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The Morphology and Taxonomy of the Halysitidae

by

Edward J. Buehler

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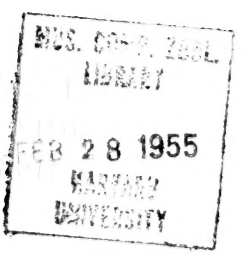

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THE MORPHOLOGY AND TAXONOMY OF THE HALYSITIDAE

ABSTRACT

The corallum of the Halysitidae consists of many slender, tubular corallites joined one to the next in linear ranks. The ranks, in turn, branch and anastomose at frequent intervals, thus bounding prismatic open spaces (lacunae). Many but not all species show dimorphism with autocorallites and mesocorallites alternating. The corallite walls are two-layered. Tabulae are abundant and closely spaced. Septa occur in some species as vertical rows of needle-like spines which are lamellar at the base. The calyces are shallow. New corallites were added both interstitially and on the free end of a rank. By the latter method the ranks lengthened until the free end joined with another rank. The coralla were loosely attached to their substratum and lived chiefly in an environment of nonclastic deposition. Ontogenetic changes and the origin and relationship to other corals are discussed.

Two genera, *Halysites* (genotype *H. catenularia* Linnaeus) and *Catenipora* (genotype *C. escharoides* Lamarck), are recognized. The stratigraphic range is Middle Ordovician to Late Silurian. The original description and locality data of every species described are quoted. Most of the North American species are redescribed and illustrated; neotypes and lectotypes are selected for some species. An identification key is given and the phylogeny discussed.

The new species, *H. encrustans, H. infundibuliformis,* and *H. magnitubus,* are described.

INTRODUCTION

Although the "chain corals" have been known to science since 1728 they have never been studied thoroughly. They are classified as the family Halysitidae with two genera, *Halysites* and *Catenipora* ranging from Middle Ordovician to Late Silurian.

Most of the literature on the Halysitidae consists of short descriptions in faunal studies, but three authors have contributed noteworthy studies specifically on this coral. They are: Fischer-Benzon (1871), Etheridge (1904), and Yabe (1915). The study by Etheridge is the most complete. None of these can be regarded as complete monographic studies although each of them has made contributions that were of great value in the preparation of this paper. The need for taxonomic revision is shown by the tendency for paleontologists to refer any specimen of the Halysitidae no matter what its characteristics, to *H. catenularia* or to erect a new species. The author has attempted to facilitate identification by compiling the original data on all species of the Halysitidae described and, wherever possible, by redescribing and photographing the type specimens.

This study was presented in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Yale University in May 1953. The work was begun while the author was a graduate student at Yale University and completed "in absentia" at the University of Buffalo.

Acknowledgment is due, first of all, to Professor Carl O. Dunbar who suggested the problem to the author and guided the study to completion. Thanks are due also to Dr. R. H. Pegrum of the University of Buffalo for encouragement and for making the facilities of the University available to the author. Those who have aided in the search for types and who have loaned specimens include Dr. G. Winston Sinclair of the University of Michigan, Mr. John Sargent of the Buffalo Museum of Science, Dr. Otto Haas of the American Museum of Natural History, Dr. H. B. Whittington of the Harvard Museum of Comparative Zoology, Dr. A. E. Wilson of the National Museum of Canada, Dr. G. M. Ehlers of the University of Michigan, Dr. Donald W. Fischer of Union College, and Dr. Jean M. Berdan of the U. S. Geological Survey. Dr. Joseph T. Gregory of the Yale Peabody Museum read the manuscript and offered valuable suggestions.

Special thanks go to Dr. Gerhard Regnéll of the Paleontological Institute at the University of Lunds, Sweden, to whom we first appealed for help in determining the nature of the genotype *Halysites catenularius* Linnaeus. He assured us that the holotype is no longer extant but that it almost certainly came from the Isle of Gotland, and suggested that a neotype should be selected from material in the Reichsmuseum at Stockholm. He

later determined that the collection in question was on loan to the British Museum of Natural History where it was under study by Drs. J. Stanley Smith and H. Dighton Thomas. He therefore wrote to Dr. Smith and presented our problem.

At our suggestion Drs. Smith and Thomas prepared a short paper selecting and describing a neotype for both *Tubipora catenularia* Linnaeus and *Catenipora escharoides* Lamarck and with great kindness supplied us with a manuscript copy so that we could adjust our manuscript while awaiting publication of this indispensable information. Our warm thanks go to Dr. Smith and Dr. Thomas for this friendly cooperation.

The bulk of the specimens used in this study were provided by Dr. Carl O. Dunbar from the collections of the Yale Peabody Museum of Natural History. These were supplemented by loans from the individuals mentioned above and by specimens collected by the author on field trips to Manitoulin Island, Ohio, Indiana, and Chaleur Bay, P. Q.

MORPHOLOGY

GENERAL STATEMENT

The corallum of the Halysitidae consists of many slender tubular corallites joined one to the next in linear ranks. The ranks in turn branch and anastomose at frequent intervals thus bounding prismatic open spaces (lacunae) in the colony. As seen from the surface, or in cross section, the corallites in a single rank bear some resemblance to the links in a piece of chain, whence the name *chain coral.* This arrangement has never been imitated by any other coral, although it has been crudely approximated by some species of *Tetradium.* Tabulae are invariably abundant and closely spaced. Real septa are lacking, but in some species are represented by vertical rows of needle-like spines which are lamellar at the base. Many, but not all, species show marked dimorphism with large and small corallites regularly alternating.

SHAPE OF THE CORALLUM

The complete shape of the corallum of the Halysitidae is usually not preserved. These corals commonly occur imbedded in a calcareous matrix and seldom weather free. Under favorable circumstances silicified specimens can be collected in blocks of stone and etched free but as normally collected they are fragmentary. They probably lived in an environment where they were generally more or less worn or broken before burial. It is not uncommon to find specimens that appear to preserve much of the original top and bottom surfaces of the corallum but these are nearly always so much broken about the sides that it is impossible to make more than a guess as to the complete size and shape of the colony. Specimens still attached to their substratum are found but are rare.

A common shape is a low and broad corallum of fairly uniform thickness

but thinning toward the periphery (pl. 3, fig. 4). However, there is wide variation in shape just as there is in *Favosites*, from tabular to globular to subcylindrical. The size varies according to the species and the age of the colony. A specimen 6 cm. in diameter by 2 cm. thick is considered a small colony. Since growth starts with a single corallite the size of the corallum increases gradually to the norm for the species, therefore it is difficult to decide whether a small specimen represents a small species or merely a young colony. A colony 30 cm. in diameter by 10 cm. thick is considered a large one but there is a specimen in Yale Peabody Museum with corallites 22 cm. long and Professor Dunbar reports a colony in the Lefevre member of the Manlius limestone in the roof of a cement quarry near Rosendale, New York, that is about 3 inches across and at least 18 inches tall.

In some species the lacunae are large, leaving wide spaces between the ranks of corallites. This tendency may be carried to the stage where the colony becomes simply a few irregular rows of corallites and has no characteristic form (pl. 4, fig. 1).

Typically the individual corallites are vertical or slightly tilted so as to radiate from the center of the colony. If, as in some colonies, the corallites radiate sharply from the center outward, a cone-shaped or hemispherical corallum is formed with a small base and a broad top (pl. 2, fig. 1; pl. 10, fig. 5).

Occasionally coralla are found with the top and bottom surfaces but slightly damaged. These show the bottom surface to be uneven, probably a crude mold of the substratum upon which the colony grew, whereas those upper surfaces observed are very even, either nearly flat or gently convex. The upper surface of a large, nearly complete specimen may be raised into two or three gentle convexities. Most of the specimens studied are broken along the sides making it impossible to determine the complete form and dimensions. Apparently the outline of the corallum was irregular as a result of an uneven or lobate peripheral growth.

DIMORPHISM

A colony of the Halysitidae may contain one, two, or possibly three different kinds of corallites. The large ones which form the apparent links in the chain will be called autocorallites. The smaller ones interpolated between the autocorallites and not readily apparent to the naked eye will be called mesocorallites (text-fig. 1). These terms have been modified from the old bryozoan terminology of "autopores" and "mesopores" which has been used extensively in descriptions of the Halysitidae. They are so similar to the old terms that they are not entirely new, yet they correctly refer to corallites rather than pores. Etheridge (1904) reported a third kind of corallite which he called the gonopore but, as will be pointed out later, it is not likely that such occur.

Dimorphism is not shown by all species of the Halysitidae. In general,

mesocorallites are lacking in Ordovician species and present in most Silurian species. Apparently the polyps of the mesocorallites were structures which did not appear until after the originally monomorphic chain corals had become well established in the Ordovician seas but the fact that they soon became a morphological characteristic of most species suggests that they conferred some beneficial service upon the colonies and were acted upon positively by selection. The monomorphic species are placed in the genus *Catenipora* and those showing dimorphism in the genus *Halysites*.

There is no clear evidence of the function of the two kinds of polyps. Apparently the mesocorallite polyps played a role in the formation of new ranks. As described in the section on "Asexual increase" the branching of the ranks in dimorphic species takes place at a mesocorallite and rarely, perhaps never, at an autocorallite. On the other hand, the ranks branch equally well in the monomorphic species in which the branching takes place in the intercorallite walls. There is no noticeable correlation between the presence or absence of dimorphism and the pattern of the corallite ranks and lacunae.

THE AUTOCORALLITES

The autocorallites normally are slightly elliptical in cross section but range from circular to broadly elliptical. In most species the cross section of the corallites holds a fairly constant shape, but in a few there is a wide variation from circular to broadly elliptical in different parts of a single corallum. The shapes described refer only to the inside of the corallites. The elliptical form of the outside is truncated at those places where adjacent corallites are joined. If the corallites are crowded so as to come in contact with others on all sides they have a polygonal cross section (pl. 5, fig. 2).

The size of the corallites in cross section (external dimensions) ranges from less than 1 mm. in diameter in the small species to 4 mm. in the large species. The commonest size is approximately 1.75 x 2 mm. There is a tendency for round cross sections to occur in the large species; most of the species which are small in size have elliptical corallites. Except for a few very slight constrictions and irregularities, the mature portions of the corallites are of equal diameter through their entire length.

The corallites are usually broken at one or both ends so that measurements of the complete length are not possible. The largest corallite measured was 4 mm. in diameter and 145 mm. in incomplete length. A length of 50 mm. and a ratio of maximum cross section diameter to length of 1:20 is especially common but there is great variation among the species. New corallites are added throughout the life of a colony but only the oldest ones extend from top to bottom the full thickness of the corallum. The others originate at various levels but once formed they almost invariably extend to the top surface of the colony. There is a tendency for several corallites to originate at the same level.

THE LACUNAE

The coralla of the Halysitidae are composed of tubular corallites arranged side by side in linear phalanxes. The term "rank" is proposed for a single row of contiguous corallites. The ranks are not straight but follow a more or less irregular course and join with other ranks or are connected with them by short cross ranks. This results in a strong buttressed structure. The number of corallites in a rank varies from one or two in some species to ten or more in others.

It is useful to have a term for the irregular shaped spaces between the ranks. The term "fenestrules" used by Etheridge (1904) has already received much acceptance in the literature, but fenestrules literally means little windows and if one thinks of the coral in three dimensions these are not in any sense little windows. They may be completely closed on the bottom. The term "meshes" which has also been used by other authors is objectionable for the same reason. It implies that the spaces perforate the entire corallum like the meshes in a net. The term lacunae does not carry that implication and will be used henceforward in this discussion. It refers simply to the vacant spaces between the ranks.

The lacunae may be classified according to shape as either (1) polygonal or (2) elongate and rounded. The polygons of the first type of lacunae may be very small and five- or six-sided, each side formed by one or two corallites, but more commonly each side contains three or four corallites. Polygonal lacunae surrounded by ranks of several corallites each average 0.5 to 1 cm. in diameter. Both sizes may be present in the same colony (pl. 6, fig. 2; pl. 7, fig. 1).

The lacunae of type 2 differ from the preceding in being more or less elongate and rounded rather than polygonal in outline (pl. 1, fig. 1; pl. 3, figs. 1, 4). This is the commonest type and also a highly variable one. Lacunae from different parts of the same colony may be elliptical, crudely dumb-bell shaped, or long and sinuous, of the type commonly referred to in the literature as labyrinthine. The sides of the elongate ones are commonly united by short cross ranks of one or two corallites. The length ranges from 1 to 6 cm. and the width from 0 to 1 cm. The lacunae of *H. agglomerata* Hall are very long but so narrow that there is no appreciable space left between the ranks. In certain large colonies the long lacunae radiate outward from a central round one like the spokes of a wheel. A large complete colony may contain several such radiating clusters (pl. 9, figs. 2, 3).

The larger the lacunae the greater is the variability in their shape. Environmental factors such as crowding undoubtedly had some effect on the shape but it is difficult to demonstrate that a certain shape resulted from environment rather than inheritance. A nearly complete specimen of *Catenipora microporus* from Louisville, Kentucky, has polygonal lacunae except for one narrow zone where they appear to have been crowded into an elongate form by stronger growth on both sides of that zone.

In spite of the variability shown by this character many species of the Halysitidae have a pattern of ranks and lacunae that is sufficiently characteristic to be of taxonomic use.

There is not sufficient evidence to prove any particular shape of lacunae as primitive. A compact growth is most common among tabulate corals and hence may represent the condition of the ancestral species. The oldest species known, *Catenipora quebecensis,* has small, polygonal lacunae. Furthermore, ontogeny shows a tendency for the lacunae to be small and angular in the first formed portions and to increase in size as the colony grows older. These facts suggest that large, elongate lacunae are the most specialized kind.

There is a correlation between size of corallites and shape of lacunae. Very small corallites usually surround small, polygonal lacunae whereas species with very large corallites have elongate lacunae.

THE CORALLITE WALLS

EXTERIOR SURFACE

In well preserved corallites the exterior is marked by very fine, closely spaced, horizontal growth lines (pl. 12, fig. 4). In most specimens these have been largely obliterated, but the coarsest varices of growth usually remain. These appear as swellings or constrictions as much as 1 mm. wide, spaced at irregular intervals ranging from 4 to 8 mm. (pl. 7, fig. 6; pl. 11, fig. 1). If preservation is favorable any one of these coarse markings may be traced around the entire corallum. They are straight or gently undulating. As they are growth lines formed at the distal edge of the coenosarc they show that the upper surface of the coralla was flat or gently undulating throughout growth and that all the corallites grew vertically at the same rate with occasional exceptions. There are no vertical markings except some very faint striations visible in a few specimens.

The walls are perfectly solid. There are no mural pores and no connections whatever between the lumena of adjacent corallites.

STRUCTURE OF THE WALLS

The thickness of the corallite walls varies greatly, depending in part on the size of the corallites. In *Halysites labyrinthica* they are approximately 0.2 mm. thick. In many of the specimens studied the walls are damaged by silicification, but calcareous specimens, especially those from the Brownsport formation of Tennessee, retain fine details. Both thin sections and peels of these specimens clearly show the wall to consist of two layers which are distinguished by a slight difference in texture (pl. 9, fig. 5). Thin sections examined under both ordinary and polarized light show that the inner layer is more coarsely crystalline than the outer but reveal no other difference. The contact between the two layers may be sharp or indistinct. In several thin sections the walls have cracked and separated at the con-

tact between the two layers and it is possible to flake away the outer layer from the surface of some corallites. The thin outer wall will be called the "primary wall" following Swann's (1947) terminology for the wall structure of the Favositidae (based on Hill's terms). It is a thin, continuous coating over the exterior of all of the corallites. The primary wall may line the rim of the calyces but it forms no part of the tabulae, septa, or intercorallite walls. This is the layer that bears the fine growth lines on the surface of the corallites. The inner wall is four or five times the thickness of the outer. It is identified with the peripheral stereozone of Swann (1947) because it forms the septa and intercorallite walls. Swann defines peripheral stereozone as "a marginal zone of dilation produced by the deposition of sclerenchyma and lining the epitheca of the Rugosa or the primary wall of the Favositidae." Some specimens show faint vertical lines in longitudinal sections of the walls and equally faint concentric lines in cross sections. These may be the growth lamellae described by Swann (1947).

THE TABULAE

Tabulae are invariably abundant and closely spaced. Most are complete but incomplete ones are common. They may be flat or nearly hemispherical with the convex side directed either up or down. The tabulae are always thinner than the corallite walls and are composed of the same material as the peripheral stereozone. They bend abruptly upward at their periphery and merge with the inner surface of the corallite wall. Many colonies show zones in which the tabulae are either closer together or farther apart than usual or are arched differently. As these zones are recognizable at the same level in any part of the colony they probably represent the influence of some environmental factor.

SEPTAL STRUCTURES

Septa are usually lacking in the Halysitidae but in some species they are represented by vertical rows of short slender spines (acanthine septa) composed of the same material as the peripheral stereozone (pl. 5, fig. 1; pl. 6, figs. 3, 4). Such septal spines are normally arranged in 12 rows, five each side and one at each end of the elliptical cross section. The spines are needle-like, round in cross section and separated by a distance somewhat greater than their diameter (pl. 11, fig. 4). Since a cross section may fall between the spines, the number of rows may appear in thin slices to be less than 12. Commonly the spines reach only about halfway to the center of the corallite, but in some species (pl. 11, fig. 5) they meet at the center and even fuse to form a rod-like columella easily seen in axial sections.

Thomas and Smith (1954) pointed out that the septa in the neotype specimen of *Catenipora escharoides* and in an unidentified specimen are fundamentally lamellar plates with pointed spines at their axial ends. The author observed several weathered specimens which showed faint vertical septal ridges on the inside of the corallites. On the other hand, the septal

structures of *Catenipora gracilis* appear to be separate trabeculae which are not joined by vertical lamellae.

Septal spines must be used with caution in taxonomy. They are extremely delicate and usually visible only in thin sections. Even then, they may show up in some parts of a corallum and not in others. No other type of septal structure such as squamulae or solid septal plates were seen in the specimens examined.

MESOCORALLITES AND INTERCORALLITE WALLS

In dimorphic species (*Halysites*) the autocorallites are usually separated from one another by one or, rarely, two mesocorallites, whereas in monomorphic species (*Catenipora*) they are in contact. The mesocorallites are normally rectangular rather than elliptical in cross section and have a diameter about one-fourth the largest diameter of adjacent autocorallites. The sides are rendered slightly convex inwardly by the rounded ends of the adjacent autocorallites and on the free sides by the rounded constrictions which mark off the "links" in the chain. The lumena are rectangular in cross section but may be reduced to a narrow slit if the intercorallite walls are exceptionally thick.

The wall structure is similar to that of the autocorallites. The primary layer of the wall extends unbroken across the exposed sides of all the corallites in a rank, the boundary between a mesocorallite and adjacent autocorallites being formed by the peripheral stereozone alone (fig. 1). The presence of the primary wall only on surfaces exposed to the exterior suggests that it was deposited by a fold of ectoderm which slightly overhung the rim of the calyces. Perhaps contact of the calicoblasts with sea water caused precipitation of $CaCO_3$ in a different form according to a process analogous to that which forms the layered shells of the molluscs.

In monomorphic species the intercorallite walls are a solid layer of peripheral stereozone probably formed by the fusion of the inner layer of adjacent autocorallites (pl. 5, fig. 1). This is significantly different from *Favosites* in which an intramural coenozone participates in the separation of adjacent corallites.

Tabulae in the mesocorallites are nearly flat in some species but more commonly are strongly arched (usually convex upward). They are thicker than those of the autocorallites and about three times as numerous. Thicker walls as well as thicker and more abundant tabulae point to the mesocorallites as loci of polyps with more abundant or more active calicoblasts.

In dimorphic forms, branching of a rank of corallites invariably takes place at a mesocorallite. For this reason Etheridge (1904) assumed that these individuals represented a third type of corallite for which he used the term gonopore. Since in other respects they do not differ from other mesocorallites we are not inclined to follow Etheridge.

The mesocorallites situated where the ranks join may be T-shaped, Y-shaped, or V-shaped in cross section (pl. 9, fig. 5). The lumen extends

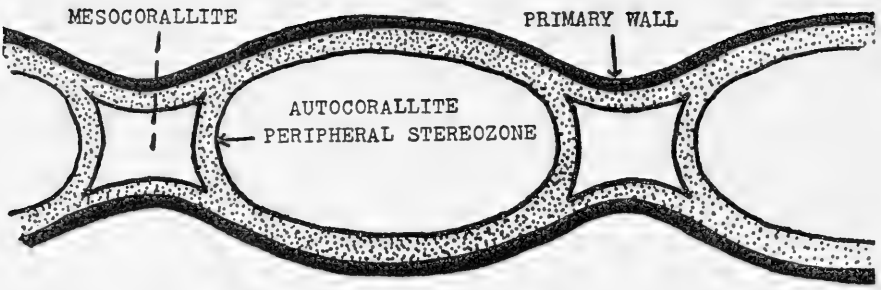


Figure 1. Composition of the corallite walls. The primary wall is indicated by solid black; the peripheral stereozone is dotted.

into all the branches. Some ranks appear to branch directly from the side of an autocorallite but careful examination always shows that they actually connect to a mesocorallite which has sent out a thin, attenuated branch so closely pressed to the side of the adjacent corallite as to appear to be part of it (pl. 3, fig. 3). The tabulae of the branching mesocorallites retain their typical form near the intercorallite walls but become very irregular both in shape and orientation near the center (pl. 9, fig. 4).

Fischer-Benzon (1871) gave detailed descriptions and illustrations of the morphology of mesocorallites but, as pointed out by Yabe (1915), he overrated their taxonomic value. Types which he regarded as characteristic of different species may be found in different parts of the same colony. This is especially true of his "chambered" and "cellular" types. He also described and figured circular or oval rods or "balken" which occur in the intercorallite walls (fig. 2). Structures resembling his figures have been observed but they are too rarely visible to be of value in classification. It is possible that they are a product of recrystallization of the peripheral stereozone material rather than anatomical structures.

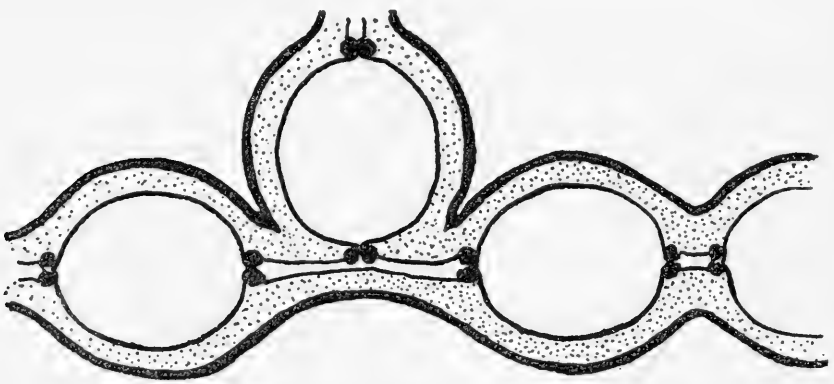


Figure 2. *Halysites regularis* Fischer-Benson 1871, showing the "balken." Modified from Taf. II, fig. 2.

Other terms which have been used for the mesocorallites are "tubules," "cellules," and "mesopores."

THE CALYX

In most specimens available for study the upper surface is either much eroded or broken so that the calyx cannot be studied, but in some (e.g., Y.P.M. 18664) the upper surface is preserved (pl. 12, fig. 1). The diameter of the autocorallites in the specimen figured is approximately 1 x 0.75 mm. and the depth of the calyx approximately equal to the diameter. In other words the polyps were practically perched on the top of their skeleton and were not long and slender or housed within the tubular corallites. The fact that the growth lines occur all the way from the very beginning of the corallites up to the brim of the calyx shows that the epidermis of the polyps just barely overhung the edge of the calyx. The calyx lips are rounded (pl. 11, fig. 4). The mesocorallite calyces are shallow platforms only a fraction of a millimeter deep.

Thomas and Smith (1954) figure a specimen with thick, solid intercorallite walls. The calicular surface of these walls is ornamented with small granules arranged in closely set parallel rows which run in the direction of the chains. Perhaps these are the ends of vertical trabeculae.

ASEXUAL INCREASE

The chain coral colonies are enlarged by at least two methods of asexual increase. One of these is the process known under such names as intermural or interstitial increase (*zwischenknospung*, von Koch 1883) in which the offset is not referable to a particular mother corallite. The other is a kind of peripheral increase. Fission has not been observed in this genus.

The first method lengthens a rank by the insertion of a new corallite between two old ones (pl. 3, fig. 5). Although this takes place most frequently where the ranks join, it may occur anywhere in a rank. In monomorphic species the new corallite originates in the intercorallite wall. It starts as a minute cupshaped structure which increases in diameter as it grows in length. Corallites with an external diameter of 2 mm. attain that size in approximately 5 mm. of vertical growth. In dimorphic species the new corallite originates in the center of a mesocorallite. These become slightly enlarged in diameter, the walls thicken, and the tiny apex of the new autocorallite takes form. Some specimens suggest that this is accomplished by the two long sides of the mesocorallite thickening and fusing together except for three spaces, one in the middle which becomes the new autocorallite and one on each end which become the two new mesocorallites. However, this cannot be demonstrated clearly enough to be stated as a fact. It is quite possible instead that the tip of the new autocorallite was formed about the base of the newly formed polyp and then fused with the mesocorallite wall.

Longitudinal sections show that the mesocorallites bifurcate and continue with halved diameter on each side of the new autocorallite. Both types of corallites rapidly enlarge to normal diameter (pl. 9, fig. 6). The tabulae

are somewhat irregularly arranged in the region of bifurcation but otherwise tabula formation continues without interruption during the process of increase. The new autocorallites are tabulated all the way down to their point of origin.

Interstitial increase serves to elongate the ranks and is especially important in those species with long ranks and meandriform lacunae. It is common for large meandriform lacunae to start out three- or four-sided with each side formed of one or two corallites and gradually add more corallites interstitially until the typical form and size is attained. Interstitial increase does not, however, show how the lacunae are formed because it can only take place between corallites that are already present and cannot initiate a new rank. From this fact alone it is obvious that another mode of increase was in operation.

There are examples of ranks which started as a single corallite connecting two meandering but somewhat parallel ranks and elongated by interstitial increase. If the two meandering ranks had come in contact so that an autocorallite of one fused with an autocorallite of the other it would be possible for the single connecting corallite mentioned above to be formed interstitially. If this were to take place frequently the formation of ranks and lacunae would be explained. Some specimens suggest that this happened occasionally but it certainly was not the chief method of forming ranks.

The formation of the corallum of the Halysitidae requires, in addition to interstitial increase, a kind of peripheral increase in which each offset (the skeleton of a bud or daughter polyp, replacing the term bud when applied to skeletal tissue) can be referred to a single parent corallite. Lindstrom (1873) believed that new corallites were formed on the side of older ones. Pocta (1902) thought that the new corallites of the Halysitidae were formed in the walls of the old, either in the narrow walls separating adjacent corallites or in the broader free walls. In the first case the corallite rank was lengthened; in the latter case a new rank was initiated which lengthened by the addition of more corallites, each on the narrow wall of the corallite preceding it. Pocta's observations although generally correct, were not completely accurate. As pointed out previously, ranks which appear to attach to the broader free wall of an autocorallite actually attach to a mesocorallite. Furthermore, Pocta in contemplating the budding of corals made the mistake, common among paleontologists, of thinking only in terms of the skeleton instead of the living polyps.

The fact that a method of peripheral increase was in operation is demonstrated by those ranks that are complete on the bottom. The corallites, instead of tapering to a point which is inserted between two other corallites, give the appearance of being of full width for their entire length and ending free on the bottom. As will be pointed out in the next few paragraphs, this appearance is superficial and does not reflect the true situation. The bottom of the tubes is rounded and covered by primary wall. In some

of these ranks all the corallites end at the same level; in others they are more or less staggered like organ pipes. Apparently the first corallite of a new rank budded with its long cross section at an angle to the rank from which it originated instead of in line with it. A second corallite budded from the distal side of the first, a third from the second, and so on until a new rank branching from an older one resulted. If the distal free ends of these ranks should meet and fuse with other ranks, the lacunae would result, as they apparently do (pl. 6, fig. 5).

The details of this budding were not clear until Dr. C. O. Dunbar called the writer's attention to some unusual specimens in the Yale Peabody Museum collection. These specimens have extremely fine growth lines preserved and by means of these it is possible to trace the course of the bud-

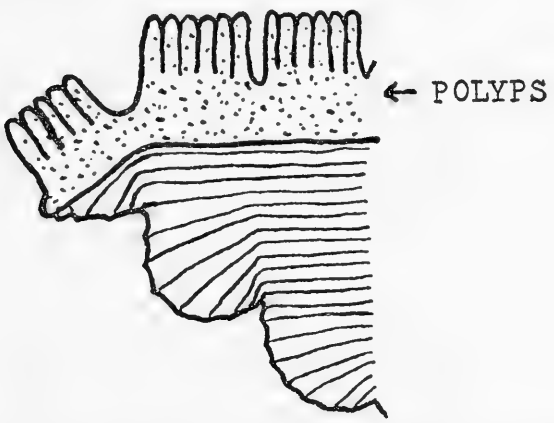


Figure 3. Diagram of peripheral budding in the Halysitidae as revealed by growth lines. For simplification a monomorphic species is illustrated. The vertical distance between the bottom of the corallites is not necessarily as great as that shown here. The beginning of a new bud is shown as a swelling at the base of the polyp at the left.

ding and subsequent growth of new corallites. Y.P.M. 18665 and 18666 from Tofta Parish, Gotland, are especially good and are illustrated on Plate 12, figures 3 and 4.

Interpretation of the growth lines shows that in the development of a new rank a bud would form at the side of a polyp. The bud would stool out laterally above the rim of the corallite and then secrete its own skeleton surrounding its base. At a very early stage of its growth it would throw off another bud, that one another, and so on until a new rank was formed (pl. 12, figs. 2, 3, 5). Although the new corallites began to grow horizontally they turned upward after 0.5 to 1 mm. of growth and then grew parallel to the other corallites. This is why the corallites are rounded at the bottom like a row of test tubes. The growth lines of the new corallites are continuous from the very beginning with the growth lines on the rest of the colony

which shows that the new polyp was at no time separated from the older ones. Apparently the bud originated as a swelling on the side of the mother polyp and grew into a new polyp without breaking fleshy continuity with the old and with little or no disturbance of the fold of coenosarc which formed the growth lines (text-fig. 3; pl. 12, fig. 3). This is shown from a different perspective in Y.P.M. 18664 (pl. 12, fig. 1) in which the upper surface of a colony is well preserved. This specimen shows that each rank of corallites presented the form of a trough, expanding at each corallite and contracting between, but evidently there was a continuous body of flesh much as in the modern brain coral.

In dimorphic species the first corallite of a new rank buds from a mesocorallite polyp but in monomorphic species the first corallite buds from an intercorallite wall where there presumably was no polyp. Either the budding took place from the fleshy connection between two adjacent polyps or there was a type of polyp present that left no record of itself in the skeleton.

The formation of the mesocorallites is not clearly displayed. Apparently the budding was almost double, first a mesocorallite polyp and very shortly thereafter an autocorallite polyp from that. In view of the important role played by the mesocorallites in the formation of new ranks it is unlikely that the autocorallites were formed first and later separated by interstitial addition of mesocorallites. Serially ground surfaces and vertical sections of corallites from several specimens were examined but the earliest stages of increase were attended by much lime deposition which obliterated detail. Some specimens suggest that the wall on the distal side of the last corallite of a developing rank would thicken and acquire two lumena at about the same time, the distal one of which became the new autocorallite and the proximal one the new mesocorallite.

There are several factors of this peripheral increase that are difficult to explain. One of these is the scarcity of ranks that are attached at one end only. If the lacunae were formed by ranks elongating and eventually fusing with others there should be many incomplete ranks that remain free at one end. Such free-ending ranks, the last corallite of which is always an autocorallite, do occur but not with the frequency one would expect.

The bottom of each new corallite of a rank is at a slightly higher level than that of the one preceding it but this distance may be so slight that the rank appears level on the bottom. This fact together with the scarcity of incomplete ranks shows that the budding was carried out quite rapidly in relation to vertical growth. Apparently the polyps budded one after the other in quick succession and then the entire rank grew vertically as a unit. Those ranks in the process of formation would be very shallow and delicate and hence would tend to be broken away in fossils. The possibility that the lacunae might have been covered with a sheet of coenenchyme or that there might have been stolonal connections between the ranks in which new

polyps could form has been considered. However, such structures should have left evidence of their presence and there is none whatever.

If rank formation took place in the manner described it is obvious that the end distal to the point of origin would impinge against another rank, thus effecting closure of the lacunae. The etched specimen of *H. infundibuliformis* (Y.P.M. 19142, pls. 1 and 2) shows with unusual clarity how the ranks were formed and how the closure of the lacunae took place. As the developing rank encountered another rank it did not merely abut against it; instead anastomosis of the living tissue took place very quickly. Some corallites show that the lips of the calices actually flared out slightly just before union, as if there were a force drawing the two polyps toward one another. The primary wall was formed where the polyp overhung the edge of the calyx, therefore the junction of the corallites would be marked by a double layer of primary wall only in the amount of vertical growth that took place between the first contact of the corallites and the fusion of the flesh. The fact that, in thin sections, primary wall is rarely seen between adjacent corallites (cracks in the peripheral stereozone between adjacent corallites may resemble primary wall but can be recognized under high magnification) shows that anastomosis of the flesh took place with little delay. This can also be seen by tracing the fine growth lines of those specimens in which they are preserved. In dimorphic species the mesocorallites are also formed very early for they are rarely absent.

When the gap is closed the rank may abut against the other between two corallites or against the side of one. Once the union is completed the vertical growth at one end will be just like that at the other, so that in cross section it is not possible to tell at which end a rank originated. There is a noticeable tendency for one end of the rank to join directly with a mesocorallite and the other with the side of an autocorallite, necessitating the indirect connection with the mesocorallites shown in Plate 3, figure 3. However, the ranks are by no means consistent in this arrangement.

In certain colonies which expand rapidly from a small initial point the lacunae are closed or partially closed at the bottom. Because of the small diameter and labyrinthine pattern of the lacunae of those forms the new ranks commonly join back to their parent rank after the formation of one or two corallites. The new corallites grew against the old and some were even joined laterally (at the base only). They then grew away from the old rank forming at first a little pocket which enlarged into a lacuna by interstitial addition of corallites. This is a rather uncommon modification of the more typical method by which the Halysitidae form lacunae.

The etched specimen (pl. 2) provides an interesting demonstration of a kind of rejuvenation. The slight constrictions in corallite diameter that cause the coarser varices of growth were accentuated in certain portions of the colony and some of the ranks ceased to grow vertically, apparently as a result of death of the polyps. As normal growth was resumed the coral

seemingly tried to replenish the dead ranks by budding new ranks from the nearest live corallite. These new ranks tended to follow the same course as the dead ones, although some diverged considerably.

VARIATION IN COLONIAL FORM

The study of variation in colonial corals may shed light on some interesting biological problems. One of these is the application of the hypodigm concept to colonial organisms, each specimen of which exhibits properties of both an individual and a small population. The most important taxonomic characters are often those of the individual corallites rather than the entire colony but it is the entire colony that is named. Thus, to a certain extent, it is necessary to base a species on a sample of populations rather than of individuals as with noncolonial animals. As pointed out by Hoffmeister (1926) and others the variation within colonies may be so great as to make species definition very difficult and cause overlap among named species. The concept of clones is another that might be applicable to study of variation in colonial corals. The entire colony consists of many individuals descended from one, the larva, without introduction of new genetic material other than by mutations. Students of colonial corals should be constantly alert for any modifications that might be a mutation and should note the extent to which the mutation is passed on to asexually produced offspring. No mutations were observed in the specimens of the Halysitidae examined, but Swann (1947) described one in a colony of *Favosites alpenensis.*

The interspecific and intraspecific variation of the Halysitidae will be discussed in the descriptions of the species. Several large colonies were examined for variation within a colony. This disclosed noticeable variation in cross section shape and dimensions of the corallites, size and shape of the lacunae, and spacing of the tabulae, which was measured in a large specimen of *H. labyrinthica* in the following manner: The long dimension of the corallites was divided by the short to give a ratio of major to minor axes which is useful in describing the ellipticity of the corallites. This gives a figure of 1 for a round corallite, 2 for a corallite twice as long as broad, etc. Measurements were made with machinists calipers. The arithmetic mean of 40 measurements was found to be 1.6, the observed range 1.3–2.0, and the standard deviation 0.2. The arithmetic mean for 20 corallites close to the center of the colony was 1.6 and that for 20 close to the periphery 1.6, both the same as that for the colony as a whole. The number of corallites per rank varies and that, in turn, causes variation in size and shape of the lacunae. Of 70 ranks counted the arithmetic mean was 3 corallites per rank, the observed range 1 to 8 per rank, and the standard deviation 1.5. Variation in spacing of the tabulae was measured in Y.P.M. 19241 in which they are unusually well displayed. Twenty-five counts of the number of tabulae per 5 mm. were made, each in a different part of the colony. The

arithmetic mean was 10 and the standard deviation 1.5. The observed range was 8 to 13.

In taking the above measurements several small areas in different parts of the colony were marked out and all pertinent measurements within those areas recorded. Both number of corallites per rank and number of tabulae in 5 mm. show skewed distributions (from the statistics presented). This distribution of the number of corallites per rank is a result of a number of unusually long ranks between which are many short cross ranks of one or two corallites each. These latter bring the arithmetic mean toward the small number. The skewness in number of tabulae per 5 mm. results from an occasional zone of crowded tabulae.

ATTACHMENT

Specimens still attached to the substratum upon which they grew are found but are not common. Fifteen such specimens were examined in the course of this study. It is remarkable that most of these were attached to a stromatoporoid of the *Clathrodictyon* type. Plate 7, figure 3 shows a specimen of *Catenipora quebecensis* which encrusts a rounded object about 2 cm. in diameter. Several such specimens were examined. The objects could not be positively identified but they showed a vesicular structure suggestive of a beatricoid stromatoporoid. This association of the Halysitidae and stromatoporoids will be discussed further in the section on ecology.

Apparently the colonies were attached to their substratum very lightly if at all and were easily broken loose by wave action. There is clear evidence that these corals could grow on a free base or at most on a very small point of attachment to a hard object. Plate 10, figure 1 shows a specimen that has grown as an encrusted mass over a stromatoporoid but a cut surface shows that very few ranks touch the surface of the substratum. Those corallites that do are flattened and slightly expanded at the bottom, somewhat like an elephant's foot. These corals probably required hard objects for attachment. During the early development of the colonies the polyps were close to the substratum and if they lived on a soft bottom they would be liable to damage by silting.

There is no evidence of a basal holotheca as in *Favosites*. Thin sections of Y.P.M. 19228 (pl. 9, fig. 1) show a thin layer of quartz continuous over the exterior of the corallites and the surface of the substratum in the lacunae, but absent where the corallites are in contact with the substratum. However, this thin quartz layer is attributed to alteration by silicification over all exposed surfaces of the specimen rather than to deposition by the animal.

ONTOGENY

Comparison of the top with the bottom of coralla that are fairly complete shows conspicuous ontogenetic changes in the size and shape of the

lacunae. Near the base the corallite ranks are arranged in such a fashion that the lacunae are of no distinct size or shape, are commonly angular in outline, and tend to be smaller than those of the more mature portions. Apparently the first formed ranks simply crept over the substratum in random direction as new corallites were added (pl. 6, fig. 5). In no specimen was it possible to demonstrate the first corallite. After the base was established the growth of the corallum was predominantly upward although new ranks continued to be added. After 1 or 2 cm. of vertical growth the lacunae become orderly looking, rounded in outline and assume the size and shape characteristic of the species.

Specimen E7748, Buffalo Museum Science, is approximately 9 cm. high. At the base, the lacunae commonly measure 0.5 x 1 cm. or 0.4 x 0.6 cm. but are highly variable both in size and shape (pl. 3, fig. 2). A crudely triangular outline is common. At the top of the colony the lacunae are quite consistently elliptical in shape and measure approximately 0.5 to 1 cm. wide and 2.5 to 3 cm. long (pl. 3, fig. 1).

No other ontogenetic changes were observed in either the corallites or coralla. Most specimens show slight constrictions in the diameter of the corallites which are recognizable over the entire colony at the same level but these are probably the result of environmental circumstances rather than genetically controlled ontogenetic events.

PALEOECOLOGY

Fossils of the Halysitidae are found in a wide variety of carbonate rocks ranging from limestone to dolomite in composition, from coarsely crystalline to very finely crystalline in texture, and of several colors. They have also been found in crinoidal limestones and in highly arenaceous or argillaceous carbonate rocks. Occasionally they occur in calcareous shale, e.g., the Wenlock formation of England. About two-thirds of the specimens studied occur in dolomite. There is a tendency for species with unusually large corallites to occur in fine-grained, brown dolomite. Attention was given to the matrix of a large number of specimens from many localities and not a single sample of sandstone was found. Apparently an environment of predominantly clastic deposition was unfavorable.

Fossils of the Halysitidae are not as common as those of many other Tabulata such as *Favosites*, but they are by no means rare. In some occurrences they are found with abundant faunas of marine invertebrates, crinoids, brachiopods, bryozoans, and other corals. Commonly (especially in the dolomite occurrences) they are found in formations that are otherwise quite sparse. The occurrence is patchy. Where there is one specimen there are usually more in the immediate vicinity and isolated specimens are unusual. Apparently the colonies were clustered in favorable spots, but these were not necessarily bioherms.

Stromatoporoids formed the substratum for over 80 per cent of the specimens observed that were fossilized in the position in which they grew.

Although the broad surface of a stromatoporoid would be an expedient place for the planula larva to settle, this percentage suggests more than mere fortuitous attachment. The nature of the relationship between the two types of organisms is not known. The corals sit on the surface of the stromatoporoids and are never immersed in them, therefore growth of the latter must have ceased before or shortly after the attachment of the coral.

ORIGIN AND RELATIONSHIPS

The origin of the Halysitidae and their relationship to other tabulate corals is in doubt because transitional forms have not been recognized. The oldest species of the Halysitidae known, *Catenipora quebecensis* Lambe, of Black River age, is in every respect a fully developed, typical representative of the family. The fact that mesocorallites are lacking in this, as well as all the other Ordovician species (from North America, at least) points to monomorphism as a primitive characteristic.

One might reasonably expect to find the ancestor of the Halysitidae in the Lower and Middle Ordovician coral faunas. Okulitch (1935) noted resemblances to the genus *Tetradium,* some species of which have corallites arranged in rows somewhat similar to those of the Halysitidae and also show similarities in septal structure. There are, however, significant differences. The corallite walls of *Tetradium* are single rather than double layered and the septal fission so characteristic of *Tetradium* and other Schizocorallia is completely alien to the Halysitidae.

The basal portion of the Halysitidae colonies shows several interesting resemblances to the Auloporidae. The genotype of that family, *Aulopora serpens* Goldfuss may form a meshwork pattern resembling that of the Halysitidae. If the upward facing apertures of *A. serpens* (or other species of *Aulopora*) were spaced so closely as to be in contact with one another and continued to grow vertically so as to form vertical tubes the result would resemble a rank of the Halysitidae corallites both in appearance and method of development. The basal view of a colony of the Halysitidae is strongly reminiscent of the spreading growth of an *Aulopora* corallum (pl. 6, fig. 5). Furthermore, *Aulopora* has structures which bear some resemblance to septal spines and tabulae, although the latter occur sparsely. It appears to have a two-layered wall (although the wall is very thick) and lacks mural pores. The fact that *Aulopora* is a Devonian and Carboniferous coral with a few Silurian species is, of course, an obstacle to regarding it as an ancestor to the Halysitidae.

Catenipora cylindricus Wilson is unusual in that the corallites are loosely joined to one another and this species may be of significance in determining the relationship of the Halysitidae. Unfortunately, it is known only from one small fragment which is not well preserved. Furthermore, its exact horizon is not known; the age is given as Ordovician because it lacks mesocorallites.

The genus *Eofletcheria* Bassler 1950 (Middle Ordovician corals formerly

referred to *Fletcheria*) is the oldest coral with tubular corallites known. It shows an interesting resemblance to the Halysitidae in the tendency of the corallites to be arranged side by side in winding chains. As with the Auloporidae, this evidence is suggestive of relationship but is not conclusive.

The features of the mature portions of the coralla of the Halysitidae, such as tubular corallites, abundant tabulae, septal spines which tend to be arranged in twelve vertical rows, and dimorphism show that they belong in the subclass Tabulata. Except for the above mentioned resemblance to the Auloporidae and *Eofletcheria* there is no basis for classifying the chain corals with any recognized family of the Tabulata. Many paleontologists place them in a family of their own, the Halysitidae (Bassler 1950; Hill 1952). The fact that certain species (*H. compacta*) have some polygonal corallites does not indicate relationship to the Favositidae as suggested by some authors. The corallites are simply crowded together so that they become polygonal as a result of mutual pressure. The method of asexual increase as well as the lack of mural pores takes *Catenipora* and *Halysites* out of the family Favositidae.

Several authors have implied relationship to other genera in their classification. Milne-Edwards and Haime (1852) made the Halysitinae a subfamily of the Chaetetidae. They included the genera *Halysites, Syringopora, Thecostegites, Chonostegites,* and *Fletcheria.* Rominger (1876) also recognized the subfamily Halysitinae but included the genera *Halysites, Syringopora, Cannapora,* and *Aulopora.* Duncan (1872) placed the genera *Halysites, Stylophyllum, Chonostegites, Columnaria,* and *Beaumontia* in the family Halysitidae. Lindstrom (1873) was convinced that *Halysites* belonged to the family Heliolitidae. To group *Halysites* and *Catenipora* with other genera of Tabulata presupposes more knowledge of the morphology and phylogeny of those corals than is available today. This was realized by Nicholson (1879) who placed the genus *Halysites* in a family by itself. Nicholson's classification is followed by most paleontologists today. (See modern editions of Zittel, Hill 1952.)

TAXONOMY

FAMILY HALYSITIDAE NICHOLSON 1879

Genus *Halysites* Fischer von Waldheim 1813

Zoognosia Tabulis Synopticus Illustrata, Editio Tertia, p. 387.

ORIGINAL DESCRIPTION: "Strata conjunctione cellularum subtubulosarum, seriebus variis cohaerentium, catenamque efformantium, orta."

Genotype (by monotypy): *Tubipora catenularia* Linnaeus 1767.

Genus *Catenipora* Lamarck 1816

Genotype: *Catenipora escharoides* Lamarck, Histoire Animaux sans Vertebres, T. II, p. 206, 1816.

Fischer von Waldheim (1813) was the first to recognize that *Tubipora catenularia* Linnaeus was not a *Tubipora* and, therefore, required a new name. He selected the generic name *Alyssites*. In 1828 he emended that name to *Halysites* according to its derivation from a Greek word meaning chain. Lang, Smith, and Thomas (1940) refer to this emendation as having been done with "obvious propriety." However, according to Opinion 148 of the International Commission on Zoological Nomenclature, a name published as an emendation of an earlier name of the same origin and meaning is to be rejected as a synonym of the earlier name unless it is clear that there was a mistake in spelling or a typographical error. This opinion clearly calls for the rejection of the name *Halysites* in favor of *Alyssites*, but to observe strict legality here it would be necessary to substitute an almost unknown name that has been used but once in a very rare publication for one that has been common in paleontological literature for 120 years. The ICZN will be petitioned to place *Halysites* on the list of *nomina conservenda*.

Other names have been used for the chain corals. Gleditsch (1765) used the name *Fungites* with two genosyntypes, a *Halysites* and a *Heliolites*. Thomas and Smith (1954) show that *Fungites* does not conform to the International Rules of Zoological Nomenclature and is therefore to be rejected. R. Ludwig in 1865–66 described *Ptychophlocolopas catenularia*. This is undoubtedly a *Halysites*. Lang, Smith, and Thomas (1940) have appealed to the International Commission on Zoological Nomenclature to suppress all of Ludwig's generic names because of their unwieldy length and his unsound classification. Lambe (1906) introduced the generic name *Labyrinthites* for corals with thick-walled, prismatic corallites in extremely short chains, frequently with two rows of corallites in a chain. The description is inadequate and gives little reason for placing *Labyrinthites* in the Haly-

sitidae as is done by some authors (Hill, 1952 and Lecompte in Piveteau, 1952). It is recommended that this name not be so used.

The monomorphic and dimorphic species should be placed in separate genera. There is plenty of precedent for this in coral taxonomy. For example, the living alcyonarian genera *Xenia* and *Heteroxenia* have been separated chiefly on that basis. Certainly the possession of two kinds of coral-lites instead of one is a morphological feature of considerable importance. The fact that all Ordovician species are monomorphic and most Silurian species dimorphic provides further basis for recognition of two genera. On the other hand, knowledge of the phylogeny is inadequate so it is not certain that dimorphism did not appear independently in several different lines or even that some dimorphic lines did not become secondarily monomorphic. Some dimorphic specimens may lack mesocorallites in certain portions of the colony but rarely to the extent that misidentification would result.

The generic name *Halysites* is restricted to the dimorphic species and the monomorphic species are placed in the genus *Catenipora.*

PROBLEMS OF TAXONOMY

The chief taxonomic problem encountered in this study was the determination of the validity of many of the specific names. Nearly half the species were named some seventy-five to one hundred years ago when paleontologic description was less precise than it is now. The descriptions, figures, and locality data are hopelessly inadequate for identification and the original specimens have been lost. In order to minimize personal opinion on the validity of these problematical species every specific name ever used for the Halysitidae is reviewed on the following pages and the original description and locality data quoted. An attempt was made to locate as many type specimens as possible, both by correspondence with and personal visit to likely institutions. In spite of the fine cooperation given by the staffs of these institutions the search often proved futile. Neotypes were designated for several North American species when there was no reasonable doubt as to the characteristics and occurrence of the originals. Although it is realized that the International Rules do not make provision for neotypes it is anticipated that the need for them will soon lead to their formal recognition.

Many species based upon specimens from other continents (from Europe in particular) could be synonymous with American species, but for practical reasons the foreign species were studied from the literature only. No attempt was made to locate and examine European types. Most of these species were named long ago and would thus have priority in cases of synonymy but they are based upon descriptions that are too inadequate for use and on type specimens that have probably been lost. In the light of our present knowledge of the effects of barriers and geographic distance on speciation, there is reason to expect that corals from another continent

could be specifically different from the contemporaneous ones of North America. This, of course, would not apply where there is good evidence of intercontinental migration routes, such as was provided by the Acadian geosyncline, but no species of *Halysites* has been erected upon specimens from the Acadian geosyncline of North America. However, Northrop (1939) and others have pointed out the close resemblance of the Middle Silurian faunas of the Gaspé, Quebec, to those of England. Study of the distribution of recent corals shows that these organisms have great powers of dispersal but that barriers have a marked effect on speciation.

H. labyrinthica from North America may prove to be a synonym of *H. catenularia* from Europe and other examples of possible synonymy could be pointed out. However, until the European specimens have been studied, it is considered more conservative to retain the specific names given the North American species than to risk incorrect identification with Eurasian species.

Although nearly 70 specific and variety names have been used for the Halysitidae many of these are synonyms and the actual number of species is probably less than one-third of that. There is a tendency for these species to be quite distinctive with little intergradation between them, and with the exception of *H. labyrinthica,* they do not show the great variability that perplexes students of recent corals (Hoffmeister 1926, Bernard 1901). If variation of the individuals within a colony can be taken as an indication of the variability of the species we have further support for this. The measurements cited on page 16 indicate little variation between different parts of a colony. The entire family too is remarkably distinctive. With the possible exception of *H. compacta* there is not a single species that is not immediately recognizable as a member of the Halysitidae.

The hard parts of the Halysitidae are simple and probably represent but a minor portion of the entire organism. The number of characters that can be used by the taxonomist are comparatively few and it is quite possible that parallel evolution and homeomorphy have produced the same combination of hard parts more than once during the evolution of the family. Furthermore, it is difficult to prove that a certain set of characteristics are not merely a phenotypic response to a certain set of environmental conditions instead of diagnostic features of a species. The stratigraphic and geographic distribution provides important clues to taxonomy.

Some of the structures of the Halysitidae have greater taxonomic value than others. The size and shape of the colony are probably conditioned more by ecology than by inherent growth factors and are not useful specific criteria. The diameter of the corallites, on the other hand, seems to be very constant within a species. The size and shape of the lacunae, although highly variable, tend to form a pattern that is characteristic for the species. The nature of the mesocorallites and the presence or absence of septal spines are often of value in distinguishing between species that otherwise look similar but septal spines must be used with caution as they are very

delicate and may not show, even in thin sections. Microstructures, such as trabeculae, which might have taxonomic value could not be demonstrated.

The practice of using variety names for the Halysitidae is not recommended. This coral is rarely found in large numbers and the samples available for study are too small to determine whether certain forms are variants of a population or distinct species. Furthermore, most of the varietal names are meaningless because they apply to the loosely used specific name *H. catenularia.* Several of the varieties that have been named, those of Lambe in particular, should be raised to the status of species. The application of subspecific and variety names to paleontology has been discussed by Newell (1948) and others but they do not discuss the special problems presented by colonial organisms.

THE GENOTYPE OF *HALYSITES*

Tubipora catenularia Linnaeus, Systema Naturae, Editio Duodecima Reformata, p. 1270, 1767.

ORIGINAL DESCRIPTION: "Tubis parallelis, connatis in laminam, contortuplicata, anastomozatum."

OCCURRENCE: "Thrown up on the shores of the Baltic Sea."

NEOTYPE (chosen by Thomas and Smith, 1954): Specimen no. 1 of the Bromell collection in the Paleontologiska Institutionen, Uppsala, Sweden, described and figured by Bromell, 1728, p. 411, no. 5, and fig. II on plate opposite page 410.

DESCRIPTION OF NEOTYPE (quoted from Thomas and Smith, 1954): "The corallum is light pink and set in a dull cream colored matrix with a slightly greenish tinge. Its upper and lower surfaces are parallel, and its height 50 mm., its length approx. 80 mm., and its breadth approx. 50. mm. The lower surface (shown as the upper surface in Bromell's figure) is weathered, causing the chains of corallites to project some 2 to 3 mm. above the matrix; the upper surface has been ground flat at some time in the past. The sides of the specimen are formed by the walls of the corallites.

"The corallites are long, tubular and parallel, and arranged in anastomosing, single, chain-like series, approximately 1.6 mm. wide, with 5 corallites to about 10 mm., the calicular centers being about 1.9 mm. apart; their walls are thin and enveloped by the epitheca. The chains are distinctly moniliform. They form rather long, narrow fenestrules, which may be nearly rectangular, gently curved or labyrinthine, which vary in length and which may reach 30 mm. in places; there are usually 7 or 8, but sometimes more and occasionally only 5, corallites in a long side, and generally 2 or 2½ in a short side; bifurcation of the chains occurs at the ends of the larger axes of the corallites, but there is anastomosis often at the side of a corallite. Long, single, prismatic tubules, which are quadrangular and either square or oblong in cross section, occur between each pair of adjacent corallites in a chain; there is always a tubule from which bifurcation of a chain takes place, and apparently always where anastomosis occurs. The

tubules are much more slender than the corallites. The external epitheca is continuous from corallite to corallite and practically smooth, except for very fine, closely arranged transverse lines. No septa are to be seen, and there are no mural pores.

"In transverse section the corallites in a chain are about 1.58 mm. wide and the calicular centers about 1.90 mm. apart: their internal axes are about 1.52 x 1.18 mm. The walls are not very much thickened by secondary sclerenchyme, and their thickness (including epitheca) averages 0.19 mm. Single tubules occur between each pair of adjacent corallites: they are sub-rectangular, elongate at right angles to the length of the chains, but occasionally square, and measure on the average about 0.31 x 0.19 mm. There are no septa. The epitheca, which is clearly differentiated from the sclerenchyme, is externally continuous on the corallites and tubules, but does not cut across between corallites and tubules.

"In longitudinal section the tabulae are complete and nearly horizontal or gently concave distally. They are closely arranged and average 11 or 12 in 5 mm. The tubules are crossed by diaphragms which resemble tabulae, which are horizontal or gently concave distally, and which average 12 to 14 in 5 mm."

Remarks: The preparation of this paper demanded an adequate description of the genotype of *Halysites*. It was found necessary to select and describe a neotype but it was obviously appropriate both for accuracy and propriety that this be done by a European paleontologist with access to Swedish material. As a result of correspondence initiated by Drs. Carl O. Dunbar of Yale University and Gerhard Regnéll of Lunds Universitets Paleontologiska Institutionen, this work was eventually undertaken by Drs. H. Dighton Thomas and Stanley Smith of the British Museum of Natural History. Their description (1954) explains fully the reasoning which governed the selection of the neotype.

THE GENOTYPE OF *CATENIPORA*

Catenipora escharoides Lamark, Histoire naturelle des Animaux sans Vertebres, p. 207, 1816 (here chosen).

Original description: "Tubulis longis, parallelis, seriatis, subdepressis, in laminas anastomosantes, convexix, osculis ovalibus."

Occurrence: "Washed up on the shores of the Baltic."

Neotype (chosen by Thomas and Smith 1954): Specimen no. 4 of the Bromell collection in the Paleontologiska Institutionen, Uppsala, Sweden, described and figured by Bromell 1728, p. 412, no. 7, and fig. on p. 412.

Description of neotype (quoted from Thomas and Smith 1954): "The corallum is a light greyish-buff colour set in a slightly darker matrix. It is a thin and rounded-quadrate, water-worn pebble measuring 90 x 57 x 10 mm. approximately. On both upper and lower surfaces the corallites project 1 or 2 mm. owing to weathering.

"The corallites are tubular, parallel, and contingent, arranged in anas-

tomosing uniserial chains; they are elongated in the direction of the chains, number 7 or 8 in 10 mm., and average about 1.35 x 1.05 mm. across; their walls, which are thin and not secondarily thickened with sclerenchyme, average, together with the epitheca, 0.17 mm. in thickness, while their inner transverse axes are 1.0 x 0.7 mm. The corallite-series which are fairly straight or slightly curved, are only slightly moniliform: they form rather straight-sided fenestrules, which average 2 to 3 mm. in width and about 10 mm. in length (though the longest is 30 mm. long), with the number of corallites in a side varying considerably, from commonly 7 or 8 to as few as 1 or as many as 28; bifurcation of the chains usually takes place at the end of the long axis of a corallite, but occurs in places at or near the middle of the long side of a corallite. No tubules are visible. The septa are 12 in number, and are long, reaching to, or nearly to, the axis; calicular views show that they are lamellar, and that they bear 3 or 4 relatively coarse spines on their upper edges; broken corallites also show that, where well preserved, the septa are low, vertical lamellae which project from the wall and bear long, axially directed spines on their inner edges: in places these spines merge and for short distances the whole septum is lamellar. The epitheca is continuous from corallite to corallite, and is ornamented with fine, closely arranged transverse grooves, which possibly correspond to the tabulae and which may be partly due to weathering. The tabulae are not seen in any of the broken corallites. There are no mural pores."

Remarks: The genus *Catenipora* contains those species which completely lack mesocorallites. There is no reason to believe that Lamarck intended the name to be used in that restricted sense. He probably was not aware of the name *Halysites*. Nevertheless, it has now been established that *Catenipora escharoides* is not only the second species of the Halysitidae to be named but also the first monomorphic species. If the monomorphic species are elevated to the status of a genus, *Catenipora* is no longer a synonym of *Halysites* but a valid generic name and *Catenipora escharoides* is the genotype.

It was necessary to select and describe a neotype. The reasoning which governed the selection of the neotype is discussed by Thomas and Smith (1954).

CATALOG OF SPECIES

Following is a list of all the species, subspecies, and varieties of the Halysitidae* that have ever been named. Those whose type specimens come from the same general geographic area are listed together in chronological order according to the date of the original description.

O = Ordovician, S = Silurian, M = Middle, L = Lower, U = Upper.

Species from northern Europe and Russia

S S Halysites catenularia Linnaeus 1767, p. 28
S Catenipora escharoides Lamarck 1816, p. 29

* The species *Halysites kitakamiensis* and *Halysites japonicus* were described in 1940 by T. Sugiyama in Sci. Rep. Tohoku Imp. Univ. 21, p. 129–131. This reference was noted after the present paper had gone to press and the descriptions are not included.

?	Halysites	attenuata Fischer von Waldheim 1828, p. 30
S	"	dichotoma Fischer von Waldheim 1828, p. 30
S	"	macrostoma Fischer von Waldheim 1828, p. 31
S	"	stenostoma Fischer von Waldheim 1828, p. 31
S	"	jacovickii Fischer von Waldheim 1828, p. 31
S	"	approximata Eichwald 1829, p. 32
S	"	communicans Eichwald 1829, p. 32
S	"	dissimilis Eichwald 1829, p. 33
?	"	distans Eichwald 1829, p. 33
S	"	exilis Eichwald 1829, p. 33
S	"	reticulata Eichwald 1829, p. 34
	"	compressus Edwards & Haime*
U O ?	Catenipora	parallelus Schmidt 1861, p. 38
S	Halysites	cavernosa Fischer-Benzon 1871, p. 39
S	"	elegans Fischer-Benzon 1871, p. 40
S	"	obliqua Fischer-Benzon 1871, p. 40
S	"	quadrata Fischer-Benzon 1871, p. 41
S	"	regularis Fischer-Benzon 1871, p. 39
S	"	keyserlingi Toll 1889, p. 45
S	"	gotlandicus Yabe 1915, p. 57
U O	Catenipora	nicholsoni (Kiaer) 1929, p. 59
?	Halysites	undulatus Kiaer*
U S	"	catenularia var. borealis Tcherneychev 1937, p. 61
U S	"	catenularia var. lata Tcherneychev 1937, p. 62
S	"	kuliki Tcherneychev 1938, p. 65
U S	Catenipora	minimus (Tcherneychev) 1937, p. 62
U ? S	Halysites	parallelus var. taimyrica Tcherneychev 1937, p. 61
U ? S	"	pseudoorthopteroides Tcherneychev 1937, p. 62

Species from Arctic regions of North America

	Halysites	parryi Konig*
S ?	"	catenularia var. harti Etheridge 1878, p. 43
S ?	"	catenularia var. fieldeni Etheridge 1878, p. 43
U O	Catenipora	agglomeratiformis (Whitfield) 1900, p. 49
U O	"	gracilis var. borealis (Wilson) 1931, p. 60
U O	"	aequabilis (Teichert) 1937, p. 63
S	"	irregularis (Teichert) 1937, p. 64
S	"	rassmusseni (Teichert) 1937, p. 65

Species from United States and Southern Canada

LS, MS, US	Halysites	labyrinthica (Goldfuss) 1826, p. 29
M S	"	meandrina (Troost) 1840, p. 34
M S	"	michelini Castelnau 1843, p. 35
M S	"	agglomerata Hall 1843, p. 35
U O	Catenipora	gracilis (Hall) 1851, p. 36
M S ?	Halysites	sexto-catenatus Owens 1862, p. 38
M S	"	compactus Rominger 1876, p. 41
LS, MS	Catenipora	catenularia var. microporus (Whitfield) 1882, p. 44
M S	Halysites	nexus Davis 1885, p. 45
S ?	"	catenularia var. nexus Foerste 1890, p. 67
M S	"	catenularia var. amplitubata Lambe 1899, p. 48
M S	"	catenularia var. nitida Lambe 1899, p. 49
M O	Catenipora	catenularia var. quebecensis (Lambe) 1899, p. 46
M S	"	catenularia var. simplex (Lambe) 1899, p. 47
M S	Halysites	radiatus Whitfield 1903, p. 50
U O	Catenipora	delicatulus (Wilson) 1926, p. 58
?	"	cylindricus (Wilson) 1926, p. 59
U O	"	pulchellus (Wilson) 1926, p. 59
U O	"	robustus (Wilson) 1926, p. 58
S	"	huronensis (Teichert) 1937, p. 64
M S	Halysites	catenularia var. brownsportensis Amsden 1949, p. 65

M S	Halysites	encrustans n. sp., p. 66
M S	"	infundibuliformis n. sp., p. 67
M S	"	magnitubus n. sp., p. 68

Asiatic species

S	Halysites	hupehensis Grabau 1925, p. 57
S	Catenipora	sapporiensis (Shimizu) 1934, p. 60
S	"	sindoensis (Shimizu) 1934, p. 61
S	Halysites	wallichi Reed *

Australian species

U S	Halysites	australis Etheridge 1898, p. 54
U O ?	Catenipora	chillagoensis Etheridge 1904, p. 57
S	Halysites	cratus Etheridge 1904, p. 53
S	"	gamboolicus Etheridge 1904, p. 56
S	"	lithostrotionoides Etheridge 1904, p. 50
S	"	orthopteroides Etheridge 1904, p. 51
S	"	peristephesicus Etheridge 1904, p. 53
S	"	pycnoblastoides Etheridge 1904, p. 54
S	"	sussmilchi Etheridge 1904, p. 52

The following species were examined in the course of this study and determined as valid.

Halysites agglomerata Hall	Catenipora delicatulus Wilson
" amplitubata Lambe	" gracilis Hall
" brownsportensis Amsden	" microporus Whitfield
" compactus Rominger	" pulchellus Wilson
" encrustans n. sp.	" quebecensis Lambe
" infundibuliformis n. sp.	" robustus Wilson
" labyrinthica Goldfuss	" simplex Lambe
" magnitubus n. sp.	
" meandrina Troost	
" nexus Davis	
" nitida Lambe	

In the catalog which follows all the species of the family are arranged according to date of publication. This will facilitate study of questions of priority. The genera are not separated as the data on many species are so inadequate that they cannot be assigned to the proper genus. These species are provisionally left under *Halysites* as their author described them.

Halysites catenularius (Linnaeus) 1767

See under section on "The genotype of Halysites" for description.

Remarks: Although *catenularia* is the original spelling, Thomas and Smith (1954) in their description of the neotype use the name *catenularius*. Other authors have spelled the name *catenulatus* and *catenulata*. The name means "in chains."

It has been the practice of most paleontologists to identify specimens of the Halysitidae as either *H. catenularia* or *H. escharoides*. These two names, especially the former, appear in the literature much oftener than any other. As the original description of *H. catenularius* by Linnaeus is

* These four species have been mentioned in various places in the literature but a description of them could not be found. It is possible that some of them are *nomina nuda*.

inadequate to define the species and the type specimens have been lost, these identifications are without foundation. The designation and description of the neotype by Thomas and Smith (see p. 24) now makes it possible to identify this species correctly. No other description should be used.

Catenipora escharoides Lamarck 1816

See under section on "The genotype of *Catenipora*" for description.

REMARKS: Most of the remarks under *Halysites catenularia* apply also to *Catenipora escharoides.* Lamarck's original description is inadequate and subsequent authors do not agree on the characteristics of the species. The designation and description of the neotype by Thomas and Smith (see p. 25) now makes it possible to identify this species correctly.

Halysites labyrinthica (Goldfuss) 1826

Plate 3, figs. 1, 2, 3, 4, 5

Catenipora labyrinthica Goldfuss, Petrefacta Germaniae, vol. I, p. 75, tab. XXV, figs. 5a, 5b, 1826.

Halysites labyrinthica Goldfuss. Teichert, K., 5th Thule exped. Rept. I 1921–1924, p. 135, 136, pl. IX, figs. 1–3, 1937.

ORIGINAL DESCRIPTION: "Catenipora laminis tubiferis contortuplicata, anastomosantibus, maculis labyrinthiformibus, tuborum ostialis ovalibus." He further characterized his species as "differentiated from the first species (*H. escharoides*) by tubes three times larger, oval apertures, and by the large labyrinthine contortions of the lamellae which do not anastomose as often." (Translated from German.)

LOCALITY: "Groningen, Germany and Drummond Island, Michigan." Middle Silurian.

REMARKS: Goldfuss' syntype from Drummond Island, Michigan, was described by Teichert (1937) as follows: "The corallum consists of rather large corallites which are arranged in large meshes. The longer diameter of the cross section of the corallites varies between 2.2 mm. and 2.6 mm. and the shorter diameter varies between 1.3 and 1.6 mm. The walls are heavy and rugose. Insofar as can be determined the tabulae of the corallites are about .6–.7 mm. from each other. Tubuli between the corallites are present. The corallites are arranged in rows of from two to eight individuals. The meshes are filled with a matrix of gray crystalline dolomite."

In his type description Goldfuss listed specimens from two different localities, and expressed no preference for one over the other. The specimen from Drummond Island, having been adequately redescribed and figured may be made lectotype for this species.

Several specimens in the author's collection from the Fossil Hill formation (Lower Clinton) Manitoulin Island, approximately 80 miles east of Drummond Island, conform to Teichert's redescription of *H. labyrinthica.* These specimens enable the description to be augmented by the following

facts: The coralla are 10–20 cm. in diameter. The lacunae tend to form a labyrinthine pattern, as implied in the name. Large ones measure 3 mm. x 30 mm. The diameter of most of the corallites is the larger on the dimensions given by Teichert (1937). The tabulae are flat. The mesocorallites are approximately 0.5 to 1.0 mm. square and thick walled.

Fischer-Benzon (1871) who wrote a very detailed description of this species mentioned four vertical rods, rectangular in cross section with rounded edges, in the intercorallite walls. The degree of silicification of the specimens from Manitoulin Island prohibits these structures from being seen if they are present. Fischer-Benzon does not tell how carefully his specimens were compared to the originals of Goldfuss.

There was a tendency among early paleontologists to list *H. labyrinthica* as a synonym of *H. catenularia.* Some specimens closely fit the description of the neotype but the corallites of *H. labyrinthica* average larger in diameter than those of the neotype of *H. catenularia.*

H. labyrinthica is one of the commonest Silurian chain corals in North America.

Halysites attenuata Fischer von Waldheim 1828

Halysites attenuata Fischer von Waldheim, Notice sur les Polypiers Tubipores Fossiles, Moscow, p. 15–19, 1828.

ORIGINAL DESCRIPTION: "The tubes are very thin, intimately joined to two others forming laminae which make irregular, very often square outlines on the surface; the apertures are elongate."

LOCALITY: Not given.

REMARKS: Fischer von Waldheim (1828) described five species of *Halysites* from the collection of the Imperial Society of Naturalists of Moscow. They are *H. attenuata, H. dichotoma, H. macrostoma, H. stenostoma,* and *H. jackovickii.* The latter of these was redescribed by Fischer-Benzon (1871). The descriptions of the other four are so meager that the names cannot be used. In fact, the names have never been mentioned in the literature except in a very few synonymies. There is, of course, the possibility that someone may find and redescribe the original specimens. The original descriptions of all five species are repeated here, translated from the French. They are copied from a rare publication which is difficult to obtain. The name of this species refers to the slender corallites.

Halysites dichotoma Fischer von Waldheim 1828

Halysites dichotoma Fischer von Waldheim, Notice sur les Polypiers Tubipores Fossiles, Moscow, p. 15–19, 1828.

ORIGINAL DESCRIPTION: . . . "corallites of thick, elongate, somewhat curved tubes originating from a common center, often dividing repeatedly into twos and reuniting at the surface in chains which have large openings and are subparallel with one another."

LOCALITY: From Serpeika a Serpoukhow, Russia. Silurian?

REMARKS: See under *H. attenuata.* The name refers to the branching of the ranks.

Halysites macrostoma Fischer von Waldheim 1828

Halysites macrostoma Fischer von Waldheim, Notice sur les Polypiers Tubipores Fossiles, Moscow, p. 15–19, 1828.

ORIGINAL DESCRIPTION: "Corallum flattened, of thick, short tubes which are assembled in squares at the surface. The apertures are round and very large."

LOCALITY: From "Grigoreva, 60 verstes from Moscow." Silurian?

REMARKS: See under *H. attenuata.* The name refers to the large diameter of the corallites.

Halysites stenostoma Fischer von Waldheim 1828

Halysites stenostoma Fischer von Waldheim, Notice sur les Polypiers Tubipores Fossiles, Moscow, p. 15–19, 1828.

ORIGINAL DESCRIPTION: . . . "corallum sub-ovoid, of very thin tubes among very thick laminae which form irregular outlines on the surface. The apertures are very small."

LOCALITY: From "Ratofka near Verea." Silurian?

REMARKS: See under *H. attenuata.* The name refers to the small diameter of the corallites.

Halysites jacovickii Fischer von Waldheim 1828

Halysites jacovickii Fischer von Waldheim, Notice sur les Polypiers Tubipores Fossiles, Moscow, p. 15–19, 1828.

Catenipora exilis Eichwald, Zoologia specialibus quam expositis animalibus, I, Vilna, tab. II, fig. 13, 1829.

Halysites jacovickii Fischer von Waldheim. Fischer-Benzon, Abhl. aus dem Geb. Naturw. von dem Naturw. Verein, Hamburg, v. band, 2 abth., p. 22, taf. 3, figs. 8, 9. 1871.

ORIGINAL DESCRIPTION: "Polyps in sub-rounded masses; tubes thin, in diverging rays, with oblong apertures, the union of the tubes by fives produces a star form, rounded at the surface."

LOCALITY: Vilna and the Government of Moscow. Silurian?

REMARKS: The original description is very incomplete but this species was redescribed and illustrated by Fischer-Benzon 1871. He supplemented the original description with the following facts: The corallites are 1.8–2.0 mm. long by 0.5 mm. wide. The septa are rudimentary. The fenestrules are in the form of polygons of almost mathematical regularity, the sides of which are composed of 1, occasionally 2 calyces.

There is little reason to doubt that *H. exilis* Eichwald is a synonym of *H. jacovickii* Fischer von Waldheim. The description is very scanty and neither species has been examined by the author. But the structure of this species is so unusual and distinctive that it is recognizable in a short description. Moreover, the type localities of the two authors are less than 50

miles apart which suggests that the specimens may be from the same formation.

Halysites approximata Eichwald 1829

Catenipora approximata Eichwald, Zoologia specialis quam Expositis Animalibus, I, Vilna, tab. II, fig. 9, 1829.

Halysites approximata Eichwald, Lethea Rossica ou Pal, de la Russie, I, pt. 2, p. 505–508, 1860.

Halysites approximata Eichwald. Fischer-Benzon, Abhl. aus dem Geb. der Naturw. von dem Naturwis. Verein Hamburg V band, 2 abth., p. 19, taf. II, fig. 9, 1871.

ORIGINAL DESCRIPTION: "The corallum is composed of large cylinders of which 2 to 4 and as many as 9 form rows of chains very close together; the meshes or interstices are almost absent or very narrow and long. The rows of cylinders are parallel to one another and often dichotomous, which results in a difference between this species and *H. catenularia,* the interstices of which are neither so long nor so narrow but always much broader and much larger."

OCCURRENCE: "Alluvial terrane of Lithuania near Vilna; Orthoceratite lime of the Isle of Dago." Silurian?

REMARKS: Eichwald (1829) described 6 species of *Halysites,* largely on the basis of the shape of the lacunae. Two of these are synonyms of other species. With the possible exception of *H. approximata* the other four names have not been used, partly because of inadequate description and partly because the descriptions are in a rare publication. Unless the original specimens can be located and described more thoroughly the validity of these species cannot be determined. The designation of neotypes is probably not feasible because of the incompleteness of the original descriptions. Eichwald's original descriptions were published in 1829 but in 1860 he redescribed the same species in somewhat greater detail. These latter descriptions are repeated here, translated from French.

According to Fischer-Benzon (1871) the calyces of *H. approximata* measure 2.6 x 1.8 mm. The claim by Eichwald and Fischer-Benzon that *H. agglomerata* Hall is a synonym of this species may be true but cannot be substantiated without further information. The name *approximata* refers to "the rows of chains very close together."

Halysites communicans Eichwald 1829

Catenipora communicans Eichwald, Zoologia Specialibus quam Expositis Animalibus, 1, Vilna, 1829.

Halysites communicans Eichwald, Lethea Rossica ou Pal. de la Russie, I, pt. 2, p. 505–508, 1860.

ORIGINAL DESCRIPTION: "The small encrusting corallite is composed of very slender and markedly elongate rows of compressed cylinders with confluent calices; the two opposite edges of the pointed extremities of the calices are depressed or absent and the calices are confluent with the edges of the two neighboring cylinders, while the two lateral sides are projecting

and very thin; the vertical lamellae, 12 in number, penetrate as far as the center."

OCCURRENCE: Pentamerous chalk of Kattentack near Hapsal; "alluvial terrane near Vilna," Lithuania. Silurian?

REMARKS: See under *H. approximata* Eichwald, 1829. In his early description Eichwald says that this species is characterized by long chains united at intervals by cross bars.

The characteristics described are not sufficiently distinctive to make identification of this species possible. The confluent calyces from which the species is named is probably characteristic of the entire family. Eichwald probably had a specimen in which the calyces were well preserved.

Halysites dissimilis Eichwald 1829

Catenipora dissimilis Eichwald, Zoologia Specialibus quam Expositis Animalibus, L. Vilna, tab. II, fig. 12, 1829.

Halysites dissimilis Eichwald, Lethea Rossica ou Pal. de la Russie, I, pt. 2, p. 505–508, 1860.

ORIGINAL (1860) DESCRIPTION: "The medium sized corallites are composed of cylinders, elongate and not compressed, which unite irregularly without, however, forming rows of chains; the fenestrules are small, irregularly angular."

OCCURRENCE: "Alluvium, Vilna; Rossia in region of Mosquens." (Moscow). Silurian.

REMARKS: In his earlier (1829) description Eichwald stressed lack of septa and arrangement of the tubes in fours.

This description is too incomplete to make identification possible. There is some resemblance to *H. compactus* Rominger. It is possible, as admitted by Eichwald himself, that his specimens do not belong in the Halysitidae. Perhaps he was dealing with a *Tetradium*.

Halysites distans Eichwald 1829

Catenipora distans Eichwald, Zoologia specialis quam Expositis animalibus I, Vilna, tab. II, fig. 10, 1829.

Halysites catenularia Linnaeus. Eichwald, Lethea Rossica ou Pal. de la Russie, I, pt. 2, p. 506, 1829.

The original description is much too incomplete to enable this species to be identified. In 1860 Eichwald discarded this name by making it a synonym of his conception of *H. catenularia* Linnaeus.

Halysites exilis Eichwald 1829

Halysites jacovickii Fischer von Waldheim, Notice sur les Polypiers Tubipores Fossiles, Moscow, p. 15–18, 1828.

Catenipora exilis Eichwald, Zoologia specialis quam Expositis Animalibus, I, Vilna, tab. II, fig. 13, 1829.

Halysites exilis Eichwald, Lethea Rossica ou Pal. de la Russie, I, pt. 2, p. 505–508, 1860.

EICHWALD'S (1860) DESCRIPTION: "The corallites are very small, composed of short, oval cylinders of which one or two form the sides of the

fenestrules which are angular and nearly as wide as long; rows of cylinders are absent."

OCCURRENCE: Pentamerous chalk of Hapsal in Esthonia, alluvium near Kowno. Silurian?

REMARKS: This species is probably a synonym of *H. jacovickii* Fischer von Waldheim. See remarks under *H. jacovickii* Fischer von Waldheim (p. 31) and *H. approximata* Eichwald (p. 32). Eichwald's description of 1829 mentions the star forms produced by the union of the calyces, also described by Fischer von Waldheim (1828) for *H. jacovickii*. The name refers to the small corallites.

Halysites reticulata Eichwald 1829

Catenipora reticulata Eichwald, Zoologia specialis quam Expositis Animalibus, I, Vilna, tab. II, fig. 11, 1829.

Halysites reticulata Eichwald, Lethea Rossica ou Pal. de la Russie, I, pt. 2, p. 505–508, 1860.

EICHWALD'S (1860) DESCRIPTION: "The cylinders are slightly compressed with elliptical orifices, almost rounded, the fenestrules are rounded with walls containing not more than 2 or 3 cylinders on each side."

LOCALITY: "Vilna, and greywacke of Baltic provinces." Silurian?

REMARKS: See under *H. approximata* Eichwald. Eichwald's earlier description (1829) stresses the net-like appearance, also implied in the name, and the apertures arranged in sevens. The description is too incomplete to enable the species to be identified with certainty. As with the other of Eichwald's species, the original specimens must be studied before the name can be used accurately.

Halysites meandrina (Troost) 1840

Plate 4, fig. 1

Catenipora meandrina Troost, 5th Report of the Geology of Tennessee, 1840.

ORIGINAL DESCRIPTION: "The tubes and apertures are in size and form like those of *C. labyrinthica* but they do not contortuously anastomose as in the latter, and meandering in an irregular manner in every direction, they form no meshes. They seem to have formed large masses."

LOCALITY: Near Nashville and in granular limestone near Brownsport, Perry County, Tennessee.

REMARKS: Troost's description is very meagre and is not illustrated. His type specimens could not be located. However, the loose, irregular form of the corallum which he describes is very unusual. Two specimens in the Yale Peabody Museum collection which have that form of corallum as well as corallites the size and form of *H. labyrinthica* and which were collected from the same locality as Troost's specimens are identified as *H. meandrina*. Troost's description is augmented as follows from these specimens.

DESCRIPTION OF NEOTYPE: The specimens are fragmentary but adequate

to show that the corallum consists of a few meandering ranks of corallites which join others at approximately 3 cm. intervals. There are approximately 10 corallites in each rank. Union of the ranks may form a few irregular shaped enclosed spaces but no compact meshwork. The corallites are oval in cross section, 2 x 1.5 mm. in diameter. The length of the tubes is not revealed. The mesocorallites are nearly square in cross section, 1.75 mm. wide. The tabulae of the autocorallites are 0.5 mm. apart, gently convex upward and very thin. The mesocorallites appear to have been tabulate but alteration by silicification makes it impossible to accurately demonstrate any mesocorallite structures. There is no trace of septa.

NEOTYPE: Yale Peabody Museum. No. 19237.

OCCURRENCE OF NEOTYPE: Lobelville formation, Short Creek in Linden, Perry County, west Tennessee. Middle Silurian.

REPOSITORY: Peabody Museum of Natural History.

Halysites michelini (Castelnau) 1843

Catenipora michelini Castelnau, Essai sur le systeme silurien de l'amerique septentrionale, Paris, p. 45, pl. 17, fig. 1, 1843.

ORIGINAL DESCRIPTION: "This species differs from the first (*H. labyrinthicus*) by its tubular cells being smaller and arranged in a manner to form figures which are more elongate and less arranged in squares; it is distinguished, on the other hand, from *H. escharoides* by those same tubes being a great deal larger, and finally from the two preceding by its ribs being more numerous and a great deal more compressed." (Translated from French.)

OCCURRENCE: Drummond Island, Lake Huron, Michigan.

REMARKS: The inadequate descriptions and figure indicate that this species is a synonym of *H. labyrinthica* Goldfuss. If by the term "ribs" Castelnau means septa it must be noted that these have not been observed in specimens of *H. labyrinthica* from the type locality, but he probably intended the term to mean the ringlike swellings on the exterior of the corallites.

This name cannot be used unless the original specimens can be found and restudied.

Halysites agglomerata Hall 1843

Plate 4, figs. 2, 3, 4

H. agglomerata Hall, Nat. Hist. of N. Y., Pt. IV, pl. 22, fig. 2, 1843.

H. agglomerata Hall, Nat. Hist. of N. Y., Pt. VI, Paleontology of N. Y., pt. II, p. 127–129, pl. XXXV, 1852.

Hall (1843) gives only a poor figure. Hall (1852) gives the original description.

ORIGINAL DESCRIPTION: "Corals consisting of cylindrical tubes arranged laterally in a continuous series forming broad explanate expansions which

are closely arranged in parallel, straight, more or less curving lines; openings of the cells circular, tubes cylindric; septa (meaning tabulae?) numerous, concave from above; spaces between the tubes cellular; exterior surface somewhat transversely striated."

Remarks: The distinguishing characteristics are the closely crowded ranks of corallites (which suggested the name) with no appreciable lacunae, and the round cross section of the corallites.

Following is a redescription of the type specimens which were kindly loaned by Dr. Otto Haas of the American Museum of Natural History. The complete dimensions of the colony are unknown but the species attained dimensions of at least 12 cm. in diameter by 8 cm. thick. The ranks are long, usually gently curved and so closely spaced that there are no appreciable lacunae. They are mostly less than 1 mm. apart. Each rank is joined to an adjacent one at intervals ranging from 6 to 8 corallites. This may be a Y-shaped union or two closely spaced, parallel ranks may be connected by a single corallite interposed between them. The corallites are circular or slightly oval in cross section and are 1.75–2.0 mm. in diameter. The exterior surface bears fine transverse striations and slightly coarser ones 3–5 mm. apart. The tabulae are well developed and many of them are so strongly curved as to be nearly hemispherical in shape. They are irregularly spaced but rarely more than 1 mm. apart. The mesocorallites are approximately 0.5 mm. wide and are square in cross section. They have numerous closely spaced tabulae which curve in the opposite direction to the curvature of the autocorallite tabulae.

This species closely resembles *H. approximata* Eichwald.

Occurrence: Niagara limestone near Sweden, Monroe County, New York. A careful search of the vicinity of Hall's type locality was made but no outcrops were found. Hall must have obtained his specimens from the till boulders which accumulated in the stream beds of the vicinity. The lithology of the matrix looks like Guelph dolomite.

Lectotype: American Museum of Natural History 1690/2. Chosen from Hall's two syntypes.

Repository: American Museum of Natural History.

Catenipora gracilis (Hall) 1851

Plate 4, fig. 7; Plate 5, fig. 1

Halysites gracilis Hall, in Foster & Whitney, Rept. on the Geology of the Lake Superior Land District, U. S. 32nd Congress Special Session Ex. Doc. 4, vol. 2, p. 202, 1851.

Halysites gracilis Hall. Lambe, Contributions to Canadian Paleontology, IV, pt. 1, p. 64–78, 1899.

Halysites gracilis Hall. Leith, Jour. of Paleontology, vol. 18, p. 268–270, pls. 42, 43, 1944.

Original description: "Coral massive, or hemispheric; cells quadrangular or sub-oval; walls thin; interspaces thicker than the walls; arranged in a series, in wide irregular reticulations. This species differs from *C. escharoides* in the almost quadrangular form of the cells and the extremely thin

walls, the reticulations are wider and the whole aspect more solid than in that species."

TYPE LOCALITY: Green shales near upper part of Hudson River group, eastern shore, Green Bay, Wisconsin.

REMARKS: Although the original description is quite incomplete this name is well established in the literature. The very distinctive characteristics of this species plus the fact that it lived during the Ordovician Period when there were comparatively few species of the Halysitidae makes it practically certain that subsequent workers have used the name as Hall intended it. Some paleontologists have used this name for other Ordovician species such as *Catenipora quebecensis* Lambe but reference to the original description, poor though it is, shows their mistake.

This name (*Catenipora gracilis*) was first used by Milne-Edwards and Haime in 1849. In 1852 they dropped the name believing that the specimens they had so designated were not separable from *H. catenularia.* Because of that it may be argued that the name *gracilis* should be dropped but to do so would accomplish nothing except make it necessary to add another name to the literature to replace one that is working satisfactorily. Hall's original description is meager though illustrated and he does mention several features that are diagnostic of the species. The locality given by Hall is enigmatic as no other specimens of the Halysitidae from the Ordovician of Green Bay, Wisconsin, could be located. In fact, specimens are rarely found in Ordovician rocks anywhere in the eastern United States. It is possible that Hall obtained his specimen from drift or was otherwise mistaken as to locality.

It was Lambe (1899) who really introduced this name into the literature. He described and figured specimens from Manitoba and elsewhere where this species is found and subsequent identifications were based upon his work. Neither Hall's original specimens nor topotype specimens could be found. Lambe's specimens are of the same age as Hall's but are from a different locality. In order to make the widely used name *gracilis* valid it would be advisable for the International Commission on Nomenclature to suppress Hall's name and make Lambe the author of the species.

A neotype should be designated from Lambe's specimens but even with the aid of the Geological Survey of Canada the specimens identified and described by him could not be located. It is proposed that the neotype be chosen from the Manitoba material described and figured by Leith (1944). The reference is in a widely available periodical. The locality and horizon of Leith's specimens are essentially the same as that of Lambe's. Furthermore, Lambe's figures are reproduced by Leith for comparison and it is obvious that the two authors are concerned with the same species.

Leith's specimens enable the original description to be augmented with the following facts: The colonies attain dimensions as great as 558.8 mm. x 368.3 mm. and 279.4 mm. high. The corallites average approximately 1.5 mm. wide by 2 mm. long in cross section. The tabulae are flat and widely

spaced, approximately 1 mm. apart. There are 10 to 12 vertical rows of very delicate, needle-like septal spines in each corallite. These project toward the center of the corallites for a distance of 0.5 to 0.75 mm. There are no mesocorallites.

There is much resemblance to *H. parallelus* Schmidt and *H. nicholsoni* Kiaer. If the three should prove to be synonymous, Hall's name would have priority.

The name, which means thin, or slender, is not particularly descriptive.

NEOTYPE: University of Manitoba 109 (Leith, Jour. of Paleontology, vol. 18, pl. 43, fig. 6, 1944).

OCCURRENCE OF NEOTYPE: Selkirk member of Red River formation, Garson, Manitoba. This species was widespread in Arctic regions during Richmond time.

Halysites sexto-catenatus Owen 1862

Halysites sexto-catenatus Owen, Report of a Geological Reconnaissance of Indiana made during the Years 1859 and 1860, Geological Survey of Indiana, xvi, 1862.

ORIGINAL DESCRIPTION: ". . . seems to differ from other chain corals in having each individual polypary more uniformly enclosed by six-sided vertical sutures than in any other species; the diaphragms of the floor are 1/16 of an inch apart."

LOCALITY: "Upper Silurian" of Huntington County, Indiana. (Probably Middle Silurian.)

REMARKS: The type specimens of this species could not be found and the original description is entirely inadequate. Owen himself was not sure that the characteristics he gave were sufficient criteria to form a new species. It is recommended that this name be discarded. It has never been used in the literature except in the original description.

Halysites parallelus Schmidt 1861

Halysites parallelus Fr. Schmidt, Archiv. fur die Naturkunde Liv., Ehst., und Kurlands, 1 serie, Bd. II, S. 229, 1861.

Halysites parallela Schmidt. Fischer-Benzon, Abh. aus dem Gebiete der Naturw. Verein, Hamburg, V band, 2 abth., p. 20, taf. II, fig. 10, 1871.

ORIGINAL DESCRIPTION: "The individual cells (calices) project only slightly if at all beyond the outer wall; the corallum consists of a contorted double lamella, the cell apertures appear to be nearly rectangular." No locality is given. European paleontologists frequently mention this species in lists of Late Ordovician fossils.

REMARKS: This name, as used in the literature, is based not on the original description but on the description and figures of some specimens which Fischer-Benzon (1871) thought resembled Schmidt's original description. The original description, however, is too incomplete to serve as a basis for identification. This name cannot be used unless the types can be found and redescribed. It is possible that Schmidt's species is a synonym of *Catenipora gracilis* Hall.

Halysites cavernosa Fischer-Benzon 1871

Halysites cavernosa Fischer-Benzon, Abh. aus dem Gebiete der Naturw. Verein, Hamburg, V band, 2 abth., p. 16–17, taf. 1, figs. 1–6, 1871.

ORIGINAL DESCRIPTION: "Calyx apertures elliptical, averaging 2.5 mm. long by 2.0 mm. wide, although they may attain a length of 3.3 mm. and a breadth of 2.4 mm.; the calyx walls undulate very slightly so that the individual calyx tubes stand out on the outer surface slightly, yet distinctly. The calyx rows are composed of numerous calices, often 20 or more, and are here and there bent in a curve; a characteristic feature is the appearance on the polyp stock of several centra in which four, five, or six calyx rows come together. The outer surface of the calyx wall is very finely striated, almost smooth; occasionally two striations may appear, running from top to bottom whereby the calyx walls become indistinctly three-sided. Perhaps these striations originated in connection with the septa and are then to be understood as rudimentary costae.

"The tabulae are bent gently downward, often showing structures as illustrated on the one side of fig. 3 of table 1."

LOCALITY: Schleck on the Windau, Kurland, East Baltic Region. Silurian.

REMARKS: This is one of five species described by Fischer-Benzon in 1871. His descriptions, reproduced here, are excellent. At present there is no reason why his species should not be recognized as valid. He shows a thorough acquaintance with the preceding literature but tends to place undue reliance on the poor descriptions given by his predecessors. If the type specimens of some of the earlier students of these corals such as Fischer von Waldheim or Eichwald could be found and restudied it is quite possible that many of Fischer-Benzon's taxonomic concepts would be shown to be erroneous and that some of his species would become synonyms. The descriptions are translated from German.

This species resembles *H. labyrinthica* but differs in the nature of the mesocorallite tabulae which are thin and highly arched in *H. cavernosa* and thick and flat in *H. labyrinthica*. *H. cavernosa* strongly resembles the *brownsportensis* var. of *Halysites* described by Amsden (1949). The lacunae of the latter are less meandriform and the autocorallites smaller but the mesocorallites are very similar. The two are certainly closely related.

Halysites regularis Fischer-Benzon 1871

Halysites regularis Fischer-Benzon, Abh. aus dem Gebiete der Naturw. Verein, Hamburg, V band, 2 abth., p. 17, taf. II, figs. 1, 2, 1871.

ORIGINAL DESCRIPTION: . . . "corallites rounded in outline, occasionally somewhat hexagonal under high magnification, averaging 2.5 mm. long; 2.2 mm. wide; tabulae bent gently downwards, simple; exterior of the calyx walls very slightly transversely striated. The calyx rows run adjacent to one another without anastomosing but send out shorter rows laterally by budding."

LOCALITY: . . . "from the strand by the Windau in Kurland." East Baltic Region. Silurian.

REMARKS: The close resemblance of this species to *H. agglomerata* Hall in form and dimensions of the corallites was noted by Fischer-Benzon, but the distinctive, bowl-shaped mesocorallite tabulae present in the latter species were not mentioned. He certainly would have mentioned them had they been present for his taxonomy was based on mesocorallite structure. Therefore it is concluded that the mesocorallite structure of the two forms is different. The rounded rather than square cornered rodlike structures which Fischer-Benzon gives as the fundamental difference between *H. regularis* and *H. labyrinthica* could not be recognized in any specimens examined for this study.

Halysites obliqua Fischer-Benzon 1871

Halysites obliqua Fischer-Benzon, Abh. aus dem Gebiete der Naturw. Verein Hamburg, V band, 2 abth., p. 19, taf. II, figs. 4, 5, 1871.

ORIGINAL DESCRIPTION: "Whereas the calyx rows are usually so arranged that the both sides of every calyx are of equal length and bear five septa each, in this form they are frequently placed oblique to one another; the one side is strongly arched and bears six septa, the other side is nearly straight and bears only four septa. If one calyx then turns its arched side to the right the one following it turns to the left, and the straight calyx sides lie collectively almost on a straight or only slightly bent line. Calices of more regular form also occur. Length of the calyx 2.3 mm.; tabulae bent gently downward, simple. The interwalls are peculiarly formed and I cannot discern with certainty whether they consist of two or four parts. In thin sections one invariably notices clearly two oblong quadrangles. These quadrangles which separate the calices bear the end septa of both calices in such a manner that when the left one sends a septum into the calyx in front the right does likewise to the calyx behind."

LOCALITY: From the strand at Windau in Kurland. From Kabillen, East Baltic Region. Silurian.

REMARKS: The characteristics of this species are so distinctive that it should be easily identified. No specimens were seen in any collections examined in the course of this study. The oblique arrangement of calyces was noted by other authors. See *H. kuliki.*

Catenipora elegans (Fischer-Benzon) 1871

Halysites elegans Fischer-Benzon, Abh. aus dem Gebiete der Naturw. Verein Hamburg, V band, 2 abth., p. 21, taf. III, figs. 4, 5, 1871.

ORIGINAL DESCRIPTION: . . . "length of calyx 1.6 mm., width 1.0 mm. The network of calyx rows is irregular as in *H. escharoides,* longer and shorter calyx rows occurring alongside each other, and frequently the calices group themselves together in little polygons the sides of which are made up of single calices; the latter characteristic produces an approximation

to *H. jacovickii.* The tabulae are simple; between each two tabulae I have been able to count only two septa, one above the other. The peculiar insertion of the septa in the calyx walls as shown in cross section is characteristic. Whereas in all other species the outer wall forms a uniform thick lamella on which the inner calyx lining with the septa is applied directly, *H. elegans* shows on the inner side of the outer wall plates or ridges running down from top to bottom between which the septa are inserted. It is extraordinary moreover, that the interwalls are not clearly isolated or limited but completely connect and coincide with the inner calyx lining."

LOCALITY: "Conglomerates from Kabillen." East Baltic Region. Silurian.

REMARKS: This is probably the same species as the one Fischer-Benzon called *H. escharoides.* The peculiar arrangement of septa, one arising from the outer wall and one from the inner wall alternately as shown in his figure 5, is anatomically improbable if not impossible. A possible explanation for his figure is that his sections were thick enough to show two layers of septal spines, those of the top layer clearly outlined but with the inner ends ground off, and those of the bottom layer complete but less clearly visible. The septal spines of *Halysites* are not always directly in line vertically and in cross section those of one level may appear to occupy the spaces between those of an adjacent level.

Catenipora quadrata (Fischer-Benzon) 1871

Halysites quadrata Fischer-Benzon, Abh. aus dem Gebiete der Naturw. Verein Hamburg, V band, 2 abth., p. 21, taf. III, figs. 6, 7, 1871.

ORIGINAL DESCRIPTION: "Calyx nearly quadratic or rectangular, 0.8 mm. long, 0.6–0.7 mm. wide; outer wall very slightly undulating; pseudocolumella strongly developed; inter-corallite wall uniformly thick, distinctly separated from the surrounding area; outer surfaces of the calyx wall finely wrinkled transversely; calyx rows forming characteristic nearly straight sided polygons."

LOCALITY: From the vicinity of Schleck on the Windau. East Baltic Region. Silurian.

REMARKS: This species, like the one just before it, is very similar to Fischer-Benzon's conception of *H. escharoides.* It differs in the square shape of the corallites in cross section.

Halysites compactus Rominger 1876

Plate 4, figs. 5, 6; Plate 5, figs. 2, 3

Halysites compactus Rominger, Report of the Geological Survey of Michigan, Lower Peninsula, III, pt. 2, pp. 78, 79, pl. XXIX, 1876.

non *Halysites agglomeratus* var. *compactus* Whiteaves, Revision of the Fauna of the Guelph formation of Ontario, Geol. Survey of Canada, vol. III, pt. II, p. 48, 49, 1895.

ORIGINAL DESCRIPTION: "Tubes oval, in chain-like lateral conjunction; but these laminae 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, 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 1½ mm."

Occurrence: "Niagara group. Outcrops of the Upper Peninsula at shore of Lake Michigan. Common at the mouth of the Manistique River."

Remarks: Dr. G. M. Ehlers of the University of Michigan kindly provided photos and thin sections of one of Rominger's syntypes, No. 8543, illustrated in the lower part of figure 3, Plate 29, of Rominger's "Fossil Corals." These permit further description of this very unique species of *Halysites.*

The specimen measures 7.3 cm. in greatest diameter and 4 cm. in greatest thickness, but is much rounded by wear. The autocorallites average 1.75 mm. in diameter. The tabulae are spaced 11 or 12 per 5 mm. Mesocorallites are present but details of structure are obscured by thick deposition of stereoplasm. They are 0.5 mm. wide and have closely spaced, strongly arched tabulae. The unusually compact appearance results from the fact that most of the corallites do not form chains. Instead of joining with just two others each corallite joins with four, occasionally five others. There are different stages of contact between the corallites; the outer walls may simply touch one another, the primary wall may be absent so that the contact consists of two fused layers of peripheral stereozone, or there may be a mesocorallite at the contact. The position of the mesocorallites is different from that in other species in that they may occur at any junction of corallites rather than just at the two narrow sides.

It would be difficult to recognize this species as a *Halysites* were it not for the fact that the less crowded portions and the basal parts of the colonies are typical of the genus. If the compact growth features are discounted there is close resemblance to *H. agglomerata* Hall. Teichert described a species, *H. irregularis,* which is very similar but lacks mesocorallites.

In 1895 Whiteaves named some specimens he had collected from the Guelph formation *H. agglomeratus* var. *compactus.* The varietal name was unnecessary as the specimens fully answer to the description of *H. agglomerata* Hall. In fact, it is very probable that the type specimens of *H. agglomerata* which were found in drift are from the Guelph formation. Rominger personally identified Whiteaves' specimens with *H. compactus* even though they differ widely from the type specimens of that species.

Lectotype: University of Michigan Museum, No. 8543. Loose specimen found at Epoufette point, Lake Michigan, Mackinac Co., Michigan, probably from strata near base of Manistique formation.

Halysites harti Etheridge 1878

Halysites catenulatus var. *harti* Etheridge, Paleontology of the coasts of the Arctic lands, Geol. Soc. of London, Quart. Jour. vol. 34, p. 583, pl. XXVIII, fig. 2, 1878.

ORIGINAL DESCRIPTION: "This form differs considerably from the usual habit of *Halysites catenulatus,* the chain-like rows of corallites constituting the corallum being much more extended and enclosing larger interspaces or areas and closely resembling the variety *Catenipora labyrinthica* of Goldfuss. The epitheca too and the walls are more coarsely rugose, the striae being coarser than in *H. catenulatus* proper; this does not appear to be due to age only; the character is well shown in Goldfuss' figure (Petr. Germ. p. 75, t. 25, f. 5). Further, the series of corallites in the winding loops are much more numerous than in the recognized specimens of *H. catenulatus.* The whole corallum is also more robust in habit, and must have been of large dimensions vertically and laterally."

LOCALITY: Cape Frazer, Arctic islands, lat. 79° 45′. Age not known; probably Silurian.

REMARKS: Resembles both *H. labyrinthica* and *H. gracilis.* See under *H. catenularia* var. *fieldeni.*

Halysites fieldeni Etheridge 1878

Halysites catenulatus var. *fieldeni* Etheridge, Paleontology of the coasts of the Arctic lands, Geol. Soc. of London, Quart. Jour. vol. 34, p. 583, pl. XXVIII, fig. 1, 1878.

ORIGINAL DESCRIPTION: "Corallum massive; base concentrically and irregularly rugose; the corallites radiate horizontally from the center of the base (resembling in habit those of *Favosites*), and then assume vertical growth when at or near the outer edge of the corallum; tabulae thick and very closely arranged, which, on weathering, gives a very rugose appearance to the corallites: reticulations between the chain-like pattern on the upper surface of the corallum very small and polygonal; calices either elliptical or polygonal; and frequently only 2 or 3 corallites occur in the space or vertical wall constituting the reticulations."

LOCALITY: Cape Hilgard, Arctic islands, lat. 79° 41′. Probably Silurian.

REMARKS: It is possible that *H. catenularia* var. *harti* and *H. catenularia* var. *fieldeni* are the same species respectively as *H. labyrinthica* Goldfuss and *Catenipora microporus* Whitfield. The latter two species occur together and Etheridge's descriptions fit them very closely but his descriptions are not good enough to make identification certain. If *H. catenularia fieldeni* Etheridge, 1878, is the same species as *C. microporus* Whitfield, 1882, then Etheridge's name has priority. However, until the type specimens can be located or topotypes collected (the latter would require an Arctic expedition) the characteristics of Etheridge's species will remain imperfectly known whereas there is no question concerning the characteristics of *C. microporus.* For that reason use of the latter name is recommended. As pointed out by Teichert the only rocks at the type locality are of Canadian

age, therefore the specimens must have come from drift and probably are of Silurian age.

Catenipora microporus (Whitfield) 1882

Plate 6, figs. 1, 2, 3, 4, 5

Halysites catenulatus var. *microporus* Whitfield, Geology of Wisconsin, Wisconsin Geol. Survey, Vol. 4, pt. 3, p. 272, pl. XIII, fig. 6, 1882.

ORIGINAL DESCRIPTION: "Corallum similar to ordinary form except in size of the cells, which are very small or minute, equal to from one-eighteenth to one-twentieth of an inch; there being that number of cells within the space of an inch as counted in a line across the face of the corallum. Intercellular spaces small, varying from one-twelfth to nearly one-fourth of an inch in their longest diameter, and usually nearly equal in length and breadth, presenting a nearly quadrilateral form. Epitheca thinner and less rugose than those of the ordinary size and form, and still more so than on *H. labyrinthicus.*"

OCCURRENCE: From Niagara group of Wisconsin. Exact location not given. Common at Manitoulin Island and Louisville, Kentucky.

REMARKS: The original description may be supplemented by the following facts: The largest colony observed was 12 cm. in maximum diameter. A typical colony is lenticular or hemispherical in shape and approximately 5 cm. in diameter. The corallite rows which make up the sides of the lacunae may contain anywhere from one to eight corallites. Three or four corallites to a rank is typical. The corallites are approximately 0.9 x 0.5 mm. in diameter. There are no mesocorallites. The walls between the corallites are thick but are solid throughout. Septal spines are present. In many of the corallites the four longest septal spines join to form a thick pseudocolumella.

Raising Whitfield's name for this fossil from varietal to specific status eliminates commitment as to the relationships of the form. The Halysitidae are too imperfectly known to justify the use of subspecific names. (See section on "Classification.")

According to Whitfield (Ann. N. Y. Acad. Sci., Vol. 12, no. 8, p. 146, 1899) the type of this species is in the collections of the University of California but careful search by the staff of that institution failed to locate it. However, selection of a neotype will be postponed pending further search for the originals. The unusually small corallites make this species easy to recognize. The specimens upon which the supplementary description is based came from the Niagaran of Manitoulin Island, Ontario, and probably are of the same age as Whitfield's specimen of Wisconsin. Large colonies are found in the Louisville limestone. Specimens which answer to Whitfield's description have been frequently reported from the Silurian of Europe under the name *H. escharoides.*

Halysites nexus Davis 1885

Plate 7, figs. 4, 5

Halysites nexus Davis, Kentucky Fossil Corals, pl. 67, figs. 4, 5, 1885.
non *Halysites catenulatus* var. *nexus* Foerste, Notes on Clinton group fossils, Boston Soc. Nat. Hist., Proc. vol. 24, p. 337–338, 1890.

ORIGINAL DESCRIPTION: A figure only, with no text.

OCCURRENCE: From upper Niagara clay beds in Workhouse Quarry and Fourth Quarry on Beargrass Creek, East Louisville, Kentucky.

REMARKS: Dr. H. B. Whittington of Harvard University kindly provided photos of Davis' type specimens. These show the following characteristics: The corallites are 2 to 2.5 mm. x 3.5 to 4.5 mm. in diameter. The specimens are too fragmentary to show the size or shape of the colonies. The longest corallite in the fragments is 2.5 cm. long. Even within that much length the corallites show a considerable degree of curvature. The fragments show no lacunae. Apparently the corallites grew in long, straggling ranks which very infrequently connected with each other. The longest rank preserved is 6 cm. long and consists of 14 corallites. The exterior surface of the corallites shows pronounced transverse wrinkling. Mesocorallites approximately 1 mm. square are present. Thin sections are not available; therefore the internal structure was not studied. This species resembles *H. regularis* and *H. meandrina* in shape of lacunae but the corallites are much larger. There is some resemblance to the western species, *H. magnitubus*.

Foerste (1890) described *H. catenulatus nexus* from Collinsville, Alabama. This is not the same species as that described by Davis as the corallites are much smaller. Davis has priority.

TYPES: Holotype, Harvard, Museum of Comparative Zoology No. 8785. Paratype, Harvard, Museum of Comparative Zoology No. 8784.

Halysites keyserlingi Toll 1889

Halysites keyserlingi Toll, Die Paleozoischen Versteinerung der Neusiberischen Insel Kotelny, Mem. l'Acad. Imp. Sci. de St. Petersburg, VII Serie, t. XXXVII, no. 3, p. 49, tab. IV, fig. 10, tab. V, figs. 1, 2, 1889.

ORIGINAL DESCRIPTION: "The hemispherical colony has a concave base and reaches a height of 4.4 cm. and a diameter of 6.7 cm. The calyx tube arises from the base of the colony and through anastomosis produces a net-like appearance in cross section. The calyx apertures are nearly circular, have a diameter of 1–1.7 mm., and form centers in which 10 or more calices lie close together, whereby they maintain the appearance of the Favositidae, and can easily lead one to the error that here a symbiosis of a *Favosites* and a *Halysites* has come about. The tabulae are very numerous, eight in one mm., and often bent so strongly downward that in thin horizontal sections they are found as concentric rings in the lumen of the calyx,

whereby they give, on cursory examination, the impression of the thickened rings of *Pachypora.*"

Occurrence: The Island of Kotelny.

Remarks: The distinguishing features are the crowding of the corallites, round apertures, and closely spaced, strongly arched tabulae. In these features *H. keyserlingi* resembles *H. agglomerata* but the corallites are smaller. There is also strong resemblance to *H. compacta.* The type specimens were not examined.

Catenipora quebecensis (Lambe) 1899

Plate 7, figs. 1, 2, 3

Halysites catenularia var. *quebecensis* Lambe, Contributions to Canadian Paleontology, Vol. 4, pt. I, p. 69, 74, 75, pl. IV, figs. 1, 1a, 1b, 1899.

Original description: "The corallites are oval and the tabulae rather flat and not very close together. This variety can be recognized by its general form of growth with small meshes and rather small corallites, and by the presence of very narrow tubules with rather distant, flat tabulae. Some of the most perfect specimens are hemispherical in shape and attain a breadth of 6 to 8 inches."

Type locality: "From Black River strata between the mouth of the Metabechuan River and Blue Point, Lake St. John, Que."

Remarks: Dr. G. W. Sinclair made a fine collection of this species from a Paleozoic outlier in the Lake St. John area, Quebec. From study of these specimens the original description is supplemented with the following facts: The colonies are hemispherical to nearly spherical in shape and range from 5 cm. to 15 cm. in diameter. A typical colony is 8 cm. in diameter by 6 cm. high. The colonies commence growth from an area about 2 cm. in diameter and rapidly increase in diameter by addition of new corallites rather than by spreading out at the base so that the colonies become hemispherical in shape with the corallites radiating from the center (Pl. 7, figs. 1, 3). Most of the lacunae are crudely circular or oval in shape but some are rectangular or very irregular. They average 4 to 6 mm. in diameter but may be as small as 2 mm. Rarely are they larger than 1 cm. in any dimension. Most of the corallite rows consist of two corallites; some have one or three or, rarely, more. The corallites are oval in cross section, 1 mm. by 1.5 mm. in diameter. The exterior surface is finely striated horizontally. The tabulae are flat and spaced 0.5 mm. to 0.75 mm. apart. There are no septal structures. The intercorallite walls are thick but have no lumen. The narrow, tabulate mesocorallites (tubuli) mentioned by Lambe were not seen despite careful examination of etched specimens, thin sections, and peels.

This is the oldest species of the Halysitidae known. The phylogenetic significance of this is discussed in the section on "Phylogeny."

Catenipora quebecensis is one of four new varieties described by Lambe in 1899. Although they differ widely in characteristics and range in age

from Black River to Middle Silurian (lower Helderberg according to Lambe) they were all classified as varieties of *H. catenularia.* It is recommended that these varietal names be raised to specific status according to the principles discussed in the section on "Problems of Classification," p. 23–24. The types were stored in the National Museum of Canada but all except the holotype of one species, *H. nitida,* and a syntype of *C. quebecensis* have been lost. A specimen in the National Museum of Canada bearing a hand-written label by Lambe is unquestionably one of the syntypes and it is here recommended that this specimen be designated lectotype. The fine suite of specimens collected by Sinclair may provide a hypodigm for the species.

LECTOTYPE: Specimen No. 11305, National Museum of Canada, Ottawa, Canada.

OCCURRENCE OF LECTOTYPE: Two miles south of Bluepoint, P. Q. Sinclair's specimens came from a small outlier of the Ordovician just north of Ste. Anne de Chicoutimi, Quebec, 20 to 70 feet above the pre-Cambrian.

Catenipora simplex (Lambe) 1899

Plate 7, fig. 6; Plate 8, fig. 1

Halysites catenularia var. *simplex* Lambe, Contributions to Canadian Paleontology, Vol. IV, pt. I, p. 70, 71, 76, 77, pl. IV, figs. 3, 3a, 1899.

ORIGINAL DESCRIPTION: ". . . large size of the corallites, its long narrow meshes and the absence of tubules." The table on pages 76 and 77 of Lambe's report gives the following information: "The length of the corallites in cross section is 4 mm., the breadth 2.5 mm. The lacunae are very long and narrow, the ranks in parallel lines. The tabulae are flat or slightly concave, 6 in 5 mm."

TYPE LOCALITY: "Of lower Helderberg age, near the mouth of the Little Cascapedia river, Quebec," according to Lambe. Actually of Silurian age.

REMARKS: Lambe's illustrations were merely diagrams. The specimens illustrated on Plate 7,8 were collected by Professor Schuchert from the La Vieille limestone of Port Daniel, P. Q. The lacunae are typically about 0.5 cm. wide by 3 or 4 cm. long. The intercorallite wall is very thin. The specimen illustrated on Plate 7, fig. 6, is remarkable for the length of the corallites. The longest is 12.5 cm. in length and is incomplete.

In size and appearance this species resembles *H. nexus* Davis, but Davis' species definitely has mesocorallites where *C. simplex* does not. The horizon which Lambe dated as lower Helderberg, has been shown by Northrop (1939) to be Middle Silurian.

As the original specimens have been lost, it is recommended that one of those collected by Professor Schuchert be designated the neotype. They agree with every detail of Lambe's description and figures and were collected from the same horizon and approximately 40 miles east of the type locality.

NEOTYPE: Yale Peabody Museum No. 19233.

OCCURRENCE OF NEOTYPE: La Vieille limestone, S.W. corner of Barachois, Port Daniel, P. Q.

Halysites amplitubata Lambe 1899

Plate 8, figs. 2, 3

Halysites catenularia var. *amplitubata* Lambe, Contributions to Canadian Paleontology, Vol. IV, pt. I, p. 71, 76, 77, pl. IV, figs. 4, 4a, 1899.

ORIGINAL DESCRIPTION: ". . . the tubules are found to be as large as and even larger than the corallites themselves. . . . septa have not been seen. The tabulae of the tubules are notably coalescent; they are close set, concave at the center and abruptly bent down at the edges. The corallites are almost circular and their tabulae are regular and distant."

TYPE OCCURRENCE: Lower Helderberg at L'Anse a la Barbe and L'Anse au Gascon, Quebec, according to Lambe. Actually of Silurian age.

REMARKS: Lambe gives the following additional data on pages 76 and 77: The autocorallites are broadly oval, 2–2.5 mm. long by 1.75 mm. wide. The average width of the mesocorallites is 2–2.5 mm. The autocorallite tabulae are flat, also slightly convex or concave, six in 5 mm. The mesocorallite tabulae are slightly concave, abruptly bent down at the edges, 20 in 5 mm.

The great development of the mesocorallites makes this species unique. The only specimen examined by the author is that at Yale Peabody Museum (19231) from Anticosti which agrees with Lambe's description except that the mesocorallites are not quite as large and the mesocorallite tabulae not as numerous. These differences are compared in the following table:

	dimensions of autocorallites	*mesocor.*	*mes. tab.*
Lambe's description	1.75 x 2–2.5 mm.	2–2.5 mm.	20/5 mm.
Anticosti specimen	1.5 x 2 mm.	1–1.5 mm.	10/5 mm.

This shows that the Anticosti specimen as a whole is slightly smaller than the type. Spacing of the tabulae is of slight taxonomic importance. The Anticosti specimen is more complete than the original. It shows the lacunae which are broad and meandrine, very similar to those of *H. labyrinthica.*

The large mesocorallites are regarded as sufficient basis for making this form a species rather than a variety.

The original specimen is lost and a neotype should be established. This will be postponed pending search for a specimen from the type locality. The original probably came from the Bouleaux formation (Northrop 1939).

Halysites nitida Lambe 1899

Plate 8, figs. 4, 5, 6, 7; Plate 9, fig. 1

Halysites catenularia var. *nitida* Lambe, Contributions to Canadian Paleontology, vol. IV, pt. I, p. 71, 76, 77, pl. IV, figs. 2a, 2b, 1899.

ORIGINAL DESCRIPTION: "The meshes made by the corallites are small; the corallites themselves are small, oval in section and separated by moderately narrow tubules; in longitudinal sections the compactness and regularity of tabulation of both the corallites and tubules is noticeable. Septal spines are present." According to the table on pages 76 and 77 of Lambe's report, the autocorallites, in cross section, are 1.45 mm. long by 1 mm. broad and the mesopores 0.5 mm. wide. The meshes are "long and narrow; corallites often in parallel rows. Meshes are from 3 to 5 mm. across." The autocorallite tabulae are "flat or slightly convex, 10 to 20 in 5 mm." and the mesocorallite tabulae "straight or slightly convex, vesicular at times, 20 in 5 mm."

TYPE OCCURRENCE: "Lower Helderberg," according to Lambe. Actually Silurian. "L'Anse a la Barbe, L'Anse au Gascon, L'Anse au Bouleaux, and L'Anse a la Vieille, Baie des Chaleurs, and Niegette near Rimouski, Que."

REMARKS: This species occurs in the La Vieille and Gascon formations. It is fairly common in the vicinity of Chaleur Bay, Quebec. The crowding of the ranks of corallites to form long narrow lacunae, the elliptical autocorallites, the well developed, square mesocorallites, and the flat tabulae are the most distinctive characteristics. The colonies are large and as a result of their compact structure are often found as well rounded cobbles. One such cobble is the remnant of a colony that was at least 18 cm. thick.

Dr. W. A. Bell of the Canadian Geological Survey kindly provided photos of the holotype.

HOLOTYPE: Geological Survey of Canada No. 104761.

Catenipora agglomeratiformis (Whitfield) 1900

Halysites agglomeratiformis Whitfield, Am. Mus. Nat. Hist., Bull. 13, p. 20, pl. 2, figs. 1, 2, 1900.

ORIGINAL DESCRIPTION: "Closely resembles *H. agglomeratis* of the N. Y. Niagara limestone except that the cells are somewhat smaller, less closely compacted, having open meshes more like *H. catenipora* but not so large. The cell walls are very thin and fragile. The tabulae in the tubes are very closely arranged and flat, differing in this last feature from those of *H. agglomeratis*."

TYPE LOCALITY: Cape Harrison, Princess Marie Bay, Arctic Canada. Richmond.

REMARKS: The lacunae are very irregular and without pattern. In cross section the corallites are approximately 1 x 1.2–2 mm. in diameter. The tabulae average 10 per 5 mm.

Roy (1941) pointed out that the rock from which Whitfield collected

his specimen is of Richmond rather than Niagaran age. The specimen upon which this species is based is so small and poorly preserved that satisfactory identification cannot be made from it. It is recommended that paleontologists refrain from using this name until such time as better specimens are collected from the type locality.

This species does not resemble *H. agglomerata* Hall as stated by Whitfield and implied by him in the name. In shape of the corallites, shape of the lacunae, lack of mesocorallites, and spacing of tabulae, it is very similar to *Catenipora gracilis*. Wilson (1926) described several species of *Catenipora* which may be varieties of *C. gracilis*. *Catenipora agglomeratiformis* resembles her *C. delicatulus*.

The holotype is in the American Museum of Natural History.

Halysites radiatus Whitfield 1903

Halysites radiatus Whitfield, Observations on a remarkable specimen of *Halysites*, Am. Mus. Nat. Hist. Bull. 19, p. 490, pl. 42, figs. 1, 2, 1903.

ORIGINAL DESCRIPTION: "Colony large (?), probably convex, at least showing distinctly diverging tubes as if rising from an initial center below. Polyp cells united laterally, forming on the surface lines or chains as in other species of the genus. Intermural spaces very irregular, owing to the tortuous windings of the lines of polyp cells. Polyp cells elliptical, about 1.5 mm. wide in the direction of the line of cells, and a little over 1 mm. wide in transverse diameter. Rays (septa) quite generally 12 in number, seldom extending quite to the center, but usually fully two-thirds of the distance. Tabulae entire, flat, or nearly so, six or more in the space of 1 mm., but occasionally nearly twice as distant. External walls of the tubes transversely corrugated."

TYPE OCCURRENCE: "Niagara group," Jackson Co., Iowa. Loose.

REMARKS: The original description does not mention the square mesocorallites which are visible in Whitfield's figure. The distinctive characteristic of this species is the strong development of the septa. Otherwise it resembles *H. labyrinthica* Goldfuss, except that the corallites are slightly smaller in diameter. The presence or absence of septal spines is not regarded as a satisfactory specific character as these are easily destroyed in fossilization and are commonly difficult to see, even in thin section. For this reason plus the fact that the holotype is a rather poor specimen the name *H. radiatus* will not be used in this paper.

The holotype is in the American Museum of Natural History.

Halysites lithostrotionoides Etheridge 1904

Halysites lithostrotionoides Etheridge, Mem. Geol. Survey of New South Wales, Paleontology, XIII, p. 23, pl. I, fig. 1, pl. VI, figs. 1, 2, pl. IX, fig. 4, 1904.

ORIGINAL DESCRIPTION: "Corallum consisting of a pyriform bunch of corallites subradiate from a common base, forming colonies at least five inches high and four inches wide. Fenestrules polygonal (pentagonal, hexagonal,

heptagonal), occasionally irregular or labyrinthine, but, on the whole, very regular, compact, and reminding one of a roughly laid tesselated pavement; sizes 2 x 2 mm., 3 x 2 mm., 4 x 2 mm., 5 x 1 mm., 5 x 2 mm., and so on; margins nearly straight in one alignment; walls flat, i.e., in one plane, and to all intents and purposes level, barely at all ribbed or corrugate. Corallites, in general, long. Epitheca transversely striate. Corallite chains farcimentiform only in the very slightest degree, hardly at all undulating the outlines of the fenestrules. Autopores long, parallelogrammatic, and very regular in form, margins straight; from one to four in each corallite chain, five being the greatest number observed and three the average; from three-quarters to one millimeter in length by one-third millimeter in width; visceral chambers nearly square in longitudinal section; tabulae complete, horizontal, half millimeter apart. Gonopores larger than the mesopores, polygonal (pentagonal or hexagonal), and a few quadrangular; walls as thick as those of the mesopores. Mesopores quadrangular to parallelogrammatic, and narrow; longest diameter about one-quarter millimeter, at right angles to the direction of the corallite chains; walls less in width than those of the autopores, and often showing a dark dividing line; tabulae complete, horizontal, one-quarter millimeter apart; visceral chambers longitudinally parallelogrammatic."

Type occurrence: Beds a & d, Spring Creek, Ph. Barton Co., Ashburnham, New South Wales.

Remarks: Etheridge (1904) described nine new species of *Halysites* from Australia. The descriptions are very thorough and well illustrated. Although some of his species closely resemble previously described ones, Etheridge described them all as new, chiefly because he realized that the confused taxonomy and inadequate descriptions made it impossible for him to compare his specimens accurately with foreign species. Furthermore, although Etheridge did not mention this point, it may be argued that geographic speciation would cause the corals of Australia to be specifically distinct from those of Europe and North America. We recommend that the specific names proposed by Etheridge not be used outside the continent of Australia.

The most distinctive characteristics of *H. lithostrotionoides* are the pattern of the lacunae, small autocorallites, the presence of mescorallites, the lack of septa, and the flat sides of the corallites resulting in smooth outlines of the fenestrules. The latter characteristic causes a superficial resemblance to *Catenipora gracilis,* but otherwise the two species are very different. The name means resembling a tesselated pavement.

Halysites orthopteroides Etheridge 1904

Halysites orthopteroides Etheridge, Mem. Geol. Survey of New South Wales, Paleontology, XIII, p. 25, pl. III, figs. 1, 2, pl. VII, figs. 4, 5, 1904.

Original description: "Corallum massive, formed of large colonies, several inches in diameter, of parallel and non-radiate corallites. Fenestrules

large, polygonal, labyrinthine, curved, or generally irregular in form, with pronounced angles, or wholly rounded outlines; sizes 6 x 5 mm., 8 x 4 mm., 10 x 5 mm., 12 x 5 mm., 8 x 3 mm., 20 x 5 mm., and so on; margins rather waved; walls strongly corrugate. Corallites very long, tall (at least 5 inches, and then incomplete), parallel. Epitheca very regularly and coarsely striate. Corallite chains moderately farcimentiform, slightly undulating the margins of the fenestrules. Autopores large, long oval, but without square or truncate ends, lateral margins rounded, two to nine in each corallite chain, four being the average number, from one to one and a quarter millimeter in length by three-quarters to one millimeter in breadth; visceral chambers transversely elongate (parallelogrammatic); tabulae complete, horizontal or concave, variable in their distance apart, but usually half a millimeter. Gonopores very much larger than the mesopores, triangular, the sides either straight or concave, sometimes one of the angles truncate; walls as thick as those of the mesopores; visceral chambers nearly rectangular; tabulae complete, horizontal, one-third millimeter apart. Mesopores transversely elongate (parallelogrammatic) reduced to mere slits, or absent; visceral chambers longitudinally elongate, very narrow; tabulae complete, horizontal, one-quarter millimeter apart."

TYPE OCCURRENCE: L. Smith's Station, Ph. Gamboola Co., Wellington, New South Wales.

REMARKS: See under *H. lithostrotionoides*. This species differs from *H. lithostrotionoides* by having longer corallites of larger diameter, more irregular lacunae, and mesocorallites that are slitlike in cross section. The latter is the most distinctive characteristic.

Halysites sussmilchi Etheridge 1904

Halysites sussmilchi Etheridge, Mem. Geol. Survey of New South Wales, Paleontology XIII, p. 26, pl. III, figs. 3, 4, pl. VII, figs. 1–3, 1904.

ORIGINAL DESCRIPTION: "Corallum expanding, sub-pyriform, the parent corallites sub-radiate from a common base, forming colonies up to seven and a half inches high by six inches wide. Fenestrules variable in size, and particularly in outline, round, oval, elongate, S-shaped, dumb-bell shaped, roughly polygonal, labyrinthine, or quite irregular, but, as a rule, one axis greatly exceeds the other; sizes 3 x 3 mm., 5 x 5 mm., 9 x 2 mm., 10 x 3 mm., 12 x 5 mm., 15 x 3 mm., and so on, up to 25 mm. in length, margins strongly undulate; walls coarsely and strongly corrugated or ribbed. Epitheca coarsely striate. Corallites long, at least four inches, and then imperfect. Corallite chains strongly farcimentiform. Autopores round or round-oval, from five to twenty-five in each corallite chain; length one to one and a half millimeters by one in breadth; visceral chambers transversely elongate (parallelogrammatic); tabulae well developed, complete, horizontal, half a millimeter apart. Gonopores well developed, triangular, quadrangular, or polygonal; tabulae complete, horizontal, one-third of a millimeter apart; walls of equal thickness to those of the autopores. Mesopores well devel-

oped, in long reentrant spaces, rectangular and narrow transversely, half to one-third millimeter in longest diameter by half a millimeter in width, but by a rounding of the angles sometimes becoming oval, occasionally double; visceral chambers transversely oblong; tabulae complete, close, horizontal, or oblique, one-quarter of a millimeter apart."

TYPE OCCURRENCE: Bed d, Spring Creek, Ph. Barton Co., Ashburnham, New South Wales.

REMARKS: See under *H. lithostrotionoides*. The most distinctive characteristics are the lack of septa, the round autocorallites, and the small mesocorallites set in reentrant spaces. There is some resemblance to *H. nitida* Lambe but the autocorallites of the latter are not as round and possess septa.

Halysites cratus Etheridge 1904

Halysites cratus Etheridge, Mem. Geol. Survey of New South Wales, Paleontology XIII, p. 27, pl. I, figs. 2, 3, pl. IV, figs. 3, 4, pl. VI, figs. 5, 6, 1904.

ORIGINAL DESCRIPTION: "Corallum massive, forming large tabular colonies of parallel and non-radiating corallites up to eight inches by five inches in size. Fenestrules large, as a rule longer than wide, some quadrangular, a few polygonal, but the geometric outline always obscure, the majority being curved, labyrinthine, or quite irregular in outline, and often almost linear; sizes 5 x 5 mm., 7 x 4 mm., 6 x 5 mm., 10 x 1 mm., 11 x 2 mm., 14 x 3 mm., margins highly undulate; walls strongly corrugate. Corallites very long, up to eight inches, parallel. Epitheca coarsely striate. Corallite chains highly farcimentiform, often contiguous laterally. Autopores large, oval to circular, the latter forming a conspicuous feature; from one to six in each corallite chain, the average being four, from one and a half to two millimeters by one to one and a half millimeters in diameter, or at times possessing the same diameter in both directions; visceral chambers transversely elongate (parallelogrammatic); tabulae complete, distant, and very regular, horizontal or slightly concave, half to three-quarters of a millimeter apart. Gonopores quadrangular, polygonal or variable in form, sometimes absent at the chain junctions, but when present, always much larger than the mesopores; walls as thick as those of the latter; visceral chambers nearly square; tabulae complete, equidistant, horizontal, one-third of a millimeter apart. Mesopores numerous, in short but very marked reentrant spaces, transversely elongate (parallelogrammatic) but not slitlike, half to three-quarters of a millimeter in longitudinal measurement by one-quarter to three-quarters of a millimeter transversely; visceral chambers longitudinally elongate (parallelogrammatic); tabulae complete, horizontal, one-quarter millimeter apart."

TYPE OCCURRENCE: One mile west of Smith's homestead, Ph. Copper Hill, Co. Wellington; L. Smith's station, Ph. Gamboola Co., Wellington, New South Wales.

REMARKS: See under *H. lithostrotionoides*. This large species slightly re-

sembles *H. nexus* Davis and *H. regularis* Fischer-Benzon. The most distinctive combination of characters is: The large, round autocorallites, presence of mesocorallites, lack of septa, and irregular lacunae. The name means "robust."

Halysites australis Etheridge 1898

Halysites australis Etheridge, Rec. Austr. Mus., III, pt. 4, p. 78, pl. XVII, 1898.
Halysites australis Etheridge, Mem. Geol. Survey of New South Wales, Paleontology XIII, p. 29, pl. VI, fig. 4, pl. VII, fig. 6, pl. IX, figs. 1, 2, 1904.

ORIGINAL DESCRIPTION: "Corallum lax and spreading, or forming loosely constructed shrub-like growths, ultimately uniting with one another to form colonies ranging up to nine inches in height. Fenestrules very variable in form and size, quadrangular, polygonal, often of irregular and rounded outline; sizes 3 x 3 mm., up to 15 x 15 mm., with intermediate gradations; margins plain, in one alignment, non-fluctuating; walls flat, or with faint broad ribs or corrugations. Complete corallites unknown, but apparently of no great length. Epitheca with delicate, fine, transverse striations. Corallite chains simple, narrow, farcimentiform only in the smallest degree. Autopores oval to long oval, with rounded ends, two to twelve on each corallite chain, the average being four to six, from three-quarters to one millimeter in longest diameter by half to three-quarters of a millimeter in width; walls very thick, solid, often presenting the appearance as if the corallites were sunk in them; septal spines long, well developed, from one to three cycles in each visceral chamber according to the distance apart of the tabulae, all meeting at the calicinal centers; pseudocolumella not observed; visceral chambers transversely elongate (parallelogrammatic), very variable in longitudinal diameter; tabulae complete, close or distant, horizontal or oblique, from three to six in the space of one millimeter vertical. Gonopores large and polygonal, here and there triangular, round or irregular; walls as thick as those of the mesopores; tabulae complete, horizontal, half a millimeter apart, mesopores transversely oblong and narrow, the corallites pipe-like to quadrangular and large; visceral chambers longitudinally elongate as a general rule; tabulae complete and equidistant, horizontal, half a millimeter apart."

TYPE OCCURRENCE: Bell River on L. Smith's station, Ph. Copper Hill Co., Wellington; Suntop, Ponto Road, Ph. Ponto Co., Lincoln; Geurie, Ph. Geurie Co., Lincoln, New South Wales. Upper Silurian.

REMARKS: See under *H. lithostrotionoides*. The most distinctive features are the loose, spreading growth, rather smooth sides of the lacunae, thick autocorallite walls, 12 septa, and thick mesocorallite walls.

Halysites pycnoblastoides Etheridge, 1904

Halysites pycnoblastoides Etheridge, Mem. Geol. Survey of New South Wales, Paleontology XIII, p. 32, pl. IV, figs. 1, 2, pl. VIII, figs. 5, 6, 1904.

ORIGINAL DESCRIPTION: "Corallum formed of large sub-pyriform masses consisting of slightly radiate corallites, producing colonies up to ten inches

by six in size. Fenestrules round, oval, quadrangular, and polygonal, occasionally irregular, but seldom labyrinthine; sizes 2 x 2 mm., 3 x 2 mm., 4 x 2 mm., 5 x 1 mm., 7 x 2 mm., 10 x 1 mm., and so on; margins highly undulate; walls strongly corrugate or ribbed. Epitheca transversely striate. Corallites long, up to five inches (and then imperfect). Corallite chains strongly farcimentiform. Autopores very numerous, oval or round, one to five in a chain, the average two, one and a half millimeters in longest diameter by one millimeter in the opposite direction; septa confined to the autoporal walls only, and distinctly visible with the pocket lens, arranged in from two to three cycles in each visceral chamber; the latter are transversely elongate (parallelogrammatic); tabulae complete, horizontal, or at times oblique, about half a millimeter apart. Gonopores very numerous, greatly exceeding the mesopores in number, polygonal or irregular in outline, nonseptate; walls as thick as those of the mesopores; visceral chambers transversely oblong (parallelogrammatic); tabulae complete, horizontal, about one-fourth of a millimeter apart. Mesopores few in number in a corallite chain, but where present large and well developed in reentrant spaces, and transversely elongate (parallelogrammatic) to quadrangular; visceral chambers nearly square; tabulae complete, horizontal or rolling, about one-third millimeter apart."

Type occurrence: Bed d, Spring Creek, Ph. Barton Co., Ashburnham, New South Wales.

Remarks: See under *H. lithostrotionoides*. The most distinctive features are the long corallites, corrugated walls of the lacunae, short ranks of corallites which average two corallites per rank, large mesocorallites and presence of septa. It resembles *H. sussmilchi* somewhat but differs in presence of septa, smaller lacunae, and more oval cross section of the autocorallites.

Halysites peristephesicus Etheridge 1904

Halysites peristephesicus Etheridge, Mem. Geol. Survey of New South Wales, Paleontology XIII, p. 34, pl. II, pl. VIII, figs. 1, 2, 1904.

Original description: "Corallum forming large, thick, tabular masses up to two feet long, consisting of long parallel corallites ascending from an extended base of attachment. Fenestrules linear, labyrinthine or convolute, often very long and clustered or almost revolving around certain given centers; sizes 2 x 2 mm., 6 x 2 mm., 13 x 1 mm., 18 x 1 mm., 23 x 1 mm., etc.; margins very undulate; walls strongly corrugate or ribbed. Epitheca fine, transversely striate. Corallites long, straight, up to six and eight inches. Corallite chains varying from short to very long, the latter predominating, strongly farcimentiform. Autopores large, from two to twenty in a chain, but with no definite average number, broad oval in outline, with bulging sides, one millimeter, or slightly more in longest diameter, by three-quarters of a millimeter; septa short, in one or two cycles, not developed on the mesoporal walls; visceral chambers generally transversely elongate (parallelogrammatic); tabulae complete, very regular, horizontal,

or occasionally oblique, half a millimeter apart. Gonopores large, very irregularly polygonal, as a rule much larger in one direction than the other, non-septate; visceral chambers nearly square, tabulae complete, horizontal, one-fifth of a millimeter apart. Mesopores well developed, transversely oblong, non-septate; tabulae complete, horizontal, one-fourth of a millimeter apart."

TYPE OCCURRENCE: Bed a, Quarry Creek, Ph. Barton Co., Ashburnham, New South Wales.

REMARKS: See under *H. lithostrotionoides*. This species is very similar to *H. pycnoblastoides* except that it has more elongate lacunae and slightly smaller autocorallites. There is some resemblance to *H. nitida*.

Halysites gamboolicus Etheridge 1904

Halysites gamboolicus Etheridge, Mem. Geol. Survey of New South Wales, Paleontology, XIII, p. 35, pl. V, figs. 1, 2, pl. VI, fig. 3, 1904.

ORIGINAL DESCRIPTION: "Corallum compact, delicate, formed of subpyriform to sub-hemispherical masses up to 5 inches by 5 inches in size. Fenestrules very irregular in outline, small, on the whole, when compared with other species of similar growth, non-geometric, no two alike, narrow or broad, elongate in either direction without being labyrinthine; sizes 3 x 2 mm., 4 x 2 mm., 5 x 5 mm., 6 x 4 mm., 10 x 3 mm., etc.; margins moderately undulate; walls not highly corrugated or ribbed. Epitheca very fine. Corallites long, slightly radiate. Corallite chains farcimentiform, delicately undulating the margins of the fenestrules. Autopores small, delicate, but well developed, oval but square ended, from two to eight in a chain, the average four, three quarters of a millimeter in longest diameter by three quarters in a contrary direction; walls thick; septa confined to the autoporal walls, from two to three cycles in each visceral chamber; the latter transversely elongate (parallelogrammatic) to nearly square; tabulae complete, distant, horizontal, concave, or now and then rolling, half a millimeter apart. Gonopores numerous, well developed, large, polygonal or irregular in outline, always larger than the mesopores, non-septate; visceral chambers transversely elongate (parallelogrammatic); tabulae complete, horizontal or oblique, one quarter millimeter apart. Mesopores well developed and constant in position in reentrant spaces, transversely elongate (parallelogrammatic), often double, or by removal of the central portion of the dividing wall horologiform; walls thick, but less so than those of the autopores; visceral chambers longitudinally elongate; tabulae complete, horizontal, one quarter of a millimeter apart."

TYPE OCCURRENCE: Ph. Gamboola Co., Wellington, New South Wales.

REMARKS: See under *H. lithostrotionoides*. The most distinctive features of this species are the small, irregular lacunae, small, oval autocorallites, and presence of septa. It shows many points of resemblance to *Catenipora microporus* Whitfield, except that it has mesocorallites.

Catenipora chillagoensis Etheridge 1904

Halysites chillagoensis Etheridge, Mem. Geol. Survey of New South Wales, Paleontology XIII, p. 36, pl. V, figs. 3, 4, pl. VIII, figs. 3, 4, pl. IX, fig. 3, 1904.

TYPE OCCURRENCE: Near Mungana, Chillagoe gold field, Queensland.

REMARKS: Etheridge did not give a complete description of this species. He promised one in a later paper but it never appeared. His figures show that *C. chillagoensis* resembles *H. australis* but lacks mesocorallites. There is also considerable resemblance to *C. gracilis* of North America. The general appearance suggests an Ordovician age but Etheridge's stratigraphic data are too deficient to confirm this.

Halysites gotlandicus Yabe 1915

Halysites gotlandicus Yabe, Tokyo Imp. Univ. Sci. Repts., Geology 4, p. 34 (10), 35 (11), Taf. VII (III), figs. 1, 2, 1915.

ORIGINAL DESCRIPTION: "Approaching *H. labyrinthicus* very closely in the chain formation of the polyp tubes, however, without mesopores. The network is very unequal in form and size; in general, however, quite broad. Rows of polyp tubes ending abruptly; polyp tubes rounded in cross section, 1.9 x 1.7 mm.–2.1 x 1.6 mm. in size. Septal spines present, short. Tabulae often flat and often concave upwards. In cross section there are 6 tabulae per 2 mm., however, they are frequently placed appreciably nearer or farther apart."

TYPE OCCURRENCE: Korkplint, North of Visby, Gotland, Sadewitz, Schlesien. Silurian (Middle?).

REMARKS: This species is based on a few poorly preserved specimens. The description states that there are no mesocorallites but the illustrations strongly suggest that there are. Study of the European species will undoubtedly show that this species is a synonym of a previously described one.

Halysites hupehensis Grabau 1925

Halysites hupehensis Grabau, Geological Survey of China, Bull., no. 7, p. 77, 1925.

ORIGINAL DESCRIPTION: "Non-spinous fenestrules up to 25 mm. long by 5 to 15 more in width. Chains with 2 to 8 links in some specimens, 7 predominating. Autopores oval with truncated ends larger than preceding, 3 x 1¾ to 2½ x 2 mm. in diameter, contracted at the ends to .5 to .75 mm., separated by slit-like mesopores which are often absent. Gonopores occasionally present, then fairly large and variously shaped. Tabulae arched, complete, about ½ mm. apart."

TYPE OCCURRENCE: Sintan shale, Hupeh Province, China. Silurian.

REMARKS: This large species may be a synonym of *H. cratus* Etheridge but it is not possible to tell with certainty from the description.

Catenipora robustus (Wilson) 1926

Halysites robustus Wilson, Canadian Dept. of Mines Museum Bull. 44, p. 14, pl. I, figs. 8, 9, 10, 1926.

ORIGINAL DESCRIPTION: ". . . a robust form growing in massive colonies. Meshes of the reticulations of the corallites mostly large, many long and narrow. No tubuli present. Corallites narrowly oval, walls thickened and slightly flattened at the ends, giving the outside of the corallite an oblong outline rather than the more oval outline of the interior. Spines not well preserved although their presence is indicated in some corallites. A longitudinal section shows strong, complete tabulae about 1 mm. apart."

TYPE OCCURRENCE: Richmond; Beaverfoot. From Palliser Pass; Fairmont Springs, Windermere district; Stanford range near head of Windermere Creek, British Columbia.

REMARKS: Wilson (1926), (1931) described the following new species and varieties: *C. robustus, C. delicatulus, C. pulchellus, C. cylindricus,* and *C. gracilis* var. *borealis.* Three of these, *C. robustus, C. delicatulus,* and *C. gracilis* var. *borealis,* closely resemble *C. gracilis* and were contemporaneous with it. They differ slightly in size and shape of corallites and spacing of the tabulae. The latter characteristic is highly variable within a specimen. It is quite possible that these three are varieties or sub-species of *C. gracilis,* but there are only a few imperfect specimens available for comparison. Wilson's nomenclature will be followed until such time as more abundant samples permit the infraspecific status of the forms to be demonstrated. *Catenipora robustus* differs from *C. gracilis* in having slightly smaller corallites which are more elliptical in cross section. Also, the walls are thicker, and the tabulae less numerous but heavier.

HOLOTYPE: National Museum of Canada, No. 6733a.

Catenipora delicatulus (Wilson) 1926

Halysites delicatulus Wilson, Canada Dept. of Mines Museum Bull. 44, p. 14, pl. II, figs. 3, 4, 5, 1926.

ORIGINAL DESCRIPTION: "A delicately formed species with the mesh of the reticulations much finer than in the preceding species. Corallites small, averaging about 3 in 5 mm., almost oblong, slightly narrower at the ends than in the center, length of corallite about one and a half times the greatest width. Where crowded the shape becomes more rectangular, and at times almost circular, a cross section shows the two contiguous ends of the walls flattened against one another. A longitudinal section shows complete tabulae, six to seven in the space of 3 mm., mostly straight, some bent a little at the contact with the wall."

TYPE OCCURRENCE: Richmond; Beaverfoot. Palliser Pass area, Beaverfoot Range near Golden, Stanford Range near head of Windermere Creek, Columbia Lake, British Columbia, Canada.

REMARKS: See under *C. robustus. Catenipora delicatulus* differs from *C.*

gracilis in having smaller, less quadrangular corallites and a finer lacunae pattern. It has twice as many tabulae as *C. robustus*. Septa are not mentioned in the description nor are they visible in the figures. *Catenipora delicatulus* resembles Whitfield's figure of *C. agglomeratiformis*.

HOLOTYPE: National Museum of Canada No. 6734.

Catenipora pulchellus (Wilson) 1926

Halysites pulchellus Wilson, Canada Dept. of Mines Museum Bull. 44, p. 15, pl. III, figs. 8, 9, 1926.

ORIGINAL DESCRIPTION: "A massive, growing colony having reticulations with a fine mesh. Corallites small, oval, slender in outline, averaging three in 5 mm., at the widest part, the whole producing a beautifully delicate chain in cross section. No intercorallite tubuli. Walls thicker than is usual in such a fine species. Tabulae complete, averaging four to five in 3 mm."

TYPE OCCURRENCE: Richmond, Beaverfoot, Sinclair gorge, British Columbia, Canada.

REMARKS: This species is characterized by the fine lacunae, elliptical corallites, and lack of both septa and mesocorallites. The elliptical rather than oblong cross section of the corallites differentiates it from *C. delicatulus*. There is considerable resemblance to *C. quebecensis* but the specimens are not adequate for reliable comparison. There is also much resemblance to some poorly preserved specimens from the Fishaven dolomite of Utah.

HOLOTYPE: National Museum of Canada No. 6735.

Catenipora cylindricus (Wilson) 1926

Halysites cylindricus Wilson, Canada Dept. of Mines Museum Bull. 44, p. 15, pl. II, figs. 6, 7, 1926.

ORIGINAL DESCRIPTION: "Massive colonies of a small form of *Halysites* coral. Meshes very fine. Corallites cylindrical, very small, averaging 1 mm. in diameter, barely in contact, some free. No intercorallite tubuli, complete rather heavy tabulae, about six to seven in 3 mm., a relationship which in the small corallites produces a relatively large space."

TYPE OCCURRENCE: Harrogate, British Columbia, Canada. Exact horizon not known.

REMARKS: The small, round, loosely joined autocorallites makes this species unique. The loose joining may provide clues to the method of asexual increase and to the origin of the Halysitidae. The figure shows little detail. Perhaps this does not belong to the Halysitidae.

HOLOTYPE: National Museum of Canada No. 6736.

Catenipora nicholsoni (Kiaer) 1929

Halysites nicholsoni Kiaer, Bergens Museums Arbok, p. 50, 51, pl. I, figs. 5–7, 1929.

ORIGINAL DESCRIPTION: "The thecal tubes are beautifully rounded, 2–3 per 5 mm., and strongly reentrant interthecally. In cross section the length of a single thecal tube is 1.8–2.6 mm. and the breadth 1.25–1.5 mm. The

space between the thecal tubes is approximately .35–.5 mm. wide. The interthecal walls are without tubuli. The tabulae are irregularly spaced, sometimes strongly bent down in the middle, and occur in the number of 8–9, rarely as few as 5 per 5 mm. Septal spines seem to be completely crushed. The meshes in one small piece are very irregular and rather open, with occasional completely isolated tubes. In that specimen the meshes have rather parallel sides and are striated longitudinally. The fragments, however, are very small for study and give the impression of a plant form." (Translation.)

TYPE OCCURRENCE: Ordovician, Upper Vikenes strata at Stord, Norway.

REMARKS: *Catenipora nicholsoni* resembles *C. gracilis* and is of the same age, but lacks septal spines, and the tubes are round. However, septal spines are often very difficult to see. The "occasional completely isolated tubes" resembles the condition in *C. cylindricus.*

Catenipora gracilis var. *borealis* (Wilson) 1931

Halysites gracilis var. *borealis* Wilson, Trans. Royal Soc. Canada IV, 25, p. 296, pl. 3, fig. 5, 1931.

ORIGINAL DESCRIPTION: "This form is similar to *H. gracilis* in having rectangular corallites but unlike it in that the diameter of each corallite which is connected with the adjacent corallite is persistently longer than the cross diameter. There is a strong tendency for the corallite to become more oval than rectangular. This feature, however, is variable . . . the tabulae . . . are much more numerous and longer than those of the species proper."

TYPE OCCURRENCE: Richmond, Putnam Highland, Canyon near Foxe Basin, Arctic Canada.

REMARKS: The rather elliptical corallites and numerous tabulae are distinctive. This form resembles *C. gracilis* so closely that the name is retained as a variety just as Wilson proposed it.

HOLOTYPE: National Museum of Canada No. 6507.

Catenipora sapporiensis (Shimizu, Ozaki, Obata) 1934

Halysites sapporiensis Shimizu, Ozaki, Obata, Shanghai Inst. of Science, Jour. Sec. II, vol. 1, p. 77, 78, pl. XVII, fig. 4, pl. XVIII, figs. 3, 4, 1934.

ORIGINAL DESCRIPTION: "Specimen smallest . . . Fenestrules somewhat irregularly polygonal, unequal in size; circumference of the fenestrules composed of 5 to 8 corallites and one side of 1 to 2. Corallites elongated oval in cross section, about .7 x 1 mm. large and closely tabulated.

"Tabulae rather thick, slightly concave upwards, 5 in a space of 1 mm. No septal spine traceable. Interstitial tube absent."

TYPE OCCURRENCE: Gotlandian deposits, northeast of Ken-Niho, northwest Korea.

REMARKS: Shimizu, Ozaki, and Obata (1934) described *C. sapporiensis* and *C. sindoensis* from what they termed "Gotlandian" deposits of north-

west Korea. They are very similar and further sampling may show that they are varieties of one species. There is some resemblance to *C. microporus* Whitfield.

Catenipora sindoensis (Shimizu, Ozaki, and Obata) 1934

Halysites sindoensis Shimizu, Ozaki, Obata, Shanghai Science Inst., Jour. Sec. II, vol. I, p. 77, pl. XVI, figs. 5, 6, 7, pl. XVII, figs. 2, 3, 1934.

ORIGINAL DESCRIPTION: "Species easily distinguishable from allied forms owing to one side of its fenestrules being almost invariably composed of a single corallite, although not always joined to another at the restricted edges. Fenestrules rather regularly polygonal, but differ in size, largest one composed of 8 corallites, smallest of 5. In my specimen, ornamentation of surface of walls not observable owing to recrystallization. Corallites oval in cross section, about 1 x 1.5 mm. traversed by numerous thin tabulae regularly distributed and concave upwards; 14 or more tabulae in space of 5 mm. Wall of corallites thicker than tabulae. No septal spines traceable. Interstitial tube absent."

TYPE OCCURRENCE: Gotlandian deposits, 2 km. northeast of Ken-Niho, northwest Korea.

REMARKS: See under *C. sapporiensis*. *Catenipora sindoensis* has slightly larger corallites and ranks composed invariably of a single corallite rather than one or two. The arrangement of corallites is similar to that of *H. jackovickii* Fischer-Benzon.

Halysites catenularius var. *borealis* Tcherneychev, 1937

Halysites catenularius var. *borealis* Tcherneychev, Trans. of Arctic Inst. of Leningrad, p. 98, 99, t. XI, figs. 5a, 5b, text-fig. 12, 1937.

ORIGINAL DESCRIPTION: "Rows of corallites forming an irregular, rather dense network in which narrow meshes with parallel sides predominate. Maximum width of meshes 2.5 mm., their maximum length 19 mm. Number of autopores in the sides of the meshes varying from 1 to 11. Autopores nearly circular in cross section, 1.3–1.5 mm. in width and 1.5–1.7 mm. in length. Corallite walls bearing on their external surface numerous small close-set folds. Tabulae in autopores horizontal or curved. In 5 mm. of length there are 10–17 tabulae. Spines numerous but short; in places they are quite destroyed. Mesopores (intermediate tubes) well developed, usually quadrate, rarer narrow and more elongate. Length of mesopores mostly .5 mm. Tabulae in mesopores horizontal, about 20 in number in the space of 5 mm. of length."

TYPE OCCURRENCE: Upper Silurian of Novaya Zemlya, Severnaya Zemlya, Russia.

REMARKS: The name *borealis* is preoccupied (Wilson, 1931). The specimen described shows points of resemblance to both *H. agglomerata* Hall and *H. nitida* Lambe.

Halysites lata Tcherneychev 1937

Halysites catenularius var. *lata* Tcherneychev, Trans. of Arctic Inst. of Leningrad, p. 99, 100, pl. X, figs. 3a, 3b, pl. XII, fig. 3, text-fig. 13, 1937.

ORIGINAL DESCRIPTION: "The rows of corallites form an irregular network with broad meshes. Maximum width of meshes 11 mm., maximum length 22 mm. Number of autopores in the sides of the meshes varying from 1 to 9. Autopores elliptical in cross section, 2.8 x 2.3 mm. in dimension. Corallite walls with small, close-set folds on their outer surface. Tabulae in autopores horizontal, equidistant. In 5 mm. of length from 9 to 11 tabulae are present. Spines wholly absent. Mesopores (intermediate tubes) well developed, rectangular, narrow, .3–.4 mm. in length. Tabulae in mesopores concave, numerous, about 25–30 in each 5 mm. of length."

TYPE OCCURRENCE: Upper Silurian of Novaya Zemlya, Severnaya Zemlya, Russia.

REMARKS: The variety name is here raised to specific status. Reasons for this are discussed in the section "Problems of Classification."

Catenipora minimus (Tcherneychev) 1937

Halysites minimus Tcherneychev, Trans. of the Arctic Inst. of Leningrad, p. 96, t. XI, figs. 4 a–c, text-fig. 10, 1937.

ORIGINAL DESCRIPTION: "Corallum small, hemispherical, 2 cm. in height by a diameter of 3.5 cm. Rows of corallites forming a regular network, consisting of regularly polygonal or slightly extended cells. Maximum width of cells 1.5 mm., maximum length 3 mm. Number of corallites in the sides of the meshes varying from 1 to 3. Close set and parallel rows of corallites are nowhere observed. Autopores (corallites) rectangular in outline, .5–.6 mm. in width and .7 mm. in length. The free portions of their walls almost parallel. Walls ornamented on their outer surface with numerous small close set folds. Tabulae complete, horizontal, slightly concave, or convex. Distances between adjacent tabulae rather constant. From 12 to 14 tabulae are present within each 5 mm. of length. Spines very poorly preserved and discernible but as numerous short, pointed tubercles. Mesopores (intermediate tubes) absolutely absent."

TYPE OCCURRENCE: Upper Silurian of Novaya Zemlya, Severnaya Zemlya, U.S.S.R.

REMARKS: This species resembles *C. microporus* Whitfield except that the dimensions are somewhat smaller.

Halysites taimyrica Tcherneychev 1937

Halysites parallelus var. *taimyrica* Tcherneychev, Trans. of the Arctic Inst. of Leningrad, p. 95, 96, t. XII, fig. 2, t. X, figs. 4 a–c, 1937.

ORIGINAL DESCRIPTION: "Distinguished by a greater diameter of corallites (in one specimen 1.5 mm. x 1 mm., in another specimen 1.5 x 2–2.5 mm.) more convex walls and the absence of spines."

TYPE OCCURRENCE: Upper Silurian, Taimyr, U.S.S.R.

REMARKS: Tcherneychev regarded this as a variety of *H. parallelus* and assumed that the reader would be familiar with the characteristics of that species which, in turn, was described in a few vague sentences. *Halysites taimyrica* shows some resemblance to *C. gracilis,* but is much younger in age.

Halysites pseudoorthopteroides Tcherneychev, 1937

Halysites pseudoorthopteroides Tcherneychev, Trans. of the Arctic Inst. of Leningrad, p. 98, t. 10, figs. 5a, b, 1937.

ORIGINAL DESCRIPTION: "Rows of corallites forming an irregular network with broad meshes. Maximum width of meshes 8 mm., maximum length 25 mm. Number of autopores in the sides of the meshes varying from 1–12. Autopores elliptical in cross section, 1–1.9 mm. in width and 1.5–2.3 mm. in length. Corallite walls ornamented on their outer surface with small, close-set transverse folds. Tabulae in the autopores horizontal, either wavy or concave, 7–11 in number in the space of 5 mm. of length. Spines not detected. Mesopores (intermediate tubes) usually well developed, but in places reduced and wholly absent. Length of mesopores mostly .5 mm., rarer less than .5 mm., or exceeding this latter (up to 1 mm.). Tabulae in mesopores mostly horizontal, oblique, concave or convex, sometimes curving up and uniting with the adjoining ones and not reaching to the opposite wall. About 18 tabulae are present in the space of 5 mm. in length."

TYPE OCCURRENCE: Upper Silurian of Novaya Zemlya, Severnaya Zemlya, U.S.S.R.

REMARKS: This species resembles *H. labyrinthica* Goldfuss. The name, *H. pseudoorthopteroides,* may have been selected to imply a resemblance to *H. orthopteroides* Etheridge. There is, in fact, considerable resemblance between the two except that the corallites of Tcherneychev's species are much the larger.

Catenipora aequabilis (Teichert) 1937

Halysites aequabilis Teichert, Rept. of the 5th Thule Exped. 1921–1924, p. 57, pl. VIII, fig. 2, pl. IX, fig. 4, 1937.

ORIGINAL DESCRIPTION: "Corallum massive, corallites small, ovate to subrectangular in cross section, long diameter 1.1 to 1.3 mm., transverse diameter .4 to .7 mm. The reticulations consist of very small meshes. The intracellular spaces are ovate to circular, though sometimes rectangular when the four walls of a mesh consist of not more than one corallite each. More frequently the meshes are composed of five to six corallites, and in some cases of seven or eight. The walls of the corallites are thin, and their thickness rarely exceeds .1 mm. The tabulae are straight and there are about eight of them in a space of 5 mm. Tubuli are absent."

TYPE OCCURRENCE: Ordovician of Iglulik Island (possibly Trenton).

REMARKS: This species shows many points of resemblance to *C. quebe-*

censis Lambe. The name *aequabilis* or "equal dimensions" refers to the shape of the lacunae.

Catenipora huronensis (Teichert) 1937

Halysites huronensis Teichert, Rept. of 5th Thule Exped. 1921–1924, v. I, p. 135, pl. X, 1937.

ORIGINAL DESCRIPTION: "Corallum small and compact, corallites compressed, the longest diameter of the cross section varying between 1 and 1.2 mm., the transverse diameter being .5 mm. with only slight variations. The walls of the corallites are thin. The tabulae are straight and there are about eight of them in a distance of 5 mm. The meshes of reticulations are in general small. Usually the corallites are arranged in rows of two or three, but in exceptional cases as many as eight individuals can be found in one row. Most of the meshes are irregularly polygonal and the diameter of the majority of them lies between 1.5 and 4 mm. Septal spines and tubuli are absent."

TYPE OCCURRENCE: Silurian of Drummond Island, Michigan.

REMARKS: The holotype of this species was identified as *Catenipora escharoides* by Goldfuss (1826). It resembles *Catenipora microporus* (Whitfield) except that the corallites are slightly larger in long dimension.

Catenipora irregularis (Teichert) 1937

Halysites irregularis Teichert, Rept. of 5th Thule Exped. 1921–1924, v. I, no. 5, p. 132, 133, pl. VII, figs. 4, 5, pl. VIII, fig. 3, 1937.

ORIGINAL DESCRIPTION: "Corallum massive; corallites irregularly subcylindrical. In places the corallites are very close together as in *Favosites,* in other places in the same individual they are arranged in short rows forming narrow meshes. The cross section of the corallites depends on their mode of occurrence. Where the corallites are closely spaced, they are pentagonal to hexagonal in cross section, where they are arranged in rows the cross section is subquadrangular to rounded. The diameter of the corallites is fairly constant and measures about 1.5 mm., but slightly larger and slightly smaller corallites are to be found. The tabulae are straight and there are seven to nine of them in a distance of 5 mm. Septal spines are usually absent, but are present in a few of the corallites. Their number appears to be twelve. Tubuli are absent."

TYPE OCCURRENCE: Silurian, hinterland of Douglas Bay, northwest of Peffer River, southeastern King William Land.

REMARKS: The *Favosites*-like arrangement of the corallites is similar to that described by Rominger in *H. compactus. Catenipora irregularis* resembles *H. agglomerata* Hall in many respects but differs significantly in its lack of mesocorallites and flat rather than arched tabulae.

Catenipora rassmusseni (Teichert) 1937

Halysites rassmusseni Teichert, Rept. of the 5th Thule Exped. 1921–24, p. 134, 135, pl. IX, figs. 5, 6, pl. X, fig. 2, 1937.

ORIGINAL DESCRIPTION: "Corallum flat. Corallites generally strongly compressed, and the largest diameter of the cross section averages 1.5 mm. though diameters up to 2 mm. and down to 1 mm. are to be found. The width of the corallites varies between .8 mm. and 1 mm. The walls of the corallites are thin, generally between .1 and .2 mm. thick. The tabulae are straight and are crowded; there are about ten of them in a distance of 5 mm. Tubuli and septal spines are absent. The meshes of reticulation are irregular in size. Some of them do not measure more than 2 mm. across, and others are formed by only three or four corallites. However, the great majority of the meshes is larger, though they are very irregular in their configuration. The corallites are arranged in rows of up to fourteen individuals, but the average number of corallites in a row is somewhat less than fourteen."

TYPE OCCURRENCE: Silurian, hinterland of Douglas Bay, northwest of Peffer River, southeastern King William Land, Arctic Canada.

REMARKS: The shape of corallites and lack of mesocorallites in this species suggests a relationship to *C. gracilis,* but the latter is an Ordovician species, whereas *C. rassmusseni* is Silurian.

Halysites kuliki Tcherneychev 1938

Halysites kuliki Tcherneychev, Transactions of the Arctic Institute of Leningrad, p. 128, 129, t. IV, figs. 2a, 2b, text-fig. 7, 1938.

ORIGINAL DESCRIPTION: "The rows of corallites form an irregular network with long, fairly narrow, fancifully curved meshes. The autopores are elliptical in cross section, from 1.2 to 1.4 mm. long, and from .9 to 1 mm. wide. In many autopores one free side is more convex than the other. Tabulae complete, feebly concave, numbering 7–8 in 5 mm. of length. No spines observed. The mesopores are greatly reduced and are almost entirely absent."

TYPE OCCURRENCE: Yaigach Island, northern U.S.S.R.

REMARKS: This species probably is related to *H. catenularius.* It also closely resembles *H. orthopteroides* Etheridge.

Halysites brownsportensis Amsden 1949

Plate 9, figs. 4, 5, 6; Plate 10, fig. 6

Halysites catenularia brownsportensis Amsden, Stratigraphy and paleontology of the Brownsport formation of western Tennessee: Yale University, Peabody Mus. Nat. Hist., Bull. 5, p. 94–95, pl. 18, figs. 1–3, 1949.

ORIGINAL DESCRIPTION: "This variety is dimorphic and has a corallum consisting of very elongate, cylindrical corallites which are attached to

each other along one edge and aligned into rows with the macrocorallites alternating in position with the microcorallites. These rows of individuals wind around and anastomose to form a somewhat massive corallum. The maximum size attained by the colonies is not known but there is one incomplete specimen which measures 6 inches in diameter and 3 inches thick. The macrocorallites are elongate tubes which are elliptical in cross section, the greatest diameter being about 2 mm. and the lesser 1.5 mm. A continuous wall encloses the macrocorallites and microcorallites and binds them together. Most of the corallites do not show any traces of septa but one macrocorallite was found which has 11 or 12 short septa. The macrocorallites possess numerous flat tabulae, 9 or 10 occupying a space of 5 mm. Between each macrocorallite is a microcorallite which has an inside diameter of about two-thirds of a millimeter. These possess closely spaced tabulae which are strongly arched upward, 22 to 25 occupying a space of 5 mm. Contiguous macrocorallites and microcorallites share a common wall."

Occurrence: Brownsport formation of western Tennessee.

Remarks: The arched mesocorallite tabulae distinguish this species from *H. labyrinthica,* the tabulae of which are flat. Otherwise the two species are very similar. *Halysites brownsportensis* agrees with the description of *H. cavernosa* Fischer-Benzon from the Silurian of Europe.

Halysites encrustans n. sp.

Plate 10, figs. 1, 2, 3, 4, 5

Description: The colonies are bunshaped, the upper surface rounded, the lower encrusting, commonly on a stromatoporoid. The holotype measures 10 x 12 cm. and 3 cm. thick. The ranks are of one or two, occasionally more corallites. These short ranks result in small, polygonal lacunae which typically measure 2 x 3 mm. although measurements vary from 3 x 4 mm. to 1 x 1 mm. The autocorallites are from 1 to 1.5 mm. in diameter. A typical one measures 1.25 x 1 mm. The tabulae are flat, spaced approximately 0.5 mm. apart. Septal spines are present. The mesocorallites are rectangular in cross section and average 0.3 x 0.75 mm. in diameter with the longest dimension transverse to the corallite ranks. The mesocorallite tabulae are closely spaced and strongly convex upward.

This species is based upon six nearly complete specimens from the La Vieille limestone near Port Daniel, P. Q. They are all so uniform in their characteristics that they unquestionably represent a species. The name is taken from the encrusting habit of growth. Although the coralla present a very compact appearance they do not show the characteristics of *H. compactus* with which they were identified by Schuchert. The lacunae are much more open and the corallites are smaller. On the other hand, the lacunae are smaller and more regular in shape than those of *C. microporus* and they never show the labyrinthine pattern of *H. labyrinthica* and *H.*

nitida. The fact that four of the specimens are attached to stromatoporoids (*Clathrodictyon vesiculosum*) suggests some sort of commensal relationship between the forms.

HOLOTYPE: Yale Peabody Museum No. 7235.

OCCURRENCE OF HOLOTYPE: La Vieille formation, Port Daniel, P. Q.

Halysites infundibuliformis n. sp.

Plate 1, fig. 1; Plate 2, fig. 1; Plate 3, fig. 6

DESCRIPTION: The corallum of the holotype measures approximately 7 x 4.5 x 4 cm. A badly silicified specimen that has been referred to this species measures 24 x 14 x 9 cm. The corallites radiate outward from a common center, causing the corallum to increase in diameter from the base upward. That portion of the holotype that may be referred to as the base measures 1.5 cm. in diameter. The lacunae are predominantly labyrinthine. Measurements of a few selected ones are 15 x 6 mm., 25 x 3 mm., and 35 x 3 mm. A few follow a tortuous course across the entire corallum. As a result of the radiating arrangement of the corallites the lacunae taper downward and some are nearly closed off on the bottom. Considered in three dimensions they are somewhat funnel-shaped, whence the specific name *infundibuliformis*. The autocorallites are 1.75–1.5 x 1–0.75 mm. in diameter and are elliptical in cross section. The mesocorallites are 0.75–0.5 mm. in diameter and are rectangular in cross section. The autocorallite tabulae are spaced 0.5 to 0.75 mm. apart and are gently convex downward. The mesocorallite tabulae are more closely spaced and are strongly convex upward.

H. infundibuliformis does not show the uniform vertical growth characteristic of most species of the Halysitidae. There was a tendency for the ranks to cease vertical growth at various levels and some even show attempts at rejuvenation. Many of the corallites are curved. Frequent interstitial increase caused the funnel shape of the lacunae.

HOLOTYPE: Yale Peabody Museum No. 19142.

OCCURRENCE: The holotype is from drift near York, N. Y., about 7 miles northwest of Geneseo. A paratype is from drift near Elma, Erie Co., N. Y. Both lithology of the matrix and location at which the finds were made suggest Lockport dolomite as the horizon. Several specimens from the Cobbleskill dolomite near Cherry Valley, N. Y., resemble this species closely enough to be conspecific with it.

REMARKS: *H. infundibuliformis* resembles the common Niagaran species *H. labyrinthica*. It differs in the radiating corallites and infundibuliform lacunae.

It is unfortunate that the holotype must be a specimen from drift. However, the occurrence of several specimens with the same diagnostic features proves that this is a hitherto undescribed species. The specimen selected as holotype shows much better preservation than any of the paratypes.

Halysites magnitubus n. sp.

Plate 2, figs. 1, 2, 3

DESCRIPTION: The holotype is a small fragment of a colony but was chosen because it shows more detail in thin section than any of the paratypes. The largest corallum examined is approximately 17 cm. in diameter by 10 cm. thick and is a badly worn fragment of a colony. The lacunae range from polygonal to labyrinthine in shape. Measurements of several that were selected to show the variation in size are: 5 x 5 mm., 11 x 9 mm., 18 x 8 mm., 22 x 4 mm., 60 x 8 mm. The number of corallites per rank is also highly variable; the observed range is from one to 11. Four is a common number. The exterior of the corallites is strongly marked by growth lines. The coralla are dimorphic. The autocorallites of the holotype are 2.5–3 x 3–3.5 mm. in diameter and elliptical in cross section. A specimen from Inyo Co., California, U.S.N.M. No. 123429, has corallites 3.5 x 4 mm. in diameter. The mesocorallites are 1–2 x .5–1 mm. in diameter. The longest dimension is in line with the ranks. The autocorallite tabulae are flat. Most are approximately 0.5 mm. apart but this distance varies from 0.2 to 0.8 mm. The mesocorallite tabulae are more closely spaced and are convex downward. No septal structures were observed.

HOLOTYPE: U. S. National Museum, No. 123428.

OCCURRENCE: The holotype was collected 9 miles SSW. of Gold Hill, Gold Hill quadrangle, Utah. Paratypes are from Thomas Mts., Fish Spring quadrangle, Utah; Laketown dolomite, Preston quadrangle, Idaho; Hidden Valley dolomite, Ubehebe Peak area, Inyo Co., California.

REMARKS: The unusually large autocorallites and variable pattern of the lacunae characterize this species. There is some resemblance to *H. nexus* Davis but the corallites of Davis' species are slightly smaller and the ranks branch irregularly without enclosing lacunae. *H. magnitubus* was common and widespread in western North America during the Silurian period.

IDENTIFICATION KEY

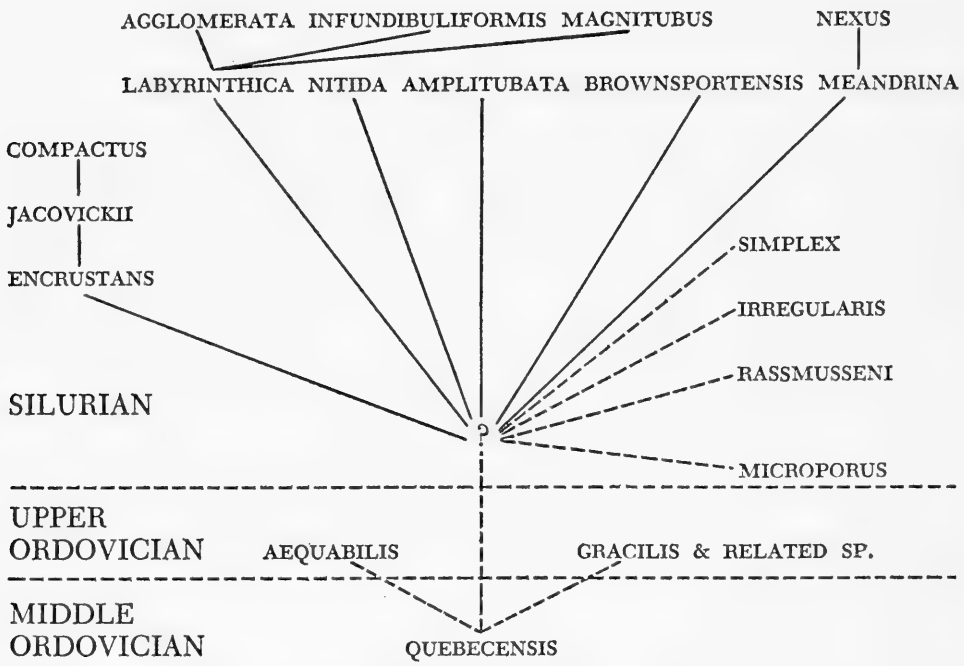
The following table gives the diagnostic features of the North American species of the Halysitidae. The names in parentheses are Eurasian species which closely resemble and may be conspecific with the American species with which they are listed.

Mesocorallites absent (Genus *Catenipora*)
Lacunae polygonal
Ranks of 1 or 2 corallites ..... ***aequabilis*** **p. 63**
Ranks of 1–4 corallites, occasionally more
Corallites between 1 and 2 mm. in diameter .. ***quebecensis*** **p. 46**
Corallites less than 1 mm. in diameter ..... ***microporus*** **p. 44**

Lacunae labyrinthine
Corallites more than 2 mm. in diameter ..... *simplex* p. 47
Corallites average 2 mm. or less in diameter
Corallites quadrangular in cross section
Corallite walls of normal thickness
Corallites average 2 mm. in diameter .....
gracilis p. 36
agglomeratiformis(?) p. 49
(*parallelus*) p. 38
Corallites average 1.5 mm. in diameter ... *delicatulus* p. 58
Corallite walls thick, general appearance robust .....
robustus p. 58
Corallites elliptical in cross section ..... *pulchellus* p. 59
Corallites strongly compressed in cross section .....
rassmusseni p. 65
Mesocorallites present (Genus *Halysites*)
Lacunae large and labyrinthine
Most lacunae more than 4 mm. wide
Lacunae markedly infundibuliform ..... *infundibuliformis* p. 67
Lacunae not markedly infundibuliform
Autocorallites 2.5 mm. or more in diameter .. *magnitubus* p. 68
Autocorallites less than 2.5 mm. in diameter
Mesocorallites may be as large as autocorallites ..... *amplitubata* p. 48
Mescorallites all smaller than autocorallites
Mesocorallite tabulae flat ..... *labyrinthica* p. 29
Mesocorallite tabulae highly arched ..... *brownsportensis* p. 65
Most lacunae less than 4 mm. wide
Lacunae 1–4 mm. wide, corallites smaller than *H. labyrinthica* ..... *nitida* p. 49
Lacunae very narrow or absent, autocorallites round in cross section ..... *agglomerata* p. 35
Lacunae small, polygonal
Ranks of 1–3 corallites ..... *encrustans* p. 66
Ranks of one corallite, lacunae smaller than diameter of corallites ..... *compactus* p. 41
Ranks loosely branching, not forming lacunae
Corallites 1.5 mm. in diameter ..... *meandrina* p. 34
Corallites 2.5 mm. in diameter ..... *nexus* p. 45
(*lata*) p. 62

PHYLOGENY

The following diagram suggests a possible phylogeny of the Halysitidae. The evidence for this is scanty and the actual situation may have been quite different. *C. quebecensis* is the oldest species and there is nothing in its structure to rule it out as an ancestor to the younger species. This ancient monomorphic lineage branched into several species in the Late Ordovician and continued into the Silurian Period with rather aberrant forms such as *C. microporus* with unusually small corallites and *C. simplex* with unusually large ones. In the Early Silurian a new lineage composed of dimorphic species appeared and rapidly underwent adaptive radiation. It is impossible to say which, if any, of the known species was ancestral to the dimorphic line. It is possible to arrange the dimorphic species in two groups, one with polygonal and one with labyrinthine lacunae, both showing a tendency toward reduction in size of the lacunae.



Catenipora: dashed lines
Halysites: solid lines

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION

The stratigraphic range of the Halysitidae is from Middle Ordovician to Upper Silurian (Black River-Manlius). Shimer and Shrock (1944) give the upper limit as Lower Devonian. This was probably taken from

Lambe (1899) who assigned the *Halysites*-bearing Chaleur series of Quebec to Helderberg rather than Middle Silurian age. The geographic range extended throughout North America and Eurasia far up into the Arctic regions of both continents and south through Asia into Australia. The distribution seems to be concentrated north of 30° N. latitude but undoubtedly the greater activity of collectors in certain areas distorts the true picture of the range somewhat.

The oldest species known is *C. quebecensis* Lambe which is found in the Black River rocks of the Lake St. John area, Quebec. Bassler (1950) also reports specimens from Middle Ordovician (Llandeilian) of Great Britain and the Middle Ordovician (upper Jewe) of Esthonia.

Catenipora has been reported (as *Halysites*) from the Upper Ordovician of Europe (England and Baltic region) and North America. It was fairly common in the Richmond seas of the Arctic. The records of occurrence suggest a holarctic center of dispersal from which the genus spread southward in both the Appalachian and Cordilleran geosynclines. Apparently it spread farther south in the Cordilleran geosyncline as it has been reported from Utah and Colorado. In the Richmond formations of the east, *Catenipora* is rare farther south than the upper Mississippi Valley, but has been reported from Texas.

There were at least two species in existence during the Late Ordovician epoch. Most of the specimens resemble *C. gracilis* closely enough to be identified with it but there was another species with small lacunae and short ranks (see *C. pulchellus* and *C. aequabilis*).

During the Silurian Period the Halysitidae extended their range farther to attain almost world wide distribution. They are found in the British Isles in formations of Llandovery, Wenlock, and Downtownian age. They are fairly common in the Silurian of Gotland, the vicinity of Oslo, western Esthonia, the Baltic Plain, East Prussia, Bohemia, western Russia, and northern Russia (Nova Zembla). The range extended across Siberia into Manchuria, China, Japan, and south to the Himalayas, New Guinea, and Australia. The excellent monograph by Etheridge (1904) permits comparison of the Australian species with those of North America and shows that few if any of the species are common to the two continents. The family occurs throughout the Silurian of the United States and Canada but is most common in the northeastern portions. Many specimens were found in formations of Niagaran age at Gaspé (Chaleur group), Manitoulin Island, western Tennessee, and Louisville, Kentucky. In western United States it has been found in Utah, Idaho, Arizona, and California. The specimens from California tend to be larger than those of the same species farther north but this may be merely an accident of sampling. At least one of the western species is peculiar to that region but several species appear to be common to both western and eastern North America. The commonest one of the western species cannot be distinguished from *H. labyrinthica* which is also the commonest one in the east. Critical study

of the western fauna is hampered by the fact that the specimens are invariably badly silicified or dolomitized and the mesocorallite structures which are so important for taxonomy are obliterated. The range extended north through Canada and into the Arctic Archipelago.

The Halysitidae were most abundant in both numbers and species during the Middle Silurian and flourished in the lime depositing seas of Niagaran age. It declined markedly during Cayugan time and became extinct near the close of the Silurian Period.

REFERENCES CITED

Amsden, Thomas, 1949, Stratigraphy and paleontology of the Brownsport formation of western Tennessee: Yale Univ., Peabody Mus. Nat. Hist., Bull. 5, p. 94, 95, pl. 18, figs. 1–3.

Bassler, Ray, 1950, Faunal list and descriptions of Paleozoic corals: Geol. Soc. America, Mem., 44.

Bernard, H. M., 1901, The unit of classification for systematic biology: Proc. Cambridge Philos. Soc., v. 11, p. 268–280.

Bromell, 1728, Lithographia Suecana: Acta Lit. Sueciae Public, p. 411, 412, fig. II on pl. opp. p. 410 and fig. on p. 412.

Castelnau, Francis *compte de*, 1843, Essai sur le systéme silurien de l'Amérique septentrionale: Paris, P. Bertrand, p. 45, pl. 17, fig. 1.

Davis, W. J., 1885, Kentucky fossil corals; a monograph of the fossil corals of the Silurian and Devonian rocks of Kentucky. In two parts: Kentucky Geol. Survey. Pt. 2, pl. 67, figs. 4, 5.

Duncan, P. M., 1872, Third report on the British fossil corals: Rept. 41st meeting British Assoc. Adv. Sci. (1871), p. 116–137.

Eichwald, C. E., 1829, Zoologia Specialis quam expositis animalibus tum vivis, tum fossilibus potissimum rossiae in universum, et poloniae in specie, in usum lectionum: Vilna, v. 1, p. 192, 193, tab. II, figs. 9–13.

—— 1860, Lethea Rossica; ou, Paléontologie de la Russie: Stuttgart, v. 1, p. 505–508.

Etheridge, Robert, 1878, Paleontology of the coasts of the Arctic lands: Geol. Soc. London, Quart. Jour., v. 34, p. 583, pl. 28, figs. 1, 2.

—— 1898, Halysites in New South Wales: Sydney. Australian Museum, Records, v. 3, p. 78–80, pl. 17.

—— 1904, Monograph of the Silurian and Devonian corals of New South Wales, Pt. 1, The genus *Halysites:* v. 13, Geol. Survey New South Wales, Paleontology, p. 1–39, pls. 1–9.

Fischer-Benzon, R. J. D. von, 1871, Mikroskopische Untersuchungen über die Structur der Halysites-Arten und einiger silurischer Gesteine aus den russischen Ostsee-Provinzen: Abh. Gebeite der Naturw. Ver. Hamburg, Band V, Abth. 2, Taf. 1–3.

Fischer von Waldheim, Gotthelf, 1813, Zoognosia tabulis synopticus illustrata: Moscow. Editio tertia, v. 1, p. 387.

—— 1828, Notice sur les polypiers tubipores fossiles: Moscow, p. 15–19.

Foerste, A. F., 1890, Notes on Clinton group fossils: Boston Soc. Nat. Hist., v. 24, p. 337, 338.

[Gl]editsch, J. G., 1765, Nachricht von einigen churmarkischen versteinerungen: Berlinisches Mag. Bd. 1, Stuck 3, p. 261–270, pls. i and ii.

Grabau, A. W., 1925, Summary of the faunas from the Sintan shale: Geol. Survey China, Bull., No. 7, p. 77.

Goldfuss, August, 1826–1833, Petrefacta Germaniae . . . Zwei Theile: Düsseldorf, p. 75, taf. 25, fig. 5.

Hall, James, 1843, Geology of New York. Part 4, comprising the survey of the fourth geological district: Albany, pl. 22, fig. 2.

—— 1851, Lower Silurian system; Upper Silurian and Devonian series. *In* Foster, J. W., and Whitney, J. D., Report on the geology of the Lake Superior land district, pt. 2: U. S., 32d Cong. Spec. Sess., S. Ex. Doc. 4, p. 212, pl. 29, fig. 1.

—— 1852, Descriptions of the organic remains of the lower middle division of the New York system: Paleontology of New York, Pt. 6, v. 2, p. 127–129, pl. 35.

Hill, Dorothy, 1952, The Ordovician corals: Royal Soc. of Queensland, Proc., v. 62.

Hoffmeister, J. E., 1926, The species problem in corals: Am. Jour. Sci. (5), v. 12, p. 151–156.

Kiaer, J. A., 1929, Den fossilforende ordovicisk-siluriske lagrekke pa Stord: Bergens Museums Arbok, H. 2, p. 50, 51, pl. 1, figs. 5–7.

Koch, Gottlieb von, 1883, Die Ungeschlechtlige Vermehrung der Paleozoischen Korallen: Paleontographica, Bd. 29.

Lamarck, J. B. P. A. de Monet de, 1816, Histoire naturelle des animaux sans vertebres, v. 2, p. 206.

Lambe, L. M., 1899, A revision of the genera and species of Canadian Paleozoic corals: Geol. Survey Canada, Contrib. Canadian Paleontology, v. 4 (1), p. 69–77, pl. 4.

—— 1906, Notes on the fossil corals collected by Mr. A. P. Low at Beechey Island, Southampton Island, and Cape Chidley in 1904: Cruise of the Neptune, p. 322–328.

Lang, W. D., and Smith, Stanley, 1937, On the coral genus *Fungites:* Ann. Mag. Nat. Hist. (10), v. 19, p. 617–619.

—— —— and Thomas, H. D., 1940, Index of Paleozoic coral genera: London. British Museum (Nat. Hist.).

Leith, E. I., 1944, *Halysites gracilis* from the Ordovician of Manitoba: Jour. Paleontology, v. 18, p. 268–270, pls. 42, 43.

Lindström, Gustaf, 1873, Nagra anteckningar om Anthozoa tabulata: Ofvers Kingl. Vetensk.-Akad. Förh., Bind 30 (4).

Linnaeus, Carolus, 1767, Systema Naturae: Ed. 12, p. 1270.

Ludwig, R., 1865–1866, Corallen aus palaolithischen formationen: Paleontographica, v. 14, p. 236.

Milne-Edwards, Henri, and Haime, Jules, 1849, Memoire sur les polypiers appartenant aux groupes naturels des Zoanthaires perfores et des Zoanthaires tabules: Compte Rendu, Acad. Sci., Paris, v. 29.

—— 1852, A monograph of the British fossil corals: Paleontographical Soc., London.

Newell, N. D., 1948, Infraspecific categories in invertebrate paleontology: Jour. Paleontology, v. 22, p. 225–232.

NICHOLSON, H. A., 1879, Tabulate corals of the paleozoic period: Manual of paleontology, 2d ed., Edinburgh.

NORTHROP, S. A., 1939, Paleontology and stratigraphy of the Silurian rocks of the Port Daniel Black Cape region, Gaspé: Geol. Soc. America, Special Paper 21.

OKULITCH, V. J., 1935, *Tetradidae*—a revision of the genus *Tetradium:* Royal Soc. Canada, Trans., ser. 3, v. 29.

OWEN, RICHARD [American], 1862, Report of a geological reconnaissance of Indiana made during the years 1859 and 1860: Geol. Survey of Indiana, v. 16, appendix, p. 362.

PIVETEAU, JEAN (editor), 1952, Traité de Paléontologie: v. 1, Paris. Masson and Cie.

POCTA, FILIP, 1902, Anthozoaires et Alcyonaires. *In* Barrande, Joachim, Systeme Silurian de centre de la Boheme: Paris, v. 7.

ROMINGER, C. L., 1876, Paleontology. Fossil corals: Rept. Geol. Survey of Michigan, Lower peninsula 1873–1876, v. 3, pt. 2, p. 78, 79, pl. 29.

ROY, S. K., 1941, The Upper Ordovician fauna of Frobischer Bay: Chicago. Field Museum of Nat. Hist., Mem., v. 2, p. 77, 78, 79.

SCHMIDT, FRIEDRICH, 1861, Untersuchungen uber die Silurischen Formation von Ehstland, Nord-Livland und Oesel: Archiv. Naturkunde Liv. Ehst und Kurlands, ser. 1, Bd. 2, p. 229.

SHIMIZU, SABURO, OZAKI, KIN-EMON, and OBATA, TADAHIRO, 1934, Gotlandian deposits of northwest Korea: Shanghai Sci. Inst., Jour., sect. 2, v. 1, p. 77, 78, pls. 16–18.

SHIMER, H. W., and SHROCK, R. R., 1944, Index fossils of North America: New York. J. Wiley and Sons.

SWANN, D. H., 1947, The *Favosites alpenensis* lineage in the Middle Devonian traverse group of Michigan: Univ. Michigan Museum of Paleontology, Contr., v. 6.

TCHERNYCHEV, B. B., 1937, The Upper Silurian and Devonian tabulata of Novaya Zemlya, Severnaya Zemlya and Taimyr: Arctic Inst. Leningrad, Trans., v. 91, p. 95–100.

—— 1938, The tabulata of Yaigach Island: Arctic Inst. Leningrad, Trans., v. 101, p. 128, 129.

TEICHERT, CURT, 1937, Ordovician and Silurian faunas of Arctic Canada: Rept. 5th Thule Exped. 1921–1924, v. 1, p. 57, 132–135, pls. 8–10.

THOMAS, H. D., and SMITH, STANLEY, 1954, The genus *Halysites* Fischer von Waldheim: Ann. and Mag. Nat. Hist., 7(12), p. 765–774, pls. xx–xxii.

TROOST, GERARD, 1840, Organic remains discovered in the state of Tennessee: Fifth Geol. Rept. to 23d General Assembly, Tennessee.

TOLL, EDUARD, 1889, Die paleozoischen versteinerung der neusiberischen insel Kotelny: Acad. Imp. Sci. St. Petersburg, Mem., ser. 7, t. 37, no. 3, p. 49, taf. 4, 5.

WHITEAVES, J. F., 1895, Revision of the fauna of the Guelph formation of Ontario: Geol. Survey Canada, v. 3, p. 48, 49.

WHITFIELD, R. P., 1882, Paleontology. Pt. 3, *in* Geol. of Wisconsin, Survey of 1873–1879, v. 4, p. 272, pl. 13.

—— 1899, List of fossils, types, and figured specimens used in the paleontological work of R. P. Whitfield, showing where they are probably to be found at the present time: New York Acad. Sci., Ann., v. 12, no. 8, p. 146.

—— 1900, Observations and descriptions of Arctic fossils: American Mus. Nat. Hist., Bull. 13, p. 20, pl. 2.

—— 1903, Observations on a remarkable specimen of *Halysites:* American Mus. Nat. Hist., Bull. 19, p. 490, pl. 42.

Wilson, A. E., 1926, An Upper Ordovician fauna from the Rocky Mountains, British Columbia: Canadian Dept. of Mines, Museum Bull. 44, p. 14, 15, pls. 1–3.

—— 1931, Notes on the Baffinland fossils collected by J. Dewey Soper during 1925 and 1929: Royal Society Canada, Trans., ser. 3, v. 25, sect. 4, p. 296, pl. 3.

Yabe, Hisakatsu, 1915, Einige bemerkungen uber *Halysites:* Tokyo Imo. Univ. Sci. Repts., Geology, v. 4, p. 25–38.

PLATES

PLATE 1

Fig. 1. *Halysites infundibuliformis* Buehler, n. sp. Specimen from Lockport dolomite (?), York, N. Y., showing shape of lacunae. Y.P.M. no. 19142. x 3. Photo loaned by Peabody Mus. Nat. Hist.

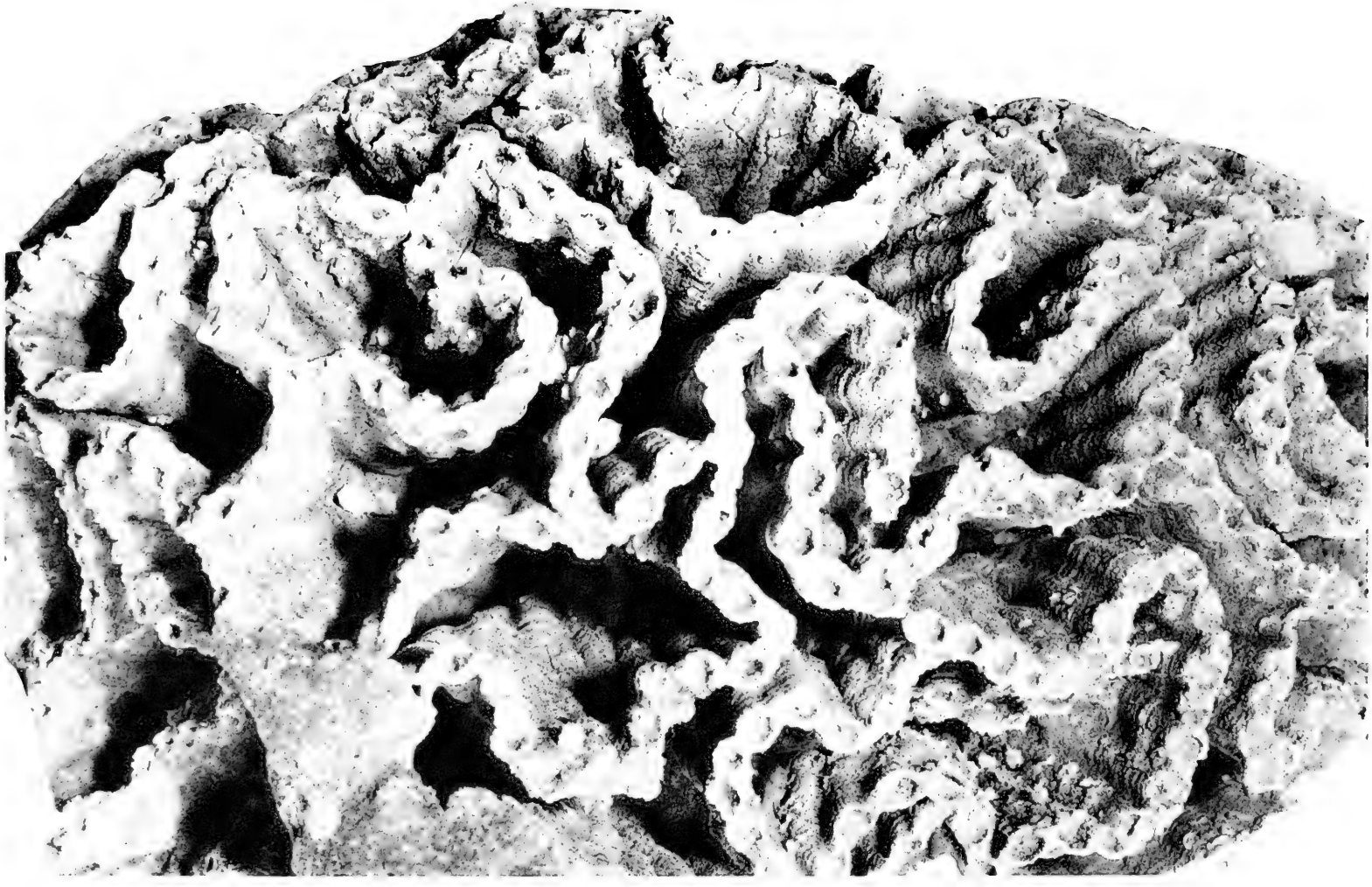


PLATE 2

Fig. 1. *Halysites infundibuliformis* Buehler, n. sp. Side view of specimen illustrated on Plate 1. Shows corallites radiating sharply from center of corallum. x 3.

PLATE 3

Figs. 1–5. *Halysites labyrinthica* (Goldfuss).

1. Top view of corallum showing shape of lacunae. From Silurian of Mackinac Co., Michigan. Buffalo Mus. Nat. Sci. no. E7748. x 1.
2. Bottom view of specimen illustrated in fig. 1, showing shape of lacunae. x 1.
3. Thin section from specimen illustrated in fig. 1, showing narrow connection between mescorallites. x 12.
4. Etched specimen from Fossil Hill formation (Lower Clinton), Manitoulin Island, Ont., Canada. Y.P.M. no. 19240. x 1.
5. Specimen from Silurian of Clarke Co., Indiana, showing interstitial increase. Y.P.M. no. 19239. x 1 2/3.

Fig. 6. *Halysites infundibuliformis* Buehler, n. sp. Thin section showing tabulae of autocorallites and mesocorallites. Y.P.M. no. 19142. x 9.

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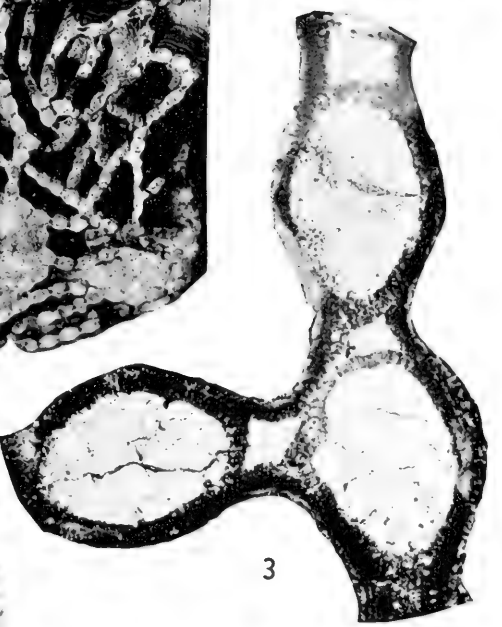

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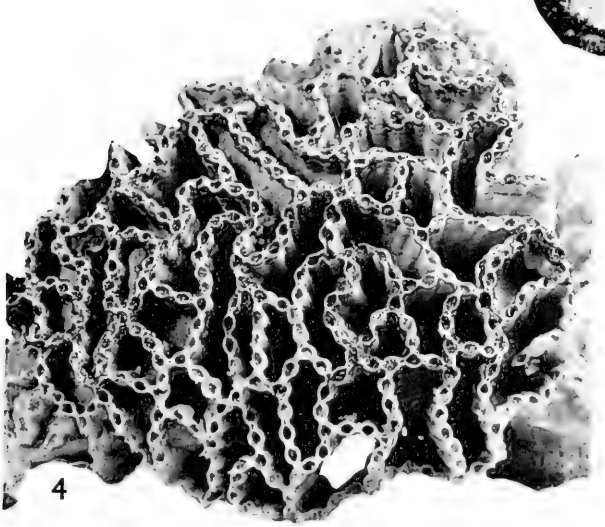

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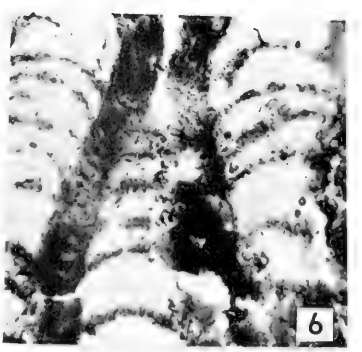

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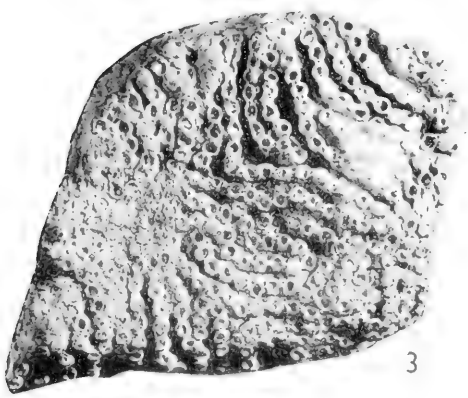

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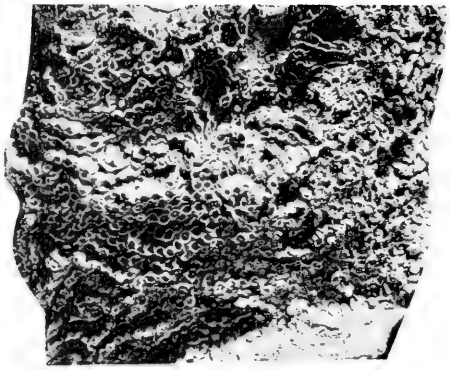

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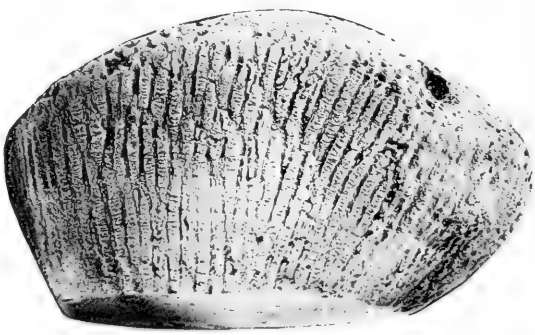

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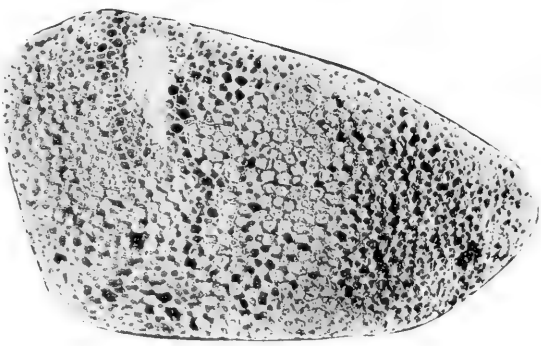

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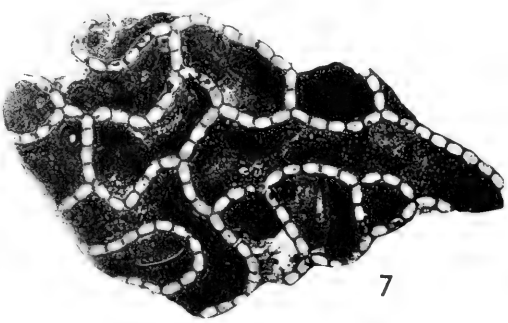

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PLATE 4

Fig. 1. *Halysites meandrina* (Troost).
Specimen from Lobelville formation, Short Creek, West Tennessee. Neotype. Y.P.M. no. 19237. x 1 1/2.

Figs. 2–4. *Halysites agglomerata* Hall.

2. Side view showing tabulae. Niagaran Age (?), Monroe Co., New York, Hall syntype. Am. Mus. Nat. Hist., no. 1690. x 1 1/3.
3. Top view of same specimen as fig. 2, showing shape of autocorallites. x 1.
4. Portion of larger corallum. Niagaran age (?), Monroe Co., New York. Lectotype chosen from Hall's syntypes. Am. Mus. Nat. Hist. no. 1690/2. x 4/5.

Figs. 5, 6. *Halysites compactus* Rominger.

5. Side view. From Epoufette Point, Mackinac Co., Michigan. Lectotype chosen from Rominger's syntypes. Univ. of Mich. Mus., no. 8543. x 1. Photo loaned by Univ. Mich. Mus.
6. Same as fig. 5. Top view. x 1.

Fig. 7. *Catenipora gracilis* (Hall).
Thin section of specimen from Selkirk limestone, Manitoba, Canada. Shows shape of autocorallites and absence of dimorphism. Y.P.M. no. 19238. x 1.

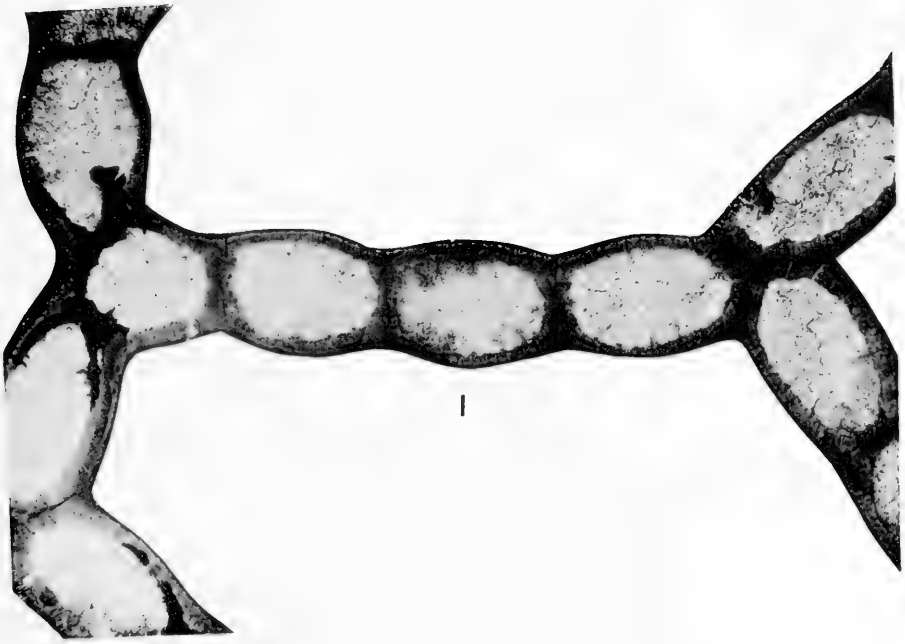
PLATE 5

Fig. 1. *Catenipora gracilis* (Hall).
Thin section of specimen illustrated on Plate 4, fig. 7. Note the delicate septal spines. x 10.

Figs. 2, 3. *Halysites compactus* Rominger.

2. Horizontal section of specimen illustrated on Plate 4, figs. 5 and 6. x 10.

3. Vertical section of specimen illustrated on Plate 4, figs. 5 and 6. x 10.



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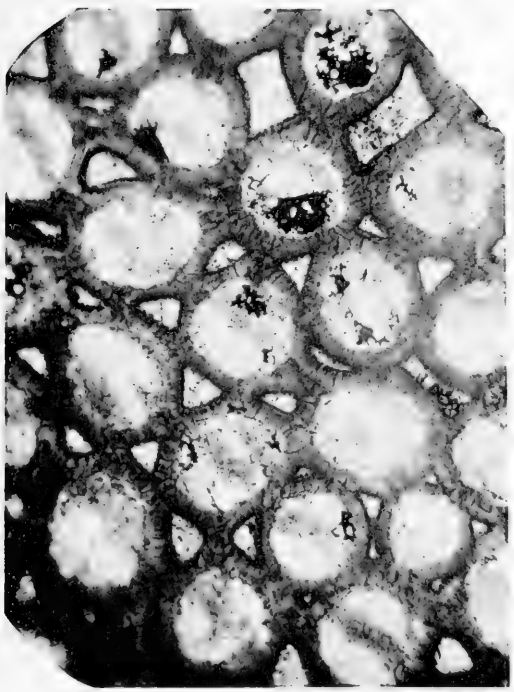

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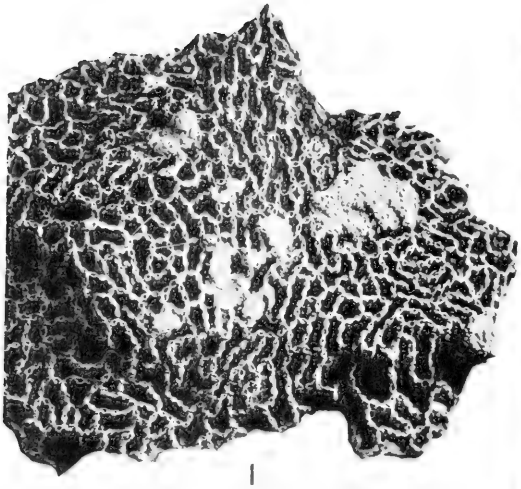

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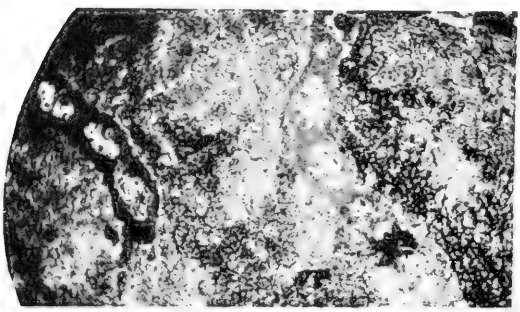

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PLATE 6

Figs. 1–5. *Catenipora microporus* (Whitfield).

1. Specimen of Niagaran age (probably from Louisville limestone), Louisville, Kentucky. Y.P.M. 19234. x 1.
2. Specimen from Fossil Hill formation (Lower Clinton), Manitoulin Island, Ont., Canada, showing shape of corallites. Y.P.M. no. 19235. x 1 3/4.
3. Thin section of specimen shown in figure 2. Specimen is badly silicified but shows septal structures. x 10.
4. Thin section of specimen from Jupiter River formation, Anticosti. Shows position of septal spines. Y.P.M. no. 19236. x 14.
5. Specimen from Louisville limestone, Beargrass quarry, Kentucky, weathered free, showing the appearance of the basal part of the colony and mode of growth. Y.P.M. no. 18668. x 5.

PLATE 7

Figs. 1–3. *Cantenipora quebecensis* (Lambe).

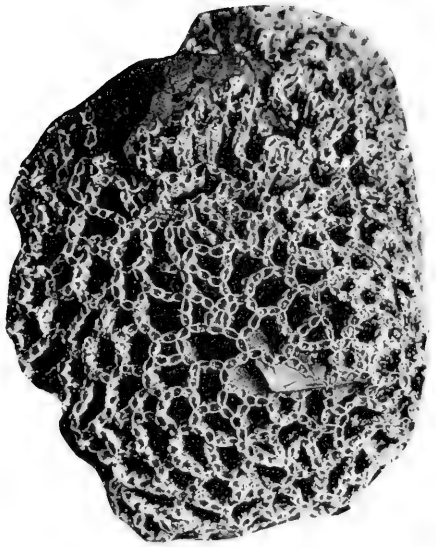
1. An etched specimen from the Middle Ordovician, north of Ste. Anne de Chicoutimi, Lake St. John area, P. Q., Canada. Specimen loaned by G. W. Sinclair. x 1.
2. Thin section of specimen from same locality as in figure 1. x 12.
3. Peel of a specimen from same locality as in figure 1. Shows how corallites radiate from fossil of an unidentified organism which serves as the base of the colony. x 1 1/2.

Figs. 4, 5. *Halysites nexus* Davis.

4. Top view of holotype. From Middle Silurian near Louisville, Kentucky. Harvard Mus. of Comp. Zool. no. 8785. Photo provided by Harvard Mus. of Comp. Zool. x 1.
5. Same as figure 4. Side view. x 1.

Fig. 6. *Catenipora simplex* (Lambe).

Side view of neotype. From La Vieille formation, Port Daniel, P. Q. Canada. Y.P.M. no. 19233. x 1.



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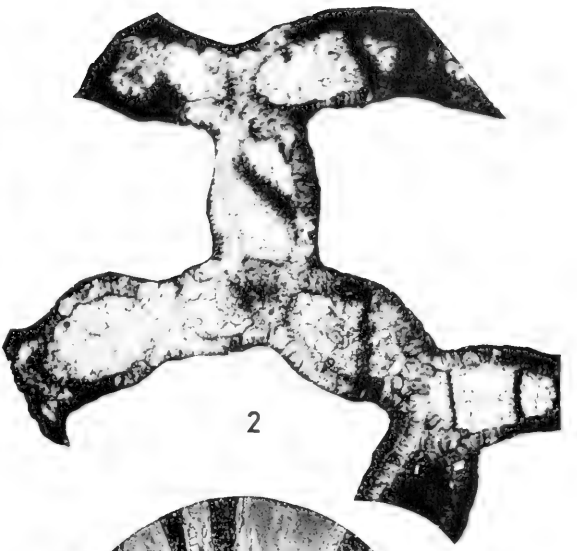

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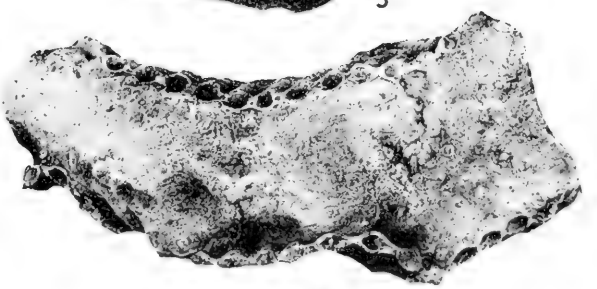

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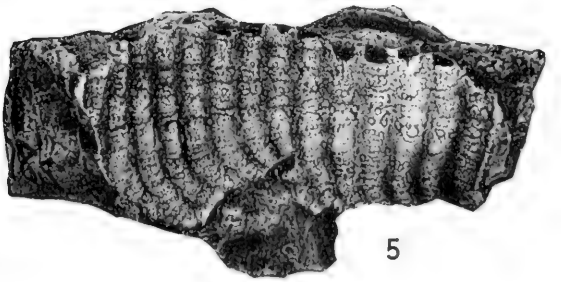

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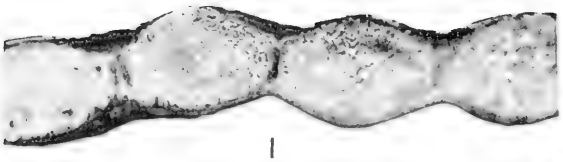

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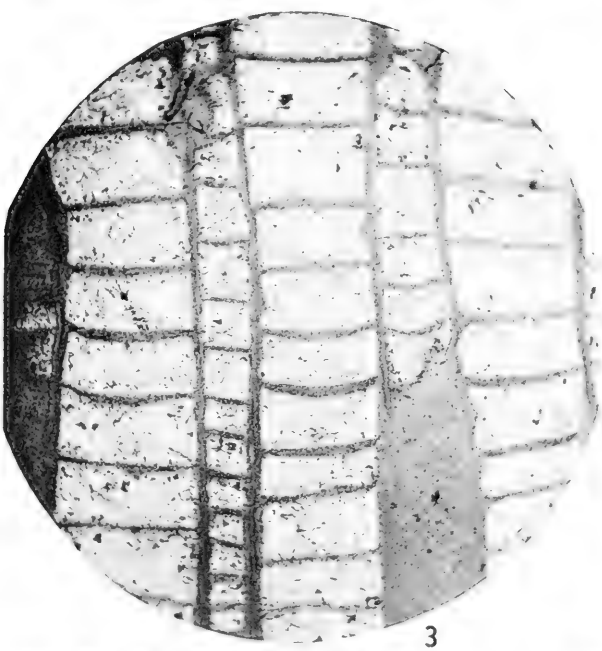

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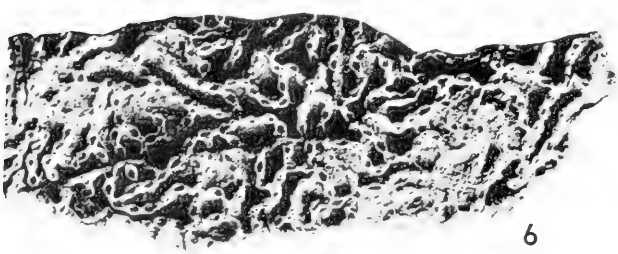

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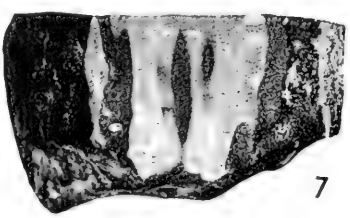

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PLATE 8

Fig. 1. *Catenipora simplex* (Lambe).
Thin section of specimen from La Vieille formation, 1/2 mi. E. of Gascons, P. Q., Canada. Y.P.M. no. 19230. x 6 1/2.

Figs. 2, 3. *Halysites amplitubata* Lambe.
2. Specimen from Middle Silurian of Anticosti. Note unusually large mesocorallites. Y.P.M. no. 19231. x 1.
3. A peel taken from specimen illustrated in figure 2. x 12.

Figs. 4–7. *Halysites nitida* Lambe.
4. Large corallum from Gascons formation, Gascons, P. Q., Canada. Y.P.M. no. 19232. x 1/2.
5. Portion of figure 4. x 1.
6. Top view of holotype. Geol. Survey of Canada no. 104761. Photo provided by Geol. Survey of Canada. x 1.
7. Same as figure 6. Vertical section. x 2.

PLATE 9

Fig. 1. *Halysites nitida* Lambe.
Thin section of specimen attached to substratum. From Chaleur series, Black Cape, P. Q., Canada. Y.P.M. no. 19228. x 2 1/2.

Figs. 2, 3. *Halysites* sp.

2. Shows arrangement of lacunae in rosettes. Internal structures obliterated by silicification. From drift, Erie Co., New York. Y.P.M. no. 19229. x 1/2.

3. Portion of fig. 2. x 1.

Figs. 4, 5. *Halysites brownsportensis* Amsden.

4. Thin section of specimen from Brownsport formation of western Tennessee. Shows tabulae of autocorallites and mesocorallites. x 10.

5. A peel of specimen from Brownsport formation of western Tennessee showing two-layered wall structure and a large mesocorallite. x 12.

Fig. 6. *Halysites* cf. *brownsportensis* Amsden.
Specimen from Chaleur series, Black Cape, P. Q., Canada. A peel showing interstitial increase. x 10.

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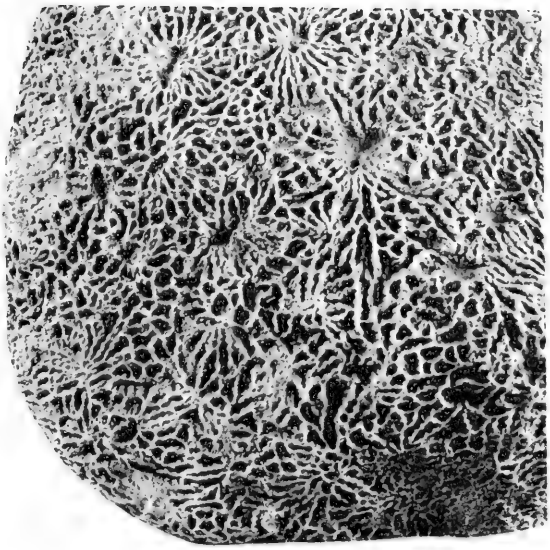

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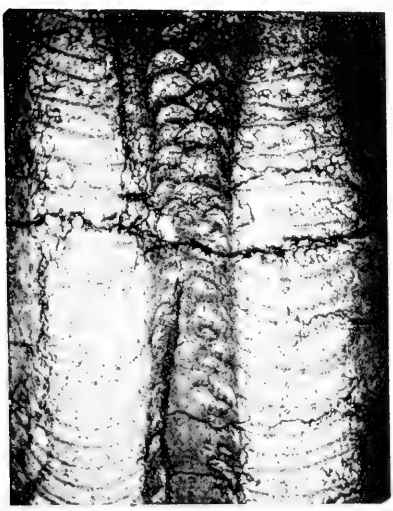

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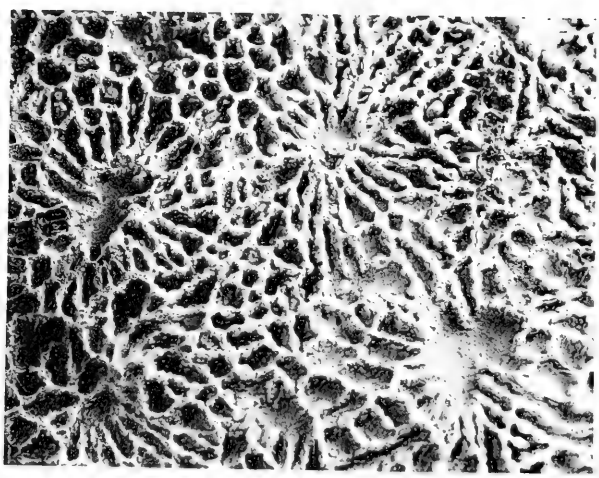

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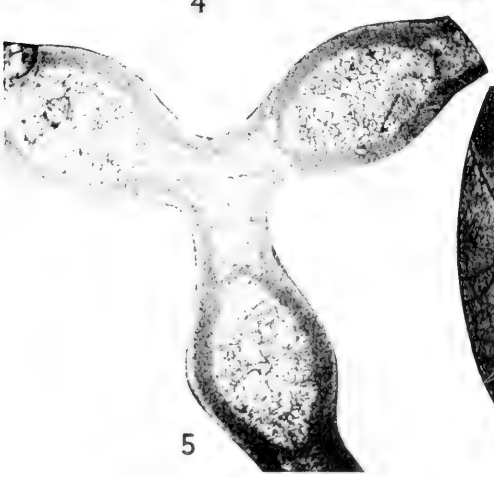

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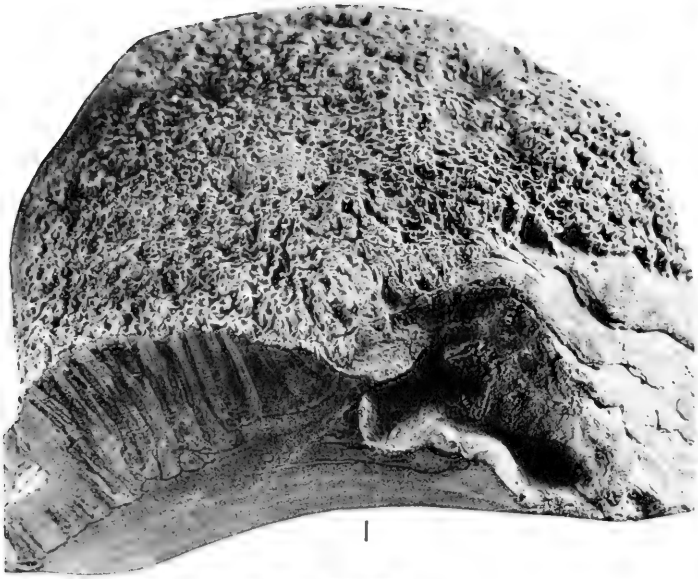

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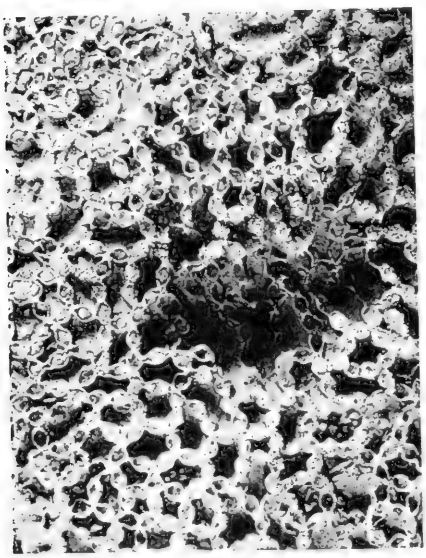

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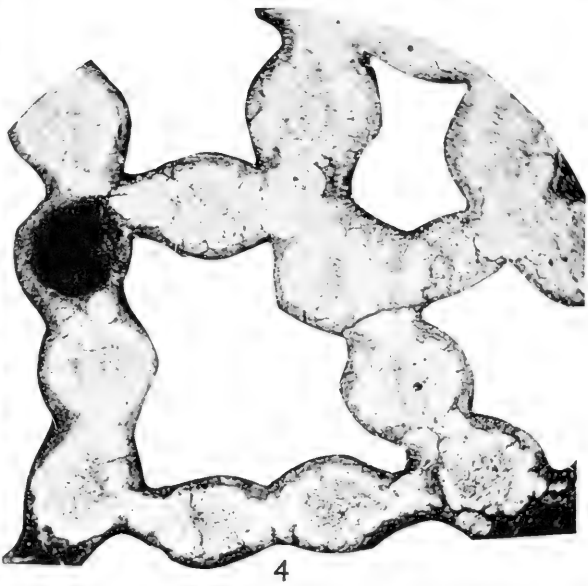

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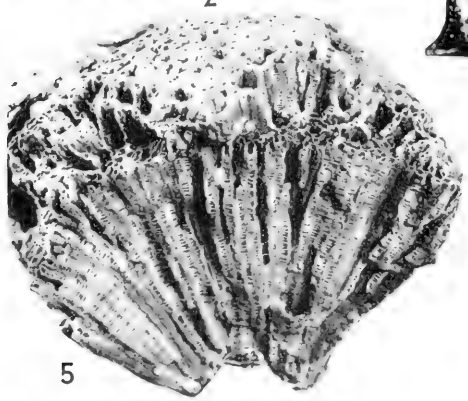

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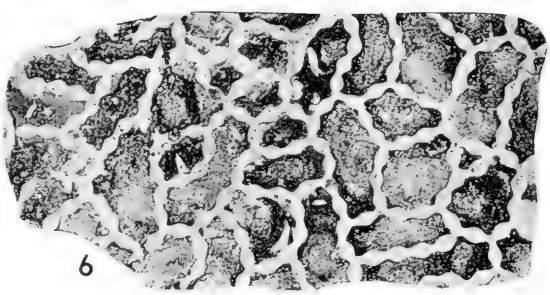

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PLATE 10

Figs. 1–5. *Halysites encrustans* Buehler, n. sp.

1. Corallum attached to *Clathrodictyon vesiculosum*. La Vieille formation, Port Daniel, P. Q. Canada. Holotype. Y.P.M. no. 7235. x 1.
2. Portion of figure 1, showing shape of corallites and lacunae. x 2.
3. Vertical section taken from holotype. x 12.
4. Cross section taken from holotype. x 12.
5. Corallum with corallites radiating from a small base. From Silurian of Chicotte cliffs, Anticosti. Y.P.M. no. 19227. x 3/5.

Fig. 6. *Halysites brownsportensis* Amsden.
A peel of a specimen from the Brownsport formation of western Tennessee. x 1.

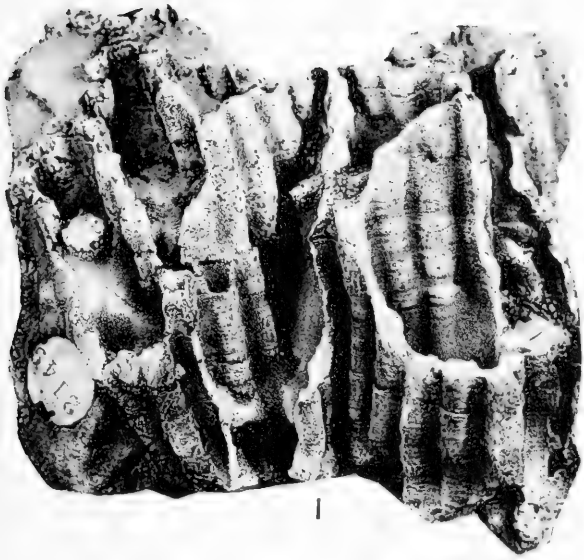
PLATE 11

Figs. 1–3. *Halysites magnitubus* Buehler, **n. sp.**

1. From Silurian of Gold Hill quadrangle, Utah. Holotype. U. S. Nat. Mus. no. 123428. x 1.
2. Top view of figure 1. x 1.
3. Vertical section taken from holotype. Shows both autocorallites and mesocorallites. x 9.

Fig. 4. *Halysites* sp.
Vertical section of unidentified specimen from Wenlock of Dudley, England, showing depth of calyx and a few septal spines. Y.P.M. no. 18664. x 12.

Fig. 5. *Catenipora* cf. *escharoides* Lamark.
Peel of specimen from Visby, Gotland, showing pseudocolumella. Y.P.M. no. 19226. x 12.



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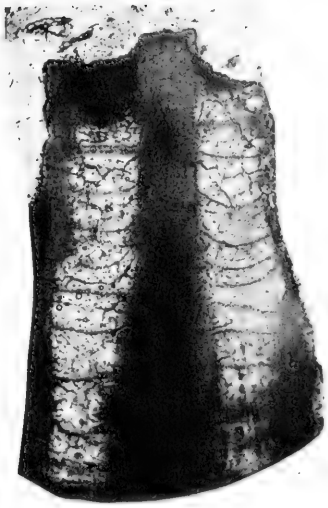

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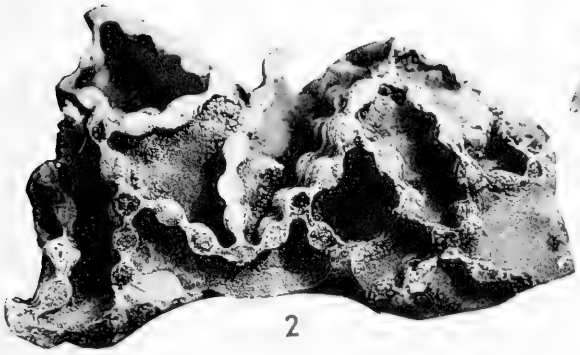

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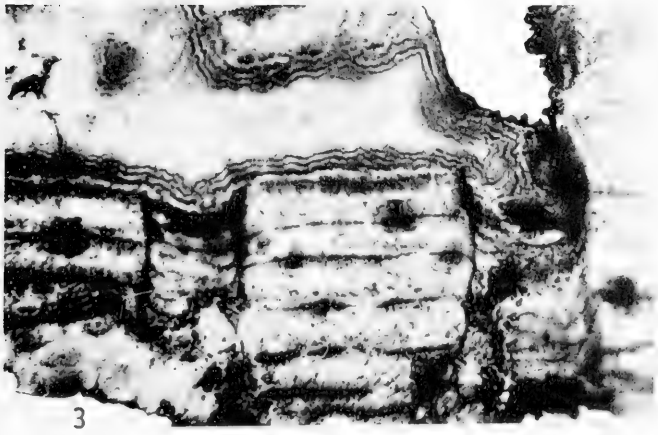

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PLATE 12

Fig. 1. *Halysites* sp.
Specimen from Wenlock of Dudley, England, showing undamaged calyces. Y.P.M. 18664. x 5.

Fig. 2. *Halysites* sp.
From Silurian of Death Valley, California. Shows formation of ranks. Specimen loaned by D. V. Garston. x 7.

Fig. 3. *Halysites* sp.
Shows fine growth lines and addition of new corallites. From Tofta Parish, Gotland. Y.P.M. no. 18665. x 5.

Fig. 4. *Halysites* sp.
Shows fine growth lines. From Tofta Parish, Gotland. Y.P.M. no. 18666. x 5.

Fig. 5. *Catenipora microporus* (Whitfield).
Shows formation of a rank. From Louisville limestone, near Louisville, Kentucky. Y.P.M. no. 18668. x 5.

INDEX

* Indicates page on which genus and species is described.