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Charles D. and Mary Vaux Walcott Research Fund

A REVISION OF THE SILURIAN BRYOZOAN GENUS TREMATOPORA

(WITH 2 PLATES)

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Associate Curator of Geology
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INTRODUCTION

The genus *Trematopora* Hall, 1851, is placed in the order Trepostomata of the Bryozoa and is the type genus of the family Trematoporidae Ulrich in Miller, 1889. The type species of *Trematopora* is *T. tuberculosa* Hall, 1852, from the Rochester shale in New York (type by subsequent designation, Ulrich, 1882, p. 241).

The name *Trematopora* was established in an article by the editors of the American Journal of Science and Arts (Hall, 1851, p. 400) in which parts of Hall's manuscript for volume 2 of the Paleontology of New York (1852) were quoted. The species of *Trematopora* listed following the diagnosis of the genus were *nomina nuda* and were not published by Hall until the next year in volume 2.

The development of the generic concept of *Trematopora* has been controlled partly by the study and preparation techniques employed by the various authors, each advance in technique adding refinements to the original very generalized description. All the work of Hall and Hall and Simpson (1851-1887) was done on external characters without the use of thin sections. In fact, Hall's primary types of the type species were sectioned for the first time for the present paper. Owing in part to the external homeomorphy common in the Trepostomata, Hall included in the genus many forms now placed in other genera, families, and orders. At various times Hall considered such diverse genera as *Trematella* Hall, *Orthopora* Hall, *Chaetetes* Fischer (part), and *Callopora* Hall (part), as subgenera of *Trematopora*.

Ulrich (1883, p. 257) was the first to section some "authentic specimens of *Trematopora tuberculosa* Hall." These sections are in the

U. S. National Museum collections and are conspecific with Hall's primary types of the species. After seeing the sections, Ulrich greatly restricted the concept of the genus and indicated the great range of forms that Hall had included in the genus. The concept established by Ulrich in 1883 has remained essentially unchanged to the present time and was the type-genus concept for the family Trematoporidae in 1889. Under Ulrich's definition of the genus, 12 species and subspecies have been assigned to *Trematopora,* ranging in age from Middle Ordovician through Middle Silurian.

The primary type specimens were made available for sectioning and study by N. D. Newell of the American Museum of Natural History. Helpful suggestions were made by Helen Duncan and W. A. Oliver, Jr., of the U. S. Geological Survey, and N. Spjeldnaes, of the University of Oslo. Thin sections were prepared by T. M. Robison of the U. S. Geological Survey. Photography was done by J. Scott, and the text figure was drawn by L. B. Isham, both of the Department of Geology of the U. S. National Museum.

INTERPRETATION OF SKELETAL MICROSTRUCTURE

The skeletal structures of most trepostomatous Bryozoa are composed of finely laminated calcite (fig. 1 and pl. 2). These laminae are assumed to have been deposited parallel to the surface of the secreting tissue (Cumings and Galloway, 1915, p. 361). Therefore, trends of the laminae within skeletal structures such as walls and diaphragms are considered to reveal something of the disposition of the original secreting tissue and the mode of growth of the skeletal structures.

In longitudinal thin sections of *T. tuberculosa,* laminae are commonly oriented parallel to the zooecial walls (fig. 1) in the endozone (immature or axial region of authors) and to the thinner walls and mesopore diaphragms in the inner region of the exozone (mature region of authors). This type of microstructure is here designated longitudinally laminated structure. Such an orientation of laminae is assumed to indicate that the depositing tissue was parallel to the walls and diaphragms, but it does not indicate whether the laminae were deposited on one or both sides of the structures.

Another type of structure is characterized by laminae that are curved or angled transversely to the walls and diaphragms as seen in longitudinal sections. The transverse laminae form V- or U-shaped patterns with apices pointing distally and aligned along the median line of a wall or diaphragm. This type of microstructure is here designated transversely laminated structure. In *T. tuberculosa,* this structure is found in the walls of zooecia and mesopores in the outer region of the exozone, and in the inner region in some of the thicker mesopore walls and in the vicinity of central pores in the mesopore diaphragms (fig. 1).

Assuming that secreting tissue was oriented parallel to the laminae, transversely laminated structure indicates that the tissue must have been wrapped around the growing edges of walls and diaphragms

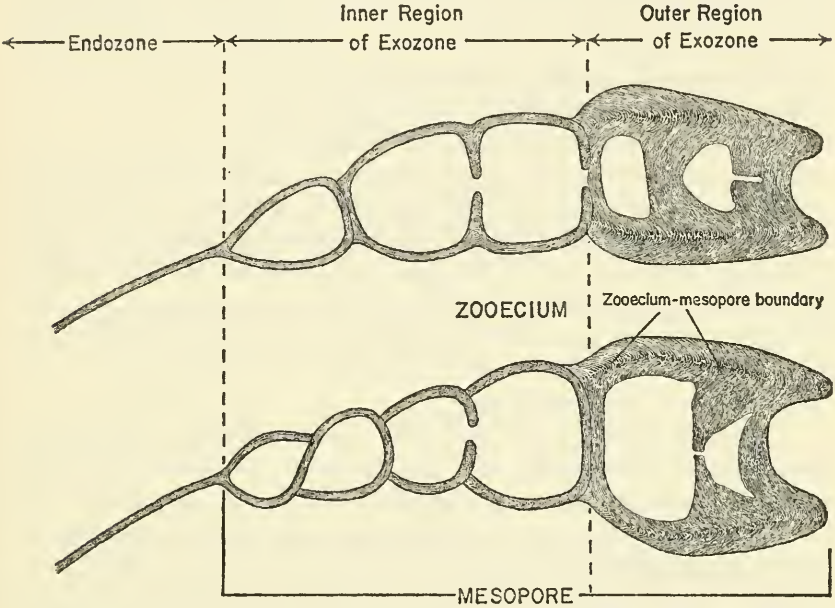

FIG. 1.—Idealized diagram of *T. tuberculosa* in longitudinal view illustrating the variety of laminated structures commonly occurring in the species. Two mesopores and an intervening zooecium are shown in profile. Few central pores of the mesopore diaphragms are intersected in a longitudinal section.

on both sides of the median lines. Thus, transversely laminated structure presumably indicates deposition from both sides of a wall or diaphragm.

Such interpretations applied to the skeletal laminae of *T. tuberculosa* and correlated with other morphologic characteristics of the species suggest that the exozone is divisible into two parts, an inner and an outer region (fig. 1) based on fundamentally different modes of growth of the mesopores. The physiologic significance of the two modes of growth is a matter for speculation. The taxonomic significance of these characters must await comparable studies in related genera.

In the inner region of the exozone, the mesopores are beaded (series of rounded chambers). This beading is produced by the mesopore walls curving transversely to the axis of the mesopore to form a diaphragm. The succession of longitudinally and transversely laminated structures along the walls and diaphragms is interpreted to indicate deposition from both sides of longitudinal as well as transverse structure throughout the inner region. Thus, at least a part of the depositing tissue of the mesopore remained behind the diaphragm and within the chamber being formed. The pore in the center of the mesopore diaphragm presumably would be necessary to allow the soft parts within the chamber to communicate with the outside environment. There is no indication as to whether the soft parts in the mesopores during the formation of the inner region consisted of anything more than a depositing tissue or mantle, but the distal diaphragm would have acted, temporarily at least, as a covering for any soft parts within the last chamber. Continuity of laminae from the distal side of a diaphragm to the wall of the succeeding mesopore chamber implies that at least the proximal part of the chamber was formed as the diaphragm developed (see middle diaphragm of the inner region in the upper mesopore of figure 1). For a more complete discussion of figure 1 see species description.

The thick-walled outer region of the exozone contains transversely laminated structure in the walls of zooecia and mesopores and longitudinally laminated structure in the thick diaphragms. The mesopores in this region are not beaded. The pattern of continuity of the laminae of walls and adjoining diaphragms (fig. 1) indicates deposition was limited to the outer surface of the walls and diaphragms, contemporaneous deposition of laminae taking place on the outermost surfaces of the zooecial wall, around the median line or boundary to the mesopore wall, and back to the distal side of the diaphragm. There is no evidence that deposition occurred on the proximal side of the diaphragm within the mesopore chamber.

The formation of the diaphragms in the inner and outer regions of the exozone is quite different. Diaphragms in the inner region were formed by continued distal growth of mesopore walls that merely curved through an angle of 90 degrees to form transverse structures. Diaphragms in the outer region were formed by an additional, transversely oriented sheet of depositing tissue that was continuous with at least the depositing tissue of the mesopore side of the walls and actively deposited calcite at the same time that the mesopore walls were being formed. This transverse sheet of tissue apparently had no counterpart in the inner region of the exozone.

Evidence concerning the position of the soft parts in the outer region of the mesopore is inadequate. Configurations of the laminae give no indications of deposition behind the distalmost diaphragm. The common occurrence of single, centrally located pores that either partly or completely penetrate the thick outer diaphragms suggest some activity within outer chambers. The majority of these central pores appear to have been cut through the laminae of the diaphragms. Their termination within outermost diaphragms suggests that activity within the outermost chambers might have been choked off by the growth of the thickened diaphragms.

SYSTEMATIC DESCRIPTION

Genus TREMATOPORA Hall, 1851

1851. *Trematopora* Hall, Amer. Journ. Sci. and Arts, ser. 2, vol. 11, p. 400.
1852. *Trematopora* Hall, Paleontology of New York, vol. 2, p. 149.
1881. *Trematopora* Hall, Nicholson, Genus *Monticulipora,* pp. 232-234.
1882. *Trematopora* Hall, Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, p. 241.
1883. *Trematopora* Hall, Ulrich, Journ. Cincinnati Soc. Nat Hist., vol. 6, p. 257.
1887. *Trematopora* Hall, Hall and Simpson, Paleontology of New York, vol. 6, p. xiv.
1893. *Trematopora* Hall, Ulrich, Geol. Minnesota, vol. 3, pt. 1, p. 308.
1911. *Trematopora* Hall, Bassler, U. S. Nat. Mus. Bull. 77, pp. 267, 268.
1882. [non] *Trematopora* Hall, Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, p. 153.

Type species.—Trematopora tuberculosa Hall, 1852.

Emended definition.—Zoaria are ramose, conspecific overgrowth is common, and monticules range from level to tuberculated. Externally, zooecia are elliptical to subcircular in cross section and walls are slightly elevated above intervening mesopores. Mesopores form shallow, subpolygonal depressions between zooecia.

The exozone is divided into an inner thin-walled region containing the earliest chambers of the mesopores and an outer thick-walled region. In the inner region, both mesopores and zooecia are polygonal to subpolygonal in cross section and mesopores are beaded and contain diaphragms with single central pores. In the outer region of the exozone, zooecia become elliptical to subcircular in cross section and the mesopores contain thickened diaphragms and are not beaded. Diaphragms are thin and few in zooecia.

In the outer region of the exozone, walls of adjacent zooecia are divided by sharply defined zooecial boundaries, as seen in longitudinal sections. Laminae on either side of a boundary converge to form a

V-shaped pattern that has extremely long limbs trending nearly parallel to the boundary and curving very slightly just before the boundary is intersected. Laminae of walls of zooecia and adjacent mesopores are more broadly curved approaching the median boundary and form a broad U-shaped pattern having limbs of varying lengths. Acanthopores are common in the zooecial walls.

Discussion.—Based on an examination of thin sections of primary types of species previously assigned to *Trematopora* now in the U. S. National Museum collections, the following species are considered correctly assigned to the genus:

T. halli Ulrich 1883, Niagaran group, Waldron, Ind.
T. whitfieldi Ulrich 1883, Niagaran group, Waldron, Ind.

The holotype section of *T. spiculata* Miller 1877, Niagaran group, Waldron, Ind., is not adequate to determine generic affinities. This species is retained in the genus until a more detailed study of additional material can be made.

The following species originally placed in *Trematopora* do not satisfy the generic definition proposed here and are not considered to belong to the genus. Their proper generic assignments must await restudy of both the species themselves and the available genera.

calloporoides Ulrich 1890, Cincinnati group, Alexander County, Ill.

cystata Bassler 1911, Kuckers shale (C2), Reval, Esthonia. This species is the type of *Aostipora* Vinassa 1920).

debilis Ulrich 1890, Girardeau limestone, Alexander County, Ill.

kukersiana Bassler 1911, Kuckers shale (C2), Reval, Esthonia.

primigenia Ulrich 1886, Decorah shale, Minneapolis, Minn.

primigenia var. *ornata* Ulrich 1886, Decorah shale, Minneapolis, Minn.

None of the Ordovician species investigated displayed the two regions of the exozone or pores in the mesopore diaphragms. Thus, the genus is limited presently to the Middle Silurian.

A close taxonomic relationship seems to exist between *Trematopora* and some or all of the Silurian and Devonian species that have been placed in the genus *Leioclema* Ulrich. These species of *Leioclema* are largely incrusting and possess many of the morphologic characters now defining *Trematopora*. In general they have elliptical zooecia with few thin diaphragms, abundant mesopores with closely spaced thicker diaphragms and an irregularly discontinuous inner region of the exozone containing beaded mesopores. Pores in the diaphragms of the mesopores are rare but do definitely occur in the following species.

Leioclema asperum (Hall) 1852, Rochester shale, Lockport, N. Y. (Only Bassler's plesiotypes of 1906 available.)
L. confertiporum (Hall) 1883, Hamilton group, New York.
L. decipiens (Hall) 1883, Hamilton group, New York.
L. passitabulatum Duncan 1939, Traverse group, Michigan.

The region now considered to be the inner region of the exozone in species of *Leioclema* from the Hamilton group of New York was interpreted as the outer part of the endozone (Boardman, in press) and diaphragm pores were overlooked.

TREMATOPORA TUBERCULOSA Hall

Pl. 1, figs. 1-4; pl. 2, figs. 1-3

1852. *Trematopora tuberculosa* Hall, Paleontology of New York, vol. 2, p. 149, pl. 40A, figs. 1a-g.
1883. *Trematopora tuberculosa* Hall, Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 6, p. 259, pl. 13, figs. 2, 2a, 2b.
1906. *Trematopora tuberculosa* Hall, Bassler, U. S. Geol. Surv. Bull. No. 292, p. 43, pl. 13, figs. 15, 16; pl. 17, figs. 1-3; pl. 25, fig. 8.

TYPE DATA

Lectotype (Hall, 1852, pl. 40A, fig. 1a) and the two paratype zoaria from syntype suite No. 1747, American Museum of Natural History.

MATERIAL STUDIED

In addition to the primary types, 55 fragmentary topotype zoaria were studied. The topotypes are from U. S. National Museum collection No. 2998 and cat. No. 43618 collected by E. O. Ulrich. U. S. National Museum catalogue numbers of illustrated topotypes are 137847 to 137850.

OCCURRENCE

Rochester shale member of the Clinton formation, Lockport, N. Y.

DESCRIPTION

Zoaria.—Zoaria are ramose and branches are circular to elliptical in cross section. Branch arrangement was affected by branches rising from conspecific secondary growth superimposed on the normal bifurcating pattern. Branches of secondary growth produced irregularities in branch arrangement, commonly causing branches to anastomose and form erratic and confused zooecial growth at surfaces of contact. These irregularities in branch arrangement were formed by random bends at ramose extensions of overgrowths beyond the distal tips of primary branches, and irregular branch angles in lateral secondary branches. The zoaria were further complicated by repetitions of thin- and thick-walled growth in the outer region of the exozone (mature region) without the formation of intervening basal laminae. This apparently rejuvenated growth formed localized swellings on the zoaria, and combined with adjacent patches of overgrowth to form some of the secondary branches.

Monticules.—Monticules are prominent tubercles. The apertures of some monticular zooecia are restricted or closed by a distal thickening of the walls, and the walls and outer diaphragms of monticular mesopores are somewhat thicker than those of surrounding mesopores. Monticular mesopores generally contain one to several more diaphragms than intermonticular mesopores.

Longitudinal View: *Endozone.*—In the endozone (immature or axial region), zooecial walls are longitudinally laminated and do not show the dark granularity that is common in the Trepostomata. The zooecial walls range from undeviating to irregularly undulating. In a few specimens the endozone is interrupted by a zone arching distally across the branch that is marked by variable thickening of the zooecial walls. Normal thin-walled zooecial growth generally continues distally from the thickened walls of the arched zones with some bifurcating but without other break. At apparently random levels within a colony, some or all of the zooecia within the endozone have been eroded and the tubes filled with mud. Subsequent growth was initiated from adjacent zooecia and the eroded areas were covered by a basal lamination of the overgrowth that continued the colony distally.

Exozone: Inner region of mesopores.—The boundary between the endozone and exozone is defined by the points of origin of the mesopores. The inner region of the exozone extends distally for one to several mesopore diaphragms, but generally not more than four. The mesopores begin proximally with walls and diaphragms that are slightly thicker than the zooecial walls of the endozone. Mesopore walls curve broadly through 90 degrees into transverse positions relative to the length of the mesopores, thereby forming diaphragms. The broad curving results in constrictions of the mesopores at the positions of the diaphragms to form cystlike chambers. In this inner region of the exozone, mesopore walls commonly are longitudinally laminated, but many, especially the thicker ones, develop transversely laminated structure, either intermittently or throughout their length.

In the inner region, mesopore diaphragms regularly display centrally located single pores that penetrate the diaphragms at right angles. In longitudinal thin sections that pass through these pores, diaphragms display transversely curved laminae that continue uninterrupted to the pores. The curved laminae immediately adjacent to the pores define the rounded boundaries of the pores.

If walls of adjacent mesopore chambers are longitudinally laminated, generally the wall of the earlier chamber is connected directly with the curved laminae on the proximal side of the intervening diaphragm and the wall of the later chamber is connected with the distal side of the diaphragm. If walls of adjacent mesopore chambers are formed by transversely curved laminae, the diaphragm and adjacent walls will appear to be a continuous unit, or the diaphragm is a direct continuation of the proximal wall and the wall of the distal chamber is discordantly joined to the distal side of the diaphragm. Rare, isolated mesopore diaphragms display complete continuity with the walls of distal chambers.

In longitudinal thin sections, mesopore diaphragms in which the pores were not intersected appear longitudinally laminated. Commonly the diaphragms are compound; the proximal half of a diaphragm is continuous with the wall of the preceding mesopore chamber, the distal half is continuous with the wall of the succeeding chamber. Other variations in diaphragm-wall relationships are less common; the two parts of the compound diaphragm can be unequal in thickness, or in extreme development a diaphragm loses its compound appearance and is wholly continuous with the preceding or very rarely the succeeding chamber walls throughout or at either end.

Outer region of mesopores.—In the outer region of the exozone, mesopores are not beaded and the walls and diaphragms display extreme thickening. This greatly thickened skeletal growth can begin on the distal side of the last thin diaphragm, the laminae covering the central pore of the thinner diaphragm and curving distally into the mesopore walls, or it can begin by an abrupt thickening of the mesopore walls. Diaphragms in this outer region are extremely variable in thickness and spacing. A single diaphragm, greater in thickness than the diameter of the enclosing mesopore, can correspond in thickness and position with a series of irregularly and closely spaced diaphragms in adjacent mesopores. Most diaphragms are planar, but a few are strongly curved and join adjacent diaphragms before reaching the mesopore wall. The last diaphragms that were formed are in the distal ends of the mesopores so that in external view the walls and diaphragms of the mesopores combine to form the very shallow polygonal depressions between the zooecia.

Many of the thick diaphragms also display centrally located pores that do not penetrate through to the distal sides of most of the thickest diaphragms. Laminae of the diaphragms generally stop abruptly at the pores without changing direction or flexing, so that the pores have no lining or apparent influence on the structure of the diaphragms. In other thick diaphragms the laminae trend in a proximal direction in varying amounts and there is a noticeable decrease in diaphragm thickness approaching the pore. The pores in the outer region also differ from the central pores of the inner region of the exozone by being consistently smaller in diameter. In addition to the pores, mesopore diaphragms and walls in the outer region contain small, dark, subspherical to elongated cavities formed by the concentric arrangement of laminae about imaginary centers. These cavities seem to be arranged at random in the walls and diaphragms.

Zooecia.—In the outer region of the exozone, undistorted wall structure of adjacent zooecia is rarely seen because of intervening mesopores and acanthopores. Zooecial boundaries are well defined, dark, slightly serrated lines or zones in two dimensions, formed by the abutting ends of laminae from adjacent zooecia. In walls formed by a zooecium and adjacent mesopore, or by adjacent mesopores, boundaries are more coarsely serrated and are commonly discontinuous along their length.

Diaphragms are not present in most zooecia and not more than two were seen in any one zooecium. If present, diaphragms are very thin, planar to slightly curved, and extend distally into the zooecial wall. Single, hollow, subspherical cystlike structures occur in the zooecial voids of a very few zooecia, more commonly in the monticules. The cyst walls are thick and are constructed of laminae that merge with the laminae of the zooecial walls. Irregular spinelike processes are common in the zooecial walls in the thick-walled outer region. These mural spines have their origins at or very near the zooecial boundaries and trend in general toward the zooecial voids at a high angle to undisturbed laminae in the walls. Zooecial wall laminae surrounding the spines are flexed about the spines in a series of irregular superposed cones and some of the laminae are pierced. The spines extend far enough to cause inflection of the walls but none were observed to break through the wall laminae and stand in relief in the zooecial voids. The cores of the spines appear structureless or hollow.

Tangential View.—In tangential sections passing through the outer region of the exozone, zooecia range from irregularly elliptical to subcircular to petaloid in cross section. Major axes of the ellipses are approximately parallel to branch length. The rare petaloid appearance is caused by extreme inflection of zooecial walls by adjacent acanthopores and mural spines. Acanthopores are large, laminated, possess well-defined central tubes, and are generally located at points of closest proximity of adjacent zooecia. Mural spines appear to begin outside the broad band of striated-appearing tissue lining each zooecium and project inwardly toward the zooecial void, strongly inflecting the laminated tissue but not breaking through to the void. Mesopores are numerous, subpolygonal to subcircular. In very shallow sections that pass through the outermost and thickest diaphragms, mesopore boundaries are concealed and interspaces between zooecia appear solid. Many of these solid interspaces do not show the smaller central pores that are the rule in sections that pass through earlier parts of the outer region.

In deeper tangential sections that pass through the inner region of the exozone, zooecia are polygonal to subpolygonal and approximately equidimensional. Mesopores are also polygonal to subpolygonal and have fewer sides than the zooecia, merely appearing to fill the spaces between zooecia. Pores in mesopore diaphragms here are several times larger in diameter than those in the outer region. Acanthopores are considerably smaller in diameter than they are in the outer region.

QUANTITATIVE DATA

The following tables are based on sections of two fragments from the lectotype, three fragments from the two paratype zoaria, and 49 fragments from 33 topotype zoaria. Sections from 55 zoaria of *Trematopora tuberculosa* were examined. All measurements are in millimeters. The axial ratio is the ratio of the diameter of the endozone to the corresponding branch diameter.

TABLE 1.—*General measurements*

	Lectotype AMNH 1747		Paratypes and topotypes	
	Frag. A.	Frag. B.	Minimum	Maximum
Diameter of zoarium	6.5	4.9	3.0	7.2
Width of endozone	5.3	3.3	2.3	5.6
No. zooecia in 2 mm. (longitudinal direction)	5½	6½	6	8
Average major axis of zooecial void per fragment	0.14	0.15	0.14	0.22
Average minor axis of zooecial void per fragment	0.12	0.12	0.09	0.14
Acanthopores per zooecium	0.73	0.63	0.50	0.5
Mesopores per zooecium	1.6	—	1.1	2.0

Table 2.—*Ontogeny*

	Average No. diaphragms in mesopores	Width of exozone	Axial ratio
	2	0.3-0.6	0.87-0.92
	3	0.5-1.0	0.74-0.90
Frag. A. lectotype..............	4	1.2	0.82
	4	0.9-1.4	0.71-0.86
	5	1.0-1.4	0.66-0.82
	6	1.4-1.8	0.75
Frag. B. lectotype..............	7	1.6	0.67
	7	1.1-1.6	0.68-0.70

DISCUSSION

The number of mesopore diaphragms and the width of the exozone are not particularly sensitive indicators for ontogenetic development of the mesopores and zooecia in *T. tuberculosa.* The variation in diaphragm counts and in width of exozone within a longitudinal thin section is unusually large because of a marked variation in the number of chambers developed in adjacent mesopores in the inner region. Also, the unusual variation in thickness and spacing of mesopore diaphragms in the outer region of the exozone makes diaphragm counts less reliable.

T. tuberculosa differs from both *T. halli* and *T. whitfieldi* in having the larger branches, tuberculated mesopores, and a broader exozone in mature specimens. Both *T. halli* and *T. whitfieldi* are smooth, rhomboporoid-sized species.

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EXPLANATION OF PLATES

Plate 1

Figs. 1-4. *Trematopora tuberculosa* Hall.

1. Longitudinal view of paratype, A.M.N.H. 1747, × 5, showing primary branch with growth direction upward and branch from secondary overgrowth with growth direction to lower right.

2a. External view of lectotype zoarium, A.M.N.H. 1747, × 2, showing tuberculated monticules.

2b. Longitudinal view of lectotype, × 20, showing beaded mesopore chambers in inner region of exozone.

2c. Tangential view of lectotype, × 20, showing aspect of both inner and outer regions of exozone. Note thin-walled polygonal tubes of inner region of monticule in upper left.

3. Tangential view of paratype, A.M.N.H. 1747, × 50, showing the smaller central pores in mesopore diaphragms of outer region of exozone.

4. Longitudinal view of topotype, U.S.N.M. 137847, × 5, showing zooecial growth at surface of contact of anastomosing branches. U.S.N.M. collection 2998.

Plate 2

Figs. 1-3. *Trematopora tuberculosa* Hall.

1. Longitudinal view of topotype, U.S.N.M. 137848, × 100, showing laminated structure of a beaded mesopore and two diaphragm pores in the inner region of the exozone.

2a. Longitudinal view of topotype, U.S.N.M. 137849, × 100, showing configuration of laminae of mesopores and small diaphragm pore in outer region of exozone.

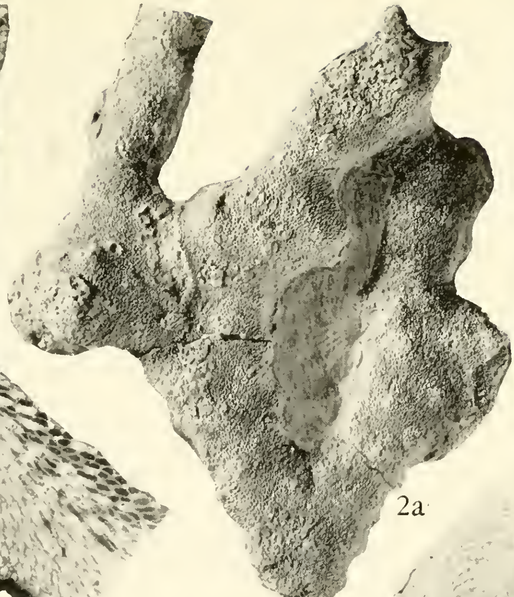
2b. Longitudinal view of same specimen, × 100, displaying a mesopore with diaphragm pore of inner region covered by first diaphragm laminae of outer region. Note discontinuous and ragged boundary between mesopore wall and zooecial wall above.

3a. Longitudinal view of topotype, U.S.N.M. 137850, × 100, showing first a diaphragm pore and then a compound diaphragm between beaded chambers in the inner region of the mesopore.

3b. Longitudinal view from same zoarium, × 100, illustrating the structure of the wall of adjacent zooecia.

3c. Tangential view from same zoarium, × 100, showing the general aspect of the outer region of the exozone, including acanthopores, mural spines, and a small pore in the center of a diaphragm of a mesopore. The dark intermediately sized spots are the randomly arranged cavities noted in species description.

1



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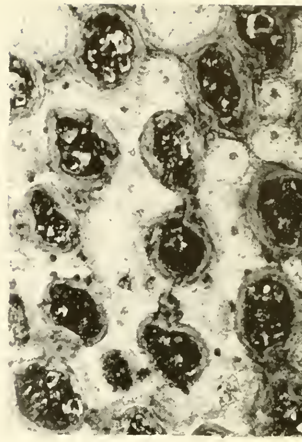

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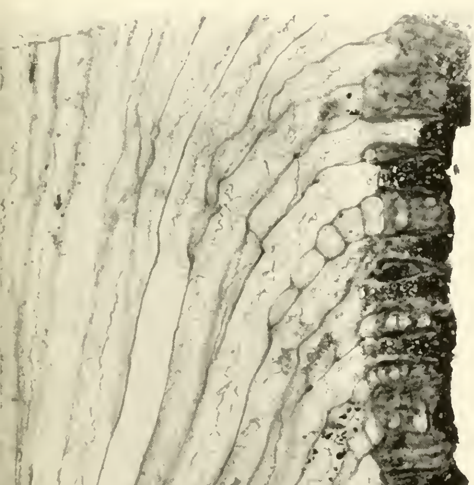

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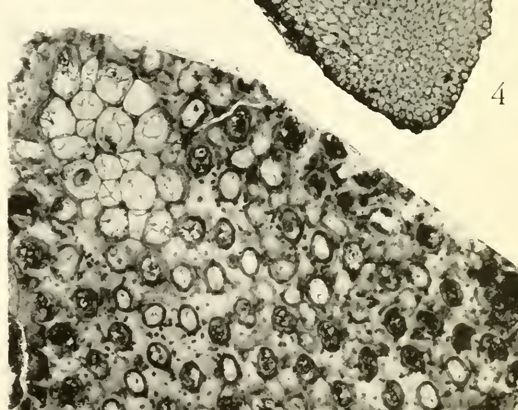
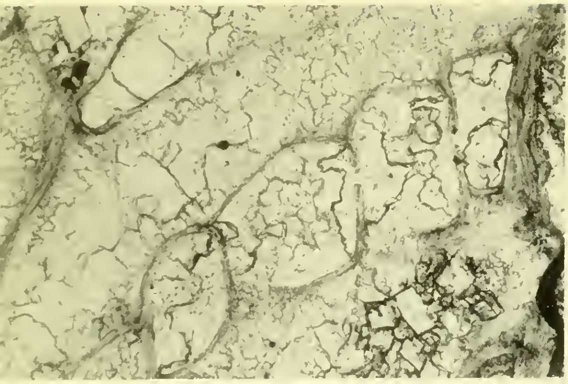


2c

TREMATOPORA TUBERCULOSA

(See explanation of plates at end of text.)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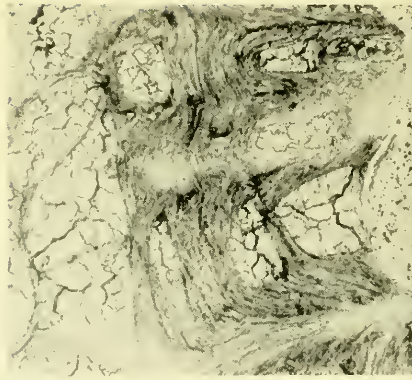
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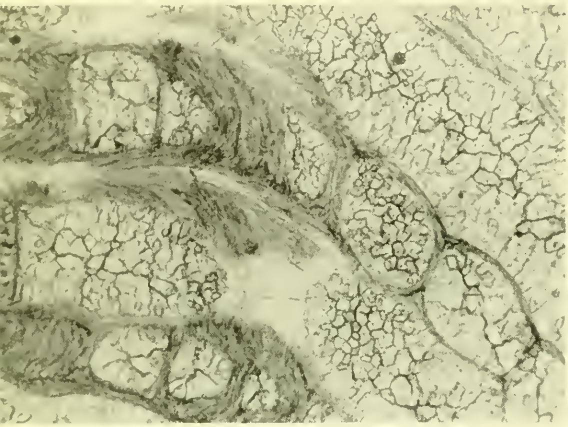
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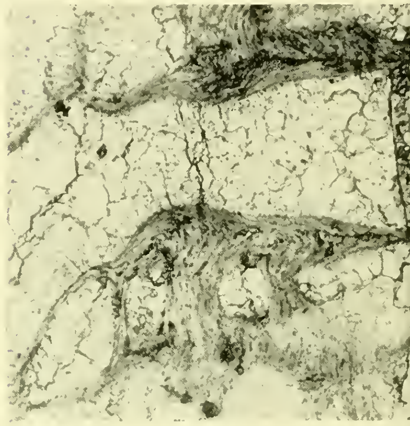
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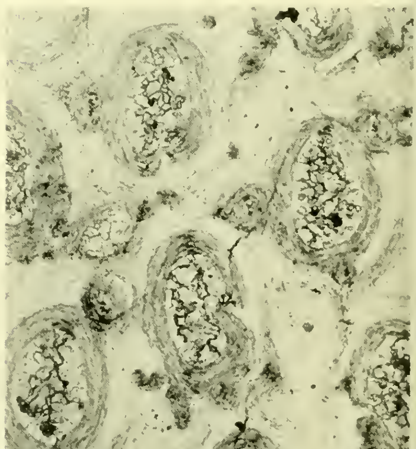
3b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TREMATOPORA TUBERCULOSA

(See explanation of plates at end of text.)