongation of the tubes they may be divided again by compound or imperfect septa. A character so changeable and peculiar to almost every one of the Devonian species of Favosites can not be used as a generic distinction for those which have it in a more marked degree than the others. Milne-Edwards has also confused with his Emmonsia a species which stands in no special relationship to the other forms; his Emmonsia cylindrica is a true typical form of a *Michelinia*.

The genus Favosites and the whole family of Favositoids had comparatively a very brief period of existence. The first forms appear in the upper Silurian deposits (Clinton group). During the Niagara period and the Devonian era, Favositoids abounded, and were the prevailing representatives of coralline life. The carboniferous strata inclose only a few of these forms, and in later deposits no representative of the genus is known. The Silurian forms differ from the Devonian Favosites by invariably having simple diaphragms, and by the spinulose character of their radial crests. The

majority of the Devonian forms, instead of longitudinal rows of teretiform spinules, have rows of horizontal squamulæ, which, as already mentioned, sometimes coalesce into transverse compound laminæ, taking the place of the regular diaphragms, which case never occurs in a Niagara species.

FAVOSITES FAVOSUS, Goldfuss.

Synon., Calamopora favosa, Goldfuss.

Favosites Niagarensis, Hall, in part.

Tubes polygonal, of uniform size in the same specimens, but in different specimens variable, from a diameter of six millimeters to that of two. Internal circumference of tubes longitudinally striate by twelve furrows, with intermediate, broader, band-like spaces, which are crowded with slender spinulose projections, either in irregularly dispersed position, or arranged in longitudinal or transverse undulating rows, in accordance with the undose, transverse wrinkles of growth visible on the outside of the well-preserved tube walls. Diaphragms convex or flat, or even deeply concave, closely approximated or wide apart. All these variations of structure are sometimes observable in one and the same specimen, but usually the different variations of form mentioned are represented by different specimens. The diaphragms are marked with concentric wrinkles of growth parallel with the polygonal outlines of the tubes, and their entire surface is ornamented by delicate granules or spinules similar to those projecting from the side walls of the tubes. The margins of the diaphragms at their junction with the side walls are deflected into siphon-like depressions, frequently twelve in number, and coinciding with the twelve longitudinal furrows. In many specimens only five or six such siphonal depressions are developed, while in the circumference of some of the very large tubes I counted twenty. These latter are exceptions. In certain specimens the diaphragms connect with the side walls without any perceptible depression.

Lateral pores connecting the tubes, of moderate size, surrounded by a raised rim, forming on each side of the polygonal tubes, according to its width, a single, or double, or triple row. The pores

are never much crowded, and hold no definite position in relation to each other in the adjoining rows, sometimes found alternating, sometimes opposite, or negligently disseminated.

External form of polyparia hemispherical, or discoid, lenticular, with a concentrically wrinkled epithecal crust on the lower centrally attached side.

Occurs abundantly in the Niagara group of Drummond's Island, Point Detour, and all along the south shore of the Upper Peninsula of Michigan; also common in the drift deposits, and in the Niagara group of Wisconsin, Iowa, etc. The above species description comprises specimens so much differing in aspect, that it seems strange to present them as belonging to one species. A Favosites with tubes six millimeters wide and one with tubes measuring only two are in great contrast. It may be said also that specimens with convex diaphragms and rough spinulose tube walls bear little resemblance to others having perfectly even diaphragms and almost smooth tube cavities; yet on careful examination of large collections of these forms, we find them all so much linked together by intermediate gradations that no line can be drawn between one and another.

Plate IV. represents four specimens, which I consider as varieties of Favos. favosus. Fig. 1 is the fragment of a large silicified specimen with tubes about four or five millimeters in width, flat diaphragms with numerous marginal depressions, and with delicately spinulose tube walls. Found at Drummond's Island. Fig. 2 is a specimen from Point Detour, with still larger tubes of similar structure. The edges of the cells are noticed in the figure to be faintly crenulated by the twelve longitudinal furrows. Figs. 3 and 4 are specimens with convex diaphragms, of different tube size, with well-developed marginal depressions; surface of diaphragms and inner face of tube walls spinulose. Found associated with the former.

Plate V.—Fig. 2 is a specimen fully agreeing with Fig. 1, Plate IV., but of smaller tube size. Favosites Gothlandica, of Goldfuss, corresponds with this specimen; Favosites Niagarensis, Hall, includes forms of this kind also, but the name Gothlandica is applied to so many entirely different forms of Favosites, that I totally abstain from using it. The name Niagarensis, Hall, I have restricted to a form with smaller tubes.

FAVOSITES NIAGARENSIS, HALL.

Tubes about one and a half millimeter wide, of equal size in the same specimens, polygonal. Diaphragms flat, placed at various distances, sometimes very close, sometimes more than one tube diameter apart. Inner surface of tubes delicately spinulose. Spinules in irregularly dispersed position. Pores situated in close proximity to the angles of the tubes, not very numerous.

External growth in convex masses, with an epithecal crust on the lower side. Occurs associated with Fav. favosus in the Niagara group of Michigan, Iowa, Kentucky, etc. It differs from that species principally in the position of the pores near the angles, and in the small tube size; is not connecting with the specimens, Fig. 2, on the same plate, by gradation, an obvious break existing between them.

Plate V.—Fig. 1 is a silicified specimen from Point Detour.

FAVOSITES HISPIDUS, NOV. SPEC.

Tubes a little over one millimeter and a half wide, equal, polygonal, radiated by long projecting spinules, almost reaching to the centre. Spinules disposed in irregular longitudinal rows, unequal in size, and more than twelve in number in the circumference of a tube. Diaphragms flat, closely set. Pores very numerous, generally forming two rows on each side. Of convex, discoidal growth, with an epitheca below, as in the other forms. Occurs associated with the preceding species in the Niagara group of Drummond's Island and Point Detour.

Plate V.—Fig. 4 is a silicified fragment found at Point Detour.

FAVOSITES VENUSTUS, HALL.

Synon., ASTROCERIUM VENUSTUM, Hall.

FAVOSITES HISINGERI, Milne-Edwards.

Tubules small, not over one millimeter wide, rounded-polygonal, of equal size. Tubes radiated by long spinules, as in the former species. Spinules in twelve distinct longitudinal rows. Diaphragms

flat, or gently convex, closely approximated. Pores in one, rarely in two rows on each side.

Grows in large, massive expansions, with an epitheca on the lower side.

Found abundantly in the Niagara group of Michigan, and loose in the drift; it likewise occurs in the Niagara strata of Iowa, Indiana, Kentucky, and New York.

Plate V.—Fig. 3 is a silicified specimen from Drummond's Island.

FAVOSITES OBLIQUUS, Nov. Spec.

Tubes polygonal, compressed, like an Alveolites, and opening oblique to the surface. Large diameter of tubes, three millimeters; small diameter variable according to the degree of compression. In rare instances the tubes are not compressed, or only slightly so, and open rectangularly to the surface. The inner circumference of the tube walls is striate by twelve longitudinal furrows with intermediate band-like spaces, each of which bears several longitudinal rows of spinules. Diaphragms subplane, with from eight to twelve marginal depressions, which, together with the longitudinal furrows and spinulose interstices, give the orifices a very decorative, stelliform aspect. The surface of the diaphragms is covered with delicate spinules, like the rest of the inner surface of the tubes. Lateral pores form a single row on each side, wherein it differs from Alveolites, which has larger pores, confined to the two lateral edges, or to their vicinity.

Large, undose expansions, with an epithecal crust on the lower side. Common in the Niagara group of Drummond's Island and Point Detour; also found in the drift of the Lower Peninsula occurs likewise near Masonville, Iowa.

Plate XXVIII.—Fig. 2, silicified specimen from Point Detour. The Niagara group of New York and Indiana contains a few other species of Favosites, which are not found in the formation of Michigan; these are:

FAVOSITES PYRIFORMIS, Hall.

(Astrocerium, Hall.)

It grows in globular or pyriform masses, with a narrow, conical basal end, surrounded by an epithecal crust. Tubes rounded-polygonal, unequal in the same specimens, and in different specimens varying from one and a half to three millimeters in diameter. Diaphragms flat, moderately close. Tube channels radiated by longitudinal rows of spinules. Pores not very numerous, in a single or double row on each side. Not figured.

Another species, which I name *Favosites spongilla*, is common in the Niagara group at Paul's Station, Indiana. It is likewise of pyriform, conical growth, with subramose excrescences from the discoid upper surface, like some forms of bathing sponges. Tubes small, not over one millimeter wide, with slightly dilating, subrotund orifices. Diaphragms convex. Tube cavity surrounded by rows of spinules. Pores not clearly visible in the small silicified specimens, not larger than a walnut. I have not figured the latter two species, as they are not found in Michigan, but have thought it well to mention them as well-marked characteristic forms of the Niagara group.

FAVOSITES HEMISPHERICUS, Yandell and Shumard.

Synon., Favosites turbinatus, Billings.

Not Fav. hemisph., Milne-Edwards.

Through misapprehension, Milne-Edwards described, under the name Emmonsia hemispherica, as synonymous with Yandell and Shumard's species, a Favosites entirely different from the specimens originally designated by that name. All the original specimens of Fav. hemisph. kept in Mr. Yandell's collection are identical with *Favosites turbinatus* of Billings. We have to restore, therefore, the name hemisphericus to this species, for which it originally was intended, and give to Milne-Edwards' species the name Favosites Emmonsii, in place of Emmonsia hemispherica, which genus, for reasons mentioned above, can not be accepted.

Favosites hemisphericus is one of the best marked species of Favosites; it has a wide range of variations, but its peculiar mode of growth makes it easily distinguishable from any other form.

The tubes of this form are about two millimeters in diameter, of unequal size, rounded-polygonal; tube cavity generally smooth, intersected by simple flat diaphragms. It occurs rarely that the diaphragms are compound and angular on the surface, formed by anchylosis of lateral, squamiform projections. Lateral pores large, usually in a single row on each side, and moderately distant. Sometimes, however, two rows of pores may be observed on a side. The mode of growth mentioned as the most characteristic feature of this species is nevertheless quite variable. We find polyparia of subspherical or of biconvex lenticular form, or in cylindrical, irregularly flexuose, root-like masses, over a foot in length, or in elongated horn-shape, all of which forms proceed from a single proliferous mother-tube. At first the polyparium is attached by its narrow and usually excentrical apex, but soon it becomes free, and the apex is folded over by the spreading margins of the rapidly enlarging corallum. The tubes diverge in graceful curves from an imaginary central axis toward the periphery. Those ends, terminating on the lateral faces of the corallum, have their walls thickened in their peripheral portion, and their orifices are all closed by opercula of concentric annular structure, with a central opening while growing, which is finally closed by a solid nodular piece. The margins of the opercula are frequently decorated by twelve carinæ converging from the margins toward the centre, but not reaching it. In specimens with excessively thickened wall substance, these radial carinæ are very obscure, or entirely obliterated. The orifices terminating on the convex disk of the corallum are all open, more thin-walled than the others, and of more pronounced polygonal form. It often happens that these centrally situated, thinner-walled tubes have been destroyed by weathering, while the exterior lateral tube ends, of massive structure, have resisted and been preserved. The upper end of such specimens is deeply excavated, and the lenticular forms are transmuted into concave, patelliform dishes. The elongated, horn-shaped specimens terminate in this case with a funnel-shaped excavation resembling the calyx of a Cyathophyllum, which resemblance is augmented by the exposure of the side faces of the septate tubes, arching from

the centre to the periphery, which bear a deceptive likeness to the radial lamellæ, with intermediate vesicular cell spaces of the calyx of a Cyathophyllum.

This species is equally common in the upper part of the Helderberg group and in the Hamilton strata in Michigan, and in the equivalent rock beds of other States east and west of it.

Plate VI.—Figs. 1 and 2 represent two silicified specimens of cylindrical growth. A part of the orifices in Fig. 1 is closed by opercula plainly exhibiting the twelve marginal radial carinations. Fig. 2 shows near the left margin opened tube channels with dimly visible lateral pores. The central part of the specimen is formed by the casts of the tube channels, with deep incisions in the place of the diaphragms, and papillose prominences represent the lateral pores. Fig. 3 is a weathered specimen of lenticular form, having a dish shape presenting opened silicified tube channels, intersected by diaphragms, and perforated by lateral pores. On the centre of the specimen I fastened artificially a small horn-shaped specimen, resembling the calyx of a Cyathophyllum. Fig. 4 is a calcified specimen, in the shape of a Dutchman's nightcap, found in the Hamilton group of Thunder Bay.

On Plate X., Fig. 2, a calcified specimen of similar growth to that on Plate VI., Fig. 3, presents the angular tubes of a specimen split open, with diaphragms and pores faintly indicated. The latter belongs to the upper Helderberg limestone, and was found in the drift of Ann Arbor. Specimen, Plate VI., Fig. 1, is from the corniferous limestone of Port Colborne. Fig. 2, Plate VI., is found in the drift. Fig. 3, Plate VI., is from the Falls of the Ohio. The small horn-shaped specimen in the centre is from the drift of Ann Arbor.

FAVOSITES EMMONSII, N. SP.

Synon., EMMONSIA HEMISPHERICA, Milne-Edwards.

FAVOSITES ALVEOLARIS, New York Reports.

Tubes unequal, rounded-polygonal, from one to one and a half millimeter in diameter. Tube channels longitudinally striate by a cycle of twelve furrows; of the intermediate band-like spaces, each one bears a vertical row of horizontal squamæ, which are

in alternating position in the adjoining rows. Diaphragms rarely simple, straight, generally compound, of anchylosed, lateral squamæ, presenting an angular, substellate surface; or the interlacing squamæ remain free, and constitute imperfect septa, instead of complete transverse diaphragms. Pores large, forming in single or double, or even triple rows on each side, according to its width, and in places they are much more numerous than in others. It is often noticeable that tubes, for a certain part of their length, are intersected by simple, straight diaphragms, without complication by lateral squamæ, and again, both above and below, are found divided by very irregularly interlacing compound septa. This form grows in large convex masses, or in discoid expansions, with a concentrically wrinkled epitheca on the lower side. Found in the upper Helderberg limestones of Mackinac, and in Monroe County, in calcified condition. Silicified specimens, partly in the shape of casts, are frequently found in the drift. The corniferous limestone of Sandusky, Ohio; of Port Colborne, Canada; of the Falls of Ohio; of Charleston Landing, Indiana, and of a great number of other localities, can be mentioned as abounding in specimens of this coral.

Plate VII.—Fig. 1 is the side-view of a calcified specimen, being a fragment of a larger mass, found at Charleston Landing, Indiana; lateral pores distinctly visible in the figure. Fig. 2 is a silicified specimen from the drift of Ann Arbor. It shows the inequality in the size of tubes (in some specimens in still greater contrast), by which I was induced to consider these forms as a distinct species (*vide* "American Journal of Science and Arts," November, 1862, Favos. heliolitiformis), an opinion which I have since changed. Other specimens are found in which the tubes have nearly all an equal size.

FAVOSITES HAMILTONENSIS, N. SP.

Synon., FAVOSITES ALPENENSIS, Winchell.

FAVOSITES DUMOSUS, Winchell.

Tubes rounded-polygonal, unequal in the same specimens and in different specimens, variable from one and a half to two and a half millimeters. Walls stout. Diaphragms regular, simple, but frequently with lateral squamæ interposed, which occasionally be-

come anchylosed with them and disturb their regularity, but never to the same degree as in the former species. Connecting pores large, forming a single row on each side. Rows of lateral squamæ, in some specimens very well developed. Other specimens or portions of specimens have smooth tube channels. Mode of growth globular, or tuberose, or in coarse ramifications, often incrusting other bodies with the basal portion. Abundantly found in the Hamilton group of Thunder Bay and Little Traverse Bay, and in the drift deposits.

Plate VII.—Fig. 3 is a specimen from Stony Point, Thunder Bay. Fig. 4 is found in the limestone bluffs of Petosky, presenting a vertical section through a specimen identical with Winchell's *Favosites dumosus*, which is often found in more slender ramifications, but also in rounded, tuberose form, in no way differing from the typical specimens of Hamiltonensis. *Favosites Billingsii* I have named a form nearly related to F. Hamiltonensis, which is the prevailing species in the Hamilton strata of Widder, C. W., and in the Hamilton group of New York. It grows in large lenticular disks, sometimes three feet in diameter; the lower side has a central point of attachment and is covered by an epithecal crust. Tubes rounded-polygonal, unequal, from two to three millimeters wide. Diaphragms flat, with marginal, punctiform depressions, similar to Favos. alveolaris, Goldfuss. Pores forming a single row on each side. Lateral squamæ rudimentary or absent. Not figured.

FAVOSITES EPIDERMATUS, Rominger.

Vide "Silliman's Journal," November, 1862.

Tubes from two to three millimeters wide, subequal in the same specimens, of obtusely polygonal outlines. Tube channels longitudinally striate by a cycle of twelve well-marked furrows, each of the intermediate band-like spaces bearing a row of horizontal squamæ, sometimes very prominent, and at others in rudimentary condition and partially obsolete. Diaphragms simple, flat, or warped by marginal depressions, more rarely of broken, angular surface through complication with the lateral squamæ, as in Favosites hemisphericus. Pores comparatively small, surrounded

by an elevated rim, in a single or double row on each side, never very much crowded. Grows in discoid, subundose expansions, with a delicately wrinkled epithecal crust on the lower side, having a narrow conical centre serving as point of attachment. Found in the upper limestones of Mackinac Island, and of frequent occurrence in the drift; likewise common in the corniferous limestone of Canada, New York, Indiana, and Kentucky. From the forms with deeply furrowed, crenulated orifices, and with irregular, compound diaphragms, insensible transitions exist to specimens with almost smooth, faintly furrowed tubes and with simple, straight diaphragms. In the size of the tubes also a considerable variation exists in different specimens.

Plate VIII.—Fig. 1 is a silicified specimen from Caledonia, N. Y., with beautifully crenulated orifices, exhibiting the longitudinal furrows and intermediate squamose projections. Fig. 2 is a silicified specimen found in the drift of Ann Arbor, seen from the lower side. Fig. 3 is a specimen from Port Colborne, showing the diaphragms with marginal depressions, and the general surface aspect.

FAVOSITES CANADENSIS.

(*Vide* "Silliman's Journal," November, 1862.)

FISTULIPORA CANADENSIS, Billings.

Undose expansions, with an epithecal crust on the lower side, sometimes of digitato-ramose or reticulated growth, with orifices on all sides of the stems. Tubes of two strikingly different sizes. The larger ones, about one millimeter wide, are circular, dispersed at subregular intervals between a mass of smaller subangular tubes about one third the size of the circular tubes. The specimens have a great resemblance to Heliolites porosus, or, as Mr. Billings thinks, to Fistulipora. The radiated structure of the tubes and the development of lateral pores are sufficient to prove the Favosites type of the species. The larger tubes are always lined with a cycle of twelve rows of horizontal squamæ; the smaller tubes are usually smooth, or exhibit only rudimentary squamæ. The diaphragms of the larger tubes are compound, by complication with the squamæ; in the smaller tubes the diaphragms are simple; all the

tubes are connected by abundant lateral pores disposed in longitudinal rows. The orifices in certain spots of the surface are often found closed by opercula.

Found in the upper Helderberg strata of Mackinac and in the drift deposits of the Lower Peninsula; also abundantly occurring in the corniferous limestone of Canada, New York, Indiana, and Kentucky.

Plate VIII.—Fig. 4 is a silicified specimen from the drift of Ann Arbor.

Plate XV.—Fig. 3 is a reticulated branching variety found at the Falls of the Ohio, kindly lent to me by Mr. Knapp, of Louisville.

I have from the same locality some subramose specimens of similar structure, but with larger tubes in contiguity and fewer interstitial smaller ones. These form a transition link to another species to be described hereafter (Favosites radiciformis).

FAVOSITES TUBEROSUS, N. SP.

Compare FAVOSITES TROOSTII, Milne-Edwards, and FAVOSITES BASALTIFORMIS PARS, Goldfuss.

Tubes rounded-polygonal, unequal in size, variable, between two and three millimeters in diameter, with larger tubes up to five millimeters occasionally intermingled. A cycle of twelve longitudinal rows of stout, horizontal squamæ lines the inner circumference of the tubes. The squamæ of the joining rows alternate in position, are not separated by intermediate furrows, but often slightly interlock with each other. Pores large and very numerous, two or three rows on each side, surrounded by a small pit instead of a projecting rim, and one of them is generally situated directly beneath each of the squamæ.

Diaphragms regular, complete, but often compound, angular on the surface through intersection with the lateral squamæ.

On the lateral surface of the subcylindrical polyparia, many orifices are found closed by concave opercula of concentrically wrinkled structure. Some of them have a small opening in the centre, which is finally closed up when the operculum is finished.

Found frequently in the drift of Michigan in silicified condi-

tion, partly in hemispherical masses, with a flat under side covered by an epitheca, or in elongated, cylindrical or tuberose form. Similar specimens occur in the corniferous limestone of Canada, New York, and at the Falls of the Ohio. At the latter locality, large convex masses are found, which are often erroneously identified with Favosites maximus, Troost. They are absolutely identical in structure with the described smaller forms.

Plate IX.—Fig. 1 is a representation of two small silicified specimens from the corniferous limestone of Port Colborne. The upper specimen seems to me identical with the American specimen of Favosites basaltica figured by Goldfuss. Its base and the lower specimen exhibit orifices closed by concave opercula. Fig. 2 is a silicified specimen from the Falls of the Ohio, presenting open tube channels intersected by diaphragms, and with the walls perforated by very numerous pores. It shows at the same time the divergence of the tubes from a basal centre. The rows of lateral squamæ are not as conspicuous in that specimen as in many others.

FAVOSITES WINCHELLI, Rominger.

Vide "Silliman's Journal," November, 1862.

Massive convex polyparia, composed of rounded-polygonal tubes from three to four millimeters in diameter. Diaphragms complete, simple, warped and depressed at the margins into several siphon-like pits, or the whole diaphragm is depressed into one deep excentrical funnel. Tube walls striate by twelve well-marked longitudinal furrows, destitute of lateral squamæ. Pores small, surrounded by a projecting rim, in one or two rows on each side, and somewhat remote in position.

Found frequently in the drift deposits of Michigan. Some specimens are inclosed in a white sand rock, associated with Oriskany sandstone fossils ; others originate from the corniferous limestone, and various specimens were collected by me from the Hamilton group of Thunder Bay. It is not uncommon in the corniferous limestone of Canada, New York, and at the Falls of the Ohio.

Plate IX.—Fig. 3 is a silicified specimen from the Hamilton

group of Alpena. Fig. 4 is from the corniferous limestone at Port Colborne, C. W.

FAVOSITES RADIATUS, N. Sp.

Tubes unequal, rounded-polygonal, one and a half to two and a half millimeters in width, radiated by twelve prominent rows of lateral squamæ with intervening deep linear furrows. Diaphragms simple, straight, or warped by marginal, siphon-like depressions; the pores are numerous, forming from one to three rows on a side. A small pit surrounds each of them, as in Favosites tuberosus. The tubes of some specimens exhibit the lateral rows of squamæ only in rudimentary development, and are nearly smooth on the inside, with flat, moderately distant diaphragms. In other specimens the squamæ project with their elongated linguiform apices nearly to the centre of the tubes.

Grows in large convex masses. Found in the Hamilton group of Thunder Bay, also at Eighteen-mile Creek, near Hamburg, N. Y.

Plate X.—Fig. 1, surface view of a partly silicified fragment of a larger convex mass, found in the Hamilton group of Alpena.

FAVOSITES NITELLA, Winchell.

Tubes rounded-polygonal, subequal, stout-walled, not fully one millimeter in width. Tube channels smooth or beset with distant lateral squamæ. Diaphragms partially simple, regular, partially of complicated, irregular form, through intersection with the lateral squamæ. Pores large, distant, in a single row on each side. Mode of growth globular or pyriform or digitato-ramose. Resembles in structure Favosites Hamiltonensis, differing from it only by much smaller tube size.

Plate XI.—Fig. 4 represents specimens from the blue shales of the Hamilton group of Little Traverse Bay. Similar specimens are found in the Hamilton strata of Thunder Bay.

FAVOSITES PLACENTA, N. Sp.

Tubes less than one millimeter wide, rounded-polygonal, subequal or unequal, larger tubes and smaller tubes clustered together in separate spots, or single circular tubes dispersed between

smaller subangular tubes, as in Favos. Canadensis. Diaphragms partially straight, simple, partially complicated, with lateral horizontal squamæ. Pores large, distant, in a single row on each side. Grows in discoid, undose expansions, with a concentrically wrinkled epitheca covering the lower side. Transition forms, of digitato-ramose form, connect this species most intimately with the former species, Fav. nitella. The specimens with single circular tubes dispersed through the mass of smaller subangular ones show a close affinity to Favosites Canadensis. Although specimens from different localities exhibit numerous minor variations, I consider this a well-marked species characteristic of the Hamilton group, from its base to the highest beds. It occurs in the upper strata of Partridge Point, in Thunder Bay, in the next lower strata of Stony Point, in the massive limestones forming the nucleus of the hillocks at Phelps' quarries, and at Broadwell's and Trowbridge's mills on Thunder Bay River. In the outcrops of Little Traverse Bay it is a frequently seen form ; the drift deposits of the Lower Peninsula likewise contain many specimens. The Hamilton strata of Bosanquet township in Canada contain it in particularly regular, discoid specimens, which caused me to name it *Placenta*. Similar forms are common in the Hamilton group of New York.

Plate XI.—Fig. 1 represents small specimens from Widder, C. W. ; one presenting the upper surface with subequal tubes, the other the under side covered by an epithecal crust. Fig. 2 gives specimens from the same locality, with unequal tubes, approaching in structure Fav. Canadensis. Fig. 3 is part of a large expansion from the Hamilton strata at Broadwell's mill, on Thunder Bay River.

FAVOSITES RADICIFORMIS, N. SP.

Cylindrical and apparently procumbent creeping stems of variable thickness, from the diameter of a finger to that of a man's wrist, and often several feet in length, with anastomosing or straddling branches. Tubes of two sizes—the larger ones circular, from one to one and a half millimeter wide, the smaller ones angular, filling the interstitial spaces between the larger tubes. Walls stout. Diaphragms rarely regular, straight, usually complicated with the rows of lateral squamæ, as is the case in Favosites

Emmonsii. Pores large and moderately numerous. The terminal parts of the stems are always formed of comparatively thin-walled, regularly formed tube orifices. On the lateral faces of the stems the orifices are often considerably narrowed and disfigured by incrassation of the tube walls, while the lateral pore channels retain their usual diameter, and become transformed into long vermicular ducts of nearly equal size with the principal tube channels. Such specimens are very unlike, in external appearance, those with normally formed tube orifices.

I have united within this species two forms, which differ from each other in the size of the tubes and of the stems, but otherwise correspond in structure. The form with larger stems and coarser tubes is found in the upper Helderberg limestones of Michigan, but particularly well preserved in the limestones of the Falls of the Ohio, and at Charleston Landing, in Indiana. The smaller form of more delicate structure is peculiar to the Hamilton group, and is found at Thunder Bay, often also in the drift associated with other Hamilton fossils.

Plate XII.—Fig. 1 represents a silicified specimen from the Falls of the Ohio, with unusually well-preserved surface characters; the central figure in the second row of the plate is a similar specimen of smaller size, and the two stems to the left of it are silicified specimens of the smaller variety, found in the Hamilton strata of Alpena. To the right of the central figure the upper fragment represents a horizontal section through a specimen formed of tube casts, narrowed by incrassation of the walls, and connected by radial branches, which are the casts of the lateral pore channels. The lower figure is a vertical section through a similar specimen, in the peripheral parts likewise presenting the tube casts in a lateral view; the centre of the specimen presents not casts, but the actual tube channels, intersected by transverse diaphragms, and in unaltered, not incrassate condition. The outer lower stem is a specimen with abnormally incrassate tube walls, to show the contrast in external appearance of various modifications of the species.

FAVOSITES LIMITARIS, N. SPEC.

Ramified and reticulated stems, from five to fifteen millimeters in thickness, forming horizontally explanate expansions or erect

fruticose ramifications. Tubes very thick-walled, opening nearly rectangularly to the surface, with circular orifices, the walls forming either a solid, undefined interstitial mass, or, in another state of preservation, the polygonal outlines of each tube are visible on the surface of the interstices as delicate engraved lines. Several varieties are observed, in regard to the mode of growth and the size of tubes. The tube orifices rarely exceed the diameter of one millimeter; often they are smaller, and in some forms they are all equal in a specimen; others have smaller and larger orifices intermingled. A part of the orifices on the side faces of the stems are often found closed by opercula, situated below the outer edge of the channels; in the interior parts of the tube channels diaphragms are not regularly developed, and are of rare occurrence. Pores large, distant, and irregularly dispersed. In older stems the tube channels not unfrequently become considerably narrowed by excessive incrassation of the tube walls, while the pore channels gain in length and width, and appear on the surface as vermicular, transverse channels connecting the tube channels, which latter are, in their narrowed condition, hardly larger than the connecting pore channels. In certain specimens the orifices are at a slightly oblique angle to the surface, and surrounded at the lower external rim by a raised margin, which approximates this species to the forms of Favositoids comprehended under the name Cladopora, in indication of which similarity of structure I selected for it the name *limitaris*, a "*joining, transitory form.*"

The different well-marked varieties, which I have considered as constituting one species, are found in the corniferous limestone of Michigan, Canada, New York, Indiana, and Kentucky, usually in silicified condition; finely preserved specimens are also found in the drift deposits of Michigan.

Plate XIII. represents four varieties of the species. Fig. 1 is the usual form found in the drift; it is likewise the most common variety in the corniferous strata of Canada West (Port Colborne) and at Caledonia, N. Y. The faintly developed lips at the lower margins of the orifices are perceptible in the figures, and in one specimen the sharply defined polygonal outlines of each tube are also plainly seen. Fig. 2 is found in the drift of Ann Arbor; stems erect, with fruticose ramification; tubes smaller than in the former variety. Fig. 3 grows in much stouter branches than the others;

the stems are usually compressed, elliptical in circumference; orifices very unequal in size. The portrayed specimen is from the Falls of the Ohio, but the same form is also found in the upper limestones of Mackinac Island. Fig. 4 resembles closely form No. 3, and occurs in association with it at the Falls of the Ohio; its tubes and stems are in all their proportions smaller. On Plate X. casts of this species are represented (Fig. 3) as they occur in the drift. The conical, subangular form of the tube channels, the almost total absence of diaphragms, the dispersed position of the pores, and the mode of gemmation of one tube from the other, are plainly conspicuous in the figures.

FAVOSITES CLAUSUS, N. SPEC.

Clustered, rapidly branching and anastomosing flexuose stems, varying from one half to one centimeter in thickness. Tubes unequal, the larger ones circular, measuring in different specimens from one half to one and a half millimeter in diameter; the smaller tubes filling the interstices between the larger ones are subangular. Orifices at the ends of the branches all open; on the sides of the stems most of them are found closed by opercula. Opercula flat or convex, some of them decorated with twelve marginal carinæ radiating toward the centre. Diaphragms partly simple and regular, but largely intermingled with irregular partial septa, formed by the development of lateral squamæ analogous to the vertical rows of leaflets in other species of Favosites. Pores numerous. Under this species I comprehend several varieties which closely resemble each other in general structure and mode of growth, but which may possibly be distinct forms. They occur in the Hamilton group and in the corniferous limestone.

Plate XIV.—Upper left-hand figure represents a silicified specimen from the Hamilton group of Thunder Bay River, near Broadwell's mills. Similar ramifications are found in the Hamilton strata of Widder and Arcona, in Canada. The tubes of this form are smaller than in the forms of the Helderberg group. The right-hand specimen in the upper row of the plate is from the corniferous limestone found in the drift of Ann Arbor; its tubes are nearly all of equal size and closed by opercula.

In the left-hand figure in the lower row, from the Falls of the Ohio,

the large circular tubes are in great contrast with the smaller subangular ones. The right-hand lower figures are single branches from the usual variety occurring in the corniferous limestone of Michigan, Canada, New York, and in the Western States. The specimens selected are also from the Falls of the Ohio.

FAVOSITES INTERTEXTUS, N. SPEC.

Irregularly reticulated masses of cylindrical or compressed elliptical stems, from one to two centimeters in thickness. Tubes quite unequal, stout-walled, the larger ones circular, the smaller subangular, filling the interstitial space between the larger tubes. Size of the larger tubes not much over half a millimeter. In the centre of the stems the tube channels are regularly formed, with moderately thick walls, and intersected by complete or incomplete squamiform diaphragms, and connected by distant pores. In the peripheral portions of the stems, the tube channels, by habitual thickening of the walls, have shrunk to filiform thinness, while the lateral pores have become more profusely developed and equal in width to the shrunken tube channels. Hereby a network of anastomosing ducts is formed, which can not be properly observed in fully-preserved specimens; in the drift, however, weathered specimens frequently occur in which the casts only of these reticulated ducts are preserved in silicified condition, the wall substance having all decayed. No one would likely recognize in these networks the casts of a Favosites if parts of the fully-preserved coral were not found in immediate contiguity to such networks. The contracted tube channels usually expand again to their normal diameter in close proximity to the surface. Found in the upper limestones of Mackinac and in the drift of the Lower Peninsula.

Plate XV.—Fig. 1 represents reticulated tube casts with the central portions of the stems formed by normally shaped tube channels. The object is too minute in the specimen. On Plate X., Fig. 4, similar casts of somewhat coarser stems are represented. On Plate XV. the upper left-hand figure is a palmate branch found in the drift of Ann Arbor; some specimens have much stouter stems, while others are only of the thickness of a lead-pencil, forming reticulated clusters.

FAVOSITES DIGITATUS, N. SP.

Cespitose masses of subparallel anastomosing stems of the thickness of a finger, or single stems with more straddling branches. Tube walls stout, joining under polygonal outlines, lined by a cycle of vertical rows of horizontal squamæ, usually fewer in number than the normal twelve. Diaphragms sometimes regular, frequently incomplete, replaced by the lateral squamæ. Pores large. Tubes in different specimens variable, from one to one and a half millimeter in diameter. The polygonal form of the orifices and the generally well-developed squamæ within the tube channels render this form at once recognizable from other branching forms of Favosites, which have their orifices always more rounded, nearly circular.

It occurs in large clustered masses in the black, shaly limestones of the Hamilton group, on the shore of Lake Huron, from Thunder Bay Island, northward; similar masses are inclosed within the limestones of Little Traverse Bay, in beds of various horizons, and preserved in calcified condition. On Thunder Bay River it is found in silicified condition in the lower beds near Trowbridge's mills; in the drift of the Lower Peninsula, also, silicified specimens associated with other characteristic Hamilton fossils can often be picked up.

On Plate XV., the six right-hand figures of the lower row are silicified specimens, of various tube size. The two outer figures and the lower central branch are from the drift of Ann Arbor; the other three branches are from the north fork of Thunder Bay River; the lower small branch has considerably thickened tube walls, forming within the polygonal, truncate, disciform tube ends a central proboscis-like prolongation. The cespitose specimens from the dark limestones, from the shore of Lake Huron and from Little Traverse Bay, can not be successfully represented by photography on account of their sombre color.

ALVEOLITES, LAMARK.

Massive convex or expanded laminar, rarely ramose, polyparia, composed of intimately united, compressed tubules, intersected by transverse diaphragms, connected by lateral pores, and longi-

tudinally crested on the inside. The tubes in the massive or laminar forms are prostrate, diverging from a central point, and open obliquely to the surface; in the ramose forms the tubes are ascending and arching outward from an imaginary central axis, as in branching forms of Favosites. Tube walls moderately stout and not expanded at the orifices, the inner margin of which is appressed to the body of the polyparium and lost in a common interstitial surface; the outer margin projects as a sharp lip. Cavities of tubes lined with longitudinal crests or rows of spinulose projections, which normally should be twelve in number, but it is rarely the case that all of them are found developed. Usually two or three of the crests, or crested rows of spinules, grow large and conspicuous; the others have a more rudimentary development, or have sometimes become obsolete. Diaphragms comparatively more distant and irregular than in Favosites. Pores very large, situated on the two lateral edges of the compressed tubes, or at least in close proximity to them. The genus Alveolites appears contemporaneously with Favosites, for the first time, in the upper Silurian strata.

ALVEOLITES NIAGARENSIS, N. SP.

Convex hemispherical masses of concentrically laminated structure, covered by an epithecal crust on the lower concave side, or undose, discoid expansions composed of superimposed layers of prostrate tubes, diverging with a slight spiral twist from a central vertex, several of which are sometimes observed on an expansion. The compressed tubes are always more convex on the upper sides, with a corresponding concavity of the lower sides, which rest on the convexities of the subjacent tubes. The compression is sometimes only moderate, and the outside of the oblique orifices is formed by a projecting arched lip; in other specimens the compression is stronger, the orifices become narrow, lanceolate, or fissure-like, with an appressed subplane lip on the outer side. The orifices of the majority of specimens are surrounded by a cycle of denticules, corresponding to longitudinal rows of spinules along the inner surface of the tube walls. The rows are rarely fully twelve in number, and some of them are always more strongly developed than others. In some specimens no denticulation of the orifices can be

observed, and the tube channels are found to be almost smooth; this is not in all cases owing to a want of development of the crests or spinules; these seem often to have been obliterated by imperfect preservation in the process of petrification.

Diaphragms somewhat distant and oblique. Pores large, marginal, causing a pouch-like dilatation of the tube wall at the spot where situated. Diameter of tubes in the wider transverse direction varies in different specimens, from a half to one millimeter, which difference in size greatly alters their aspect. The degree of compression of the tubes, their more erect or more prostrate position in various specimens also cause numerous variations in their appearance, but no tangible line between one and another of the forms exists. I have, for this reason, considered all of them as representing the modifications of one and the same species. It occurs in great abundance in the Niagara group of Drummond's Island, at Point Detour, and in other localities. It is often found also in the drift of the Lower Peninsula. The specimens are all silicified, and in but few of them are the more delicate structural characters well preserved. Certain specimens found in the drift exhibit principally the silicified casts of the tube channels, which have the form of flattened bands with rounded mamiform protrusions and intermediate indentations of the lateral margins; on the summit of each protrusion a pore channel or its cast is situated.

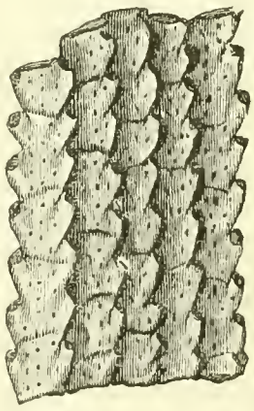


Plate XVI.—Fig. 1 represents a silicified specimen from the drift of Ann Arbor. Fig. 2 is found at Drummond's Island. The latter specimen exhibits the longitudinal rows of spinules very distinctly, but the object is too small to be properly seen in the not magnified figure.

ALVEOLITES SQUAMOSUS, Billings.

Convex masses of irregular growth, covered by an epithecal crust on the partially free, centrally attached under side, or sometimes incrusting other marine bodies. Tubes in the broader, transverse direction from one half to one millimeter in diameter, and in the other direction quite variable, in accordance with the degree of depression of the tubes, which are convex on the upper side and concave on the lower. Orifices very oblique, with a sharp lip on the outer margin. Tube channels longitudinally crested by twelve well-developed rows of spinules, of which generally some are larger than the others. Diaphragms not very close, and irregularly oblique. Pores large, marginal, but not causing a pouch-like dilatation of the tubes as in the Niagara species.

Found in the upper Helderberg limestones of Michigan, and in the drift; common also in the Helderberg limestones of Canada, New York, Ohio, Louisville, etc.

On Plate XVI., Fig. 3 is a silicified specimen found in the drift, giving a surface view; Fig. 4, likewise found in the drift, is composed of casts of the tubes. They are delicately punctured by impressions of the longitudinal rows of spinules. They exhibit the laterally situated pores and the distant, irregular diaphragms. The figures are of natural size.

ALVEOLITES VALLORUM, Meek.

(Palæontology of Mackenzie River.)

Specimens resembling the forms described by Mr. Meek, from Mackenzie River, are frequently found among the drift pebbles of Lake Superior. In some of them the tube walls are preserved; in others only the casts of the tube channels, which have the form of narrow, flat bands, connected with each other by short marginal bridges, representing the pore channels. The bands are longitudinally striate by fine, punctiform impressions, and transversely intersected by numerous closely approximated diaphragms. The width of the tube casts is about one millimeter, and their thickness one fourth of a millimeter.

Plate XVII.—Fig. 3 is a silicified specimen split in two, formed of tube casts. Found on the shore of Lake Superior, at Whitefish Point. Among the pebbles of the same locality other specimens of Alveolites are found, which agree with Alveolites squamosus, Billings.

ALVEOLITES SUBRAMOSUS, N. SP.

Incrusting expansions of irregular form, dependent from the incrusted object in the first stages of growth, subsequently of mamillate or digitato-ramose form. Orifices not over half a millimeter wide, margined on the outer side with a convex projecting or a flattened appressed lip; denticulated by crests, one of which in the median line of the inner body side of the tubes is much more prominent than the others. Pores large, rather remote. Diaphragms distant. Found in the Hamilton group of Thunder Bay, at Stony Point, and other localities. In mode of growth it perfectly resembles the branchlets from the Devonian strata of the Eifel, described by Milne-Edwards under the name of Alveolites subequalis, but its tubes are more minute and more strongly compressed than in that form.

Plate XVIII.—Fig. 4 represents calcified specimens from Stony Point, Thunder Bay, etc.

ALVEOLITES GOLDFUSSII, BILLINGS.

Undose, discoid expansions, with an imperfectly developed epitheca on the lower side, exhibiting the prostrate tube walls diverging from a central point of attachment. Orifices oblique to the surface, rarely denticulated at the margins, but interiorly, spinulose longitudinal crests are found well developed in polished sections. The tubes are seen in various degrees of compression in the same specimens; usually their transverse diameter is twice larger than their height, but sometimes tubes nearly as wide in one direction as in the other, and almost erect, as in an ordinary Favosites, can be observed. The size of the tubes is larger than in Alveolites squamosus, measuring in the larger diameter from one and a half to two millimeters.

Pores large, situated on the lateral edges of the tubes. Diaphragms well developed, irregularly oblique or straight transverse. Found in the Hamilton strata, of Thunder Bay region, near Sunken Lake; more common in the Hamilton group of Widder, C. W., and in the Hamilton strata of Iowa.

Plate XVII.—Fig. 2 gives a surface view of part of a specimen from Widder, C. W.

LIMARIA STEININGER.

Synon., CŒNITES EICHWALD.

Small branching stems or laminar expansions, composed of thick-walled, conico-cylindrical tubules, with transversely compressed orifices, opening obliquely to the surface, surrounded on the outer side by an exsinuated lip, bearing two teeth projecting into the cavity. From the median line of the inner side of the walls, another tooth-like crest projects between the two outer ones. The tubes are connected by lateral pores, and intersected by transverse diaphragms. The diaphragms are regularly found in the thin-walled tube portions, but are rarely developed in tubes with thickened walls.

From Alveolites Limaria ~~this~~ differs only by more conical, stout-walled tubes, of less compressed and more rounded form in the central or basal parts of the polyparia. The number of longitudinal crests is in Limaria more restricted than in Alveolites, and rarely exceeds three. The three dentiform projections at the orifices of Limaria are the only structural difference separating it from the genus Cladopora, which has smooth, not crested tube channels; there are also, however, in species of Cladopora indications of crests, and the generic arrangement of many of the species in question is more a matter of individual arbitration than based upon any obvious typical difference.

LIMARIA RAMULOSA, HALL.

Found in the Niagara group of Lockport, etc. I have not been able to find it in Michigan. Another form of ramulets, which, according to the denticulated structure of their tube orifices, belong to the

genus Limaria, is *Cladopora verticillata* of Winchell and Marcy. It is of common occurrence in the Niagara group of Indiana, Wisconsin, and Kentucky, but has not been met with in Michigan.

LIMARIA LAMINATA, HALL.

Thin, undose, laminar expansions covered by an epithecal crust on the lower side. Tubes stout-walled, forming a massive interstitial surface between the orifices, which is sometimes larger than a tube diameter, other times less. Orifices, if well formed, crescent-shaped and less than half a millimeter in diameter. The convex side of the crescent forms a more or less projecting lip, with two rather obscure, dentiform crests; on the concave side of the crescent another more conspicuous crest occupies the median line. The specimens exhibit on their surface at various intervals certain centres, around which the orifices are disposed in spirally twisted rows; the concave sides of the orifices are always directed toward these imaginary central points. Of common occurrence in the Niagara group of Drummond's Island, and at Point Detour, but many of the specimens have by silicification lost the finer details of structure.

Plate XVIII.—Fig. 2 represents a specimen from Point Detour, of natural size.

LIMARIA CRASSA, N. SP.

Grows in thick, laminar expansions, of undose surface, covered on the lower side by an epitheca. Often several such laminæ are superimposed, and sometimes two leaves stick together at the epithecal side, and a lamina with orifices on both sides is the result. Orifices variable in the same specimens. If normally formed they are kidney-shaped, separated by massive interstitial spaces formed by the thick tube walls. They open obliquely to the surface, with a lip on the outer margin. In other tubes the lip scarcely projects, and the orifices appear as an unsymmetrically oval opening surrounded by a massive interstitial surface. Often, also, the tubes are joined, with nearly erect, subangular, less thick-walled orifices. On the inner side of the walls a conspicuous crest projects from the median line, and on the outer walls two others of smaller size fork

over the opposite one; by a great thickening of the walls, the crests become obsolete. Pores are large and numerous. Diaphragms developed in the thinner-walled tubes. Found in the Niagara limestone of Point Detour, Drummond's Island, and in the exposures of the Niagara group along the shore of Lake Michigan, in the west part of the Upper Peninsula.

Plate XVIII.—Fig. 1 represents fragments from Point of Barques, on Lake Michigan (southwest of the mouth of Manistic River).

CLADOPORA, Hall.

Ramose and anastomosing stems or laminar expansions, with orifices on one or both sides, composed of thick-walled, elongate, conical tubules, opening obliquely to the surface, with dilated orifices. Tubules laterally connected by pores. Diaphragms have originally been denied by the author in his genus Cladopora, but their occasional development is proved by many actual observations, although usually the tube channels, in specimens, are found open throughout all their length.

The tube cavity of Cladopora is said to be destitute of longitudinal furrows or crests, in distinction from Limaria and Striatopora, but this is merely through habitual obsolescence of a character which properly belongs to the entire Favositoid family, and which in some of the most characteristic species of Cladopora has been recognized in rudimentary development.

CLADOPORA LAQUEATA, N. Sp.

Large, reticulated, horizontal expansions, formed of round or compressed elliptical stems, from two to four millimeters in diameter, with narrow, intervening loops of elongate, lanceolate form. Tubes very thick-walled. Orifices separated by broad interstitial spaces, transversely oval, somewhat dilated, nearly one millimeter wide in transverse direction, with a stout lip on the exterior margin; the interior margin impressed and confluent with the massive interstitial surface. Pores plainly discernible. Diaphragms sometimes noticeable, closing off the peripheral tube ends. By silicification the finer surface details of the specimens are generally much impaired.

Occurs in the Niagara group of Point Detour, and all along the exposures of the south shore of the Upper Peninsula.

Plate XVIII.—Fig. 3 represents a fragment of a large expansion in silicified condition. Found near Seul Choix, on shore of Lake Michigan. In mode of growth this species bears much resemblance to Cladopora reticulata, Hall; but the latter is a more delicately built species, with smaller, nearly circular tube orifices.

In the drift deposits of Michigan, specimens of *Cladopora multipora*, Hall, are often met with.

CLADOPORA LICHENOIDES, N. SP.

Irregularly undose, laminar expansions, covered by an epithecal crust on the lower side, which is formed by prostrate, flattened tubes, coalesced intimately and diverging horizontally from a central apex. Toward their peripheral ends the tubes bend into a suberect position and lose their flattened form, becoming rounded and dilated near the orifices. These are sometimes nearly upright, and join with acute margins, resembling an ordinary Favosites; at other times the obliquity of the orifices is more pronounced, and the outer tube margins form an arched projecting lip, while the inner margin merges into a narrow, common, interstitial surface. The flattened tubes, forming the base of the expansions, connect by numerous lateral pores situated on both edges; the erect, more rounded portions of the tubes have the pores irregularly dispersed over their circumference.

Diaphragms sparingly developed at irregular, remote intervals, often closing the peripheral tube ends, under the form of opercula. The tube cavity is generally smooth, without crests or longitudinal furrows, which induced me to place this species with Cladopora, and not with Alveolites, under which it might otherwise be classed with propriety. Found frequently in the drift of Michigan. It occurs in place in the corniferous limestone of the Falls of the Ohio, in Canada and New York, etc.

Plate XVII.—Fig. 1 gives a surface view of silicified specimens from the Falls of the Ohio. Fig. 4 is a specimen found in the drift of Ann Arbor, exhibiting the casts of tubes seen from the basal side of an expansion. The flattened form of the prostrate channels, with numerous short marginal pore connections, the gemmation of

young tubes from older ones, the disposition of distant diaphragms, the more rounded and dilating peripheral tube ends, bent into suberect position—all can be studied in such casts to much better advantage than in the most perfectly preserved specimens.

CLADOPORA FISHERI, Billings.

Synon., Alveolites Fisheri, Billings.

Palmate, laminar expansions, attached by a clumsy, massive root portion to other bodies. Orifices on both sides of the leaves, opening obliquely to the surface, with a sharp lip on the exterior side; the inner tube margin merges into a common interstitial surface, of variably broader or narrower extent. The thickness of the tube walls and the obliquity of the orifices vary much in different parts of the specimens, and accordingly the surface characters are quite changeable. On the terminal edges of the fronds the tubes are thin-walled and the orifices join with sharp, crested outlines. In the central and basal portions of the expansions, the walls are thickened, and the oblique orifices separated by intervening solid interstitial spaces, margined on the exterior side by a lip, which surrounds a transversely oval, or often a nearly circular mouth. Sometimes the orifices are not lipped, and form shallow, undefined depressions in the massive wall substance, at the bottom of which the narrower part of the tube channels begins. Again, these superficial pits are circumscribed by polygonal, carinated outlines. A difference also exists in the upper and lower surfaces of the fronds, which seem to have grown in horizontally spreading direction. The upper side is always marked by sharper, more projecting contour lines, while on the lower surface all the contours are dull and rounded.

The orifices are about one half a millimeter wide, or somewhat larger, oval or kidney-shaped on the external margin; the inner tube portions are round or subangular. Pore channels are large and numerous. Diaphragms frequently developed under the form of superficial opercula, frequently noticed also in the inner portions of the tube channels, but in specimens with very stout-walled tubes rarely observed. The original specimens described by Billings were found in the Hamilton group of Widder, C. W., in calcified con-

dition; identical, but silicified specimens occur in the Hamilton group of Thunder Bay, and in boulders of the drift which inclose other characteristic Hamilton fossils. Entirely similar specimens are found in the corniferous limestone of the Falls of the Ohio, and at Charleston Landing, Indiana.

Plate XIX.—Fig. 1 represents a silicified specimen from the drift of Ann Arbor. Fig. 4 is a specimen from the Hamilton group of Widder, C. W., the typical locality for Mr. Billings' specimens.

CLADOPORA CANADENSIS, N. Sp.

Palmate, laminar expansions, like the former species, with which it is found associated and agreeing in general structure. Tubes much smaller. Orifices at the ends of the fronds subrotund or triangular, with a convex, centrally indented lip on the outer side. On the stouter central and basal parts of the expansions, the lips are appressed, opening, transversal, fissure-like, or the lips have, besides the central indentation, two lateral ones, giving the orifices an arched, semi-lunar form. On the under side of the fronds the orifices are impressed into the massive interstitial wall substance, with a shallow depressed space surrounding them, which is defined by very obtuse rounded, subpolygonal outlines. On the upper surface, all is raised into stronger relief. Found in the Hamilton group of Widder, C. W.

Plate XIX.—Fig. 3 is a representation of one of these specimens.

CLADOPORA TURGIDA, N. Sp.

Stout laminar expansions, with orifices on both sides. Tubes thick-walled, with a narrow cylindrical channel, which dilates near the surface into transversely oval or kidney-shaped oblique orifices, spreading, with the inner part of the margins, into a common interstitial surface, on which, by slightly raised carinæ, the polygonal outlines of each tube are defined. The outer margin projects as a short lip sinuated on both sides, or simply straight. In well-preserved specimens, on the expanded part of the orifices, longitudinal furrows are faintly developed, as in the genus Striatopora. A difference is noticeable between the upper and under side of the fronds.

Pores well developed. Diaphragms rarely observed excepting as opercula. Diameter of orifice a little over one millimeter; internal tube portions half a millimeter. Found in the Helderberg group of Mackinac Island, at Port Colborne, C. W., and likewise in the drift of Ann Arbor.

Plate XIX.—Fig. 2 is a silicified fragment found in the drift of Ann Arbor.

CLADOPORA CRYPTODENS, Billings.

Alveolites cryptodens, Billings.

Cylindrical polyp stems, from five to ten millimeters in diameter, with distant, dichotomous, straddling ramification. Tubes opening with oblique dilated orifices, which either join with acute edges, each of them being a circumscribed pit, or have the inner part of the walls spread into an indefined, common interstitial surface, from which the convex lips forming the front margin of the orifices project like the teeth of a rasp. Tube size variable in different specimens; in the variety with larger tubes the transverse diameter of the dilated orifices is about one and a half millimeter, the interior cavity of the channels measuring about a half of one millimeter. In the variety with smaller tubes the orifices measure about one millimeter externally, and the internal channels one third of a millimeter. The tube cavities usually appear to be smooth, but in well-preserved silicified specimens, cleared by acids of the surrounding limestone, the tube channels exhibit three crests, two projecting from the exterior side of the wall, and one intermediate between the two, from the opposite inner wall side. These crests are not noticeable on the dilated orificial part of the tubes, but are distinctly seen in the neck of the channel, where the narrower part begins. Transverse diaphragms are rarely found developed. Pores are large and irregularly dispersed. The crested condition of the tube channels would bring this species under the genus Limaria, or perhaps under Alveolites, where Billings placed it, but, considering the general habitus of the specimens, I have placed them under Cladopora, as being nearest related to the forms composing this genus, which is only deprived of crests through the incomplete de-

velopment of a character typical for the whole family to which it belongs.

Found in the upper Helderberg limestones of Michigan, New York, Canada, and in the Western States; also common in the drift deposits of Michigan.

Plate XX.—Fig. 1 represents several fragments of branches with the larger tubes. Orifices somewhat variable in different branches. Fig. 2 is the variety with smaller tubes, corresponding in all particulars with the larger tubed form. All the specimens figured are selected from the Falls of the Ohio, as being better preserved than those from any other locality.

CLADOPORA ROEMERI, Billings.

Alveolites Roemeri, Billings.

Cylindrical or compressed branching stems of about five millimeters diameter. Orifices comparatively large, oblique to the surface, and joining with their expanded margins in an indefined interstitial surface, or under subangular, obtusely crested outlines, inclosing shallow, obliquely funnel-shaped pits, the outer margins of which project as arched lips; the inner walls of the pits spread insensibly, merging into the lips of the adjoining pits. External diameter of orifices about one millimeter; interior tube channel one third of a millimeter. The orifices are frequently closed by opercula situated below the external margins. Diaphragms in most of the specimens sparingly developed. Pores large and irregularly disposed.

Occurs in the Hamilton strata of Widder, Canada West, in calcified condition. Silicified specimens are found in the corniferous limestone and in boulders of that formation, mingled with the drift of the Southern Peninsula.

Plate XX.—Fig. 3 represents specimens from the typical locality of Widder, Canada West.

CLADOPORA ALPENENSIS, N. Sp.

Branching cylindrical stems, from five to ten millimeters in diameter. Orifices slightly oblique, dilated, joining under linear polygonal outlines on an even, narrow, interstitial surface; external

margins not projecting as a lip, excepting a small nodular projection in the centre of the outer margin, which gives the transversely widened, elliptical mouths a faint kidney shape. The inner expanded margin of the orifices is very delicately striate in radial direction. Diameter of orifices externally about one millimeter; internal tube cavity about half a millimeter wide. Diaphragms rarely noticed. Pores large and irregularly dispersed.

Found in silicified condition in the upper strata of the Hamilton group of Thunder Bay.

Plate XX.—Fig. 4 represents a few of the branchlets. The linear polygonal outlines of the tubes are recognizable in the figures; the striation of the margins is too delicate to be seen on them.

CLADOPORA LABIOSA, Billings.

Alveolites labiosa, Billings.

Small, branching, reticulated stems, from two to five millimeters in diameter, growing from an attached, massive root portion in horizontally spreading direction. Orifices oblique to the surface, subcircular, surrounded on the exterior side by a prominent convex lip; the interior part of the orificial tube walls spreads into an undefined, flat, interstitial surface. By wearing of the surface the lips often become deeply sinuated in the centre, and then the orifices are acutely triangular. In certain specimens considered to be a variety of this species, the closely crowded small orifices are surrounded by small pits impressed in the thick wall substance and open on the surface with less obliquity than in other specimens, and with only a small lip developed on the exterior margin. The size of the tubes differs somewhat in the specimens, but a more obvious difference in appearance is caused by the variations in the width of the interstitial spaces. In some specimens the orifices are separated by interstices less than the diameter of a tube, while in others the interstitial space is two or three times as large. In adult parts of stems the intervals between the orifices are always greater than they are near the terminal branchlets. The diameter of tubules at the orifices is about half of one millimeter; internally the channels are narrower. Within the cavity of some tubes, on the outer side of the walls, two crests can be noticed by looking into

the orifices, but in others of equally well-preserved specimens no crests are recognizable. Lateral pores well developed. Transverse diaphragms have not been observed. The casts of tubes often found in drift specimens are always uninterrupted, thread-like, laterally connected by short transverse bars representing the pores, and exhibiting the intercalation of new young tubules, connecting by a perforation at the apex with their mother-tubes.

Found abundantly in the drift of Michigan, in a porous cherty rock containing many other corniferous limestone fossils. In Canada and New York it is common in the corniferous limestone; occurs also at the Falls of the Ohio.

Plate XXI.—Fig. 2 represents a number of branchlets of variable form. The two lower figures on the left side are excepted; they are described under the name of *Cladopora rimosa;* but in the lower tier of this plate the smaller central specimen is considered as a variety of *Cladopora labiosa.*

CLADOPORA RIMOSA, N. SP.

Reticulated expansions of small teretiform or elliptically compressed stems, much resembling the former species. Orifice openings very oblique to the surface, transversely compressed, fissure-like, margined by a sharp closely-appressed lip on the outer side. Diameter of orifices in transverse direction from one half to two thirds of a millimeter; interior tube channels cylindrical and much narrower. Interstitial spaces large and flat. This form is the usual associate of Cladopora labiosa, and may perhaps be only a variety of that species; but the two forms are so constant, not merging into one another through transition forms, that I believe them to be distinct. Found in the drift of the Lower Peninsula.

Plate XXI.—Fig. 2, the two lower left-hand stems. The larger forked specimen is broken off from a disciform basal expansion incrusting the stem of a Cyathophyllum Hallii.

CLADOPORA PINGUIS, N. SP.

Horizontally expanded, branching and anastomosing stems of usually compressed elliptical form, but sometimes cylindrical. Diameter of stems from five to ten millimeters. Orifices in the older

stems subreniform shallow pits, impressed into a massive common wall substance, composing broad interstitial spaces. The actual tube opening, commencing at the bottom of these pits, is narrow, fissure-like, and margined by a small lip which does not project above the pit. In the ends of the branches the tube walls are less thickened, and the orifices not surrounded by pits, subcircular, margined by a moderately projecting convex lip. These terminal parts of the ramifications resemble the specimens figured as Clad. labiosa. The three right-hand branchlets and future collections may demonstrate the three last-described species to be only modifications of one; but for the present this direct affinity between them is not proved, wherefore I point them out as specifically distinct. Found associated with the other forms in the drift of the Lower Peninsula.

Plate XXI., Lower tier.—The two larger specimens were found in the drift of Ann Arbor, in a porous cherty rock, originating from decomposition of a siliceous limestone, of which sometimes an unaltered nucleus forms the centre of the boulders. The specimen in the centre below the two figures represents a variety of Cladopora labiosa.

CLADOPORA PULCHRA, N. SP.

Small cylindrical stems, from three to five millimeters in thickness, growing in reticulated ramifications, composed of thick-walled conical tubules, diverging in a curve from an imaginary longitudinal axis, opening almost at a rectangle to the surface, with circular orifices separated by interstitial walls wider than a tube diameter. The end of each tube either projects as a small monticulose protuberance above the general surface, and is defined from the adjoining tubes by delicate linear furrows circumscribing polygons, or the lower half only of each tube wall projects under the form of a low semicircular lip. In other specimens the single ends of the tubes do not project, and are not defined in their circumference, their orifices opening on the massive surface as simple circular perforations, surrounded at the outside by a shallow depressed area. Tube diameter at the orifices one third to one half millimeter, near the centre of the stems much narrower. Lateral pores numerous, in unequally dispersed position. Diaphragms sparingly developed. On the casts of the tubes which frequently occur in weathered drift

specimens, a cycle of longitudinal carinations is faintly visible. In its structure this elegant small species approaches Favosites limitaris, which could likewise be not inappropriately arranged under the genus Cladopora. The thick-walled conical tubes, the greater obliquity of the orifices to the surface, with a sometimes well-developed prominent lip, bring this form nearer to the Cladopora type than to Favosites. Very common in the drift boulders of the corniferous formation in Michigan ; it occurs in place in the Helderberg limestones of Canada, and at the Falls of the Ohio, near Louisville.

Plate XXI.—Fig. 1 represents a number of variations, amongst which are found stems with smaller tubes and with larger tubes, with projecting monticulose orifices and with lipped mouths, or with massive surface of the stems, with the orifices impressed as shallow pits. Some of the stems represented exhibit also sharp, linear, polygonal furrows circumscribing the tubes.

CLADOPORA ROBUSTA, N. SP.

Palmato-ramose, occasionally reticulated stems, of round or compressed elliptical form, growing in horizontal expansions, spreading sometimes over the space of several square feet. Stems attaining a thickness of from one to two centimeters. Tube openings oblique to the surface, with gently dilating orifices, joining under subacute margins, by which the surface is divided into a network of rhomboidal spaces with rounded corners. The lower angle of the rhomboids is formed by the projecting semicircular lips of the orifices, which, by wearing off, become emarginated and acutely triangular in shape. Transverse diameter of orifices about one millimeter, in other varieties smaller. Diameter of tube channels below the peripheral surface one quarter to one half of a millimeter. Tube walls stout, thickening near the periphery. Lateral pores distant. Diaphragms sometimes observed, but not developed in the majority of the specimens. Several varieties, in manner of growth and size of tubes, can be distinguished.

Found in the corniferous limestone and in the Hamilton group. The Hamilton specimens occur in the vicinity of Alpena, on Thunder Bay ; the specimens of the corniferous strata are frequently found in the drift of Michigan, but the Falls of the Ohio is the locality where this species can be found in greatest perfection and in

greatest abundance. The represented specimens are from that locality.

Plate XXII.—Fig. 1 represents two silicified branches with larger tubes. Fig. 2 is a branch of smaller tube size.

CLADOPORA IMBRICATA, N. SP.

Cylindrical ramified stems, attaining a diameter of two centimeters, attached by a massive basal expansion. Tubes opening very obliquely to the surface, with narrow, transversely compressed orifices, joining under rhomboidal outlines. The sharp subarcuate lips forming the exterior margin of the orifices are closely appressed to the body of the stems, and arranged in an imbricating order like the scales of a fish.

Transverse diameter of orifices two millimeters by a width of only half a millimeter across the centre of the lanceolate mouths. Internally the tube cavity becomes nearly circular and much narrower, not over half a millimeter in diameter. Pores distant. Diaphragms have not been observed. Some specimens found in the drift of Michigan seem to belong to this species, which is not uncommon in the Helderberg limestones at the Falls of the Ohio.

On Plate XXII., lower row, the two outer stems on the right-hand side are figures of silicified specimens found at the Falls of the Ohio.

The next two species described, found in the Helderberg limestones at the Falls of the Ohio, have not been recognized in the strata of Michigan, but in order to give the description of this tribe of corals more completeness, I have allowed myself, in behalf of science, to transgress a step beyond the prescribed limits. It is very probable, however, that future collectors will find these forms in Michigan.

CLADOPORA ASPERA, N. SP.

Cylindrical stems, from one to two centimeters in thickness, growing in horizontally spreading, reticulated ramifications, which are attached by a massive basal expansion. The tubes composing the basal part are prostrate, diverging toward the circumference of the disk; the orifices are compressed, fissure-like, covered by a scaly, flat

lip, while the inner part of the walls forms an undefined, common interstitial surface. The orifices of the stems are of quite different shape; their tubes diverge from an imaginary axal line in an ascending curve toward the periphery of the stems, opening there in various degrees of obliquity, under crested polygonal outlines, which inclose shallow conical pits, at the bottom of which the tube channels open as narrow, transverse, more or less curved fissures, about one millimeter wide in the longer direction, and one quarter of a millimeter in the shorter. The body side of these pits is formed of spreading walls, which help to form the front part of the orifices next above. The outer half of the pits is formed by the obliquely truncated ends of the extremely massive tube walls, and projects under the form of a clumsy lip, giving the stems a very rough appearance. The outer transverse diameter of the orificial pits is nearly two millimeters; the compressed, band-like tube channels become circular at short distance in from the peripheral ends, and are about one third of a millimeter in width. Pore channels distant. Diaphragms have not been noticed.

Plate XXII., Lower tier.—Upper third figure from the right side represents a silicified fragment of a reticulated expansion, from the Falls of the Ohio.

CLADOPORA EXPATIATA, N. SP.

Reticulated expansions of cylindrical or compressed palmate stems, of a diameter from one to two centimeters, attached by a massive basal expansion. Tubes of the basal part diverging outward, prostrate, and more compressed than those of the stems, with a sharp scaly lip at the outer margin. Tube walls generally very stout. Orifices of the stems variable in the same specimens. Usually they open with no great obliquity to the surface, and join under irregular, polygonal crested outlines inclosing deep conical cell pits, narrowing into cylindrical tube channels. The dilated margins are not converted on the outer side into a lip, but form a uniform network, as in a Favosites. Often also, by incrassation of the tube walls, the cell pits become partly filled, and shallower in the expanded marginal portion, while the crests of their circumference are rounded off. In other specimens the tubes open with greater obliquity to the surface, and do not join with crested margins encir-

cling orificial pits, but the body portion of the orificial walls spreads into a common interstitial surface, and the front walls project as sharp semicircular lips. Transitions from one of the surface characters described into the other can be followed out in nearly every larger specimen. The end branches generally differ somewhat from the older stems, and the orifices of the upper surface of the prostrate expansions are not quite alike to those of the under side. The dilated orificial pits are nearly always wider in the transverse direction of the stems than in the vertical; their diameter is about one and a half millimeter; that of the inner tube channels about one third to one half millimeter. Pores distant. Diaphragms sparingly developed. From the former species, this one differs in having smaller tubes, and less compressed, nearly circular orificial openings; but great similarity exists between them, and by reason of the great variability in the surface structure of both, it is sometimes hard to tell to which class certain specimens belong.

Plate XXII., Lower row.—The three left-hand figures are silicified fragments from the Falls of the Ohio, representing a few of the modifications in which the species occurs.

STRIATOPORA, Hall.

Ramose stems, composed of thick-walled conical tubes, opening on the surface with oblique dilated orifices, in all particulars corresponding with the structure of Cladopora, from which they mainly differ by a cycle of longitudinal furrows radiating across the expanded tube margins, a difference which, as previously remarked, is not at all peculiar to Striatopora, but belongs to the essential family characters of all Favositoids, and happens to be more obviously developed in the forms called Striatopora than in the next related Cladopora. In addition to the longitudinal furrows, the intermediate band-like spaces also sometimes bear rows of spinules; and as another peculiarity in Striatopora, the abundant development of lateral pores may be mentioned.

STRIATOPORA HURONENSIS, N. Sp.

A single fragment of a stem eight millimeters in diameter is the only specimen I have seen; but as being one of the first representa-

tives of the genus, and positively differing from Striatopora flexuosa, Hall, found in the same geological horizon, I thought it proper to describe even a fragment when well characterized.

Orifices obliquely funnel-shaped, joining with edged margins. The body side of the orificial walls is spreading and forms part of the exterior walls of the orifices above; the outer side of the oblique orificial funnels is margined by an erect semicircular lip. Diameter of orifices in transverse direction two millimeters; in longitudinal three millimeters. Twelve deep longitudinal furrows, with intermediate obtuse crests, give the cells a star form. The tubes are distinctly intersected by diaphragms with marginal depressions. Pores are somewhat obscured by the rough silicified surface of the specimen, but are recognizable. Found in the Niagara group of Point Detour, Lake Huron.

Plate XXIV.—Fig. 2 upper fragment, natural size. *Striatopora flexuosa*, Hall, has not been observed among the fossils of the Niagara group in Michigan.

STRIATOPORA RUGOSA, Hall.

Synon., Cyathophora Iowensis, Owen.

Stems with dichotomous branches, from five to ten millimeters in diameter, composed of very thick-walled tubes opening obliquely to the surface, with dilated mouths, bounded on the exterior side by a prominent semicircular lip. The inner body side of the walls of the orifices is flattened, spreading into a common, broad, interstitial mass. Diameter of orifices two millimeters; of interior channels one millimeter. Pores large, distant. Diaphragms not observed. The radial striæ are, in all the numerous specimens which I have examined, totally obsolete, for which reason this form would have a more appropriate place under the genus Cladopora.

Occurs frequently in the Hamilton strata of Thunder Bay, and is found in the drift.

Plate XXIV., Fig. 2—The ~~central~~ left figure represents a stem from Thunder Bay.

STRIATOPORA CAVERNOSA, N. SP.

Stunted ramifications of cylindrical or compressed stems, from one to two centimeters in diameter. Tubes large, in comparison with the size of the stems, and very unequal through the frequent intercalation of young tubes. Orifices oblique to the surface, rounded, or of irregular shape, joining with obtusely edged stout walls. They form gradually dilating, spacious, deep funnels, which are longitudinally grooved by a cycle of twelve well-marked striæ. A remarkable abundance of large irregularly dispersed pores perforates the tube walls within the orificial funnels, and even close to their external edges. Diaphragms flat, well developed. Diameter of full-grown tubes at the orificial ends from two to three millimeters; internal tube cavities one millimeter wide. Occurs in the drift of Michigan, associated with corniferous limestone fossils, and is found in place in the corniferous limestones of Port Colborne, Canada West; rarely also at the Falls of the Ohio.

On Plate XXIII., Fig. 3, are small silicified fragments found in the drift of Ann Arbor.

STRIATOPORA LINNÆANA, BILLINGS.

Dichotomously branching stems, from a few millimeters to one centimeter in diameter. Orifices moderately oblique to the surface, joining under acute polygonal margins, which inclose funnel-shaped orifices, and project on their outer margin as prominent lips. Tubes very unequal in size, through the frequent intercalation of young tubes. Orificial margins grooved by a cycle of twelve deep furrows, and the interstitial, band-like spaces are decorated with longitudinal rows of spinules, which in the narrower neck portion of the tube channels project as stelliform radii. Pores large and very abundant, perforating also the expanded parts of the orificial walls. Diaphragms well developed in some of the specimens. Diameter of the peripheral tube margins about two millimeters; of interior parts one millimeter or less.

Occurs in the Hamilton group of Thunder Bay in silicified condition, and at Widder, in Canada West, in calcified form.

Plate XXIII., Fig. 5.—The three upper specimens were found at Thunder Bay, near Alpena; the three lower specimens are from Widder, Canada West. Fig. 6 of the same plate represents a larger form, found in the corniferous limestone of the Falls of the Ohio, which does not seem to differ much from the Hamilton form, except by a more robust growth, and by less definitely circumscribed orifices.

DENDROPORA, MICHELIN.

The corals, one of which is described by Michelin under the name of Dendropora, have been placed by Milne-Edwards with the sub-order Seriatoporinæ, through misapprehension of their structure, attributing to them a central columella which does not exist. Their structure is in all essential points identical with the Favositinæ. Milne-Edwards divides these forms into three genera: Dendropora, Rhabdopora, and Trachypora, according to certain surface characters which I have not considered important enough to justify the separation. In the following pages, therefore, I use the name Dendropora for all of them, and give the subjoined definition of the term *Dendropora:*

Branching and frequently reticulated stems, variable in diameter from one millimeter to more than one inch. The stems are attached to other bodies by an incrusting basal expansion; they are composed of very thick-walled, intimately united conical tubules, diverging from an imaginary axal centre in ascending curves. The tube channels are laterally connected by pore channels and transversely septate by diaphragms. The interior tube ends are only moderately thick-walled, but in approaching the periphery the walls thicken very much by the addition of concentric layers within the expanding channels, and constitute by their intimate union a broad interstitial surface separating the orifices. In some forms this interstitial surface is covered by spinulose ridges and granulations; in others by flexuose longitudinal rugæ, or by a combination of both granules and rugæ, with intermediate punctiform or short fissure-like porosities, which are not cell spaces of an independent tissue element, but are merely superficial punctations and engravings of the substance of the tube walls. The orifices usually project with their margins above the general surface, but sometimes

they appear as impressed pits, or have at least no projecting rim. Their form is either circular or elongate elliptical. Sometimes they are disposed in regular longitudinal rows on the stems, but are also often irregularly dispersed. The obliquity of the tube mouths to the surface is variable, and in some species they open almost rectangularly to it. In a part of the species the tube channels are longitudinally striate, as in Striatopora, but usually this striation is obscure.

DENDROPORA ORNATA, N. SP.

Circular stems, from one to two centimeters in diameter, with dichotomous ramification. Orifices circular or oval, rising above the surface by a monticulose circumvallation, or nearly even with it, of unequal size and irregularly dispersed over the massive interstitial surface of the stems, which is usually wider than a tube diameter, with exception of the ends of the stems, where the orifices are separated by comparatively narrow intermediate walls. The interstitial surface is decorated by granules and short ridges disposed in loose radial order around the circumference of the orifices. Peripheral diameter of orifices about one and a half millimeter; within they gradually contract to a diameter of not more than half a millimeter. The terminal ends of the branches have somewhat larger orifices with thinner walls, greater obliquity to the surface, and are surrounded by a more or less projecting lip on the exterior side, as in the case of specimens of Cladopora or Striatopora, from which these parts differ only by the granulated edges of the interstitial walls. In polished vertical sections, through calcified stems, the tubes are found to be decorated with a cycle of longitudinal rows of spinules, and the development of distant transverse diaphragms and of large connecting pores can likewise be ascertained. Found rarely in the Hamilton group of Thunder Bay, but very common in the Hamilton strata of New York, at Darien, Eighteen-Mile Creek, Seneca Lake, etc.; at Widder, in Canada, it also sparingly occurs.

Plate XXIII.—Fig. 1 represents specimens from Darien, in calcified condition.

Plate XXIV., Fig. 2.—Figure to the right is a young silicified branchlet found at Alpena, Mich. It exhibits a scar of attachment at the lower end. The ends of the branches are formed

of thin-walled tubes with nearly contiguous orifices. The granulose decorations of the interstitial surface are obscure in this specimen.

DENDROPORA NEGLECTA, N. SP.

(Compare *Favosites polymorpha*, Billings, *Canad. Journ.*, 1859, p. 111, Fig. 12, with exclusion of the other figures.)

Stems from five millimeters to two centimeters in diameter, with irregularly straddling branches. Orifices very unequal, circular or oval, narrow, funnel-shaped, oblique, or almost rectangular to the surface, surrounded by a prominent rim, or nearly even with the interstitial surface, which is quite spacious and decorated with ridges and granulations as in the former species. Many of the stems, however, are nearly smooth on the surface, either through the wearing off of the decorations or through original want of their development. Older stems are sometimes found with nearly solid surface, the orifices having become narrowed to minute punctiform openings by excessive incrassation of the tube walls. The central portions of the stems are always formed by thinner-walled tubes or tube ends, with subangular outlines and of regular Favosites structure, having connecting pores, transverse diaphragms, and being longitudinally striate by faint spinulose ridges.

Found in the drift of Michigan, associated with other fossils of the corniferous limestone formation. It is found in place at Port Colborne, Canada, at Caledonia, N. Y., and at the Falls of the Ohio. At the latter place some large stems, over one inch in diameter, are found, which are usually much altered by silicification ; but most of these specimens have, on small circumscribed spots of the stems, the surface characters finely preserved, and exhibit longitudinally oval, funnel-shaped orifices of equal size, two millimeters in length and one and a half in transverse direction. The broad interstitial surface is either smooth or decorated with obtuse papilli. Lateral pores and transverse diaphragms distinctly observable. These may constitute a different species from the former.

Plate XXIII.—Fig. 4 represents silicified stems of the usual form found in the drift in Michigan, and in the corniferous limestone of Port Colborne ; the outer stem on the right side is altered by thick-

ening of the tube walls, but in other specimens the alteration reaches a still higher degree.

DENDROPORA ELEGANTULA, Billings.

Synon., Trachypora Elegantula, Billings.

Small ramified stems, from two to five millimeters in diameter. Orifices longitudinally oval, oblique, effuse above, the remainder of the circumference being edged by a projecting rim; they are arranged in four longitudinal rows on the stems, but often the regularity of the rows is disturbed by interposition of single orifices in the intervals between. Interstitial spaces broad, decorated with flexuose and interlacing rugæ, covered by delicate granules, and rendered minutely porous by a superficial punctiform and fissure-like perforation of the wall substance. On the surface the walls of the single tubes are quite undefined, while in the centre of the stems the walls are much thinner, and are well defined from one another, exhibiting lateral connecting pores and transverse diaphragms. The bottom of the conically dilating orifices is generally formed of a stout obliquely situated diaphragm. Diameter of orifices in transverse direction one millimeter; in longitudinal one and a half millimeter; internal tube cavity much narrower.

Occurs rarely in the Hamilton group of Thunder Bay, near Broadwell's mills, where it is associated with several other species of Dendropora. The specimens represented on Plate XXIII., Fig. 2, are from the Hamilton group of Widder, C. W., the locality from which Billings described his original specimens.

DENDROPORA ALTERNANS.

Stems of about four millimeters in diameter, with remote oval orifices in quincuncial position, forming about five loose, alternating, longitudinal rows in the circumference of a stem. Diameter of orifices lengthwise from one and a half to two millimeters, and one millimeter in transverse direction. Margins raised into an obtuse circumvallation. Surface minutely punctate by acutely pointed granules, but not ornamented with longitudinal rugæ. Occurs associated

with the former species in the Hamilton group of Thunder Bay River, near Broadwell's mills.

Plate XXIV., Fig. 1.—The two larger stems on the upper rock-piece are representations of this form in natural size.

In the upper right-hand corner of the same piece a small, flat, basal expansion and a stem of another smaller species of Dendropora are represented. The tubes of these are arranged in distant, irregularly quincuncial order; the interstitial surface exhibits the same ornamentations by rugæ as Dendropora elegantula, but the species is, on the whole, smaller, and the arrangement of the tubes is different.

The material at my command is not sufficient to enable me to give full characteristics of the latter kind, but I think it is specifically a distinct form.

DENDROPORA PROBOSCIDALIS, N. Sp.

Small reticulated branchlets, not much over one millimeter in diameter. Orifices forming proboscidal, spoon-like projections, disposed in five or six longitudinal alternating rows on the circumference of the stems, or of more irregularly dispersed position. Interstitial surface longitudinally rugose, and dotted by punctiform and fissure-like porosities. Diameter of orifices about one third of a millimeter. Occurs with the former at Broadwell's mills; rarely also at Partridge Point, Thunder Bay, in the highest beds of the formation.

Plate XXIV., Fig. 4.—The ~~upper~~ lower group of stems, ~~except the two on the left side,~~ gives a magnified view of the branchlets. Enlargement two diameters.

DENDROPORA (?) RETICULATA, N. Sp.

With doubt I arranged, under the genus Dendropora, the coral of which a description follows: Reticulated horizontal expansions of small cylindrical stems about two millimeters in diameter, composed of moderately thick-walled conical tubules, the outlines of which in their longitudinal extension can be distinctly seen. Orifices erect, circular, with free margins. Stems similar to Aulopora spicata of

Goldfuss, in external structure, but more minute, the diameter of the tubes being only one third to one half millimeter. Interstitial surface smooth, neither rugose nor granulose. Found in the upper strata of the Hamilton group at Partridge Point, and in the lower beds on Thunder Bay River, at Broadwell's mills.

Plate XXIV., Fig. 1.—The lower piece represents a reticulated expansion from Partridge Point, Thunder Bay. On the same plate, Fig. 4, the ~~lower~~ upper row of stems ~~and the two stems on left side of the upper row are~~ magnified fragments (two diameters) of the same kind, found at Broadwell's mills, on Thunder Bay River.

THECIA, Milne-Edwards.

Massive or rarely dendroid polyparia with the general structure of Favosites. Tube walls very thick, forming, by their junction under defined polygonal outlines, solid interstitial spaces as wide or even wider than a tube diameter; sometimes, however, the walls do not exceed in thickness those of an ordinary Favosites, and the dilated tube margins join with edged polygonal margins. Tubes radiated by twelve spinulose, longitudinal crests almost extending to the centre, with intermediate, narrow, linear furrows. The internal crests of the orifices are sometimes prolongated externally, and extend as low radial rugæ across the surface of the interstitial spaces from one tube into the other; or the interstices, if large, are irregularly granulose on the surface. Transverse diaphragms well developed, flat or convex, projecting within the orifices as a central boss and covered with spinules or granules like the other surface of the tube cavity. Lateral pores large and abundant. Tubes frequently subject to incrassation at the expense of the lumen of the tube cavities, while the pore channels retain their original diameter and become longer. The external appearance of such specimens becomes thereby considerably altered, and in silicified specimens, in which the silex is deposited in the peculiar concentric, annular dots so often noticed, the structure becomes so much obscured that it would be impossible to recognize their true nature if it were not that other, better preserved specimens, only partially altered in this way, can be found amongst them. The genus Protaræa of Milne-Edwards,

placed by him with the Zoantharia perforata, is intimately related to Thecia. It is composed of short conical tubules, communicating by lateral pores, radiated by twelve granuloso-spinulose crests, and intersected by convex diaphragms of spinulose surface. The tubules are incrusting and never attain any great length.

THECIA MAJOR, N. SP.

(Compare Favosites Forbesii. Roemer, Silur. Fauna of Tennessee.)

Discoid, lenticular expansions, covered on the lower side by a concentrically wrinkled epitheca, with diverging striæ, indicating the outlines of procumbent tubes, which bend into an erect position before they open on the upper surface of the disks. Diameter of tubes two millimeters, joining under well-marked, obtusely crested, polygonal margins, which inclose dilated orificial pits. Walls stout, but variable in thickness in different portions of the same specimens. Twelve radial crests extend half way to the centre; their edges are decorated with two rows of granulose spinules. Diaphragms numerous, partially flat, partially convex, forming a monticulose projection with spinulose or granulose surface. Pores large and abundant. Occurs in the Niagara group of Drummond's Island, Point Detour, and in many other localities on the south shore of the Upper Peninsula. Found also in abundance at Charleston Landing, Indiana; at Louisville, Ky., and in many Niagara outcrops of the West.

Plate XXV.—Fig. 1, specimens in calcified condition seen from the upper and lower side, both from Charleston Landing, Indiana. Fig. 2 represents a silicified specimen found at Point of Barques, on Lake Michigan. The upper end of the specimen exhibits well-preserved tube orifices with radial crests, convex diaphragms, spinulose surface decorations, etc.; the lower portion is formed of tube casts with flat diaphragms, crenulated at the circumference by the indentations made by the radial crests of the walls; the perfect correspondence of the structure of Thecia with Favosites is most beautifully to be seen in the represented specimen.

THECIA MINOR, N. SP.

(*Vide* Roemer, Silur. Fauna of Tennessee, Tb. 2, Fig. 4.)

THECIA SWINDERIANA.

General structure perfectly conformable with the former species. Discoid expansions covered on the lower side by an epitheca, concentrically wrinkled, and exhibiting the prostrate tube channels diverging from the centre. The main difference between the two forms lies only in the size of their tubes, which in this latter form is only one millimeter instead of two, as in the former. The specimens vary considerably in their surface characters. Some have only moderately stout tube walls, and join with gently dilating mouths under edged polygonal margins. With the increase of the thickness of the walls the orifices lose their circumscribed form, and the thickened walls combine into a common, broad, interstitial surface impressed with small, circular, radiated cell pits. The radial crests often extend across the interstitial spaces from one orifice into the other as superficial rugæ, mingling with additional irregular rugæ and granulations by which the interstitial surface is decorated. By a still greater degree of incrassation of the tube walls the orifices become almost closed, punctiform, while the lateral pore channels remain as large as ever, and prolongate in proportion to the thickening of the wall substance. Such specimens appear as massive expansions, perforated by horizontal vermicular channels, of stelliform arrangement around the narrow, punctiform, central tube channels in vertical position, and their identity with the other well-formed specimens would scarcely be supposed, if all possible gradations from normally formed ones to the disfigured altered specimens were not plentifully found associated with them. Found at Point Detour, Drummond's Island, and in other Niagara outcrops, in association with the former species; occurs also in the drift of the Lower Peninsula, and in the Niagara group of Indiana and Kentucky.

Plate XXV.—Fig. 3 represents a calcified specimen found at Louisville, Ky.; the Michigan specimens are all silicified, with not nearly so well-preserved surface characters.

THECIA RAMOSA, N. SP.

Stout, branching, and sometimes reticulated, anastomosing stems, from half an inch to two inches in diameter, composed of thick-walled, conico-cylindrical tubes ascending and diverging from a central imaginary axis. Orifices unequal, of polygonal form, from one to two millimeters wide at the edges of the dilating margins, radiated by twelve prominent spinulose crests, extending through the whole length of the channels. Transverse diaphragms partly simple and complete, partly incomplete, represented by lateral squamiform, horizontal leaflets. Pores large and very numerous. Older stems are often much altered in appearance by excessive thickening of their tube walls, and contraction of the tube channels, with obliteration of the radial crests. It is sometimes difficult to distinguish them from similarly altered stems of Favosites radiciformis, with which they are found associated. Occurs in the upper Helderberg strata of Mackinac Island, and is not uncommon in drift boulders on the Southern Peninsula of Michigan. It is found in great perfection and frequency in the Helderberg limestones of the Falls of the Ohio. The silicified specimens represented on Plate XXV., Fig. 4, are from the latter mentioned locality.

VERMIPORA, HALL.

(Twenty-sixth Annual Report of the State Cabinet.)

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

Mr. Hall places these forms with the Bryozoa, and gives of their structure a description different from mine. He has overlooked

the principal Favositoid characters of the tubes, *diaphragms*, and *lateral pores*, but I think these organs can be found in his specimens as well as in those I have under consideration.

VERMIPORA NIAGARENSIS, N. SP.

Short club-shaped branchlets about one centimeter in thickness. Tubules half a millimeter wide, slowly diverging from an imaginary central axis in a curve. The outer free end of the tubes is more abruptly bent, and opens rectangularly to the surface of the stems. In the interior of the stems the tubes are polygonal by mutual pressure; the free ends are perfectly circular, annulated by delicate wrinkles of growth, and in some a faint longitudinal striation is observable. Transverse diaphragms flat and distant. Pores large, irregularly dispersed. Found in the Niagara group of Point Detour, Lake Huron, and in Iowa, near Masonville.

Plate XXIV., Fig. 3.—Lower figures are specimens from the Niagara group of Masonville, Iowa, magnified about two diameters.

VERMIPORA FASCICULATA, N. SP.

Small branching stems, from two to five millimeters in diameter; tubules one half millimeter wide, ascending in almost parallel fascicules in the stems, until their ends, with an abrupt bend outward, become free. Diaphragms, intersecting the tubes and connecting pores, are plainly observable, as well as the intercalation of new tubes by lateral gemmation.

Found in the Hamilton group of Thunder Bay, and frequently in boulders of the drift, which, according to the rock character and associated fossils, belong to the corniferous limestone formation.

Plate XXIV., Fig. 3.—The upper specimens artificially crowded together. A part of them represents specimens of the corniferous limestone found in the drift; the outer specimen on the right-hand side and the slender central stem are from the Hamilton group of Alpena. Magnified two diameters.

QUENSTEDTIA, N. GEN.

Single cylindrical tubules, multiplying by lateral gemmation of either single tubes, or many at once, surrounding the mother-tube in a verticil, and remaining for a while in close contact with it, and amongst themselves. After some distance the young tubes bend outward with their ends, which separate and become free diverging branches, which, in their turn, again become mother-tubes by renewed gemmation. The tubes are intersected by remote transverse diaphragms. In places of contiguity they connect by lateral pore channels, and in well-preserved specimens longitudinal rows of spinulose crests project from the inner side of the tube walls.

QUENSTEDTIA UMBELLIFERA.

Synon., AULOPORA UMBELLIFERA, Billings.

AULOPORA CORNUTA, Billings.

Tubules about two millimeters in diameter, delicately annulated by wrinkles of growth. At variable intervals, single tubes, or from six to twelve in a verticil, sprout from their sides and remain closely attached to them and to one another for the length of about five millimeters, when they bend outward and separate, radially diverging as free branches, which themselves soon throw out new verticils. The central tube always grows straight on, at intervals, continuing to gemmate. Loose stems with a verticil of branches at the end have remote resemblance to a small Crinoid head on its stem. Within the circle of branch tubes the central tube is generally dilated by a bulbiform inflation. The basal apices of the young tubes do not communicate with the older tube by simply opening into it, but by a narrow circular pore, narrower than the entire width of the channels. Besides these connections with the basis, the young tubes connect by lateral pore channels with the old tube, and laterally also among themselves. Diaphragms are quite distant, and not always observable; the longitudinal rows of spinules also are only noticed in very favorably preserved specimens but are sometimes very well developed. By

examination of larger clusters it can be ascertained that the same stems which usually send forth verticillate branches often also give off single or only two or three branches. Mr. Billings considers these as a different species, and names them Aulopora cornuta, but frequently both forms are often seen as parts of one and the same colony of stems.

Found in the drift of Michigan, associated with fossils of the corniferous limestone. It is common in the corniferous limestone of Port Colborne, C. W. I also discovered several specimens fully identical with the form of the corniferous limestone, in the Hamilton group of Thunder Bay.

Plate XXXIII., Fig. 3.—The upper figures grouped together are specimens from the drift, natural size.

QUENSTEDTIA NIAGARENSIS.

Tubes fully two millimeters in diameter, branching from a mother-tube in irregular clusters, and diverging after a short space of contiguity with production of new lateral tubes. Lateral pores are large and surrounded by a projecting rim. Longitudinal crests, or rather rows of spinules, distinctly seen. Diaphragms are not preserved in the specimens from Michigan ; others found in Iowa exhibit them. Found in the Niagara group of Point Detour, Lake Huron, and at Masonville, Iowa.

Plate XXXIII., Fig. 3.—Lower solitary specimen, found at Point Detour.

MICHELINIA, De Koninck.

Including Chonostegites, Milne-Edwards.

Compound polyparia formed of elongate, conical tubes, intimately connected in their whole length, or in rare instances with the contiguity interrupted at intervals by constrictions. The tube channels are in places of contiguity connected by lateral pores ; their cavity is intersected by a succession of diaphragms of compound, irregularly vesiculose structure, and the sides of the tubes are longitudinally striate by numerous linear furrows, with intermediate rows of spinu-

lose prominences. This structure is in general conformity with the structure of Favosites, from which it differs in the vesiculose nature of the diaphragms, and in having a much greater number of longitudinal furrows. In Favosites these never exceed the number 12, but in Michelinia they are more than double that number. The tubes of Michelinia are usually also of much larger size than in Favosites. The genus Michelinia appears nearly contemporaneous with Favosites in the upper Silurian strata. A small nummiform species, which to my knowledge has not yet been described, occurs in the Niagara group of Tennessee. Another somewhat larger but very similar form is found in the lower Helderberg strata of Schoharie County, N. Y., which is described by Mr. Hall under the name of Michelinia lenticularis. None of these have been found in Michigan. The Devonian formation contains a variety of forms, nearly all of which are represented in Michigan. Formerly the casts of small specimens of Michelinia were through misapprehension classed under the name of Pleurodictyum problematicum, as being a fossil of peculiar organization. I have exposed this error in an article published in 1862 in *Silliman's Journal.*

MICHELINIA CONVEXA, D'ORBIGNY.

Hemispherical masses, with a depressed, turbinate, discoid under side, covered by a concentrically wrinkled epitheca, formed of diverging, large, conical tubes of unequal size and of rounded-polygonal outlines, the larger ones attaining a diameter of one centimeter; walls stout. Transverse diaphragms globoso-convex, composed of larger and smaller irregularly interlacing vesiculose plates. Vertical furrows in the circumference of a tube about forty, with intermediate rows of short, spinulose projections. The surface of the diaphragms is generally smooth; in rare instances they are covered with granular prominences. Pore openings small, surrounded by a projecting rim, irregularly dispersed, and in some parts much more crowded than in others. Found in the drift, associated with corniferous limestone fossils in silicified condition. Very common in the corniferous limestone of Port Colborne, C. W.

Plate XXVI.—Fig. 1, view from above; Fig. 2, view of the lower side of silicified specimens from Port Colborne.

MICHELINIA CYLINDRICA, Milne-Edwards.

Synon., Emmonsia cylindrica, Milne-Edwards.

Michelinia intermittens, Billings in parte.

Synon., Favosites Maximus, Troost.

Large, convex masses, formed of slowly diverging, subparallel, obtusely polygonal, sometimes circular tubes of unequal size, from five to seven millimeters in diameter. The tubes have either straight walls, or are at regular, short intervals constricted by ring-like carinæ projecting into the tube cavity. The carinæ, caused by constriction of the walls, correspond with each other in the adjacent tubes, but the contiguity of the tubes is usually not interrupted by them. The tubes with straight walls are polygonal in outlines; those with constrictions are circular; transitions from one form into the other are noticeable, sometimes in the same specimens. Inner surface of tubes longitudinally striate and densely covered with irregularly dispersed, spinulose projections, which also spread over the surface of the diaphragms. Diaphragms compound, of interlaced, vesiculose plates, not near so convex as in the former species, and in close approximation. Lateral pores very irregular, and of different sizes; in the specimens with constricted tubes they are confined to the dilated parts, interstitial between the annular, projecting carinæ. Occurs with the other species in the drift deposits of Michigan; it is the most common species of the genus at the Falls of the Ohio, and is found in many localities of Ohio and Indiana.

Plate XXVI.—Fig. 3 gives a side view of a silicified specimen from the Falls of the Ohio. Fig. 4 is a surface view of a large, convex mass from the same locality.

MICHELINIA FAVOSITOIDEA, Billings.

Convex masses of diverging, intimately united, polygonal tubes, of unequal size, from three to five millimeters in diameter. Basal part

broadly attached with the centre; marginal parts free and covered by an epitheca. Diaphragms nearly flat, often simple, and scarcely vesiculose, closely approximated; other times the vesiculose character is more pronounced. Pores small, irregularly distributed. Longitudinal striæ and spinulose rows much more delicate and minute than in the other species.

Found in the drift of Michigan, and in the corniferous limestone of Canada and New York.

Plate XXVII.—Fig. 4 represents a silicified specimen found in the drift of Ann Arbor.

MICHELINIA INSIGNIS, N. SP.

Lenticular convex disks of large size, formed of diverging tubes, prostrate on the lower side, and composing by their united walls an epithecal crust with diverging, radial rugæ, and with annular, concentric wrinkles of growth. Diameter of tubes from two to three millimeters. Tubes sometimes moderately stout-walled and joining with acute margins of polygonal outlines; at other times the walls are thickened, somewhat dilated at the orifices, with obtuse rounded interstitial margins. In the same specimens elsewhere, the orifices of the tubes may be projecting, with raised circular margins, and the sides of the tubes may be found only in loose lateral contiguity with teretiform walls, and annulated by fine wrinkles of growth, with faintly indicated longitudinal striation. The tube cavity is lined by from thirty to forty longitudinal rows of spinules or spinulose ridges, which project nearly to the centre of the tubes as radiations. Diaphragms closely set, concave, simple or compound, of vesiculose plates. Pores numerous, small, irregularly dispersed. Found silicified in the Hamilton group near Alpena, also in the Hamilton group of Darien, N. Y., in calcified condition; likewise in the Helderberg group of the Falls of the Ohio, and in several other localities of Kentucky, Crab Orchard, etc.

Plate XXVII.—Fig. 1 is a fragment of a large mass in calcified condition, found at the Falls of the Ohio, presenting a vertical section. Fig. 2 is a silicified specimen from Alpena, Thunder Bay, seen from the under side. Fig. 3 is the same, seen from above.

MICHELINIA TROCHISCUS, N. SP.

Synon., ASTRÆA STYLOPHORA, Eaton.

Small hemispherical masses, not often exceeding the diameter of two inches, usually smaller. The depressed conical or flat basal side is covered by a concentrically wrinkled epitheca, and is attached by a broad central scar to other marine bodies, to Gasteropod shells, Crinoid stems, and very frequently to the surface of Fistulipora. (See Worth. Geol. of Illin., Vol. III., Pl. 9, Fig. 1*b*.) Tubes very unequal, rounded-polygonal, from four to seven millimeters wide. Cavity longitudinally striate by numerous spinulose crests. Diaphragms irregular and not much crowded. Pores dispersed without order.

Occurs in the Hamilton group of Thunder Bay, and is very common in the Hamilton group of New York. The small specimens found in the upper Helderberg limestones of Michigan, Ohio, and Indiana, which are the forms to which Pleurodictyum problematicum has principally to be referred, are almost the same, if not an identical form, with Michelinia trochiscus. I have not figured this species.

MICHELINIA CLAPPII.

Synon., CHONOSTEGITES CLAPPII, Milne-Edwards.

MICHELINIA INTERMITTENS, PARS, Billings.

Convex or discoid masses, formed of tubular, closely aggregated, subparallel or diverging polyp stems, from five to eight millimeters diameter, multiplying by marginal buds. Tubes annulated by alternate constrictions and dilatations into an urn shape of the intermediate segments, having horizontally spreading margins, which unite with those of the adjoining tubes, forming continuous laminar floors, whereby the otherwise free tubes are held together and communicate with each other by transverse channels crossing the laminæ.

In some specimens the constrictions are not so deep as in others, and the tubes then come in more intimate contact with their sides, which in such case communicate by lateral pores, and fully resemble the tubes of an ordinary form of Michelinia. The tubes are transversely intersected by interlacing vesiculose diaphragms of compound structure; the channel walls longitudinally striate by furrows and rows of spinules, conformable with the structure of Michelinia.

Occurs frequently in the drift of Michigan, and is common in the corniferous limestone of Canada and New York; it is rarely seen at the Falls of the Ohio, where Michelinia cylindrica, a closely related form, is abundant.

Plate XXVIII.—Figs. 3 and 4 represent a side view and a surface view of silicified specimens.

HALYSITINÆ.

Colonies of tubular polyp cells, multiplying by lateral gemmation, radiated by a cycle of twelve longitudinal crests or rows of spinules, and transversely septate by diaphragms of variable form, straight or funnel-shaped. The tubes are either free, loosely attached to each other, or laterally connected into laminar rows, or again distant and connected by short transverse branches, sometimes indiscriminately anchylosed into irregular conglomerated masses. The subordinate genera are Halysites, Syringopora, Cannapora, and Aulopora.

HALYSITES, Fischer.

Catenipora, Lamark.

Elliptical tubes, intimately connected at their lateral edges into chain-like single rows, which form erect laminar expansions, bent into tortuous curves, and composing, by the mutual junction and intersection of the laminæ, a network of irregular loops. Tubes radiated by twelve longitudinal crests, and transversely septate by closely set flat diaphragms. No lateral connection between the tubes by pores.

HALYSITES CATENULATA, Linn.

Synon., Halysites esharoides.

Catenipora labyrinthica, Goldfuss, etc.

A great variety of forms of the chain coral are found which in general structure are perfectly alike, but differ widely in the size of the tubes, in the shape of the orifices, and in the mode of reticulated connection between the catenate laminæ. Some specimens have elongate, lanceolate orifices, in others the form is oval, and in others still nearly circular. In those with large elliptical orifices the longer diameter is often five millimeters, and the shorter in the transverse direction three millimeters; in others the proportions of the diameters of the orifices are two and a half millimeters by two millimeters. In the smallest built specimens they measure one millimeter only in the long direction, and one half in the shorter. The loops of the laminæ are in some forms narrow, in one direction nearly as wide as in the other; in other specimens the loops are large, or the flexuose laminæ may for long distances run in close proximity, parallel with each other, before they make occasional connection by short transverse branches. The contrast between these various forms is very great, and it is evident that various specific forms exist; but while attempting to define them, I found so endless a series of transitory connecting forms that I desist from making a distinction, and use here the collective name of H. catenulata for all. Found in the Niagara group of Michigan, as one of the most widely distributed characteristic fossils; likewise common in the Niagara group of other States east and west. The first specimens of the chain coral are found in the upper beds of the Hudson River group, in the west portion of the Upper Peninsula of Michigan, but their preservation is so imperfect that it is impossible to determine whether these oldest specimens represent another species or not.

Plate XXIX.—Figs. 1, 2 and 4 represent three of the many varieties in which the coral is found associated in the strata of Drum-

mond's Island and of Point Detour, all in silicified condition. Fig. 3 of the same plate I considered sufficiently characteristic to be described as a distinct species.

HALYSITES COMPACTUS, N. SP.

Tubes oval, in chain-like, lateral conjunction, but these laminæ are so closely approximated, that no retiform loops are formed by them; they come in contiguity with each other from all sides, and leave only small, angular, lacunose interstices in the corners of their intersection, which are not larger than the tube orifices themselves. By this close approximation of the tubes on all sides many of them become pressed into a polygonal form and resemble a Favosites, from which they differ, however, in the absence of lateral pores. The diaphragms of the tubes are closely approximated, flat, concave or convex in the same specimens. Their diameter is about one and a half millimeter. Found in the Niagara group along the outcrops of the Upper Peninsula, at the shore of Lake Michigan.

Plate XXIX.—Fig. 3 represents a lateral section and a surface view of a specimen found at Epoufette Point. In a stratum of an outcrop at the mouth of Manistique River this species is quite common.

SYRINGOPORA, GOLDFUSS.

Synon., THECOSTEGITES, Milne-Edwards.

Aggregated, sub-parallel, tubular polyp-stems, multiplying by lateral budding, and at irregular intervals connected with each other by short, transverse, tubular branchlets. The tubes are intersected by numerous irregularly funnel-shaped diaphragms, and radiated by twelve longitudinal rows of spinules, which are sometimes obsolete. The colonies of erect stems are at the base formed of horizontally prostrate and attached ends, very much resembling the creeping expansions of Aulopora, from which the young colonies are often hard to be distinguished.

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 prolongated 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 is another drift specimen, 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 the specimen 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 laminæ, separated by small vesiculose 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 Verneuilli, 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 row 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 row, 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 millimeters 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 arachnoidea*, Hall; these have no affinity with Aulopora, their structure being the same as in the jurassic and cretaceous genera Proboscina, Berenicea, or Stromatopora, 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 incrusted 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 subpolygonal 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 laminæ 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.

The specimens were found by Mr. 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.

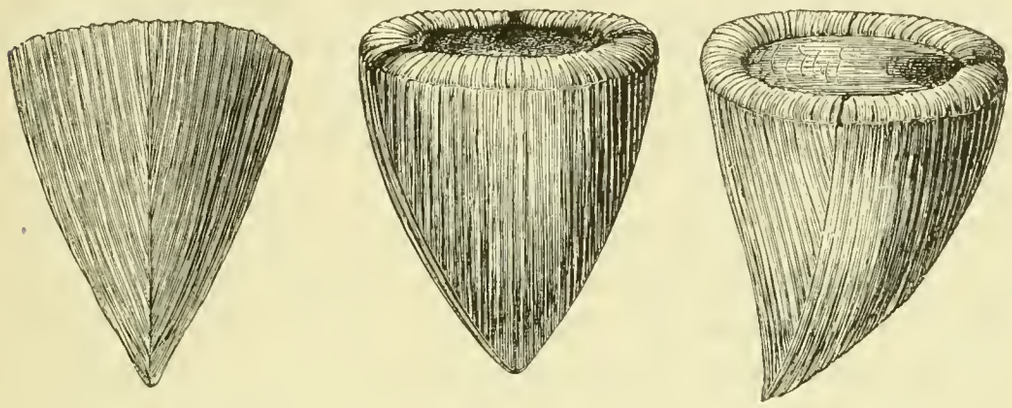
So called in allusion to the radial rugæ or plications of the stony, calcareous polyp cells, which are the only part of these animals that has been preserved. The Zoantharia apora of a similar structure are distinguished from these by a difference in the arrangement of the radial plications. Milne-Edwards 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 axal 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



APERTURAL GAP. CENTRAL GAP. LATERAL GAP.

in the apertural gap the striæ 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 striæ 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 striæ 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, monticulose 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 vesiculose, 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 vesiculose, 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 row.—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 row.—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 specimen s~~h~~re 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 row.—The ~~left~~ right-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 row.—The two ~~right~~ left-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-cylin-

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 row 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 in 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, by 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 expatiated 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 row 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 epithecal 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 axal 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 row 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 row 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 periphera 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 dilatations 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 row.—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 surfa ce. 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 row.—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 Cyathophylloid 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 epithecal 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 laminæ 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 row, 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 row, 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 sructure 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 row.—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 row, 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 row.—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 row 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. The specimens which I have identified with *Acervularia Davidsoni*, Milne-Edwards, are in closest generic connection with Diphyphyllum, and resemble the species just described in many respects, although I do not consider them specifically identical.

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 axal 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 row.—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 Yandelli*, 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 styliform protuberance ; or the bottom of the cell remains even while

crossed by the carinæ. On the expanded marginal portion of the calyces the plications lose their crest form and are reduced to rounded rugæ, 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 monticulose 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 rugæ of the cell cups, which meet

and intermingle with those of the adjoining cells. The radial striæ 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 rugæ 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 rugæ 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 form Point Detour.

STROMBODES ALPENENSIS, N. SP.

Massive horizontal expansions, covered on the lower side by an epithecal 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' lime-kilns, 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 epithecal 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 row.—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 in the lower row 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. Epithecal 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 row.—The left-hand figure 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 row.—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 spongiose 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 spongiose axal 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 epithecal 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 row—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 row, 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 row.—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 apicical 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 row, 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 axal 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 row.—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 row.—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 row.—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 row.—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 row.—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. Rafinesque, 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 row.—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.

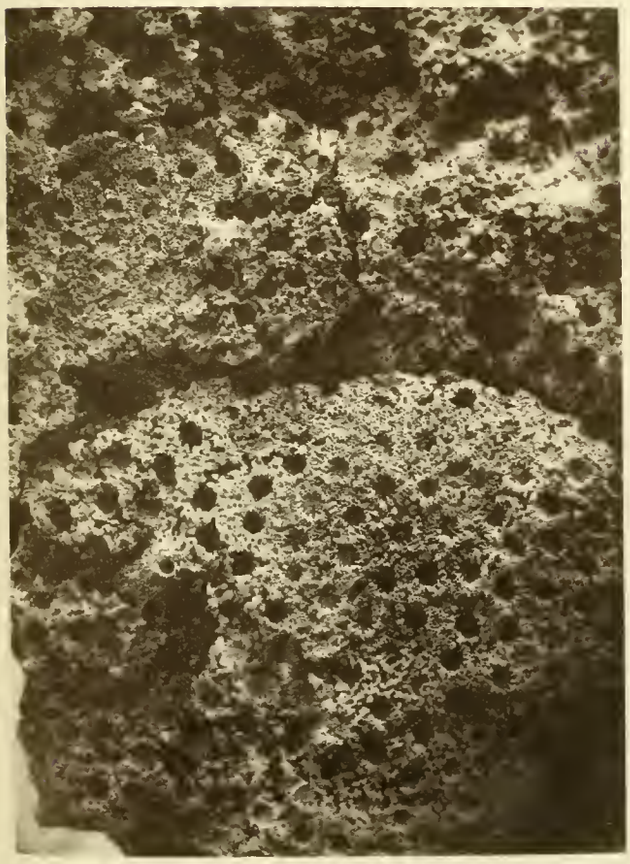
AMPLEXUS YANDELLI, MILNE-EDWARDS.

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 row.—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.

PLATE I



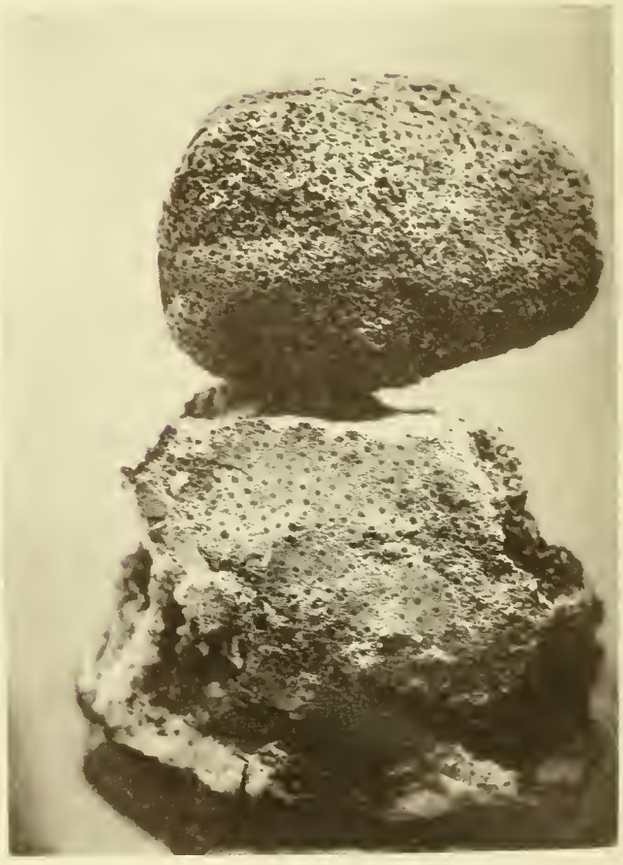


PLATE II

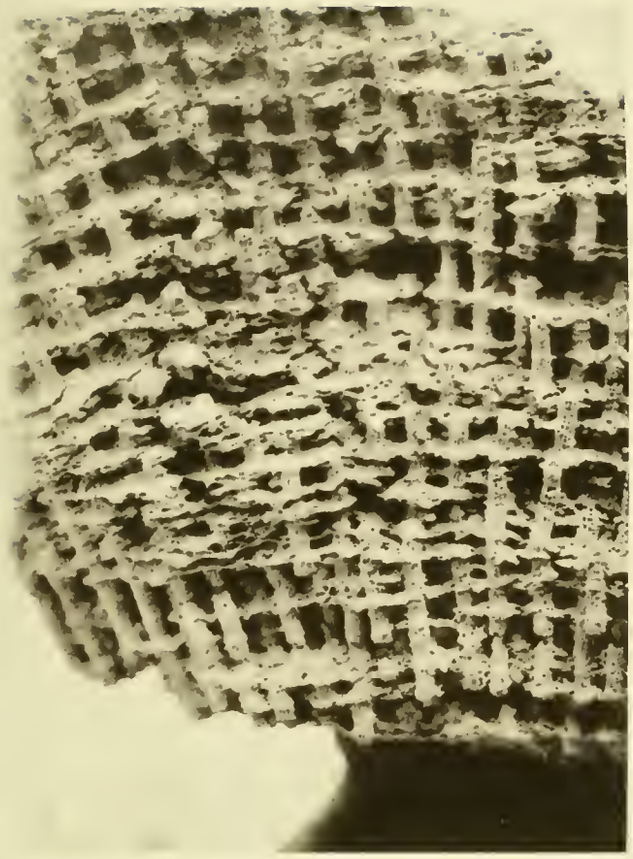


PLATE III

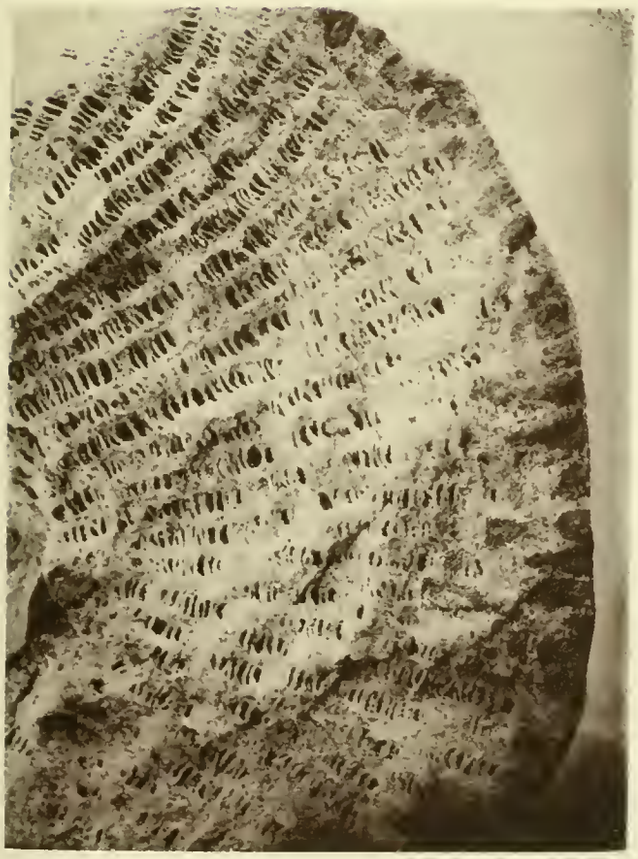
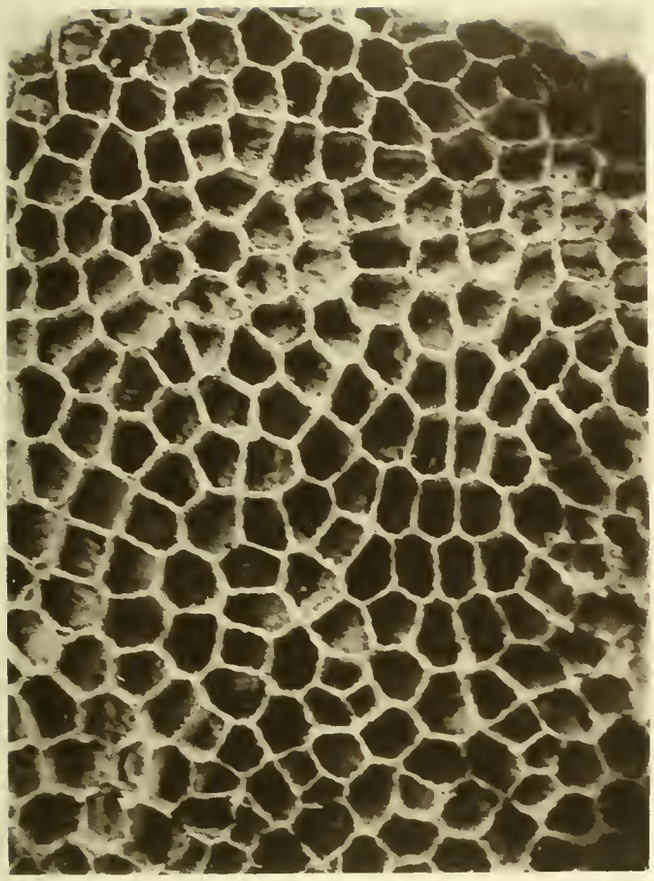
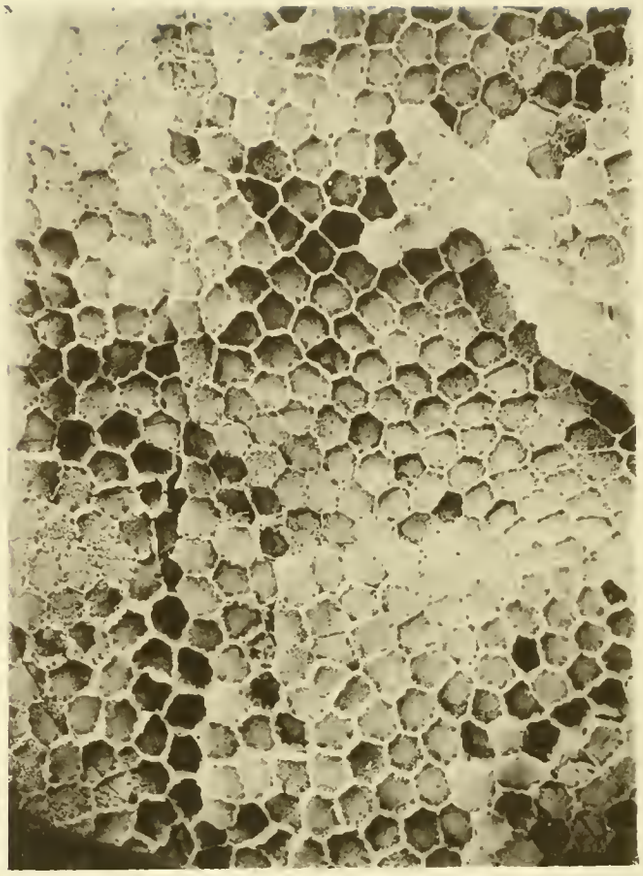


PLATE IV





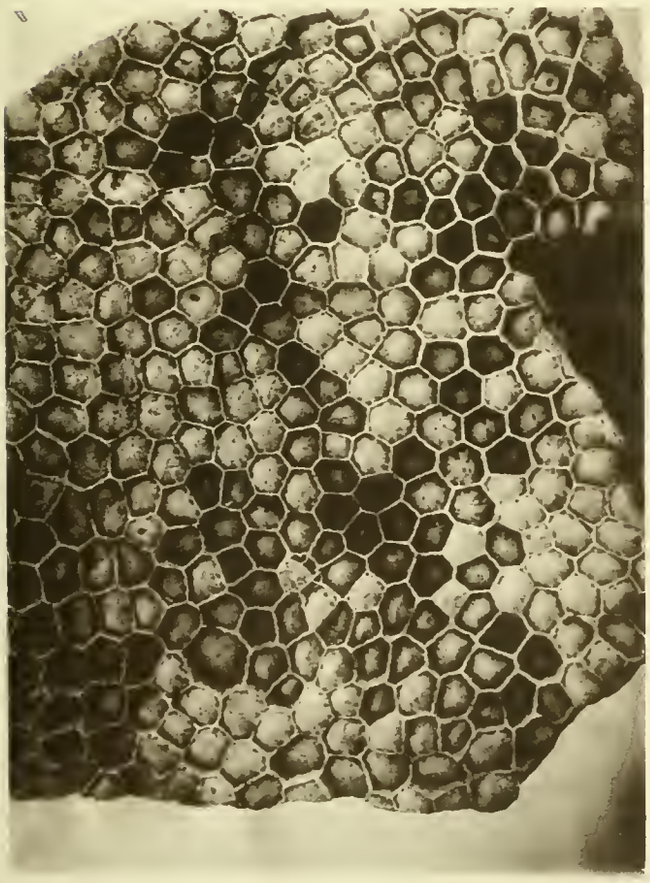
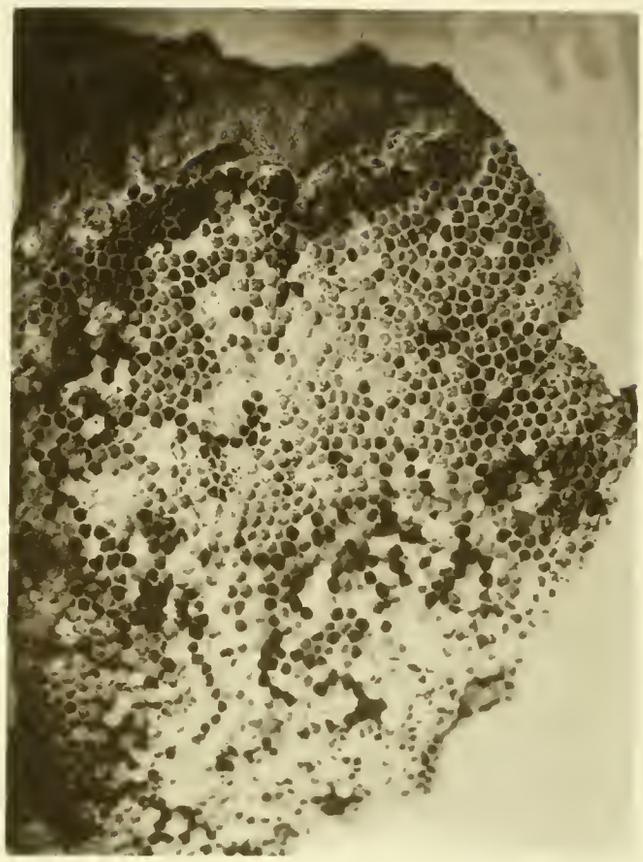


PLATE V



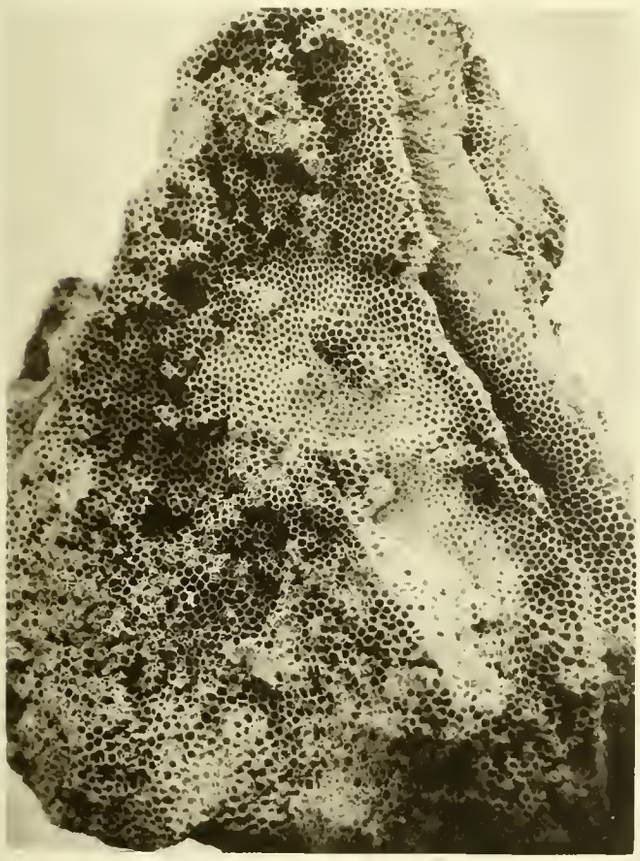
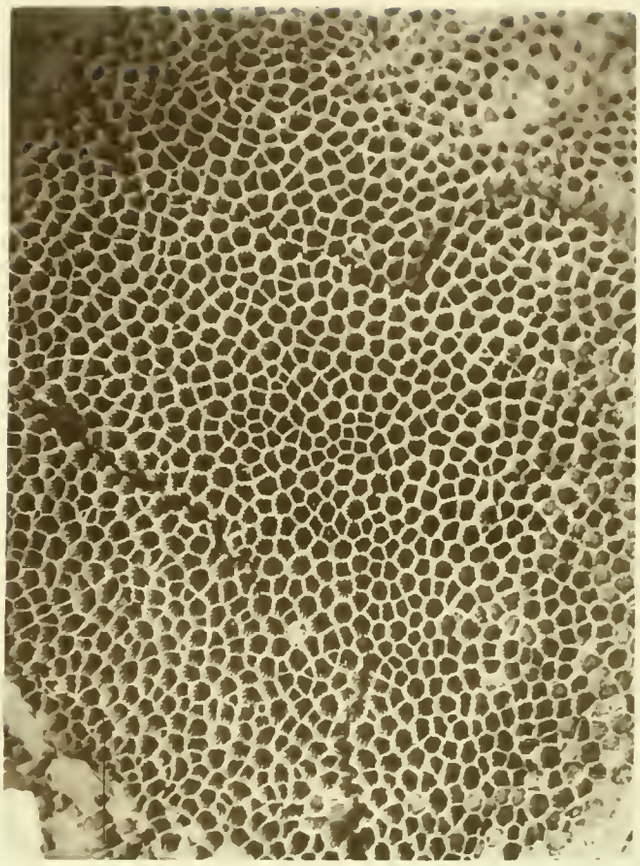


PLATE VI

PLATE VII

PLATE VIII



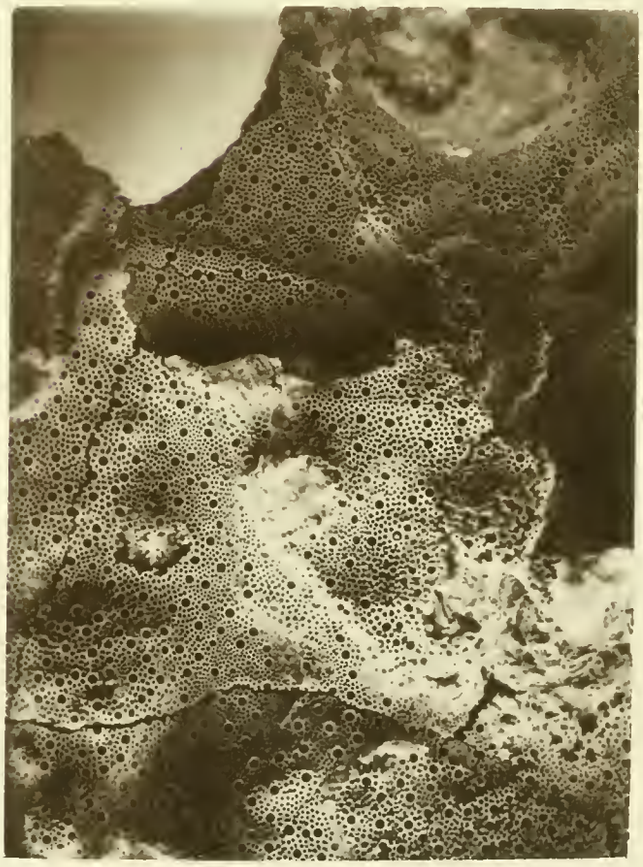


PLATE IX

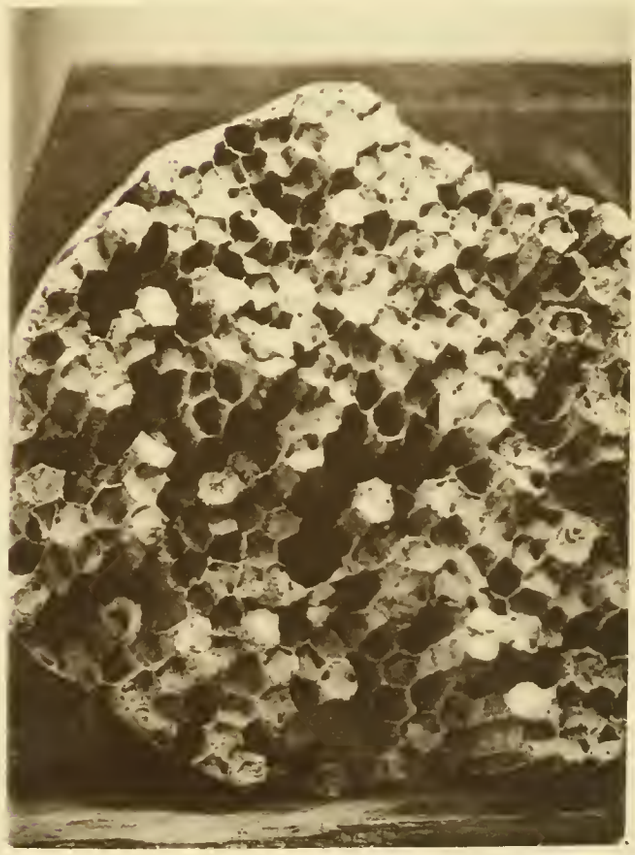
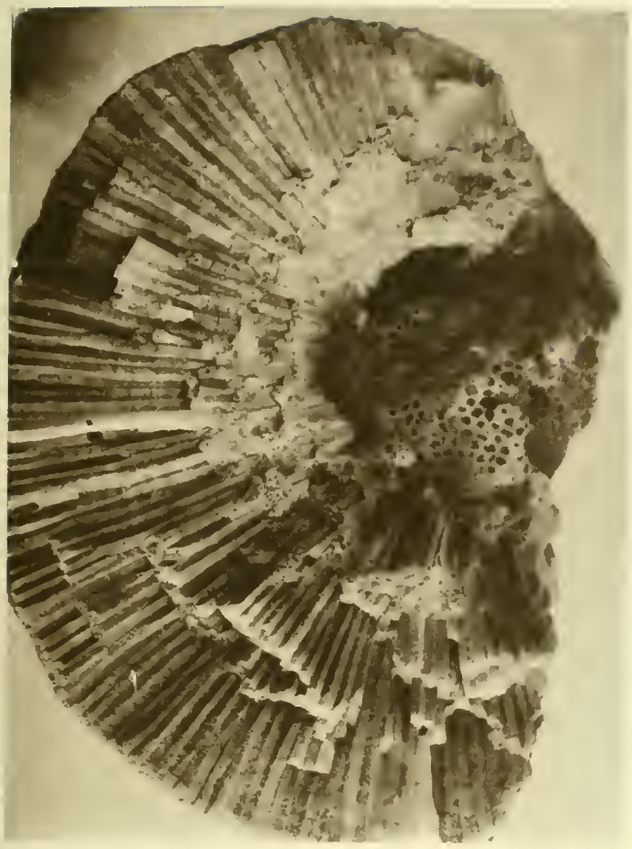


PLATE X



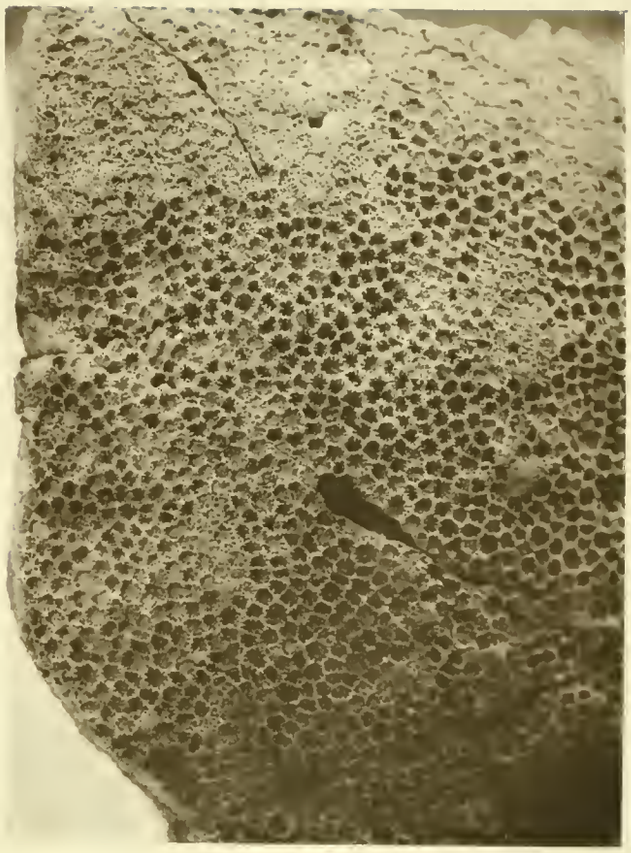


PLATE XI

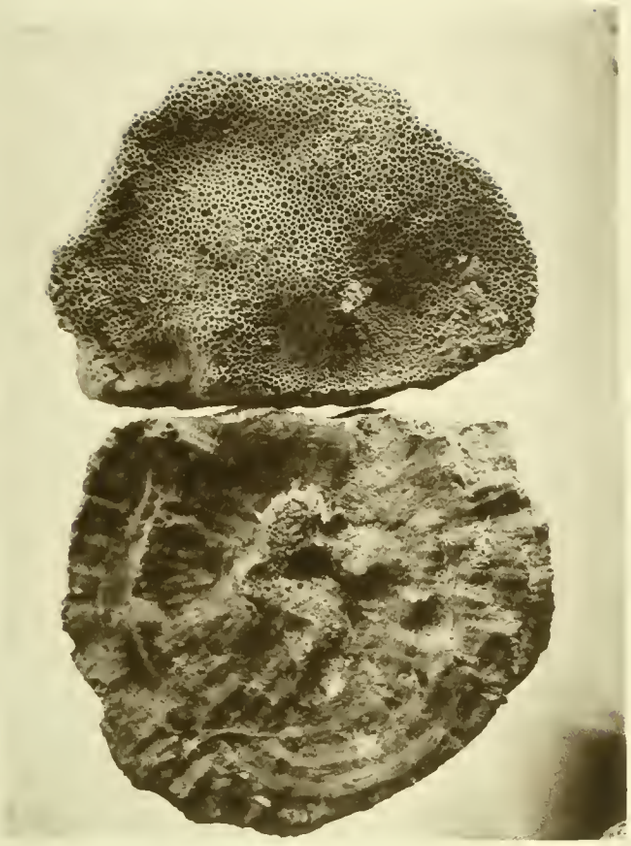
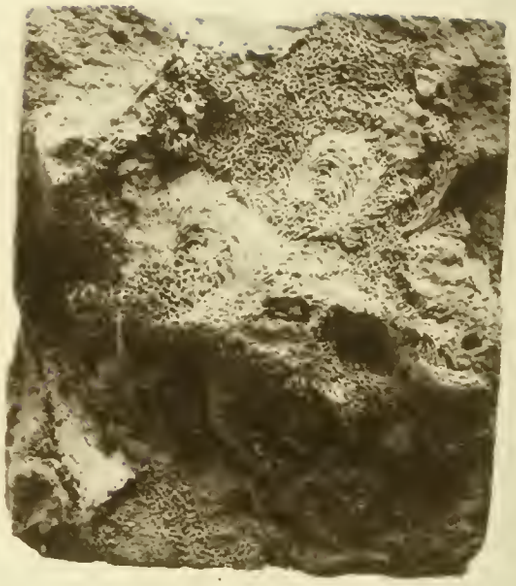


PLATE XII

PLATE XIII

PLATE XIV

PLATE XV



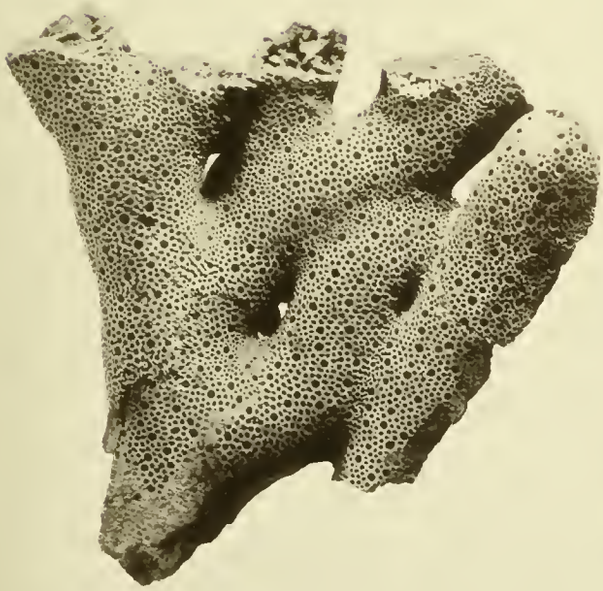
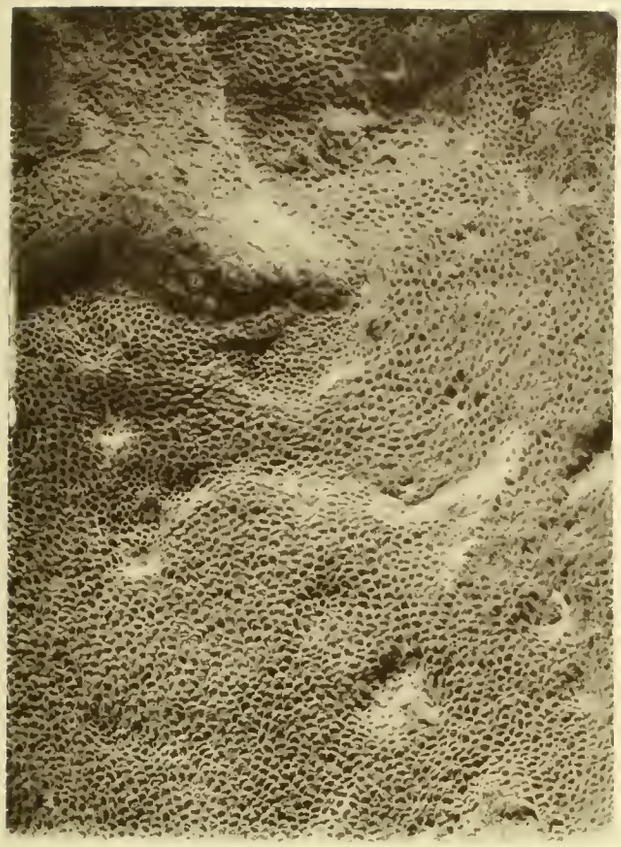


PLATE XVI

PLATE XVII



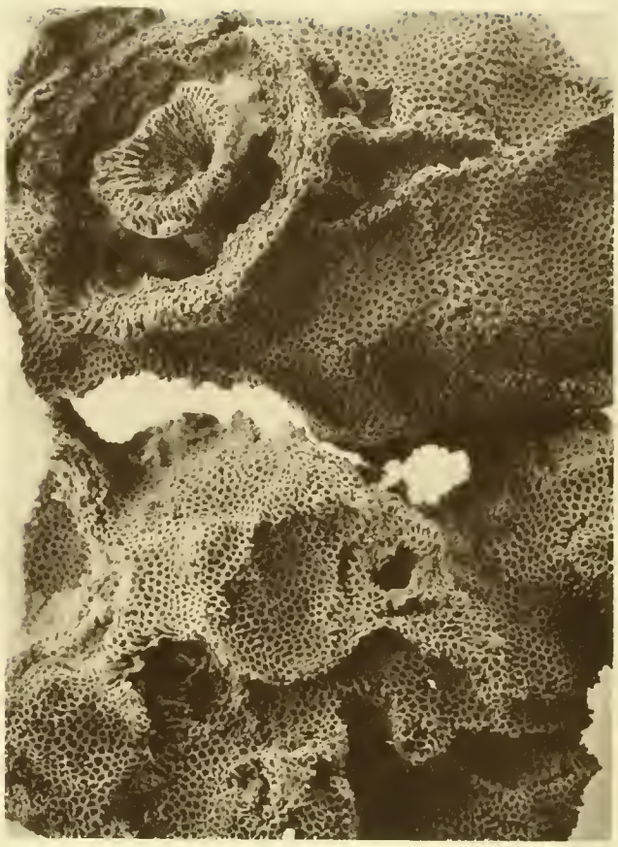
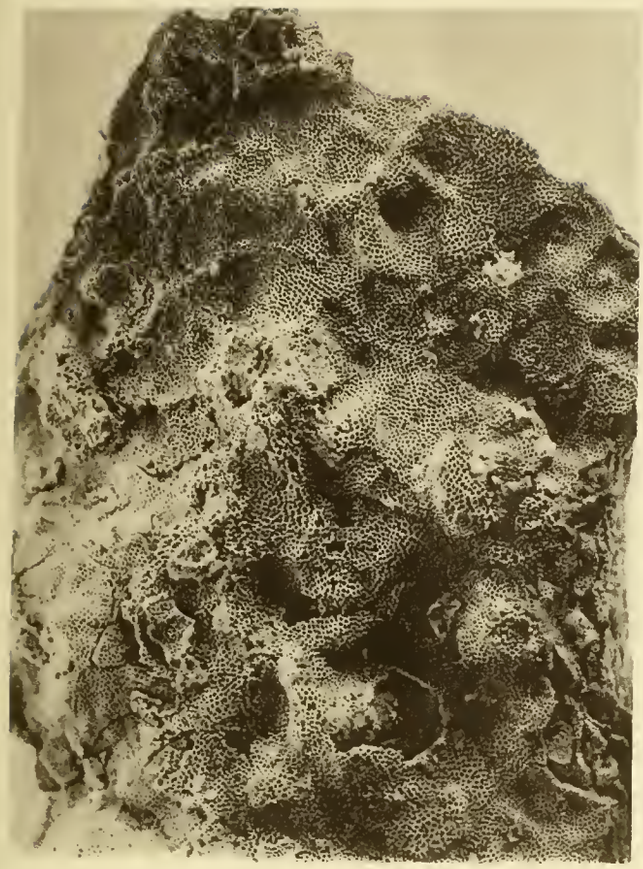
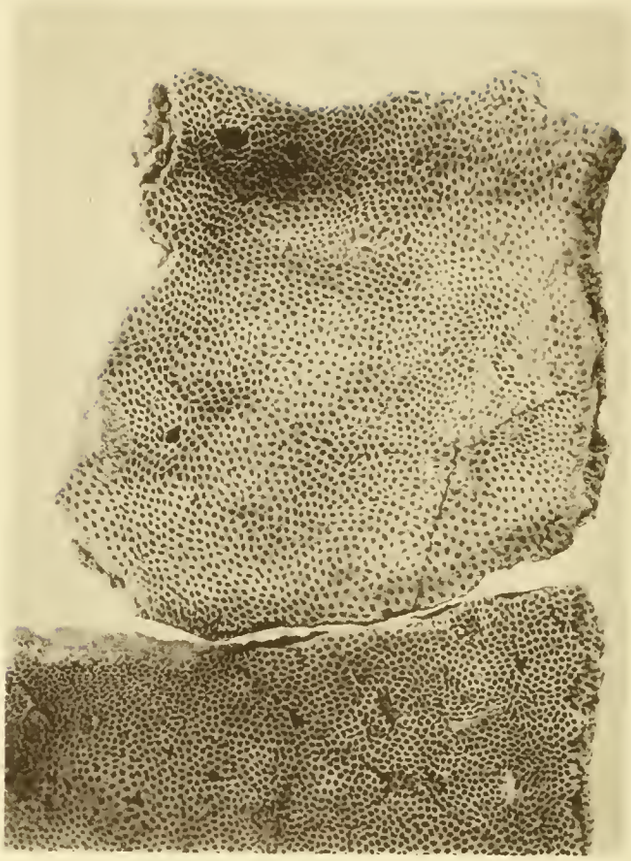


PLATE XVIII





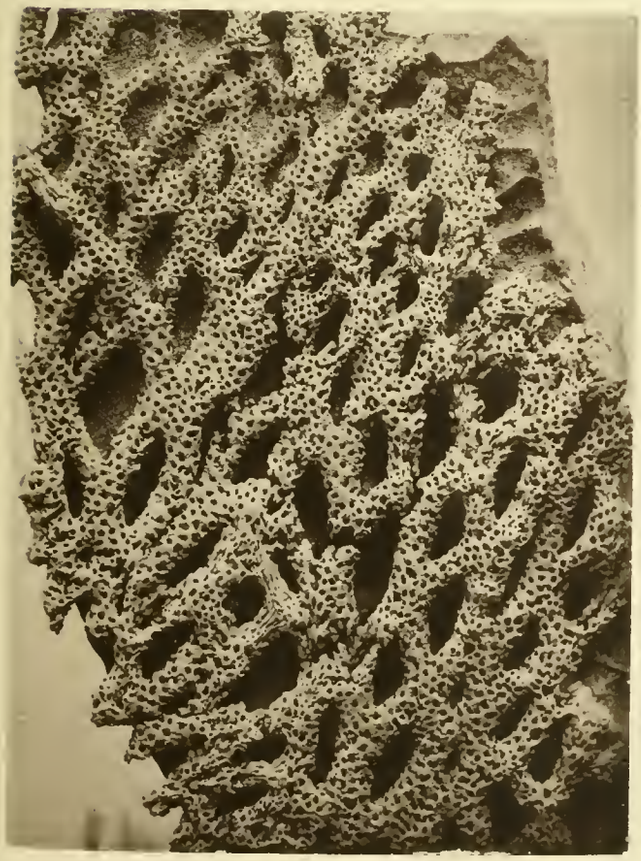


PLATE XIX

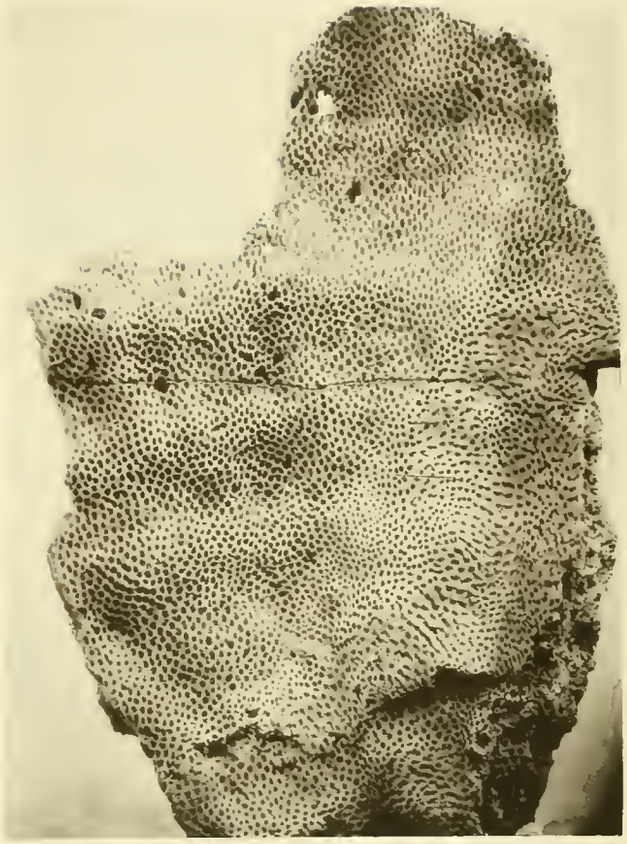
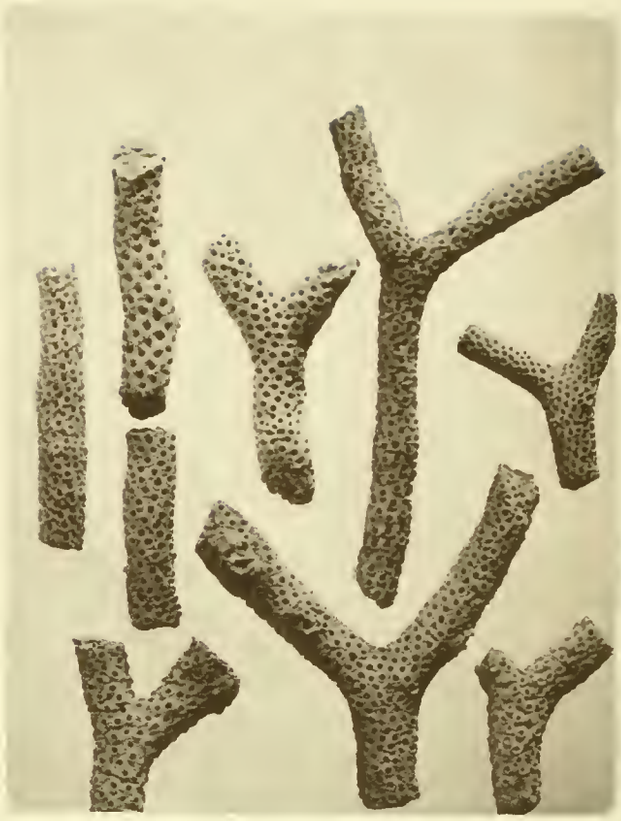


PLATE XX

PLATE XXI



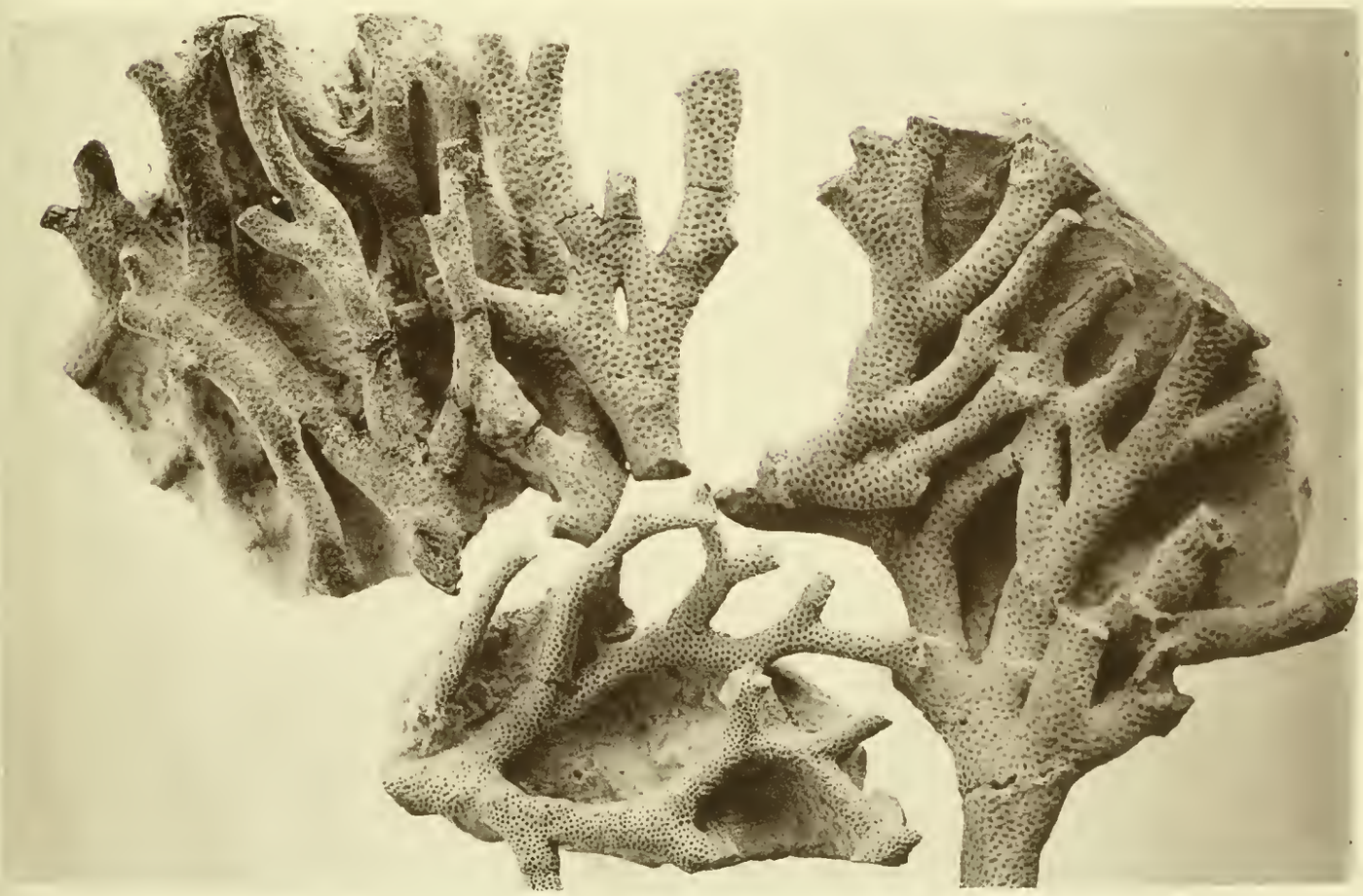


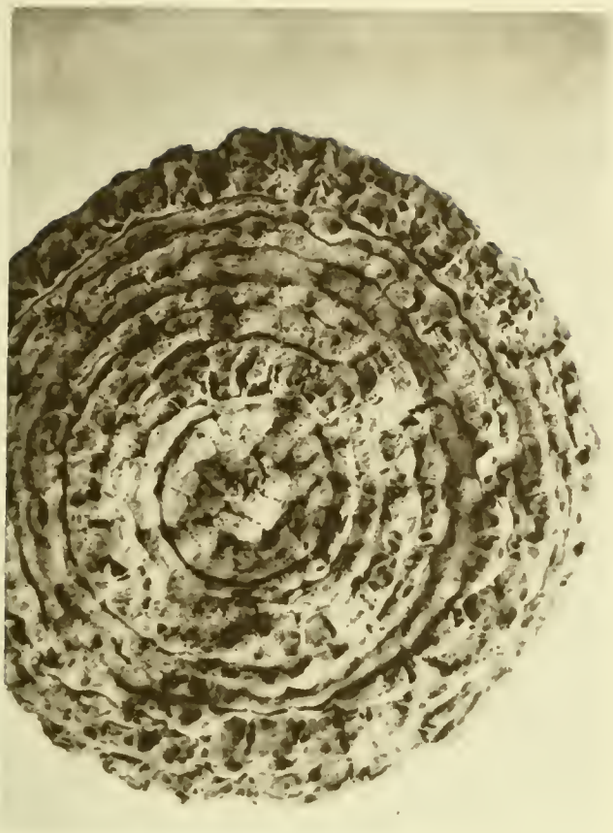
PLATE XXII

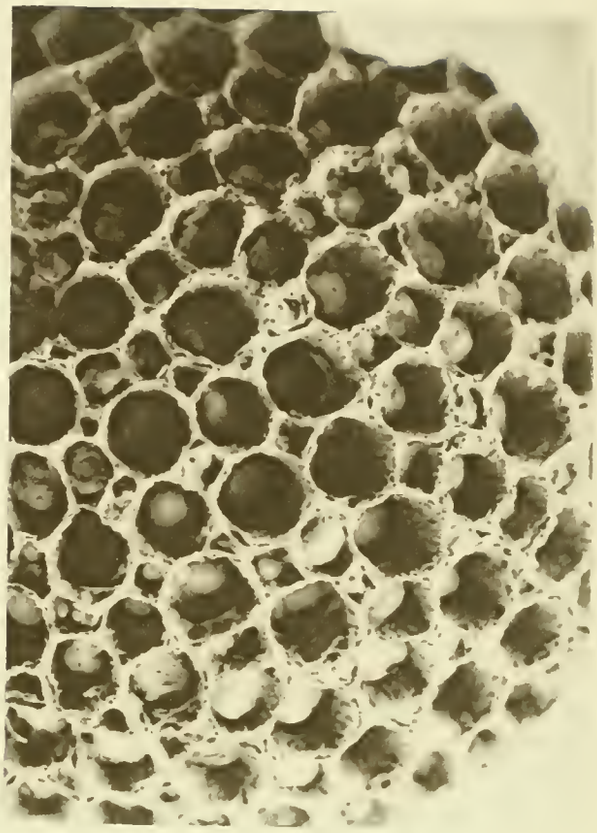
PLATE XXIII

PLATE XXIV

PLATE XXV

PLATE XXVI





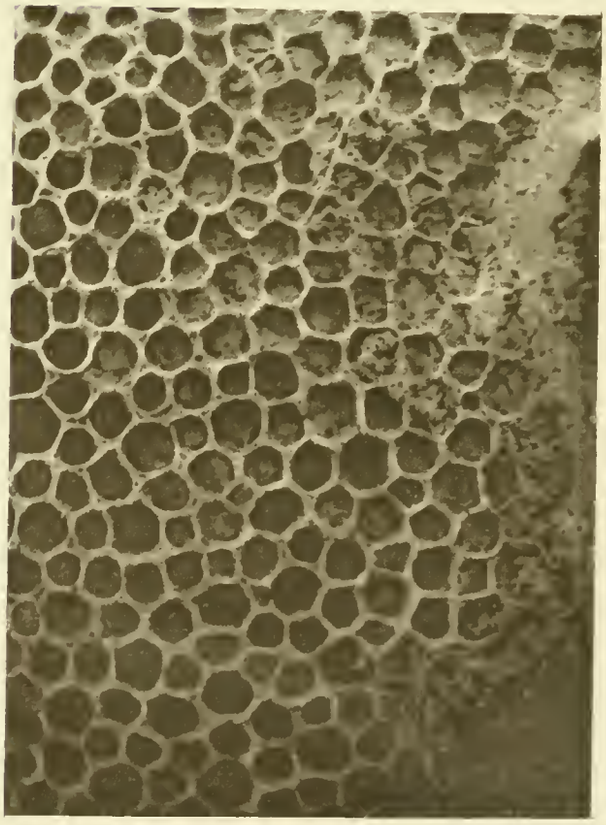
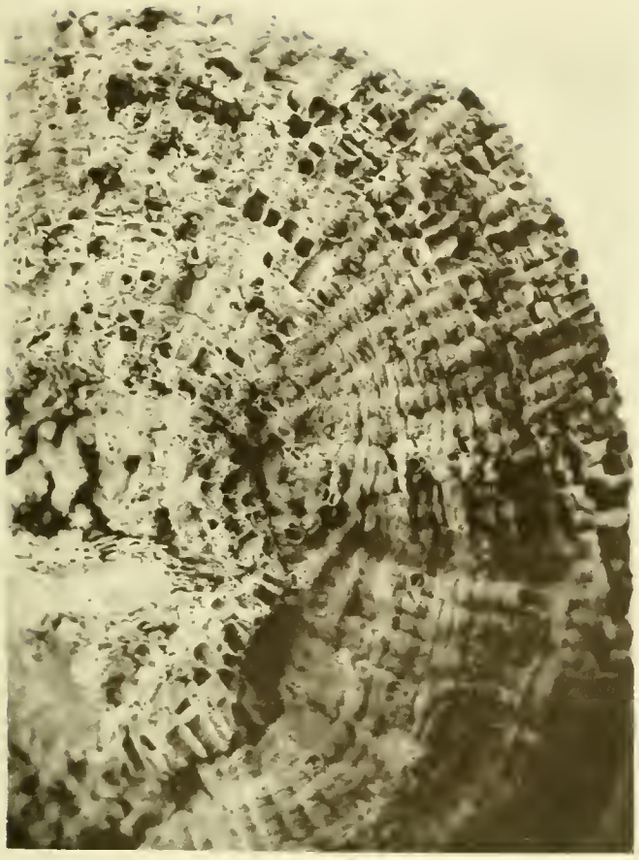
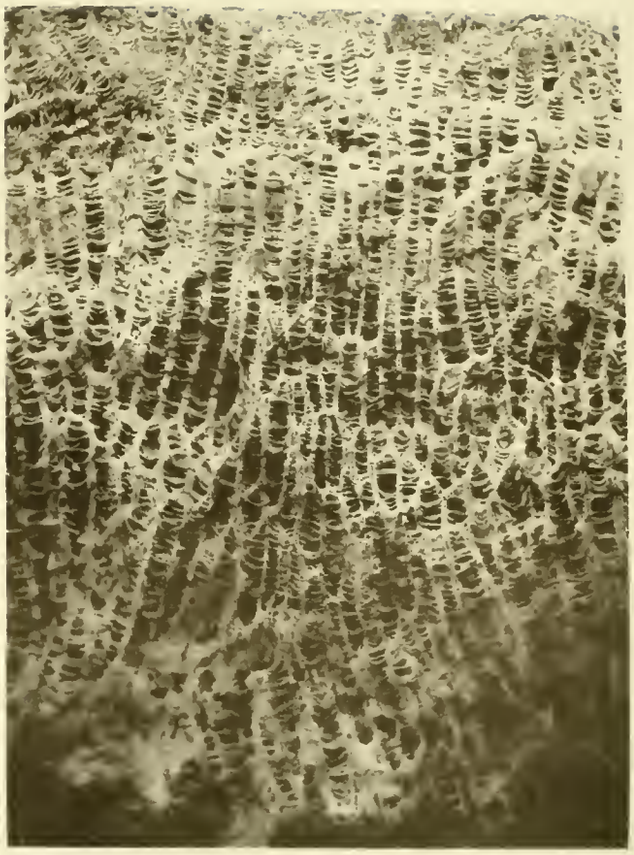
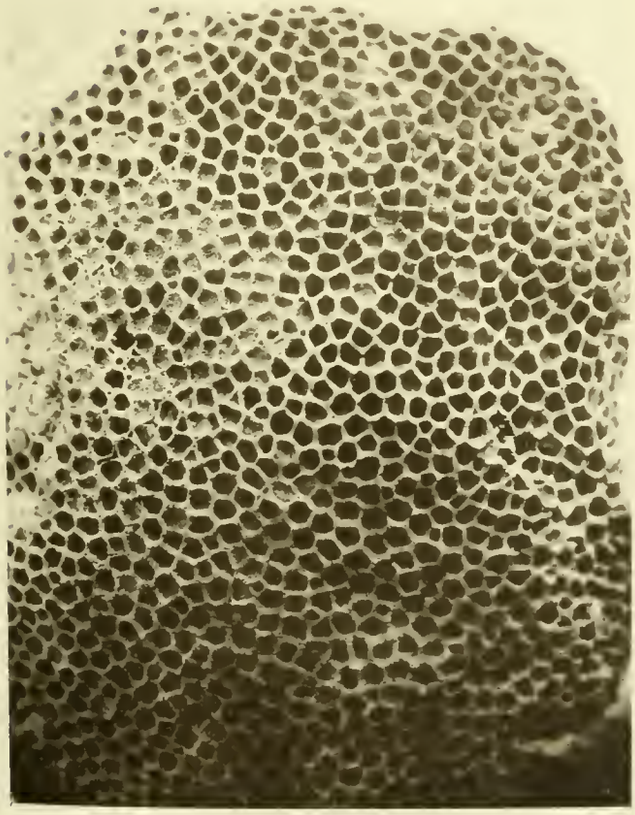


PLATE XXVII







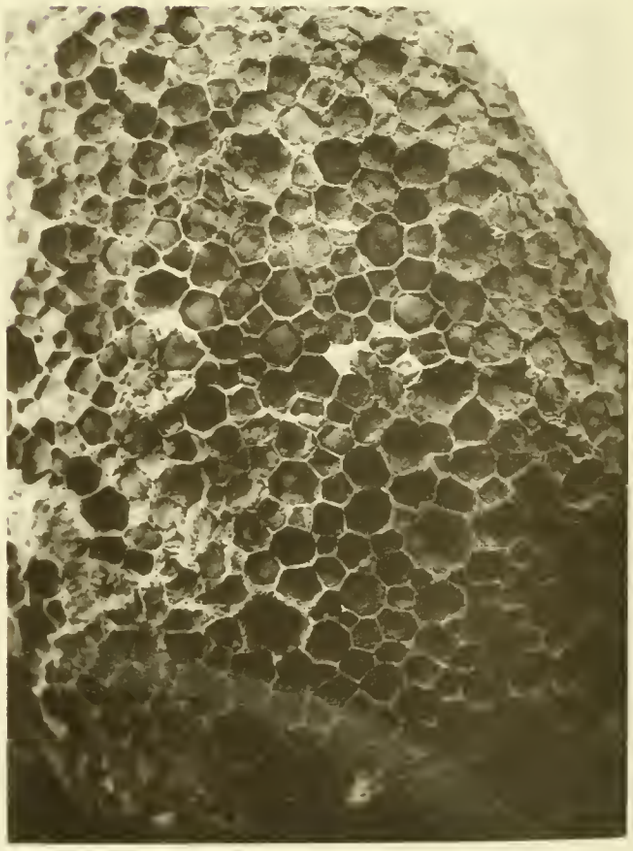
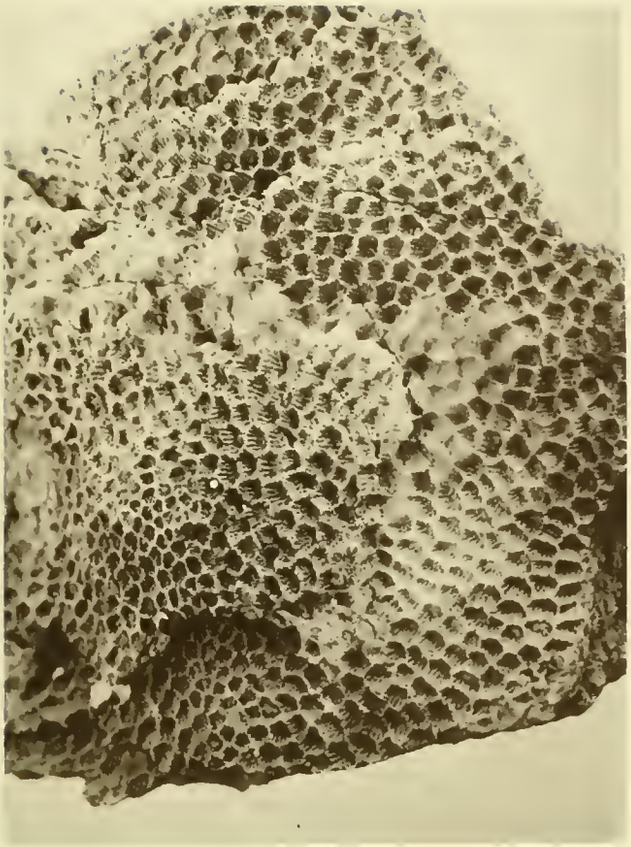


PLATE XXVIII



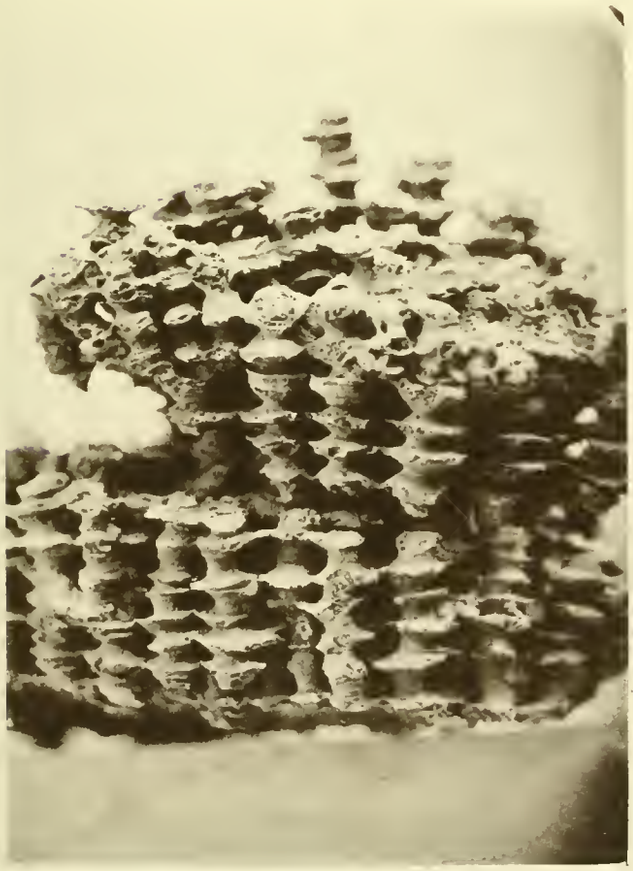
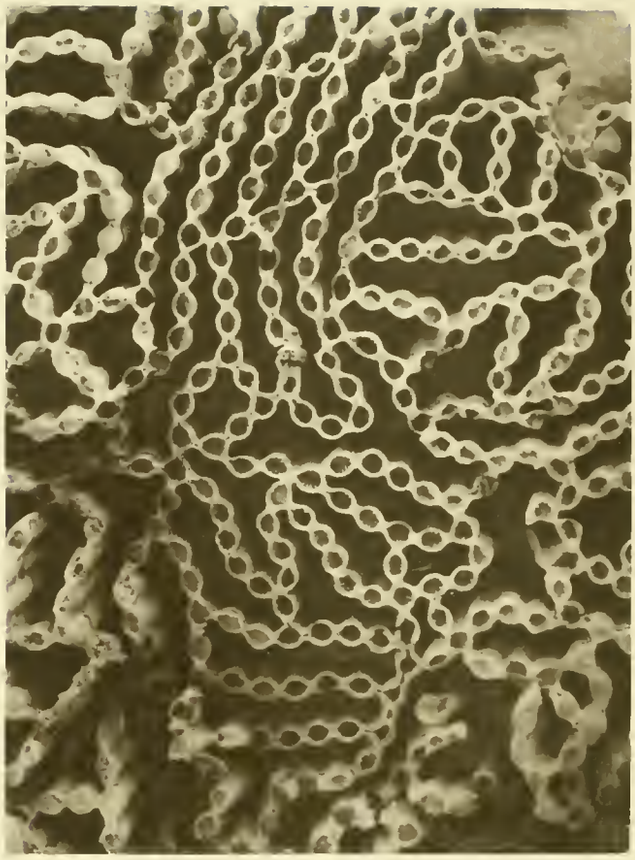


PLATE XXIX



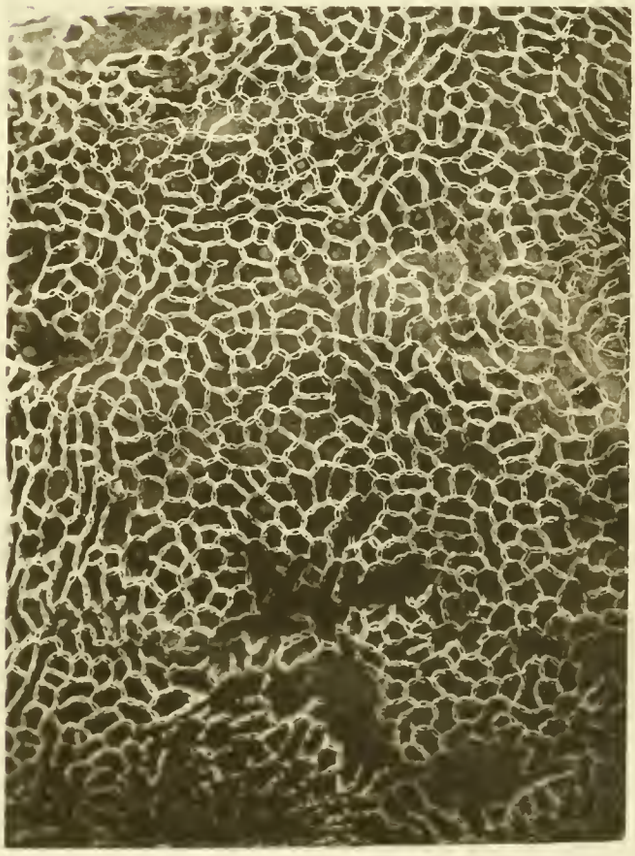


PLATE XXX

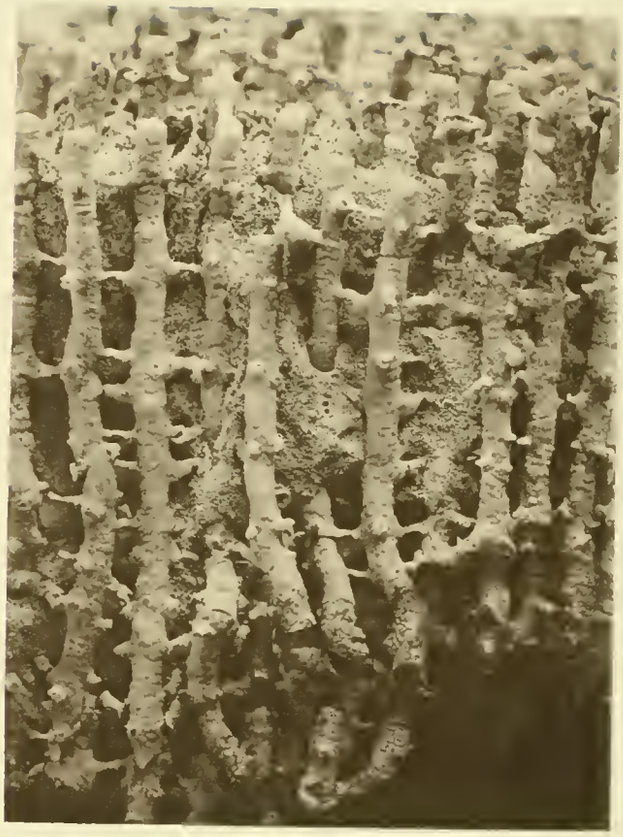
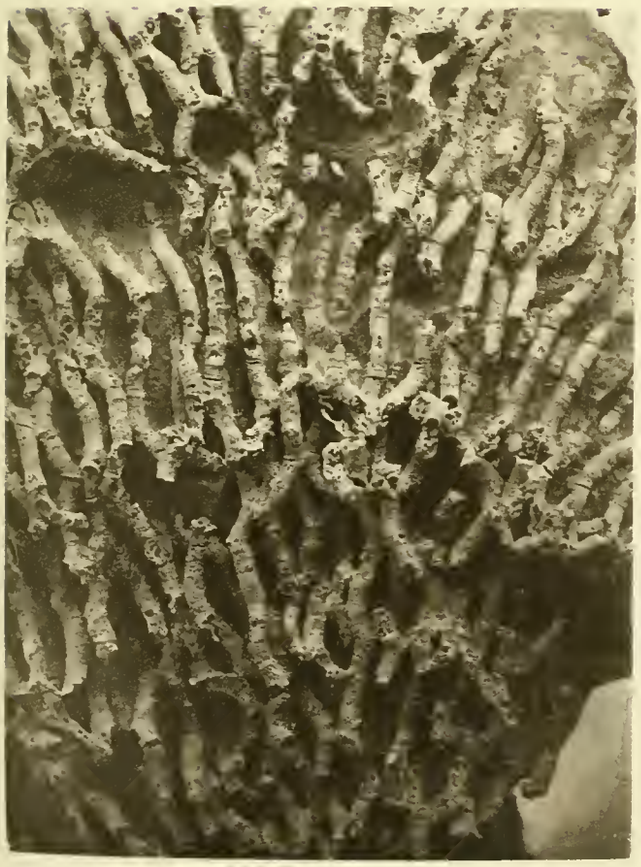


PLATE XXXI



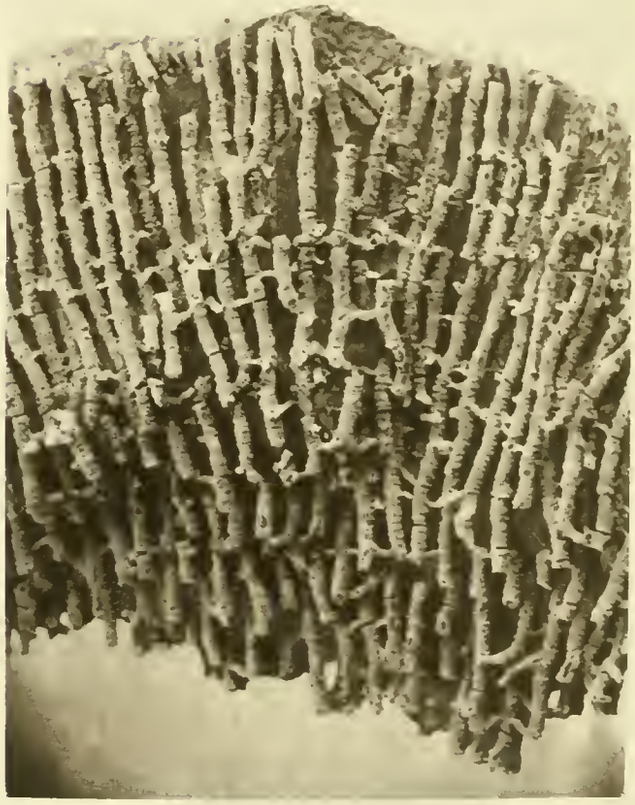
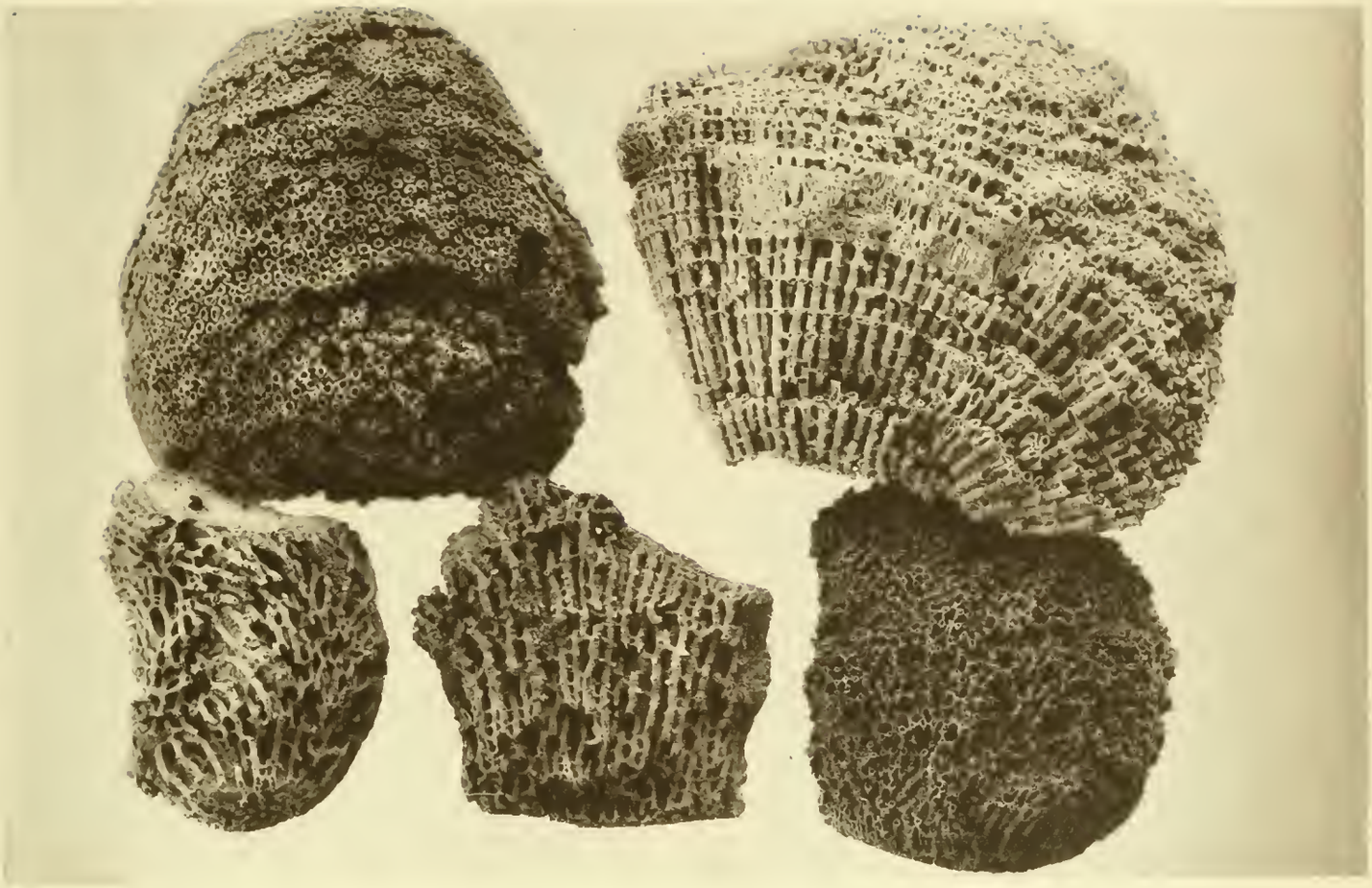


PLATE XXXII



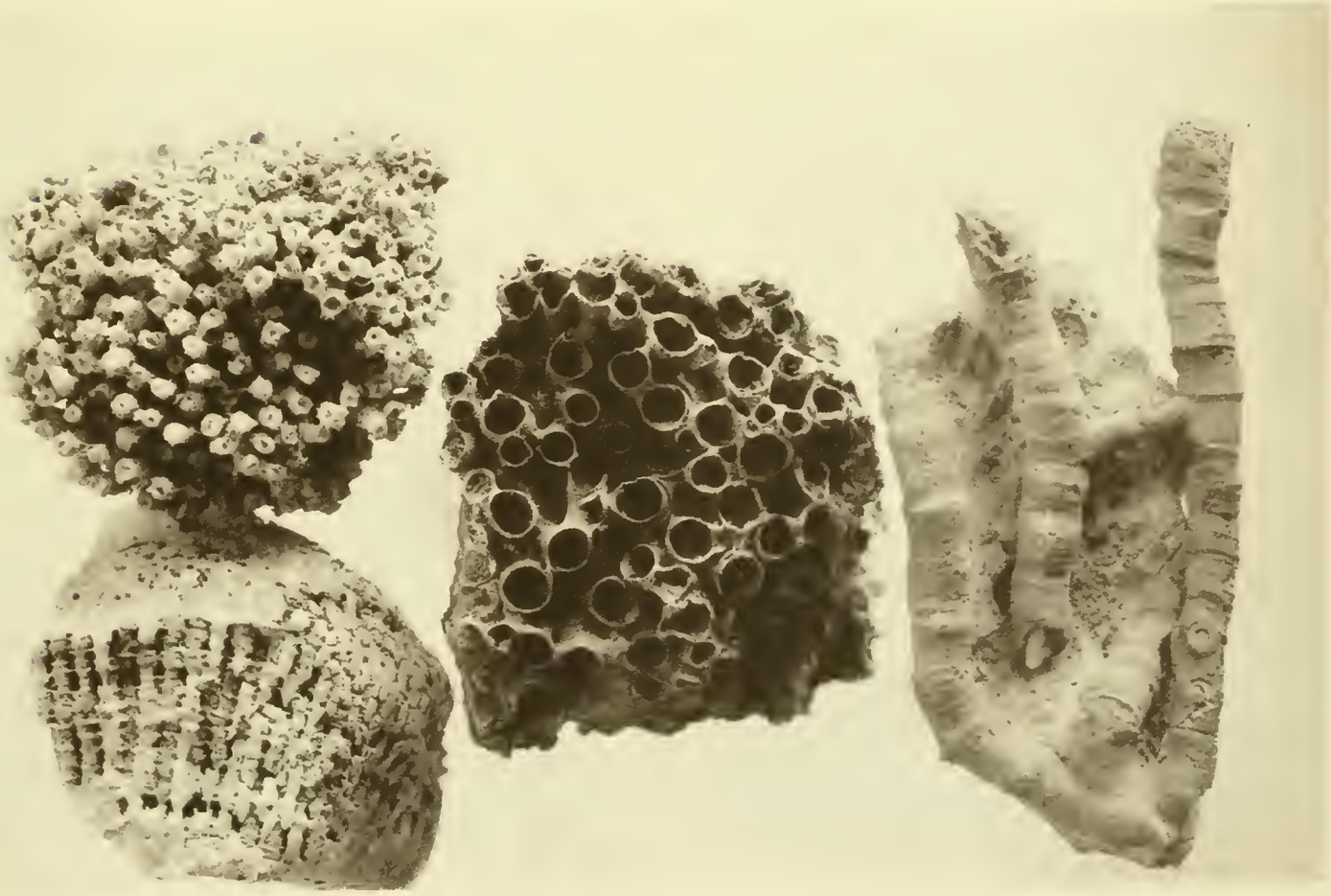


PLATE XXXIII

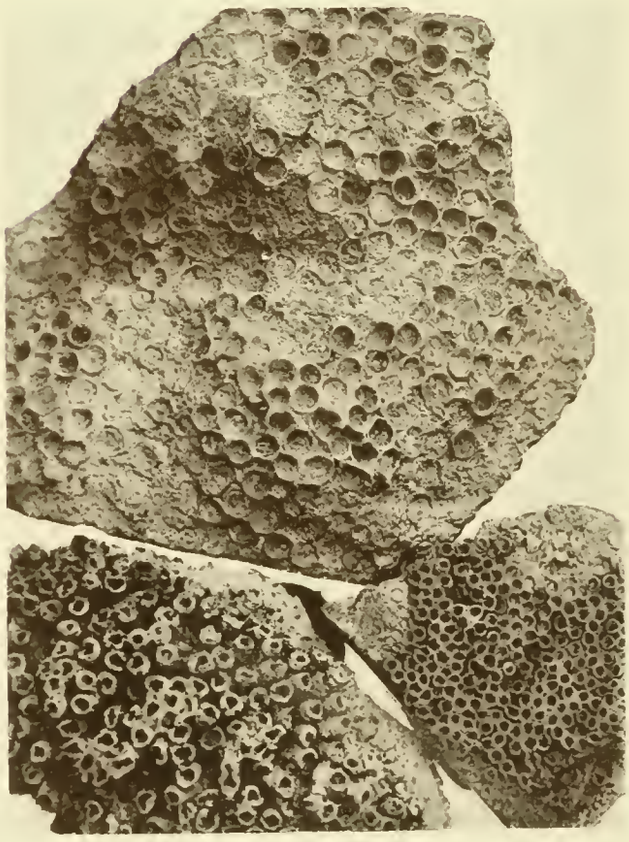
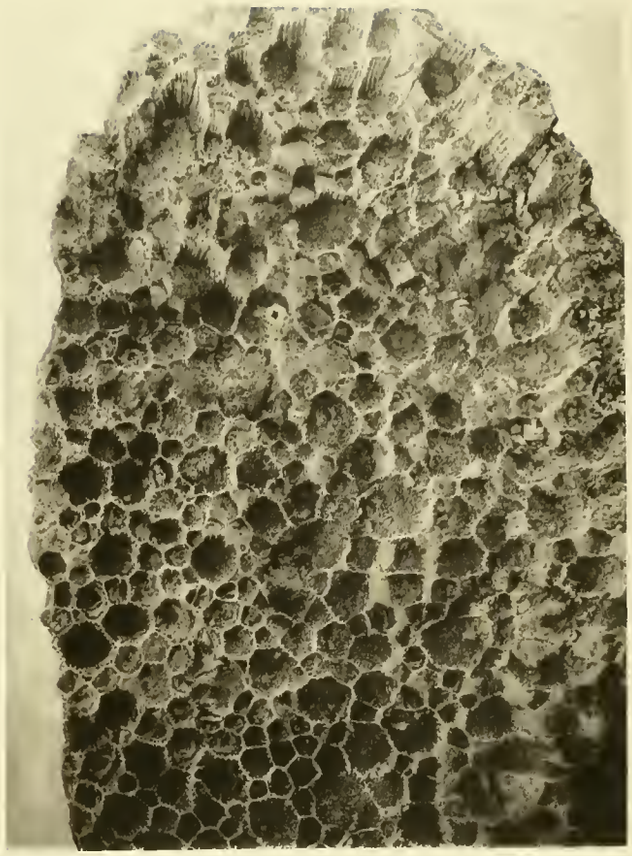


PLATE XXXIV



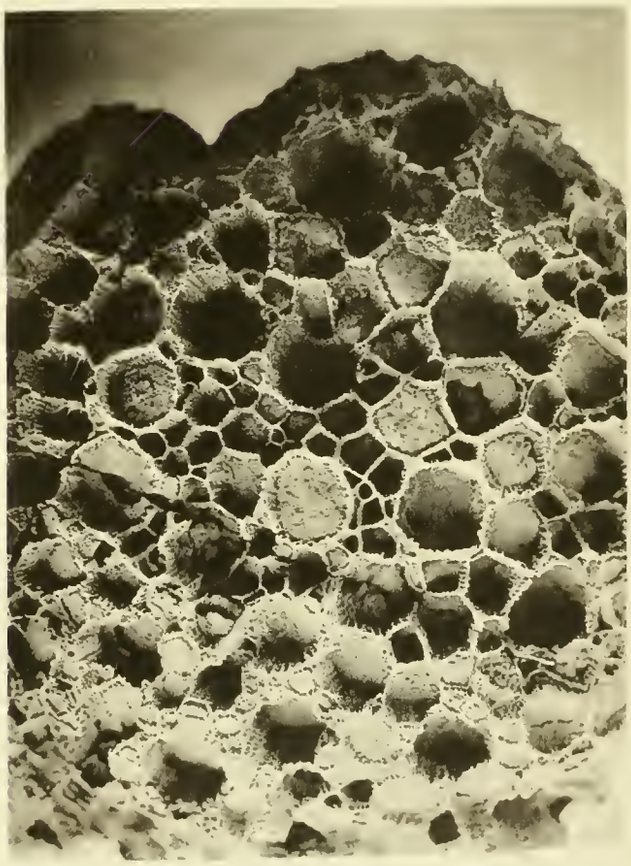


PLATE XXXV

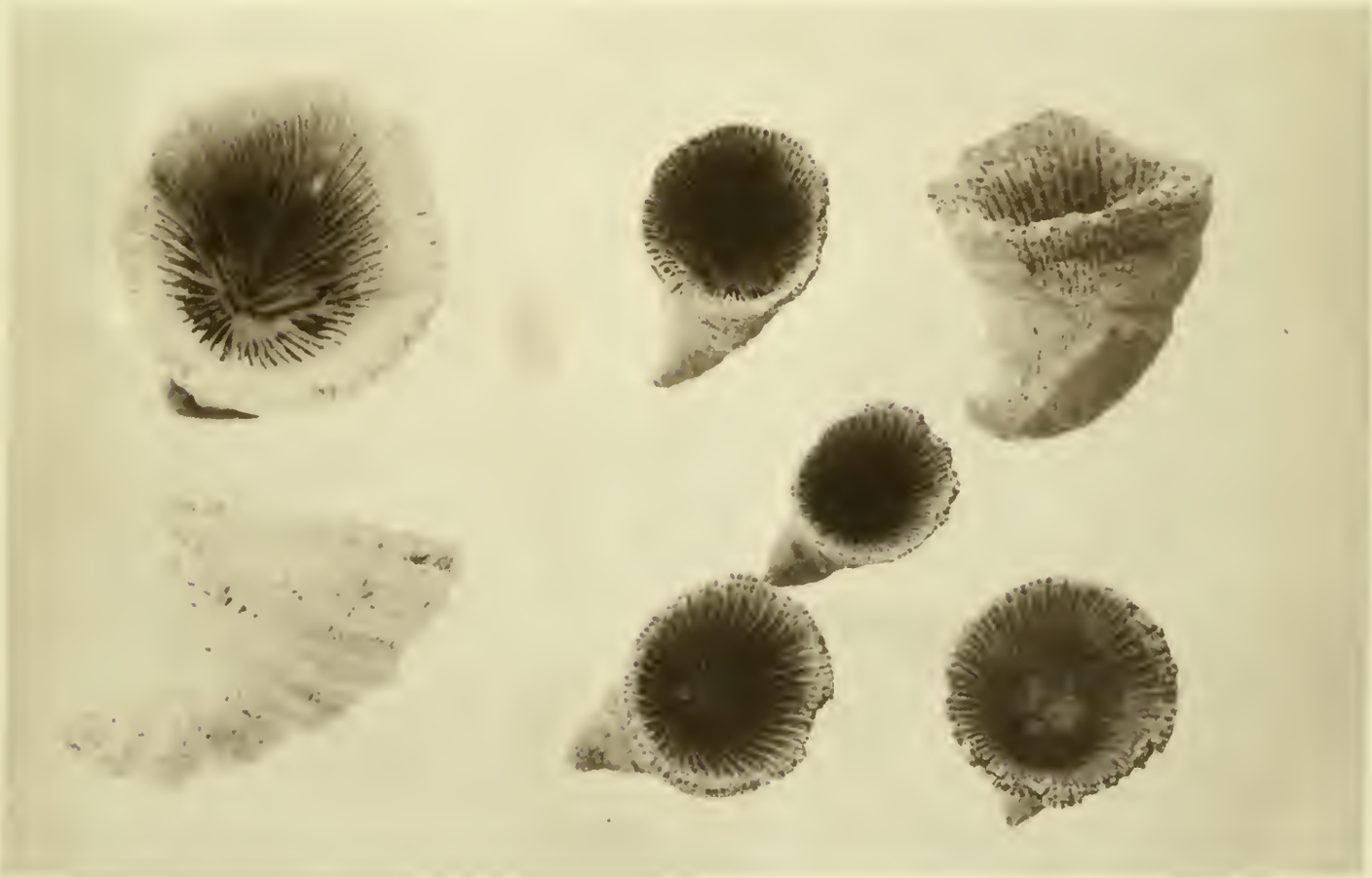
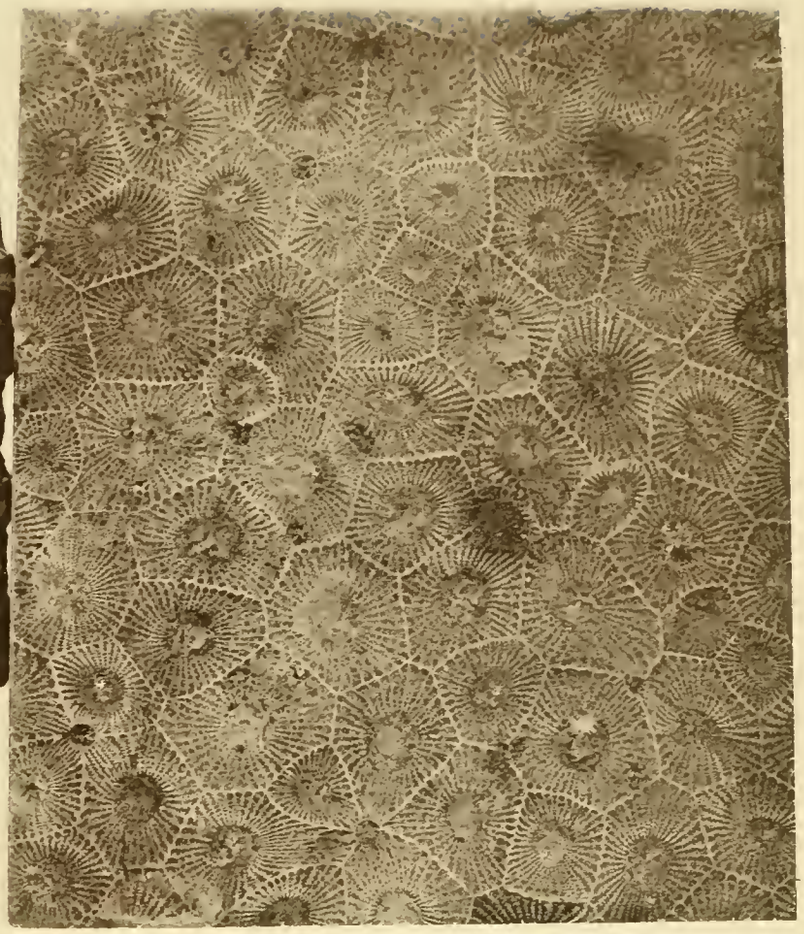
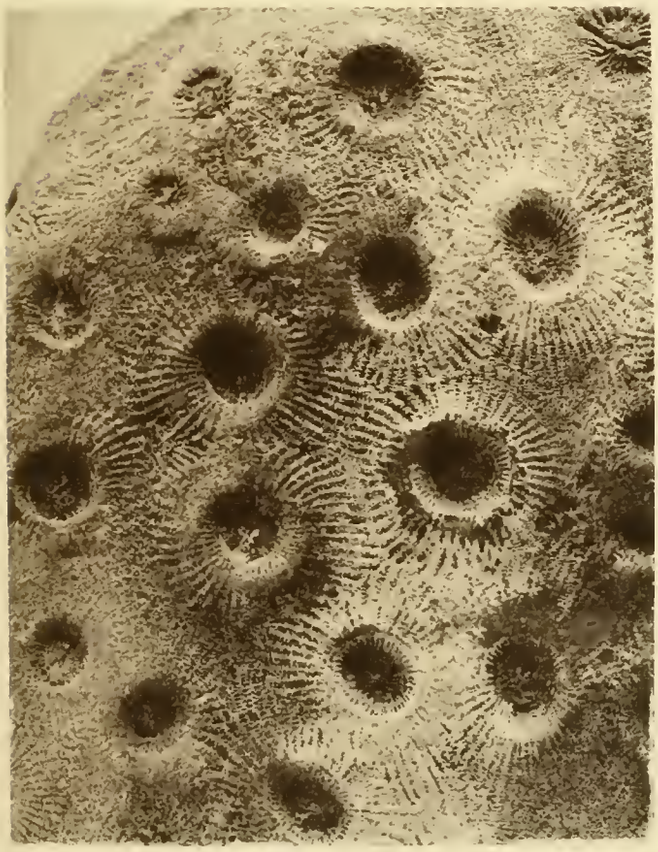


PLATE XXXVI

PLATE XXXVII





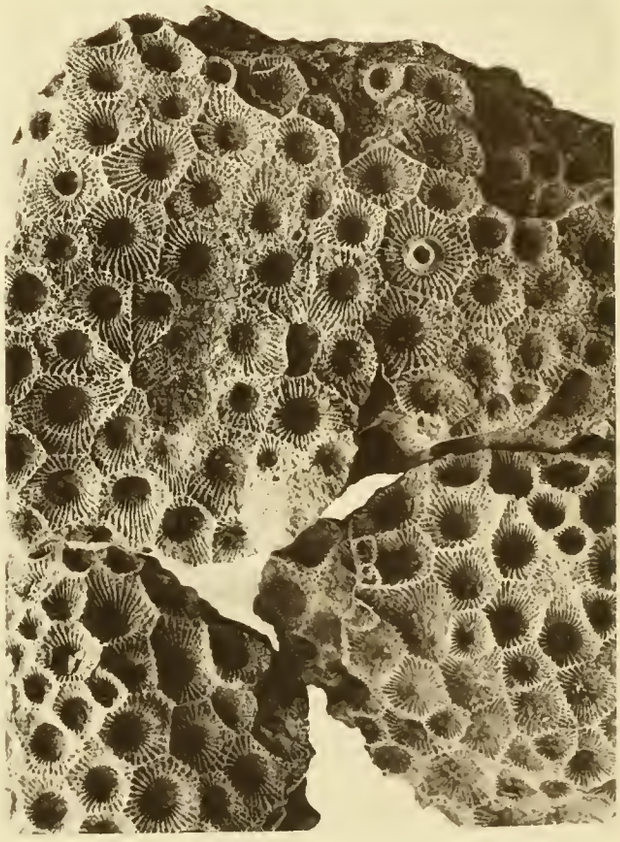


PLATE XXXVIII

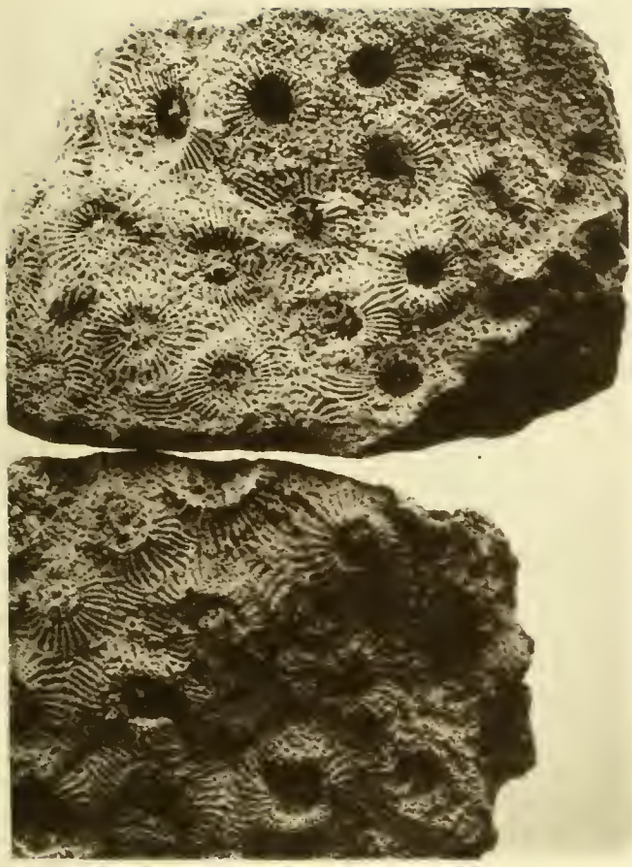


PLATE XXXIX

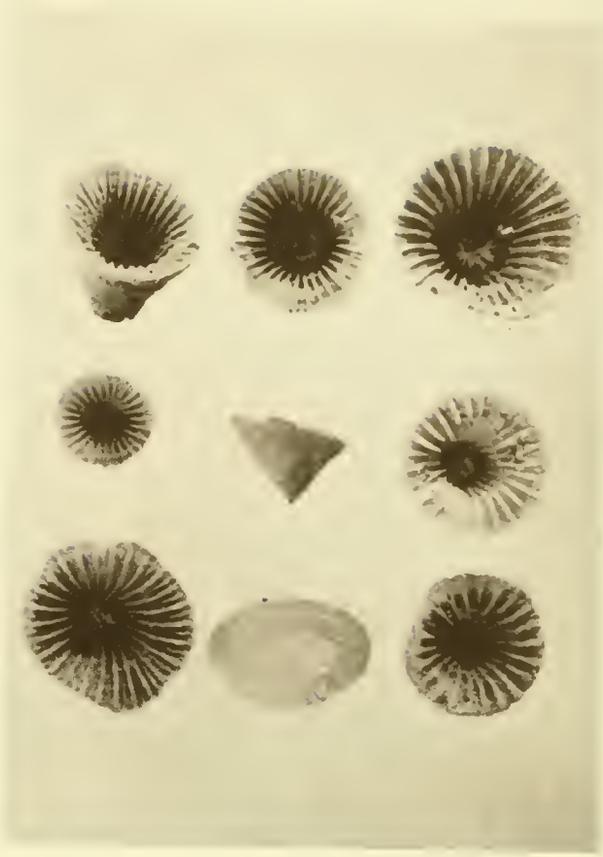


PLATE XL

PLATE XLI

PLATE XLII

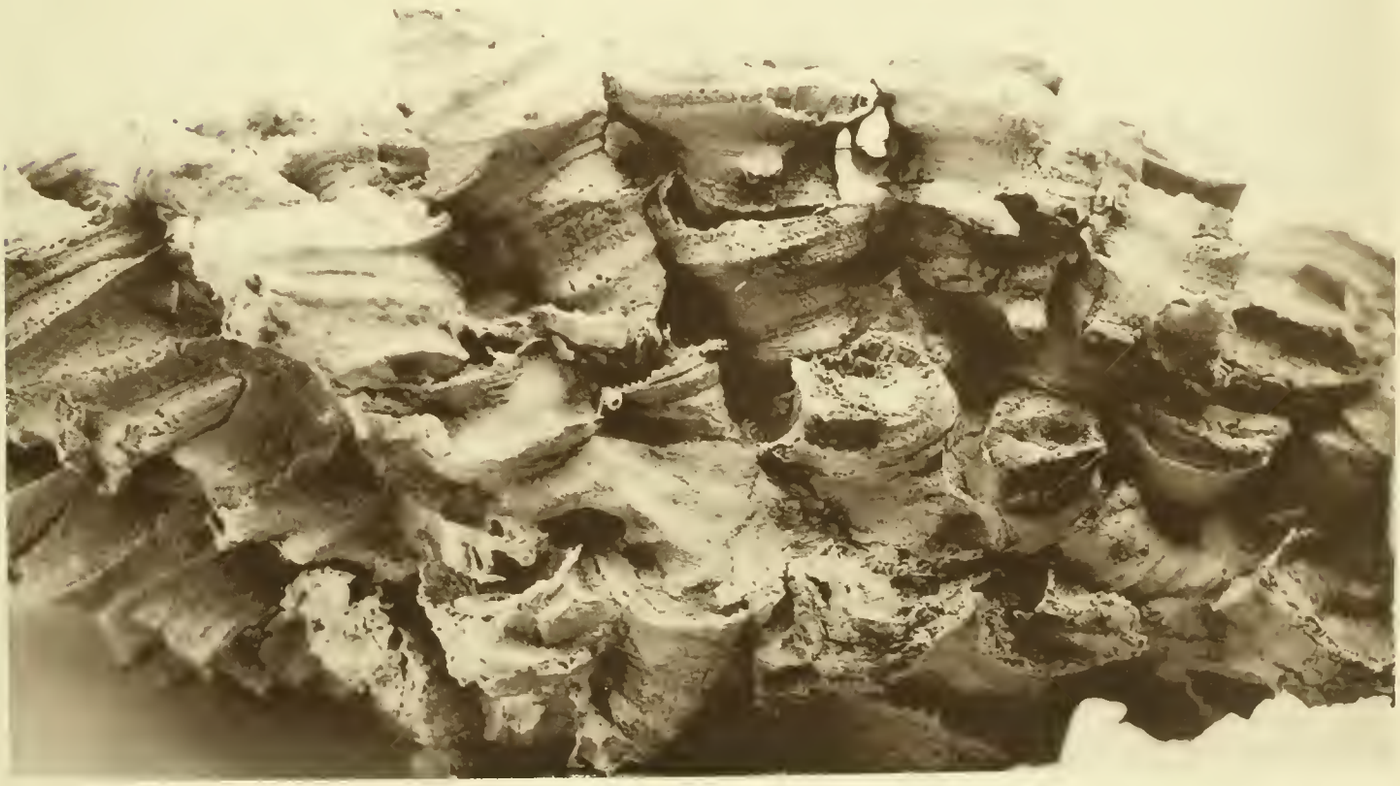


PLATE XLIII

PLATE XLIV

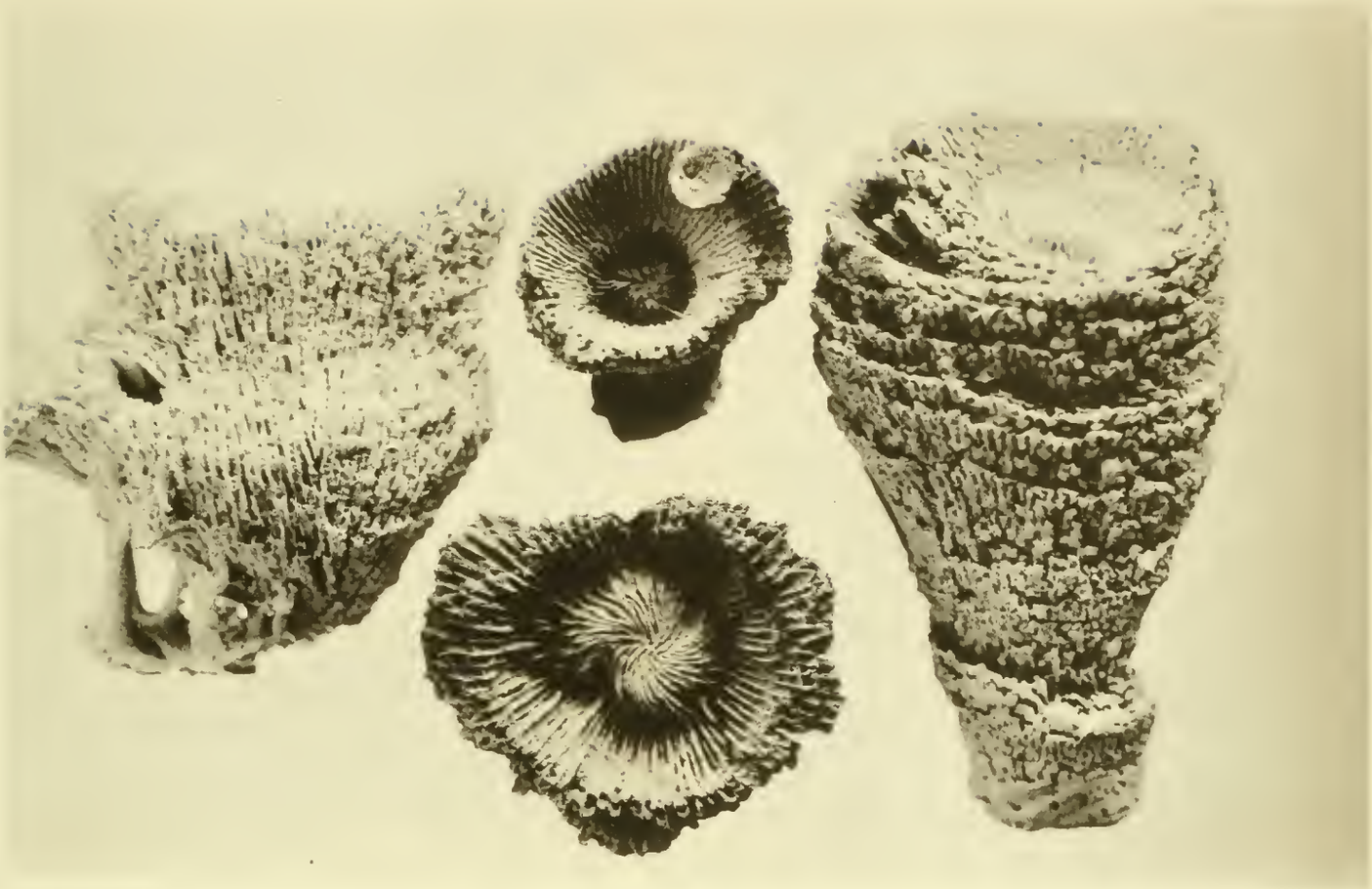


PLATE XLV

PLATE XLVI

PLATE XLVII

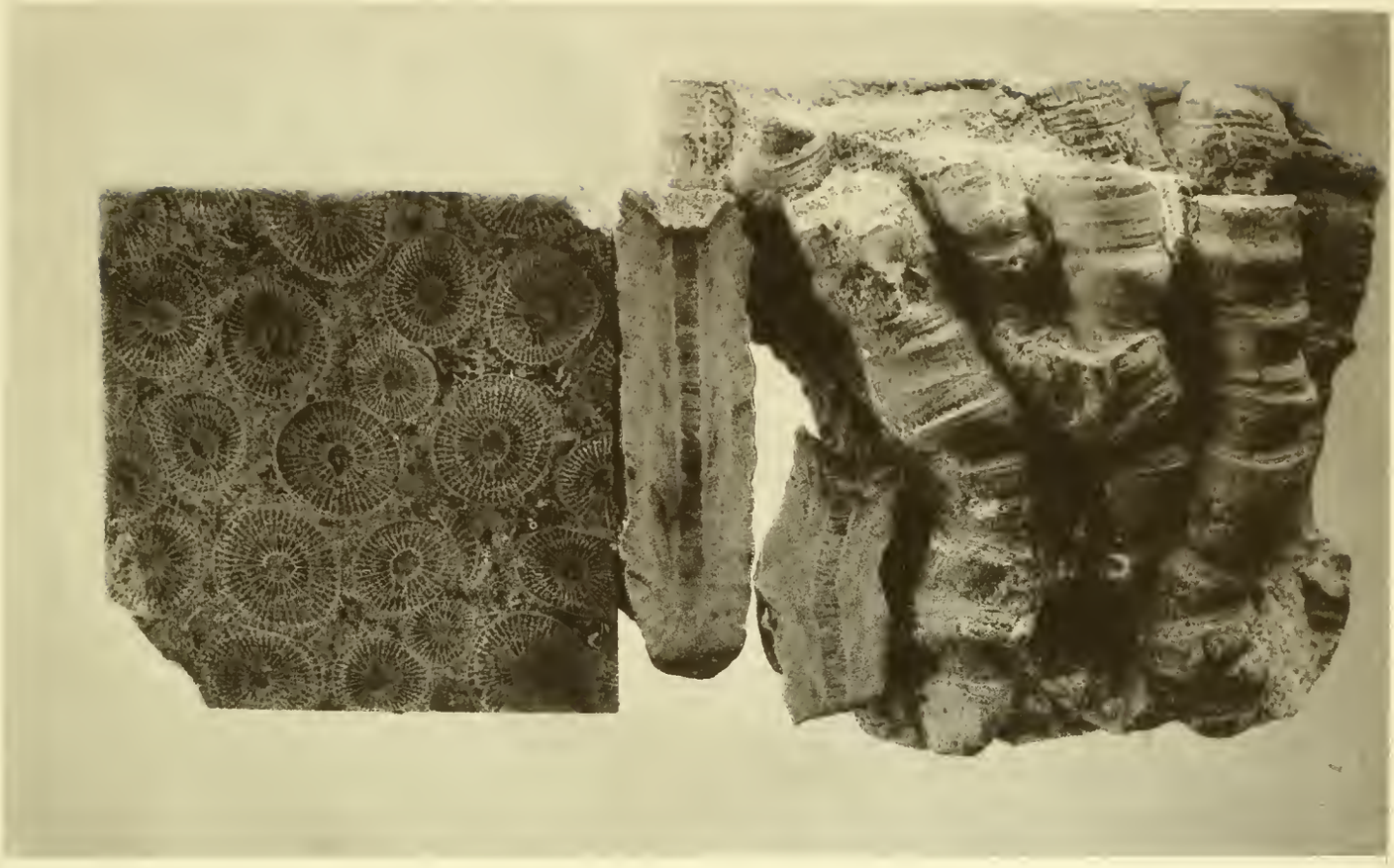


PLATE XLVIII

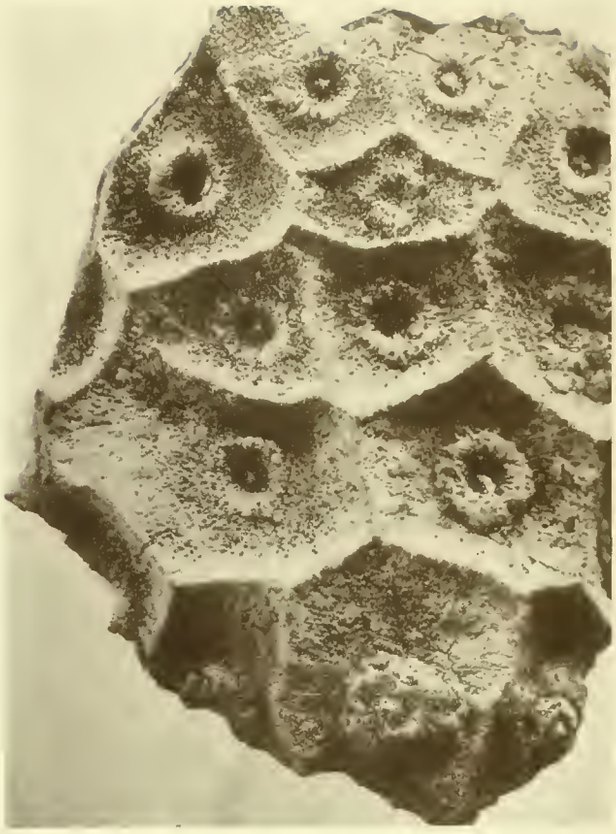


PLATE XLIX

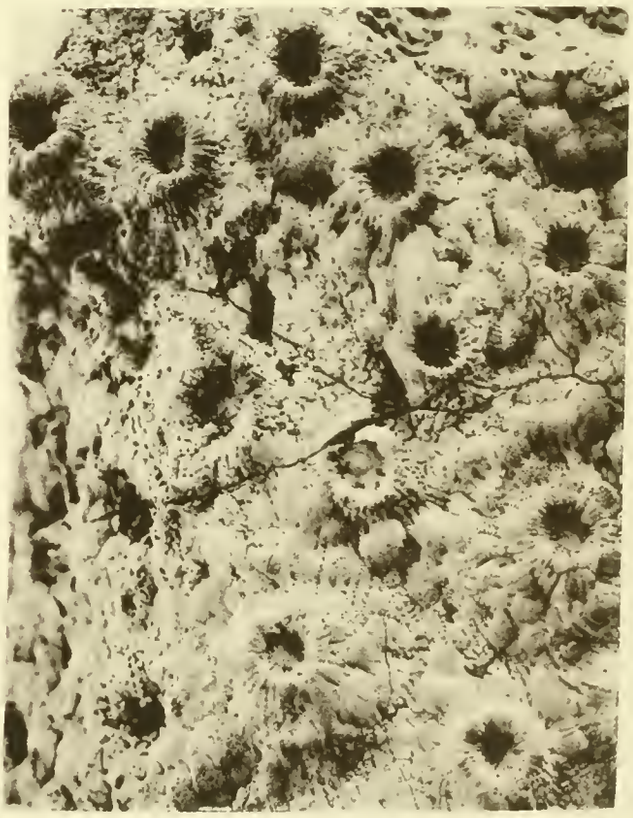


PLATE L

PLATE LI

PLATE LII

PLATE LIII

PLATE LIV

PLATE LV

PLATE LV