SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
Bulletin 77

THE EARLY PALEOZOIC BRYOZOA OF THE BALTIC PROVINCES

BY

RAY S. BASSLER
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The scientific publications of the United States National Museum consist of two series—the *Proceedings* and the *Bulletins*.

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The *Bulletins*, the first of which was issued in 1875, consist of a series of separate publications comprising chiefly monographs of large zoological groups and other general systematic treatises (occasionally in several volumes), faunal works, reports of expeditions, and catalogues of type-specimens, special collections, etc. The majority of the volumes are octavos, but a quarto size has been adopted in a few instances in which large plates were regarded as indispensable.

Since 1902 a series of octavo volumes containing papers relating to the botanical collections of the Museum, and known as the *Contributions from the National Herbarium*, has been published as bulletins.

The present work forms No. 77 of the *Bulletin* series.

Richard Rathbun,
Assistant Secretary, Smithsonian Institution,
In charge of the United States National Museum.

Washington, D. C., *December 1, 1911.*

TABLE OF CONTENTS.

	Page.
Introduction	1
Distribution of Early Paleozoic Bryozoa	3
General Geology of Baltic Russia	4
Cambrian strata	8
A 1. Blue clay and associated strata	10
A 2. Ungulite sandstone	10
Ordovician and Early Silurian strata	11
A 3. Dictyonema beds	11
B 1. Glauconite sandstone	11
B 2. Glauconite limestone	12
B 3. Orthoceras limestone	13
C 1. Echinospherites limestone	13
C 2. Kuckers shale	14
C 3. Itfer beds	15
D 1. Jewe limestone	15
D 2. Kegel beds	15
D 3. Wassalem beds	15
E. Wesenberg limestone	16
F. Lyckholm and Borkholm	16
Paleontology of the Baltic area	19
Ordovician formations of Upper Mississippi Valley	25
Stones River group	26
Black River group	27
The Bryozoan faunas of American Black River and earliest Trenton deposits	27
Ordovician and Early Silurian strata of Arctic America	32
Stratigraphic correlations	36
The Bryozoan faunas	45
Terminology	46
Bibliography	48
Range of Baltic Ordovician and Early Silurian Bryozoa	49
Descriptions of genera and species	54
Ctenostomata	54
Cyclostomata	58
Cryptostomata	112
Trepostomata	176
Amalgamata	177
Integrata	265
Undetermined genera and species	339
Explanation of plates	350
Index	375

LIST OF ILLUSTRATIONS.

PLATES.

		Facing page.
1.	Geologic map of the Russian Baltic Provinces. (After von Schmidt.)	350
2.	Early Paleozoic Bryozoa of the Baltic Provinces	352
3.	Early Paleozoic Bryozoa of the Baltic Provinces	354
4.	Early Paleozoic Bryozoa of the Baltic Provinces	356
5.	Early Paleozoic Bryozoa of the Baltic Provinces	358
6.	Early Paleozoic Bryozoa of the Baltic Provinces	360
7.	Early Paleozoic Bryozoa of the Baltic Provinces	362
8.	Early Paleozoic Bryozoa of the Baltic Provinces	364
9.	Early Paleozoic Bryozoa of the Baltic Provinces	366
10.	Early Paleozoic Bryozoa of the Baltic Provinces	368
11.	Early Paleozoic Bryozoa of the Baltic Provinces	370
12.	Early Paleozoic Bryozoa of the Baltic Provinces	372
13.	Early Paleozoic Bryozoa of the Baltic Provinces	374

TEXT FIGURES.

			Page.
FIG.	1.	Map of Baltic Sea area, showing distribution of Ordovician and Silurian strata. (After von Schmidt.)	5
	2.	Map of the North Polar region, showing distribution of Silurian strata in North America and northern Europe, with the hypothetical shore lines. (After Weller.)	40
	3.	Generalized paleogeographic map, showing supposed distribution of land and water during Black River and early Trenton times	43
	4.	Bathymetric chart of the North Polar Seas, suggesting routes of migration for marine organisms. (After Nansen.)	44
	5.	Vinella repens. *a*, two colonies, natural size; *b*, portion of one of the colonies, × 18; *c*, another portion of same zoarium, × 18; *d*, another specimen, natural size, attached to a fragment of shell; *e*, small portion of same, × 18. (After Ulrich.)	56
	6.	Heteronema priscum. *a*, a colony attached to a valve of Obolus, × 4; *b*, a portion of the same, × 20; *c*, parts of two colonies, × 35, with one growing over another; *d*, small portion of another zoarium, × 50	58
	7.	Stomatopora arachnoidea. *a*, portion of a delicate zoarium, × 9; *b*, part of the same, × 20, illustrating the detailed structure	60
	8.	Corynotrypa delicatula. Specimens figured by Ulrich as Stomatopora proutana. *a*, fragment of a zoarium, × 9; *b* and *c*, two groups of zoœcia, × 25; *d*, several zoœcia of unusual size, × 25	62
	9.	Corynotrypa barberi. *a*, portion of the type-specimen, × 9, incrusting a bifoliate bryozoan; *b*, several zoœcia, × 20; *c*, part of a small colony, × 9, growing upon a species of Heliolites	63
	10.	Corynotrypa inflata. *a* and *b*, zoarium, natural size, and a portion, × 9; *c*, three zoœcia of same, × 18, showing the porous wall; *d*, a vertical section of a zoœcium, × 18; *e* and *f*, small portion of a colony, incrusting Rafinesquina alternata, × 9 and × 18; *g*, outline of zoœcia, × 18, showing three "gems" springing from one parent cell. (After Ulrich.)	65

Page.

FIG. 11. Corynotrypa abrupta. *a* and *b*, portions of the type-specimen, × 9 and × 20 66

12. Corynotrypa abrupta. *a* and *b*, portion of a zoarium, × 9 and × 20, incrusting a crinoid column 66

13. Corynotrypa schucherti. *a* and *b*, portions of the type-specimen, incrusting a Streptelasma, × 9; *c*, several zoœcia of the same, × 20 67

14. Corynotrypa dissimilis. *a* and *b*, a typical example of the species, × 9 and × 20, incrusting the epitheca of the bryozoan Diplotrypa nummiformis; *c* and *d*, poorly preserved specimen of the species, × 9 and × 20, growing upon a specimen of Heliolites 68

15. Mitoclema boreale. Fragment of a zoarium, × 9 70

16. Mitoclema? mundulum. *a* and *b*, fragments, natural size, and × 9; *c*, original of *b*, × 18, showing surface character. (After Ulrich.) *d*, portion of young example, × 9 70

17. Protocrisina exigua. *a* to *e*, Wiman's views of Crisinella oeilensis. *a*, fragment, natural size; *b*, celluliferous surface, × 10, showing the circular zoœcia and accessory pores; *c*, noncelluliferous face, × 10; *d* and *e*, two transverse sections, × 10. *f* to *i*, Ulrich's views of Protocrisina exigua. *f*, two fragments, natural size; *g*, celluliferous face, × 18, with zoœcial openings and accessory pores; *h*, noncelluliferous side, × 18, with pores; *i*, transverse section, × 18 72

18. Protocrisina ulrichi. *a*, portion of a zoarium, natural size; *b*, another fragment, showing the noncelluliferous side, natural size, and enlarged eight diameters; *c*, celluliferous side of another fragment, × 8 74

19. Ceramopora spongiosa. *a*, portion of a zoarium, natural size; *b* and *c*, tangential section, × 9, and portion of same, × 20; *d*, tangential section of three zoœcia, × 20; *e* and *f*, vertical sections, × 9 and × 20 77

20. Ceramopora invenusta. *a*, tangential section, × 20; *b*, tangential section, × 20; *c*, vertical section, × 20, through a zoarium 79

21. Ceramopora intercellata. *a*, edge view of the fragmentary type, × 1; *b* and *c*, tangential section, × 20, and a portion, × 35; *d*, vertical section, × 20, through one layer of the zoarium 80

22. Ceramoporella granulosa minor. *a*, tangential section, × 20; *b*, vertical section, × 20, through a single layer of zoœcia 82

23. Ceramoporella uxnormensis. *a* and *b*, tangential section, × 20 and × 35; *c*, vertical section, × 20 83

24. Cœloclema crassimurale. *a*, fragment of a zoarium, natural size, with end view of the same showing the central tube; *b*, tangential section, × 20; *c*, vertical section, × 20, through one side of a zoarium. 84

25. Cœloclema laciniatus. *a*, Eichwald's type-specimen, natural size, of Coenites laciniatus; *b*, surface of the same, enlarged 85

26. Crepipora schmidti. *a*, vertical section, × 20; *b*, tangential section, × 20 87

27. Crepipora lunatifera. *a*, the type-specimen, incrusting Hormotoma insignis (Eichwald), two-thirds natural size; *b*, view of the zoœcia at the surface, × 9; *c* and *d*, tangential sections, × 20 and × 35, illustrating zoœcial structure; *e*, vertical section, × 20, through the zoarium 88

28. Crepipora incrassata. *a*, edge view of the type-specimen, natural size; *b*, tangential section, × 20; *c*, vertical section, × 10, cutting two layers of zoœcia; *d*, portion of a vertical section, × 20... 90

Page.

FIG. 29. Anolotichia rhombica. *a*, tangential section, × 20; *b*, another tangential section, × 20; *c*, vertical section, × 20; *d* and *e*, two portions of a vertical section 92

30. Anolotichia brevipora. *a*, vertical section, × 20, exhibiting short, immature, and mature regions; *b*, tangential section, × 20, with tubules in lunaria; *c*, portion of same, × 35 94

31. Anolotichia revalensis. *a*, vertical section, × 9; *b*, portion of the same, × 20; *c*, a normal tangential section, × 20 96

32. Anolotichia impolita. *a* and *b*, surface of a well-preserved example, × 9, and × 18; *c*, small portion of a tangential section, × 18, showing lunaria and tubuli; *d*, vertical section, × 9 (after Ulrich). 97

33. Anolotichia impolita. *a*, fragment of zoarium, natural size; *b* and *c*, tangential and vertical sections, × 18 98

34. Anolotichia sacculus. *a*, a type-specimen, natural size, with most of the zoarium exfoliated and showing the impression of the epitheca; *b*, vertical section, × 20; *c*, tangential section, × 20; *d*, another tangential section, × 20; *e*, two lunaria, × 35, exhibiting number and distribution of tubuli 99

35. Favositella interpuncta. *a*, vertical section, × 20; *b*, tangential section, × 20, with structure of zoœcia and mesopores 101

36. Favositella exserta. *a*, edge view of a zoarium, natural size; *b*, surface view, × 9, of the sectioned type; *c*, tangential section, × 20, exhibiting the small prominent lunarium; *d*, vertical section, × 9, through portions of two layers; *e*, portion of the same, × 20, illustrating wall structure in more detail 102

37. Favositella discoidalis. *a* and *b*, top and side views of a zoarium, natural size; *c*, surface of same, × 9; *d*, tangential section, × 20; *e* and *f*, vertical section, × 9, illustrating slight variation in structure 104

38. Favositella? punctata. *a*, celluliferous side of a zoarium, × 2; *b*, basal side of same specimen, × 2; *c*, tangential section, × 20; *d*, vertical section, × 20 105

39. Scenellopora socialis. *a* and *b*, copy of Eichwald's views of Ceramopora socialis; *a*, zoarium, natural size, incrusting an Echinosphaerites; *b*, one of the groups of zoœcia of the same, enlarged.... 108

40. Fistulipora primæva. *a*, the type-specimen, natural size; *b*, surface of same, × 8; *c*, tangential section, × 20; *d*, vertical section, × 8; *e*, portion of same section 110

41. Chilotrypa immatura. *a*, a fragment, × 2, with a few zoœcial apertures enlarged; *b*, tangential section, × 20, showing arrangement and shape of zoœcia; *c*, vertical section, × 20, with expanding and contracting central tube; *d*, transverse section, × 20........ 111

42. Ptilodictya flabellata. *a*, zoarium, natural size, parted along the mesial lamina; *b*, view enlarged, showing longitudinal arrangement of zoœcia 114

43. Ptilodictya gladiola. Tangential section, × 20 115

44. Escharopora subrecta. *a* and *b*, a typical specimen, natural size, and the basal portion of the same, × 9; *c*, view of the central part of the same zoarium, × 9; *d* and *e*, two specimens, natural size, broader than usual; *f*, surface of the lower part of another example, × 18, showing unusual conditions; *g*, tangential section, × 18, cutting the immature and mature parts of the zoarium; *h*, portion of a vertical section, × 18 117

Page.

FIG. 45. Phænopora ensiformis. Wiman's illustrations of the Borkholm form of this species; *a* and *b*, two small zoaria, natural size; *c*, surface, × 10; *d*, transverse section, × 10 118

46. Arthropora simplex. *a*, several segments in their natural position, life size; *b*, surface of a well-preserved fragment, × 18; *c*, several zoœcial apertures of the same, × 35; *d*, tangential section, × 18; *e*, vertical section, × 18 120

47. Graptodictya perelegans. *a*, tangential section, × 20, of the type-specimen; *b*, several zoœcia, × 40; *c*, vertical section, × 20; *d*, transverse section, × 20 121

48. Graptodictya bonnemai. *a*, portion of a zoarium, natural size; *b*, tangential section, × 20; *c* and *d*, several zoœcia of the same, × 40, with one still further enlarged, × 60; *e*, vertical section, × 20 123

49. Graptodictya proava. *a*, Eichwald's view of the type-specimen of his Coscinium proavum, natural size; *b*, tangential section of Hall's type of Clathropora flabellata, × 30 124

50. Graptodictya proava. *a*, tangential section, × 20, cutting the striated edge of a branch and the adjoining zoœcia; *b*, portion of the same, × 40; *c*, vertical section, × 20 125

51. Graptodictya obliqua. *a*, the type-specimen, natural size; *b*, tangential section, × 20; *c*, vertical section, × 20 126

52. Stictoporella cribrosa. *a*, nearly complete zoarium natural size; *b* and *c*, surface of a specimen with numerous mesopores, × 9 and a portion × 18; *d*, vertical section, × 18; *e*, tangential section of an average specimen, × 18 128

53. Stictoporella cribrosa. *a* and *b*, tangential and vertical sections, × 24, of a well-developed Russian example 129

54. Stictoporella gracilis. *a*, Eichwald's original figure (Eschara gracilis); *b* and *c*, copies of Eichwald's illustrations of Micropora gracilis; *b*, a zoarium, natural size, and *c*, surface of same, enlarged 130

55. Stictoporella gracilis. *a*, tangential section, × 20; *b*, vertical section, × 20 131

56. Rhinidictya mutabilis. *a*, a young specimen, described as variety minor, natural size; *b*, the usual mature specimen; *c*, surface view, × 9, of a young example; *d*, several apertures of the same, × 35; *e*, surface of original of figure *b*, × 9. (After Ulrich.) 132

57. Rhinidictya exserta. *a* and *b*, two typical fragments, natural size; *c*, tangential section, × 20, through mature zone of an old example; *d*, vertical section, × 20, of the same specimen 133

58. Rhinidictya exserta. *a*, Eichwald's original view of this species; *b*, view of his second specimen 134

59. Phyllodictya flabellaris. *a*, vertical section, × 20, showing the long, zoœcial tubes; *b*, minute structure of the interzoœcial spaces, × 60; *c*, tangential section, × 20, with portion of a macula and adjoining zoœcia; *d*, several zoœcia of the same section, × 35 135

60. Phyllodictya varia. *a*, portion of a large zoarium, natural size; *b*, fragment with subparallel margins, natural size; *c*, surface of the same, × 9; *d*, two rows of apertures, × 18; *e*, surface of an old zoarium, × 9; *f*, vertical section, × 18; *g*, tangential section, × 18 .. 137

61. Pachydictya elegans. *a*, tangential section, × 18; *b*, a single zoœcium of the same section, × 35; *c*, transverse section, × 18, Pachydictya foliata, showing the median tubuli distinctly 138

Page.

FIG. 62. Pachydictya elegans. *a*, nearly complete zoarium, natural size, branching more frequently than usual; *b*, enlargement of surface of same, × 18; *c*, fragment, × 1.5, with young Streptelasma attached 139

63. Pachydictya flabellum. *a*, fragment, natural size; *b*, surface of same, enlarged; *c*, transverse view of branch. (Copied from Eichwald's figure of Stictopora flabellum.) 140

64. Pachydictya flabellum. *a*, tangential section, × 20; *b*, another tangential section, × 20, showing the appearance in the early portion of the mature zone; *c*, tangential section of a young example, × 20, with open mesopores; *d*, the usual aspect of vertical sections, × 20; *e*, vertical section, × 20, of young specimen 141

65. Pachydictya cyclostomoides. Eichwald's view of Micropora cyclostomoides. *a* and *b*, fragment, natural size, and a portion enlarged. 142

66. Pachydictya cyclostomoides. *a*, tangential section, × 20, showing the large oval zoœcia; *b*, vertical section, × 20 142

67. Pachydictya bifurcata. *a* and *b*, two fragments, × 1.5; *c*, tangential section, × 20; *d*, portion of a transverse section, × 20, with well-marked median tubuli 143

68. Pachydictya bifurcata. *a* to *g*, Wiman's figures of Rhinidictya borkholmiensis. *a* to *d*, four fragments, natural size; *e*, surface of fragment, × 10; *f*, vertical section, × 10; *g*, transverse section, × 10; *h* to *j*, Eichwald's figures of Stictopora scalpellum; *h*, fragment, natural size; *i*, surface, enlarged; *j*, end view of same 144

69. Coscinium prænuntium. *a*, tangential section, × 20; *b*, vertical section, × 20 146

70. Arthrostylus conjunctus. *a*, lateral view of the central portion of a segment, × 18; *b*, small portion of noncelluliferous side of same, × 18. (After Ulrich.) 147

71. Arthrostylus obliquus. *a*, side view of portion of a segment, × 18; *b*, noncelluliferous side, × 18, of the upper portion of a segment. (After Ulrich.) 148

72. Helopora divaricata. *a*, fragment, natural size, and × 7; *b*, portion of the same, × 18; *c*, transverse section, × 18. (After Ulrich.) 150

73. Arthroclema armatum. *a*, large segment of the primary series, showing a sharply defined, articulating socket, natural size, and × 18; *b*, opposite side of another segment of the primary set, × 18; *c*, a segment of the tertiary series, × 18; *d*, complete segment of the secondary set, × 18. (After Ulrich.) 151

74. Sceptropora facula. *a*, single segment of this fine species, × 18; *b*, vertical section, × 18, through an entire segment; *c*, transverse section, × 18, cutting the lower end of a segment; *d*, transverse section, × 18, through the expanded celluliferous portion. (After Ulrich.) 153

75. Sceptropora francisa. *a*, group of three segments, natural size; *b*, the largest segment, × 9; *c*, basal portion of the same specimen, × 20; *d*, tangential section, × 20; *e* and *f*, vertical and transverse sections, × 20 154

76. Nematopora delicatula and N. consueta. *a*, zoarium, natural size, and × 18, of Nematopora delicatula; *b*, transverse section of same. (After Ulrich.) *c* and *d*, two fragments, natural size, and × 18, of the Trenton specimens referred by Ulrich to N. delicatula and here renamed N. consueta 155

Page.

FIG. 77. Nematopora ovalis. *a*, zoarium, natural size, of the form described by Ulrich as Nematopora quadrata; *b*, portion of the same, × 18; *c*, vertical section, × 18; *d*, transverse section, × 50; *e*, fragment of Nematopora ovalis, natural size, and × 18, with five rows of zoœcia; *f*, another fragment, natural size, and × 18, with only four rows. (After Ulrich.) ... 157

78. Nematopora fragilis. *a*, fragment, natural size, showing mode of branching; *b*, portion of the same, × 18; *c*, transverse section, × 50; *d*, vertical section, × 18. (After Ulrich.) ... 157

79. Nematopora lineata. *a*, fragment, natural size; *b*, surface of same, × 18; *c*, vertical section, × 18; *d* and *e*, two transverse sections, × 18; *f*, portion of *e*, × 50, showing minute axial canals and wall structure. (After Ulrich.) ... 158

80. Glauconome plumula. *a* to *d*, fragments of four zoaria; *e*, noncelluliferous side, × 10; *f*, celluliferous face, × 10; *g* and *h*, two transverse sections, × 10. (After Wiman.) ... 160

81. Glauconome strigosa. Wiman's figures of this species, described by him as "species No. 1"; *a* and *b*, two fragments, natural size; *c*, view, × 10, of the celluliferous face; *d*, side view, × 10; *e*, transverse section, × 10 ... 161

82. Rhombopora esthoniæ. *a*, fragment of zoarium, natural size; *b*, tangential section, × 20; *c*, portion of another tangential section, × 20, cutting a macula; *d*, vertical section, × 20; *e*, transverse section, × 20 ... 163

83. Nematotrypa gracilis. *a*, fragment of zoarium, natural size; *b*, tangential section, × 20; *c*, portion of the same, × 40; *d*, tangential section, × 50; *e*, vertical section, × 20; *f*, transverse section, × 20, showing growth from central axis ... 165

84. Lichenalia concentrica. *a*, epithecal side of a fragmentary specimen; *b*, portion of a tangential section, × 20; *c*, a tangential section, × 20; *d*, a tangential section, × 6; *e*, a portion of a tangential section, × 20; *f*, a vertical section, × 20; *g*, a more diagrammatic vertical section, × 20 ... 167

85. Chasmatopora tenella. Celluliferous face enlarged. (After Eichwald.) ... 170

86. Chasmatopora reticulata. Ulrich's figures of Phylloporina reticulata, *a* and *b*, two fragments, natural size, exposing the reverse side; *c*, portion of *b*, × 9; *d*, portion of *a*, × 9, showing broader branches; *e*, celluliferous side of a fragment, × 18 ... 171

87. Chasmatopora furcata. Eichwald's views of Polypora furcata. *a*, zoarium, natural size; *b*, an enlargement of the nonporiferous side, showing distinct rows of papillæ; *c*, celluliferous face enlarged ... 172

88. Pseudohornera bifida. Eichwald's views of Thamniscus bifidus. *a* and *b*, zoarium, natural size, showing the noncelluliferous side, and portion of the same, enlarged ... 173

89. Pseudohornera bifida. *a*, tangential section, × 20; *b*, vertical section, × 20; *c*, transverse section, × 20 ... 173

90. Pseudohornera bifida. *a*, an ordinary specimen, natural size; *b*, noncelluliferous side of a larger, more complete zoarium, × 2; *c*, surface of same, × 4 ... 174

91. Pseudohornera orosa. Wiman's views of his species Thamniscus orosus. *a* and *b*, two views, natural size, of the many-branched zoarium; *c*, noncelluliferous side of a specimen, × 10; *d*, celluliferous surface, × 10 ... 174

Page.

FIG. 92. Fenestella striolata. *a*, zoarium, natural size; *b*, nonporiferous side enlarged; *c*, small portion of poriferous side, enlarged. (After Eichwald.) 175

93. Monticulipora arborea bispinulata. *a*, one of the type-specimens, natural size, incrusting a brachiopod fragment; *b* and *c*, tangential section, × 20, and a portion, × 30; *d* and *e*, a vertical section, × 20 and × 30 180

94. Monticulipora dagoensis. *a*, tangential section, × 20; *b*, portion of same, × 35; *c*, vertical section, × 20 181

95. Orbignyella germana. *a*, the type-specimen, natural size; *b*, view of the usual characters seen in tangential section, × 20; *c*, tangential section, × 20; *d*, portion of the same, × 35; *e*, vertical section, × 20, with acanthopores little developed; *f*, another vertical section, × 20 182

96. Orbignyella expansa baltica. *a*, tangential section, × 20; *b*, several zoœcia of the same, × 35; *c*, vertical section, × 10, through an entire zoarial layer; *d*, portion of the same section, × 20 184

97. Homotrypa similis. *a*, surface of a Minnesota specimen, × 18; *b*, two portions of a tangential section, × 18, *c*, vertical section, × 18. (After Ulrich.) 186

98. Homotrypa similis. *a*, fragment of a branched zoarium, natural size; *b*, tangential section, × 20; *c*, vertical section, × 20 186

99. Homotrypa subramosa. *a*, fragment of a zoarium, natural size; *b*, surface of an ordinary fragment, × 9; *c*, a tangential section, × 18; *d*, tangential section, × 18; *e*, vertical section of a typical example, × 18. (After Ulrich.) 188

100. Homotrypa subramosa. *a*, tangential section of a Russian specimen, × 20; *b*, several zoœcia of the same, × 60; *c*, two portions of a vertical section, × 20 188

101. Homotrypella instabilis. *a* and *b*, two fragments, natural size; *c*, surface of a well-preserved example, × 18; *d*, tangential section, × 18; *e*, another tangential section, × 18; *f*, small portion of a tangential section, × 50; *g*, vertical section, × 18. (After Ulrich.) 190

102. Homotrypella instabilis. *a*, *b*, and *c*, vertical sections, × 20; *d*, tangential section, × 20 191

103. Homotrypella cribrosa. *a*, vertical section, × 20; *b*, tangential section, × 20; *c*, several zoœcia, × 35 193

104. Homotrypella hospitalis crassa. Ulrich's views of Atactoporella crassa. *a*, tangential section, × 18, of the Minnesota type; *b*, vertical section of the same, × 18; *c*, several zoœcia in tangential section, × 50 194

105. Homotrypella hospitalis crassa. *a*, a Russian example, natural size; *b*, tangential section, × 40; *c*, tangential section, × 40; *d*, *e*, and *f*, three vertical sections, × 20, illustrating the characters in various parts of the zoarium 195

106. Mesotrypa discoidea orientalis. *a*, *b*, and *c*, top, basal, and side views of a zoarium, natural size; *d*, tangential section, × 20; *e*, a portion of the same, × 40; *f*, vertical section, × 20 197

107. Mesotrypa egena. *a*, side view of type-specimen, natural size; *b*, tangential section, × 20; *c* and *d*, portions of the same, × 35; *e* and *f*, two portions of a vertical section, × 20 199

108. Mesotrypa expressa. *a*, side view of the type-specimen; *b*, view of the same example fractured lengthwise; *c*, tangential section, × 20; *d*, a portion of the same, × 35; *e* and *f*, two vertical sections, × 20 200

Page.

FIG. 109. Mesotrypa milleporacea. *a*, the epithecal side of a fragmentary zoarium, natural size; *b* and *c*, a tangential section, × 20, and several zoœcia, × 35; *d*, tangential section of the same specimen, × 20; *e*, vertical section, × 20 202

110. Mesotrypa milleporacea parva. *a*, a zoarium, × 2; *b* and *c*, a tangential section, × 20, with several zoœcia, × 35; *d*, vertical section, × 20 203

111. Dekayella prænuntia and varieties. *a*, fragment of a variety, natural size; *b*, tangential section, × 18, of the typical form; *c*, tangential section, × 18, of variety simplex; *d*, and *e*, small portions of two tangential sections, × 50; *f*, vertical section, × 9, of specimen with numerous mesopores; *g*, minute structure of walls in sections, × 50 206

112. Leptotrypa hexagonalis. *a*, the original type of the species, natural size, incrusting a Hyolithes; *b*, surface of the same, × 12. (After Ulrich.) *c*, a fragment of limestone with a Hyolithes incrusted by this delicate bryozoan 208

113. Leptotrypa hexagonalis. *a*, tangential section of the American type of the species, × 20; *b*, several zoœcia of the same section, × 30; *c*, vertical section, × 20 209

114. Leptotrypa hexagonalis. *a*, tangential section, × 20; of a Russian example; *b*, vertical section, × 20; *c*, a vertical section, × 20; *d*, tangential section, × 20 209

115. Stigmatella massalis. *a*, side view of the type-specimen, natural size; *b* and *c*, tangential section, × 20, and a portion of the same, × 35; *d*, vertical section, × 8; *e*, portion of the same section, × 20; *f*, part of vertical section, × 20, through a macula 211

116. Stigmatella inflecta. *a*, side view of the type-specimen, natural size; *b*, tangential section, × 20; *c*, another tangential section, × 20; *d*, several zoœcia of the same section, × 40; *e*, vertical section, × 20 213

117. Stigmatella foordii. *a*, a large specimen of Callopora foordii, of the natural size; *b*, tangential section of the same; *c*, vertical section of the same. (After Nicholson.) 215

118. Stigmatella foordii. *a*, vertical section, × 20; *b*, tangential section × 20; *c*, portion of the same section, × 35; *d*, another portion, × 35; *e*, several zoœcia of a tangential section, × 50 216

119. Stigmatella claviformis. *a* and *b*, two of the club-shaped zoaria, natural size; *c*, view of zoœcia in tangential section, × 18; *d*, vertical section through the middle of a zoarium, × 18. (After Ulrich.) .. 217

120. Constellaria varia. *a*, fragment of a zoarium, natural size; *b*, surface of a mature specimen, × 9; *c*, tangential section, × 18; *d*, small portion of the same, × 50, with two mural tubuli; *e*, vertical section of average example, × 18. (After Ulrich.) 219

121. Constellaria varia. *a*, tangential section, × 20, cutting several rays of a macula; *b*, vertical section, × 20, passing through a macula .. 220

122. Constellaria varia. *a*, vertical section, × 20, of a small example; *b*, transverse section of the same specimen, × 20 220

123. Stellipora revalensis. *a*, vertical section, × 20; *b*, tangential section, × 20, illustrating structure of two rays of a cluster 222

124. Stellipora apsendesoides. A zoarium, × 3, attached to a specimen of Echinospherites 223

125. Nicholsonella gibbosa. Eichwald's figures of Heteropora gibbosa; *a*, zoarium, natural size; *b*, the surface enlarged 225

Page.

FIG. 126. Nicholsonella gibbosa. *a* and *b*, top views of two irregular zoaria, natural size; *c*, side view of a third specimen of more regular form; *d*, an example with low monticules, viewed from above; *e*, tangential section, × 20, through a macula; *f*, portion of the same section, × 20, cutting the ordinary zoœcia; *g*, several zoœcia, × 40, illustrating the minute structure; *h*, vertical section, × 8; *i*, portion of the same section, × 20 225

127. Dianulites fastigiatus. *a*, side view of a zoarium, showing the epitheca; *b*, top or celluliferous surface, enlarged; *c*, edge view of a broken fragment, enlarged, illustrating the uneven fracture; *d*, the type-specimen of Dianulites detritus Eichwald, natural size. (After Eichwald.) 230

128. Dianulites fastigiatus. *a*, vertical section, × 9; *b*, part of the same section, × 20, showing the wall structure; *c*, tangential section, × 20; *d*, another part of the same section, × 40 231

129. Dianulites petropolitana. *a*, tangential section, × 20; *b*, vertical section, × 8; *c*, several tubes of the same, × 20 233

130. Dianulites petropolitana. *a*, tangential section of the form "hexaporites," × 20; *b*, small portion of the same, × 35; *c*, several zoœcia of a tangential section, × 35; *d*, vertical section, × 8, passing through a macula 234

131. Dianulites petropolitana. *a* and *b*, side and basal views; *c* and *d*, tangential section, × 20, and wall structure of same much enlarged; *e* and *f*, vertical section, × 9 and × 20 235

132. Dianulites petropolitana. Ulrich's views of Monotrypa (Chaetetes) cumulata, *a* and *c*, tangential section, × 9, and a small portion, × 35, showing wall structure; *b*, vertical section, × 9 236

133. Dianulites grandis. *a*, the type-specimen, two-thirds natural size, in side view; *b*, view showing simplicity of structure seen in the ordinary tangential section, × 8; *c*, portion of the same, × 20; *d*, tabulation in vertical section, × 8, cutting four layers of zoœcia; *e*, several tubes of a single layer, × 20 238

134. Dianulites collifera. *a* and *b*, type-specimen, natural size; *c*, surface, × 9; *d*, the usual aspect presented in tangential sections, × 20; *e*, vertical section of several tubes, × 20; *f*, a zoœcium, × 35, in a tangential section 239

135. Bythopora subgracilis. *a*, an ordinary fragment, natural size; *b*, surface of specimen, × 9; *c*, tangential section of a poorly preserved fragment, × 18; *d*, vertical section, × 18. (After Ulrich.) 241

136. Bythopora subgracilis. *a* and *b*, tangential and vertical sections, × 20, of a well-preserved Russian example 241

137. Eridotrypa ædilis. Copies of Eichwald's figures of Cladopora ædilis. *a* and *c*, two fragments of the natural size; *b* and *d*, enlargements of the same specimens 243

138. Eridotrypa ædilis. Copies of Ulrich's figures of Eridotrypa mutabilis. *a*, specimen of average size; *b*, surface of another example, × 18; *c*, tangential sections, × 18; *d*, a zoœcium of the same section, × 50; *e*, vertical section, × 18 244

139. Eridotrypa ædilis minor. Copied from Ulrich's figures of Eridotrypa mutabilis minor. *a*, *b*, and *c*, three average fragments; *d*, surface of a fragment, × 9; *e*, tangential section, × 18; *f*, vertical section, × 18 245

140. Eridotrypa exigua. *a*, group of fragments, natural size; *b* and *c*, two of them, × 9 246

Page.

FIG. 141. Lioclema vetustum. *a*, a zoarium, natural size, incrusting an Echinospherites; *b*, tangential section, × 20; *c*, portion of the same, × 35; *d*, vertical section, × 20 247

142. Lioclema spineum. *a*, tangential section, × 9; *b*, the detailed structure of an acanthopore, × 40; *c*, portion of a tangential section, × 20; *d*, vertical section, × 20 248

143. Lioclemella clava. *a*, the type-specimen, natural size; *b*, tangential section, × 20; *c*, vertical section, × 8; *d*, portion of the same, × 20. 250

144. Orbipora distincta. *a* and *b*, basal and celluliferous sides of a young zoarium, natural size, described by Eichwald as Chaetetes hemisphericus; *c*, side view of the same specimen; *d*, celluliferous surface enlarged. (After Eichwald.) 253

145. Orbipora distincta. *a* and *b*, top and side views, natural size, of one of Eichwald's type-specimens of Orbipora distincta; *c*, celluliferous face enlarged; *d*, worn portion of zoarial base enlarged; *e*, vertical section; *f*, *g*, and *h*, views of a larger example; *i*, side view of zoœcial tubes. (After Eichwald.) 253

146. Orbipora distincta. *a*, tangential section, × 20; *b*, vertical section, × 8; *c*, small portion of the same section, × 20 254

147. Orbipora distincta. *a*, tangential section, × 20; *b*, a portion of a zoœcial wall, × 35 254

148. Orbipora solida. *a*, side view, natural size, of the type-specimen; *b*, tangential section, × 20; *c*, vertical section, × 8; *d*, another vertical section, × 20 256

149. Orbipora acanthophora. *a*, type-specimen, natural size; *b*, tangential section, × 20; *c*, several zoœcia of the same section, × 20; *d*, vertical section, × 20 257

150. Orbipora indenta. *a*, the type zoarium, natural size; *b*, tangential section, × 20; *c*, portion of the same section, × 35; *d*, vertical section, × 20 258

151. Esthoniopora communis. *a* and *b*, two vertical sections, × 20 260

152. Esthoniopora communis. *a*, side view of an average specimen, natural size; *b*, basal view showing epitheca and cicatrix of attachment; *c*, tangential section, × 20, of average zoœcia; *d*, several zoœcia of the same section, × 35; *e*, vertical section, × 8; *f*, portion of the same section, × 20 261

153. Esthoniopora communis. *a*, tangential section, × 20; *b*, vertical section, × 20; *c*, a zoœcial tube of the same section, × 20; *d*, vertical section, × 20 262

154. Esthoniopora communis. *a*, tangential section, × 20; *b*, vertical section, × 6, through a single zoarial layer; *c*, a portion of the same, × 20 262

155. Esthoniopora communis. An unusual form of zoarium, natural size.. 263

156. Esthoniopora curvata. *a* and *b*, side and basal views of a normal example, natural size; *c*, tangential section, × 20; *d*, vertical section × 8, through portions of two layers; *e*, another vertical section, × 20. 264

157. Petalotrypa folium. *a*, surface of the type-specimen, × 9; *b*, tangential section, × 20; *c*, a few zoœcia of the same, × 40; *d*, vertical section, × 20 266

158. Trematopora primigenia. *a* to *c*, three fragments, natural size; *d*, base of a zoarium, life size; *e*, surface of a typical example, × 9; *f*, surface of another specimen, × 18; *g*, the usual appearance in tangential section, × 18; *h*, several zoœcia of the same section, × 50; *i*, vertical section, × 18. (After Ulrich.) 269

Page.

FIG. 159. Trematopora kuckersiana. *a*, tangential section, × 20; *b*, vertical section, × 20; *c*, another vertical section 270
160. Trematopora cystata. *a* and *b*, two fragments, natural size; *c*, tangential section, × 20; *d*, several zoœcia, × 40; *e*, vertical section of a branch 271
161. Batostoma magnopora. *a*, small specimen of natural size; *b*, tangential section, × 18; *c*, part of axial region in transverse section, × 18; *d*, vertical section of zoarium with a narrow mature zone, × 9. (After Ulrich.) 273
162. Batostoma magnopora. *a*, a small Russian example referred to the species, natural size; *b*, tangential section of same specimen, × 20; *c* and *d*, vertical section, × 10, and a portion, × 20 273
163. Batostoma fertile. *a* and *b*, a large and a small specimen, natural size; *c*, surface of the larger specimen, × 9; *d*, tangential section of the same example, × 18; *e*, vertical section, natural size, and a portion, × 18. (After Ulrich.) 275
164. Batostoma fertile circulare. *a* and *b*, surface of a typical example, × 9, with a portion, × 18; *c* and *d*, two tangential sections, × 18, from different parts of the mature zone. (After Ulrich.) 276
165. Batostoma mickwitzi. *a*, tangential section, × 20; *b*, vertical section, ×8; *c*, several tubes of the mature zone, × 20, in vertical section; *d*, vertical section, × 20 277
166. Batostoma winchelli. *a* and *b*, two fragments of natural size; *c*, surface of *a*, × 9 and × 18; *d*, tangential section, × 18; *e*, small portion of a tangential section of a young specimen, × 18; *f*, several zoœcia of figure *d*, × 50; *g*, vertical section, × 18, of an ordinary specimen. (After Ulrich.) 278
167. Batostoma winchelli spinulosum. *a*, a Russian example, natural size; *b*, tangential section, × 20; *c*, several zoœcia of another tangential section of the same specimen, × 20, exhibiting the normal development of acanthopores noted in American examples; *d*, vertical section, × 20 279
168. Batostoma winchelli spinulosum. *a* and *b*, tangential section, × 18, and a single zoœcium, × 50, with numerous acanthopores. (After Ulrich.) 280
169. Batostoma granulosum. *a*, the sectioned type-specimen, natural size; *b*, tangential section of mature zone, × 20; *c*, vertical section, × 20 281
170. Hemiphragma tenuimurale. *a*, the Russian example sectioned, natural size; *b*, view of tangential section; *c*, vertical section, × 20. 282
171. Hemiphragma tenuimurale. Ulrich's views of the Minnesota types. *a*, surface of specimen, × 9; *b*, vertical section, × 18; *c*, tangential section, × 18 283
172. Hemiphragma irrasum. Views of the Minnesota types, after Ulrich. *a* and *b*, two fragments, natural size; *c*, surface of an average example, × 9; *d* and *e*, tangential sections, × 18; *f*, vertical section of branch, × 9 284
173. Hemiphragma irrasum. *a*, view, natural size, of a zoarium; *b*, tangential section of the same specimen, × 20; *c*, several zoœcia, × 35; *d*, vertical section, × 20 285
174. Hemiphragma panderi. *a*, vertical section, × 20; *b*, the usual view seen in tangential section, × 20; *c*, portion of same, × 40 286

Page.

FIG. 175. Hemiphragma glabrum. *a* and *b*, two fragments, natural size; *c*, basal portion of a zoarium, natural size; *d*, tangential section, × 20; *e*, vertical section, × 20; *f*, several zoœcia of a tangential section, × 35 288

176. Hemiphragma pygmæum. *a*, side view of a typical specimen, × 2; *b*, an ordinary tangential section, × 20; *c*, portion of the same, × 35; *d*, vertical section, × 20 289

177. Hemiphragma multiporatum. *a*, side view of the type-specimen; *b*, tangential section, × 8; *c*, portion of the same, × 20; *d*, vertical section, × 20, including a macula; *e*, a part of the same section, × 20 291

178. Hemiphragma subsphericum. *a* and *b*, two portions of a tangential section, × 20 and × 8, in each case cutting a macula; *c*, zoœcia of the same section, × 40; *d*, vertical section, × 8; *e*, part of the same section, × 20 292

179. Hemiphragma subsphericum. *a* to *d*, four views of zoaria, natural size 293

180. Hemiphragma rotundatum. *a*, side view of the type-specimen, natural size; *b*, tangential section of the type, × 20; *c*, a vertical section, × 20, illustrating the tabulation of both zoœcia and mesopores; *d*, a few zoœcia, × 35 294

181. Hemiphragma maculatum. *a*, a fragment, × 2, exhibiting portions of two maculæ; *b*, tangential section, × 20, through the intermacular zoœcia; *c*, several zoœcia of the same section, × 40; *d*, vertical section, × 20 296

182. Hemiphragma batheri. *a* and *b*, two fragments, natural size; *c*, a tangential section, × 20; *d*, vertical section of a branch, × 20 297

183. Anaphragma mirabile. *a*, view of branch, natural size; *b*, tangential section, × 20; *c*, several zoœcia of another part of this section, × 20; *d*, a vertical section, × 9; *e*, portion of the same section, × 20, showing the structure in more detail 298

184. Anaphragma mirabile cognata. *a*, view of fragment, natural size; *b*, tangential section, × 20; *c* and *d*, vertical section, × 8, and a portion, × 20 300

185. Dittopora clavæformis. *a*, tangential section, × 20; *b*, vertical section of the same specimen, × 20 303

186. Dittopora annulata. Copy of Eichwald's illustrations of Chætetes annulatus. *a*, fragment of a normal mature zoarium, natural size; *b*, small portion of the same magnified; *c*, end view of a fragment enlarged; *d*, view of cells in section; *e* and *f*, fragment of an old example and a portion enlarged; *g*, end view of branch, magnified 304

187. Dittopora annulata. *a*, tangential section of a mature example, × 20, passing through the outer deposit of interzoœcial tissue in which the mesopores are barely visible; *b*, another tangential section, × 20, cutting a macula at a lower level and exhibiting the mesopores; *c*, vertical section, × 20, of a young example, showing the occurrence of semidiaphragms in the bend from the immature to the mature region; *d*, similar section of an older specimen, × 20, with the mesopores well developed and their outer portions filled by tissue 305

188. Dittopora colliculata. Eichwald's figures of Trematopora colliculata. *a* and *b*, fragment of zoarium, natural size, and surface of same, enlarged 306

Page.

FIG. 189. Dittopora colliculata. *a*, tangential section of a young example, × 20, showing the characteristic shape of zoœcia and the larger set of acanthopores; *b*, vertical section of the same specimen, × 20..... 307

190. Dittopora colliculata. *a*, small portion of a tangential section, × 20, with the walls of the mesopores visible. The large and small set of acanthopores are clearly developed; *b*, another tangential section, × 20, with the mesopores and small ancanthopores obliterated by the interzoœcial tissue. This thin section was prepared from a specimen identified by Dybowski as Trematopora pustulifera; *c*, vertical section, × 20, showing the occurrence of semi-diaphragms only in the bend to the mature zone 308

191. Monotrypa jewensis. *a*, profile view of a small zoarium, natural size; *b*, surface of the same specimen, × 10; *c*, vertical section, × 8, illustrating the crinkled walls and few diaphragms; *d*, portion of the same section, × 20; *e*, tangential section, × 20, cutting a macula; *f*, another tangential section, × 20, with numerous young zoœcia resembling mesopores 311

192. Diplotrypa petropolitana. Nicholson's illustrations of Monticulipora (Diplotrypa) petropolitana, introduced for comparison. *a*, profile view of an average specimen, natural size; *b*, basal view of same showing wrinkled epitheca; *c*, tangential section, × 20; *d*, vertical section through an immature and a mature zone, × 20......... 313

193. Diplotrypa petropolitana. *a*, tangential section, × 20; *b*, a portion of the same, × 35; *c*, vertical section, × 8; *d* and *e*, portions of a vertical section, × 20.. 314

194. Diplotrypa petropolitana. *a*, small portion of a tangential section, × 8; *b*, parts of same section, × 20; *c*, vertical section, × 8; *d*, portion of same, × 20.................................... 315

195. Diplotrypa petropolitana. *a*, vertical section, × 8; *b*, portion of the same section, × 20; *c*, another portion, × 20; *d*, vertical section, × 20, through a macula; *e*, a tangential section, × 20........... 316

196. Diplotrypa bicornis. *a*, an example natural size; *b*, and *c*, two views of the surface, enlarged. Copied from Eichwald's figures of Ceriopora bicornis... 317

197. Diplotrypa bicornis. *a*, vertical section, × 20; *b*, small portion of the same section enlarged; *c*, a tangential section, × 20.......... 318

198. Diplotrypa bicornis. *a*, tangential section, × 20; *b*, part of the same section, × 40; *c*, vertical section, × 20; *d*, vertical section, × 40.. 319

199. Diplotrypa moniliformis. *a*, side view of a zoarium, natural size; *b*, tangential section, × 20; *c*, vertical section, × 8; *d*, portion of the same section, × 20.. 321

200. Diplotrypa hennigi. *a*, side view of a zoarium, natural size; *b*, tangential section, × 20; *c*, vertical section, × 20.............. 322

201. Diplotrypa westoni. *a* and *b*, side and basal views of a zoarium, natural size; *c*, tangential section, × 8; through a macula and adjoining zoœcia; *d*, portion of the same section, × 20; *e*, vertical section, × 8; cutting a macula; *f*, several tubes of the same, × 20.. 324

202. Hallopora multitabulata. *a*, view of typical specimen, natural size; *b*, surface of the same, × 9; *c*, surface of a finely preserved example, × 18; *d*, vertical section, × 9............................ 326

203. Hallopora goodhuensis. *a* and *b*, two fragments of natural size; *c*, surface of a specimen, × 9; *d*, axial region of a transverse section, × 18. (After Ulrich.)................................. 327

Page.

Fig. 204. Hallopora goodhuensis. *a*, tangential section, × 20, of a small specimen; *b*, vertical section of the same specimen, × 20 328

205. Hallopora wesenbergiana. *a*, tangential region, × 20; *b*, tangential section, × 20; *c*, vertical section, × 20, showing characteristic tabulation 328

206. Hallopora splendens. *a*, fragmentary specimen, natural size; *b*, tangential section, × 20; *c*, usual aspect of tangential sections, × 20; *d*, vertical section, × 20; *e*, another vertical section, × 20 330

207. Hallopora dumalis. *a* to *d*, view of four representative fragments, life size; *e*, surface of the slender specimen, × 9; *f*, surface of another specimen, × 18; *g*, vertical section, × 18; *h*, tangential section, × 18. (After Ulrich.) 331

208. Hallopora undulata. *a* and *b*, typical specimens of the natural size; *c*, surface of original of figure *b*, × 9; *d*, vertical section, × 18. (After Ulrich.) 332

209. Hallopora tolli. *a*, small fragment, natural size; *b*, tangential section, × 20; *c* and *d*, two portions of a vertical section, × 20, exhibiting tabulation 333

210. Hallopora elegantula. *a*, tangential section, × 18; *b*, transverse section, × 18; *c*, tangential section, × 20, through the mature zone; *d* and *e*, two vertical sections, × 18 and × 20, showing slight differences; *f*, surface view of several zoœcia, × 20 335

211. Hallopora ? dybowskii. *a*, tangential section, × 20, with zoœcia less angular than usual; *b*, vertical section, × 8, showing curved diaphragms; *c*, several tubes of the same, × 20 336

212. Hallopora ? dybowskii. *a*, side view of a small example, natural size; *b*, basal view; *c*, an average tangential section, × 20; *d*, vertical section, × 8; *e*, portion of the same, × 20; *f*, a long vertical section, × 8 337

213. Hallopora ? tenuispinosa. *a*, an ordinary fragment, natural size; *b*, tangential section, × 20; *c*, portion of the same, × 35; *d*, vertical section, × 20; *e*, portion of a transverse section, × 20 339

214. Archeopora lamella. Eichwald's views of his type-specimens, one (*a* and *b*, natural size and enlarged) showing mesopores, and the second (*c* and *d*) apparently with solid interzoœcial spaces 340

215. Archeopora angulosa. *a* and *b*, the incrusting type-specimen, natural size and enlarged, showing angular zoœcia and open mésopores. (After Eichwald.) 341

216. Archeopora punctata. *a* and *b*, the type-specimen, natural size and enlarged. (After Eichwald) 341

217. Archeopora radians. *a* and *b*, the type-specimen, natural size and enlarged. (After Eichwald) 342

218. Calamopora reticulata. *a* and *b*, zoarium natural size and surface enlarged. (After Eichwald) 343

219. Dianulites apiculatus. *a* to *d*, four views of Eichwald's type of Chætetes apiculatus; *e*, celluliferous surface enlarged. (After Eichwald.) 344

220. Micropora rhombica. Fragment of zoarium, enlarged. (After Eichwald.) 345

221. Myriolithes fastigiatus. *a*, the type-specimen, natural size and slightly enlarged. (After Eichwald.) 346

Page.

FIG. 222. Orbipora fungiformis. *a* and *b*, celluliferous and epithecated sides of the type-specimen; *c*, celluliferous surface enlarged; *d*, basal side, enlarged.......... 346

223. Pteropora pennula. *a* and *b*, Eichwald's views of the type-specimen, natural size and enlarged.......... 347

224. Pteropora exilis. *a* and *b*, zoarium natural size, enlarged. (After Eichwald.).......... 347

225. Stictopora scalpelliformis. *a*, Eichwald's figure of the surface enlarged; *b* and *c*, Eichwald's original figure of the same species.... 348

226. Vincularia megastoma. *a* and *b*, type-specimen, × 1 and enlarged; *c*, cross-section of same. (After Eichwald.).......... 348

THE EARLY PALEOZOIC BRYOZOA OF THE BALTIC PROVINCES.

By Ray S. Bassler.
Curator of Paleontology, United States National Museum.

INTRODUCTION.

The Cambrian and Ordovician strata of Baltic Russia have been the occasion of many paleontologic memoirs, mainly because the rocks are composed in part of unconsolidated materials yielding an abundance of most beautifully preserved fossils. The exquisite preservation of these specimens, especially the trilobites, is attested in museum collections the world over. The large number of species in these strata is evident when it is known that in 1860, in his Lethæa Rossica, Eichwald described or recorded the occurrence of no less than 500 Ordovician forms and that since then many more species have been added to the faunal list by other students. In this host of species only a few American forms were recognized, indeed, almost invariably no attempt has been made by either European or American students to identify trans-Atlantic species. The splendid trilobite fauna of the Russian Ordovician is undoubtedly the best known and most completely described. Next in importance come the brachiopods and echinoderms, particularly the cystids, which have received very detailed study. The mollusca, although numerous in described species, still require much investigation, but the ostracods and the bryozoans are the least known of all the classes.

In the present work I have endeavored to present as complete a study of the Russian Ordovician Bryozoa as the available collections would allow. It was my intention to limit the work to this subject, but in the course of study several additions have been made. First, the description of a single Cambrian form, of especial interest in being the oldest known bryozoan, was added. Then, when the studies were nearly completed, the authorities of the British Museum sent to the United States National Museum for determination, two collections of Bryozoa obtained by Dr. F. A. Bather, from certain Ordovician formations on the island of Oeland, in the Baltic Sea. These contained faunas so intimately related to those of the Russian provinces that I have incorporated the results of their study. In addition I have presented an account of the stratigraphy and detailed lists of species of both the Baltic area and the American region which the Russian faunas and formations most closely resemble. The study of these bryozoan faunas has indicated that the greater part of the Russian Ordovician section may be directly correlated with the Black River group of America, while the Upper Lyckholm and Borkholm limestones are the equivalents of the Richmond group.

Recent studies based upon paleontologic and diastrophic criteria have indicated that the Richmond group of America, with its equivalent in Baltic Russia, the upper part of the Lyckholm and the Borkholm limestones, should be classed as earliest Silurian. The bryozoan faunas of these several formations afford ample evidence of this fact, thus making it advisable to add their description and discussion to the present work.

Summing up, the paleontologic portion of this paper includes the description of a single Cambrian bryozoan, of numerous Ordovician species from the Baltic provinces of Russia and Sweden, and, finally, of the faunas of the early Silurian, the Upper Lyckholm and the Borkholm limestones.

In the course of a general study of the West-European Paleozoic rocks in the summer of 1903, Prof. Charles Schuchert, at my request, gathered as many Bryozoa as possible from the Ordovician rocks outcropping in the shore region of Esthonia, Russia, between St. Petersburg and Reval. He was fortunate in having as companions during this trip Prof. Friedrich von Schmidt, and Dr. August von Mickwitz, whose authoritative knowledge of the geology and paleontology of the region made these collections of unusual value for stratigraphic purposes. Later, through Prof. Schuchert, these collections were increased by the generous gift to the United States National Museum, from Dr. Mickwitz, of his fine lot of Russian Ordovician Bryozoa, this gift being made upon the conditions that the collection be studied and a named set be returned to the donor. Prof. George Mikhailowski, director of the University Museum at Dorpat, was also kind enough to loan collections of these fossils in his museum, which were of especial value since they had been studied and labeled by Dybowski. I am also indebted to Dr. F. A. Bather, of the British Museum, for the loan of the bryozoan material collected by him from several of the Swedish formations on the island of Oeland. In this way a considerable amount of material was at my disposal for study, and a detailed comparison of these various bryozoan faunas with those from

America was made possible. My studies on these collections have been in progress for some years, but other duties, as well as the large amount of labor required to study and illustrate the faunas, have prevented prompt publication.

During the progress of these studies I have had the continued advice of my friends, Dr. E. O. Ulrich, of the United States Geological Survey, and Prof. Charles Schuchert, of Yale University, to both of whom I am under obligations. As many of the Russian forms have proved to be identical with American species described by Dr. Ulrich, it has been my especial good fortune to enjoy the benefit of his mature judgment upon difficult and debatable points. Prof. Schuchert has kindly read and criticized that part of my manuscript dealing with the geology and stratigraphy. I am also indebted to Miss Francisca Wieser, who, in her usual skilled manner, has prepared many of the drawings and has retouched all of the photographs illustrating this volume. The illustrations of the internal structure were drawn under a camera lucida by myself.

In order that a representative collection of these bryozoan faunas should be available to European students, the United States National Museum has forwarded an almost complete set of the species herein described to the British Museum. On the other hand, the authorities of the British Museum have deposited a good set of Ordovician bryozoans from the island of Oeland in the collections of the United States National Museum. As a result of this exchange of material, the collections of both institutions have practically a complete representative set of these species. A second quite complete set has been placed in the Mickwitz collection, now preserved in the museum at Reval.

DISTRIBUTION OF EARLY PALEOZOIC BRYOZOA.

The exceeding richness of the North American Ordovician strata in Bryozoa has long been known, and "monticuliporoids" from the Cincinnati and other regions usually form a part of every paleontological collection. At the present time about 500 species of Bryozoa have been described from American strata of this geologic period, and an equally large number of new forms is known. With further searching it is almost inevitable that many more new species will be discovered—indeed, a conservative estimate would place the described species at not more than one-third of the probable number of Ordovician forms. The oldest known American form is a new species of *Nicholsonella* occurring in the Beekmantown rocks of Arkansas. Exclusive of this occurrence, the class is unrepresented in America until the Stones River division of the Mohawkian is reached, when a prolific fauna is encountered.

Fortunately for correlation purposes the described forms are almost entirely from standard Ordovician sections in which the position and range of each species is fairly well known. Thus, in New York and Canada at least the characteristic bryozoans of the various horizons have been determined; in the Cincinnati uplift a large fauna has been described; in Illinois the faunas of formations, either poorly represented or absent in the other regions, are partially worked out, while, finally, the species of the Middle Ordovician in Minnesota have been published in considerable detail.

In marked contrast with this prolific representation is the exceeding scarceness of Bryozoa in most of the Ordovician areas of Europe. In the British Isles very few species have been noted, partly because the strata here are mainly slates and sandstones, indicative of conditions ill fitted for bryozoan life. Similar conditions obtain in the Bohemian Ordovician, and correspondingly few bryozoans are known. The Ordovician of Spain and France has likewise yielded few specimens of this class. However, certain limestones in Scandinavia and most of the Ordovician and early Silurian formations of western Russia abound in Bryozoa, and it is with the faunas of these two areas that the present work is concerned.

GENERAL GEOLOGY OF BALTIC RUSSIA.

The lower Paleozoic formations of Russia outcrop in a broad belt extending from Lake Ladoga westward to the islands of Oesel and Dago, where they are hidden to a great extent by very recent deposits. The extent of outcrop and the larger unconformities are indicated on the accompanying map published by Dr. F. von Schmidt (Pl. 1), which is introduced to show the location of the various fossil localities in addition to the geology. This belt of outcrop continues under the Baltic Sea in a broad curve to the southwest, for essentially the same formations of the lower part of the section are exposed on the island of Oeland. The Borkholm limestone is known to outcrop under the Baltic because of the numerous bowlders containing this fauna in the drift on the island of Gothland. These drift bowlders have been carefully studied by Wiman, who has published an excellent paper upon the subject entitled "Uber die Borkholmer Schicht im Mittelbaltischen Silurgebiet."[1] The accompanying sketch map (fig. 1), modified after a chart by von Schmidt, shows the distribution of the Ordovician and Silurian rocks in this western portion of the Baltic area.

The Cambrian and Ordovician deposits of the area are of unusual interest in that they are made up in considerable part of unconsoli-

[1] Bull. Geol. Inst. Univ. Upsala, vol. 5, pt. 2, No. 10, 1902, pp. 149-222, pls. 5-8.

dated materials. Their strata in certain portions of the Baltic provinces have apparently never been covered by younger deposits and have been so little disturbed that the sediments often have remained as originally deposited. As a result the included fossils are in an especially fine state of preservation.

In spite of this apparently undisturbed condition of the strata both the paleontologic and stratigraphic records show great time breaks in the sequence. Thus the entire Middle Cambrian is wanting, and, according to the present results, the greater portion of the North American Ordovician section is absent.

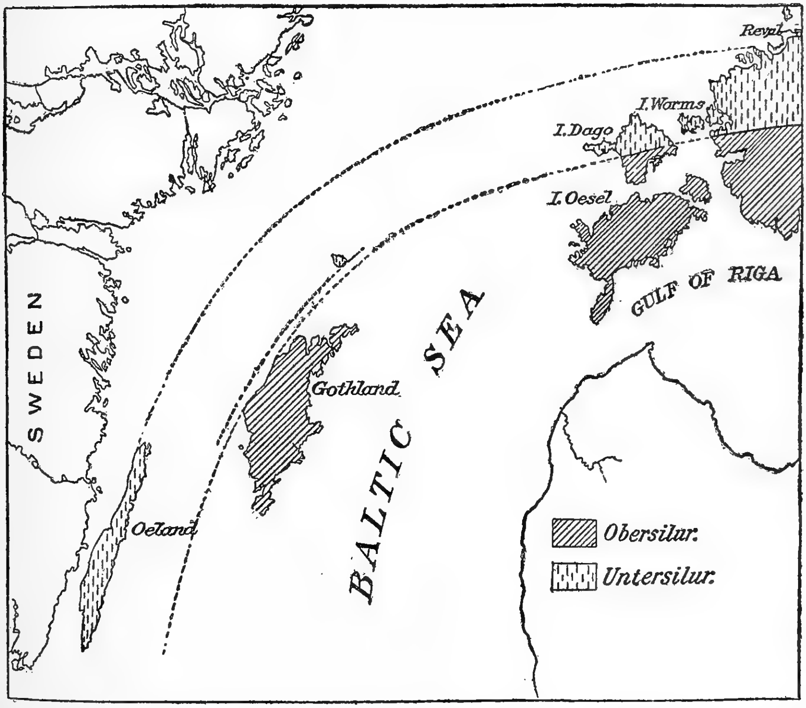


FIG. 1.—MAP OF BALTIC SEA AREA, SHOWING DISTRIBUTION OF ORDOVICIAN AND SILURIAN STRATA. (AFTER VON SCHMIDT.)

The Cambrian and Ordovician strata of the Baltic area have been divided by von Schmidt into six general divisions, designated by the letters A to F. In an earlier classification the same author recognized three zones with several subdivisions. The lettered divisions have since had geographic names applied to most of them, although in a few cases a lithologic designation, or the name of a characteristic genus of fossils has been retained. These several classifications are tabulated on the following page.

Table of Cambrian and Ordovician formations in Russia.

[After von Schmidt.]

Formation.	von Schmidt's terms.	
	Later.	Older.
Ordovician:		
Borkholm limestone	F2	Zone 3
Lyckholm limestone	F1	2a
Wesenberg limestone	E	2
Jewe limestone	D	1b
Itfer limestone	C3	1a
Kuckers shale	C2	
Echinospherites limestone	C1	1
Orthoceratite (Vaginoceras) limestone	B3	
Glauconite limestone	B2	
Glauconite sandstone	B1	
Cambrian:		
Dictyonema shale	A3	
Ungulite sandstone	A2	
Blue clay and associated formations	A1	
Granite		

Since the publication of the above table three divisions have been recognized in formation D. The Jewe limestone has been restricted to the lower division, D1; shaly strata succeed the limestone beds of D1 and form the Kegel beds, D2, while D3, consisting of very fossiliferous, thin bedded blue limestones and shales, forms the closing member of the formation. The Orthoceratite limestone is often cited simply as the Orthoceras limestone, and is so designated throughout the present work.

The long-continued researches of the late Prof. F. von Schmidt upon the Cambrian and Ordovician rocks of the Russian Baltic provinces have resulted in such a detailed knowledge of the geology that the stratigraphic section is now fairly well known. Pander, von Eichwald, de Verneuil, Keyserling, Holm, and Lamansky have contributed in a lesser degree to the stratigraphy, while, in addition to these, von Schmidt, von Mickwitz, von Huene, Jaekel, Koken, Pahlen, Dybowski, Wysogorski, and Bonnema have published researches on the paleontology of the region. The paleontological work of these authors has not, as a rule, been of a general nature, although Eichwald's Lethæa Rossica is an important exception. Thus, von Schmidt has elaborated the Ordovician trilobites in great detail, while similarly Koken has monographed the gastropods, Jaekel has studied the cystids, and Dybowski has described some of the monticuliporoids. More recently, Bonnema has published upon the Ostracoda of the Kuckers shale.

A number of authors have attempted correlations of the Russian Cambrian and Ordovician rocks with the North American sequence, but the ideas of most of these are reflected in the following table adapted from Credner's tables on pages 397 and 420 of his "Elemente der Geologie:"

Table of Cambrian and Ordovician strata.

[Adapted after Credner.]

	Baltic Russia.	North America.
Lower Silurian.	Pent. borealis beds Raiküll beds Borkholm beds Lyckholm beds Wesenberg beds Kegel and Jewe beds Brandschiefer Echinospherites limestone	Hudson River shale. Utica shale.
	Vaginaten limestone	Trenton limestone. Black River limestone. Birdseye limestone.
	Glauconite limestone and sands	Chazy limestone.
Cambrian	Dictyonema shale	Calciferous sandstone.
	Obolus sandstone to the lowest conglomerate	Potsdam group. St. John (Acadian) group.
	Blue clay to the top of the Olenellus mickwitzi zone. Lower sandstone.	Georgia group (Olenellus series).

The basis for correlation of the Ordovician portion of this table is rather difficult for the American student to determine. Probably there is none other than an arrangement of the formations in the two areas upon the supposition that corresponding strata are or should be present in each.

Probably the best expression of opinion as to this correlation is that given in the table on page 8, translated from Kayser's tables, pages 74 and 119 of his "Lehrbuch der Geologie," 1908, although this offers the same objection. Here, however, the identification of the strata ranging from the Orthoceras (Vaginaten) limestone to the Wesenberg, with the Mohawkian, and the Lyckholm-Borkholm series with the Cincinnatian, is more in line with the results brought out from a study of the bryozoan faunas.

Table of Cambrian and Ordovician strata.

[Adapted after Kayser.]

	European Russia.	North America.
Upper Silurian	Strata with smooth Pentamerus	Oswegan (Clinton-Medina beds).
Lower Silurian (Ordovician).	Borkholm and Lyckholm beds Wesenberg beds	Cincinnatian. Mohawkian.
	Jewe, Itfer, Kuckers beds Echinospherites limestone	Trenton limestone. Black River-Birdseye limestone.
	Vaginaten limestone Glauconite limestone	Chazy limestone } Quebec group of Canada.
	Glauconite sand, Dictyograptus shale.	Beekmantown limestone. } Quebec group of Canada.
Upper Cambrian or Olenus- (Dicellocephalus) beds.	Ungulite sandstone	Potsdam sandstone.
Middle Cambrian or Paradoxides beds.	....	St. John or Acadian group.
Lower Cambrian or Olenellus beds.	Fucoid sandstone, Blue clay, sand	Georgia group.

Von Schmidt's descriptions of the stratigraphy of the Russian Cambrian and Ordovician are contained in several papers, chief of which is his "Revision des Ostbaltischen Silurischen Trilobiten."[1] In 1882 a short description of these strata by the same author appeared in the Quarterly Journal of the Geological Society of London,[2] while still another article appeared in 1897, in the Guide of the Excursions of the Seventh International Congress.[3] From various sources, but mainly from these several articles and from the collections in the United States National Museum, I have compiled the following notes on the stratigraphy of the region concerned in the present paper. The stratigraphic relations of the rocks forming these notes are graphically represented in the accompanying composite columnar section.

CAMBRIAN STRATA.

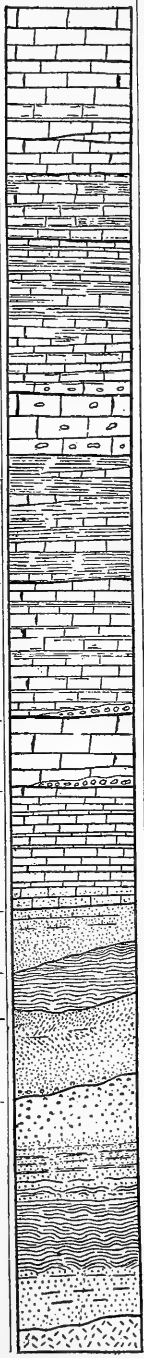
The sparing development of Cambrian rocks in the Russian Baltic area is a striking feature. These rocks occur in a long, narrow belt either paralleling or outcropping along the cliffs of the Gulf of Finland. A lower blue clay and an upper sandstone deposit, usually not exceeding a combined thickness of about 100 feet, are the important

[1] Mem. de l'Acad. imp. sci. St. Petersburg, ser. 7, vol. 30, 1881, pp. 17–41.

[2] On the Silurian (and Cambrian) Strata of the Baltic Province of Russia, as compared with those of Scandinavia and the British Isles.

[3] VII Congress Geol. Internat., 1897, pt. 12.

Composite section of Cambrian-Early Silurian strata of Baltic Russia.



Period.	American equivalents.	Maximum thickness.	Columnar section.	Description of strata.
Silurian.	Upper Cincinnatian (Richmond).	15′		Early Silurian limestone. Formation F. F 2. Borkholm limestone. Massive, siliceous, white limestone. F 1. Lyckholm limestone (upper part). Gray to yellow argillaceous limestone with many corals, *Halysites*, *Calapœcia*, *Heliolites*, etc.
		50′		Middle Ordovician strata. F 1. Lyckholm limestone (lower part). Magnesian limestone holding *Maclurea*, *Subulites*, and other gastropods closely related to American Trenton species.
Ordovician.	Middle Mohawkian (Lowville, Black River, and Early Trenton).	30′		Formation E. Wesenberg limestone. Fossiliferous yellow shale and thin limestone interbedded.
		100′		Formation D. D 3. Wassalem beds. Very fossiliferous thin bedded blue limestone and shale. D 2. Kegel beds. Shaly, fossiliferous limestone. D 1. Jewe beds. Siliceous limestone and shale holding many fossils.
		30′		Formation C. C 3. Itfer limestone. Rather massive, siliceous limestone.
		50′		C 2. Kuckers shale. Unusually fossiliferous bituminous shales, with thin limestone bands.
		50′		C 1. Echinospherites limestone. Thin bedded limestone with many trilobites and cystids.
		20′		"Obere Linsenschicht." Zone of phosphatic pebbles. Formation B. B 3. Orthoceras (Vaginaten) limestone. Rather massive gray limestone crowded with cephalopods. "Untere Linsenschicht." Zone of phosphatic pebbles.
		40′		B 2. Glauconite limestone. Thin bedded, light green to reddish limestone, sandy in the lower part. B 1. Glauconite sandstone. Unconsolidated green sand. Middle Ordovician brachiopods in upper part.
		10′		Dictyonema shales, A 3. Dark brown to reddish bituminous clays holding graptolites, particularly *Dictyonema flabelliformis*.
Canadian.	Beekmantown.	10′		Upper Cambrian, Ungulite sandstone, A 2. Unconsolidated, yellow sandstone. Upper layers crowded with *Obolus apollinis*.
Cambrian.	Saratogan.	60′		Lower Cambrian, blue clay and associated strata, A 1. Unfossiliferous sandstone correlated with the Fucoid sandstone of Sweden.
	Georgian.	300′		Sandstone and clays holding *Mesonacis mickwitzi*. Plastic blue to green clay. Lower sandstone with glauconite grains. Pre-Cambrian granite.

formations, although locally other sediments are present. These two predominating members gave rise to Schmidt's divisions A1 and A2.

A1. Blue clay and associated strata.—This division, corresponding to the Lower Cambrian of the general time scale, is composed mainly of plastic, blue to green clay with sandy layers, resting directly upon pre-Cambrian gneiss and granite. In a well boring near St. Petersburg, a maximum thickness of 300 feet for these clays and associated sandy layers was noted. Interbedded with the clay are sandy layers which, in the lower part of the division, sometimes form a well-defined bed of sandstone. Glauconite grains supposed to be casts of foraminifera, and doubtful remains of algæ, are the only organic remains noted in these lowest beds. Alternating clay and sandstone strata holding large numbers of a very small *Orthoceras*-like fossil named *Volborthella*, and fragments of stalks and arms, probably of cystids, termed *Platysolenites*, succeed the more typical unfossiliferous blue clay which forms the middle division of the formation. Other fossils of this horizon are *Mesonacis mickwitzi*, two species of *Scenella*, medusæ, and the brachiopod, *Mickwitzia monilifera*. The medusæ and the last-mentioned species are known from the Lower Cambrian Eophyton sandstone of Sweden. This fact, in connection with the occurrence of *Mesonacis*, fixes the age of the strata. Thirty to fifty feet of unfossiliferous sandstone succeed this Russian equivalent of the Eophyton sandstone, and upon stratigraphic grounds are correlated with the Fucoid sandstone, the next higher member of the Lower Cambrian in Sweden.

A2. Ungulite sandstone.—The Lower Cambrian is followed by an unconsolidated yellow sandstone quite distinct from the underlying Fucoid sandstone, but bearing a conglomerate composed of fragments of the latter at its base. Phosphatic brachiopods, chiefly *Obolus apollinis*, are exceedingly abundant in the upper beds of this division which has received the name of Ungulite sandstone on account of the resemblance of this brachiopod's muscular impression to the mark of a horse's hoof. The change of sedimentation and the basal conglomerate are indicative of a gap between the two formations, the length of which can not be determined from the Russian section. Comparison with the Swedish section places this Ungulite sandstone in the Upper Cambrian.[1]

Until the present time, the Cambrian strata of Russia, as well as of other countries, have yielded no bryozoans, but the valves of a number of specimens of *Obolus* from the Ungulite sandstone were found to be incrusted with a ctenostomatous-like bryozoan described here in later pages as *Heteronema priscum*.

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[1] Prof. Schuchert has called my attention, too late for correction in the text, to the fact that the sandstone holding *Obolus apollinis* in Sweden is now referred to the basal Ordovician by the Swedish geologists. If this correlation be correct, *Heteronema priscum*, the oldest-known bryozoan, is of more recent age than hitherto supposed.

ORDOVICIAN AND EARLY SILURIAN STRATA.

Very fossiliferous limestones and shales compose the greater portion of the Russian Ordovician. The lowest strata are of dark colored bituminous shales or plastic clays formerly regarded as of Cambrian age, but, with later evidence, now assigned by some authors to the lowest Ordovician. Following these beds is a glauconitic sandstone and then come the more calcareous strata of Middle and Upper Ordovician and Early Silurian age.

A3. Dictyonema beds.—The uppermost strata of Schmidt's Cambrian division A are dark brown to reddish bituminous shales and clay, named for their characteristic fossil *Dictyonema flabelliforme.* These strata, which are thin—indeed often absent—are correlated with similar graptolite beds in Scandinavia, England, and elsewhere, and are probably the only equivalent in Russia of the American Beekmantown. Bryozoans are unknown in these strata.

B1. Glauconite sandstone.—Resting upon the eroded Dictyonema shale, or upon the lower Ungulite sandstone, are loose, more or less unconsolidated green sands of variable thickness, although seldom exceeding 10 feet. These strata have been considered as the base of the Ordovician by von Schmidt, and in the latest edition of Kayser's "Lehrbuch der Geologie, II, Geologische Formationskunde," the Dictyonema shale and the Glauconite sandstone are correlated with the American Beekmantown. The unconformable position of the Glauconite sandstone, and the presence of Middle Ordovician fossils in its upper portion, are indicative that it is, in part at least, the initial deposit of the succeeding limestones and shales.

A very detailed account of the strata and faunas of formation B has been published by Lamansky[1] who recognizes two subdivisions in B1, namely, a lower subdivision (B1a), with the phosphatic brachiopods, *Obolus siluricus* and *O. lingulæformis*, reminders of Cambrian time, as the characteristic fossils, and an upper subdivision (B1b) holding species of *Megalaspis* and of *Orthis*. These Cambrian-like brachiopods are probably persistent forms with little stratigraphic value, but the fauna occurring in the upper part of the greensand where the sand grains are associated with dolomitic material and clay, is composed of typical Middle Ordovician fossils. These species are listed in the accompanying table, where it may be noted that brachiopods and trilobites make up practically the entire list. Comparing this with the preceding and succeeding groups of species, it becomes evident that this is clearly not a derivative of the underlying Cambrian fauna. The general association is much like the succeeding Ordovician faunas, even though entire classes, such as the echinoderms, bryozoans, etc., are unrepresented. Gradually and without break the Glauconite

[1] Die Aeltesten Silurischen Schichten Russlands (Etage B); Mem. Comite Geol., new ser., vol. 20, 1905.

sandstone passes into the Glauconite limestone. The Glauconite sandstone is apparently the record of a transgressing sea and its several parts may therefore be of different ages. No bryozoans have been found in division A3. Likewise none has been recorded from division B1, although it is probable that some of the bryozoans listed as occurring in B2 will also be found in the upper part of B1.

B2. Glauconite limestone.—The presence of scattered glauconite grains gives this limestone a light green tinge, although in places it is of a reddish color with scattered greenish spots. The lowest beds are sandy and are marked by the trilobite *Megalaspis planilimbata* Angelin. The upper beds contain less glauconite and more shale. Throughout gastropods are wanting and cephalopods are rare, but trilobites, brachiopods, and bryozoans are not uncommon. *Orthis parva* Pander, *Porambonites reticulatus*, *P. altus*, *P. parvus*, and *Clitambonites plana* of the same author are the predominating brachiopods, while *Dittopora clavæformis* Dybowski, *D. annulata* Eichwald, *Stictoporella gracilis* (Eichwald), *Dianulites fastigiatus* Eichwald, *D. petropolitanus* Dybowski, and *Diplotrypa bicornis* Eichwald, are the most abundant of the described bryozoans.

Among the trilobites the genus *Asaphus* is well represented, and species of *Pterygometopus*, *Cheirurus*, *Lichas*, and *Ampyx* are present. The peculiar *Bolboporites* and the cystid genera *Glyptocystites* and *Echinoencrinites* make their first appearance here.

A local movement at the end of this division gave rise to slight erosion and to the formation in Esthonia of a thin zone of phosphatic concretions known to the Russian geologist as the "Untere Linsenschichten." West of Reval this band is absent and the Glauconite limestone is followed by a sandstone phase of the overlying Orthoceras limestone. The time break here is slight since the change in fauna is not great.

In his studies Lamansky has recognized three subdivisions in B2 in the government of St. Petersburg, and has described and listed their faunas. The lowest subdivision (B2a) is composed of rather compact, brightly colored limestone layers, rich in glauconite, and 5 to 10 inches thick. This zone, which altogether is only about 6 feet thick, is known as the "horizon with *Megalaspis planilimbata*, *M. limbata*, and *Asaphus priscus*," and contains a fauna of which brachiopods related to those of the underlying division B1b form a considerable part. The strata of subdivision B2b are less compact, thinner limestone layers with some shale, also amounting to about 6 feet in thickness. Glauconite is less abundant in this zone, which receives its designation from the characteristic trilobites *Asaphus bröggeri* and *Onchometopus volborthi*.

Subdivision B2c, the "horizon with *Asaphus lepidurus* and *Megalaspis gibbus*," is a gray, rather compact limestone 8 to 10 feet thick, holding less glauconite than either of the two preceding zones. As the list shows, its fauna is closely related to the preceding as well as the following strata.

Lamansky's subdivisions of B2 and B3 were published after the bryozoans studied were collected, so that I am unable to place the species in their proper zones.

B3. Orthoceras limestone.—This is a hard gray limestone varying from 3 to 20 feet in thickness and crowded with individuals belonging to several species of *Orthoceras* and *Vaginoceras*. The names Orthoceratite, Orthoceras, Vaginoceras, or Vaginaten limestone have at various times been applied to these rocks. Of these, I have selected the name Orthoceras limestone for use in the present work. The phosphatic concretionary layer at the base of the Orthoceras limestone has already been mentioned, as has also the sandy phase of the formation west of Reval. The fauna of the limestone is large and includes a considerable number of cephalopods and gastropods, both of these groups being very sparsely represented in the underlying strata. The trilobites, however, lead in the number of species, with the gastropods second in importance. Among the trilobites are species of *Asaphus*, *Ampyx*, *Megalaspis*, *Pterygometopus*, and *Cybele*, as well as many other genera. The gastropod genera *Maclurea*, *Oxydiscus*, *Salpingostoma*, *Raphistoma*, *Bucania*, *Holopea*, *Clisiospira*, and *Sinuites*, well known in American deposits, are represented. The brachiopods are more abundant than the gastropods in individuals if not specifically, but the bryozoans are rather sparsely represented and belong almost entirely to new species. *Orthis*, *Clitambonites*, *Porambonites*, *Plectambonites*, and *Rafinesquina* are, as usual in these deposits, the most important of the brachiopod genera.

The Orthoceras limestone has been studied carefully by Lamansky, who recognizes three horizons, namely, B3a, the horizon holding *Asaphus expansus* and *A. lamanskii*, B3b, with *Asaphus raniceps* as the characteristic fossil, and B3c, with *Asaphus eichwaldi* and *Ptychopyge globifrons* as horizon markers. The fauna of each of these divisions is indicated in the lists on pages 19 to 25.

Following the Orthoceras limestone is another concretionary layer known as the "Ober Linsenschicht." As many new species and a decided change in lithology occur above this layer, the Russian geologists begin a new formation with the next horizon.

C1. Echinospherites limestone.—Formation C is divided into two well-defined members, namely, C1, a thin-bedded limestone named after its characteristic fossil, a species of *Echinospherites*, followed by C2, a bituminous shale deriving its name from exposures at Kuckers, Esthonia. A third member, C3, a hard limestone 20 to 30 feet thick, with numerous siliceous concretions, has been distinguished at a few localities as the Itfer limestone. The most characteristic fossils of the lowest division, C1, are a cephalopod, *Orthoceras regulare* Schlotheim, in the lower bed, C1a, and the concretionlike cystid *Echinospherites* distinguishing the upper part of the division, C1b. The *Echinospherites, E. aurantium,* is an especially noteworthy fossil on account of its abundance and wide distribution. In America a species of *Echinospherites* that I am unable to distinguish from *E. aurantium* is abundant at numerous localities in the Middle Ordovician rocks of the Appalachian Valley and in the Kimmswick limestone of Black River age in the Mississippi Valley.

Trilobites, gastropods, cystids, and brachiopods are as numerous in the Echinospherites limestone as in the underlying Ordovician formations, and are represented by essentially the same genera. A bryozoan fauna of 23 species, of which 11 are new, is described in the following pages. Of these 23 species, 6 are characteristic fossils of the Black River group of North America.

C2. Kuckers shale (Brandschiefer).—Faunally, the bituminous shales and thin-bedded limestones making up the several members of division C2 are closely related to the limestone of C1, although the bryozoans and ostracods are developed in greater abundance both in species and individuals. The thin bands of bituminous shales in C2 are often crowded with bifoliate and other delicate bryozoans (see pl. 12), while the more solid zoaria of the trepostomatous Bryozoa sometimes entirely compose the thin limestone layers. The strata of this stage, which average from 30 to 50 feet in thickness, are well shown at Kuckers, near Jewe, north of Lake Peipus, but the bryozoans herein described from this formation come from other localities, principally Baron Toll's estate, near Jewe, Esthonia. Most of the Kuckers fossils are probably the best preserved of all from the Russian Ordovician strata, but they have not received the detailed study given to the faunas of other Baltic formations.

A fauna of 46 species of Bryozoa was found in the collections from the Kuckers, with 14 species common to Russia and the Black River group of America.

The ostracode fauna has been carefully studied by Bonnema,[1] who recognizes 34 species distributed among well-known American Middle Ordovician genera, such as *Primitiella, Tetradella, Ceratopsis, Ctenobolbina, Ulrichia,* and *Bollia.* None of these is identified with American forms, although the species are in many instances closely allied. Species closely related to these Kuckers forms occur in the underlying and overlying Ordovician rocks in Russia, but they await description.

The trilobites are less numerous than in the underlying strata, but their genera are essentially the same. The recorded brachiopods are few in species, but this portion of the fauna has not received especial attention.

[1] Beitrag zur Kenntnis der Ostrakoden der Kuckersschen Schicht (C2), Mitteilungen aus dem Mineralogisch-Geologischen Institut der Reichs-Universitat zu Gronongen, vol. 2, pt. 1, 1909.

C3. Itfer beds.—In the vicinity of Itfer, north of Wesenberg, in Esthonia, a hard limestone 20 to 30 feet in thickness, bearing siliceous concretions, succeeds the shaly Kuckers zone and forms a passage bed to the richly fossiliferous Jewe formation. Although the described species are less numerous, the fauna of these Itfer beds is essentially the same as in the other members of division C. Only one bryozoan from these Itfer beds, *Batostoma granulosum*, has come to my notice.

D1. Jewe limestone.—Very fossiliferous, impure limestone and shale, averaging 100 feet in thickness, compose formation D, in which three divisions are recognized by the Russian students, (1) a lower zone of siliceous limestone and shales well exposed near Jewe and termed the Jewe limestone, (2) more shaly strata known as the Kegel beds, and (3) very fossiliferous thin-bedded, blue limestones and shales well shown at Wassalem, whence they derive their name. The species of these three divisions are much alike, and likewise are quite similar to many of the forms in formation C.

The cystids, trilobites, and gastropods are the only groups of D1 which have hitherto received detailed study. The collections of bryozoans from the Jewe limestone were not very extensive, but they showed 29 species, of which 8 are identical with American Middle Ordovician forms.

D2. Kegel beds.—The shaly strata making up this division have received probably less study than the Jewe limestone, judging from the list of described species, but from a few samples before me, I should judge the fauna to be a large and varied one. A fragment of limestone less than half a cubic inch in size, preserved only for a trilobite head upon it, was found upon thin sectioning to contain no less than 9 species of Bryozoa. This fragment and a few additional specimens afforded the 12 species of Kegel bryozoans noted in this paper.

D3. Wassalem beds.—The thin-bedded, blue, argillaceous limestone and shale of this division is the most fossiliferous of all the Russian formations as far as bryozoans are concerned. Some of the layers are literally one mass of these organisms, as is evident from plate 13, which represents the surface of one of the thin limestone layers.

The preservation of the specimens from D3 is most beautiful on the exterior, but the interior is sometimes destroyed by a form of dolomitization. Similar conditions of preservation prevail in the Ordovician (Decorah shales) bryozoans of Minnesota, and the lithologic resemblance of the strata comprising the Russian division D3 to these American beds is most striking. This lithologic similarity is borne out in the bryozoan faunas of the two areas, for of the 43 species now known from the Wassalem, 26 are American Middle Ordovician forms. A glance over the table on page 50, giving the list of species with their distribution, will show the large percentage of typical Black River species. The large number of species determined from the Wassalem beds was made possible by the study of the Mickwitz collection which was especially rich in bryozoans from this division.

E. Wesenberg limestone.—Succeeding the Jewe limestone is an equally fossiliferous and widespread formation of thin limestone and shale named from its occurrence at Wesenberg. Both the limestones and shales of the Wesenberg are of a yellowish color and seldom exceed 30 feet in thickness.

The fauna of the Wesenberg limestone is strikingly like that of the lowest Trenton strata of the United States, classed under the names Clitambonites, Nematopora, and Fusispira beds. Several species of *Clitambonites* occur in the Wesenberg, and in America the earliest occurrence of the genus is in the bed named for it. At least one of the species in the two areas is not very dissimilar. Other species of brachiopods which are common to the two beds, or are represented by closely related forms, are *Dalmanella testudinaria* (small variety), *Plectorthis plicatella, Plectambonites sericeus* (variety), *Strophomena* cfr. *scofieldi*, and *Rafinesquina* cfr. *deltoidea.*

The Russian Wesenberg pelecypods have not been studied in detail, but specimens before me, in a few cases, resemble American forms. The gastropods of both areas are well known and show some similarity; thus the large *Pleurotomaria insignis* Eichwald is certainly the same as *Hormotoma major* Hall, from the earliest Trenton of Missouri and Minnesota, and the Russian examples of *Maclurea neretoides* Goldfuss are close to American species. Among the corals a *Protarea* and a *Streptelasma* like *S. profundum*, are represented in each area. Considerable resemblance is shown in the bryozoans, indeed, a slab of the Wesenberg limestone covered with numerous examples of *Hallopora goodhuensis, Eridotrypa ædilis* and variety *minor, Pachydictya elegans,* and with the incrusting *Corynotrypa inflata,* resembles very greatly material from the Clitambonites bed.

F. Lyckholm and Borkholm.—The uppermost strata of the Baltic region assigned to the Ordovician by authors, comprise gray to white limestones attaining a thickness of 65 feet and restricted to Esthonia and the islands of Worms and Dago. Schmidt recognized two zones in this formation, which he designated F, a lower Lyckholm zone (F1), of gray and yellow, sometimes dolomitic limestone, and an upper Borkholm zone (F2), of hard, white siliceous limestone. The faunas of the Borkholm and of the upper part of the Lyckholm are essentially the same and upon their evidence no necessity exists for recognizing two zones. The bryozoans, ostracods, and corals of these beds are of genera and often of species characteristic of the Richmond formation of America. Among the corals, for example, are species of *Tetradium, Favosites, Heliolites, Plasmopora,* and *Calapœcia,* an assemblage of forms that, on the whole, is distinctly Silurian in character. A similar coral zone is widespread in the Richmond group of western North America, where it follows argillaceous and magnesian rocks of Galena-Trenton age.

Although there is no direct evidence in published work, it seems probable that a similar Galena-Trenton zone underlies the coral beds of the Lyckholm. In a fauna collected from the lower Lyckholm by Prof. Schuchert, every species is closely related to forms from the typical Galena of the Mississippi Valley, and elsewhere in North America. At many places to the north, west, and east of Minnesota the Galena fauna is followed directly by the coral bed of the Richmond. In America the lithology of these Galena-Trenton and Richmond strata is so similar that both have been uniformly included in a single magnesian limestone formation. Without the evidence of the fossils the presence of a great time break in this formation might not be suspected. The bryozoans of the lower Lyckholm are, like those of the American Galena, distinctly Trenton in character, while those of the upper Lyckholm and Borkholm include characteristic American Richmond species.

These latter strata also contain small forms of an undoubted *Atrypa*, *Leptæna rhomboidalis*, a typical *Streptis*, a *Stricklandinia*, and other brachiopods of Silurian affinities. Of the 19 species of Bryozoa identified in the Lyckholm, 5 can not be considered in correlation, as they are here described for the first time. Five additional species of the list either are known to come from the lower beds of the formation or are long ranged geologically. Of the remaining 9, *Corynotrypa abrupta* Bassler, *Nematopora fragilis* Ulrich, and *Anaphragma mirabile* Ulrich and Bassler are characteristic Richmond fossils, while *Corynotrypa dissimilis* (Vine), *Pachydictya bifurcata* (Hall), *Glauconome plumula* Wiman, *Orbignyella expansa baltica*, new variety, and *Hallopora elegantula* (Hall) are either identical or closely related to typical Silurian bryozoans. Thus on the evidence of the bryozoans the upper Lyckholm is of early Silurian age.

The bryozoan fauna of the Borkholm is clearly of Silurian age, since practically every species is of a well-known Richmond or early Niagaran type. The list of the strictly Borkholm species, with their occurrence in America or their American representative added in parentheses, follows:

List of Borkholm Bryozoa.

Corynotrypa dissimilis (Vine) (Niagaran of America.)
Ptilodictya flabellata Eichwald (*Ptilodictya expansa* Hall).
Ptilodictya gladiola Billings (Richmond of America).
Pachydictya bifurcata (Hall) (Niagaran of America).
Sceptropora facula Ulrich (Richmond of America).

Nematopora lineata (Billings) (Richmond of America).
Glauconome plumula Wiman (*Glauconome* sp., Niagaran of America.)
Glauconome strigosa (Billings) (Richmond of America).
Lichenalia concentrica Hall (Niagaran of America).
Hallopora elegantula (Hall) (Niagaran of America).
Chasmatopora tenella (Eichwald) (*Chasmatopora angulata* Hall, in early Niagaran of America).
Fenestella striolata Eichwald (*Fenestella granulosa* Whitfield, Richmond of America).
Protocrisina exigua Ulrich (Richmond of America).
Phænopora ensiformis (Hall) (Early Niagaran of America).
Pseudohornera orosa (Wiman).

In the following table I have given the figures showing the total number of bryozoan species in the various Russian formations in the first column and the number of American species common to the two areas in the second. With scarcely an exception, all of these American Middle Ordovician species are from the Black River group and the earliest Trenton, while the American species, found also in the upper Lyckholm and Borkholm, are all of early Silurian types.

Summary of Baltic and American Ordovician and Early Silurian Bryozoa.

Formation.	Total number of Baltic species.	Number of species common to American and Baltic areas.
Early Silurian.		
Borkholm limestone (F2)	15	10
Lyckholm limestone (F1) (including the lower part, of possible Middle Ordovician age)	19	10
Middle Ordovician.		
Wesenberg limestone (E)	24	10
Wassalem beds (D3)	43	26
Kegel beds (D2)	12	1
Jewe limestone (D1)	29	8
Itfer beds (C3)	1	0
Kuckers shale (C2)	46	11
Echinospherites limestone (C1)	23	6
Orthoceras limestone (B3)	14	2
Glauconite limestone (B2)	11	2

Summarizing the foregoing remarks, it would appear, from a study of the Bryozoa, at least, that the Russian Baltic section is far from complete; indeed, is composed of fragments only of the great North American sequence. Thus the entire Cambrian is represented by only a few hundred feet of strata, and all of the Canadian by the thin Dictyonema beds, probably of Beekmantown age. Beginning with the invading Glauconite sandstone and continuing until the close of the Wesenberg, the faunas are uniformly of Middle Ordovician age and represent the Black River and earliest Trenton formations of the American section. A later Trenton horizon is probably represented in the lower Lyckholm. The remainder of the Lyckholm and all of the Borkholm are, in American terms, of Richmond (earliest Silurian) age.

PALEONTOLOGY OF THE BALTIC AREA.

Although it was my intention to treat only of the Russian Ordovician bryozoan faunas, it became necessary, in order to get an idea of the associated forms, to compile lists showing the distribution of the other groups of organisms. As such lists of these Russian species have never been assembled in one publication, they are reproduced herewith for the benefit of future workers on these faunas. These lists, however, do not contain all the species that have been named, for Eichwald especially has described a large number which are not included because they have never been assigned to any horizon other than the "calcaire à Orthoceratites," which includes all of the formations from B to F, inclusive. Similar lists of the Ordovician fossils of the upper Mississippi Valley are given in part 2, volume 3, of the Minnesota Geological Survey, to which the student is referred when making comparisons between the two areas. The following lists, however, do not include the Bryozoa, which are tabulated on a later page.

MISCELLANEOUS.

Astylospongia globosa Eichwald, B3.
Aulocopella cepa (Roemer) F1.
Aulocopium aurantium Oswald, F1, ?F2.
Cyclocrinus spasski Eichwald, D3, F1.
Mastopora concava Eichwald, D1, E.
Phyllograptus sp., B3.
Receptaculites eichwaldi Schmidt, D1.
Receptaculites orbis Eichwald, C1.
Siphonia cylindrica Eichwald, B1.
Solenopora spongioides Dybowski, D3, D1, C1, F1. (=*S. compacta* Billings).
Stromatopora mammillata Schmidt, F2.

ANTHOZOA.

Acantholithus asteriscus Roemer, F1, F2.
Alveolites? *hexagona* Schmidt, F1.
Coccoseris megastoma var. *minor* Lamansky, F1.
Coccoseris micraster Lamansky, F1.
Coccoseris microporus Eichwald, F2.
Coccoseris ungerni Eichwald, F1.
Coelophyllum amalloides Dybowski, F2.
Columnaria fascicula Kutorga, F1, F2.
Cyathophyllum middendorfii Dybowski, F2.
Endophyllum contortiseptatum var. *præcursor* Weissern, F2.
Favosites asper d'Orbigny, F2.
Halysites catenularius Linnæus, F1, F2.
Halysites escharoides Lamarck, F1, F2.
Halysites parallela Schmidt, F1, F2.
Halysites undulata Kiaer, F1, F2.
Heliolites hirsutus Lamansky, F1.
Heliolites interstinctus, Linnæus, F1.
Heliolites parvistella Roemer, F1.
Labechia conferta Edwards and Haime, F1.
Petraia darcoceras Dybowski, F1.
Petraia silurica Dybowski, F1.
Pholidophyllum tubulatum Schlotheim, F2.
Proheliolites dubius Schmidt, F1.
Propora bacillifera Lamansky, F1, F2.
Propora cancellata Lamansky, F2.
Propora conferta Edwards and Haime, ?F1, F2.
Propora tubulata Edwards and Haime, F1.
Protarea vetusta Hall, F1.
Protarea sp., E.
Streptelasma cfr. *profundum* Hall, E.
Streptelasma corniculum Hall, F1.
Streptelasma elongatum Phillips, F2.
Streptelasma europæum Roemer, F1, F2.
Calapœcia cribriformis Nicholson, F2.
Syringophyllum organon Linnæus, F2.
Tetradium sp., F2.

ECHINODERMATA.

Asteroblastus foveolatus (Eichwald), B3.
Asteroblastus sublævis Jaekel, B2a.
Asteroblastus tuberculatus Schmidt, B3.
Asteroblastus volborthi Schmidt, B3.
Asterocrinus munsteri Eichwald, B2a.
Blastoidocrinus sp., B3.
Bolboporites sp., B3a, B3b.
Bolboporites semiglobosa Pander, B2a, B2b, B2c.
Bolboporites triangularis Pander, B2a, B2b, B2c.
Bolboporites triangularis var. *uncinata* Pander, B2a, B2b, B2c.
Caryocystites aranea Schlotheim, C1.
Caryocystites balticus (Eichwald), C1.
Chirocrinus atavus Jaekel, B3.
Chirocrinus degener Jaekel, B3, C1.
Chirocrinus giganteus Leuchtenberg, B2a, B2b.
Chirocrinus granulatus Jaekel, C2.

Chirocrinus insignis Jaekel, B3.
Chirocrinus ornatus Eichwald, B3.
Chirocrinus penniger (Eichwald), B3.
Chirocrinus radiatus Jaekel, B3.
Chirocrinus striatus Jaekel, B3.
Chirocrinus sculptus Schmidt, B3.
Chirocrinus volborthi (Schmidt), B3.
Cryptocrinus lævis Pander, C1.
Cyathocrinus? exilis Eichwald, B2b, B2c.
Cyathocystis plautinæ Schmidt, C1.
Cyathocystis rhizophora Schmidt, D3.
Cystoblastus kokeni Jaekel, C2.
Cystoblastus leuchtenbergi Volborth, C1.
Dactylocystis mickwitzi Jaekel, D3, E.
Dactylocystis schmidti Jaekel, D3.
Echinoencrinites angulosus Pander, B2a, B2b, B2c, B3.
Echinoencrinites angulosus var. *compta* Jaekel, B3.
Echinoencrinites angulosus var. *quadrata* Jaekel, B3.
Echinoencrinites lævigatus Jaekel, B3a.
Echinoencrinites lahuseni Jaekel, B3.
Echinoencrinites reticulatus Jaekel, B2c, B3.
Echinoencrinites senckenbergi Muller, B3a.
Echinoencrinites senckenbergi var. *interlævigata* Jaekel, B3a.
Echinoencrinites striatus (Pander), B3.
Echinospherites aurantium (Gyllenhahl), C1, C2, C3, D1, D3.
Echinospherites difformis Jaekel, C3, D3.
Echinospherites pirum Jaekel, C3, D3.
Erinocystis angulata Jaekel, B3.
Erinocystis sculpta Jaekel, B3.
Erinocystis volborthi Jaekel, B3.
Glaphyrocystis compressa Jaekel, F1.
Glaphyrocystis wohrmanni Jaekel, F1.
Glyptocystites sp., B3a.
Glyptocystites giganteus Linnæus, B2c.
Glyptosphærites leuchtenbergi Angelin, B3.
Haplocrinus? monile Eichwald, B2a, B2b, B2c.
Hemicosmites extraneus Eichwald, D3.
Hemicosmites grandis Jaekel, F1.
Hemicosmites lævis Jaekel, C1.
Hemicosmites malum Pander, C1.
Hemicosmites pocillum Jaekel, D3.
Hemicosmites pulcherrimus Jaekel, D3.
Hemicosmites rudis Jaekel, D3.
Hemicosmites tricornis Jaekel, F2.
Hemicosmites verrucosus Eichwald, F1.
Hybocrinus dipentus Lindstrom, C1, C2.
Mesocystis pusyrewskii Hoffman, B2b, B3.
Pentacrinus? antiquus Eichwald, B2c.
Protocrinites fragum Eichwald, C1.
Scoliocystis pumila (Eichwald), B3.
Scoliocystis thersites Jaekel, B3.

A number of other species of echinoderms, especially crinoids, were described by Eichwald, but almost all of them require restudy to determine their exact position in the section. Among these was the first echinoid, *Bothriocidaris globulus* Eichwald.

BRACHIOPODA.

Atrypa imbricata Sowerby, F1, F2.
Atrypa marginalis Dalman, F2.
Atrypa cf. *nodostriata* Hall, F2.
Atrypa undifera Schmidt, F2.
Aulacomerella angusta Huene, F1.
Aulacomerella macroderma (Eichwald), F1.
Christiania oblonga (Pander), C1.
Clitambonites adscendens (Pander), B3b, B3c, C1.
Clitambonites anomala (Schlotheim), D, E.
Clitambonites concava (Pahlen), B3b, B3c.
Clitambonites emarginata (Pahlen), E.
Clitambonites hemipronites (de Buch), C1.
Clitambonites inflexa (Pander), B3a, B3b, B3c, C1.
Clitambonites ingrica (Pahlen), B2a, B2b, B2c.
Clitambonites marginata (Pahlen), C2.
Clitambonites ornata (Verneuil), B3b, B3c.
Clitambonites plana (Pander), B2a, B2b, B2c.
Clitambonites plana var. *alta* (Pahlen), B2a, B2b.
Clitambonites plana var. *excavata* (Pahlen), B2c.
Clitambonites pyramidalis (Pahlen), C2.
Clitambonites pyron (Eichwald), B3b, B3c, C1, D.
Clitambonites radians (Eichwald), B3a.
Clitambonites sinuata (Pahlen), F1, F2.
Clitambonites squamata (Pahlen), C2.
Clitambonites trigonula (Eichwald), B3b.
Clitambonites verneuili (Eichwald), F1, F2.
Clitambonites wesenbergensis (Pahlen), E.
Craniella? papillifera Huene, F1.
Dalmanella testudinaria (Dalman), C1, D, E.
Dinobolus schmidti Davidson, F1.
Discina gibba Lamarck, F2.
Eleutherocrania gibberosa Huene, F1, F2.
Leptæna imbrex Pander, B3a, B3b.
Leptæna nefedjewi Eichwald, B3a, B3b, B3c.
Leptæna rhomboidalis (Wilckens), F2.
Leptæna schmidti Tornquist, F1, F2.
Lingula birugata Kutorga, B3a, B3b, B3c.
Lingula lata Pander, B3c.
Lingula longissima Pander, B2b, B2c.
Lingula quadrata Eichwald, F1.
Lycophoria nucella Dalman, B3a, B3b, B3c.
Obolus siluricus Eichwald, B1.
Obolus lingulæformis Mickwitz, B1.
Orthis abcissa Pander, B2a, B1b.
Orthis actoniæ Sowerby, F1, F2.
Orthis bocki Lamansky, B1b.
Orthis callactis Dalman, B3a, F1.
Orthis calligrama Dalman, B3a, B3b, B3c, C2.
Orthis christianiæ Kjerulf, B1b.
Orthis concinna Lamansky, F1.
Orthis elegantula mut. *estona* Wysogorski, F1.
Orthis extensa Pander, B3a, B3b.
Orthis flabellulum Sowerby, F1.
Orthis incurvata Lamansky, B1b.
Orthis lyckholmensis Wysogorski, F1.
Orthis obtusa Pander, B2b, B2c.
Orthis obtusa var. *eminens* Verneuil, B3a.
Orthis orthambonites Verneuil, B2a, B2c.
Orthis oswaldi von Buch, F1, F2.
Orthis parva Pander, B2a, B2b, B2c.
Orthis parva Pander, var., B3a, B3b.
Orthis parvula Lamansky, B1b.
Orthis recta Pander, B1b.
Orthis sadewitzensis Roemer, F1, F2.
Orthis schmidti Wysogorski, B2a.
Orthis solaris von Buch, F1.
Orthis striata Pander, B1b.
Orthis tetragona Pander, B2a, B1b.
Orthis tetragona var. *lata* Pander, B1b.
Orthis transversa Pander, B1b.
Orthis transversa var. *latestriata* Lamansky, B1b.
Orthis vespertilio Sowerby, F1.

Philhedra rivulosa Kutorga, B3c.
Platystrophia biforata (Schlotheim), E.
Platystrophia biforata lynx Eichwald, F1, F2.
Platystrophia bifurcata (Eichwald), C1.
Platystrophia chama (von Buch), C2.
Plectambonites sericeus (Sowerby), E, F2.
Plectambonites transversa (Pander), C1.
Plectella eminens Lamansky, B1b.
Plectella extensa Lamansky, B1b.
Plectella gracilis, Lamansky, B1b.
Plectella media Lamansky, B1b.
Plectella obtusa Lamansky, B1b.
Plectella semiovata Lamansky, B1b.
Plectella unciniata Lamansky, B1b.
Plectorthis plicatella (Hall), E.
Porambonites æquirostris Schlotheim, C1.
Porambonites altus Pander, B2a, B2b, B2c.
Porambonites bröggeri Lamansky, B1b.
Porambonites deformata Eichwald, C1.
Porambonites gigas Eichwald, E, F1.
Porambonites intercedens Pander, B3a, B3b, B3c.
Porambonites parvus Pander, B2a, B2b, B2c.
Porambonites planus Pander, B2a, B2b, B2c.
Porambonites reticulatus Pander, B2b, B2c.
Porambonites teretior (Eichwald), C2.
Porambonites triangularis Pander, B2a, B2b, B2c.
Pseudocrania antiquissima Eichwald, B3c.
Pseudocrania cranoides Huene, F1, F2.
Pseudocrania depressa Eichwald, D.
Pseudocrania petropolitana Pander, B2b, B2c.
Pseudocrania planissima Eichwald, C1, C2.
Pseudocrania scutella Huene, B3a, B3b, B3c.
Pseudometoptoma concentricum Huene, F1, F2.
Pseudometoptoma curvatum Huene, F1.
Pseudometoptoma monopleurum Huene, F1, F2.
Pseudometoptoma siluricum Eichwald, B3c.
Rafinesquina imbrex (Pander), C1.
Siphonotreta unguiculata Eichwald, B3a, B3b, C1, C2.
Siphonotreta verrucosa Eichwald, B2b, B2c.
Streptis sp., F2.
Stricklandinia sp., F2.
Strophomena assmussi Verneuil, D, F1.
Strophomena deltoidea Conrad, E, F1.
Strophomena expansa Sowerby, F2.
Strophomena jentzschi Gagel, B3a, B3b, B3c.
Strophomena luna Tornquist, F1, F2.
Strophomena rugosa Blainville, D, E.
Strophomena near *scofieldi* Winchell and Schuchert, E.
Strophomena semipartita Roemer, F1.
Strophomena tenuistriata Sowerby, F1, F2.
Triplecia dorsata (Hisinger), C2.
Triplecia insularis Eichwald, F1.

CEPHALOPODA.

Cyrtoceras angulosum Schmidt, F1.
Cyrtoceras archiaci Verneuil, B3c.
Cyrtoceras sphinx Schmidt, F1.
Discoceras antiquissimum (Eichwald) F1, F2.
Endoceras commune Wahlenberg, B3c.
Endoceras duplex Schlotheim, B3b, B3c.
Endoceras hasta Eichwald, F1.
Endoceras trochleare Hisinger, B3a, B3b, B3c.
Endoceras vaginatum Schlotheim, B3a, B3b, B3c.
Estonioceras ariense Schmidt, B3c.
Estonioceras imperfectum Schlotheim, B3c.
Estonioceras perforatum Schroeder, B3c.
Gomphoceras sp., E.
Gomphoceras lituus Hisinger, C1.
Gomphoceras odini Verneuil, C1.
Orthoceras arcuolyratum Hall, F1.
Orthoceras atavus Brögger, B1b.
Orthoceras calamiteum Portlock, F2.
Orthoceras cuneolus Eichwald, F1.
Orthoceras exaltatum Eichwald, F1.
Orthoceras fenestratum Eichwald, F1.
Orthoceras ibex Eichwald, F1.
Orthoceras regulare Schlotheim, C1.
Planctoceras falcatum Schlotheim, B3c.

PTEROPODA.

Conularia sp., B3a.
Conularia buchi Eichwald, B2c.
Conularia quadrisulcata Leuchtenberg, B3b.
Conularia cf. *trentonensis* Hall, F1.
Hyolithes acutus Eichwald, B3c.
Hyolithes striatus Eichwald, C2.
Tentaculites sp., E.
Tentaculites anglicus Salter, F1.
Tentaculites annulatus Schlotheim, F2.

PELECYPODA.

Ambonychia radiata Hall, F1, F2.
Modiola devexa Eichwald, F1.
Modiola incrassata Eichwald, F1.

Twenty-eight species of Ordovician pelecypods belonging to *Avicula*, *Pterinea*, *Modiolopsis*, *Cypricardia*, *Grammysia*, and other genera, are described by Eichwald, but are not more definitely located geologically.

GASTROPODA.

Bucania contorta Eichwald C1, D1, D2, C1, F1.
Bucania cornu Koken, F1.
Bucania crassa Koken, F1.
Bucania crassiuscula Koken, D1, D2.
Bucania cycloides Koken, D2.
Bucania cycloides Koken, mut., F1.
Bucania radiata (Eichwald), C1, C2, C3, D1, D2, E, F1.
Bucania radiata (Eichwald), mut. *macer* Koken, B3.
Bucania salpinx Koken, C1.
Bucaniella conspicua Koken.
Bucaniella decurrens (Eichwald), B3.
Bucaniella jugata Koken, C1.
Bucaniella jugata Koken, mut., C2.
Bucaniella lateralis Koken, D1, D2.
Bucaniella lineata Koken, D1, D2.
Bucaniella obtusangula Koken, C1, D1, D2.
Bucaniella revaliensis Koken, B3.
Bucaniella rudicostata Koken, C1.
Bucaniella silurica (Eichwald), B3.
Bucaniella undata Koken, C1.
Clisiospira ingrica Koken, B3.
Cyclonema lineatum Koken, D2.
Cymbularia aequalis Koken, F1.
Cymbularia angusta Koken, C1.
Cymbularia cultrijugata Koken, D1, D2.
Cymbularia galeata Koken, C1, C2.
Cyrtolites grandis Koken, C1.
Carinaropsis rostrata (Eichwald), C1, D1, D2, ?E.
Carinaropsis rostrata (Eichwald), mut., B3.
Eccyliopterus centrifugus Koken, C1.

Eccyliopterus increscens (Eichwald), C1.
Eccyliopterus increscens (Eichwald), mut., C2.
Eccyliopterus tolli Koken, C2.
Ectomaria kirnaensis Koken, F1.
Ectomaria nieszkowskii Koken, F2.
? *Eunema piersalense* Koken, F1.
? *Eunema rupestre* (Eichwald), F1, F2.
? *Eunema rupestre* var. *sulcifera* Eichwald, F1.
? *Eunema schmidti* Koken, F1, F2.
Euomphalus carinifera Koken, F1.
Euomphalus devexus Eichwald, C1, C2, C3, D1, D2.
Euomphalus dimidiata Koken, F2.
Euomphalus gradatus Koken, F1, F2.
Euomphalus helocoides Koken, F2.
Euomphalus laminosus Koken, F1.
Euomphalus turbiniformis Koken, D1, D2.
Gonionema angulosum Koken, C1.
Gonionema angulosum var. *cingulata* Koken, B3.
Gonionema gradatum Koken, B3.
Gonionema reticulatum Koken, B3.
Helicotoma superba Koken, F2.
Holopea ampullacea Eichwald, F1.
Holopea ampullacea var. *coronata* Koken, F1.
? *Holopea eichwaldi* Koken, B3, C1.
Holopea nitida Koken, B3.
Isospira bucanioides Koken, D1, F1.
Lytospira anguina Koken, C3.
Lytospira evolvens Koken, C1.
Lytospira tubicina Koken, B3.
Lytospira valida Koken, F1.
Maclurea dilatata Koken, B3.
Maclurea helix Eichwald, B3, B3c.
Maclurea neritoides Eichwald, F1.
Maclurea planorbis Koken, B3.
Murchisonia exilis Eichwald, E, F1.
Murchisonia insignis Eichwald, F1.
Murchisonia insignis Eichwald, mut., E.
Murchisonia meyendorfii Koken, F2.
Murchisonia scrobiculata Koken, F1.
Murchisonia spectabilis (Schmidt), F1.
Oxydiscus ingricus (Verneuil), B3.
Oxydiscus planissimus (Eichwald), D2.
Palæacmœa constricta (Eichwald), C1.
Platyceras constrictum Koken, D1, D2.
Platyceras meyendorfi Koken, D2.
Pleurotomaria baltica Eichwald, E.
Pleurotomaria chamæconus Koken, F1.
Pleurotomaria elliptica (Hisinger), B3, C1, C2, E.
Pleurotomaria elliptica (Hisinger), mut., C3.
Pleurotomaria inflata Koken, C1, C2, B3.
Pleurotomaria lahuseni Koken, D1.
Pleurotomaria lenticularis Hall, E.
Pleurotomaria maritima Koken, C1.
Pleurotomaria nodulosa Schmidt, F1.
Pleurotomaria notabilis Eichwald, F1.
Pleurotomaria notabilis Eichwald, mut., C3.
Pleurotomaria notabilis Eichwald, mut., C2.
Pleurotomaria notabilis Eichwald, mut., D1, D2.
Pleurotomaria nötlingi Koken, F1.
Pleurotomaria numismalis Koken, F1.
Pleurotomaria plicifera Eichwald, F1.
Pleurotomaria rossica Koken, C1, C2.
Pleurotomaria rotelloidea Koken, F1.
Pleurotomaria rudissima Koken, B3.
? *Polytropis cingulata* Koken, B3, C1.
Pollicina corniculum Eichwald, B3.
Pollicina crassitesta Koken, B3.
Pycnomphalus borkholmensis Koken, F1, F2.
Raphistoma acutangulum Koken, C2.
Raphistoma acutangulum Koken, mut., D1.
Raphistoma applanatum Koken, B3.
Raphistoma lineolus (Eichwald), B3, C1.
Raphistoma marginale Koken, C1.
Raphistoma marginale Koken, mut., C2.
Raphistoma marginale Koken, mut., C3.
Raphistoma marginale Koken, mut., D1, D2.
Raphistoma mutans Koken, C1.
Raphistoma qualteriatum Schlotheim, B3, B3a, B3b, B3c.
Raphistoma scalare Koken, C1.
Raphistoma scalitoides Koken, B3, ?C1.
Raphistoma wesenbergense Koken, E.
Salpingostoma carrolense Koken, C1.
Salpingostoma compressum (Eichwald), C2.
Salpingostoma dilatatum (Eichwald), F1.
Salpingostoma locator (Eichwald), B3, B3c.
Salpingostoma megalostoma (Eichwald), C1.
Sinuites sp., B3a.
Sinuites sp., B3c.
Sinuites sp., B3b.
Sinuites bilobatus Sowerby, F1.
Sinuites bilobatus Sowerby, mut., D1, D2.
Sinuites bilobatus Sowerby, mut., E.
Sinuites nanus Eichwald, B3, C1.
Sinuites naviculoides Koken, B3.
Sinuites rugulosus Koken, B3, C1.
Sinuites rugulosus Koken, mut., C2.
Subulites amphora Eichwald, D1, D2.
Subulites bullatus Koken, F1.
Subulites gigas Eichwald, F1.
Subulites inflatus Eichwald, E, F1.
Subulites peregrinus (Schlotheim), C1, C2.
Subulites subula Koken, E, F1.
Subulites subula var. *revaliensis* Koken, C1, C3.
Subulites wesenbergensis Koken, E.
Temnodiscus accola Koken, C1, C3, D1, D2.
Temnodiscus secans Koken, B3.
Trochonema minor Koken, F2.
Trochonema panderi Koken, F2.
Trochonema peraltum Koken, F2.
Tryblidium esthonum Koken, F2.
Tryblidium lindstromi Koken, F2.
Turbo balticus Koken, C1, D1, D2.
Worthenia aista Koken, F1.
Worthenia borkholmensis Koken, F2.
Worthenia esthona Koken, F1.
Worthenia esthona Koken, mut., D1, D2.
Worthenia esthona Koken, mut., C2, C3.
Worthenia initialis Koken, B3.
Worthenia mickwitzi Koken, C1, C2, C3, D1, D2.
Worthenia mickwitzi Koken, mut., E.
Worthenia silurica (Eichwald), C1, C2, C3, B3, D1, D2, F1.
Worthenia tolli Koken F2.
Worthenia vermetus Koken, F1.

OSTRACODA.

Bollia granulosa Krause, C2.
Bollia minor var. *kuckersiana* Bonnema, C2.
Bollia minor var. *robusta* Bonnema, C2.
Bollia ornata (Krause), C2.
Bollia ornata var. *latimarginata* Bonnema, C2.
Ceratopsis cornuta (Krause), C2.
Ceratopsis schmidti Bonnema, C2.

Ctenobolbina carinata (Krause), C2.
Ctenobolbina kuckersiana Bonnema, C2.
Ctenobolbina (*Entomis*) *obliqua* var. *kuckersiana* (Bonnema), C2.
Ctenobolbina (*Entomis*) *oblonga* var. *kuckersiana* (Bonnema), C2.
Ctenobolbina (*Primitia*) *rossica* (Bonnema), C2.
Cytherellina jonesii Bonnema, C2.
Cytherellina krausei Bonnema, C2.
Cytherellina ruedemanni Bonnema, C2.
Cytherellina ulrichi Bonnema, C2.
Entomis quadrispina Krause, C2.
Entomis variolaris Bonnema, C2.
Eurychilina (*Primitia*) *decumana* (Bonnema), C2.
Eurychilina (*Primitia*) *dentifera* (Bonnema), C2.
Eurychilina (*Entomis*) *flabellifera* (Krause), C2.
Eurychilina (*Primitia*) *kapteyni* (Bonnema), C2.
Eurychilina (*Primitia*) *kuckersiana* Bonnema, C2.
Leperditia brachynota Schmidt, F2.
Macronotella kuckersiana Bonnema, C2.
Primitia esthonica Bonnema, C2.
Primitia molli Bonnema, C2.
Primitia tolli Bonnema, C2.
Primitiella kuckersiana Bonnema, C2.
Tetradella calkeri Bonnema, C2.
Tetradella calkeri var. *convexa* Bonnema, C2.
Tetradella (*Strepula*) *kuckersiana* Bonnema, C2.
Tetradella (*Strepula*) *kuckersiana* var. *acuta* Bonnema, C2.
Ulrichia cf. *bidens* Krause, C2.
Ulrichia kuckersiana Bonnema, C2.

Although not as abundant as in the Kuckers shale, Ostracoda are present in all the Russian formations except A and B1. A few of them have been described, but not definitely placed in the section.

TRILOBITA.

Acidaspis kuckersiana Schmidt, C2.
Acidaspis kuckersiana var. *mickwitzi* Schmidt, D2.
Agnostus glabratus var. *ingrica* Schmidt, B2a, B2b.
Agnostus glabratus var. *insignis* Schmidt, B2c.
Amphion brevicapitatus Lamansky, B2b, B2c.
Amphion fischeri Eichwald, B3a, B3b, B3c, B2c.
Ampyx dubius Schmidt, C1a.
Ampyx knyrkoi Schmidt, B2c.
Ampyx linnarssoni Schmidt, B2a.
Ampyx nasutus Dalman, B2c, B3a, B3b.
Ampyx rostratus Dalman, C1b, C2.
Ampyx volborthi Schmidt, B3a, B3b.
Apatocephalus serratus Sars and Boeck, B1b, B2b, B2a, B2c.
Arges wesenbergensis Schmidt, E, F1.
Asaphus acuminatus Sars and Boeck, B3a.
Asaphus bröggeri Schmidt, B2b.
Asaphus cornutus Pander, C1a.
Asaphus cornutus var. *holmi* Schmidt, C1a.
Asaphus delphinus Lawrow, C1a.
Asaphus devexus Eichwald, C1b.
Asaphus devexus var. *applanata* Schmidt, C1a.
Asaphus eichwaldi Schmidt, B3b, C1a.
Asaphus eichwaldi var. *expansoides* Lamansky, B3c.
Asaphus eichwaldi var. *lepiduroides* Lamansky, B3c.
Asaphus expansus Dalman, B3a.
Asaphus kowalewskii Lamansky, B3c, C1a.
Asaphus lævissimus Schmidt, C1a.
Asaphus lævissimus var. *laticauda* Schmidt, C1a.
Asaphus lamanskii Schmidt, B3a.
Asaphus latus Pander, C1a.
Asaphus latus var. *plautini* Schmidt, C1a.
Asaphus lepidurus Nieszkowski, B2c.
Asaphus major Schmidt, B3b, B3c.
Asaphus nieszkowskii mut. *itferensis* Schmidt, C3.
Asaphus nieszkowskii mut. *jewensis* Schmidt, D1.
Asaphus nieszkowskii mut. *kegelensis* Schmidt, D2.
Asaphus nieszkowskii cf. *lepidus* Tornquist, C1b, C2.
Asaphus ornatus Pompeckj, C1a, C1b.
Asaphus pachyophthalmus Schmidt, B3c.
Asaphus platyurus Angelin, C1a.
Asaphus platyurus var. *laticauda* Schmidt, C1a
Asaphus priscus Lamansky, B2a.
Asaphus raniceps Dalman, B3b.
Basilicus kegelensis Schmidt, D1.
Basilicus kuckersiana Schmidt, C2.
Basilicus lawrowi Schmidt, C1a, C1b.
Bronteus laticauda Wahlenberg, F1.
Calymmene senaria Conrad, F2.
Calymmene stacyi Schmidt, F1, F2.
Ceratolichas inexpectatus Schmidt, C2.
Chasmops brevispina Schmidt, D1.
Chasmops bucculenta Sjogren, D1, D2.
Chasmops eichwaldi Schmidt, F1, F2.
Chasmops marginata Schmidt, D1, D2.
Chasmops maxima Schmidt, D1, D2.
Chasmops mutica Schmidt, D1, D2.
Chasmops nasuta Schmidt, C1a.
Chasmops odini Eichwald, C1b, C2.
Chasmops odini var. *itferensis* Schmidt, C3.
Chasmops præcurrens Schmidt, C1a, C1b.
Chasmops wenjukowi Schmidt, D1.
Chasmops wesenbergensis Schmidt, E, F1.
Chasmops wrangeli Schmidt, C3.
Cheirurus exsul Beyrich, C1a.
Cheirurus cf. *glaber* Angelin, F1.
Cheirurus gladiator Eichwald, C1b.
Cheirurus ingricus Schmidt, B3b.
Cheirurus insignis Schmidt, B3a.
Cheirurus macropthalmus Kutorga, C1b.
Cheirurus ornatus Dalman, B2c, B3b, B3c.
Cheirurus spinulosus Nieszkowski, C1b, C2, C3.
Conolichas æquilobus Steinhardt, D1, D2.
Conolichas schmidti Dames, D2.
Conolichas triconicus Dames, C3.
Crotalurus barrandei Volborth, B3a, B3b, B3c, C1a.
Cybele affinis Schmidt, C1a.
Cybele bellatula Dalman, B3a, B3b.
Cybele bellatula var. *wohrmanni* Schmidt, B2c.
Cybele brevicauda Angelin, E, F1.
Cybele coronata Schmidt, C2.
Cybele grewingkii Schmidt, D1, D2.
Cybele kutorgæ Schmidt, C3, D1, D2.
Cybele panderi Schmidt, B3a, B3b, B3c, C1a.
Cybele revaliensis Schmidt, C1b.
Cybele rex Nieszkowski, C2, C3.
Cybele worthi Eichwald, C1a, C1b.
Cyphaspis planifrons Eichwald, C2.
Cyrtometopus affinis Angelin, B3a, B3b, B3c.
Cyrtometopus aries Schmidt, C1a, C1b.
Cyrtometopus cf. *aries* Schmidt, B2a, B2c.
Cyrtometopus clavifrons Dalman, B2a, B2b, B2c.
Cyrtometopus gibbus Angelin, B2b.
Cyrtometopus plautini Schmidt, C2.
Cyrtometopus primigenius var. *lamanskii* Schmidt, B1b.

Cyrtometopus pseudohemicranium Nieszkowski, D1.
Cyrtometopus pseudohemicranium var. *dolichocephala* Schmidt, C2, C3.
Cyrtometopus tumidus Angelin, B2c.
Diaphanometopus volborthi Schmidt, B2c, B3a.
Encrinurus multisegmentatus Portlock, E, F1, F2.
Encrinurus seebachi Schmidt, E, F1.
Harpes spasskii Eichwald, B2c, B3a, C1a.
Harpes wegelini Angelin, F1.
Harpides plautini Schmidt, B2a, B2b, B2c.
Homolichas angustus (Beyrich), F1, F2.
Homolichas deflexus (Sjogren), D2.
Homolichas depressus (Angelin), C2.
Homolichas eichwaldi (Nieszkowski), E,? F1.
Homolichas pahleni Schmidt, D1.
Hoplolichas conicotuberculatus Nieszkowski, C1b, C2.
Hoplolichas furcifer Schmidt, C1a.
Hoplolichas plautini Schmidt, C1a, C1b.
Hoplolichas tricuspidatus (Beyrich), C1a, C1b.
Hoplolichas tricuspidatus var. *longispina* Schmidt, C2.
Illænus angustifrons Holm, F1, F2.
Illænus ariensis Holm, C1a.
Illænus atavus Eichwald, C1a.
Illnæus cæcus Holm, F1.
Illænus centrotus Dalman, B2a, B2b, B2c, B3b.
Illænus centrotus var., B3a.
Illænus chiron Holm, C1b.
Illænus chudleighensis Holm, C1a.
Illænus crassicauda (Wahlenberg), C1a, C1b.
Illænus dalmani Volborth, C1a.
Illænus esmarckii Schlotheim, B3a, B3b, B3c.
Illænus intermedius Holm, C1b.
Illænus jewensis Holm, D1, D2.
Illænus ladogensis Holm, B3a.
Illænus laticlavius Eichwald, B3b, B3c.
Illænus linnarssoni Holm, C2, C3, D2, E, F1.
Illænus masckei Holm, F1.
Illænus oblongatus Angelin, C1a, C1b, C2, C3.
Illænus oculosus Holm, C1a.
Illænus plautini Holm, C1a, C1b.
Illænus revaliensis Holm, B3c.
Illænus romeri Volborth, C1b, F1, F2.
Illænus schmidti Nieszkowski, C1a, C1b.
Illænus sinuatus Holm, C1a.
Illænus sphæricus Holm, C2, C3.
Illænus sulcifrons Holm, C1a.
Illænus tauricornis Kutorga, C1a, C1b.
Illænus triquetrus (Volborth), C1b.
Isotelus platyrhachis Steinhardt, F1.
Isotelus remigium Eichwald, E.
Isotelus robustus Roemer, F1, F2.
Leiolichas illænoides Nieszkowski, D1, D2.
Megalaspides schmidti Lamansky, B1b.
Megalaspis acuticauda Angelin, B2c, B3a, B3b.
Megalaspis centron Leuchtenberg, B3a.
Megalaspis gibba Schmidt, B3a, B3b.
Megalaspis gibbosa Schmidt, B2c.
Megalaspis heros Dalman, B3b, B3c.
Megalaspis hyorrhina Schmidt, B2b.
Megalaspis knyrkoi Schmidt, B2c.
Megalaspis kolenkoi Schmidt, B2b.
Megalaspis lawrowi Schmidt, B3a, B3b, C1a.
Megalaspis limbata Sars and Boeck, B2a.
Megalaspis longicauda Leuchtenberg, B3c.
Megalaspis mickwitzi Schmidt, B2c.
Megalaspis planilimbata Angelin, B1b, B2a.
Megalaspis planilimbata var. *leuchtenbergi* Lamansky, B1b.
Megalaspis pogrebowi Lamansky, B1b.
Megalaspis polyphemus Brogger, B2a.
Menocephalus minutus (Nieszkowski), C2.
Mesonacis (*Olenellus*) *mickwitzi* (Schmidt), A1.
Metopias celorhin Angelin, B2c, B3a, B3b, B3c, C1a.
Metopias hubneri Eichwald, C1b.
Metopias kuckersianus Schmidt, C1b, C2.
Metopias pachyrrhina Dalman, B3a, B3b, B3c.
Metopias pachyrrhina var. *longerostrata* Schmidt, B3a, B3b.
Metopias platyrhina Schmidt, B3a.
Metopias verrucosa Eichwald, B3b, B3c, B2c.
Nieszkowskia cephaloceras Nieszkowski, C1b, C2.
Nieszkowskia tumidus Angelin, C1a, C1b.
Niesczkowskia variolaris (Linnæus), C1b, C2.
Nileus armadillo Dalman, B3a.
Nileus armadillo var. *depressa* Sars and Boeck, B2b, B2c.
Niobe emarginula Brogger, B3a, B3b.
Niobe frontalis Dalman, B3a, B3b.
Niobe læviceps Dalman, B1b, B2a.
Niobe lindstromi Schmidt, B2b.
Niobe volborthi Schmidt, B3a.
Ogygia dilatata var. *panderi* Schmidt, C2.
Ogygia dilatata var. *plautini* Schmidt, C1a.
Onchometopus schmidti Lamansky, B2c.
Onchometopus stacyi Schmidt, B3c.
Onchometopus volborthi Schmidt, B2b, B2c, C3.
Pharostoma denticulata Eichwald, C1a.
Pharostoma nieszkowskii Schmidt, C2.
Pharostoma pediloba Roemer, E, F1.
Platylichas cicatricosus Loven, F2.
Platylichas docens Schmidt, F1.
Platylichas hamatus Schmidt, F1.
Platylichas laxatus McCoy, F1.
Platylichas margaritifera Nieszkowski, F2.
Platylichas st. mathiæ Schmidt, D1.
Platymetopus dalecarlicus Angelin, F1.
Platymetopus holmi Schmidt E.
Platymetopus lævis Eichwald, F1.
Platymetopus lineatus Angelin, F1.
Proetus kertelensis Schmidt, F1.
Proetus ramisulcata Nieszkowski, F1, F2.
Proetus wesenbergensis Schmidt, E.
Proetus wohrmanni Schmidt, B2c, B3a.
Pseudasaphus globifrons Eichwald, B3c.
Pseudasaphus tecticaudata Steinhardt, C1a, C1b, C2.
Pseudasaphus tecticaudata var. *præcurrens* Schmidt, B3c, C1a.
Pseudosphærexochus conformis Angelin, F1, F2.
Pseudosphærexochus hemicranium Kutorga, C1b.
Pseudosphærexochus pahnschi Schmidt, D2.
Pseudosphærexochus roemeri Schmidt, F1, F2.
Pterygometopus exilis Eichwald, C1b, C2.
Pterygometopus kegelensis Schmidt, D2.
Pterygometopus kuckersiana Schmidt, C2.
Pterygometopus lævigata Schmidt, C3, D1, D2.
Pterygometopus nieszkowskii Schmidt, E.
Pterygometopus panderi Schmidt, C1a, C1b.
Pterygometopus sclerops Dalman, B2b, B2c.
Pterygometopus trigonocephala Schmidt, B2c, B3a, B3b.
Ptychometopus volborthi Schmidt, B2a, B2b, B2c.
Ptychopyge angustifrons Dalman, B2a, B2b, B2c, B3a, B3b.

Ptychopyge angustifrons var. *gladiifera* Schmidt, B3a
Ptychopyge cincta Brögger, B2c.
Ptychopyge globifrons Eichwald, B3c.
Ptychopyge inostranzewi Lamansky, B1b.
Ptychopyge knyrkoi Schmidt, B2c.
Ptychopyge limbata Angelin, B2c, B3a.
Ptychopyge pahleni Schmidt, B2a, B2b, B2c.
Ptychopyge plautini Schmidt, B2b, B2c.
Ptychopyge truncata Nieszkowski, B2c.
Ptychopyge truncata var. *bröggeri* Schmidt, B2c, B3a.
Remopleurides elongatus var. *elongata* Schmidt, C2.
Remopleurides emarginatus Tornquist, F1.
Remopleurides nanus Leuchtenberg, B2a, B3a, B3b B3c, C1a.
Sphærexochus angustifrons Angelin, C3, F1.
Sphærexochus conformis Angelin, F1, F2.
Sphærexochus roemeri Schmidt, F1, F2.
Sphærocoryphe cranium Kutorga, C1b, C2.
Sphærocoryphe hubneri Schmidt, C3.
Sphærocoryphe granulata Angelin, F1, F2.
Trinucleus seticornis Hisinger, F1.

ORDOVICIAN FORMATIONS OF UPPER MISSISSIPPI VALLEY.

The general time scale of early Paleozoic deposits in North America is indicated in the table on page 38, but of all these formations only those of the Ordovician and early Silurian need be discussed in the present work, since the Cambrian, Ozarkian, and Canadian contain, with two possible exceptions, no Bryozoa.

In the preceding pages I have pointed out that the bryozoan faunas of Baltic Russia from formations hitherto assigned to the Ordovician (Lower Silurian), are closely allied to those contained in strata of Middle Ordovician and early Silurian age in northern North America, and especially in the upper part of the Mississippi Valley. The stratigraphy and paleontology of these two time divisions have received much study in Iowa, and more especially in Minnesota, so that the section in these two States can now be used for comparison. The composite section and a discussion of the individual beds follows:

Composite geologic section of Ordovician, northeastern Iowa and southeastern Minnesota.

	Feet.
Early Silurian (Richmond group)	—
Ordovician:	
Trenton group—	
Stewartville dolomite—	
(*b*) Porous, soft, yellowish dolomite and mottled magnesian limestone (Maclurea bed) containing the *Maclurina manitobensis* fauna	0–100
(*a*) Unfossiliferous, sandy mudstone	0–20
Prosser limestone—	
(*c*) Cherty, nonmagnesian, light blue, fine-grained limestone	10–20
(*b*) Thin bedded, occasionally shaly, fine-grained, bluish limestone containing the Fusispira bed fauna. Locally the basal strata of this division contain the fauna of the Nematopora bed	20–35
(*a*) Thin bedded, shaly limestone containing large examples of *Receptaculites oweni* at the top and the Clitambonites bed fauna at the base	20–45
Black River group—	
Decorah shale—	
(*f*) Shaly gray limestone filled with a variety of *Prasopora insularis*	0–8

Ordovician—Continued.

Black River group—Continued.

Decorah shale—Continued. — Feet.

(*e*) Gray, greenish or blue shale with nodular gray limestone in the upper part and knotty, calcareous masses in the remainder. (Fucoid bed.) *Dinorthis pectinella* and *Camarocladia rugosa* abundant, but other fossils are rare and are of species found in the underlying bed........ 0–10

(*d*) Blue shale weathering greenish gray, with fossiliferous, even or knotty plates of limestone. Fossils abundant. (Phylloporina bed.)........ 10–15

(*c*) Green to blue shales with numerous bryozoans and mollusca. (Ctenodonta bed.)........ 0–10

(*b*) Greenish blue shale with a few thin plates of limestone. Fossils numerous, chiefly bryozoans. (Rhinidictya bed.).. 0–34

(*a*) Soft green shales and irregular layers of limestone with numerous fossils, particularly bryozoans. (Stictoporella bed.).... 3–10

Platteville limestone (Lowville age)—

(*b*) Blue to gray fine-grained dolomite weathering brownish to yellow. Fossils occurring as casts, numerous in certain layers. (Vanuxemia bed.)........ 0–12

(*a*) Thin bedded, fine-grained, locally somewhat argillaceous limestone, often cobbly or shaly toward the base........ 15–28

Stones River group—

"Lower Buff" dolomite—

Bluish gray dolomite, weathering grayish buff, more or less cellulose, usually thick bedded in the middle part, thin and impure above, and sometimes conglomeratic and sandy at the base. Fossils few........ 6–13

Glenwood shales—

Soft green shale or clay, the lower part of a rusty color, and commonly with grains of quartz sand derived from the underlying St. Peter........ 1–6

St. Peter sandstone........ —

STONES RIVER GROUP.

The best development of this group is in its type-locality, central Tennessee, where its several formations are quite fossiliferous. Each of the Stones River faunas seems to be of southern origin and to have little in common with those of the Black River. With the exception of one or two species of the long-lived *Corynotrypa*, not a single bryozoan of the many known Stones River forms is strictly identical with any in the Black River group or in the Baltic Ordovician. The few fossils found in the St. Peter sandstone, Glenwood shale, and "Lower Buff" dolomite, comprising the Stones River of the Minnesota-Iowa basin of deposition, likewise have little relationship to the faunas of later times and need not be mentioned further. A considerable number of species has been recorded from the "Lower Buff" dolomite, but, almost without exception, these belong to the lower members of the Platteville limestone described later.

BLACK RIVER GROUP.

The extensive development of this group in the Minnesota-Iowa area was pointed out about 15 years ago by Ulrich, and is indicated by the same writer in his recent work upon the revision of the Paleozoic systems of North America. During Black River time, oscillations of the continental sea were frequent and are manifested in numerous unconformities. At no single locality are all of the divisions noted in the composite section developed, but most of these are present at and in the vicinity of St. Paul. To the south in Minnesota and in northern Iowa the overlaps are more pronounced and the hiatuses more frequent. Farther south, in eastern Missouri, the Black River deposits of Minnesota and Iowa are overlapped by the uppermost division assigned to the group, the Kimmswick formation, a crystalline limestone containing specimens of *Echinospherites* which can not be distinguished from the common Baltic species. The faunas of the several Black River formations are quite large and characteristic. They have been described by Ulrich, Clarke, Schuchert, Winchell, and Scofield, in the third volume of the "Geological and Natural History Survey of Minnesota," where the Black River group is referred to as the "Trenton shales," or as the "Black River shales." Complete lists of these various faunas are given in the introduction to part 2 of the volume. Here the Black River shales are divided into four beds, named in ascending order, according to the characteristic fossils, the Rhinidictya bed, Ctenodonta bed, Phylloporina bed, and Fucoid bed. In this introduction, the Stictoporella bed, forming the lowest division of the "Trenton shales" of previous reports, was assigned to the Stones River group, but more extended study on the part of Ulrich has convinced him that this bed should form the introductory strata of the Black River shales, or, as they are now known, the Decorah shales. Trenton shales, Black River shales, and Decorah shales, as the terms are employed for this area, are, therefore, synonymous. The underlying Upper Buff and Lower Blue limestones of the region contain the fauna characteristic of the Lowville formation of New York, and, following the more recent stratigraphic work, they are regarded as the lowest division of the Black River group. To this division the name Platteville limestone has been applied by Bain.

THE BRYOZOAN FAUNAS OF AMERICAN BLACK RIVER AND EARLIEST TRENTON DEPOSITS.

The earliest Black River deposits of the upper Mississippi Valley are of blue to gray fine-grained dolomitic and argillaceous limestone apparently little suited to bryozoan life, although fossils of other classes are often quite numerous. The few bryozoans that do occur are almost always found on the surface of thin-bedded limestone layers containing more calcareous material than usual. As indicated in the following table, but a single species of this fauna has been noted in Russian strata.

BRYOZOA OF THE PLATTEVILLE LIMESTONE IN MINNESOTA.[1]

Rhinidictya trentonensis Ulrich.
Rhinidictya nicholsoni Ulrich.
Rhinidictya pediculata Ulrich.
Escharopora angularis Ulrich.
**Leptotrypa hexagonalis* Ulrich.

The soft green shales and thin-bedded limestones comprised in the first division of the Decorah shale, the Stictoporella bed, frequently contain so many bryozoans that other fossils, in comparison, seem to be wanting. Several species of *Stictoporella*, *Pachydictya frondosa*, and *Anolotichia impolita*, are characteristic of the bed, but a majority of the species pass into the succeeding beds of the Decorah shale. Of the entire fauna, 38 species, 14 are present in the Baltic Middle Ordovician, where most of them occur in the formations ranging from B3 to D3.

BRYOZOA OF THE STICTOPORELLA BED.

**Corynotrypa delicatula* (James).
Berenicea minnesotensis Ulrich.
Favositella laxata Ulrich.
**Anolotichia impolita* Ulrich.
Ceramoporella distincta Ulrich.
Ceramoporella inclusa Ulrich.
**Rhinidictya mutabilis* Ulrich.
Rhinidictya exigua Ulrich.
Rhinidictya fidelis Ulrich.
Rhinidictya trentonensis Ulrich.
Pachydictya foliata Ulrich.
Escharopora angularis Ulrich.
Escharopora ? limitaris Ulrich.
**Escharopora subrecta* Ulrich.
**Arthropora simplex* Ulrich.
Stictoporella angularis Ulrich.
**Stictoporella cribrosa* Ulrich.
Stictoporella angularis intermedia Ulrich.
Stictoporella frondifera Ulrich.
**Arthrostylus obliquus* Ulrich.
**Helopora divaricata* Ulrich.
**Chasmatopora reticulata* (Hall).
Monticulipora grandis Ulrich.
Homotrypa minnesotensis Ulrich.
Homotrypa exilis Ulrich.
Homotrypa separata Ulrich.
Aspidopora parasitica Ulrich.
**Dekayella prænuntia simplex* Ulrich.
**Dekayella prænuntia nævigera* Ulrich.
Hallopora angularis (Ulrich).
Hallopora incontroversa (Ulrich).
**Batostoma fertile* Ulrich.
**Batostoma fertile circulare* Ulrich.
Batostoma ? decipiens Ulrich.
**Hemiphragma irrasum* Ulrich.
Stomatotrypa ovata Ulrich.
Nicholsonella ponderosa Ulrich ?.
Leptotrypa informis Ulrich.

The lithology of the next bed, named the Rhinidictya bed on account of the large number of *Rhinidictya mutabilis* contained in it, is very similar to the underlying Stictoporella bed. The similarity is borne out by the faunas, which differ only because of the new species introduced. Of the bryozoans, 58 species have been described, and of these 23 are known in the Baltic strata underlying F1.

[1] In this and the following lists, all species marked (*) are common to Russia and America.

BRYOZOA OF THE RHINIDICTYA BED.

Stomatopora arachnoidea (Hall).
Corynotrypa barberi Bassler.
Corynotrypa delicatula (James).
Berenicea minnesotensis Ulrich.
Spatiopora labeculosa Ulrich.
Favositella laxata Ulrich.
Ceramoporella inclusa Ulrich.
Rhinidictya mutabilis Ulrich.
Rhinidictya mutabilis major Ulrich.
Rhinidictya mutabilis senilis Ulrich.
Rhinidictya exigua Ulrich.
Phyllodictya frondosa Ulrich.
Phyllodictya varia Ulrich.
Pachydictya fimbriata Ulrich.
Escharopora subrecta Ulrich.
Escharopora confluens Ulrich.
Escharopora ? limitaris Ulrich.
Arthropora simplex Ulrich.
Stictoporella cribrosa Ulrich.
Helopora alternata Ulrich.
Arthroclema striatum Ulrich.
Arthroclema cornutum Ulrich.
Chasmatopora reticulata (Hall).
Monticulipora incompta Ulrich.
Atactoporella typicalis præcipta Ulrich.
Atactoporella insueta Ulrich.
Homotrypella instabilis Ulrich.
Homotrypella multiporata Ulrich.
Homotrypella ovata Ulrich.
Homotrypella hospitalis crassa (Ulrich).
Homotrypa intercalaris Ulrich.
Homotrypa subramosa Ulrich.
Aspidopora parasitica Ulrich.
Mesotrypa infida Ulrich.
Mesotrypa ? spinosa Ulrich.
Bythopora herricki Ulrich.
Bythopora subgracilis (Ulrich).
Dekayella prænuntia Ulrich.
Dekayella prænuntia simplex Ulrich.
Dekayella prænuntia echinata Ulrich.
Dekayella prænuntia multipora Ulrich.
Hallopora undulata (Ulrich).
Hallopora multitabulata (Ulrich).
Hallopora ampla (Ulrich).
Batostoma magnoporum Ulrich.
Batostoma varium Ulrich.
Batostoma winchelli Ulrich.
Batostoma winchelli spinulosum Ulrich.
Batostoma minnesotense Ulrich.
Batostoma ? decipiens Ulrich.
Hemiphragma irrasum Ulrich.
Stromatotrypa ovata Ulrich.
Trematopora ? primigenia Ulrich.
Trematopora ? primigenia ornata Ulrich.
Trematopora ? primigenia spinulosa Ulrich.
Nicholsonella laminata Ulrich.
Nicholsonella ponderosa Ulrich.
Stigmatella claviformis Ulrich.

The Ctenodonta bed division of the Decorah shales is scarcely distinguishable from the Rhinidictya bed at most localities. In Goodhue County, Minnestoa, it contains few bryozoans, but an abundance of Mollusca of which species of *Ctenodonta* are most common. The few bryozoans registered from this bed show an unusual percentage common to Russia and America.

BRYOZOA FROM THE CTENODONTA BED.

Corynotrypa delicatula (James).
Spatiopora lineata incepta Ulrich.
Rhinidictya mutabilis Ulrich.
Rhinidictya mutabilis major Ulrich.
Pachydictya fimbriata Ulrich.
Stictoporella cribrosa Ulrich.
Dekayella prænuntia echinata Ulrich.
Hallopora undulata (Ulrich).
Batostoma varium Ulrich.
Stigmatella claviformis Ulrich.

Following the Ctenodonta bed are shales much resembling those of the Rhinidictya bed, and like them, crowded with Bryozoa. Here, however, the bifoliate forms are less abundant and monticuliporoids predominate. *Phylloporina*, or, as it should now be called, *Chasmatopora*, is present, often in great numbers, giving the name to the division. The Fucoid bed which succeeds the Phylloporina contains a limited fauna, mainly because it seems ill-suited for bryozoan life. The few species occurring in it are listed below with those of the Phylloporina bed. The entire bryozoan fauna amounts to 50 species, with 16 occurring also in the Baltic area.

BRYOZOA OF THE PHYLLOPORINA AND FUCOID BEDS.

**Vinella repens* Ulrich.
**Stomatopora arachnoidea* (Hall).
**Corynotrypa delicatula* (James).
**Corynotrypa inflata* (Hall).
Proboscina tumulosa Ulrich.
**Ceramoporella granulosa minor* Bassler.
Crepipora subæquata Ulrich.
Favositella laxata Ulrich.
Ceramoporella inclusa Ulrich.
Cœloclema trentonense Ulrich.
Ceramophylla frondosa Ulrich.
**Rhinidictya mutabilis* Ulrich.
Rhinidictya mutabilis major Ulrich.
Rhinidictya paupera Ulrich.
Rhinidictya exigua Ulrich.
Eurydictya multipora (? Hall).
Pachydictya occidentalis Ulrich.
Trigonodictya conciliatrix Ulrich.
Arthropora bifurcata Ulrich.
Stictoporella rigida Ulrich.
Stictoporella dumosa Ulrich.
**Arthrostylus conjunctus* Ulrich.
Arthroclema pulchellum Billings.
Chasmatopora halli (Ulrich).
Chasmatopora corticosa (Ulrich).
Atactoporella ramosa Ulrich.
**Homotrypella cribrosa* Bassler.
**Homotrypella hospitalis crassa* (Ulrich).
Homotrypa minnesotensis Ulrich.
**Homotrypa subramosa* Ulrich.
Homotrypa tuberculata Ulrich.
Prasopora simulatrix Ulrich.
Prasopora contigua Ulrich.
Prasopora conoidea Ulrich.
Prasopora lenticularis Ulrich.
Bythopora alcicornis Ulrich.
**Eridotrypa ædilis* (Eichwald).
**Eridotrypa ædilis minor* (Ulrich).
Dekayella prænuntia echinata Ulrich.
Dekayella trentonensis (Ulrich).
**Hallopora multitabulata* (Ulrich).
Hallopora ampla (Ulrich).
**Hallopora dumalis* (Ulrich).
Hallopora pulchella (Ulrich).
Hallopora pulchella persimilis (Ulrich).
Calloporina crenulata (Ulrich).
Batostoma montuosum Ulrich.
**Hemiphragma irrasum* Ulrich.
Stellipora antheloidea Hall.
**Stigmatella claviformis* (Ulrich).

The Fucoid bed closes the Black River in Minnesota, but in northern Iowa a shaly gray limestone filled with a variety of *Prasopora insularis* forms the last apparent member of the group. Numerous bryozoans occur in this bed, but lists of the species have never been published. However, the fauna is essentially the same as the underlying Black River shales with about 40 per cent of the species present in the Russian deposits.

As indicated in the correlation table on page 38, the Trenton strata of the upper Mississippi Valley comprise only the lower portion of this group. In Minnesota the group may be divided into four faunal zones. The lowest consists of yellowish to light green shales with interbedded thin, impure limestones. Fossils of all classes are rather numerous, although the bryozoans as usual make up the largest part of the fauna. A species of *Clitambonites* is one of the characteristic fossils and has given the name to the bed. Thirty-six species of bryozoans have been recorded from the Clitambonites bed, and of these, 16 occur also in the Baltic Middle Ordovician. The similarity of the Clitambonites bed to the Wesenberg limestone has been remarked upon in a preceding paragraph.

BRYOZOA OF THE CLITAMBONITES BED.

Stomatopora arachnoidea (Hall).
**Corynotrypa delicatula* (James).
**Corynotrypa inflata* (Hall).
Ceramoporella interporosa Ulrich.
**Rhinidictya mutabilis* Ulrich.
**Pachydictya elegans* Ulrich.
Pachydictya acuta Hall.
**Graptodictya proava* (Eichwald).
Escharopora recta Hall.
Phænopora incipiens Ulrich.
Arthropora bifurcata Ulrich.
Arthropora reversa Ulrich.
Helopora mucronata Ulrich.
Arthroclema pulchellum Billings.
Monticulipora arborea Ulrich.
Monticulipora cannonensis Ulrich.
**Homotrypella hospitalis crassa* Ulrich.
Homotrypella ovata Ulrich.
Homotrypella mundula Ulrich.
**Homotrypa subramosa insignis* Ulrich.
**Homotrypa similis* Foord.
Homotrypa callosa Ulrich.
Prasopora insularis Ulrich.
Aspidopora elegantula Ulrich.
**Eridotrypa ædilis* (Eichwald).
**Eridotrypa ædilis minor* Ulrich.
Dekayella trentonensis Ulrich.
**Hallopora multitabulata* (Ulrich)
Hallopora ampla (Ulrich).
**Hallopora goodhuensis* (Ulrich).
Calloporina crenulata (Ulrich).
**Hallopora dumalis* (Ulrich).
Batostoma humile Ulrich.
**Hemiphragma irrasum* Ulrich.
**Hemiphragma tenuimurale* Ulrich.
Leptotrypa acervulosa Ulrich.

The two next faunal zones of the Minnesota-Trenton, the Nematopora bed and the Fusispira bed, have been combined in the list of bryozoan species herewith given. It will be noted that of the 40 species in these beds only 14 are common to the American and Baltic areas. No bryozoans have been found in the Maclurea bed which terminates the Minnesota-Trenton. The next overlying rocks are of earliest Silurian (Richmond) age, and contain the fauna of the upper Lyckholm and Borkholm limestones, at least so far as the bryozoans and corals are concerned.

BRYOZOA OF THE FUSISPIRA AND NEMATOPORA BEDS.

**Stomatopora arachnoidea* (Hall).
**Corynotrypa delicatula* (James).
**Corynotrypa inflata* (Hall).
Berenicea minnesotensis Ulrich.
Diastoporina flabellata Ulrich.
Favositella laxata Ulrich.
Cœloclema trentonensis Ulrich.
**Mitoclema ? mundulum* Ulrich.
Rhinidictya exigua Ulrich.
Rhinidictya minima Ulrich.
Pachydictya pumila Ulrich.
Pachydictya acuta Hall.
Pachydictya magnipora Ulrich.
Nematopora conferta Ulrich.
**Nematopora consueta* Bassler.
Nematopora granosa Ulrich.
**Nematopora ovalis* Ulrich.
Helopora quadrata Ulrich.
Helopora mucronata Ulrich.
**Arthroclema armatum* Ulrich.
**Chasmatopora reticulata* (Hall).
Monticulipora grandis Ulrich.
Prasopora simulatrix Ulrich.
Prasopora selwyni Nicholson.
Prasopora oculata Foord.
Prasopora affinis Foord.
Homotrypa callosa Ulrich.
**Homotrypa similis* Foord.
Mesotrypa quebecensis Ami.
Mesotrypa discoidea Ulrich.
Mesotrypa ? rotundata Ulrich.
**Eridotrypa ædilis* (Eichwald).
**Eridotrypa exigua* Ulrich.
**Hemiphragma tenuimurale* Ulrich.

Hemiphragma ottawense (Foord).
Diplotrypa limitaris (Ulrich).
Diplotrypa neglecta Ulrich.
Monotrypa intabulata Ulrich.
**Dianulites petropolitana* Dybowski (*Monotrypa cumulata* Ulrich).
**Constellaria varia* Ulrich.

Tabulating the preceding lists of bryozoans with the total number of American species and the number of species common to American and Baltic areas, it will be noted, as may be determined from the following table, that on an average about 35 per cent of the species are alike in the two regions.

Summary of American and Baltic Ordovician bryozoa.

Formation.	Total number of American species.	Number of species common to American and Baltic areas.
Trenton group:		
Fusispira and Nematopora beds	40	14
Clitambonites bed	36	16
Black River group:		
Decorah shale—		
Phylloporina bed	50	16
Ctenodonta bed	10	6
Rhinidictya bed	58	23
Stictoporella bed	38	14
Platteville limestone	5	1

This percentage of common species is almost duplicated in the summary of Baltic and American forms given on page 50, where the species are tabulated with reference to the Russian formations. Excluding the Lyckholm and Borkholm bryozoans believed to be of early Silurian age, there are 134 Ordovician species described in this work, with 52 common to the two areas, thus giving practically the same percentage. This similarity of percentages leads me to believe that, even with more work upon these bryozoan faunas, the number of new species will be counterbalanced by the discovery of American forms in such a ratio as to maintain about this same figure.

ORDOVICIAN AND EARLY SILURIAN STRATA OF ARCTIC AMERICA.

The northward extension of the early Paleozoic strata in America is of importance to substantiate the assumption that the Baltic faunas usually entered this country from the north. As far back as 1854 siliceous limestones holding Black River or Chazy fossils were reported by Alexander Murray as occurring on islands in Lake Nipissing, northern Ontario. Later N. H. Winchell[1] described this limestone as resting unconformably upon the gneiss and trap rocks of the islands, and published the following list of fossils determined by E. O. Ulrich:

[1] Amer. Geologist, vol. 18, 1896, pp. 178-179.

BLACK RIVER FOSSILS FROM ISLANDS OF LAKE NIPISSING, ONTARIO.

Ormoceras tenuifilum Hall.
**Escharopora subrecta* Ulrich.
Helopora mucronata Ulrich.
Escharopora ? limitaris Ulrich.
Rhinidictya mutabilis var. *major* Ulrich.
**Phyllodictya varia* Ulrich.
**Batostoma winchelli* Ulrich
**Callopora multitabulata* Ulrich.
Rhynchotrema inequivalvis Castelnau.
Leperditia fabulites Conrad.
Aparchites neglectus Ulrich.

This list is evidence of the equivalence of the Nipissing strata with the Black River strata of Minnesota and Iowa. The species marked with an asterisk occur in the Baltic deposits, where also nearly every one of the other bryozoan forms is represented by a variety or closely related species.

Middle Ordovician faunas are known from a number of localities in the far North. These areas have been discussed and the fauna of the most important fossiliferous locality, Silliman's Fossil Mount, at the head of Frobisher Bay, Baffin Land, has been described by Schuchert in an article entitled "On the Lower Silurian (Trenton) Fauna of Baffin Land." [1] These various localities have been registered upon the accompanying paleogeographic map (fig. 3), and Schuchert's conclusions as to the extent of the deposits and his summary of results are copied below:

From the foregoing description of localities it appears that Middle Lower Silurian horizons are very extensive in eastern Arctic America. Such are known in places on either side of Hudson Strait, Frobisher Bay, the interior of Baffin Land, and to the north of this land at various localities between latitudes 79° and 80° north. As far as known, these strata unconformably overlie very ancient crystalline rocks, and are in turn overlain by Upper Silurian beds of Niagara or Wenlock age. Lower Cambrian rocks are found in southern Labrador, but in the region of Baffin Land such are not known to be present. Here, then, there seems to be a complete break from the Laurentian to the Trenton, followed by another break paleontologically, in the absence of the Cincinnatian beds, and probably the lower horizons of the Upper Silurian. The Lower Silurian fossils of this area indicate nothing older than the typical Trenton of New York and the Galena of Wisconsin and Minnesota, and nothing younger than the Utica stage of the United States. The thickness of these beds is not less than 900 feet, and probably exceeds this.

This summary is based on information known to the author, and, while the evidence is meager, the essential geological age and the sequence of the rocks of Baffin Land seem to be established [pp. 148-149].

* * * * * * *

The only Lower Silurian horizons known in northeastern Arctic America are of Trenton and Utica age. The latter zone appears only on the north shore of Frobisher Bay, but the Trenton is found in various places from the north shore of Hudson Strait to latitude 81° north. The Lower Silurian is thickest on Akpatok Island, where it is from 400 to 500 feet in depth. Dr. Bell, however, estimates the entire thickness of these strata in this region to be not less than 900 feet.

[1] Proc. U. S. Nat. Mus., vol. 22, 1900, pp. 143-177.

In Baffin Land, and apparently elsewhere in Arctic America, the Lower Silurian strata rests unconformably on old crystalline rocks. To the north of Baffin Land, the former are overlain by beds of Niagara or Wenlock age.

The Trenton faunas, occurring in various places around the insular Archaean nucleus of North America, have much in common, and this indicates that the conditions at that time were very similar, while the sea was in communication throughout. As yet, however, the distribution of the strata, together with their faunas, are well known only to the south and southeast of the Archaean nucleus, yet that of the west (Manitoba) and of the northeast (Baffin Land) show direct communication.

The Baffin Land fauna had an early introduction of Upper Silurian genera in the corals *Halysites*, *Lyellia*, and *Plasmopora*. In Manitoba similar conditions occur in the presence of *Halysites*, *Favosites*, and *Diphyphyllum*. Other Upper Silurian types do not appear to be present.

The Trenton fauna of Silliman's Fossil Mount, at the head of Frobisher Bay, has 72 species, of which 28 are restricted to it. This fauna shows an intimate relationship with that of the Galena of Minnesota, Iowa, and Wisconsin. Fifty-seven per cent of the species of Baffin Land also occur in the Galena of the regions just mentioned.

The Trenton fauna of Baffin Land shows that the corals, brachiopods, gastropods, and trilobites have wide distribution, and are therefore less sensitive to differing habitats apt to occur in widely separated regions. On the other hand, the cephalopods, and particularly the pelecypods, indicate a shorter geographical range. The almost complete absence of Bryozoa in the Baffin Land Trenton contrasts strongly with the great development of these animals in Minnesota and elsewhere in the United States [p. 175].

Most of the fossils upon which Schuchert's studies were based are in the collections of the United States National Museum, and the opportunity is thus afforded of comparing them directly with other Ordovician faunas and of making more detailed correlations. The results of a second study of these northern faunas lead to the following conclusions:

(1) It is improbable that Utica strata occur in the far north, since the only fossil noted of any value in making such a correlation is *Triarthrus becki*, which is now known to occur also in the oldest Trenton. Of course it is possible that an arm of the sea extended northward during Utica time and allowed the deposition of these particular strata.

(2) The Trenton age of the principal Ordovician deposits was determined by Schuchert by the percentage composition method. He found that of the 72 species known from the Silliman's Mount locality, 54 were common to other areas. Comparing these 54 with known horizons in Minnesota, it was found that 10 occur in the Lowville, 17 in the Black River, 38, or about 70 per cent, in the Trenton, and 11 in the Cincinnatian. This prevalence of Trenton species seemed to be a good indication of the presence of a single fauna of that particular age. However, this method of correlation is open to some objections and has often been the occasion of error. In this particular example, the fossils were derived from the débris of a considerable thickness of strata, and there is just as much if not more

reason for believing that the Lowville, Black River, Trenton, and Richmond rocks are actually present in the section as for assuming that only Trenton strata occur. The former view is strengthened by the unquestioned stratigraphy of areas further south and west. Ulrich's identification of recent collections made by Kindle in Alaska, has shown the occurrence of a Black River fauna followed by a coral fauna of Richmond age. In Manitoba and elsewhere in Canada, the early Trenton strata (Maclurea bed) are succeeded by the Earliest Silurian Richmond group. The same succession of Richmond strata upon Trenton or older rocks is present in various parts of the Rocky Mountain area of the United States, especially in the Big Horn Mountains, and even as far south as El Paso, Texas. The most prevalent zone of the Richmond group contains numerous corals of Silurian genera; *Halysites*, *Lyellia*, *Plasmopora*, and *Calapœcia*. This is the same fauna noted on other pages of this work as present in the upper Lyckholm and Borkholm limestone of Baltic Russia. The 11 "Cincinnatian" species recorded by Schuchert from Silliman's Mount includes this same coral fauna, and it therefore seems certain that the Richmond group is represented in the section. The Richmond age of these corals was further evidenced by the fact that two very characteristic brachiopods, a variety of *Platystrophia acutilirata* and of *Plectambonites sericeus* came to light when I carefully searched a fragment of limestone adhering to one of the corals. This particular variety of *Plectambonites* is highly characteristic of the Richmond in America and Europe. It is distinguished by the occurrence of small teeth along the edge of the cardinal area of the dorsal valve.

The 38 strictly Trenton species, when compared with Minnesota faunas, are found to be characteristic of the *Clitambonites*, *Nematopora*, and *Maclurea* beds of the Minnesota-Iowa composite section, or, in other words, probably occur in strata equivalent to the early Trenton (Stewartville and Prosser limestone) of the more southern area. The species of *Fusispira*, *Maclurea*, *Maclurina*, *Receptaculites*, *Ischadites*, and other genera listed by Schuchert as occurring in the Silliman's Mount fauna, and elsewhere only in the Minnesota Trenton, are associated with a gray, fine grained rock which, when carefully prepared, furnished a small fauna of Ostracoda including a *Leperditia* with Trenton affinities, but more especially the two bryozoans characteristic of the Nematopora bed in Minnesota, *Nematopora ovalis* Ulrich and *Pachydictya pumila* Ulrich.

Concerning the occurrence of Lowville limestone at Silliman's Fossil Mount, the evidence is not as conclusive as that for the Lower Trenton and Richmond divisions, indeed, it is probable that only the equivalent of the Decorah shale is present since the 10 Lowville species listed by Schuchert occur also in that formation. Schuchert's list, however, shows enough characteristic Black River species to make it certain that some part of this group is represented in the section. Many of the specimens of these particular species show a slight difference in color and preservation from the Trenton forms discussed above. The more recent study of this Baffin Land fauna disclosed the presence of at least six species of Bryozoa, so that the remarks above concerning the practical absence of these forms are less to the point. Indeed, it is believed that the bryozoans are present, but because of their uninteresting aspect to the usual student, were not collected.

Summing up, it seems probable from Schuchert's results, combined with the more detailed correlations of the present paper, that the geologic section at Baffin Land consists of Black River strata resting upon the old crystalline rocks, followed by an early Trenton formation equivalent to the Stewartville and Prosser limestones of Minnesota, and this in turn succeeded unconformably by the widespread coral zone of the Richmond group. The same succession of strata, so far as the Trenton and Richmond divisions are concerned, is present on Akpatok Island, near the south shore of Hudson Strait, where the species listed below were collected. Those marked with an asterisk are characteristic Richmond forms, while the remaining refer to Trenton and possibly Black River species:

Receptaculites oweni Hall.
**Streptelasma robustum* Whiteaves.
**Calapœcia canadensis* Billings.
**Rafinesquina lata* Whiteaves.
**Leptæna unicostata* (Meek and Worthen).
Plectambonites sericea (Sowerby).
Orthis tricenaria Conrad.
Orthis (Dinorthis) meedsi arctica Schuchert.
Orthis (Hebertella) bellirugosa (Conrad).
Orthis (Dalmanella) testudinaria (Dalman).
Platystrophia biforata (Schlotheim).
?*Rhynchotrema inequivalvis* (Castelnau).
Cyrtoceras manitobense Whiteaves.

STRATIGRAPHIC CORRELATIONS.

The exact position within the Ordovician system of the Russian formations under discussion can be determined only by comparison with sections in other parts of the world. The Baltic section has rather generally been regarded, especially by European geologists, as an excellent illustration of continuous sedimentation from some time in the Cambrian on well into the Silurian. The error of this view must be apparent to all who will compare the Baltic sequence with the much greater development of corresponding parts of the geological column in America. The exceeding inadequacy of the Baltic section as the type for the Eopaleozoic is graphically shown in the accompanying correlation table.

In the foregoing pages I have attempted to show (1) that, judging from the bryozoan faunas, the strata ranging from the Glauconite sandstone to the Wesenberg should be correlated with the American Black River; (2) that the Wesenberg and early Lyckholm show affinities with the early Trenton; and (3) that the upper Lyckholm and Borkholm closely resemble certain divisions of the Richmond group, relations more definitely indicated on the correlation table. I have also pointed out that there is a striking similarity in the lithology of several of the corresponding formations in Russia and America. This resemblance, as also the faunal similarity, is particularly notable in comparing the Baltic succession with the section in central and northern North America.

Finally, from a study of the lists given on pages 19 to 25, it will be evident that there are comparatively few fossils of other classes than the Bryozoa and corals common to the two areas. The reasons for this unequal community of species are perhaps to be sought in natural and inherent differences in modes of dispersal pertaining to the several classes. While it is possible that I have recognized too many species of Bryozoa as common to the two areas, it is to be said, on the other hand, that my specific work has been checked up by the foremost authority on fossil Bryozoa. Furthermore, specific discrimination has been carried to a greater degree of refinement than ever before attempted, and this refinement naturally affects all the species. If the species had been less closely drawn, a much greater percentage of those common to the two areas would doubtless have resulted. Respecting the other classes the possibility is recognized that future and similarly close comparative study will show a decidedly greater community of species, but it seems altogether unlikely that the percentage will ever approximate that attained by the Bryozoa.

Correlation table of Eopaleozoic deposits in America and Baltic Russia.

General time scale with provisional units.					Units of Upper Mississippi Valley.		Units of Baltic Russia.	
Silurian	Cayugan							
	Niagaran							
	Richmondian	Girardeau		100'	Noix oolite	50'	Borkholm limestone (F2)	15'
		Whitewater		70'	Maquoketa shale	200'	Lyckholm limestone (upper part, F1)	30'
		Liberty		110'	Wykoff limestone	100'		
		Waynesville		60'	Fernvale limestone	50'		
		Arnheim		80'				
Ordovician	Cincinnatian	Maysville	McMillan	150'				
			Fairview	250'				
		Eden	McMicken	2,000'				
			Southgate					
			Economy					
			Utica	200'				
	Mohawkian	Trenton	Catheys	150'				
			Perryville	100'				
			Flanagan	50'				
			Bigby	150'				
			Wilmore	120'				
			Hermitage	100'	Stewartville dolomite (Maclurea bed)	120'	Lyckholm limestone (lower part, F1)	[illegible]0'
			Prosser	100'	Prosser limestone: Fusispira bed; Nematopora bed; Clitambonites bed	100'	Wesenberg limestone (E)	30'
							Wassalem beds (D3)	40'
							Kegel limestone (D2)	30'
							Jewe limestone (D1)	30'
		Black River	Kimmswick	200'			Itfer limestone (C3)	30'
			Decorah	90'	Decorah shale	90'	Kuckers shale (C2)	50'
			Watertown	50'			Echinospherites limestone (C1)	50'
			Lowville	400'	Platteville limestone	40'	Orthoceras limestone (B3)	20'
							Glauconite limestone (B2)	40'
							Glauconite sandstone (B1)	10'
	Chazyan	Holston	Holston	1,000'				
		Stones River	Carters	100'	Lower Buff dolomite	13'		
			Lebanon	120'	Glenwood shale	6'		
			Ridley	100'				
			Pierce	30'				
			Murfreesboro	100'				
	Unnamed	Joachim		100'				
		St. Peter		200'	St. Peter sandstone	100'		
		Everton		150'				

Canadian	Beekmantown	Bellefonte	2,100′			Dictyonema shale (A3)	10′
		Axeman	160′				
		Nittany	1,270′				
		Stonehenge	670′				
Ozarkian	Jefferson City, Roubidoux		1,400′	Shakopee limestone	70′		
				New Richmond sandstone	20′		
	Gasconade, Proctor, Eminence		3,000′	Oneota dolomite	175′		
				Jordan sandstone	120′		
	Potosi		200′				
	Elvins		200′	St. Lawrence limestone	100′		
Cambrian	Upper			St. Croix sandstone	500′	Ungulite sandstone (A2)	60′
	Middle						
	Lower					Blue clay and sandstone (A1)	300′

The foremost American students of paleontology and paleogeography have recognized three major faunal realms in the Northern Hemisphere, each of which was a center of development and dispersal. These three realms are, first, the Atlantic; second, the Arctic; and, third, the Pacific. Whenever opportunity offered, the faunas of one or more of these oceanic basins invaded the submerged portions of the continent. Most frequently but a single fauna occupied the interior of the continent; occasionally faunas from two of the major regions of dispersal were present, and rarely all three may have been represented contemporaneously. For North America the South Atlantic center of dispersal was probably the most important, at

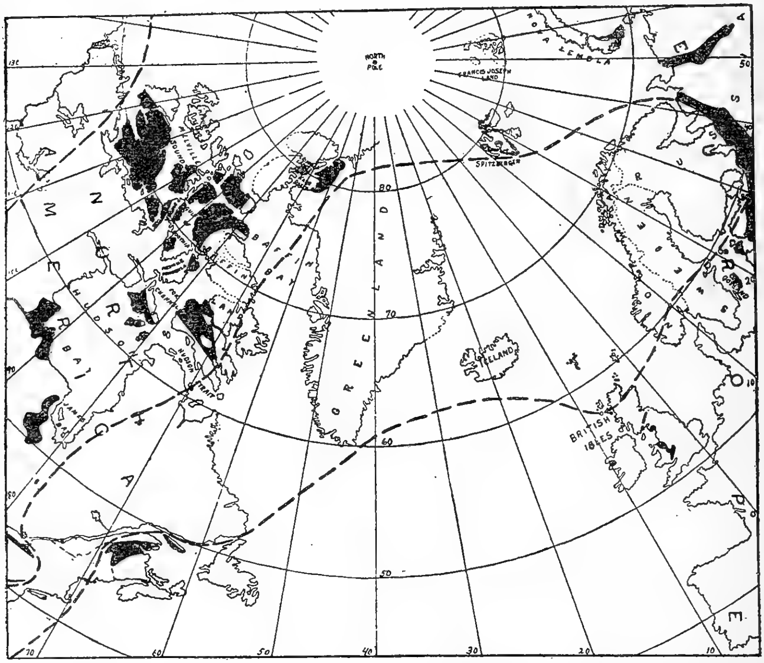

FIG. 2.—MAP OF THE NORTH POLAR REGION, SHOWING DISTRIBUTION OF SILURIAN STRATA IN NORTH AMERICA AND NORTHERN EUROPE, WITH THE HYPOTHETICAL SHORE LINES. (AFTER WELLER.)

least in earlier and middle Paleozoic times, with the Arctic center second in importance. The Ordovician and Silurian faunas of the Baltic region and the central and northern parts of North America have so much in common that it seems probable they were all derived from the Arctic region, from which, whenever the opportunity afforded, they migrated into the adjacent continental areas. The identity of the middle Silurian faunas of North America and northern Europe has been established by Weller (fig. 2), but the earlier Silurian and Ordovician faunas have not hitherto been believed to show any similar community. This belief may rest on the fact that the classes of organisms which require a shore line for migration have been most studied in the two areas and sufficient resemblances between them have not been noted. The types which are less dependent on continuity of shore line are the corals, crinoids, ostracods, and bryozoans, and these show the greatest similarity in the two areas. The trilobites, gastropods, and other classes usually requiring such a shore line only occasionally exhibit identical species. Some of their species suggest forms of the Mississippi Valley, but as a rule these faunas are strange to the American paleontologist and would serve very poorly for exact correlation with the American strata. However, the classes to which a shore line is not essential for migration show numerous species in common. Thus, the bryozoans, which in the Baltic area have received comparatively little attention, show as a result of the present study that 65 species out of 161 are common to this region and to America.

In correlating the Russian strata, hitherto referred to the Ordovician, with only middle Ordovician and early Silurian strata of America, other factors than faunal similarity must be considered. According to the correlation table on page 38 all strata of Chazyan, upper Trenton, and of Cincinnatian time are unrepresented in the Baltic section if the presence of numerous identical species is to be counted a good criterion in correlation. Excepting the long-lived *Corynotrypa delicatula* and a few other cyclostomatous bryozoans, so far as America is concerned, not a single species of the numerous Mohawkian bryozoans is known in the underlying formations. Similarly, the upper Trenton and Cincinnatian strata contain no species of bryozoans in common with the underlying early Trenton and older rocks. With the large number of species that has been described, this is most conclusive evidence for the distinctness of the faunas and upon these data alone the correlation of the Russian strata here advocated would be justified.

The Black River strata containing the greatest percentage of Russian species are thickest in the northern part of North America and overlap to extinction southward. For example, the southernmost outcrops of the Decorah shale are in northern Tennessee where they occur very locally overlying the Lowville limestone and are here never over a few feet in thickness. Similarly, the lower Trenton horizon designated as the Clitambonites and Nematopora beds in my section on a previous page, overlap southward until in southern Tennessee, where they rest upon the Lowville limestone, they are only a few inches in thickness. Besides this, there is diastrophic evidence that the seas of this time entered the continent from the north. In Russia, on the other hand, we have no stratigraphical evidence of corresponding overlaps of Ordovician strata upon any rocks younger than the Dictyonema shales.

Possibly future researches will reveal localities where the Glauconite sandstone and overlying strata rest upon rocks younger than the Dictyonema beds, which may be correlated with the American Chazyan, and thus afford physical as well as faunal proof of the age of the Russian beds.

It is of course possible that the lower part of the Russian section succeeding the Dictyonema shale should be correlated with the American Chazyan. The Russian faunas from B1 to the upper part of F1 are remarkably uniform in character, changing only with the introduction of new species. They seem to have developed almost continuously, the few breaks in the sequence being of minor importance. As these faunas are limited to northern areas, their center of origin and dispersal was undoubtedly the Arctic Ocean, from which they invaded whenever opportunity offered. It is perhaps impossible, as yet, to fix the date of their origin, consequently we can not prove that they did not tenant the Arctic Ocean and possibly invaded the Baltic Basin as early as Chazyan time. Nor is it improbable that they continued existence in these northern provinces even to the close of the Ordovician. However, in the absence of definite evidence tending toward such conclusions we are obliged provisionally to rely on faunal similarity with the standardized American sequence in determining the relative ages of the Russia Ordovician formations.

Respecting the upper part of the Baltic section, comprising the upper Lyckholm and Borkholm, the range of possible error in correlation with American deposits is much narrower and the problem on the whole much less involved. As shown on page 35, the highly characteristic Borkholm coral fauna is well developed in Arctic America. Here it follows immediately on beds containing faunas comparable with those found in Russia in a similar position with respect to the upper Lyckholm and Borkholm. It was also shown that these lower beds are strictly equivalent and presumably contemporaneous with the Black River and early Trenton formations in the upper Mississippi Valley. As the middle Ordovician position of these American strata is unquestionably established, a similar assignment of their Russian equivalents seems, at least for the present, justifiable.

In the more southern portions of Canada and in the United States the coral zone of the Lyckholm-Borkholm is recognized at many localities. It is well developed in the so-called Noix oölite of Missouri and Illinois, which holds not only the same genera, but in many cases identical species of corals with distinct Silurian affinities. This oölite, as well as the underlying formations of Richmond age, contain the bryozoans which have been noted also in the upper Lyckholm and in the Borkholm formations. Though similar to the preceding

Ordovician faunas in Russia and Arctic America, of Arctic origin and development, the upper Lyckholm-Borkholm fauna is more sharply distinguished from the lower Lyckholm and preceding faunas than the

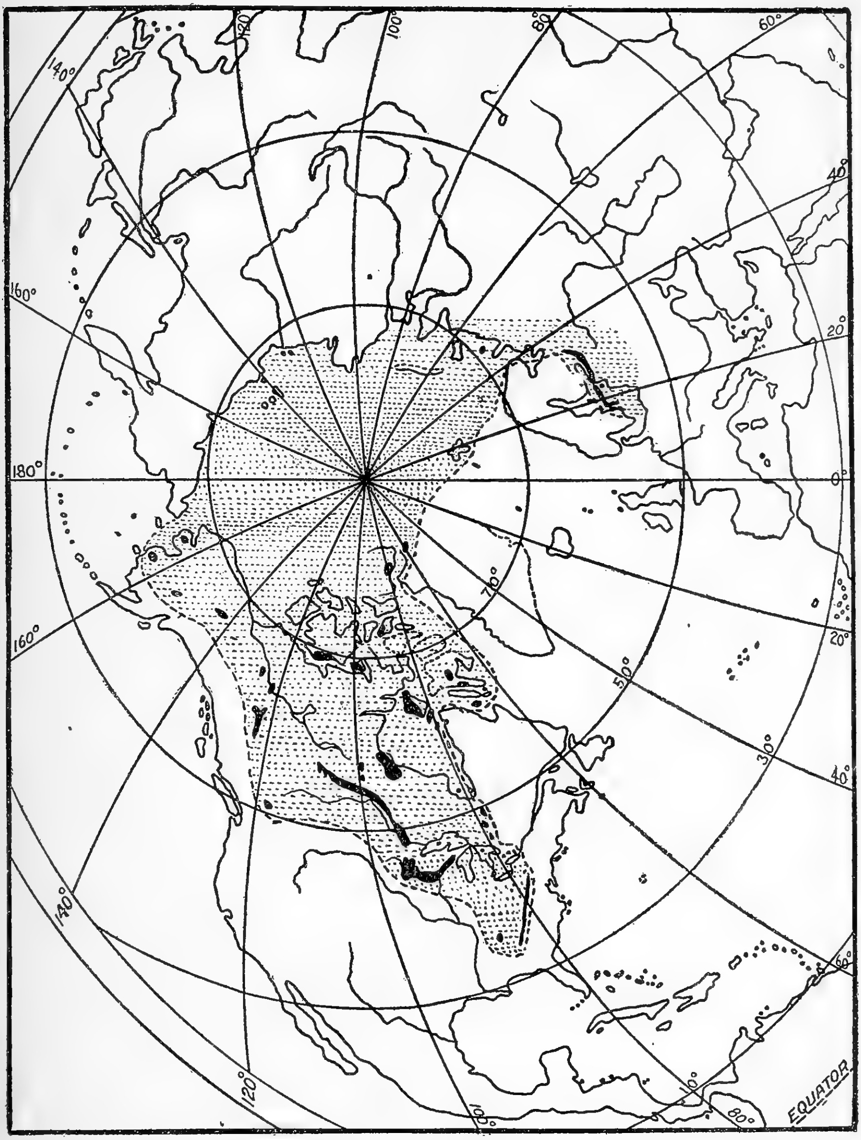

FIG. 3.—GENERALIZED PALEOGEOGRAPHIC MAP SHOWING SUPPOSED DISTRIBUTION OF LAND AND WATER DURING BLACK RIVER (DECORAH) AND EARLY TRENTON (PROSSER) TIMES. ACTUAL OUTCROPS SHOWN IN BLACK.

latter are from each other. This fact offers another argument for the belief that a line passes through the Lyckholm that represents a very considerable time break and adds to the plausibility of the correlation of the Wesenberg as not younger than early Trenton.

On the accompanying paleogeographic map (fig. 3) I have plotted all of the localities discussed in the preceding pages as well as other areas where Black River and early Trenton strata are known to contain the faunas under discussion. Except for local variations of minor importance the distribution of these two formations in America is essentially the same, so that this map will serve for both. Although

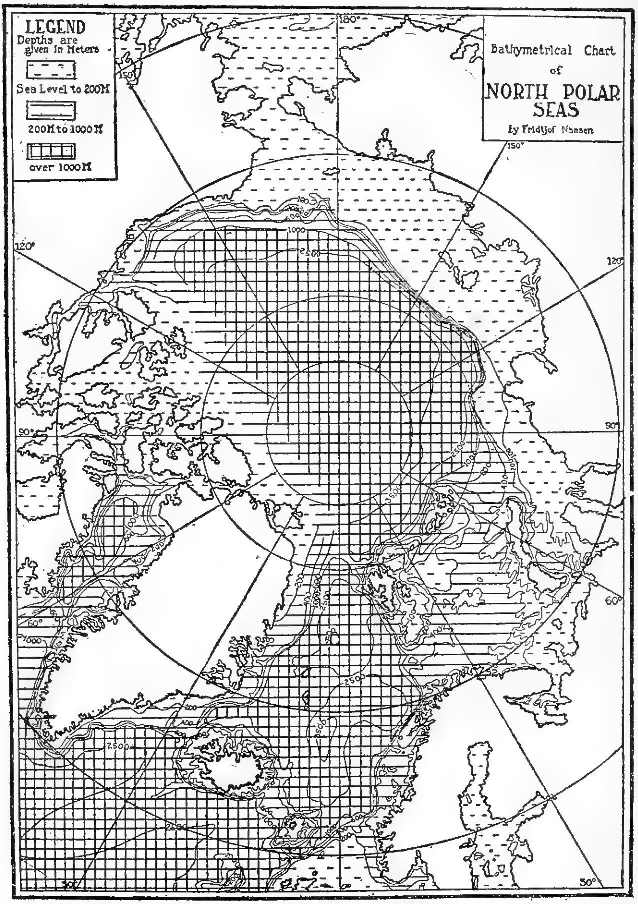

FIG. 4.—BATHYMETRIC CHART OF THE NORTH POLAR SEAS, SUGGESTING ROUTES OF MIGRATION FOR MARINE ORGANISMS. (AFTER NANSEN.)

the Ordovician rocks of the Baltic area fail to outcrop some distance east of St. Petersburg, due perhaps entirely to overlap by younger strata, they may extend across northern Russia under cover, for outcrops are known in the Ural Mountains and along the shore of the Kara Sea. The latter locality is of particular interest in the present connection, for here, along the shores of Yugor Strait, Nansen collected a fauna which Kiaer [1] correlated with the Baltic C1. With such an eastward extension of the Baltic Ordovician faunas, it is quite possible that in time they may be proven to be circum-polar. East of the Ural Mountains and west of Alaska little of the Ordovician geology is known, so that here, in drawing the outlines of the Black River-Early Trenton Sea, I have simply followed the present day coast.

In this connection Nansen's bathymetric chart of the North Polar Seas, which I have introduced (fig. 4), is of interest in showing possible routes of migration for marine faunas. Believing in the permanence of continental land masses and oceanic deeps, it is thought that essentially similar conditions prevailed in early Paleozoic times.

THE BRYOZOAN FAUNAS.

Although the bryozoans in many instances constitute the larger portion of a fauna, the study given them is almost invariably less than that of any other class. This is due to the fact that they have a reputation for being one of the most difficult classes of organisms. Their small size requires the use of a hand lens or a microscope, and in the fossil forms frequently the preparation of thin sections. Yet the necessity for thin sections is to the advantage of the student, for by their use he is less liable to error. It is in this very fact that the fossil Bryozoa are so valuable to the stratigrapher. In areas where other fossils are too imperfect or ill preserved for identification, the merest fragments of bryozoans can be identified with certainty by properly prepared thin sections. Again, the bryozoans are of great importance to the stratigraphical geologist because they occur usually in great abundance over wide areas and preserve their specific characters with little change.

Of the various classes that are represented in the Ordovician rocks of Baltic Russia, bryozoans in all probability rank first in number of species and individuals. As indicated on some of the plates at the end of this volume, certain shales are often crowded with them and thin limestone bands are frequently one mass of their fragmentary remains.

All of the trepostomatous bryozoans and many of the Cryptostomata and Cyclostomata require thin sections for their initial study. Directions for the preparation of such thin sections have been given in the report of the "Geological Survey of Illinois," volume 8, 1890, page 292; in the "Final Report of the Geological and Natural History Survey of Minnesota," volume 3, 1893, page 100; in "Bulletin 173 of the United States Geological Survey," 1900, page 122, and, more recently, in the "Thirty-second Annual Report of the Indiana

[1] J. Kiaer in Nansen's North Polar Expedition, vol. 4, No. 11, 1902.

Geological Survey," 1907, page 736. As detailed directions are given in each of these volumes, it is unnecessary to repeat them here.

It is of course needless to make thin sections of every specimen. After a species has been determined, the internal characters of other specimens believed to belong to the same species can be determined by slightly etching with acid whatever parts one wishes to study, and, after moistening the etched areas, examining them under a hand lens. With this very simple method, the structural details can be seen distinctly. Comparison then with sectioned material or with species which have been described and figured will in most cases serve to establish the identity of the specimen.

Most of the terms employed in the description of fossil bryozoans are defined in the following notes on terminology:

TERMINOLOGY.

Zoarium.—The composite structure formed by repeated gemmation. Although fairly constant for each species, the form which results is very variable. Gemmation in a plane produces *unilaminar* sheets, which are sometimes free, but are often *parasitic* (incrusting) upon other organisms; in the former case the protecting covering on the under side is the *epitheca.* Hollow branches lined with an epitheca are a special form of this mode of gemmation. Two unilaminar sheets growing erect, back to back, form a *bilaminar* or *bifoliate* expansion or *frond.* The epithecæ of the two layers of zoœcia thus brought together form a *mesotheca* (mesial or medial laminæ). The small pores seen in the mesotheca, or between the walls of adjoining zoœcia of certain species when thin sections of well-preserved specimens are examined under the microscope, have been given the name of *median tubuli* by Ulrich.

Zoœcium.—The cavity inhabited by the animal. The bounding wall is constructed of laminated tissue. In particularly well-preserved specimens, thin sections reveal very small tubular passages penetrating the walls of adjoining zoœcia. To these Ulrich has applied the name *communication pores.* As will be noted in the descriptions of certain species in this work, the Ceramoporidæ show especially well-marked pores of this nature.

In some forms, especially among the Trepostomata, the zoœcia have the form of elongated tubes, which are crossed by partitions termed *diaphragms.* The general term *tabulæ* is sometimes employed in place of *diaphragms.* The opening upon the surface of the zoœcium or of the vestibule among the Cryptostomata is the *aperture.* It is often closed by a *zoœcial cover* (closure or operculum).

One side of the zoœcial cavity in some of the Trepostomata is lined with a series of superimposed vesicles, the *cystiphragms;* their purpose or use is unknown.

Among the Cryptostomata plates frequently project from the walls into the cavity; that upon the posterior wall of the zoœcium is the *superior hemiseptum,* that upon the outer wall the *inferior hemiseptum.* The opening of the zoœcium among the Cryptostomata is the *orifice;* the tubular shaft which is left above the orifice as the surface of the zoarium is thickened by strengthening or protective tissue is the *vestibule.*

Maculæ.—A common surface character among a large number of Paleozoic bryozoans and many more recent species is the occurrence at regular intervals of areas made up of larger zoœcia and more numerous mesopores, or of mesopores alone. These areas or spots of special development are designated under the general name of *maculæ.* When the maculæ are elevated, they are known as *monticules* or *tubercles,* according to the sharpness of elevation.

Mesopores (interstitial cells).—Tubular structure occurring between the zoœcia; they are usually smaller than the zoœcia and are angular or irregular in outline in cross sections. The number and size of the mesopores varies greatly sometimes even in the same species. If diaphragms are present they are invariably more abundant in the mesopores, thus affording a ready means of discriminating between the zoœcia and mesopores. The development of mesopores is practically restricted to the peripheral portion of the zoarium and their use simply to fill up whatever spaces were left between the zoœcia. Mesopores are, therefore, simply cells filling the interzoœcial spaces.

An interesting development of mesoporelike cells has been noted in many of the Russian massive bryozoans, such as *Diplotrypa bicornis, Esthoniopora communis,* and *Dianulites petropolitana.* In old examples of these species the basal portion of the zoarium shows no true zoœcia, but in their place are numerous thick-walled, closely tabulated, mesoporelike cells. With age more and more tissue is deposited upon the walls until finally the openings of the mesopores are practically obliterated. Possibly the zoarium of such massive species rested in muddy deposits during life, and normal zoœcia developed only where a food supply was available. The Russian specimens of *Leptotrypa hexagonalis* which have been invariably found incrusting a species of *Hyolithes* likewise develop a basal layer of such thick-walled mesopores. In every case this layer is found only on the flat side of the *Hyolithes.* Other species which incrust *Hyolithes,* such as *Mesotrypa expressa,* likewise show this layer only on the flat side of the shell. If this layer of smaller cells is developed only on the basal portion of the zoarium, its occurrence on the flat side of the *Hyolithes* is probably indicative that the bryozoan attached itself to only dead shells which would naturally drop to the bottom flat side down.

Interspace.—The part of the surface of the zoarium between the apertures of the zoœcia.

Vesicular tissue.—In a number of forms the space between the zoœcia is occupied by tissue composed of irregularly superimposed vesicles. This probably served to give strength to the zoarium and to protect the zoœcia.

Acanthopores.—Small cylindrical tubes usually situated at the angles of junction of adjoining zoœcia, forming spinelike projections upon the surface. Thin sections show that the acanthopore is not a mere surface ornament but is a tube inclosed in the wall substance of the zoœcium and developed generally only in the mature region. This tube, with its inclosing wall substance, sometimes reaches a size as great as that of the ordinary mesopore.

Lunarium.—In the Ceramoporidæ and Fistuliporidæ especially, the posterior portion of the zoœcial wall is more or less thickened and elevated above the general surface and curved to a shorter radius to form the crescentic structure known as the lunarium.

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Although the list of articles dealing with the Russian Ordovician Bryozoa is not a small one, practically all of value that has been published is contained in Dybowski's "Chaetetiden der Ostbaltischen Silur-Formation" and in Eichwald's "Lethæa Rossica." As neither of these works is easily obtained, the illustrations and some of the observations of both authors have been incorporated in the present work, in the effort to embody in this volume all available information regarding the subject. The following list is believed to contain most of the publications referring to the Russian Ordovician Bryozoa:

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1830. Pander, C. H. Beitrag zur Geognosie d. Russlands.

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RANGE OF BALTIC ORDOVICIAN AND EARLY SILURIAN BRYOZOA.

In the following table I have arranged all of the species recognized as valid in the present volume in biologic order, and have indicated their geologic range in both Russian and American formations. The latter are abbreviated as follows:

Platteville = P; Clitambonites = C; Stictoporella = St; Nematopora = N; Rhinidictya = R; Fusispira = F; Ctenodonta = Ct; Richmond = R; Phylloporina = Ph; Clinton = Cl.

Table showing range of Baltic Ordovician and early Silurian Bryozoa.

Species.	Russian formations.													American formations.									Miscellaneous horizons.
														Black River group.					Earliest Trenton.		Early Silurian.		
	A2.	B1.	B2.	B3.	C1.	C2.	C3.	D1.	D2.	D3.	E.	F1.	F2.	P.	St.	R.	Ct.	Ph.	C.	N and F.	Ri.	Cl.	
CTENOSTOMATA.																							
Vinella repens Ulrich								×			×							×					
Heteronema priscum, new species	×																						
CYCLOSTOMATA.																							
Stomatopora arachnoidea (Hall)					×	×						×				×		×	×	×	×		
Corynotrypa delicatula (James)						×		×		×					×	×	×	×	×	×	×		
Corynotrypa barberi Bassler												×											Ottosee shale.
Corynotrypa inflata (Hall)											×							×	×	×	×		
Corynotrypa abrupta Bassler												×									×		
Corynotrypa schucherti Bassler											×												
Corynotrypa dissimilis (Vine)												×	×									×	
Mitoclema boreale, new species				×						×	×												
Mitoclema? mundulum Ulrich						×														×			
Protocrisina exigua Ulrich													×								×		
Protocrisina ulrichi, new species						×																	
Ceramopora spongiosa, new species										×													
Ceramopora invenusta, new species											×												
Ceramopora intercellata, new species												×											
Ceramoporella granulosa minor, n. var								×		×								×					
Ceramoporella uxnormensis, new species										×													
Cœloclema crassimurale, new species								×		×													
Cœloclema laciniatus (Eichwald)						×																	
Crepipora schmidti, new species								×															
Crepipora lunatifera, new species											×												
Crepipora incrassata, new species										×													
Anolotichia rhombica, new species											×												Chasmops limestone.
Anolotichia brevipora, new species						×																	
Anolotichia revalensis, new species				×																			
Anolotichia impolita (Ulrich)						×									×								
Anolotichia sacculus, new species						×																	
Favositella exserta, new species						×																	
Favositella discoidalis, new species					×																		
Favositella ? punctata, new species										×													
Spatiopora lineata incepta Ulrich											×						×						

Scenellopora socialis (Eichwald)					×																		
Fistulipora primæva, new species			×																				
Chilotrypa immatura, new species												×											
CRYPTOSTOMATA.																							
Ptilodictya flabellata Eichwald													×										
Ptilodictya gladiola Billings													×								×		
Escharopora subrecta (Ulrich)										×					×	×							
Phænopora ensiformis Hall													×									×	
Arthropora simplex Ulrich										×					×	×							
Graptodictya bonnemai, new species						×		×			×												
Graptodictya proava (Eichwald)										×									×				
Graptodictya obliqua, new species												×											
Stictoporella cribrosa Ulrich										×					×	×	×						
Stictoporella gracilis (Eichwald)			×																				
Rhinidictya mutabilis (Ulrich)										×				×	×	×	×	×	×	×			
Rhinidictya exserta (Eichwald)									×		×												
Phyllodictya flabellaris, new species				×																			
Phyllodictya varia Ulrich										×						×							
Pachydictya elegans Ulrich						×					×								×				
Pachydictya flabellum (Duc de Leuchtenberg)											×												
Pachydictya cyclostomoides (Eichwald)						×		×	×														Chasmops limestone.
Pachydictya bifurcata (Hall)												×	×									×	
Coscinium prænuntium, new species				×																			
Arthrostylus conjunctus Ulrich										×								×					
Arthrostylus obliquus Ulrich					×										×								
Helopora divaricata Ulrich						×									×								
Arthroclema armatum Ulrich			×																	×			
Sceptropora facula Ulrich													×								×		
Sceptropora francisca, new species										×													
Nematopora consueta, new name						×														×			
Nematopora ovalis Ulrich						×														×			
Nematopora fragilis Ulrich												×									×		
Nematopora lineata (Billings)													×								×		
Glauconome plumula Wiman												×	×										
Glauconome strigosa (Billings)													×								×		
Rhombopora esthoniæ, new species								×															
Nematotrypa gracilis, new species					×	×		×															Do.
Lichenalia concentrica Hall													×									×	
Chasmatopora tenella (Eichwald)													×										
Chasmatopora reticulata (Hall)										×					×	×				×			
Chasmatopora furcata (Eichwald)						×																	
Pseudohornera bifida (Eichwald)						×				×	×												
Pseudohornera orosa (Wiman)													×										
Fenestella striolata Eichwald													×										
TREPOSTOMATA.																							
Monticulipora arborea bispinulata, n. var.										×													
Monticulipora dagoensis, new species												×											
Orbignyella germana, new species										×													

Table showing range of Baltic Ordovician and early Silurian Bryozoa—Continued.

Species.	Russian formations.													American formations. Black River group.					American formations. Earliest Trenton.		American formations. Early Silurian.		Miscellaneous horizons.
	A2.	B1.	B2.	B3.	C1.	C2.	C3.	D1.	D2.	D3.	E.	F1.	F2.	P.	St.	R.	Ct.	Ph.	C.	N and F.	Ri.	Cl.	
TREPOSTOMATA—continued.																							
Orbignyella expansa baltica, n. var.												×											Niagaran.
Homotrypa similis Foord										×									×	×			
Homotrypa subramosa Ulrich						×										×		×					
Homotrypella instabilis Ulrich					×	×										×							
Homotrypella cribrosa, new species										×								×					
Homotrypella hospitalis crassa (Ulrich)										×						×		×	×				
Mesotrypa discoidea orientalis, n. var.								×															
Mesotrypa egena, new species									×														
Mesotrypa expressa, new species						×																	
Mesotrypa milleporacea, new species						×		×	×														Chasmops limestone.
Mesotrypa milleporacea parva, n. var.						×																	
Dekayella prænuntia Ulrich						×				×						×							
Dekayella prænuntia simplex Ulrich										×					×	×							
Dekayella prænuntia nævigera Ulrich										×					×								
Leptotrypa hexagonalis Ulrich						×								×									
Stigmatella massalis, new species									×														
Stigmatella inflecta, new species				×	×																		
Stigmatella foordii (Nicholson)						×																	
Stigmatella claviformis (Ulrich)										×						×	×	×					
Constellaria varia (Ulrich)								×		×										×			
Stellipora revalensis Dybowski						×																	
Stellipora constellata Dybowski												×											
Stellipora apsendesoides, new species					×																		
Nicholsonella gibbosa, new species			×	×																			
Dianulites fastigiatus Eichwald			×		×																		Do.
Dianulites petropolitana Dybowski			×	×	×						×									×			Asaphus, Chasmops.
Dianulites grandis, new species												×											
Dianulites collifera, new species												×											
Bythopora subgracilis (Ulrich)										×						×							
Eridotrypa ædilis (Eichwald)								×	×	×	×							×	×	×			
Eridotrypa ædilis minor (Ulrich)											×							×	×				
Eridotrypa exigua Ulrich								×												×			
Lioclema vetustum, new species						×																	
Lioclema spineum, new species				×	×	×																	Chasmops limestone.
Lioclemella clava, new species								×	×	×													

Orbipora distincta (Eichwald)					×	×		×															Do.
Orbipora solida, new species				×																			
Orbipora acanthophora, new species																							Asaphus limestone.
Orbipora indenta, new species																							Do.
Esthoniopora communis, new species		×	×	×	×		×																
Esthoniopora curvata, new species				×	×																		Chasmops limestone.
Petalotrypa folium, new species									×														
Trematopora primigenia Ulrich										×						×							
Trematopora kuckersiana, new species					×		×																
Trematopora cystata, new species					×			×															
Batostoma magnopora Ulrich									×							×							
Batostoma fertile Ulrich				×											×								
Batostoma fertile circulare Ulrich				×											×								
Batostoma mickwitzi, new species										×													
Batostoma winchelli (Ulrich)								×			×					×							
Batostoma winchelli spinulosum Ulrich										×						×							
Batostoma granulosum, new species							×	×															
Hemiphragma tenuimurale Ulrich										×									×	×			
Hemiphragma irrasum (Ulrich)				×											×	×		×	×				
Hemiphragma panderi (Dybowski)						×		×															
Hemiphragma glabrum, new species										×													
Hemiphragma pygmæum, new species																							Do.
Hemiphragma multiporatum, new species				×	×																		
Hemiphragma subsphericum, new species											×												
Hemiphragma rotundatum, new species			×	×	×																		
Hemiphragma maculatum, new species					×																		
Hemiphragma batheri, new species																							Do.
Anaphragma mirabile Ulrich and Bassler												×									×		
Anaphragma mirabile cognata, n. var										×	×												
Dittopora clavæformis Dybowski			×																				
Dittopora annulata (Eichwald)			×	×	×																		
Dittopora colliculata (Eichwald)						×				×	×	×											Do.
Monotrypa jewensis, new species								×	×														
Diplotrypa petropolitana Nicholson			×	×	×	×	×	×	×	×	×	×											Do.
Diplotrypa bicornis (Eichwald)			×		×	×		×															Do.
Diplotrypa moniliformis, new species								×															
Diplotrypa hennigi, new species						×																	
Diplotrypa westoni Ulrich																				×			Do.
Hallopora multitabulata (Ulrich)										×						×		×	×				
Hallopora goodhuensis (Ulrich)										×	×								×				
Hallopora wesenbergiana (Dybowski)				×						×	×												
Hallopora splendens, new species								×															
Hallopora dumalis (Ulrich)						×												×	×				
Hallopora undulata (Ulrich)										×						×	×						
Hallopora tolli, new species						×		×	×														
Hallopora elegantula (Hall)												×	×										
Hallopora? dybowskii, new species					×	×		×				×											Do.
Hallopora? tenuispinosa, new species									×			×											

DESCRIPTIONS OF GENERA AND SPECIES.

Order CTENOSTOMATA Busk.

The Paleozoic fossils referred to this order of the Bryozoa have been made the subject of a small monograph [1] to which the reader is referred for a more detailed discussion than can be given at present. As remarked in that work, little is known about these peculiar types of fossil Bryozoa, and, while their classification with the Ctenostomata is perhaps a little better than a mere working theory, it rests mainly on highly suggestive resemblances between the fossil organism and the supposed corresponding parts of living forms, and on conjectures as to the unknown parts. Again, their reference to the Ctenostomata is supported by more and stronger arguments and opposed by fewer objections than when comparison is made with any other class of organisms. As these fossils are comparatively rare in American strata, which have been searched quite thoroughly for them, it is not surprising that only a few specimens have been found in the Russian and Swedish deposits. However, the few examples that have appeared in the various collections studied have been fairly well preserved and their identification with American forms can be made with a correspondingly greater degree of certainty.

With a possible exception, the various species referred to as Paleozoic Ctenostomata have been thought to be founded upon the creeping bases of the zoarium and not upon the zoœcium itself. The possible exception was in the case of *Rhopalonaria* in which it was assumed that the fusiform swellings are really the zoœcia instead of the creeping base. The zoœcia in both *Rhopalonaria* and *Vinella* were probably deciduous and were developed by budding from these pores.

The chemical composition of the zoarium of the recent Ctenostomata and of their supposed fossil representatives does not entirely agree, although in each instance it differs from that of the other orders of Bryozoa. In the recent Ctenostomata the zoarium is horny or membraneous. The Paleozoic representatives contain more calcareous matter, although a considerable portion of their constitution is corneous and shows a style of preservation quite unlike that of associated bryozoans. Quite frequently these fossil forms have been so changed that their substance now occurs as black and corneous, or is replaced entirely by iron pyrites.

The Ctenostomata may be briefly defined as follows: Zoœcia usually isolated and developed by budding from the internodes of a distinct tubular stolon or stem. Orifice terminal, with an operculum of setæ. Zoarium horny or membranaceous. Marsupia wanting.

[1] Ulrich and Bassler, Smiths. Misc. Coll., vol. 45 (Quart. issue, vol. 1, pts. 3 and 4), 1904, pp. 256–294, pls. 65–68.

Family VINELLIDÆ Ulrich and Bassler.

All of the forms referred to this family are fossil and are believed to represent merely the creeping base of the zoarium. This base consists of simple, delicate, partially ramifying, tubular threads, which, in one genus, are arranged without any regular order, in a second proceed from more or less definite centers, and in a third are locally jointed. The second of these, *Vinella,* is represented in the collections under study by its type species, *Vinella repens,* while the first is recognized very doubtfully for the reception of a very interesting new form, *Heteronema priscum.*

Genus VINELLA Ulrich.[1]

Vinella Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 173.—Miller, North Amer. Geol. and Pal., First App., 1892, p. 685.—Vine, Proc. Yorkshire Geol. Polyt. Soc., vol. 12, 1892, p. 84.—Ulrich, Geol. Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 112.—Pocta, Syst. Sil. Centre Boheme, vol. 8, pt. 1, 1894, p. 17.—Simpson, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 604.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 19—Ulrich and Bassler, Smiths. Misc. Coll., vol. 45, 1904, p. 273.—Bassler, Bull. 292, U. S. Geol. Surv., 1906, p. 12.

Zoarium parasitic, consisting of very slender, tubular threads or stolons, arranged more or less distinctly in a radial manner. Surface of threads with a single row of small pores. These may be wanting locally, and vary considerably in the degree of their separation. Zoœcia unknown, probably deciduous.

Genotype.—Vinella repens Ulrich. Middle Ordovician of America and Europe.

VINELLA REPENS Ulrich.

Text fig. 5.

Vinella repens Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 174, fig. 1.—Vine, Proc. Yorkshire Geol. Polyt. Soc., vol. 12, 1892, p. 84, pl. 3, figs. 1–4.—Ulrich, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 114, pl. 1, figs. 1–5.—Simpson, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 604, fig. 222.—Ulrich and Bassler, Smiths. Misc. Coll., vol. 45, 1904, p. 274, pl. 68, figs. 1–3.

Original description.—Zoarium repent, the stolons delicate, thread-like, often longitudinally striate, straight or flexuous; from 0.06 to 0.11 mm. in diameter; bifurcating often and sometimes arranged in a radial manner about a central node. Where best preserved, very small pores arranged uniserially along the center of the upper surface of the threads; about 11 in 2.5 mm. Zoœcia unknown, probably deciduous.

Three specimens of this species have been identified in the Russian collections, one from the Jewe limestone (D1) incrusting a ramose bryozoan, and two from the Wesenberg limestone (E) growing upon

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[1] In the synonymy throughout this work, only those references deemed of importance to the student in the present connection are given. More complete citations can be found in Bull. 173, U. S. Geological Survey.

brachiopod shells. Although all three are in a fair state of preservation, they add no new features to the original description given above.

Vinella repens is a characteristic Black River fossil in America, and the occurrence of such typical examples of the species in the same general horizon in Russia is only another instance of the stratigraphic value of these delicate bryozoans. The fine radiating threads of this species are so different from any other associated bryozoan that comparisons are unnecessary. Usually the preservation is by

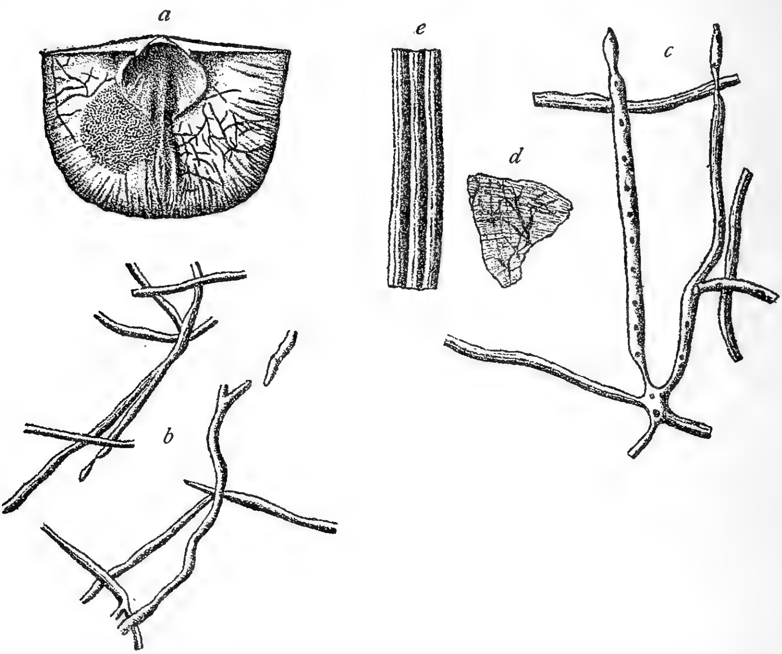

FIG. 5.—VINELLA REPENS. *a*, TWO COLONIES, NATURAL SIZE, ATTACHED TO THE INNER SIDE OF A VENTRAL VALVE OF STROPHOMENA SEPTATA; *b*, PORTION OF ONE OF THE COLONIES, ×18. THE PORES ARE ABSENT, PROBABLY NOT HAVING BEEN PRESERVED; *c*, ANOTHER PORTION OF SAME ZOARIUM, ×18, SHOWING A NUCLEUS WITH FIVE DIVISIONS OF THE TUBULAR STOLON RADIATING FROM IT. THIS PORTION OF THE SPECIMEN ALSO PRESERVES SOME OF THE PORES MARKING THE POINTS WHERE THE ZOŒCIA WERE ATTACHED; *d*, ANOTHER SPECIMEN, NATURAL SIZE, ATTACHED TO A FRAGMENT OF SHELL; *e*, SMALL PORTION OF SAME, ×18, WITH THREE TUBES LYING PARALLEL WITH EACH OTHER. THE LONGITUDINAL LINES ARE STRONGER THAN USUAL. PHYLLOPORINA BED OF BLACK RIVER (DECORAH) SHALES AT ST. PAUL, MINNESOTA. (AFTER ULRICH.)

the black iron pyrites, which gives a clue in the identification of poor specimens.

Occurrence.—Not uncommon in the Phylloporina bed of the Black River (Decorah) shales in Minnesota. Less common in the Jewe limestone (D1) at Baron Toll's estate (Cat. No. 57507, U.S.N.M.), and in the Wesenberg limestone (E) at Wesenberg, Esthonia (Cat. No. 57179, U.S.N.M.).

Typical American specimens of this species are in the collections of the British Museum.

Genus HETERONEMA Ulrich and Bassler.

Heteronema ULRICH and BASSLER, Smiths. Misc. Coll., vol. 45, 1904, p. 278.

Original description.—Zoaria, so far as known, consisting of usually simple, or locally jointed, delicate, sparsely ramifying, tubular, creeping threads, arranged without apparent order. Pores rarely observed, apparently always in a single row.

Genotype.—*Heteronema capillare* Ulrich and Bassler. Silurian, island of Gothland.

The species referred to this genus represent the simplest forms of the Vinellidæ and are distinguished from the type genus *Vinella* first because of this extremely simple structure, but mainly on account of the absence of the highly characteristic nuclei and consequent radial arrangement of the threads. The following new species forms such a regular network by dichotomous branching that it must be doubtfully referred to *Heteronema.* A species from the Upper Ordovician (Maysville formation) of Ohio has a somewhat similar growth, and it is possible that with more knowledge these two will be referred to a new genus. *H. priscum* is of further interest in that it is the oldest known bryozoan. The Ctenostomata are usually considered the simplest of bryozoans, and theoretically species of this order should obtain in the oldest rocks. The discovery of such a simple type of the order in the Cambrian is therefore in keeping with our knowledge of the class.

HETERONEMA PRISCUM, new species.

Text fig. 6.

This species is founded on a number of specimens, all of which consist of large or small patches incrusting the smooth shells of the brachipod *Obolus.* It was at first believed that these incrustations represented a reticulate surface ornamentation, but this view was soon disproved by the different composition of the threads and mainly by the fact that in some specimens one set of threads was growing over another.

The zoarium consists of thin, dark, corneo-calcareous threads bifurcating dichotomously so uniformly that a rather regular network results. The individual meshes of this network average 0.4 mm. in diameter, while the threads themselves are less than 0.02 mm. wide. Frequently, as shown in figure 6 *c*, one zoarium may be noted growing over one or more previous incrustations. Upon examination under a high power of the microscope small pores rather regularly arranged are seen along the middle line of the threads, while the zoarial substance itself appears very faintly granulose. The threads are not always of uniform diameter and occasionally are somewhat bulbous.

As noted in the general remarks upon the Ctenostomata, the reference of these fossil forms to that order seems the best arrangement under the circumstances. In the case of the present species particularly its unquestionable reference to the Bryozoa must be substantiated by future discoveries.

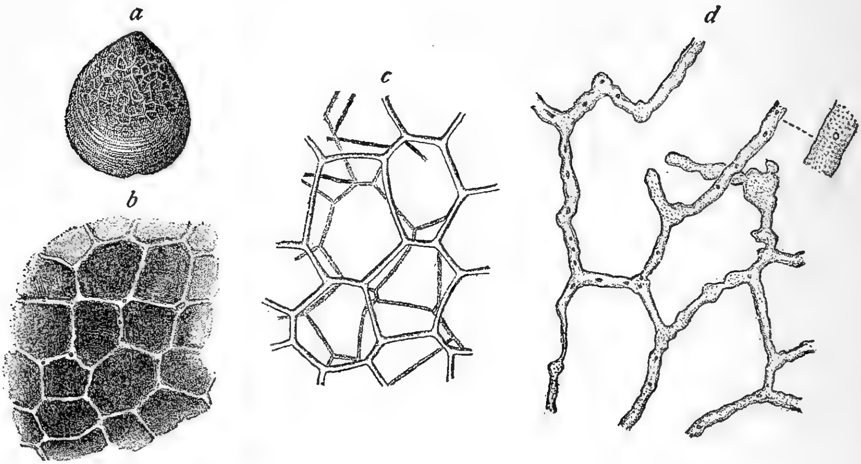

Fig. 6.—Heteronema priscum. *a*, a colony attached to a valve of Obolus, ×4; *b*, a portion of the same, ×20, illustrating the method of branching; *c*, parts of two colonies, ×35, with one growing over another; *d*, small portion of another zoarium, ×50, showing the microscopic structure of the threads. Ungulite sandstone (A2), Upper Cambrian, Jegelecht Falls, Esthonia.

Occurrence.—An abundant species in the Upper Cambrian (Ungulite) sandstone (A2) at Jegelecht Falls, Esthonia.

Cotypes.—Cat. No. 57180, U.S.N.M.

British Museum collections, one specimen.

Order CYCLOSTOMATA Busk.

The bryozoans belonging to this order have a simplicity of structure highly characteristic in both zoaria and zoœcia. The zoœcia are especially simple throughout the order, so that the classification is based almost entirely upon their arrangement and method of growth. The recent forms show that this same simplicity extends to the polypide, and that the larvæ of the different families are practically identical. The zoœcia are simple, calcareous tubules with plain, uncontracted, usually rounded apertures and with minutely porous walls. The interzoœcial spaces may or may not be filled with solid strengthening deposits. Marsupia and appendicular organs are wanting, but the ovicell is present in the form of a large cell or an inflation of the zoarial surface set aside for reproductive purposes.

The simplest Cyclostomata are comprised in Busk's families Diastoporidæ and Idmoneidæ and in the Entalophoridæ of Reuss, all of which have numerous fossil species. Each of these families is represented, although somewhat sparsely, in the Russian strata under discussion.

The much-debated Ceramoporidæ and Fistuliporidæ are more numerously represented both in genera and species. These families, considered by many authors as tabulate corals but by Ulrich as trepostomatous bryozoans, were doubtfully referred by the latter in 1900 [1] to the Cyclostomata. Further studies have shown the wisdom of this course, and I believe enough evidence can now be assembled to establish the Ceramoporidæ and Fistuliporidæ as undoubted Cyclostomata. Both have the minutely porous wall structure of typical members of the order, and, in addition, most of their genera show oœcia exactly as in recent forms.

Family DIASTOPORIDÆ Busk.

Only the simplest of the diastoporoid genera are represented in the Russian collections, and most of their species prove to be identical with American forms. The same condition holds for the Idmoneidæ and the Entalophoridæ, but the remaining families, while represented by the same genera, have in most cases new, although analogous, species.

Genus STOMATOPORA Bronn.

Stomatopora BRONN, Pflanzenth., 1825, p. 27.—D'ORBIGNY, Pal. Francais, Terr. Cret., vol. 5, 1854, p. 833.—HAIME, Bry. Foss. Form. Juras., 1854, p. 159.

Stomatopora (part) PICTET, Traite de Pal., ed. 2, vol. 4, 1857, p. 142.—HINCKS, British Marine Polyzoa, 1880, p. 424.—ZITTEL, Handbuch d. Pal., vol. 1, 1880, p. 598.—ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 149.—VINE, Proc. Yorkshire Geol. Polyt. Soc., vol. 9, 1887, p. 186.—MILLER, North American Geol. and Pal., 1889, p. 325.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, p. 367; Geol. Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 115; Zittel's Textbook of Paleontology (Eng. ed.), vol. 1, 1896, p. 260.—SIMPSON, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 597.— NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 20.—CUMINGS, Amer. Journ. Sci., ser. 4, vol. 17, 1904, p. 75; 32nd. Ann. Rep. Dept. Geol. Nat. Res. Indiana, 1907, p. 757.

Aulopora (part) GOLDFUSS, REUSS, HALL, NICHOLSON.

Zoarium of delicate, adnate, uniserially arranged, subtubular zoœcia with subterminal, exsert apertures and minutely porous walls.

Genotype.—Stomatopora dichotoma (Lamouroux). Jurassic of Europe.

Previous definitions of the genus *Stomatopora* have included the simple unilinear species with clavate zoœcia and with constricted apertures. These have been recently classed under the new genus *Corynotrypa*.[2]

[1] Zittel's Textbook of Paleontology, English edition, vol. 1, p. 267.

[2] Bassler, Proc. U. S. Nat. Mus., vol. 39, 1911, pp. 497-527.

Species of *Stomatopora* have also been classed with the coral genus *Aulopora*, which has a somewhat similar growth and cell aperture. This coral, however, in addition to other differences, is invariably of much larger size and lacks the porous walls of the bryozoan.

STOMATOPORA ARACHNOIDEA (Hall).

Text fig. 7.

Aulopora arachnoidea HALL, Nat. Hist. New York, Pal., vol. 1, 1847, p. 76, text fig., pl. 26, figs. 6*a–c*.—NICHOLSON, Pal. Ohio, vol. 2, 1875, p. 216, pl. 23, figs. 1, 1*b*.
Stomatopora arachnoidea NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 419.—CUMINGS, 32nd. Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 885, pl. 32, figs. 2–2*c*.

The American specimens referred to this species occur in all the divisions of the Middle and Upper Ordovician, and in the Richmond group of earliest Silurian age. The various Russian examples having the characters of typical *Stomatopora* agree in all respects with *S. arachnoidea*, save that they are of slightly more delicate growth. This difference is not even of varietal importance, since, as shown from the study of American examples, a large number of specimens would undoubtedly remove it.

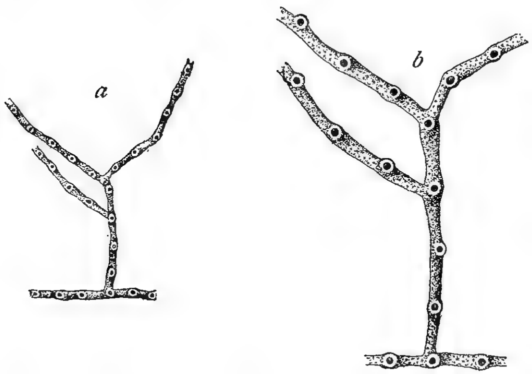

FIG. 7.—STOMATOPORA ARACHNOIDEA. *a*, PORTION OF A DELICATE ZOARIUM, ×9, GROWING UPON THE CELLULIFEROUS SIDE OF A SPECIES OF HELIOLITES; *b*, PART OF THE SAME, ×20, ILLUSTRATING THE DETAILED STRUCTURE. LYCKHOLM LIMESTONE (F1), HOHENHOLM, ISLAND OF DAGO.

The zoarium in *Stomatopora arachnoidea* is of slender, delicate incrusting, frequently dividing, more or less parallel edged branches made up of simple zoœcia arranged in a single series. The apertures are circular, somewhat exsert, and are almost as wide as the branches, 4 to 5 in 2 mm.; walls of zoœcia finely porous.

There is no chance to confuse this species with any associated bryozoan, save, possibly, the various forms of *Corynotrypa*. The latter agree in their simple, unilinear, adnate growth, but differ decidedly in their club-shaped zoœcia.

Occurrence.—In America this species is found throughout the Middle and Upper Ordovician and earliest Silurian at various localities in the United States and Canada. The occurrences in Russia are (1) in the Echinospherites limestone (C1), 4 miles east of Reval, where a specimen was found incrusting a ramose bryozoan (Cat. No. 57182, U.S.N.M.); (2) a small example incrusting a crinoid plate in the Kuckers shale (C2), Baron Toll's estate, near Jewe (Cat. No. 57181, U.S.N.M.); and (3) several large colonies growing upon the celluliferous face of *Heliolites*, from the Lyckholm limestone (F1), at Hohenholm, island of Dago, Baltic Sea (Cat. No. 57183, U.S.N.M.).

Numerous specimens from American localities are in the British Museum.

Genus CORYNOTRYPA Bassler.

Corynotrypa BASSLER, Proc. U. S. Nat. Mus., vol. 39, 1911, p. 501.
Stomatopora (part) of authors.

This genus was recently instituted for the reception of species hitherto assigned to *Stomatopora*, in which the zoarium consisted of adnate, simple, subtubular zoœcia arranged unilinearly but of a distinctly oval-pyriform to elongate-clavate shape. The zoœcium is further distinguished by having its proximal end constricted and united to the preceding zoœcium by a narrow stolon of variable length; the distal portion of the zoœcium is expanded and bears the aperture which is subterminal, circular, and surrounded by a more or less distinctly elevated peristome; zoœcial walls, as in *Stomatopora*, finely porous.

The points of agreement and difference between *Stomatopora* and *Corynotrypa* may be easily discerned by comparing the illustration of *S. arachnoidea* (fig. 7) with the views of *C. delicatula* and other species figured on the following pages. In discriminating species of *Corynotrypa*, the characters which have been found to be most valuable are the size and shape of the zoœcium and its angle of divergence obtained by measuring the rate of expansion of its sides, beginning at the distal end of the stolon. The slender, tubular connecting portion designated the stolon is the most variable of all characters and is consequently of little aid in the separation of species.

Genotype.—*Corynotrypa delicatula* (James). Ordovician and early Silurian of North America and Europe.

CORYNOTRYPA DELICATULA (James).

Text fig. 8.

Hippothoa delicatula JAMES, Paleontologist, No. 1, 1878, p. 6.
Stomatopora delicatula NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., p. 419.—BASSLER, Proc. U. S. Nat. Mus., vol. 30, 1908, p. 55, pl. 3, figs. 4–7.
Stomatopora proutana MILLER, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 39, pl. 1, figs. 4–4*b*.—ULRICH, Geol. and Nat. Hist. Surv. Minnesota, Final Rep., vol. 3, pt. 1, 1893, p. 117, pl. 1, figs. 8–12.
Rhopalonaria pertenuis ULRICH, Fourteenth Ann. Rep. Geol. and Nat Hist. Surv. Minnesota, 1886, p. 59.
Stomatopora tenuissima ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 175, fig. 2; Geol. and Nat. Hist. Surv. Minnesota, Final Rep., vol. 3, pt. 1, 1893, p. 116, pl. 1, figs. 16, 17.
Stomatopora delicatula-tenuissima NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 419.
Corynotrypa delicatula BASSLER, Proc. U. S. Nat. Mus., vol. 39, 1911, p. 506, text figs. 3*a*, 4–7.

This neat, incrusting fossil is extremely abundant in America, where it is known in most of the Ordovician formations, beginning with the Stones River. In Russia, on the contrary, it appears to be less common, although specimens have been found in divisions C2, D1, and D3. The zoœcia in the specimen from the Wassalem beds are larger than in the more common form of the species and agree exactly with examples from the lower beds of the Black River group of Minnesota and elsewhere. The other localities, however, afford specimens of the more typical size, and the range in this respect is therefore the same as in the American examples.

In both the large and smaller forms the zoarium is incrusting and consists of uniserially arranged, slender, club-shaped zoœcia, increas-

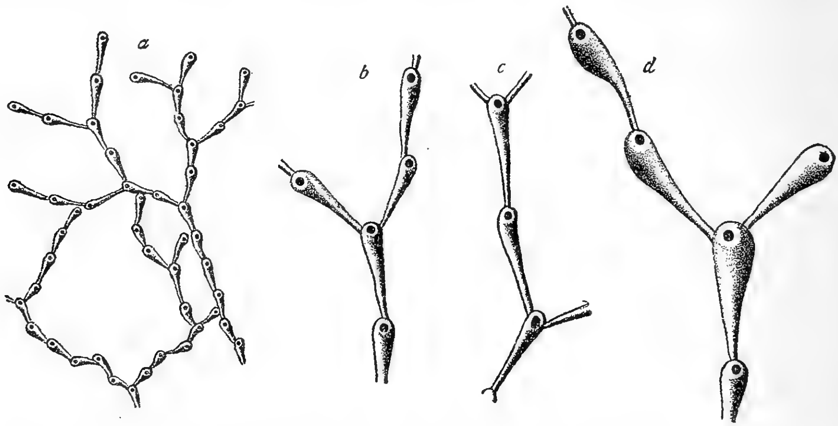

FIG. 8.—CORYNOTRYPA DELICATULA. SPECIMENS FIGURED BY ULRICH AS STOMATOPORA PROUTANA. *a*, FRAGMENT OF A ZOARIUM, ×9; *b* AND *c*, TWO GROUPS OF ZOŒCIA, × 25; *d*, SEVERAL ZOŒCIA OF UNUSUAL SIZE, ×25. BLACK RIVER (DECORAH) SHALES, ST. PAUL AND MINNEAPOLIS, MINNESOTA. (AFTER ULRICH.)

ing gradually in size from the narrow proximal end to the rounded anterior portion. The aperture is small, subterminal, with a slightly elevated border, and about one-third the diameter of the anterior third of the zoœcia. The measurements for the two forms are as follows: Typical specimens have zoœcia 0.04 mm. in diameter at the proximal end, increasing to 0.12 to 0.15 mm. at the widest part of the rounded anterior portion. The zoœcia vary from 0.6 to 0.8 mm. in length, and 8 to 10 occur in 5 mm. The larger form varies from 0.8 to 1.1 mm. in length and from 0.2 to 0.3 mm. in diameter at the anterior portion. The stolon is of variable length, as shown in figures 8*a* and 8*c*. The angle of divergence in both large and small zoœcia is about 15°.

While *Corynotrypa delicatula* is closely related to several American forms, there is but one Russian bryozoan near enough to require detailed comparison. This is *C. barberi,* occurring in the Lyckholm beds on the island of Dago. Comparison of figures 8 and 9 will show that the latter species has much larger zoœcia, expanding more abruptly at the anterior end instead of increasing gradually in size. *C. inflata* has shorter zoœcia and a greater angle of divergence, while *C. abrupta* has a still greater rate of expansion. The other Russian species referred to the genus, *C. dissimilis* and *C. schucherti*, are much coarser in every way.

Occurrence.—The original types were found in the Lower Cincinnatian strata at Cincinnati, Ohio, but the species occurs abundantly in nearly all the divisions of the Stones River and higher Ordovician rocks of North America. It is also well represented in the Richmond formation now assigned to the earliest Silurian. In Russia the known occurrences are as follows: (1) A specimen with rather large zoœcia, incrusting a bifoliate bryozoan, in the Wassalem beds (D3) at Uxnorm,

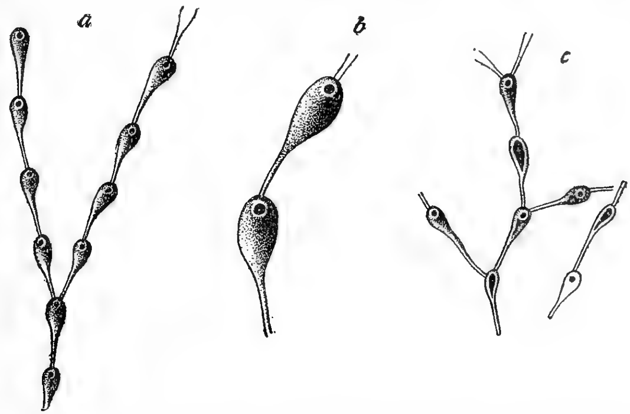

FIG. 9.—CORYNOTRYPA BARBERI. *a*, PORTION OF THE TYPE-SPECIMEN, ×9, INCRUSTING A BIFOLIATE BRYOZOAN; *b*, SEVERAL ZOŒCIA, ×20. MIDDLE ORDOVICIAN, OTTOSEE FORMATION, KNOXVILLE, TENNESSEE; *c*, PART OF A SMALL COLONY, ×9, GROWING UPON A SPECIES OF HELIOLITES. EARLY SILURIAN, LYCKHOLM FORMATION, HOHENHOLM, ISLAND OF DAGO, ESTHONIA.

near Reval (Cat. No. 57114, U.S.N.M.); (2) a typical example growing upon a fragment of *Rhombopora esthoniæ*, from the Jewe limestone (D1), Baron Toll's estate, near Jewe (Cat. No. 57505, U.S.N.M.); and (3) the impression of an example on the figured specimen of *Anolotichia sacculus* from the Kuckers shale (C2) at the same locality (Cat. No. 57506, U.S.N.M.).

The collections of the British Museum contain numerous specimens of the species from American localities.

CORYNOTRYPA BARBERI Bassler.

Text fig. 9.

Corynotrypa barberi BASSLER, Proc. U. S. Nat. Mus., vol. 39, 1911, p. 509, text fig. 8.

At first sight this species seems to be only an exceptionally large form of *Corynotrypa delicatula*, but upon closer inspection other differences may be noted. These are, especially, the rapid swelling of the zoœcia after the stolonal portion has been left behind, and the marked difference between the stolon and the zoœcium proper. In *C. delicatula* the angle of divergence is so small (15°), and the increase in the zoœcial diameter so gradual that it is difficult to discriminate between the stolon and the zoœcium proper. *C. barberi*, however, with equally slender and long stolons, has an angle of 30°, which is sufficient to cause the zoœcium to stand out prominently. Comparisons of equally magnified views of this and related species indicate the unusually large size of the zoœcium in *C. barberi*, although its stolon has practically the same dimensions as the more delicate forms. The dimensions of the species are as follows: An average zoœcium, including the stolon, is 1 mm. long and 0.23 mm. wide at its greatest diameter. The angle of divergence, as noted before, is 30°.

Occurrence.—Common in the Middle Ordovician (Ottosee) shales in east Tennessee and southwest Virginia. Specimens indistinguishable from the types occur in the Lyckholm limestone (F1), incrusting *Halysites*, at Hohenholm, island of Dago, Baltic Sea.

Holotype.—Cat. No. 57105, U.S.N.M.; *Paratype*, Cat. No. 57106, U.S.N.M.

One specimen from the Lyckholm limestone, island of Dago, is in the collections of the British Museum.

CORYNOTRYPA INFLATA (Hall).

Text fig. 10.

Alecto inflata Hall, Nat. Hist. New York, Pal., vol. 1, 1847, p. 77, pl. 26, figs. 7*a*, *b*.
Hippothoa inflata Nicholson, Pal. Ohio, vol. 2, 1875, p. 268, pl. 25, figs. 1–1*b*.
Stomatopora inflata Vine, Quart. Journ. Geol. Soc. London, vol. 37, 1881, p. 615.—Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 176, fig. 3*c*; Geol. and Nat. Hist. Surv. Minnesota, Final Rep., vol. 3, pt. 1, 1893, p. 117, pl. 1, figs. 13–21; Zittel's Textbook of Paleontology (Eng. ed.), 1900, p. 261, fig. 412B.—Simpson, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 597, figs. 202–204.—Ruedemann, Bull. New York State Mus., No. 49, 1901 [1902], p. 12, pl. 1, figs. 2, 3.—Cumings, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 886, pl. 32, figs. 1, 1*a*.
Corynotrypa inflata Bassler, Proc. U. S. Nat. Mus., vol. 39, 1911, p. 515, text figs. 12, 13, 14.

A single specimen from the Wesenberg limestone has characters so typical of this abundant American form that I have no hesitancy in identifying it as above. The essential characters of *Corynotrypa inflata* are as follows:

Zoarium adnate, usually upon ramose or solid bryozoans or brachiopods; zoœcia typically short, pyriform, with the stolon but slightly developed; eight or nine zoœcia in 5 mm.; angle of divergence averaging 40°. Exclusive of the stolon, a single zoœcium is 0.4 mm. long and 0.26 mm. wide. The aperture has a distinct peristome, is direct, circular, about 0.09 mm. in diameter, and situated near the anterior end.

Occurrence.—The original types came from the Trenton rocks of New York, where the zoarium is of more delicate growth than in the higher formations; but specimens of *C. inflata* are generally abundant in all of the Middle and Upper Ordovician and earliest Silurian (Richmond) formations of North America. Typical examples have been

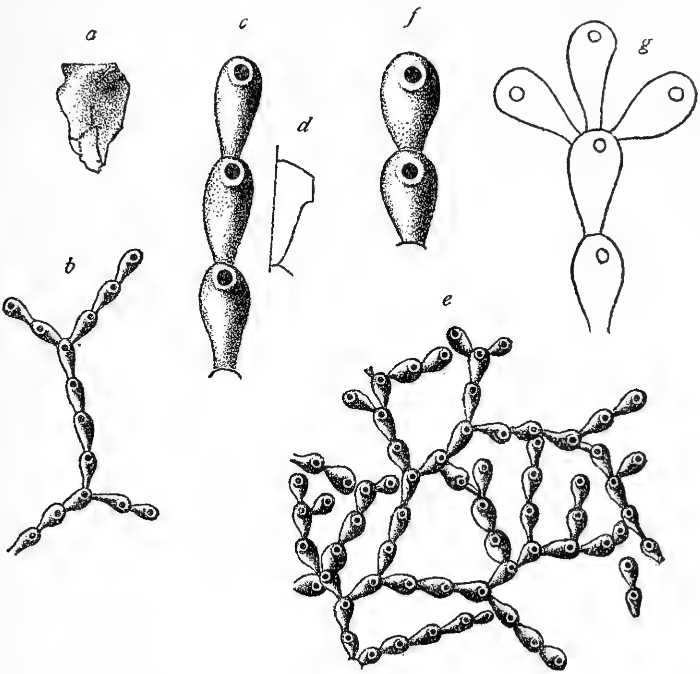

FIG. 10.—CORYNOTRYPA INFLATA. *a* AND *b*, ZOARIUM, NATURAL SIZE, AND A PORTION, ×9; *c*, THREE ZOŒCIA OF SAME, ×18, SHOWING THE POROUS WALL; *d*, A VERTICAL SECTION OF A ZOŒCIUM, ×18. LOWER PORTION OF THE TRENTON FORMATION AT CANNON FALLS, MINNESOTA. *e* AND *f*, SMALL PORTION OF A COLONY, INCRUSTING RAFINESQUINA ALTERNATA, ×9 AND ×18; *g*, OUTLINE OF ZOŒCIA, ×18, SHOWING THREE "GEMS" SPRINGING FROM ONE PARENT CELL. UPPER ORDOVICIAN (MAYSVILLE), CINCINNATI, OHIO. (AFTER ULRICH.)

found in the Middle Ordovician (Wesenberg) limestone (E), at Wesenberg, Esthonia, Russia (Cat. No. 57115, U.S.N.M.).

Numerous specimens from American localities are in the collections of the British Museum.

CORYNOTRYPA ABRUPTA Bassler.

Text figs. 11, 12.

Corynotrypa abrupta BASSLER, Proc. U. S. Nat. Mus., vol. 39, 1911, p. 517, text figs. 16, 17.

Zoarium adnate, consisting of frequently branching, elongated, rather large, clavate zoœcia, much swollen at the anterior end. The tubular proximal stolonal portion is almost threadlike, being not more than 0.04 mm. in width. This diameter is retained until the anterior third or fourth is reached, when the zoœcium abruptly swells, with an angle of divergence of 50°, and becomes rounded, with a diameter of 0.20 to 0.25 mm. An average zoœcium and its stolon is 1.0 mm. long, but in individual zoœcia of the same zoarium the threadlike proximal portion may range in length from less than 0.10 mm. to 1 mm. The swollen anterior zoœcial portion, however, is fairly constant in its measurements, as no deviation from a width ranging between 0.20 mm. and 0.25 mm., and a length of 0.32 mm. to 0.40 mm. has been observed. The apertures are round, subterminal, bordered by a slightly elevated rim, and small, averaging only about 0.09 mm. in diameter.

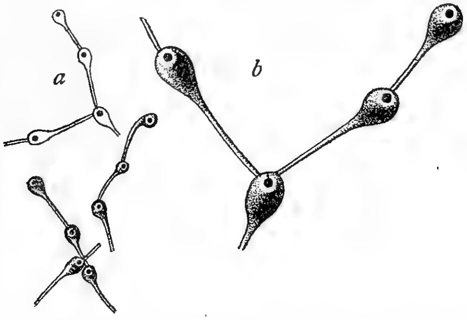

Fig. 11.—*Corynotrypa abrupta*. *a* and *b*, portions of the type-specimen, ×9 and ×20, incrusting a fragment of *Rhynchotrema capax*. Richmond group, Iron Ridge, Wisconsin.

Corynotrypa abrupta is easily distinguished from all other species of the genus by the narrow stolon and the very abrupt swelling of the zoœcium proper. In related species such as *C. inflata* (Hall) and *C. delicatula* (James), the angle of divergence is less, giving a different shape to the zoœcium as a whole. The extreme variation in the length of the narrow proximal portion is noted above, and is indicative of the fact that this part of the zoœcium is the least stable in simple species of Cyclostomata.

Occurrence.—The American specimen illustrated in figure 11, upon which the species is based, incrusts a fragment of *Rhynchotrema capax* and was found in the highest beds of the Maquoketa shale of the Richmond group, at Iron Ridge, Wisconsin. The Russian examples assigned to the species were found associated with *Calapœcia cribriformis* Nicholson, *Halysites* sp., *Streptelasma*, and other fossils of the coral bed, in the Lyckholm limestone (F1), at Kertel, island of Dago.

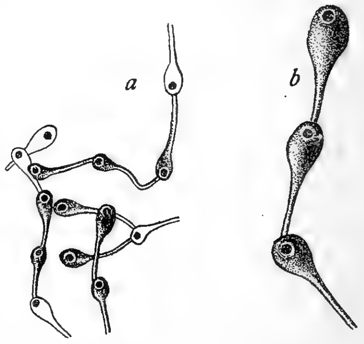

Fig. 12.—*Corynotrypa abrupta*. *a* and *b*, portion of a zoarium, ×9 and ×20, incrusting a crinoid column. Early Silurian, Lyckholm formation, Kertel, island of Dago, Esthonia.

Holotype.—Cat. No. 54173, U.S.N.M.; *Paratype*, Cat. No. 57109, U.S.N.M.

CORYNOTRYPA SCHUCHERTI Bassler.

Plate 6, fig. 1; text fig. 13.

Corynotrypa schucherti BASSLER, Proc. U. S. Nat. Mus., vol. 39, 1911, p. 525, text fig. 26.

Zoarium branching frequently, uniserial, incrusting, in the case of the type-specimen, an example of *Streptelasma*. Zoœcium comparatively large, averaging 1 mm. in length, irregularly club-shaped, the anterior half swollen, with a maximum diameter of 0.40 mm., tapering gradually in the posterior half to the narrowest part with a width of 0.15 mm., where it joins the distal end of the preceding one.

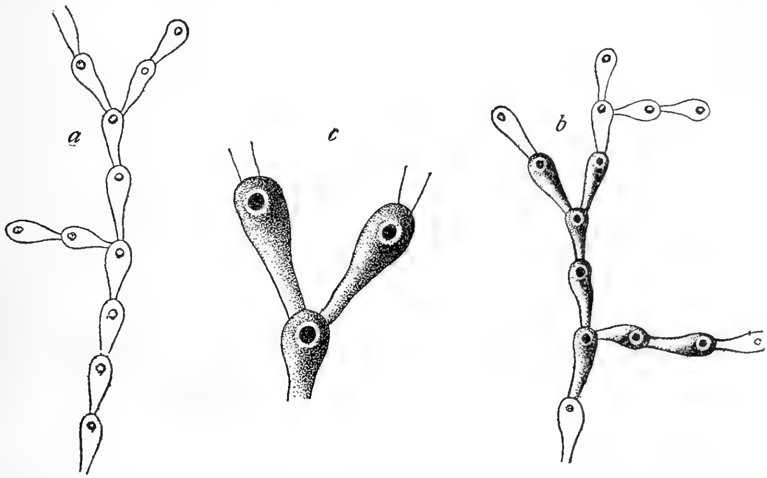

FIG. 13.—CORYNOTRYPA SCHUCHERTI. *a* AND *b*, PORTIONS OF THE TYPE-SPECIMEN, INCRUSTING A STREPTELASMA, ×9; *c*, SEVERAL ZOŒCIA OF THE SAME, ×20. WESENBERG LIMESTONE (E), WESENBERG, ESTHONIA.

Apertures subterminal, surrounded by a slight border, and with a diameter slightly more than one-third that of the zoœcium.

This species, which is named in honor of Prof. Charles Schuchert, who collected the type-specimen, is related most closely to the common American form *C. inflata*, but differs conspicuously, however, in having larger, less regular, more elongate and less rapidly expanding zoœcia. In general, *C. schucherti* is intermediate in its character between *C. inflata* and *C. dissimilis*.

Occurrence.—Rare in the Wesenberg limestone (E) at Wesenberg, Esthonia.

Holotype.—Cat. No. 57111, U.S.N.M.

British Museum collections, one specimen.

CORYNOTRYPA DISSIMILIS (Vine).

Text fig. 14.

Stomatopora dissimilis VINE, Quart. Journ. Geol. Soc. London, vol. 37, 1881, pp. 615, 616, figs. 1–8; vol. 38, 1882, p. 50.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 15, pl. 4, figs. 15–19.

Stomatopora recta RINGUEBERG, Bull. Buffalo Soc. Nat. Hist., vol. 5, 1886, p. 20, pl. 2, figs. 15, 15*a*.

Stomatopora minor HENNIG, Arkiv fur. Zool., Kong. Sven. Vet.-Akad. Stockholm, vol. 3, No. 10, 1906, p. 24, pl. 3, fig. 6.

Aulopora, species, HALL, Nat. Hist. New York, Pal., vol. 2, 1852, pl. 50, figs. 27, 29.

Corynotrypa dissimilis BASSLER, Proc. U. S. Nat. Mus., vol. 39, 1911, p. 523, text fig. 23.

The identification of this species in Russian strata is based on specimens from the Lyckholm limestone differing in no appreciable manner

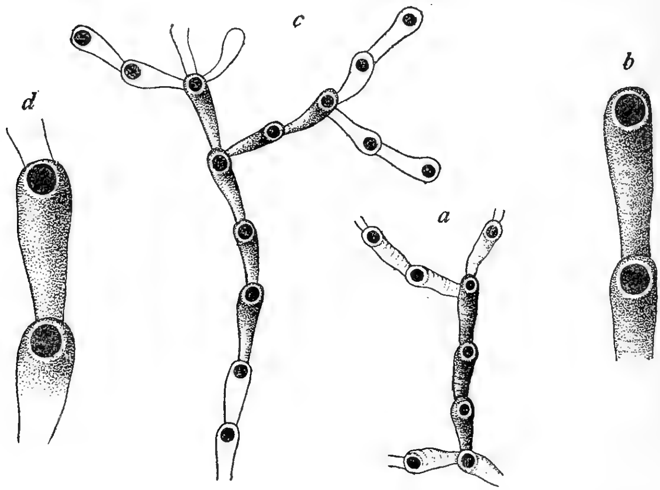

FIG. 14.—CORYNOTRYPA DISSIMILIS. *a* AND *b*, A TYPICAL EXAMPLE OF THE SPECIES, ×9 AND ×20, INCRUSTING THE EPITHECA OF THE BRYOZOAN DIPLOTRYPA NUMMIFORMIS. SILURIAN, ROCHESTER SHALE, LOCKPORT, NEW YORK; *c* AND *d*, POORLY PRESERVED SPECIMEN OF THE SPECIES, ×9 AND ×20, GROWING UPON A SPECIMEN OF HELIOLITES. EARLY SILURIAN, LYCKHOLM FORMATION, KERTEL, ISLAND OF DAGO ESTHONIA.

from the common Middle Silurian *Corynotrypa dissimilis*. The zoarium is parasitic, consisting of uniserial branching zoœcia, subcylindrical or club-shaped, 0.15 to 0.20 mm. in diameter at the proximal end and increasing slowly to twice this width at the widest portion of the distal end. Average zoœcia are 1.15 mm. in length, with 5 to 6 in 5 mm.; the apertures are subterminal, bounded by a slightly developed, rim-like border and so large that they occupy more than three-fourths of the zoœcial diameter. The typical form of the species, however, is well marked transversely by fine wrinkles or striations. In the Russian specimens these striations are absent entirely, the surface being smooth and minutely porous as in other species of the genus. Aside from the absence of transverse striations, the zoœcia in these specimens show a tendency to be slightly larger and relatively more expanded at their anterior end, differences which the study of more material will probably remove, and which are insufficient for the recognition of even a variety.

Occurrence.—The earliest appearance of *C. dissimilis* is in the Lyckholm limestone (F1), at Kertel, island of Dago (Cat. No. 57112, U.S.N.M.). It has also been found in the Borkholm limestone (F2) at Borkholm, Esthonia (Cat. No. 57113, U.S.N.M.). The types of the species are from the Buildwas beds of the Wenlock shales, Shropshire, England. The species occurs also in the Silurian beds, island of Gothland, where it has been given the name *Stomatopora minor* by Hennig. It is abundant in the Rochester shales at Lockport and other localities in western New York, and at Grimsby, Ontario, and in the Osgood beds at Osgood, Indiana.

Family ENTALOPHORIDÆ Reuss.

The Entalophoridæ comprise ramose Cyclostomata with the circular apertures exsert and opening on all sides. The single genus discussed in the present paper was instituted for American Paleozoic forms and has been placed by some writers as a synonym of the recent genus *Spiropora* Lamouroux, but the latter, according to Ulrich, has a definite central axis from which the zoœcia originate, while, in species of *Mitoclema*, this axis is absent and the tubes have their origin in the manner of ordinary ramose forms. These two genera, although probably closely related, exhibit the same differences distinguishing genera in other families.

Genus MITOCLEMA Ulrich.

Mitoclema Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 150; Geol. Surv. Illinois, vol. 8, 1890, pp. 336, 369; Geol. Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 122.—Simpson, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 598.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 22.—Bassler, Bull. 292, U. S. Geol. Surv., 1906, p. 18.

Zoarium ramose, cylindrical, consisting of long tubular zoœcia, which are thin-walled and prismatic in the axial region, diverge gradually from the center, and bend abruptly outward near the surface, often becoming free and much exserted; apertures terminal, circular, usually arranged in regular transverse or subspiral series.

Genotype.—*Mitoclema cinctosum* Ulrich. Middle Ordovician of Kentucky and Tennessee.

MITOCLEMA BOREALE, new species.

Plate 6, fig. 8; text fig. 15.

Zoarium of small, ramose, cylindrical, frequently bifurcating branches, averaging 0.8 mm. in diameter. Interzoœcial surface smooth, minutely but clearly porous. Zoœcia tubular, with rounded apertures, 0.15 mm. in diameter, projecting only slightly above the general surface of the branch, and arranged in ascending spiral rows.

Measuring along one of these rows, four zoœcia may be counted in a distance of 2 mm.

Mitoclema boreale is distinguished from all other species of the genus by the slight projection of the apertures above the zoœcial surface. Externally the species has a great resemblance to *Diploclema trentonense* Ulrich,[1] with which I had at first identified it, but thin sections showed it to be distinct. A section across the end of a branch failed to reveal the bifoliate features characteristic of *Diploclema,* but showed instead that the zoœcia proceeded from the center of the branches as in the type-species of *Mitoclema.*

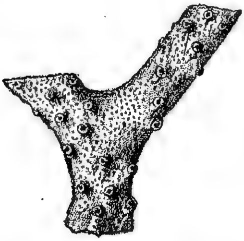

FIG. 15.—MITOCLEMA BOREALE. FRAGMENT OF A ZOARIUM, ×9. WESENBERG LIMESTONE (E), WESENBERG, ESTHONIA.

Occurrence.—Abundant in the Wesenberg limestone (E) at Wesenberg, Esthonia, where the figured specimens were obtained. Less common in the Orthoceras limestone (B3) at Port Kunda (Cat. No. 57186, U.S.N.M.) and in the Wassalem beds (D3) at Uxnorm, Esthonia (Cat. No. 57185, U.S.N.M.).

Cotypes.—Cat. No. 57184, U.S.N.M.

One specimen from Wesenberg is in the British Museum collections.

MITOCLEMA ? MUNDULUM Ulrich.

Text fig. 16.

Mitoclema ? mundulum ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 177, figs. 4 *a–c;* Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 123, pl. 2, figs. 4–6

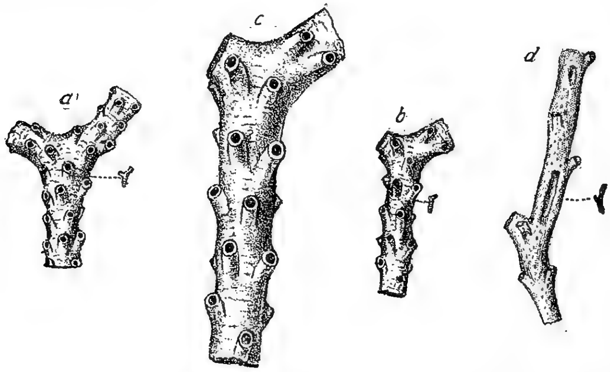

FIG. 16.—MITOCLEMA? MUNDULUM. *a* AND *b*, FRAGMENTS, NATURAL SIZE, AND ×9; *c*, ORIGINAL OF *b*, ×18, SHOWING SURFACE CHARACTER. NEMATOPORA BED OF TRENTON, CANNON FALLS, MINNESOTA. (AFTER ULRICH.) *d*, PORTION OF YOUNG EXAMPLE, ×9. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, NEAR JEWE, ESTHONIA.

A single specimen from the Kuckers shale, Baron Toll's estate, has all the characters of young specimens of *Mitoclema? mundulum*

[1] Geol. Surv. Illinois, vol. 8, 1890, p. 369, pl. 53, figs. 9–9c.

described by Ulrich from the Lower Trenton shales of Minnesota. Ulrich's description is as follows:

Zoarium ramose, very small, the branches cylindrical, 0.5 or 0.6 mm. in diameter, with faint transverse striæ or wrinkles over the spaces between the zoœcial apertures. The latter are drawn out tube-like, about 0.15 mm. in diameter, and project strongly upward and outward from the surface of the small stems. Their arrangement is in rapidly ascending spiral series, with four or five in 2 mm. As near as can be determined from the material at hand, the zoœcial tubes diverge equally to all sides of the branches from an imaginary axis.

Occurrence.—Common in the Nematopora bed of the Trenton, at Cannon Falls, Minnesota. Apparently rare in the Kuckers shale (C2), Baron Toll's estate, near Jewe, Esthonia.

Plesiotype.—Cat. No. 57187, U.S.N.M.

Family IDMONEIDÆ Busk.

This family is represented in the Ordovician and early Silurian rocks by the single genus, *Protocrisina*, which is possibly incorrectly placed here. Typical Idmoneidæ are most abundant in the late Cretaceous and Cenozoic times.

Genus PROTOCRISINA Ulrich.

Protocrisina Ulrich, Geol. Surv. Illinois, vol. 8, 1890, p. 369.—Pocta, Syst. Sil. Centre Boheme, vol. 8, pt. 1, 1894, p. 16.—Ulrich, Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 262, text fig. 417.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 21.

Protocrisina is a somewhat unusual genus distinguished from all other genera of similar growth by the occurrence of small pores on both sides of the branches. The generic characters are as follows:

Zoarium consisting of narrow, bifurcating branches, celluliferous on one face only; zoœcia subtubular, with prominent, circular apertures arranged in intersecting diagonal series; on both faces small pores irregularly distributed.

Genotype.—*Protocrisina exigua* Ulrich. Earliest Silurian (Richmond) of the United States, Canada, and Sweden.

Only a single species has hitherto been recognized in this genus, but the collections of the United States National Museum now contain representatives of at least five distinct forms. The genotype was described from specimens obtained in the Richmond group, but the same species or a closely related variety was recognized in the early Trenton strata of New York and Canada. The latter form was described by Hall as *Gorgonia? perantiqua*,[1] but his description and figures were, like many others of that early period, hardly sufficient for the certain identification of the species. Hall's type-specimen,

[1] Nat. Hist. New York, Pal., vol. 1, 1847, p. 76, pl. 26, figs. 5*a*, *b*.

in the collection of the American Museum of Natural History, proves to belong to a valid species of *Protocrisina*, differing from the genotype in its more luxuriant growth of rigid, closely placed, remotely bifurcating branches spread upon a plane. The zoœcial structure is very similar in the two species and, although the close relationship of *Protocrisina exigua* Ulrich and *P. perantiqua* (Hall) is recognized, it is believed that the difference in growth is sufficient for specific recog-

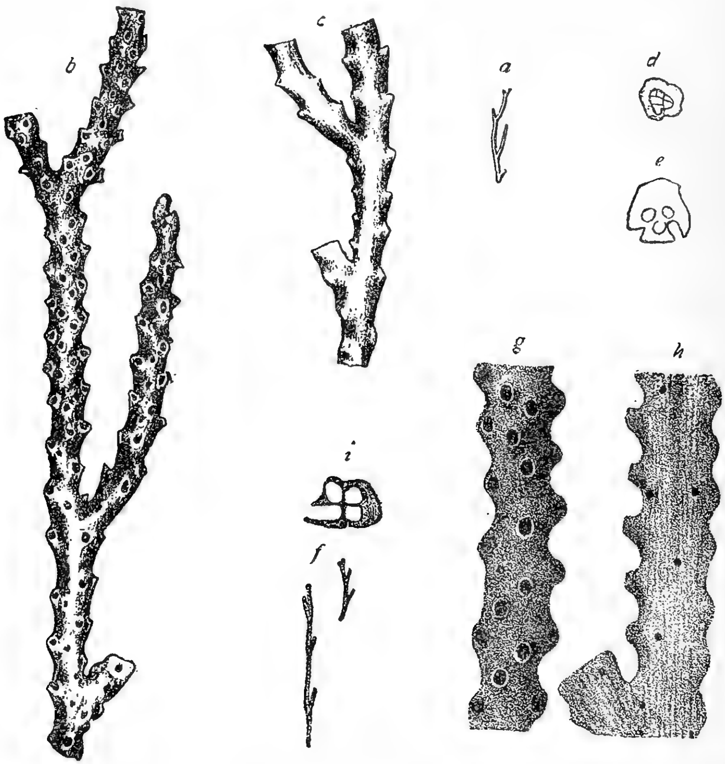

FIG. 17.—PROTOCRISINA EXIGUA. *a* TO *e*. WIMAN'S VIEWS OF CRISINELLA ŒILENSIS. *a*, FRAGMENT, NATURAL SIZE; *b*, CELLULIFEROUS SURFACE, ×10, SHOWING THE CIRCULAR ZOŒCIA AND ACCESSORY PORES; *c*, NONCELLULIFEROUS FACE, ×10; *d* AND *e*, TWO TRANSVERSE SECTIONS, ×10. BORKHOLM DRIFT, ÖJLE MYR, ISLAND OF GOTHLAND. *f* TO *i*, ULRICH'S VIEWS OF PROTOCRISINA EXIGUA. *f*, TWO FRAGMENTS, NATURAL SIZE; *g*, CELLULIFEROUS FACE, ×18, WITH ZOŒCIAL OPENINGS AND ACCESSORY PORES; *h*, NONCELLULIFEROUS SIDE, ×18, WITH PORES; *i*, TRANSVERSE SECTION, ×18. FERNVALE LIMESTONE OF RICHMOND GROUP, WILMINGTON, ILLINOIS.

nition. This same close relationship between Black River or early Trenton and Richmond species has been noted in a number of instances. Three well-marked new species are known. The first is described in the present work as *Protocrisina ulrichi*, while the second and third, which await description, are not uncommon in the Nematopora bed of the Trenton in Minnesota, and in the Middle Ordovician (Ottosee) shales of eastern Tennessee, respectively.

PROTOCRISINA EXIGUA Ulrich.

Text fig. 17.

Protocrisina exigua Ulrich, Geol. Surv. Illinois, vol. 8, 1890, p. 405, pl. 29, figs. 4–4*c*; pl. 53, figs. 11–11*e;* Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 262, text fig. 417.—Cumings, Amer. Journ. Sci., ser. 4, vol. 20, 1905, pl. 7, fig. 53.

Crisinella œilensis Wiman, Bull. Geol. Inst. Univ. Upsala, vol. 5, pt. 2, 1902, p. 181, pl. 6, figs. 12–16.

In the small bryozoan fauna described by Wiman from drift bowlders of the Borkholm formation is a species, *Crisinella œilensis* so similar to the American *Protocrisina exigua* that I am forced, even in the absence of specimens, to consider them synonymous. The figures of both Ulrich's and Wiman's species are reproduced here, and show at a glance their practical identity. Indeed, the only difference to be observed is that Wiman has omitted the small pores on his figure of the noncelluliferous side, although he shows them distinctly on the other face. These pores are so easily overlooked that their omission is probably due to faulty observation rather than to real absence.

The original description of *Protocrisina exigua* is as follows:

Zoarium ramose; branches slender 0.6 mm. wide, 0.3 to 0.45 mm. thick, dividing dichotomously at a very acute angle at intervals varying from 2 to 7 mm. Celluliferous side strongly convex, smooth, with four, occasionally only three, series of zoœcia. Reverse faintly convex, flattened or slightly concave in the central part, finely striate, the striæ often minutely granulose. Zoœcia subtubular, thin-walled within, with prominent tubular mouths. Apertures subcircular, 0.09 mm. in diameter, 5 or 5½ in 2 mm. vertically; arranged in oblique rows. A small number of circular pores, 0.04 mm. in diameter, are scattered over both the reverse and celluliferous faces.

Occurrence.—Common in the Fernvale shales of the Richmond group in Illinois and other States where these strata outcrop. The European examples were obtained from drift bowlders of the Borkholm limestone (F2) at Ojle Myr, island of Gothland.

Specimens from American localities are in the collections of the United States National Museum and the British Museum.

PROTOCRISINA ULRICHI, new species.

Plate 12; text fig. 18.

Zoarium of ramose, slender branches, averaging 0.4 mm. in width, dividing dichotomously at rather regular intervals of about 4 mm. and at an angle averaging 35°. Celluliferous side slightly convex, with two rows of quite regularly arranged zoœcia, noncelluliferous side smooth and flattened with a distinct sulcus along its mid-length. Zoœcial apertures oval, 0.15 mm. in their longer diameter, arranged alternately in distinct diagonal and also longitudinal rows; measuring longitudinally, 5 to 6 zoœcia in 2 mm. The accessory pores are extremely small, circular to elongate, and are abundant on both sides of the zoarium. On the celluliferous face they are almost entirely restricted to the middle length and occur in a unilinear series. The same restriction to the mid-length is present on the noncelluliferous face, where, however, the pores open at the bottom of a sulcus extending the full length of the branch. Occasionally a few of the same pores are found outside of this middle line.

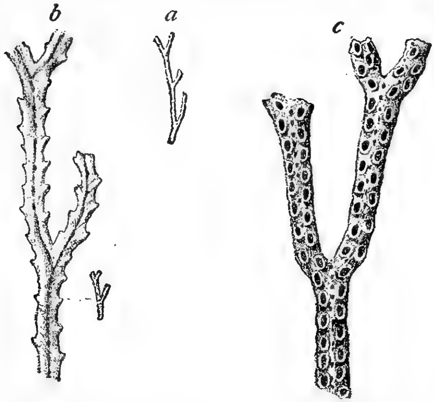

Fig. 18.—Protocrisina ulrichi. *a*, portion of a zoarium, natural size; *b*, another fragment, showing the noncelluliferous side, natural size, and enlarged eight diameters. The median row of pores is most conspicuous; *c*, celluliferous side of another fragment, × 8, exhibiting the regular arrangement of the zoœcia and accessory pores. Kuckers shale (C2), Baron Toll's estate, Esthonia.

The above description applies to the normal or average branches. Old examples show greatly thickened stems with the regular arrangement of the zoœcial apertures and accessory pores quite indistinct. When compared with other members of the genus, the common occurrence of the pores along a middle line is the most distinctive character of *P. ulrichi*, but other features are the large size of the apertures and their regular arrangement in two longitudinal rows.

Occurrence.—Not uncommon in the Kuckers shale (C2), Baron Toll's estate, near Jewe, Esthonia.

Cotypes.—Cat. No. 57188, U.S.N.M.

British Museum collection, three specimens.

Family CERAMOPORIDÆ Ulrich.

This very characteristic family of Bryozoa is well represented in the Russian deposits by new or described species of all its genera save two unusual types, *Ceramophylla* and *Chiloporella*, each of which is known only from a single species. In America, specimens of ceramoporoid bryozoans are often exceedingly abundant, but the collections from Russia have yielded comparatively few examples of the rather numerous species determined. This, however, may be due to a lack of systematic collecting rather than to actual scarcity of material. The family is one of the most important of Paleozoic bryozoans and is undoubtedly the progenitor of the equally important Fistuliporidæ, so prolific in Silurian, Devonian, and Mississippian rocks. The Ceramoporidæ are sparsely represented in the Silurian and the family is essentially an Ordovician one.

Externally a ceramoporoid may be identified by its more or less oblique aperture with a portion of its margin elevated into an overarching hood known as the lunarium. This elevated portion accentuates the oblique aspect of the aperture and often gives an imbricated appearance to the zoœcia. The internal structure in the family is equally characteristic, in fact, so much so that the term "ceramoporoid structure" has its own definite meaning. Thin sections, magnified 20 or more times, show that the cell walls are minutely porous and are composed of irregularly laminated and intimately connected tissue. Microscopic examination is, however, not necessary for a preliminary determination of a ceramoporoid because the intimately connected tissue forming the cell walls, from its very nature, will show no distinct fracture. If a trepostomatous bryozoan be broken, the fracture will be clean-cut and clear, separating adjoining cells, but in the case of a ceramoporoid, the break will proceed through or across the walls indiscriminately, and present a dull, structureless surface such as would be produced in an amorphous body. This style of fracture, however, is not limited to the Ceramoporidæ but is present in the Fistuliporidæ and all the families referred to the Cyclostomata. Undoubtedly this order of Bryozoa must have had a different chemical composition from other orders like the Trepostomata. The latter seem to contain more crystalline calcite in their structure, while the Cyclostomata apparently have more corneous material as a part of their skeleton. Certain genera, *Ceramopora* especially, distinctly show large pores piercing the walls and thus connecting adjoining zoœcia and mesopores. Good examples of such connecting pores are illustrated on the following pages. The zoœcia in the different members of the family are sometimes in contact but more frequently they are separated by more or less irregularly shaped mesopores which are free from any connecting or strengthening tissue. The Fistuliporidæ, on the other hand, may be said to differ principally in having the inter-zoœcial spaces occupied by vesicular tissue. Such vesicular tissue, although poorly developed, is shown in the primitive fistuliporoids described on later pages as *Fistulipora primæva* and *Chilotrypa immatura*.

Various methods of growth obtain in the Ceramoporidæ, and in some cases the shape of the zoarium constitutes a good generic character. Another genus, on the contrary, may include a variety of forms of growth, in which case it must be distinguished by other features such as the development and shape of the lunarium, the occurrence of minute tubules traversing the lunarium lengthwise, and the presence or absence of mesopores. These distinctive features are cited under the discussion of the individual genera. The chief characters of the family have been described by Nickles and Bassler as follows:

> Zoarium variable; maculæ or clusters of mesopores or of zoœcia larger than usual at regular intervals; zoœcia tubular, at first prostrate, continue obliquely or directly to the surface, often with a few diaphragms; apertures commonly oblique, provided with a lunarium; mesopores generally present, always irregular and usually without diaphragms; walls minutely porous, formed of intimately connected and irregularly laminated tissue.

Genus CERAMOPORA Hall.

Ceramopora Hall, Amer. Journ. Sci., ser. 2, vol. 11, 1851, p. 400; Nat. Hist. New York, Pal., vol. 2, 1852, p. 168.—Pictet, Traite de Pal., vol. 4, 1857, p. 170.—Eichwald, Lethæa Rossica, vol. 1, 1860, p. 412.—Zittel, Handbuch d. Pal., 1880, p. 617.—Vine, Quart. Journ. Geol. Soc. London, vol. 36, 1880, p. 358.—Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 156.—Foerste, Bull. Sci. Lab. Denison Univ., vol. 2, 1887, p. 169.—Hall and Simpson, Nat. Hist. New York, Pal., vol. 6, 1887, p. xviii.—James and James, Journ. Cincinnati Soc. Nat. Hist., vol. 11, 1888, p. 36.—Miller, North Amer. Geol. and Pal., 1889, p. 296.—Ulrich, Geol. Surv. Illinois, vol. 8, 1890, pp. 380, 462.—Pocta, Syst. Sil. Centre Boheme, vol. 8, pt. 1, 1894, p. 112.—Ulrich, Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 267.—Simpson, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 563.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 23.—Bassler, Bull. 292, U. S. Geol. Surv., 1906, p. 18.—Hennig, Archiv. fur Zool., vol. 4, No. 21, 1908, p. 1.

This, the typical genus of the family, is sparsely represented in American deposits, where, however, all the valid species so far described occur in the Silurian. The discovery of several undoubted forms in the Russian Ordovician is, however, only in line with what would be expected of the geological distribution of the genus. A number of genera were represented in the species originally assigned to *Ceramopora* by Hall and others, but in 1890 Ulrich [1] restricted the genus to the type species *C. imbricata,* making its discoidal growth, peculiar spongy basal tissue in connection with the indefinite wall structure, large mural openings, and absence of diaphragms, the characteristic features. Since that time additional species have been discovered so that at present growth in the genus may be free, discoid, lamellate, massive, or incrusting, the basal spongy layer may be absent and diaphragms may or may not occur. In addition to the ceramoporoid structure, the diagnostic features of the genus are, externally, the occurrence of large, irregular zoœcia, comparatively large and equally irregular open mesopores, prominent but often poorly defined lunaria, and, internally, the presence of especially large openings in the walls, allowing communication between the cells. While this delimitation of the genus seems rather indefinite when compared with more sharply defined genera in the family, the very irregularity of the lunarium, zoœcium, and mesopores, gives such an unusual aspect to a zoarium that species may be determined without much trouble. Indeed, the recognition of a species of *Ceramopora* is a matter more readily performed by a study of actual specimens than by its description.

Genotype.—Ceramopora imbricata Hall. Niagaran of the United States and Canada.

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[1] Geol. Surv. Illinois, vol. 8, pp. 380, 462.

CERAMOPORA SPONGIOSA, new species.

Text fig. 19.

Zoarium a small, explanate mass several centimeters in diameter and less than 5 mm. thick. Celluliferous surface smooth; noncelluliferous basal side lined with a strongly wrinkled epitheca. The maculæ in young expansions are small, slightly depressed areas from which the zoœcia radiate; in old examples they are represented by clusters of irregular, thick-walled mesopores. Zoœcia large, 4 to 5 in 2 mm., irregularly polygonal in outline, with occasional mesopores. Walls of both zoœcia and mesopores irregular in shape and thickness.

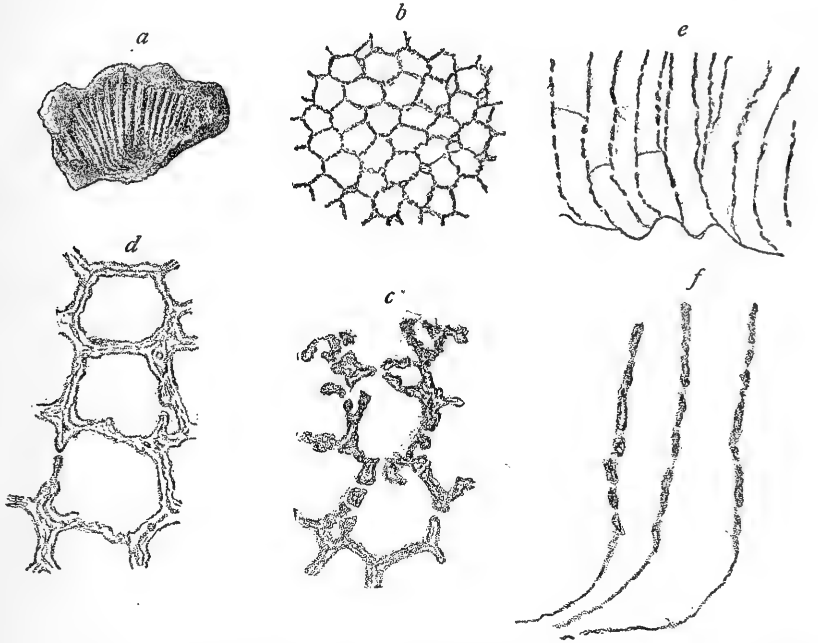

Fig. 19.—Ceramopora spongiosa. *a*, portion of a zoarium, natural size, showing concentric rings of epitheca; *b* and *c*, tangential section, ×9, and portion of same, ×20, showing the numerous connecting pores; *d*, tangential section of three zoœcia, ×20, exhibiting structure of walls and of the lunarium; *e* and *f*, vertical sections, ×9 and ×20, with tabulation and connecting pores. Wassalem beds (D3), Uxnorm, Esthonia.

Lunarium of considerable size but so irregular in old specimens that it can hardly be separated from the equally irregular zoœcial wall. In young examples the relations of the zoœcia, mesopores, and lunaria are more clearly shown. Here the zoœcium is more rounded and has a distinct, slightly elevated, hood-shaped lunarium overarching the proximal fourth of the zoœcial cavity. Mesopores are represented in such specimens by shallow pit-like depressions just behind the lunarium.

While a considerable variation is shown at the surface of specimens according to their age, the internal characters of the species are more constant. The most obvious feature of thin sections is the unusual number and size of the connecting pores, which give almost a spongy aspect. The views seen in tangential sections are shown in figure 19 *b, c, d,* where it may be noticed that the lunarium is not clearly outlined from the rest of the zoœcial wall. The mural pores are perhaps shown more clearly in vertical sections, especially under a high power of magnification, as in figure 19 *f*. A few delicate diaphragms placed irregularly are developed in the tubes.

Ceramopora spongiosa is the oldest known species of the genus and differs from all other forms in its few mesopores, large, indistinct lunarium, and numerous connecting pores.

Occurrence.—Not uncommon in the Wassalem beds (D3) at Uxnorm, near Reval, Esthonia.

Holotype.—Cat. No. 57189, U.S.N.M.

Thin sections of the type-specimen are in the collections of the British Museum.

CERAMOPORA INVENUSTA, new species.

Plate 6, fig. 3; text fig. 20.

This bryozoan presents the most unusual surface characters of any species known to me, indeed, the zoœcial and mesopore walls are so irregular and bear so many knob-like acanthopores or granules that specimens show considerable resemblance to certain sponges or to stromatoporoids. This unusual appearance pertains only to the mature portions of the zoarium, for young specimens have the usual imbricated cells and lunaria of a ceramoporoid.

The zoarium is incrusting; the type-specimen, an expansion over 5 cm. long, is growing upon a large gastropod, while other examples are incrusting ramose bryozoans. The zoœcial surface is smooth, with distinct maculæ of thick-walled mesopores distributed at intervals of 4 to 5 mm. The zoœcia are large, 3 to 4 in 2 mm., direct, and, except in young stages, show little trace of a lunarium. The apertures are irregularly rounded and are frequently indented by the expanded zoœcial walls. The latter are thick but the thickness varies on account of the presence of numerous large, granular-like acanthopores. Whenever one of these structures is developed, the walls expand to accommodate it, thus giving the irregular or indented effect seen at the surface and in tangential sections. Such granules or modified acanthopores are known in a number of ceramoporoids, especially in certain species of *Ceramoporella,* but they are unusually well developed in the present form. Mesopores are numerous and sometimes isolate the zoœcia completely.

Tangential sections bring out particularly the thick, irregular cell walls and the numerous large granules or acanthopores. The lunarium, although scarcely distinguishable, is represented in such sections by a slight thickening of the wall. The cell walls are unusually contorted in the macular spaces, which, as shown in figure 20 *a*, are composed almost entirely of mesopores. Vertical sections show the usual short, immature region with thin walls bending gradually into the thick walled mature zone. Diaphragms are absent in all of the sections studied.

The incrusting zoarium, thick-walled, irregularly rounded zoœcia

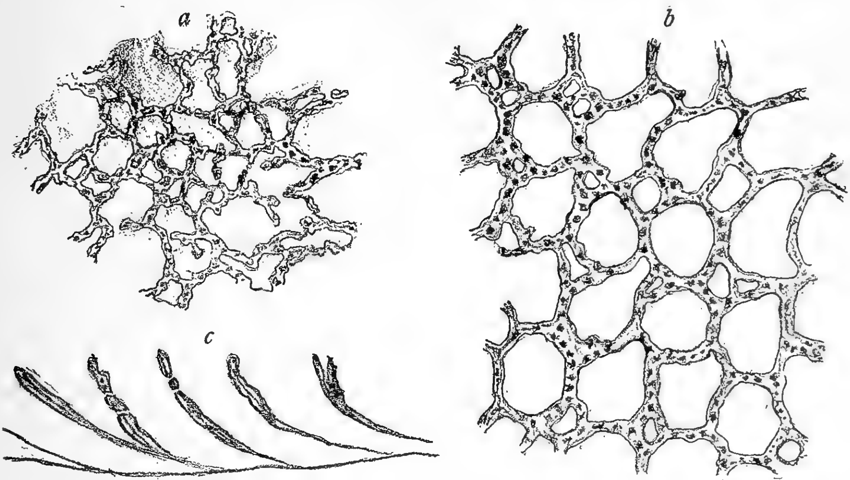

FIG. 20.—CERAMOPORA INVENUSTA. *a*, TANGENTIAL SECTION, ×20, THROUGH A MACULA AND NEIGHBORING ZOŒCIA; *b*, TANGENTIAL SECTION, ×20, SHOWING THE IRREGULAR ZOŒCIA AND NUMEROUS GRANULES OR ACANTHOPORES; *c*, VERTICAL SECTION, ×20, THROUGH A ZOARIUM EXHIBITING THE CHARACTERISTIC COMMUNICATION PORES. WESENBERG LIMESTONE (E), WESENBERG, ESTHONIA.

with large granular structures, indenting the aperture, gives an aspect to the present form quite different from any other species of the genus.

Occurrence.—Not uncommon in the Wesenberg limestone (E) at Wesenberg, Esthonia.

Holotype.—Cat. No. 57190, U.S.N.M.

A fragment of the type-specimen and thin sections are in the collections of the British Museum.

CERAMOPORA INTERCELLATA, new species.

Plate 6, fig. 2; text fig. 21.

Externally this new form has less resemblance to *Ceramopora* than the two species just described; but thin sections bring out the characteristic ceramoporoid structure, and especially numerous connecting mural pores. The type-specimen is a flat, epithecated expansion, consisting of two superposed layers of zoœcia, as shown in figure 21 *a*. The celluliferous face bears the apertures of large polygonal zoœcia, nearly always completely isolated by numerous irregularly polygonal mesopores. The poriferous side is smooth, but exceptionally large maculæ composed entirely of mesopores are present at intervals of 5 mm. A portion of a macula with several zoœcia and their intervening mesopores is shown on plate 6, figure 2. A lunarium occupying about one-fifth of the apertural wall is present, but it is little elevated and is hardly distinguishable either at the surface or in thin sections. An average zoœcium is 0.40 mm. in diameter and three may be counted in a distance of 2 mm.

The essential internal characters are believed to be shown in the accompanying figures. After leaving the immature region, which, as in other incrusting or lamellate ceramoporoids, is quite short, the zoœcial walls thicken and numerous connecting pores are developed.

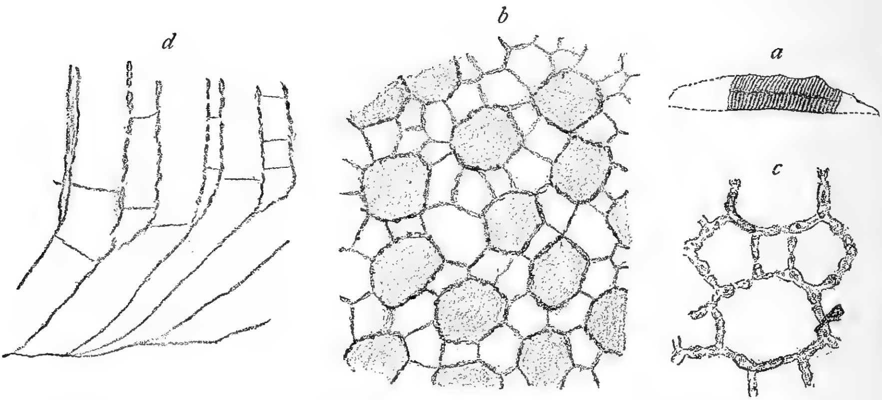

FIG. 21.—CERAMOPORA INTERCELLATA. *a*, EDGE VIEW OF THE FRAGMENTARY TYPE, ×1; *b* AND *c*, TANGENTIAL SECTION, ×20, AND A PORTION, ×35, EXHIBITING THE INDISTINCT LUNARIUM AND CONNECTING PORES; *d*, VERTICAL SECTION, ×20, THROUGH ONE LAYER OF THE ZOARIUM. LYCKHOLM LIMESTONE (F1), HOHENHOLM, ISLAND OF DAGO, ESTHONIA.

A few thin diaphragms are inserted in both the zoœcial tubes and the mesopores. The connecting pores are equally conspicuous in the tangential section, where also the lunarium may be detected as a slight thickening of the posterior portion of the zoœcial wall.

The lamellate growth, large, angular zoœcia, isolated by numerous mesopores, and the large maculæ, are characters so different from other species of *Ceramopora* that comparison is unnecessary.

Occurrence.—Apparently rare in the Lyckholm limestone (F1) at Hohenholm, island of Dago.

Holotype.—Cat. No. 57191, U.S.N.M.

A thin section of the type-specimen is in the collections of the British Museum.

Genus CERAMOPORELLA Ulrich.

Ceramoporella Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 156.—Miller, North Amer. Geol. and Pal., 1889, p. 297.—Ulrich, Geol. Surv. Illinois, vol. 8, 1890, pp. 380, 464; Geol. and Nat. Hist. Surv. Minnesota, vol, 3, pt. 1, 1893, p. 328.—Pocta. Syst. Sil. Centre Boheme, vol. 8, pt. 1, 1894. p. 15.—Ulrich, Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 267.—Simpson, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 564.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 23.—Bassler, Bull. 292, U. S. Geol. Surv., 1906, p. 20.—Cumings, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 742.

Zoarium of incrusting layers, which by superposition may form masses; zoœcia short, tubular with thin walls; apertures oval, oblique, the lunarium forming a hood; mesopores abundant, often completely encircling the zoœcia.

Genotype.—*Ceramoporella distincta* Ulrich. Upper Ordovician (Eden and Maysville) of the Ohio Valley.

Until recently this genus has included all of the parasitic Ordovician ceramoporoids, but the discovery of the foregoing Russian species of incrusting, although otherwise typical *Ceramopora* in Ordovician strata, causes this conception to be modified. *Ceramoporella* includes two well-marked sections or groups of species, one in which the zoœcia are inclined to be rhomboidal or polygonal in outline and more or less in contact, and another with rounded or ovate apertures and numerous mesopores. One or more distinct species of each section usually occur in each of the Ordovician formations, while a few species are of such generalized types of structure that they range through several formations and can be distinguished at best only as varieties. The new variety following belongs to the latter category.

CERAMOPORELLA GRANULOSA MINOR, new variety.

Text fig. 22.

In 1890 Ulrich described a new species of *Ceramoporella* from the Fernvale shale division of the Richmond group, at Wilmington, Illinois, naming it *C. granulosa* [1] because of the numerous, acanthopore-like granules occurring in the walls. Further study has shown that this same species, variously modified, occurs in most of the Ordovician formations commencing with the Black River. Only one of these varieties has received a name, but all of them differ from the type form in minor details only. Thus, the present form differs only in having slightly smaller zoœcia and fewer granules.

In the species itself as well as in the varieties, the zoarium is incrusting a foreign body and by the superposition of several layers forms masses of some size. The zoarial surface is smooth and granulose, with the usual maculæ. Zoœcial apertures oval, opening at the

[1] Geol. Surv. Illinois, vol. 8, p. 466, pl. 41, figs. 2, 2 *a*.

surface directly, from 0.2 to 0.3 mm. in diameter, about 6 in 2 mm. Numerous small mesopores are present among the zoœcia and usually isolate them. Lunarium narrow but prominent, occupying one-fourth to one-third of the wall's circumference. Thin sections show the usual laminated wall tissue of the Ceramoporidæ. The granules or acanthopore-like structures are most pronounced in tangential sections.

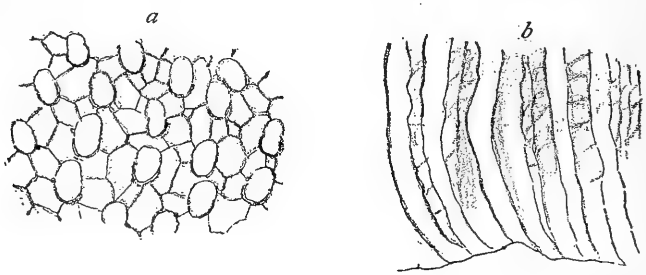

FIG. 22.—CERAMOPORELLA GRANULOSA MINOR. *a*, TANGENTIAL SECTION, ×20, SHOWING FEW GRANULES AND GENERAL ARRANGEMENT OF ZOŒCIA AND MESOPORES; *b*, VERTICAL SECTION, ×20, THROUGH A SINGLE LAYER OF ZOŒCIA. JEWE LIMESTONE (D1), BARON TOLL'S ESTATE, ESTHONIA.

Occurrence.—The new variety *minor* is described from specimens occurring in the Jewe limestone (D1), Baron Toll's estate, near Jewe. It is also known from the Wassalem beds (D3) at Uxnorm, Esthonia, and from the Black River (Decorah) shales of Minnesota.

Holotype.—Cat. No. 57192, U.S.N.M.

The collections of the British Museum contain a specimen from the Jewe limestone, Baron Toll's estate.

CERAMOPORELLA UXNORMENSIS, new species.

Text fig. 23.

Zoarium incrusting, forming expansions several millimeters thick and as many centimeters in width. Surface smooth but with clusters of larger zoœcia from which the ordinary ones radiate. Zoœcia with moderately thick walls; apertures subrhomboidal to irregularly polygonal, oblique on account of the small but distinct overarching lunarium. Zoœcia arranged in rather regular radiating series about the maculæ; five zoœcia in 2 mm. Mesopores few, often entirely absent.

The most conspicuous feature of thin sections is the unusual thickness and distinctness of the lunarium, characters which are not so well shown at the surface. In vertical sections the zoœcial tubes are prostrate and thin-walled in the axial region, but thicken and show the characteristic laminated wall structure in the peripheral zone. Both regions are without diaphragms.

Although closely allied to several American Ordovician species, such as *Ceramoporella ohioensis* (Nicholson) and *C. whitei* (James), the present form may be distinguished by its unusually thick and distinct lunarium. The type-specimen is in such condition that the surface could not be figured, but by slight etching, such a view as shown in figure 23*a* is obtained.

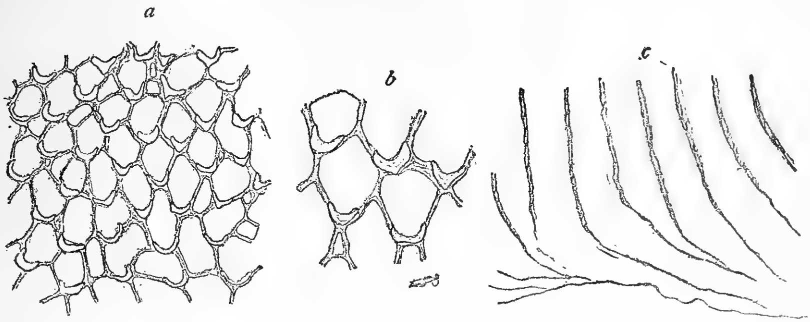

FIG. 23.—CERAMOPORELLA UXNORMENSIS. *a* AND *b*, TANGENTIAL SECTION, ×20 AND ×35, ILLUSTRATING THE SHAPE OF ZOŒCIA AND THE THICK LUNARIUM; *c*, VERTICAL SECTION, ×20. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

Occurrence.—Apparently rare in the Wassalem beds (D3) at Uxnorm, Esthonia.

Holotype.—Cat. No. 57194, U.S.N.M.

Thin sections of the type-specimen are in the collections of the British Museum.

Genus CŒLOCLEMA Ulrich.

Cœloclema ULRICH, Journ. Cincinnati Soc. Nat Hist., vol. 5, 1882, p. 137; vol. 7, 1884, p. 49.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, pp. 24, 211.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 21.—CUMINGS, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 742.

Diamesopora (part) ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 380, 467; Geol. Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 330.

Diamesopora ULRICH, Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 268.

Zoœcia very much as in *Ceramoporella* but differing in forming a zoarium of ramose, hollow branches lined internally with a striated epitheca.

Genotype.—*Diamesopora vaupeli* Ulrich. Upper Ordovician (Eden) of the Ohio Valley.

This genus is readily distinguished from related members of the Ceramoporidæ by its zoarial characters. Five species have been described from the American Ordovician and Silurian deposits, while at least three new forms await description. The following new species is closely related to one of the undescribed American Middle Ordovician forms, but differs from this as well as all other species of the genus in its larger zoœcia and unusually thick walls.

CŒLOCLEMA CRASSIMURALE, new species.

Plate 7, fig. 12; text fig. 24.

This new species is founded upon a single fairly well preserved specimen 18 mm. long and 5 mm. in diameter. The zoœcial layer averages a millimeter in thickness, while the axial tube, now filled with clay, varies from 1 to 1.5 mm. in diameter. The zoœcial apertures are rather large, 4 in 2 mm. measuring along their greater length, and are irregularly oval in shape. Maculæ are present at regular intervals, and form depressed spaces from which the zoœcia radiate somewhat irregularly. Mesopores are numerous, small, and very irregular in shape and position. Both zoœcia and mesopores

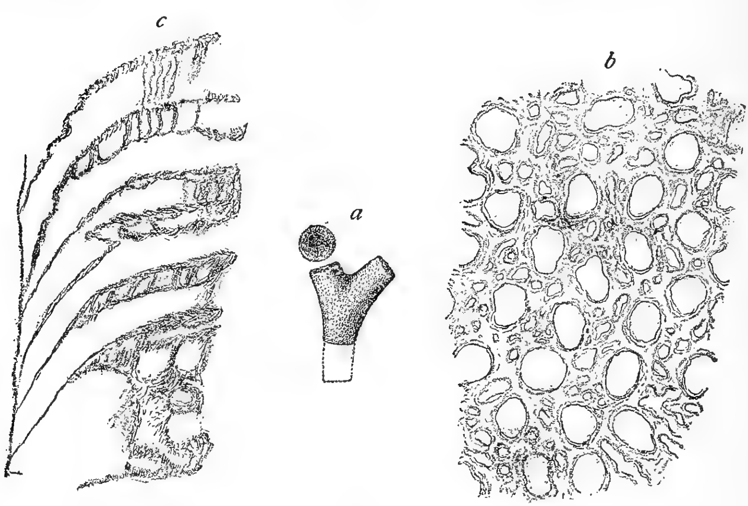

FIG. 24.—CŒLOCLEMA CRASSIMURALE. *a*, FRAGMENT OF A ZOARIUM, NATURAL SIZE, WITH END VIEW OF THE SAME SHOWING THE CENTRAL TUBE; *b*, TANGENTIAL SECTION, ×20, EXHIBITING THE THICKNESS OF WALLS, OBSCURE LUNARIUM, AND SMALL, IRREGULAR MESOPORES; *c*, VERTICAL SECTION, ×20, THROUGH ONE SIDE OF A ZOARIUM. JEWE LIMESTONE (D1), BARON TOLL'S ESTATE, ESTHONIA.

have unusually thick walls. The lunarium is inconspicuous both at the surface and in thin sections.

Although closely related to the typical forms of the genus, *C. crassimurale* proves upon comparison to have larger zoœcia and thicker walls than any described form. None of the associated bryozoans has a central tube, and this fact alone will aid in its determination.

Occurrence.—Rare in the Jewe limestone (D1), Baron Toll's estate. Specimens which are believed to represent the parasitic base of this species have been found in the Jewe limestone associated with the type-specimen, and also in the Wassalem beds (D3), at Uxnorm. At the latter locality no specimens of the erect, hollow stems have been noted.

Holotype.—Cat. No. 57195, U.S.N.M.

British Museum's collections, thin section of the type-specimen.

CŒLOCLEMA LACINIATUS (Eichwald).

Text fig. 25.

Cœnites laciniatus Eichwald, Lethæa Rossica, vol. 1, 1860, p. 459, pl. 27, fig. 9.

Eichwald has given two figures, here reproduced, of a ceramoporoid bryozoan from the "calcaire à schiste argileux inflammable," which I have little hesitancy in identifying as a species of *Cœloclema* occurring in the Kuckers shale. His description cites the type-specimen as an incrusting lamella with the surface irregularly undulating. The specimens before me agree exactly with Eichwald's figure of the zoœcia, and, moreover, appear to be incrusting, undulating lamellæ, but careful examination showed that they represent in reality the flattened sides of a hollow, tubular, ramose zoarium. Such zoaria spread out at their base into an incrusting expansion, and it is possible therefore that Eichwald's type represents the base instead of the flattened branch. At any rate, I believe that the recognition of *Cœnites laciniatus* as a species of *Cœloclema* is in keeping with the facts.

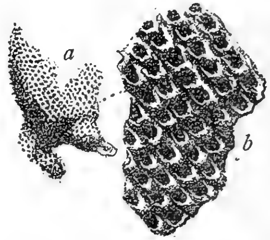

Fig. 25.—Cœloclema laciniatus. *a*, Eichwald's type-specimen, natural size, of Coenites laciniatus; *b*, surface of the same, enlarged. Kuckers shale (C2), Esthonia. (After Eichwald.)

The internal structure, although poorly preserved in the specimens studied, agrees in all respects with that of typical *Cœloclema*. The zoœcial apertures as shown in Eichwald's enlargement of the surface, are arranged in diagonal rows with a distinct, although little arched, lunarium. Measuring along one of these rows, four zoœcia occur in 2 mm. The hollow zoarium of this species, when uncrushed, is about 5 mm. in diameter; the zoœcial layer itself is less than 0.5 mm. thick.

Occurrence.—Apparently rare in the Kuckers shale (C2) at Erras and Reval, Esthonia. (Cat. No. 57197, U.S.N.M.)

Genus CREPIPORA Ulrich.

Crepipora Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 157.—Miller, North Amer. Geology and Paleontology, 1889, p. 299.—Ulrich, Geol. Surv. Illinois, vol. 8, 1890, pp. 380, 469; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 322.—Pocta, Syst. Sil. Centre Boheme, vol. 8, pt. 1, 1894, p. 15.—Ulrich, Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 268.—Simpson, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 566.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 23.—Hennig, Archiv fur Zool., vol. 4, No. 21, 1908, p. 9.

Zoarium incrusting lamellate or massive, or in one species forming hollow branches; zoœcia long, tubular, thin-walled, with diaphragms; apertures angular or subpyriform, lunarium not overarching, its ends usually projecting; mesopores generally restricted to the maculæ, which are elevated or depressed.

Genotype.—*Crepipora simulans* Ulrich. Upper Ordovician (Maysville) of the Ohio Valley.

Crepipora is closely related to the genus *Ceramoporella*, incrusting forms of the former being very similar to such species as *Ceramoporella uxnormensis* described on page 82. Perhaps the most obvious generic difference is the practically complete restriction of the mesopores to the maculæ in *Crepipora*, although other equally good characteristics are the more direct zoœcial apertures, the better developed maculæ, and the greater distinctness of the lunarium.

The zoarial growth in *Crepipora* varies from thin, incrusting sheets to solid massive or hemispherical, and in one case regular hollow branches. The surface shows thin-walled, erect, rhomboidal to polygonal zoœcia, each having a small but distinct lunarium on the proximal edge. Maculæ of mesopores developed at regular intervals are a feature of the surface, where they appear as minutely porous elevations or depressions. In thin sections the maculæ and lunaria are most evident, although the ceramoporoid structure described under the discussion of the family is likewise conspicuous.

At least 15 new or described American species of *Crepipora* are known, and these, in addition to the three new forms here defined, make the genus one of the more prolific members of the Ceramoporidæ. The three Russian forms have little relationship with each other specifically, but are good examples of the range of structure in the genus. The first, *C. schmidti*, is closely related to the genotype *C. simulans*, from the middle Cincinnatian strata of the United States, differing particularly in having considerably larger zoœcia. The second species is unusual in the irregular angularity of its zoœcia, its very distinct crescentic lunarium, and the unusual development of mesopores. *C. incrassata* has particularly thick walls, but a quite unusual character seen only in this species, so far as known, is the rounded, ovicell-like structure noted in the thin sections of the type-specimen.

The occurrence of these cystlike bodies in an undoubted species of *Crepipora* is of great interest in its bearing upon the zoological position of the ceramoporoids and related monticuliporoids. These two groups, together with the fistuliporoids, have been assigned to the alcyonarian corals by most writers, but with the present discovery in *Crepipora*, ovicell-like structures are now known to occur in representatives of each group. This fact, together with others indicating the bryozoan relations of these disputed organisms, will be discussed in another paper at a later date.

CREPIPORA SCHMIDTI, new species.

Text fig. 26.

Cfr. *Crepipora simulans* Ulrich, Geol. Surv. Illinois, vol. 8, 1890, p. 470, pl. 39, figs. 4, 4*a*; pl. 40, figs. 3, 3*a*; text fig. 8*b*, p. 320.

This species is represented in the collections by only the type-specimen, which is a small, well-developed zoarium incrusting a gastropod. Although variable in this respect, the greatest thickness of this zoarium does not exceed 2 mm. Other specimens undoubtedly will show a greater thickness of the individual crust or will be made up of a number of crusts growing successively upon each other. The maculæ are indistinctly marked in the specimen at hand, but, as in similar incrusting species, they are composed of clusters of mesopores surrounded by slightly larger zoœcia. Zoœcial apertures comparatively large, direct, rhomboidal to subpolygonal in shape, averaging 0.4 mm. in their greater diameter; walls of zoœcia thin. Four to

Fig. 26.—Crepipora schmidti. *a*, vertical section, ×20, showing laminated wall structure; *b*, tangential section, ×20, with simple polygonal zoœcia and crescentic lunaria. Jewe limestone (D1), Baron Toll's estate.

five zoœcia may be counted in a length of 2 mm. Lunarium well marked at the surface where it overarches the aperture slightly, occupying about one-fifth of the wall, but not extending into the zoœcial cavity. The lunarium is quite distinct in tangential sections but shows no additional characters to those noted at the surface. Vertical sections exhibit a very short, thin-walled, immature zone in which the zoœcia are prostrate, and a longer mature region where they are direct and have thicker walls. Diaphragms are thin and very few or wanting entirely.

The chief difference between this new species and the closely related American form, *Crepipora simulans* Ulrich, lies in the size of the zoœcia. *C. schmidti* has four to five zoœcia in 2 mm., while *C. simulans* has seven in the same distance, thus making the diameter of the former about one-half again as great. Another incrusting Russian species, *Crepipora lunatifera*, from the Wesenberg formation, differs in having still larger zoœcia, more distinct crescentic lunaria with their ends projecting into the zoœcial cavity, and zoœcia of an irregularly angular shape.

The specific name is in honor of the late Dr. Friedrich von Schmidt, in appreciation of his life-long work upon the geology and paleontology of the Russian Ordovician.

Occurrence.—Apparently rare in the Jewe limestone (D1), Baron Toll's estate, near Jewe, Esthonia.

Holotype.—Cat. No. 57198, U.S.N.M.

CREPIPORA LUNATIFERA, new species.

Text fig. 27.

Zoarium forming a broad but thin crust upon foreign objects, with the individual layers less than a millimeter in thickness. The type-specimen consists of several fragmentary zoœcia incrusting an exam-

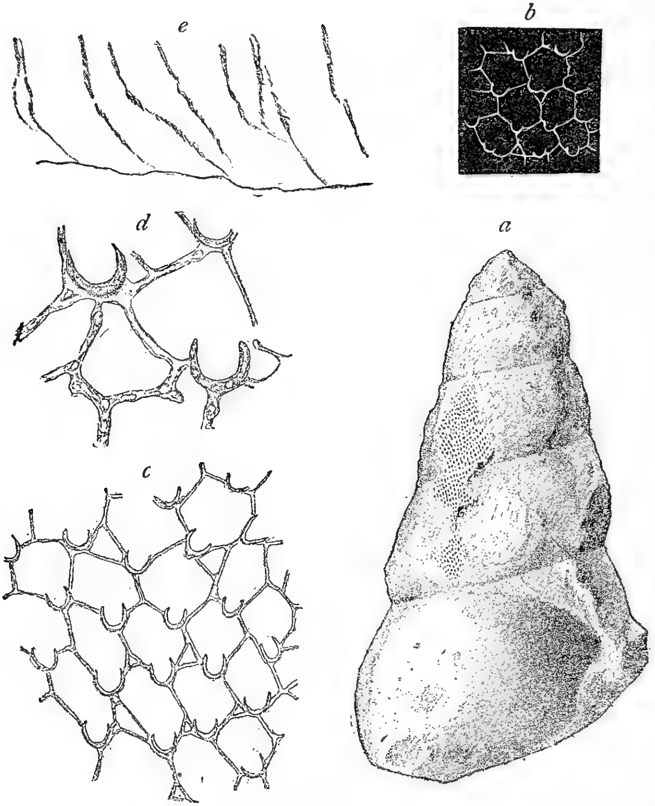

Fig. 27.—Crepipora lunatifera. *a*, the type-specimen, incrusting Hormotoma insignis (Eichwald), two-thirds natural size; *b*, view of the zoœcia at the surface, ×9; *c* and *d*, tangential sections, ×20 and ×35, illustrating zoœcial structure; *e*, vertical section, ×20, through the zoarium. Wesenberg limestone (E), Wesenberg, Esthonia.

ple of the large gastropod *Hormotoma insignis* (Eichwald). The surface of these zoaria is smooth with no conspicuously marked maculæ, although groups of large zoœcia clustered about a few mesopores are present. Such groups, although easily overlooked, may be detected both at the surface and in tangential sections, by the fact that the lunaria are directed away from their centers. The zoœcia are arranged in somewhat curved series about the maculæ, but this regularity is obscured by the usually irregular shape of the apertures. The latter may be said to be irregularly rhomboidal in outline as a rule, with a small but very distinct crescentic lunarium at the proximal angle. With the introduction of an occasional mesopore, the rhomboidal shape is destroyed and an irregularly angular aperture results. Zoœcial walls thin. Lunaria small, crescentic, with the ends projecting into the zoœcial cavity. Mesopores more numerous than usual in the genus, averaging about one to every four zoœcia.

In tangential sections the shape of the zoœcia and the small, distinct, crescentic lunaria are the salient features. Vertical sections show very simple zoœcial tubes without tubulæ and with walls exhibiting the loose porous structure of the ceramoporoids.

The difference between this and the preceding species has been mentioned under the description of the latter. No other incrusting Russian Ordovician bryozoan has so distinct a lunarium, so that this character alone will aid in the recognition of *C. lunatifera*.

Occurrence.—Rare in the Wesenberg limestone (E) at the quarries, Wesenberg, Esthonia.

Holotype.—Cat. No. 57199, U.S.N.M.

One specimen and a thin section of the type-specimen are in the collections of the British Museum.

CREPIPORA INCRASSATA, new species.

Text fig. 28.

Zoarium massive, the type and only specimen being of an irregular, discoidal shape, 13 mm. at its greatest height, and 40 mm. in its longer diameter, composed of four superimposed layers of zoœcia. The upper celluliferous side is slightly convex, while the lower side, which is uneven and somewhat wrinkled, shows either the bases of the zoœcia or their basal covering forming the epitheca. The celluliferous surface is smooth and bears maculæ of mesopores, which, although inconspicuous to the eye, are readily seen with a lens or in thin sections. The zoœcial apertures open upon the surface directly, are polygonal in outline, have comparatively thick walls, with their proximal fourth elevated and slightly arched over the cavity. This overarching portion, the lunarium, is not distinctly separated from the rest of the wall as in other species of the genus. An average zoœcium is 0.4 mm. in diameter but counting from a macula and including the larger zoœcia next to the cluster of mesopores, four and one-half zoœcia may be measured in 2 mm. Mesopores are present but are confined to the maculæ exclusively.

While the massive growth, large, thick walled, direct zoœcia, with broad, rather indefinite lunaria, are sufficient to recognize this species, its most interesting characters are brought out in thin sections. In tangential sections, the thick zoœcial walls and the large, somewhat undefined lunarial thickening, are characters which would be expected from a study of the surface. The rounded cyst-like bodies seen in zoœcial tubes in vertical sections, are, however, most unexpected, and are structures which are here noted for the first time in this group of the ceramoporoid bryozoans. The significance of these bodies and the bearing of this discovery upon the zoological position of the whole group have been mentioned in the remarks under the genus. I can only add here that their occurrence in the tubes as well defined, rounded vesicles, distinct from the diaphragms and attached at one side to the zoœcial wall, is indicative of their physiological importance. From comparison with recent species, they

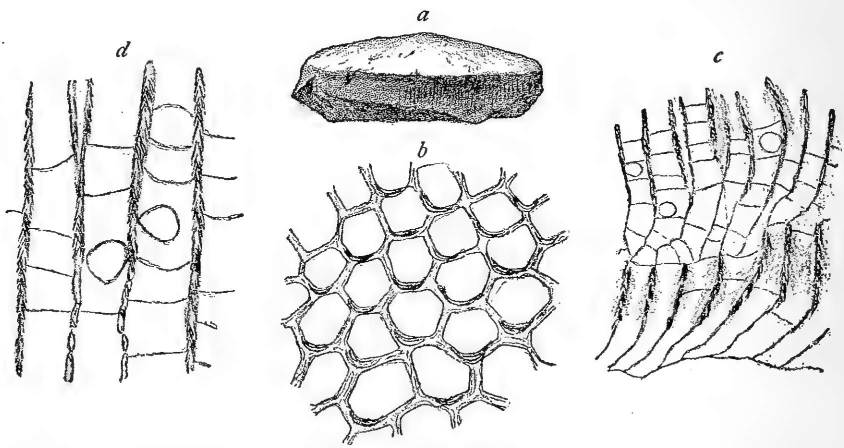

FIG. 28.—CREPIPORA INCRASSATA. *a*, EDGE VIEW OF THE TYPE-SPECIMEN, NATURAL SIZE; *b*, TANGENTIAL SECTION, ×20, SHOWING THE THICK WALLS AND OBSCURE LUNARIUM; *c*, VERTICAL SECTION, ×10, CUTTING TWO LAYERS OF ZOŒCIA; *d*, PORTION OF A VERTICAL SECTION, ×20, ILLUSTRATING OVICELL-LIKE BODIES AND STRUCTURE OF WALLS. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

would seem to bear most resemblance to the ovicells of cyclostomatous bryozoans.

Vertical sections also show the porous, laminated wall structure and the thin, delicate diaphragms occurring in this genus. In the present form the latter average their own diameter apart in the mature portion. The massive zoarium, thick walled, polygonal zoœcia, large, indefinite lunarium, and, internally, the rounded bodies occurring occasionally in the tubes, distinguish *C. incrassata* from all other species of the genus.

Occurrence.—A single specimen was presented to the United States National Museum by Dr. August von Mickwitz, who found it in the Wassalem beds (D3) at Uxnorm, Esthonia.

Holotype.—Cat. No. 57200, U.S.N.M.

British Museum's collections contain a fragment of the type-specimen and thin sections.

Genus ANOLOTICHIA Ulrich.

Anolotichia ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 381, 473; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 326; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 268.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 24.

Zoarium ramose, digitate, laminate, or incrusting; zoœcial tubes long, subpolygonal, intersected by remote diaphragms; lunarium elevated at the surface, traversed by two to six minute, vertical, closely tabulated tubes; mesopores sparingly developed.

Genotype.—*Anolotichia ponderosa* Ulrich. Earliest Silurian (Richmond) of Illinois.

When this genus was established by Ulrich, the genotype and another species were all that were known possessing the characteristic minute lunarial tubes. Since then four or five new forms have been identified in American strata, and these, with the new Russian species here described, constitute a fair representation for the genus. With the discovery of these additional species, the shape of the zoarium pertaining to the genus has been extended to include parasitic and free explanate forms. Several writers have considered the occurrence of minute tubuli traversing the lunarium longitudinally a character of too little importance for generic recognition, but their presence in at least eleven distinct species seems sufficient answer to such criticism. Sardeson, in describing *Anolotichia impolita,* in his discussion of the "Problem of the Monticuliporidea,"[1] seems to regard the lunarial tubes as deceptive lucid spots at the tooth-like points of the lunarium, and not distinct pores at all. I may be misjudging him as his language is not clear to me, but, nevertheless, it is a fact that distinct tubuli, varying from one to seven in different species, do penetrate the lunarial walls and retain their structure no matter whether the cells are filled with calcite or clay. Moreover, these small tubes are crossed at frequent intervals by distinct tabulæ, an occurrence which I have verified in a number of instances and which indicates to me that these pores certainly contained modified polyps or were occupied by some other definite structure.

In its wall structure, *Anolotichia* is a typical ceramoporoid, and, aside from the lunarial tubuli which form the most distinctive generic character, the genus is closely related to *Chiloporella* and *Crepipora.* Thin sections are almost always a necessity in distinguishing the lunarial tubuli, although sometimes they may be seen distinctly under a hand lens when the surface is rubbed smooth and then slightly etched with acid. Hitherto, mural pores, allowing communication between the zoœcia as in *Ceramopora,* have not been observed in *Anolotichia,* but their occurrence in several undoubted species of the latter genus was discovered in the course of the present study.

[1] Journal of Geology, vol. 9, Nos. 1 and 2, 1901, pp. 1, 149.

ANOLOTICHIA RHOMBICA, new species.

Plate 2, fig. 9; plate 6, figs. 6, 7; text fig. 29.

Dianulites rhombicum Dybowski, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 33, pl. 1, fig. 9.

Not *Chætetes rhombicus* Nicholson, Quart. Journ. Geol. Soc. London, vol. 30, 1874, p. 507, pl. 29, figs. 11–11*b*.

This well-marked form, for which I have adopted the specific name applied to it by Dybowski, is a common and characteristic fossil of the Wesenberg beds. It was intelligently described by Dybowski, who, however, very erroneously considered it to be the same as Nicholson's *Chætetes rhombicus*. The latter is a synonym of *Chætetes* (now *Rhombotrypa*) *quadrata* Rominger, a very abundant ramose trepostomatous bryozoan highly characteristic of the Richmond group in North America. The only point of agreement between the two species is the frequently rhombic shape of their zoœcia, the one character that misled Dybowski. Through the courtesy of Dr. Mikhailowski, I have had the opportunity of studying an authentic specimen, indeed probably the type-specimen, of Dybowski's *Dianulites rhombicus*, and I am, therefore, able to make the above identification with certainty.

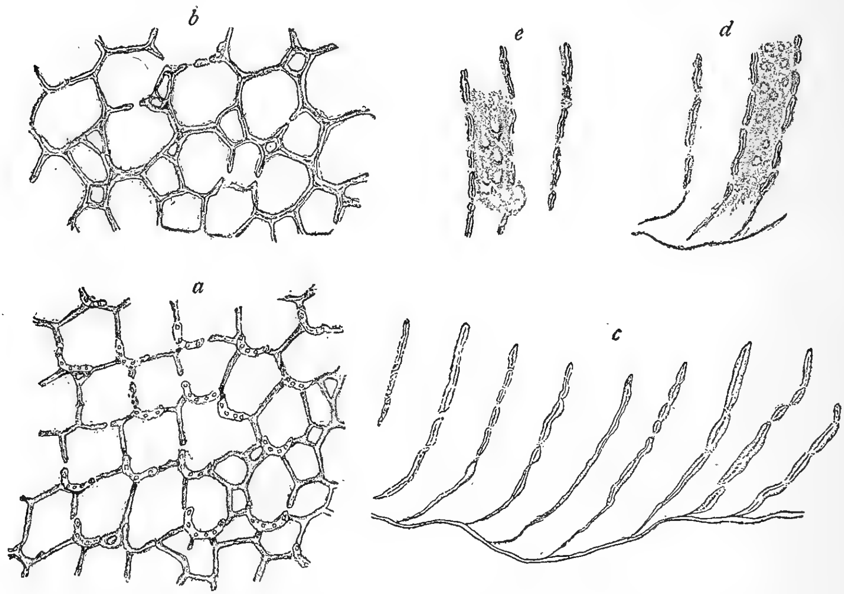

Fig. 29.—Anolotichia rhombica. *a*, tangential section, ×20, with portion of a macula represented; *b*, another tangential section, ×20, with the lunarium inconspicuous, but exhibiting connecting pores; *c*, vertical section, ×20, with structure of walls and connecting pores visible; *d* and *e*, two portions of a vertical section cutting the walls both vertically and longitudinally, and exhibiting the connecting pores. Wesenberg limestone (E), Wesenberg, Esthonia.

The zoarium of *Anolotichia rhombica* is of thin, free, undulating masses with a wrinkled epitheca on the basal side and a smooth, celluliferous surface. The specimen shown on plate 6, figure 6, is 40 mm. in its greatest width, and does not exceed 2 mm. in thickness. By the superposition of several layers of zoœcia, the thickness of a zoarium may reach as much as 6 or 8 mm. The celluliferous face bears indistinct maculæ of zoœcia slightly larger than the average at regular intervals of about 4 mm., but such areas are best determined by the radiate arrangement of the zoœcia about them. The maculæ sometimes occupy the central portion of low, domelike elevations, but a plain, smooth, celluliferous surface is of more frequent occurrence. Zoœcia large, 4 to 5 in 2 mm., with thin walls and direct subrhomboidal apertures. Mesopores few, with an occasional one scattered among the zoœcia, but most frequently restricted entirely to the maculæ. Lunaria usually a well marked, erect crescent, situated in the acute angle of the zoœcium, and directed away from the maculæ.

The essential features of the internal structure are believed to be shown in the accompanying figures, so that it will only be necessary to call attention to a few points. The vertical section is exceptionally like that shown in explanate species of many other ceramoporoid bryozoans, with the exception that the cell walls are pierced by distinct connecting pores which give a beaded aspect to the walls. None of the various vertical sections studied has shown a trace of diaphragms, so that these are apparently wanting entirely. The large connecting pores penetrating the zoœcial walls are plainly visible in both vertical and tangential sections, but especially in the former. Their appearance in specimens with clay-filled zoœcia is shown in figures 29 *c* to *e*, the pores themselves being occupied by solid, earthy material and thus sharply marked off from the calcareous wall of the zoœcium itself. When the zoœcial tubes have been filled with calcite, the pore is naturally not so distinctly visible, although it can still be discerned without difficulty. In figure 29 *c* the zoœcial walls are cut across directly so that their edges only are visible, but in figures 29 *d* and *e*, portions of the same section, the flat side of a wall has been included in the section. The latter figures, therefore, show transverse views of the pores in the shaded areas and vertical sections of them in the remaining portions.

The occurrence of four to six tubules in each lunarium is the most striking feature of tangential sections. Their appearance and the general shape, size and position of the lunarium, are shown in figure 29 *a*. The rhomboidal shape of the zoœcia so characteristic of surface views is not as well marked in thin sections, especially where mesopores are introduced. The aspect of part of a macula and its surrounding zoœcia is illustrated in figure 29 *b*. In both figures, the disconnected walls showing here and there are indicative of the connecting pores so well shown in the vertical sections.

Compared with other species of *Anolotichia*, the present form shows most resemblance to *A. revalensis*, new species, from the Orthoceras limestone. The latter, however, has distinctly larger polygonal zoœcia, practically no mesopores, and is decidedly more robust. An undescribed form in the Rhinidictya bed of the Black River (Decorah) shales at St. Paul, Minnesota, is probably the American representative, differing mainly in having fewer lunarial tubuli.

Occurrence.—Common in the Wesenberg limestone (E) at Wesenberg, Esthonia; also found in the Chasmops limestone at Räbeck and Hulterstad Church, island of Oeland.

Cotypes.—Cat. No. 57201, U.S.N.M.

Specimens and thin sections from Wesenberg and from the island of Oeland are in the collections of the British Museum.

ANOLOTICHIA BREVIPORA, new species.

Text fig. 30.

The type-specimen of this species incrusted the inner side of the living chamber of a cephalopod. In the process of weathering, the shell has been completely removed, leaving the bryozoan with the celluliferous side buried in the rock, and the basal membrane exposed.

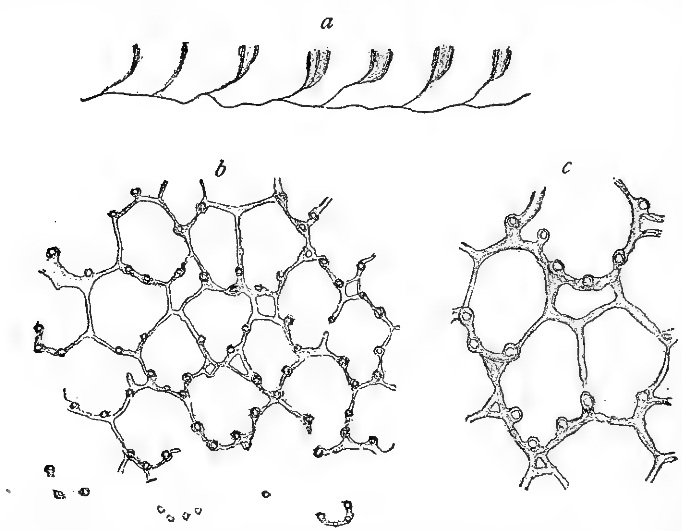

FIG. 30.—ANOLOTICHIA BREVIPORA. *a*, VERTICAL SECTION, ×20, EXHIBITING SHORT, IMMATURE, AND MATURE REGIONS; *b*, TANGENTIAL SECTION, ×20, WITH TUBULES IN LUNARIA; *c*, PORTION OF SAME, ×35, SHOWING STRUCTURE OF LUNARIUM IN DETAIL. KUCKERS SHALE (C2), REVAL, ESTHONIA.

The surface characters of the species can not be figured at present, but the thin sections show a structure so distinct from other species that there should be little trouble in its identification. One especial feature is the unusual tenuity of the zoœcial layers, and the extreme brevity of the mature and immature regions. While several layers may be superposed and thus form masses a millimeter or more thick, an individual layer is not more than 0.35 mm. thick. As illustrated in figure 30 *a*, the vertical section shows a very short, thin-walled immature region which passes almost directly into an equally short mature zone, where the walls are thickened and assume the ceramoporoid structure, and mesopores are introduced. Tabulæ are wanting in both regions.

The view shown in the tangential section, figure 30 *b*, is precisely the same that can be obtained by examination of the celluliferous surface after it has been slightly etched and moistened. The lunaria are rather indefinite in themselves, but the occurrence of three or four distinct lunarial tubes along the posterior third of the zoœcial wall plainly indicates their position. That the lunarium is present and arises into an arch and that the tubuli are distinct structures is shown in the lower part of figure 30 *b*, where the section has cut only the most elevated portions of the zoarium. The distinctness of these tubuli and the indistinctness of the lunarium itself is further illustrated in figure 30 *c*.

The zoœcia are irregularly rhomboidal to subpolygonal, thin-walled, and average 0.45 mm. in diameter. About four occur in 2 mm. Mesopores are few, averaging less than one to a zoarium.

The extremely thin incrusting zoarium, thin-walled, polygonal zoœcia, indistinct lunaria, and quite distinct lunarial tubuli are characters which separate *Anolotichia brevipora* from all other species of the genus.

Occurrence.—Kuckers shale (C2), Reval, Esthonia.

Holotype.—Cat. No. 57202, U.S.N.M.

Fragments and thin sections of the type-specimen are in the collections of the British Museum.

ANOLOTICHIA REVALENSIS, new species.

Plate 6, figs. 4, 5; text fig. 31.

Two well-preserved specimens, one an expansion of considerable size and four or more millimeters in thickness, incrusting a large gastropod, and a second smaller and much thinner example parasitic upon a cephalopod, form the types of this new species. The thin sections figured below are of the larger specimen, while the thin, smaller example is illustrated on plate 6. While these two type examples show a parasitic growth for the species, it is possible that other specimens will prove to be free, lamellate expansions. Zoaria of the latter method of growth commence as parasitic expansions, which, with increasing size, become free.

The surface of this species is without conspicuous macular elevations, but the maculæ are distinctly visible areas 4 mm. apart, from which the zoœcia radiate. The zoœcia are conspicuously large and irregularly polygonal, with thin walls; three to four zoœcia in 2 mm. The lunarium is comparatively small, occupying about one-fifth of the zoœcial wall, but it arises from one of the angles as a distinct crescent, its ends projecting into the zoœcial cavity, but the structure as a whole not overarching it. Mesopores few, their usual number being shown in the tangential section, figure 31 *c*.

Excepting that the tubes are of greater diameter on account of the larger zoœcia, the vertical section shows the same characters noted in the description of *Anolotichia rhombica*. Connecting pores are present but are not as numerous as in that species. The zoœcial walls are of considerable thickness compared with similar species and show the laminated structure clearly. In addition to the points

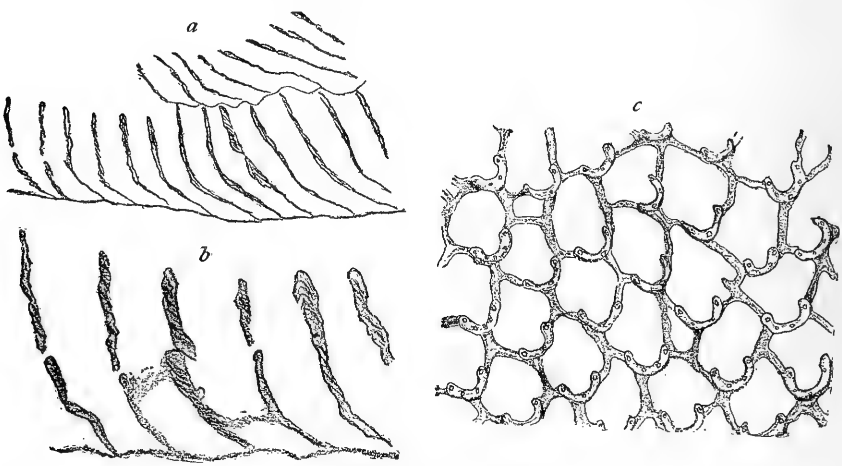

FIG. 31.—ANOLOTICHIA REVALENSIS. *a*, VERTICAL SECTION, ×9, WITH TWO LAYERS OF ZOŒCIA; *b*, PORTION OF THE SAME, ×20, ILLUSTRATING LAMINATED WALL TISSUE; *c*, A NORMAL TANGENTIAL SECTION, ×20. ORTHOCERAS LIMESTONE (B3), REVAL, ESTHONIA.

pertaining to the zoœcia, mentioned above, the occurrence of distinct lunarial tubuli, varying in number from three to five, can be seen in tangential sections.

Care is necessary in separating *Anolotichia revalensis* from the similar *A. rhombica*, but it is believed that the larger size and irregularly polygonal shape of the zoœcia in the former are sufficiently different from the smaller and more distinctly rhomboidal form of the latter. The other explanate ceramoporoids have a zoœcial structure which is not comparable to that of the present species.

Occurrence.—Apparently uncommon in the Orthoceras limestone (B3) at Reval, Esthonia.

Cotypes.—Cat. No. 57203, U.S.N.M.

British Museum collections, specimen and thin section.

ANOLOTICHIA IMPOLITA (Ulrich).

Plate 7, fig. 11; text figs. 32, 33.

Crepipora impolita ULRICH, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 77.

Anolotichia impolita ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 327, pl. 28, figs. 15–20; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 268, fig. 437 A–C.—SARDESON, Journ. Geol., vol. 9, 1901, p. 13, pl. A, fig. 12.

In the collections made by Prof. Schuchert from the Kuckers shale, on Baron Toll's estate, are five small, ramose bryozoans which have all of the characters of young specimens of the abundant American form *Anolotichia impolita.* The only differences I can point out in the Russian specimens are, first, a slight decrease in the size of the zoœcia; second, a slightly obliquely directed lunarium; and, third, a less polygonally outlined zoœcium. However, as all of these specimens have a very narrow, mature region, and the zoarium itself is small, there is little doubt that they are only young stages of a species growing into more robust branches. Almost all of the American specimens of *Anolotichia impolita* are of heavy, full-grown zoaria, but a few examples before me show the youthful condition. After carefully comparing these and the Russian specimens, I am convinced that more mature fragments of the latter could not be distinguished even as a variety from the American species. Both the American and Russian examples are illustrated here, and comparisons of figures 32 and 33 will show their identity of structure.

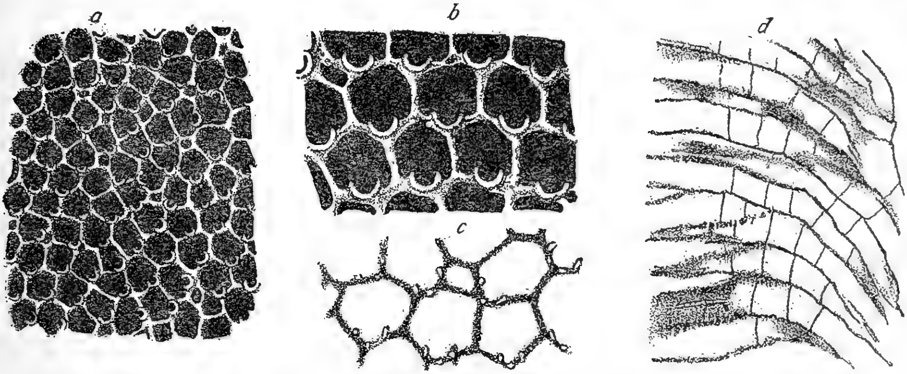

FIG. 32.—ANOLOTICHIA IMPOLITA. *a* AND *b*, SURFACE OF A WELL-PRESERVED EXAMPLE, ×9, AND ×18; *c*, SMALL PORTION OF A TANGENTIAL SECTION, ×18, SHOWING LUNARIA AND TUBULI; *d*, VERTICAL SECTION, ×9. STICTOPORELLA BED OF BLACK RIVER (DECORAH) SHALES, ST. PAUL, MINNESOTA. (AFTER ULRICH.)

Ulrich's description of the species is as follows:

Zoarium large, bushy, consisting of abundantly and irregularly divided solid branches, the latter varying from 5 to over 20 mm. in diameter. At the base the branches may coalesce, and here they are always stronger than at their terminations. Rarely the zoarium is not branched, but occurs as an irregular mass with lobe-like excrescences. Zoœcia large, with moderately thin walls, direct, hexagonal or subrhomboidal apertures. The latter are subequal (there being no distinguishable clusters of large ones), are arranged in rather regular series with 11 in 5 mm. Lunarium well developed, appearing as a small crescentic elevation usually in one of the angles. Mesopores few, sometimes appearing to be absent entirely, occasionally forming small clusters of from two to six.

Internal characters.—In tangential sections the walls of contiguous zoœcia appear to be thoroughly amalgamated, the lunarium is represented by two or three small lucid spots (lunarial tubuli) on one side of the tube, the end ones projecting slightly into its cavity. In vertical sections the tubes are scarcely to be called vertical even in the axial region, curving outward with a uniform curve from the beginning. Their walls are composed of rapidly alternating dark and lighter shades of schlerenchyma, so that they appear more or less distinctly lineate transversely. The cause of these lines, which are closest in the peripheral part of the zoarium, is unknown, unless the light ones, which are of uniform width and, especially in the axial region, narrower than the dark bands, represent rows of perforations. Exceedingly delicate diaphragms, their diameter or more apart, occur chiefly in the outer and middle part of the tubes. The axial portion of transverse sections is very nearly like tangential, the only difference being that the walls are a little thinner and small tubes comparatively more abundant.

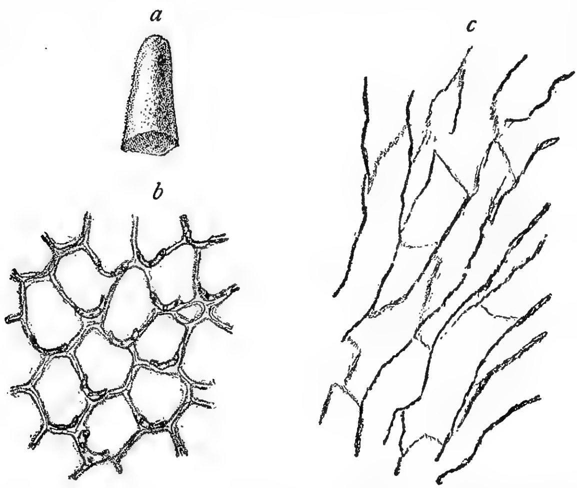

Fig. 33.—Anolotichia impolita. *a*, fragment of zoarium, natural size; *b* and *c*, tangential and vertical sections, ×18, introduced for comparison with figure 32. Kuckers shale (C2), Baron Toll's estate, Esthonia.

Occurrence.—Very abundant in the Stictoporella bed of the Black River (Decorah) shale at various localities in Minnesota and Iowa. Rather uncommon in the Kuckers shale (C2), Baron Toll's estate, near Jewe, Esthonia.

Plesiotype.—Cat. No. 57204, U.S.N.M.

One specimen from Baron Toll's estate is in the collection of the British Museum.

ANOLOTICHIA SACCULUS, new species.

Text fig. 34.

Zoarium a small, sack-like body, narrow at the lower end, broad in the upper portion. The two type-specimens are of about equal size, but the more perfect one, shown in figure 34 *a*, is about 15 mm. high and 12 mm. at its greatest width. The zoœcial layer forming this hollow body is less than a millimeter in thickness, with the zoœcial apertures opening on the outer side, and the inner, noncelluliferous face bearing a well wrinkled epitheca. The two specimens known were broken from the solid rock so that most of the zoœcial layer adhered to the matrix and left the clay filled central space with a mold of the epitheca to represent the zoarium. In figure 34 *a*, a portion of the zoœcial layer itself is seen adhering to the clay mold, which, however, represents the shape of the zoarium equally well.

Surface of zoarium smooth, maculæ inconspicuous, but, as in other species of the family, readily determined by the radial arrangement of the zoœcia about them. At the surface the zoœcia are subrhomboidal in outline, have rather thick walls which bear a small, distinct

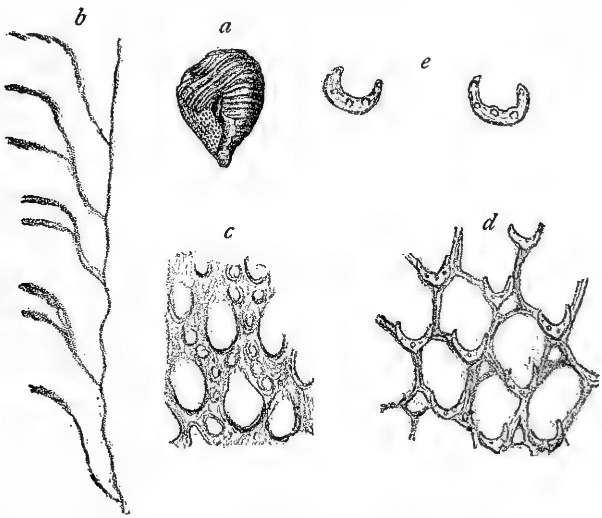

FIG. 34.—ANOLOTICHIA SACCULUS. *a*, A TYPE-SPECIMEN, NATURAL SIZE, WITH MOST OF THE ZOARIUM EXFOLIATED AND SHOWING THE IMPRESSION OF THE EPITHECA; *b*, VERTICAL SECTION, ×20; *c*, TANGENTIAL SECTION, ×20, SHOWING NUMEROUS MESOPORES AND INDISTINCT LUNARIA; *d*, ANOTHER TANGENTIAL SECTION, ×20, WITH THE NORMAL OCCURRENCE OF LUNARIA AND TUBULI; *e*, TWO LUNARIA, ×35, EXHIBITING NUMBER AND DISTRIBUTION OF TUBULI. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

lunarium in the acute angle; about four zoœcia in 2 mm. The lunarium occupies about one-fifth of the apertural wall and bears four or five of the tubules characterizing the genus. Mesopores are few at the surface, averaging about one to a zoœcium (see fig. 34 *d*), but deep tangential sections show them in comparative abundance (fig. 34 *c*). In such sections the zoœcia are oval-shaped and the lunarium is poorly developed. Vertical sections show the characteristic lamination and porous structure of the walls common to all ceramoporoids, and in addition indicate that diaphragms are absent.

The hollow form of growth is sufficient to distinguish the present species from others of the genus, although other differences may be noted by comparing the figures with those of the other species of *Anolotichia* here described.

Occurrence.—Kuckers shale (C2), Baron Toll's estate, Esthonia.

Cotypes.—Cat. No. 57205, U.S.N.M.

A thin section of one of the type-specimens is in the collection of the British Museum.

Genus FAVOSITELLA Etheridge and Foord.

Favositella Etheridge and Foord, Ann. and Mag. Nat. Hist., ser. 5, vol. 13, 1884, p. 472.

Bythotrypa Ulrich, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 324; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 268.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 24.

Specimens of the type-species of the genus *Favositella* have recently come into the possession of the National Museum, and, upon being sectioned, have proved to belong to the same generic group well described by Ulrich under the name of *Bythotrypa*. The figures by Etheridge and Foord illustrating the internal structure are accurate and sufficient for the identification of the species, but the title of their article and their description of the genus, written evidently with the supposed relationship of *Favositella* to *Favosites* in mind, are so misleading that the identity of *Bythotrypa* and *Favositella* has hitherto not been noted. With the two described species of *Bythotrypa*, several new American forms, the three species described in the present paper, and the type-species of *Favositella*, as well as one or two undescribed forms from the European Silurian, *Favositella* attains a specific representation equal to that of many of the other ceramoporoid genera.

The authors of *Favositella* recognized distinct "mural pores of a large size, remote and irregularly disposed" in their thin sections, which caused them to consider the genus as related to *Favosites*. They further state that "in some specimens the mural pores have been filled with chalcedony of a concentric structure. It may be noted that the pores are so large as to be seen on a polished surface." The specimens and thin sections used in my study of *Favositella interpuncta*, the type-species, show these same pore-like structures, but I am unable to recognize them as pores for the very simple reason that in sections they appear, not in the zoœcial tissue or penetrating the walls, but isolated in the zoœcial cavity. Thus, in a tangential section, these "pores" may be seen as individual, round bodies in the clay-filled zoœcial cavity, or in the mesopores, with no relation to the walls. From their position and composition it is evident that they have nothing to do with the bryozoan itself, but are simply rounded, siliceous bodies included in the other material filling the cell cavity. The appearance of these included bodies in thin sections is shown at *c* in figure 35.

Curiously enough, mural pores do exist in this species, as is indicated in the accompanying figures of a tangential and a vertical section.

They are most apparent in the latter because more opportunity is afforded to show them as they pierce the walls. However, these pores do not differ from the usual pores seen in other ceramoporoid genera, so that their occurrence can not be considered as an important generic characteristic. The minute structure of the zoœcia in *F. interpuncta*, the style of lunarium, arrangement and occurrence of mesopores, is precisely the same as in *Bythotrypa laxata*, the genotype of *Bythotrypa*. Moreover, each species has the same internal structure, particularly the loose, irregular, vesicular tissue formed by mesopores.

Ulrich has given a clear, concise definition of *Bythotrypa* which I quote, as it applies without change to the genotype of *Favositella*.

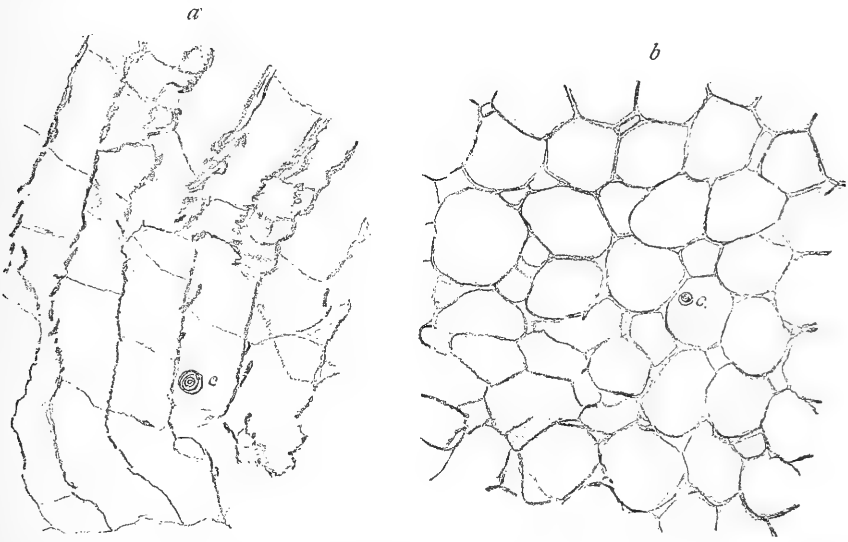

FIG. 35.—FAVOSITELLA INTERPUNCTA. *a*, VERTICAL SECTION, ×20, SHOWING THE LOOSE VESICULAR-LIKE TISSUE DEVELOPED IN THE MATURE REGION, THE PORES CONNECTING ADJOINING ZOŒCIA AND AN INCLUDED CONCENTRIC BODY AT *c*; *b*, TANGENTIAL SECTION, ×20, WITH STRUCTURE OF ZOŒCIA AND MESOPORES AND ONE OF THE INCLUDED SILICEOUS BODIES AT *c*. WENLOCK SHALE, WENLOCK, ENGLAND.

Zoaria massive or lamellate. Zoœcia forming long continuous tubes, intersected by thin diaphragms, their walls minutely crenulate and with the structure characterizing the ceramoporoids. Lunarium well defined, large, projecting above the rest of the aperture margin. Mesopores numerous, open at the surface, interiorly forming a species of vesicular tissue unusually loose and irregular in construction.

The loose, irregular vesicular tissue formed by the mesopores is the character most relied upon in separating species of *Bythotrypa*, or, as they should now be designated, *Favositella*. This tissue is similar to the vesicular filling of the interzoœcial spaces in the Fistuliporidæ. As remarked by Ulrich, *Bythotrypa* represents probably a premature evolution of the fistuliporoid type that either became extinct or was reabsorbed into the parent stock. The Silurian occurrence of the genus in rocks containing typical Fistuliporidæ would suggest that it represents a more permanent line of development, possibly giving rise to such genera as the Devonian *Pinacotrypa*.

Genotype.—Favositella interpuncta (Quenstedt).[1] Silurian (Wenlock shale) of England.

FAVOSITELLA EXSERTA, new species.

Text fig. 36.

Zoarium a lamellate expansion several centimeters in width and usually about 4 mm. thick. Under surface, as usual in such forms of growth, wrinkled and covered with an epithecal membrane.

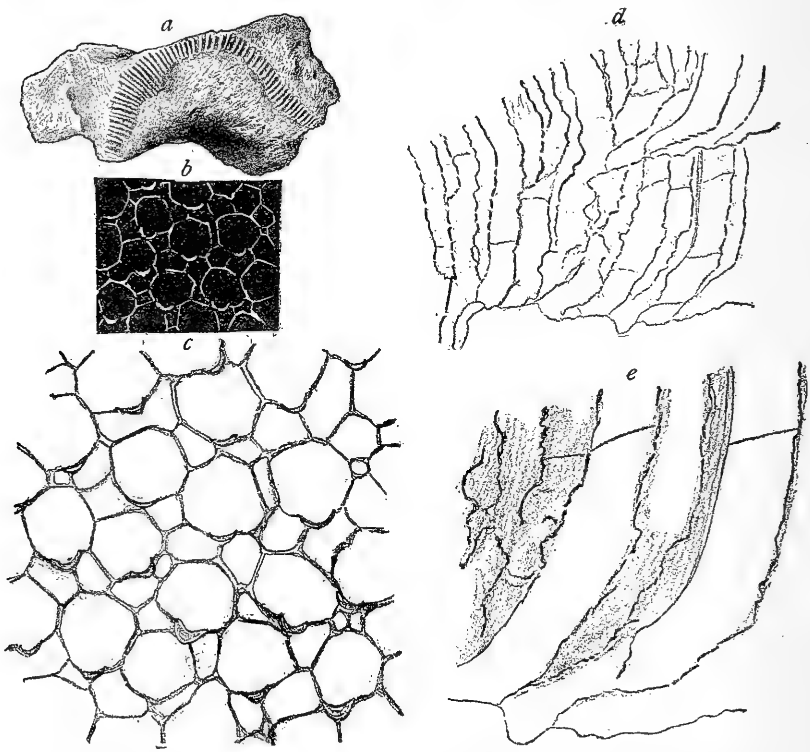

FIG. 36.—FAVOSITELLA EXSERTA. *a*, EDGE VIEW OF A ZOARIUM, NATURAL SIZE, IMBEDDED IN THE ROCK; *b*, SURFACE VIEW, ×9, OF THE SECTIONED TYPE; *c*, TANGENTIAL SECTION, ×20, EXHIBITING THE SMALL PROMINENT LUNARIUM; *d*, VERTICAL SECTION, ×9, THROUGH PORTIONS OF TWO LAYERS; *e*, PORTION OF THE SAME, ×20, ILLUSTRATING WALL STRUCTURE IN MORE DETAIL. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

Zoœcial apertures rather large, direct, subpolygonal, and nearly equal in size, 0.47 mm. in diameter, on the average with three to four in 2 mm. Lunarium small, occupying less than one-seventh of the zoœcial wall, but so sharply elevated that it is a prominent surface feature. Walls of both zoœcia and mesopores quite thin. Meso-

[1] *Favosites interpuncta* Quenstedt, Petref. Deutschl., Abth. 1, 1881, p. 10, pl. 143, fig. 9.

pores irregularly angular, of variable size, sometimes nearly as large as the zoœcia, and frequently abundant enough to surround a zoœcium. They are most abundant in the maculæ which are developed at more or less regular intervals, but are not a conspicuous surface feature.

In tangential sections the thin-walled cells with the small, although well developed, thick, crescentic lunarium form the important feature. Vertical sections show less important specific characters, although here the generic characters are best illustrated. These are, first, the ceramoporoid wall structure with small mural pores and fine, transversely laminated tissue, and, second, the loose vesicular structure formed by the mesopores. A few thin diaphragms occur in the tubes. The vesicular structure is formed by the great irregularity of the mesopore walls, allowing them at times to coalesce. Sometimes an oblique or irregularly placed tabula occurs in the mesopores and by its position increases the vesicular appearance.

The small but sharply elevated lunarium externally, and the loose, vesicular internal structure, are diagnostic of the species.

Occurrence.—Apparently common in the Kuckers shale (C2), Baron Toll's estate, near Jewe, Esthonia.

Holotype.—Cat. No. 57177, U.S.N.M.

Specimens and thin sections in the collections of the British Museum.

FAVOSITELLA DISCOIDALIS, new species.

Text fig. 37.

Cfr. *Bythotrypa laxata* ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 325, pl. 28, figs. 21–25.

Zoarium a small, discoidal mass, with a concentrically wrinkled epitheca on the flat basal side, and the upper surface slightly convex. None of the specimens examined exceeds 20 mm. in diameter and 6 mm. in height. The zoœcial apertures open directly at the surface, are large, nearly equal in size, and range in shape from subovate to obscurely polygonal. An average single zoœcium is 0.6 mm. in diameter, with three usually occurring in 2 mm. The lunarium, although clearly developed and occupying nearly one-fourth of the zoœcial circumference, overarches the aperture but slightly. Mesopores few for the genus, the number shown in the accompanying illustrations (figs. 37 *c, d*) being the maximum seen. Seldom do the mesopores attain the size of the zoœcia from which they can always be distinguished when almost as large, by the absence of a lunarium. As in other species of the genus, the mesopores, at more or less regular intervals, cluster together and form maculæ, which, however, in the present form, are small and inconspicuous.

In tangential sections the zoœcia are seen to vary from subangular or polygonal to subovate in outline, their shape being determined by the number of intervening mesopores. The mesopores are usually small, irregular in shape, and few in number. Both zoœcia and mesopores have thin walls which have the indefinite structure characteristic of the Ceramoporidæ. The lunarium is ill-developed in some of the zoœcia and at best it appears only as a thickened border occupying the posterior fourth of the zoœcial walls, and with its ends not projecting into the zoœcial cavity. Where the lunarium is apparently absent, its place is indicated by the regularly curved form of the zoœcial wall, the opposite portion of the zoœcium being angular or less uniformly curved. Sometimes additional layers of light-colored tissue are deposited upon the lunarium, adding to its distinctness in tangential sections.

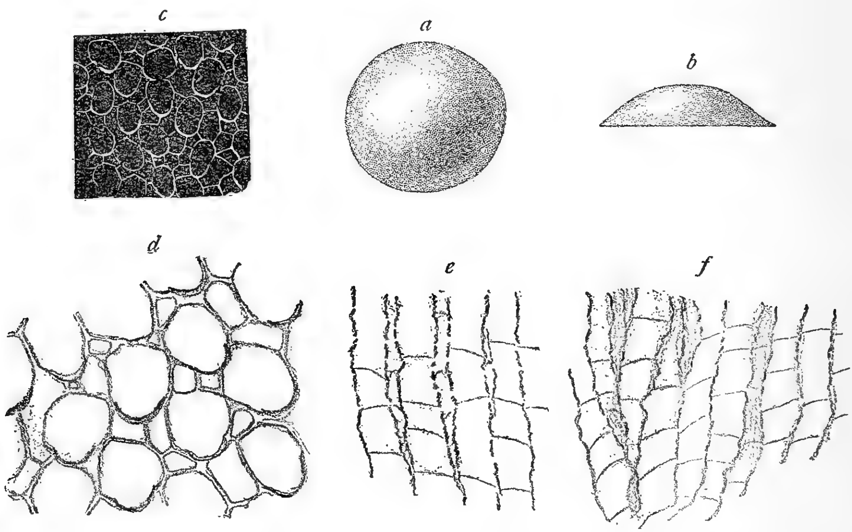

FIG. 37.—FAVOSITELLA DISCOIDALIS. *a* AND *b*, TOP AND SIDE VIEWS OF A ZOARIUM, NATURAL SIZE; *c*, SURFACE OF SAME, ×9; *d*, TANGENTIAL SECTION, ×20; *e* AND *f*, VERTICAL SECTION, ×9, ILLUSTRATING SLIGHT VARIATION IN STRUCTURE. ECHINOSPHERITES LIMESTONE (C1), KATLINO, GOVERNMENT OF ST. PETERSBURG.

The characteristic loose vesicular structure is somewhat incompletely developed in the present species, mainly because of the small size of the zoarium. It is clearly indicated, however, in the vertical sections figured. Thin diaphragms are developed in the tubes at intervals slightly greater than their own diameter.

The present form is probably most closely allied to *Favositella laxata* (Ulrich), which holds approximately the same stratigraphic position in America. *Favositella laxata* differs, however, first in forming quite large zoaria, second, in having smaller zoœcia (the average zoœcium being 0.4 mm. in diameter), and, finally, in possessing more numerous mesopores. The tabulation and other internal features of both species are practically identical. Compared with associated bryozoans, there are several species with a similar method of growth, but none of them has the internal vesicular tissue. The species is represented by only a few specimens, all of which are small. It is possible that, with more examples, the resemblance to *F. laxata* will be found such that *F. discoidalis* may be considered only as a variety. At any rate, the two forms are closely related.

Occurrence.—Apparently rare in the Echinospherites limestone (C1) at Katlino and at Pulkowa, government of St. Petersburg.

Holotype.—Cat. No. 57176, U.S.N.M.

Sections of the type-specimen are in the British Museum.

FAVOSITELLA ? PUNCTATA, new species.

Text fig. 38.

Cfr. *Archeopora punctata* EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 406, pl. 24, fig. 19.

This interesting bryozoan is undoubtedly a member of the Ceramoporidæ, but its generic position is a matter of less certainty. As a provisional arrangement, I have placed it under *Favositella,* recognizing the fact that future studies will most probably cause its reference elsewhere.

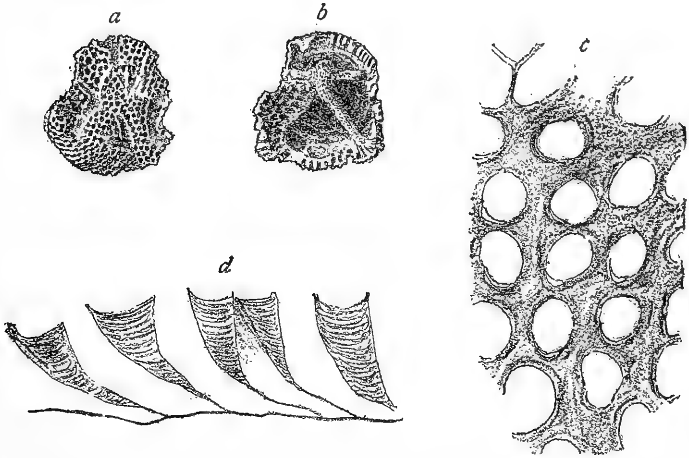

FIG. 38.—FAVOSITELLA? PUNCTATA. *a,* CELLULIFEROUS SIDE OF A ZOARIUM, ×2, WITH THE ELONGATED, ALMOST CONFLUENT MACULÆ; *b,* BASAL SIDE OF SAME SPECIMEN, ×2, SHOWING ATTACHMENT TO A SMALL, RAMOSE BRYOZOAN; *c,* TANGENTIAL SECTION, ×20; *d,* VERTICAL SECTION, ×20. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

The zoarium is thin and explanate, beginning growth upon some foreign object, as the ramose bryozoan shown in figure 38 *b,* and continuing until a lamellate, epithecated expansion, a centimeter or more in diameter, and several millimeters thick results. The celluliferous surface presents no monticules or tubercules, but is uneven because of the narrow, slightly depressed, elongated maculæ, which are bare of apertures and are often almost confluent. Apertures irregularly rounded with the posterior fourth slightly raised to form the lunarium, which, however, is not conspicuous either at the surface or in sections. The average aperture is 0.38 mm. in its longer diameter and 0.30 mm. wide; four occur in 2 mm. Interzoœcial spaces solid, showing no trace of mesopores.

Tangential sections show irregularly rounded to oval zoœcia, with evidence of the lunarium at their posterior end. Mesopores are absent, the interzoœcial spaces being filled with a solid tissue which, in vertical sections, is seen to be of the usual laminated type common to the Ceramoporidæ. In the short, immature regions the zoœcia have especially thin walls. Diaphragms are wanting in both regions.

The lamellate zoarium with its conspicuous, elongate, solid maculæ externally, and the solid, zoœcial interspaces of laminated tissue seen in sections, will serve to distinguish the present species from all other Ordovician forms. Certain unplaced ceramoporoids from the Silurian seem to have a similar structure, but, as they are undescribed, comparisons are unnecessary.

Eichwald's figures of *Archeopora punctata* have a slight resemblance to *Favositella? punctata*, and it is for the reason of their possible synonymy that I have selected the same specific name for the latter. Notes on *Archeopora punctata* are given on a later page of this work.

Occurrence.—Not uncommon in the Wassalem beds (D3) at Uxnorm, near Reval, Esthonia.

Holotype.—Cat. No. 57178, U.S.N.M.

Specimens and thin section in the collections of the British Museum.

Genus SPATIOPORA Ulrich.

Spatiopora Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 155; vol. 6, 1883, p. 166.—Foord, Contr. Micro-Pal. Cambro-Sil., 1883, p. 20.—Miller, North Amer. Geol. and Pal., 1889, p. 323.—Ulrich, Geol. Surv. Illinois, vol. 8, 1890, p. 381; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 319; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 269.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 24.—Bassler, Bull. 272, U. S. Geol. Surv., 1906, p. 21.—Cumings, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 756.—Hennig, Archiv fur Zool., vol. 4, No. 21, 1908, p. 12.

The single species of this genus noted in the Russian strata is so like an American form that it has not been differentiated. *Spatiopora*, briefly defined, is a ceramoporoid genus in which the characteristic wall structure is present, but mesopores and lunaria are practically absent. The zoarium is usually found incrusting the shells of Orthocerata, and the zoœcia, as a whole, show great resemblance to the Trepostomata.

Genotype.—*Spatiopora aspera* Ulrich. Upper Ordovician (Maysville) of the Ohio Valley.

SPATIOPORA LINEATA INCEPTA Ulrich.

Plate 7, figs. 9, 10.

Spatiopora maculosa var. *incepta* ULRICH, Geol. Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 320.
Spatiopora lineata-incepta NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 407.

The Black River (Decorah) shales of Minnesota have yielded several examples of a species of *Spatiopora* which was briefly defined by Ulrich as *S. maculosa* var. *incepta.* Further study of these specimens showed that they might be classed with more reason as a variety of the middle Cincinnatian form, *S. lineata* Ulrich. The zoarium of both the Russian and American specimens is a thin crust spread over shells of *Orthoceras* (Pl. 7, fig. 9). The surface is smooth, but under a hand lens numerous blunt acanthopores are occasionally seen. Maculæ are present at regular intervals and contain the only mesopores which occur. The zoœcia are thin-walled and have little to distinguish them from simple incrusting Trepostomata. Thin sections, however, show the characteristic ceramoporoid structure.

Occurrence.—Rare in the upper Black River (Decorah) shales at Chatfield, Minnesota, and in the Wesenberg limestone (E) at Wesenberg, Esthonia.

Plesiotype.—Cat. No. 57206, U.S.N.M.

Genus SCENELLOPORA Ulrich.

Scenellopora ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 150.—MILLER, North Amer. Geol. and Pal., 1889, p. 322.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, p. 368; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 268.—SIMPSON, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 593.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 24.

This genus was established for a simple, pedunculate, ceramoporoid bryozoan from Middle Ordovician strata of eastern Tennessee. In the type and only described species the upper surface is slightly concave and celluliferous, the zoœcial aperture occupying the summits of low ridges radiating from the center. A second species with surface characters much as in Eichwald's *Ceramopora socialis* is known from the same strata holding the type. This new species and *C. socialis* both agree in being parasitic, differing in that respect from the genotype, and causing, therefore, a slight revision in the generic diagnosis.

Genotype.—*Scenellopora radiata* Ulrich. Middle Ordovician of Tennessee.

SCENELLOPORA SOCIALIS (Eichwald).

Text fig. 39.

Ceramopora socialis Eichwald, Lethæa Rossica, vol. 1, 1860, p. 412, pl. 26, fig. 21.

A single well-preserved specimen incrusting an *Echinospherites* in the collection before me agrees so well with Eichwald's figure of *Ceramopora socialis* that I have no doubt of its identity. The first clue to the identification of this species is the distinctness of the several groups of zoœcia with their central, solid areas, growing together as a parasitic expansion. Each of these groups, when magnified, is seen to consist of a macula free from cell openings, from which zoœcia with strongly elevated lunaria radiate. The lunaria encircle the posterior three-fourths or more of the zoœcial apertures, and are distinctly arched. Eichwald's figure of the surface enlarged is incorrect in showing the elevated lunarial walls as completely surrounding the cell opening. Measuring along one of the radiating rows of zoœcia, about four apertures occur in 2 mm.

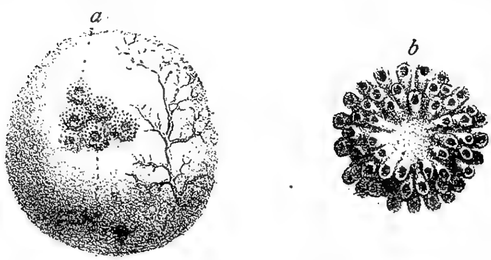

Fig. 39.—Scenellopora socialis. *a* and *b*, copy of Eichwald's views of Ceramopora socialis; *a*, zoarium, natural size, incrusting an Echinospherites; *b*, one of the groups of zoœcia of the same, enlarged. Echinospherites limestone (C1), Pulkowa, government of St. Petersburg.

The incrusting zoarium of small groups of zoœcia with well-developed, arched lunaria will readily distinguish this from all associated bryozoans.

Occurrence.—Apparently rare in the Echinospherites limestone (C1) at Poulkowa and Katlino, government of St. Petersburg.

Plesiotype.—Cat. No. 57207, U.S.N.M.

Family FISTULIPORIDÆ Ulrich.

This family comprises a number of genera quite similar in their general characteristics to the members of the Ceramoporidæ, but differing conspicuously in having the zoœcial interspaces occupied by vesicular tissue. This difference is not merely one of convenience in classification but is a natural one, as shown by the history of the two families. The Ceramoporidæ are almost restricted to the Ordovician, while the Fistuliporidæ are highly characteristic of the later Paleozoic rocks. With the exception of one or two undescribed primitive species of *Fistulipora* in the Middle Ordovician strata of the Appalachian Valley, the following species are the only Ordovician representatives of the family. Each, as would be expected, is a primitive member of its genus.

Genus FISTULIPORA McCoy.

Fistulipora McCoy, Ann. and Mag. Nat. Hist., ser. 2, vol. 3, 1850, p. 131.—Milne-Edwards and Haime, Pol. Foss. Terr. Pal., 1851, p. 219.—Milne-Edwards, Hist. Nat. des Corall., vol. 3, 1860, p. 238.—Nicholson, Pal. Prov. Ontario, 1874, p. 63.—Dybowski, Verh. Mineral. Gesell. St. Petersburg, vol. 10, 1876, p. 180.—Nicholson, Pal. Tabulate Corals, 1879, p. 292; The Genus Monticulipora, 1881, p. 91.—Nicholson and Foord, Ann. and Mag. Nat. Hist., ser. 5, vol. 16, 1885, p. 500.—Ulrich, Geol. Surv. Illinois, vol. 8, 1890, pp. 382, 474.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, pp. 25, 266.—Bassler, Bull. 292, U. S. Geol. Surv., 1906, p. 22.—Hennig, Archiv fur Zool., vol. 4, No. 21, 1908, p. 16.

Didymopora Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 156.

Dybowskia Waagen and Pichl, Pal. Indica, ser. 13, 1886, pp. 717.

Dybowskiella Waagen and Wentzel, Pal. Indica, ser. 13, 1886, pp. 910, 916.

Lichenalia (not Hall, 1852) Hall and Simpson, Nat. Hist. New York, Pal., vol. 6, 1887, p. xvi.—Miller, North Amer. Geol. and Pal., 1889, p. 311.—Simpson, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 559.

Fistuliporella Simpson, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 560.

Zoarium ranging in the various species from incrusting to massive and subramose. Zoœcia more or less rounded with a distinct lunarium. Interzoœcial spaces smooth or granulose at the surface, occupied internally by one or more series of vesicles.

Genotype.—Fistulipora minor McCoy. Carboniferous of England.

The following new species can not be considered anything else than a primitive *Fistulipora*. It possesses the generic characters of a lunarium and vesicular interspaces, but the lunarium is poorly outlined, and, indeed, when best shown it appears as only a broad curve at one end of the cell. The vesicular interspaces also at times have the tabulated aspect of the mesopores in some of the ceramoporoids.

FISTULIPORA PRIMÆVA, new species.

Text fig. 40.

Zoarium a small, elongate, dome-shaped mass, 12 mm. in height and 9 mm. wide. Surface smooth and exhibiting large, rounded zoœcial apertures, isolated from each other by closed interspaces. Distinct maculæ of closed mesopores and larger zoœcia on a plane with the surface, at intervals of about 4 mm., measuring from center to center. Zoœcial apertures irregularly rounded, averaging 0.36 mm. in diameter, with three in 2 mm. Lunarium represented by an obscure broad curve occupying the anterior third of the cell wall, little raised above the general surface. Interspaces averaging the zoœcial diameter in width, closed at the surface by a thin covering through which the openings of the vesicular species are indistinctly visible. Large, distinct granular spines dot the surface of these spaces and sometimes occur on the cell wall.

In thin sections the large granules of the surface are seen to be the ends of continuous thick acanthopore-like tubes composed of a granular, black material quite different in structure from the usual wall substance. These tubes follow the walls in their course to the surface, but they are not limited to any particular tube or direction. In some sections they are seen to cross diagonally from one side of a cell wall to the other before reaching the surface. Tangential sections

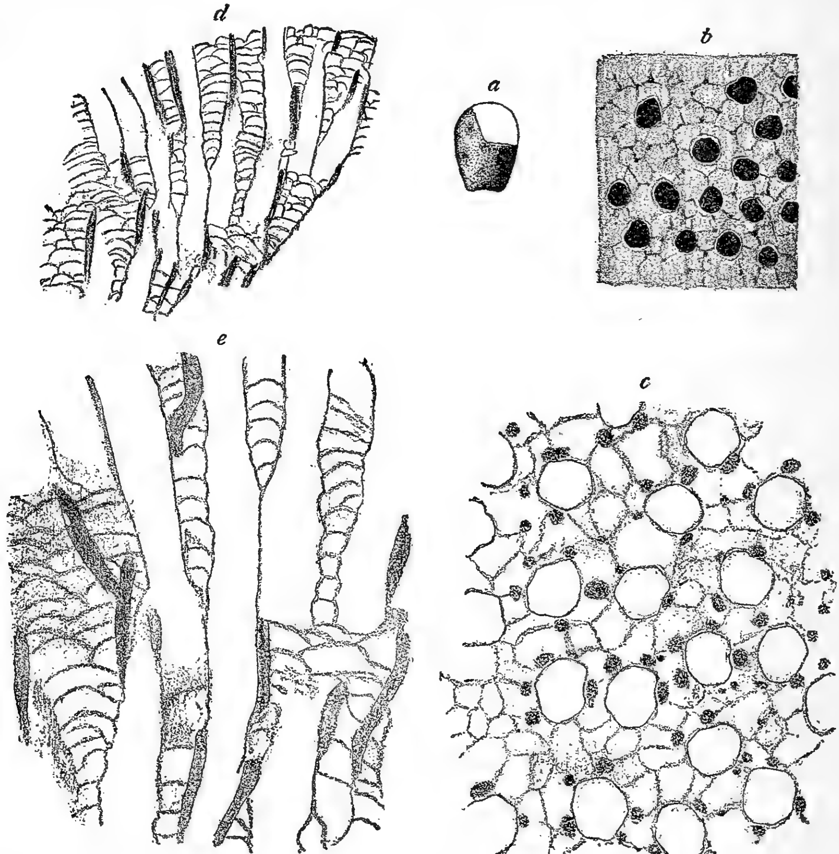

FIG. 40.—FISTULIPORA PRIMÆVA. *a*, THE TYPE-SPECIMEN, NATURAL SIZE; *b*, SURFACE OF SAME, ×8, EXHIBITING A PORTION OF A MACULA AND SURROUNDING ZOŒCIA; *c*, TANGENTIAL SECTION, ×20, SHOWING OBSCURE LUNARIUM AND NUMEROUS LARGE GRANULES; *d*, VERTICAL SECTION, ×8; *e*, PORTION OF SAME SECTION, ×20. GLAUCONITE LIMESTONE (B2), PAWLOVSK, GOVERNMENT OF ST. PETERSBURG.

show irregularly rounded zoœcia with thin walls separated by vesicular areas with equally thin walls. Here the lunarium is as indistinctly developed as at the surface, while the granular tubes are just as clearly shown.

The fistuliporoid vesicles and the large, dark granular structure of this species are so unusual in an Ordovician bryozoan that comparisons with other species are unnecessary.

Occurrence.—Rare in the Glauconite limestone (B2) at Pawlovsk, government of St. Petersburg.

Holotype.—Cat. No. 57208, U.S.N.M.

A thin section of the type-specimen is in the collection of the British Museum.

Genus CHILOTRYPA Ulrich.

Cheilotrypa ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 7, 1884, p. 49.

Chilotrypa MILLER, North Amer. Geol. and Pal., 1889, p. 297.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, p. 382; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 269.—SIMPSON, Fourteenth Ann. Rep. State Geol. New York for the year 1894, 1897, p. 554.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 26.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 24.

The zoœcial characters of this genus are essentially the same as in *Fistulipora*, but the zoarium is of small, ramose branches with a narrow, irregularly expanding and contracting axial tube. The genus may be said, therefore, to be the equivalent in the Fistuliporidæ of *Cœloclema* in the Ceramoporidæ. The following species is the earliest known, and naturally has primitive characters.

Genotype.—*Chilotrypa hispida* Ulrich. Mississippian of the United States.

CHILOTRYPA IMMATURA, new species.

Text fig. 41.

Zoarium of very narrow, irregularly cylindrical, smooth branches, about 1 mm. in diameter, with small, macular areas at intervals of 2.5 mm. Apertures with their proximal end slightly raised into a

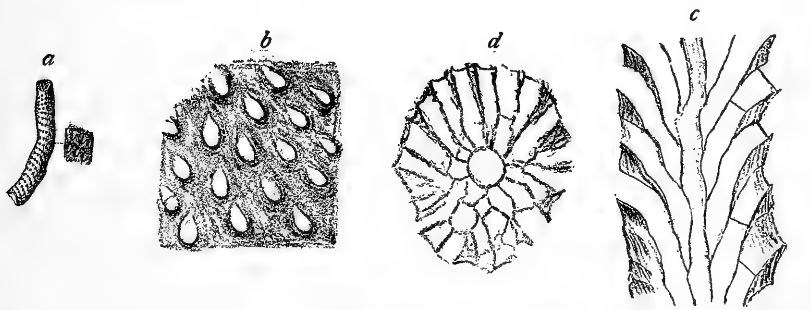

FIG. 41.—CHILOTRYPA IMMATURA. *a*, A FRAGMENT, ×2, WITH A FEW ZOŒCIAL APERTURES ENLARGED; *b*, TANGENTIAL SECTION, ×20, SHOWING ARRANGEMENT AND SHAPE OF ZOŒCIA; *c*, VERTICAL SECTION, ×20, WITH EXPANDING AND CONTRACTING CENTRAL TUBE; *d*, TRANSVERSE SECTION, ×20, SHOWING CENTRAL TUBE AND THICKNESS OF ZOARIAL LAYER. LYCKHOLM LIMESTONE (F1), KERTEL, ISLAND OF DAGO, ESTHONIA.

lunarium, arranged in ascending spiral rows, elongate oval, five in 2 mm. Interzoœcial spaces closed at the surface. Ends of branch show the hollow, axial tube, about 0.16 mm. in diameter. The tube is a prominent feature of vertical sections, where it is seen to slightly expand and contract. Such sections also show the zoœcia to arise from the basal membrane or epitheca forming the wall of this tube, and to proceed to the surface in a gentle curve. In the immature region their walls are thin and diaphragms are absent. In the mature zone the walls thicken, interzoœcial spaces are developed, and an occasional diaphragm is inserted. In well-developed species of *Chilotrypa* the interzoœcial spaces are filled with vesicles precisely as in *Fistulipora*, but in the present form the vesicles are almost entirely absent and their place is occupied by laminated tissue similar to that occurring in the more primitive Ceramoporidæ. Tangential sections exhibit elongate oval zoœcia with a slight lunarial thickening at the proximal end.

The delicate cylindrical branches with a small, central axial tube, and small, elongate apertures arranged in ascending spirals, are different enough from all other bryozoans to require no comparisons. While the species has some resemblance to *Cœloclema*, it is believed that the majority of its characters show it to be a primitive form of *Chilotrypa*.

Occurrence.—Apparently rare in the Lyckholm limestone (F1) at Kertel, island of Dago.

Holotype.—Cat. No. 57209, U.S.N.M.

British Museum, thin sections of type-specimen.

Order CRYPTOSTOMATA Vine.

This order of the Bryozoa was proposed by Vine in 1883 as a suborder to include mainly the bifoliate ptilodictyoid genera. Since that time the detailed studies of Ulrich have extended the limits of the order so that it now embraces such families as the Fenestellidæ and Acanthocladiidæ, in addition to the Ptilodictyonidæ and related families. A concise definition of the order has been given by Ulrich in the English edition of Zittel's Textbook of Paleontology. This is as follows:

> Primitive zoœcium short, pyriform to oblong, quadrate, or hexagonal, sometimes tubular, the aperture anterior. In the mature colony the aperture is concealed, occurring at the bottom of a tubular shaft ("vestibule"), which may be intersected by straight diaphragms or hemisepta, owing to the direct superimposition of layers of polypides. Vestibular shaft surrounded by vesicular tissue, or by a solid calcareous deposit; the external orifice rounded. Marsupia and avicularia wanting.

Comparing the Cryptostomata with the other orders of Bryozoa, it is found to be most closely related to the Chilostomata; in fact, the cryptostomatous bryozoans are probably only the Paleozoic representatives of the Chilostomata so abundant in Mesozoic, Cenozoic, and recent times. As pointed out by Ulrich, the Cryptostomata differ, however, first, in having neither marsupia nor avicularia; second, in the much greater deposit of calcareous matter upon the front of the zoœcia, thus producing the vestibule; third, in that successive layers of polypides are often developed, one directly over the other, in a continuous tube; and, fourth, in that whenever a zoarium attains an uninterrupted width of more than 8 mm., it exhibits clusters of cells differing more or less, either in size or elevation, from the average zoœcia.

The generic and even specific representation of the Cryptostomata in the Baltic Ordovician and early Silurian strata is exceptionally like that in the corresponding beds of America.

Family PTILODICTYONIDÆ Zittel.

Zoarium bifoliate, composed of two layers of zoœcia, grown together back to back, usually jointed, at least at the base, and forming leaf-like expansions or compressed branching or inosculating stems; mesotheca without median tubuli; zoœcia usually have hemisepta and semielliptical orifices; apertures usually ovate, surrounded either by a sloping area or a ring-like peristome; vestibules separated by thick walls.

Genus PTILODICTYA Lonsdale.

Ptilodictya LONSDALE, Murchison's Silurian System, 1839, p. 676.—EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 387.—ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, pp. 151, 162.—FOERSTE, Bull. Sci. Lab. Denison University, vol. 2, 1887, p. 155.—HALL and SIMPSON, Nat. Hist. New York, Pal., vol. 6, 1887, p. xix.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, p. 390; Geol. Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 163; Zittel's Text-book of Paleontology (Eng. ed.), 1896, p. 279.—SIMPSON, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 541.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 45.—HENNIG, Archiv. fur Zool., K. Sven. Vet.-Akad. Stockholm, vol. 2, No. 10, 1905, p. 16.—CUMINGS, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 754.

Escharopora (not Hall, 1847) HALL, Twenty-sixth Ann. Rep. New York State Mus., 1874, p. 99; Thirty-second Ann. Rep. New York State Mus., 1879, p. 161.

Heterodictya NICHOLSON, Geol. Magazine, new ser., vol. 2, 1875, p. 33; Pal. Prov. Ontario, 1875, p. 79.—MILLER, North Amer. Geol. and Pal., 1889, p. 309.

Zoarium, a simple, unbranched, lanceolate or falciform frond, narrow or wide, which articulates with a small basal expansion; in the young condition the zoarium consists of longitudinally arranged narrow, oblong-quadrate zoœcia, new zoœcia of different width and arrangement being added subsequently on each side; walls of vestibules thick, solid, and with a double row of minute dots.

Genotype.—Flustra lanceolata Lonsdale. Silurian of Europe.

With the Richmond group assigned to the Silurian, the genus *Ptilodictya* becomes restricted almost entirely to this period, the single exception being a species in the Lower Devonian of Ontario. *Ptilodictya* is closely related to *Escharopora* and differs most obviously in the arrangement of its zoœcia in parallel longitudinal rows.

PTILODICTYA FLABELLATA Eichwald.

Text fig. 42.

Ptilodictya flabellata Eichwald, Lethæa Rossica, vol. 1, 1860, p. 389, pl. 24, figs. 10 *a*, *b*.
Cfr. *Ptilodictya expansa* Hall, Twelfth Ann. Rep. Indiana Geol. Nat. Hist., 1883, pl. 12, figs. 2, 3.

Although this species is briefly described by Eichwald, his figures are sufficient to show that it is undoubtedly a *Ptilodictya* closely related to the typical earliest Silurian forms. A very similar, perhaps identical American species from the Clinton formation of Ohio, has been illustrated by Hall as *Ptilodictya expansa.*

Although specimens of *Ptilodictya flabellata* have not occurred in the collections before me, I have no hesitancy in including it as a valid species. Eichwald records the species as from the compact Ordovician (Orthoceratite) limestone, near Hohenholm, island of Dago, which will place it in either the Lyckholm or Borkholm division of formation F. For various reasons, chiefly on account of its Silurian affinities, and its geographic location, I would regard *Ptilodictya flabellata* as belonging to the same fauna holding *Hallopora elegantula, Sceptropora facula, Lichenalia concentrica,* etc., namely, that of the Borkholm horizon.

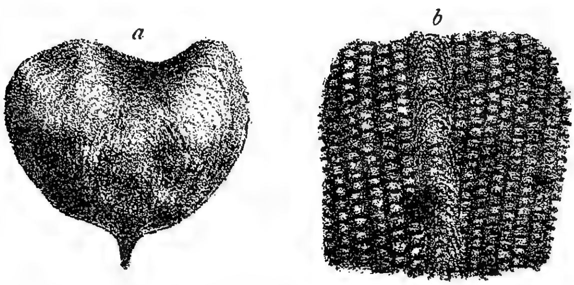

Fig. 42.—Ptilodictya flabellata. *a*, zoarium, natural size, parted along the mesial lamina; *b*, view enlarged, showing longitudinal arrangement of zoœcia. "Calcaire compacte à Orthoceratites," island of Dago, near Hohenholm. (After Eichwald.)

Occurrence.—Hohenholm, island of Dago, probably in the Borkholm limestone (F2).

PTILODICTYA GLADIOLA Billings.

Text fig. 43.

Ptilodictya gladiola Billings, Cat. Sil. Foss. Anticosti, 1866, p. 10.
Ptilodictya lanceolata Eichwald (not Goldfuss), Lethæa Ross., vol. 1. 1860, p. 388.

An elongated, lamellate, slightly curved bifoliate bryozoan with the cells arranged in longitudinal rows, has been described by Eichwald as *Ptilodictya lanceolata* (Goldfuss), and recorded as from the Ordovician limestone of Lyckholm, as well as from various Silurian localities. The Ordovician specimens belong, in all probability, to the form described by Billings as *Ptilodictya gladiola,* which differs from typical *P. lanceolata* mainly in having smaller zoœcia. Billings's careful description of *P. gladiola* applies equally well to the Russian example before me, and for that reason is quoted:

> Polyzoary, consisting of a single elongated, narrow, two-edged, unbranched frond, usually curved, gradually expanding from an acute point to a width of about 1 line in a length of from 1 to 28 lines, moderately convex, often subangular along the middle and with flat slopes to the edges, which are acute. Cells oblong; when perfect, nearly rectangular at their extremities; when worn, one or both ends rounded; their length about twice their width, 6 to 8 in the length of 1 line, arranged in very regular longitudinal rows, of which there are about 12 where the width of the frond is 1 line. The largest frond seen is 28 lines in length and 1¼ in width at the larger extremity.

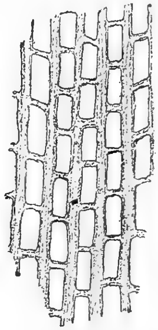

FIG. 43.—PTILODICTYA GLADIOLA. TANGENTIAL SECTION, ×20, SHOWING THE LONGITUDINAL ARRANGEMENT OF THE ZOŒCIA. BORKHOLM LIMESTONE (F2), BORKHOLM, ESTHONIA.

Occurrence.—The American type was found in the earliest Silurian strata equivalent to the Richmond formation, on the island of Anticosti, Gulf of St. Lawrence. The European specimens believed to belong to the same species, occur in the Borkholm limestone (F2) at Borkholm and Lyckholm, Esthonia.

Plesiotype.—Cat. No. 57210, U.S.N.M.

Genus ESCHAROPORA Hall.

Escharopora HALL, Nat. Hist. New York, Pal., vol. 1, 1847, p. 72.—ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 167; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 279.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 45.—CUMINGS, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 745.

Ptilodictya (part), various authors.

Although long considered a synonym of *Ptilodictya*, the species of *Escharopora* form a natural assemblage related to the former genus in its general zoarial and zoœcial characters but differing mainly in the arrangements of their apertures. In *Ptilodictya* the zoœcial apertures are arranged in regular longitudinal rows; in *Escharopora* their arrangement is in diagonally intersecting series. The internal structure of the two genera is essentially the same.

All of the species of *Escharopora* are of Ordovician age while the oldest known forms of *Ptilodictya* occur in the earliest Silurian (Richmond) deposits. The close relationship between the two genera is thus apparent from their geologic distribution, *Ptilodictya* being undoubtedly a derivative of the earlier genus.

Genotype.—*Escharopora recta* Hall. Middle Ordovician of New York and Canada.

ESCHAROPORA SUBRECTA (Ulrich).

Text fig. 44.

Ptilodictya subrecta Ulrich, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 63; Geol. and Nat. Hist Surv. Minnesota, vol. 3, pt. 1, 1893, p. 168, pl. 12, figs. 5–29.

Cfr. *Micropora rhombica* Eichwald, Lethæa Rossica, vol. 1, 1860, p. 395.

The only species of *Escharopora* recognized in the Baltic strata is represented by a number of well preserved examples from the Wassalem beds (D3) at Uxnorm. These agree in all their characters and show the same range of variation as the abundant American form *E. subrecta*, the types of which are before me for comparison. Ulrich has given a very detailed and careful description of the species and has illustrated it most fully in his third volume of the Minnesota reports. Certain of his figures are exactly duplicated in the Russian specimens, and these have been selected for illustrating the species at the present time.

The zoarium is usually a simple, smooth, bifoliate expansion with the lower portion gradually tapering to a pointed, articulating, finely striated basal extremity, as shown in figures 44 *a* and *b*. Older specimens may reach the size shown in figures 44 *d* and *e*, and, as in the latter, somewhat inconspicuous monticules may be developed. The finely striated basal portion is composed of elongated groove-like spaces which become wider further up in the zoarium and gradually change into the elongate confluent zoœcial aperture characteristic of the species. This change is illustrated in figure 44 *b*, and the usual aspect and arrangement of the aperture is shown in figure 44 *c*.

Measuring lengthwise there are about 11 apertures in 5 mm. and diagonally 9 to 10 in half that distance. Six of the central rows occur in 1 mm., measuring transversely. As indicated in several of the figures, the walls frequently fail to join and thus leave narrow channels between the apertures. In old examples, such as shown in figure 44 *e*, these channels are sometimes replaced by mesopores (fig. 44 *f*), giving a less regular arrangement to the zoœcia.

The two sections reproduced in figures 44 *g* and *h* exhibit the internal structure clearly enough to make its detailed description unnecessary. However, the long, primitive cell in tangential section and the slight development of hemisepta as shown in the vertical, are to be noted.

The simple, pointed, bifoliate zoarium and the elongate, somewhat confluent, diagonally arranged zoœcia of *Escharopora subrecta* are so unlike any associated Russian forms that comparisons are hardly needed. The pointed base is usually preserved and this alone gives a good clue to the species. Other bifoliate species with pointed bases, such as *Graptodictya proava* have a quite different zoarium.

In all probability Eichwald has described this same species under the name of *Micropora rhombica*, but his figures and description are of little value for accurate identification.

Occurrence.—In America *Escharopora subrecta* is a common fossil

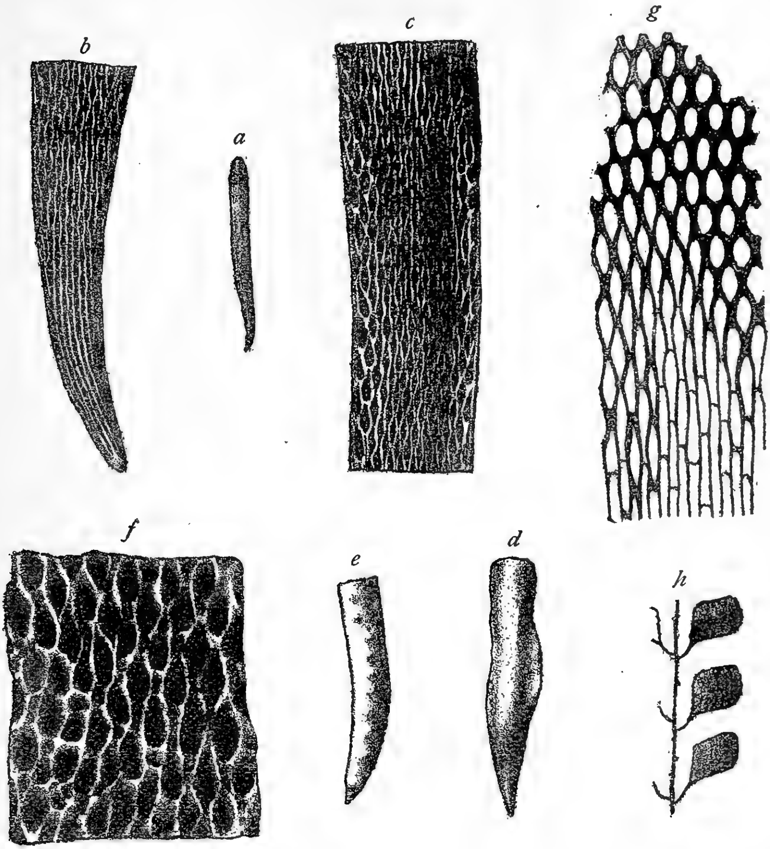

FIG. 44.—ESCHAROPORA SUBRECTA. *a* AND *b*, A TYPICAL SPECIMEN, NATURAL SIZE AND THE BASAL PORTION OF THE SAME, ×9; *c*, VIEW OF THE CENTRAL PART OF THE SAME ZOARIUM, ×9; *d* AND *e*, TWO SPECIMENS, NATURAL SIZE, BROADER THAN USUAL, THE LATTER EXHIBITING A ROW OF MONTICULES; *f*, SURFACE OF THE LOWER PART OF ANOTHER EXAMPLE, ×18, SHOWING UNUSUAL CONDITIONS; *g*, TANGENTIAL SECTION, ×18, CUTTING THE IMMATURE AND MATURE PARTS OF THE ZOARIUM; *h*, PORTION OF A VERTICAL SECTION, ×18. BLACK RIVER (DECORAH) SHALES, ST. PAUL AND MINNEAPOLIS, MINNESOTA. (AFTER ULRICH.)

in the lower beds of the Black River (Decorah) shales of Minnesota and Iowa. In Europe it is known only from the Wassalem beds (D3) at Uxnorm, where specimens are equally abundant. (Cat. No. 57211, U.S.N.M.)

British Museum, specimen and thin section from the Wassalem beds, at Uxnorm.

Genus PHÆNOPORA Hall.

Phænopora HALL, Amer. Journ. Sci., ser. 2, vol. 11, 1851, p. 379; Nat. Hist. New York, Pal., vol. 2, 1852, p. 46.—PICTET, Traite de Paleontologie, 2d. ed., vol. 4, 1857, p. 169.—ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 152.—FOERSTE, Bull. Sci. Lab. Denison Univ., vol. 2, 1887, p. 157.—MILLER, North Amer. Geol. and Pal., 1889, p. 314.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, p. 392; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 173.—POCTA, Syst. Sil. Center Boheme, vol. 8, pt. 1, 1894, p. 8.—ULRICH, Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 279.—SIMPSON, Fourteenth Ann. Rep. State Geologist New York for the Year 1894, 1897, p. 541.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 46.—HENNIG, Archiv. fur Zool., K. Sven. Vet.-Akad. Stockholm, vol. 2, No. 10, 1905, p. 10.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 55.

Like *Ptilodictya* and *Escharopora*, except that there are two mesopores in each interspace between the ends of the apertures.

Genotype.—Phænopora explanata Hall. Silurian (Clinton) of Canada.

PHÆNOPORA ENSIFORMIS Hall.

Text fig. 45.

Phænopora ensiformis HALL, Nat. Hist. New York, Pal., vol. 2, 1852, p. 48, pl. 18, figs. 8 *a–c*.—NICHOLSON and HINDE, Canadian Journal, new ser., vol. 14, 1874, p. 142.—NICHOLSON, Pal. Province Ontario, 1875, p. 45, figs. 19, 2, 2*a*.—ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 172.—FOERSTE, Geol. Surv. Ohio, vol. 7, 1895, p. 598.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 55, pl. 27, figs. 8, 9.

Phænopora cf. *ensiformis* WIMAN, Bull. Geol. Inst. Univ. Upsala, vol. 5, pt. 2, 1902, p. 180, pl. 6, figs. 25–28.

Specimens of this species have not occurred in the collections before me, but I have no reason to doubt that Wiman's provisional identification can be accepted as correct. His figures certainly refer

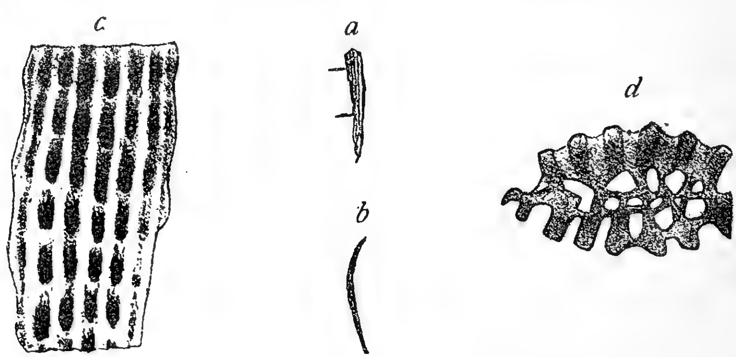

FIG. 45.—PHÆNOPORA ENSIFORMIS. WIMAN'S ILLUSTRATIONS OF THE BORKHOLM FORM OF THIS SPECIES; *a* AND *b*, TWO SMALL ZOARIA, NATURAL SIZE; *c*, SURFACE, ×10; *d*, TRANSVERSE SECTION, ×10. BORKHOLM DRIFT, ÖJLE MYR, ISLAND OF GOTHLAND.

to a form like *Phænopora ensiformis* in which the two mesopores at the end of the zoœcia are poorly developed. The occurrence of other early Silurian types, such as *Hallopora elegantula* and *Lichenalia con-*

centrica in the Borkholm limestone, is also indicative of the fact that the presence of *Phænopora ensiformis* would not be unexpected.

The zoarium is a narrow bifoliate expansion pointed at the base for articulation and averaging 25 mm. in length and 2 mm. in width; each face bears from seven to eleven parallel rows of zoœcia with six zoœcia in 2 mm. measuring longitudinally; the apertures are arranged in linear series between slightly raised longitudinal lines, are quadrangular in shape, and measure about 0.18 by 0.30 mm. In the marginal series they are oval, slightly oblique, and somewhat larger than in the middle rows. The characteristic two mesopores occupying the inner spaces between the ends of the apertures are often discerned with difficulty, but upon close examination or by use of thin sections the mesopores may be found in the position normal for *Phænopora*.

Occurrence.—Abundant in the Clinton rocks of western New York and Ontario and not uncommon in the Rochester shale of the same region. Rare in the Clinton rocks of Ohio and also in the Osgood beds at Osgood, Indiana. Wiman obtained the species from drift bowlders of the Borkholm formation (F2) at Öjle Myr, island of Gothland.

Specimens from American localities are in the collections of the United States National Museum and the British Museum.

Genus ARTHROPORA Ulrich.

Arthropora ULRICH, Journ Cincinnati Soc. Nat. Hist., vol. 5, 1882, pp. 152, 167.—MILLER, North Amer. Geol. and Pal., 1889, p. 293.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, p. 393; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 176.—POCTA, Syst. Sil. Center Boheme, vol. 8, pt. 2, 1894, p. 14.—ULRICH, Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 279.—SIMPSON, Fourteenth Ann. Rep. State Geologist of New York for the Year 1894, 1897, p. 605.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 46.—CUMINGS, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 739.

Zoarium bushy, composed of numerous articulating equal segments, spread in a plane; apertures elliptical, surrounded by a delicate peristome; interspaces with one or more thread-like ridges variously disposed and with a row of minute papillæ.

Genotype.—*Stictopora* (*Ptilodictya*) *shafferi* Meek. Upper Ordovician (Maysville) of the Ohio Valley.

The members of this interesting genus are readily distinguished from all other species of the family by their segmented character. Although complete zoaria are rare, their disjointed segments are readily identified by the rounded and pointed ends adapted for articulation. The genus is rather numerously represented in American Ordovician strata, but in Russia only a single species has been noted.

ARTHROPORA SIMPLEX Ulrich.

Text fig. 46.

Arthropora simplex ULRICH, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 65; Geol. Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 177, pl. 14, figs. 12–21.

The identification of this neat little species in Russian strata is based in part upon a small single specimen from Uxnorm, which does not present all of the specific and generic characters because the important pointed base for articulation with the preceding segment is broken away. That the species is undoubtedly present in

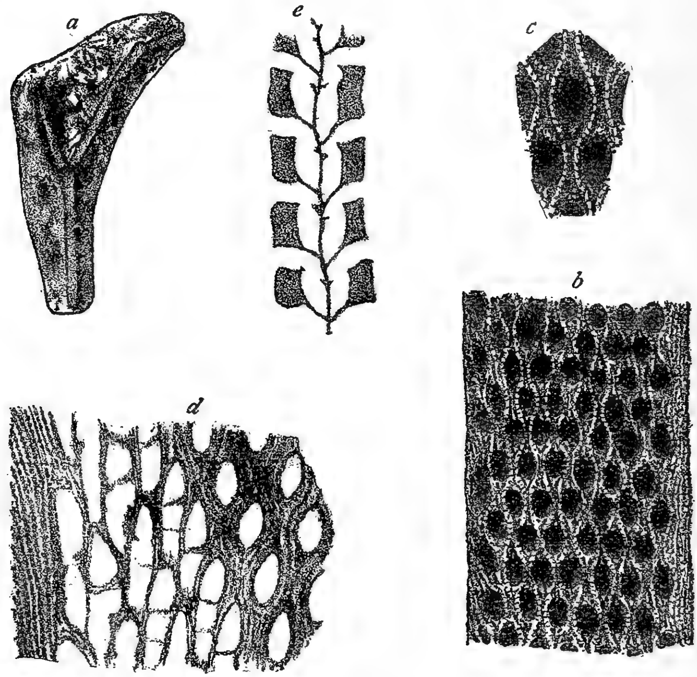

FIG. 46.—ARTHROPORA SIMPLEX. *a*, SEVERAL SEGMENTS IN THEIR NATURAL POSITION, LIFE SIZE; *b*, SURFACE OF A WELL-PRESERVED FRAGMENT, ×18; *c*, SEVERAL ZOŒCIAL APERTURES OF THE SAME, ×35; *d*, TANGENTIAL SECTION, ×18, SHOWING STRUCTURE OF THE DIFFERENT PARTS OF THE ZOARIUM; *e*, VERTICAL SECTION, ×18, ILLUSTRATING FORM OF ZOŒCIA AND HEMISEPTA. BLACK RIVER (DECORAH) SHALE, MINNEAPOLIS, MINNESOTA. (AFTER ULRICH.)

the Wassalem beds seems most certain from thin sections of specimens accidentally encountered in the interior of limestone fragments which were being studied for other species. To assist in the identification of the species a few of Ulrich's figures are introduced and the following abridged description is inserted:

Zoarium jointed, consisting of narrow, bifoliate, unbranched stems, rounded and solid at the ends for articulation; averaging 18 mm. in length, 1.5 mm. in width, and less than 1 mm. in thickness. Zoœcial apertures elliptical and surrounded by a thin, granose peristome, which is elevated and prolonged at each end. The surface is also ornamented by a thin, papillose, wavy ridge separating the longitudinal rows of zoœcia. The simple, unbranched segments of this species with their ends rounded for articulation with each other will distinguish them from all other associated bryozoans.

Occurrence.—An abundant fossil in the lower half of the Black River (Decorah) shales, in Minnesota and Iowa; apparently rare in the Wassalem beds (D3) at Uxnorm. (Cat. No. 57212, U.S.N.M.).

American specimens are in the collections of the British Museum.

Genus GRAPTODICTYA Ulrich.

Graptodictya ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, pp. 151, 165.—MILLER, North Amer. Geol. and Pal., 1889, p. 307.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, p. 393.—POCTA, Syst. Sil. Center Boheme, vol. 8, pt. 1, 1894, p. 14.—SIMPSON, Fourteenth Ann. Rep. New York State Geologist for the Year 1894, 1897, p. 541.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 46.—CUMINGS, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 747.

This genus may be considered as an *Arthropora* with the jointed character of the zoarium limited to the base alone. The zoœcial structure and surface ornament are alike in both genera, but the rather large, single, narrow branching frond of *Graptodictya* with a pointed, striated base articulating with a small basal expansion is

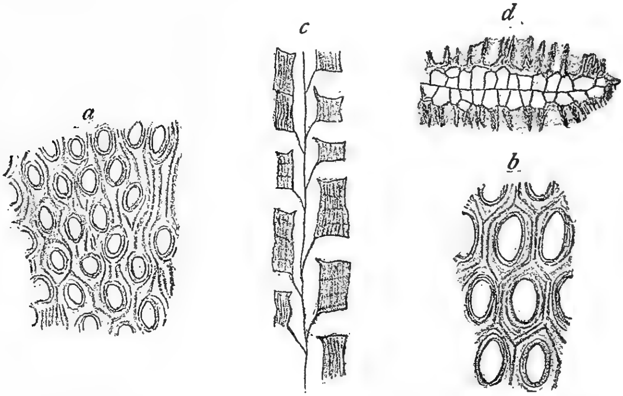

FIG. 47.—GRAPTODICTYA PERELEGANS. *a*, TANGENTIAL SECTION, ×20, OF THE TYPE-SPECIMEN; *b*, SEVERAL ZOŒCIA, ×40; *c*, VERTICAL SECTION, ×20; *d*, TRANSVERSE SECTION, ×20. RICHMOND GROUP, CLARKSVILLE, OHIO.

quite different from the numerously segmented method of growth in *Arthropora.*

The Russian specimens referred to the genus include a species very similar in growth and other features to the American genotype, and in addition two cribrose forms—a method of growth which hitherto had not been recognized in the genus. The method of growth in the two latter species *Graptodictya proava* (Eichwald) and *G. obliqua,* new species, is exactly the same as in *Clathropora*, where many students would probably refer both of them. However, in the latter genus the zoœcial structure is exactly the same as in *Ptilodictya*, from which *Clathropora* is distinguished only by its cribrose or clathrate zoarium. Granting that this is a sufficient generic distinction, new genera would be necessary for the clathrate species of *Graptodictya* and of *Stictoporella*, but I am unwilling to believe at present that such genera would be of any advantage. The zoœcia of both *Graptodictya* and *Arthropora* differ from those of *Ptilodictya* in having low peristomes and in being separated from each other by solid interspaces bearing one or more tortuous, fine, elevated lines.

Although *Graptodictya* has been defined by Ulrich and compared with related genera on several occasions, no illustrations of the internal structure of the type species have ever been published. On account of the close relationship between *Graptodictya perelegans*, the genotype, and the new species *G. bonnemai*, I am taking this opportunity to present the accompanying views of the former (fig. 47) to illustrate the generic structure, as well as for comparison with the latter species.

Genotype.—Graptodictya perelegans (Ulrich). Earliest Silurian (Richmond) of the Ohio Valley.

GRAPTODICTYA BONNEMAI, new species.

Plate 8, fig. 3; text fig. 48.

Cfr. *Graptodictya* (*Ptilodictya*) *perelegans* (Ulrich), Journ. Cincinnati Soc. Nat. Hist., vol. 1, 1878, p. 94, pl. 4, figs. 16, 16*a*.

The close relationship existing between this new species and the genotype has been noted under the generic remarks. The internal structure of the two is practically identical, and, were it not for certain differences in method of growth, they could hardly be distinguished specifically. As it is, *Graptodictya bonnemai* is most certainly the forerunner of *G. perelegans*, and the occurrence of such similar species in the Middle Ordovician and earliest Silurian strata is but another instance of the close relationship between the faunas of these two periods.

Critically compared, the zoarium of *G. bonnemai* is found to branch much less frequently than its later representative. Each species branches dichotomously at regular intervals; in *G. perelegans* this branching occurs at intervals averaging 4 mm.; in the present form 10 mm. is the usual distance between the bifurcations. This gives a more delicate aspect to the Russian form. Other differences may be noticed in the shape of the apertures, which in *G. bonnemai* are, as a rule, more elongate, but this is a character which varies with age and must therefore be used with caution.

The dichotomously branching, slender, ribbon-like zoarium of *G. bonnemai* with its long, narrow base, pointed for articulation, and the beautiful surface character of the zoœcia, forms one of the prettiest species in the Baltic Ordovician. The specific name is in honor of Dr. J. H. Bonnema, of The Hague, Holland, in appreciation of his excellent work upon the Ostracoda of the Kuckers formation.

Occurrence.—A common fossil in the Kuckers shale (C2), Baron Toll's estate, Esthonia. Specimens referred to the species occur also

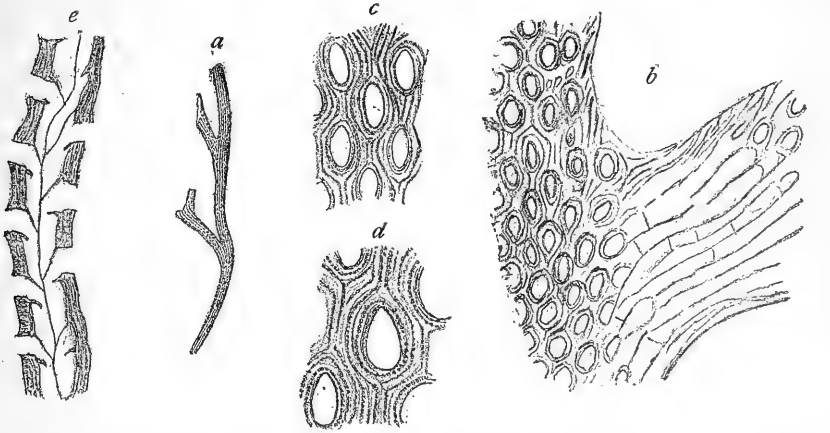

FIG. 48.—GRAPTODICTYA BONNEMAI. *a*, PORTION OF A ZOARIUM, NATURAL SIZE, SHOWING THE POINTED BASE AND FREQUENCY OF BRANCHING; *b*, TANGENTIAL SECTION, ×20, CUTTING BOTH MATURE AND IMMATURE REGIONS; *c* AND *d*, SEVERAL ZOŒCIA OF THE SAME, ×40, WITH ONE STILL FURTHER ENLARGED, ×60; *e*, VERTICAL SECTION, ×20, ILLUSTRATING THE PROMINENT SUPERIOR HEMISEPTUM. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

in the Jewe limestone (D1), Baron Toll's estate, and in the Wesenberg limestone (E) at Wesenberg, Esthonia.

Cotypes.—Cat. No. 57213, U.S.N.M.

Specimens from the Kuckers shale (C2), Baron Toll's estate, are in the collections of the British Museum.

GRAPTODICTYA PROAVA (Eichwald).

Plate 8, fig. 2; plate 9, figs. 1–6; text figs. 49, 50.

Gorgonia proavus EICHWALD, Urwelt Russlands, vol. 2, p. 44, pl. 1, fig. 5.

Coscinium proavus EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 398.

Stictoporella cribrosa SARDESON (not Ulrich), Journ. Geol., vol. 9, 1901, p. 157, pl. B, figs. 7–9.

Clathropora flabellata HALL, Foster and Whitney's Rep. Geol. Lake Superior Land District, pt. 2, 1851, p. 207, pl. 24, figs. 2*a*, *b*.

Stictoporella flabellata NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 416.

?*Coscinium proavium* BILLINGS, Geol. Canada, Geol. Surv. Canada, 1863, p. 158, fig. 122.

This splendid species, with its large, cribrose zoarium and conspicuously striated, pointed base, furnishes probably the most showy cabinet specimen of any of the Russian bryozoans. Fragments are abundant in the Wassalem beds (D3) at several localities in Esthonia, and more complete specimens preserving the pointed base are by no means rare. Although Eichwald gives but a single illustration of the species, a view, natural size, of a zoarium preserving the pointed base (fig. 49 *a*), there can be little question that his type of *Coscinium proavus* and the specimen figured in the present work are identical, mainly because *Graptodictya proava* is the only known cribrose Middle Ordovician Russian bryozoan with the pointed base and dimensions shown in his figure. This same species has been found in American strata, as determined from my study of the specimen (see fig. 6, pl. 9) which Sardeson, in his "Problem of the Monticuliporoidea"[1] figures and describes at length under the name of *Stictoporella cribrosa* Ulrich. In spite of Sardeson's statement to the contrary, it is a fact that species of *Stictoporella* have an expanded incrusting base and never have a pointed base for articulation. Comparison of figures of both species here presented can not fail to convince the discriminating person of numerous zoarial and zoœcial differences between *Stictoporella cribrosa* Ulrich and *Graptodictya proava*. Indeed, observers who have had opportunity to study numerous examples of these several types of structure, assign them to separate families, as in the present work. *Graptodictya proava* is known from a second American locality, namely, along the Escanaba River in Michigan, below the upper falls. A fine, large example from this place was made the type of Hall's *Clathropora flabellata*. Through the courtesy of Dr. E. O. Hovey, of the American Museum of Natural History, I have had the opportunity of studying this type and of presenting an illustration of its minute structure to show the specific identity. The specimen itself has been broken out of the solid limestone and thus is parted along the mesial lamina. Its cribrose zoarium has the same dimensions seen in the large examples of *G. proava*, and it clearly arises from a pointed base, although a portion of this is broken away.

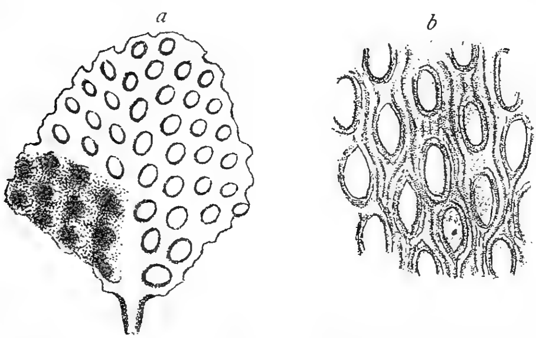

FIG. 49.—GRAPTODICTYA PROAVA. *a*, EICHWALD'S VIEW OF THE TYPE-SPECIMEN OF HIS COSCINIUM PROAVUM, NATURAL SIZE, SHOWING THE CRIBROSE ZOARIUM AND THE CHARACTERISTIC STRIATED, POINTED BASE. "CALCAIRE À ORTHOCERATITES," NEAR REVAL, ESTHONIA; *b*, TANGENTIAL SECTION OF HALL'S TYPE OF CLATHROPORA FLABELLATA, ×30, INTRODUCED FOR COMPARISON. LOWEST TRENTON, ESCANABA RIVER, MICHIGAN.

The cribrose, bifoliate bryozoan, figured by Billings as *Coscinium proavus* Eichwald, may be correctly identified, but in the absence of

[1] Journ. Geol., vol. 9, 1901, p. 150.

the illustrated specimen, which appears to be lost, the matter can not be settled. As the basal portion is not shown, the specimen may be a cribrose *Stictoporella.*

Description.—Zoarium of narrow, bifoliate branches averaging 2.5 mm. in width, inosculating so frequently that a broad frond, with circular or elliptical openings, results. The lower portion of the cribrose zoarium is prolonged into a striated base which is long, narrow, and pointed in young examples (see fig. 2, pl. 9), and short and more or less rounded in older specimens (see figs. 1, 3, 6, pl. 9). This base articulates with an expanded attachment, as shown in figure 5, plate 9. An average zoarium is 50 mm. in its longer diameter, but larger specimens frequently occur.

Fenestrules sometimes circular but generally elliptical, and averaging 1.5 by 1.8 mm. Although their size and arrangement is more

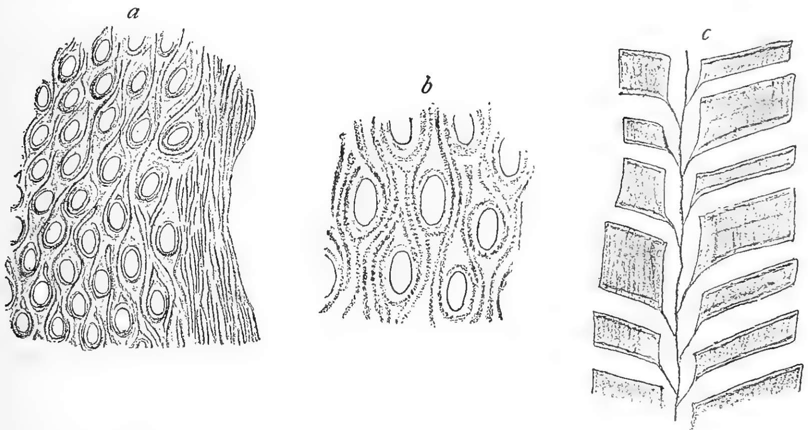

FIG. 50.—GRAPTODICTYA PROAVA. *a*, TANGENTIAL SECTION, ×20, CUTTING THE STRIATED EDGE OF A BRANCH AND THE ADJOINING ZOŒCIA; *b*, PORTION OF THE SAME, ×40; *c*, VERTICAL SECTION, ×20. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

or less irregular, large examples, such as illustrated on plate 9, figure 1, show them disposed in irregular, diagonal, intersecting rows.

Zoœcia subpolygonal, sometimes subrhomboidal in outline with elliptical to circular apertures. Interspaces solid with one or two fine, elevated, papillose lines. Mesopores restricted almost entirely to the edges of the branches, where they form a band around the fenestrules about 0.5 mm. wide. In the lower portion of old zoaria, the fenestrules are often obliterated by the greatly increased width of this band of mesopores. Occasionally a small mesopore or two may be noted among the ordinary zoœcia. The articulating pointed base is composed of elongate, narrow, modified zoœcia separated by wide, solid interspaces with numerous elevated lines, this combination of elongate zoœcia and intervening lines producing the striated appearance. The attached socketlike basal expansion is made up of similarly modified zoœcia and broad interspaces. In all cases, the elevated lines traversing the interspaces are minutely papillose. Views of the internal structure are given in figure 50.

Occurrence.—Eichwald mentions two localities for his species, first, the "calcaire à Orthoceratites" at Reval, and, second, the dolomite [Lyckholm-Borkholm formation] at Borkholm. The numerous examples coming from the Wassalem beds (D3) at Uxnorm, in the vicinity of Reval, identical with his figured specimen, cause me to believe that the latter was derived from the same place. Eichwald's Borkholm specimens probably belong to the species next described as *Graptodictya obliqua.* The American occurrences are (1) in the Clitambonites bed of the lower Trenton limestone, near Kenyon, Minnesota, and (2) in the lowest Trenton or late Black River limestone, along the Escanaba River, Michigan, below the falls.

Plesiotypes.—Cat. No. 57216, U.S.N.M.

Specimens and thin sections from the Wassalem beds at Uxnorm, Esthonia, are in the collections of the British Museum.

GRAPTODICTYA OBLIQUA, new species.

Plate 8, fig. 4; text fig. 51.

Compared with other cribrose species, this new form differs so decidedly in zoœcial structure that it need be discriminated only from the abundant *Graptodictya proava* (Eichwald), of the Wassalem beds. Careful comparison shows the following differences: First,

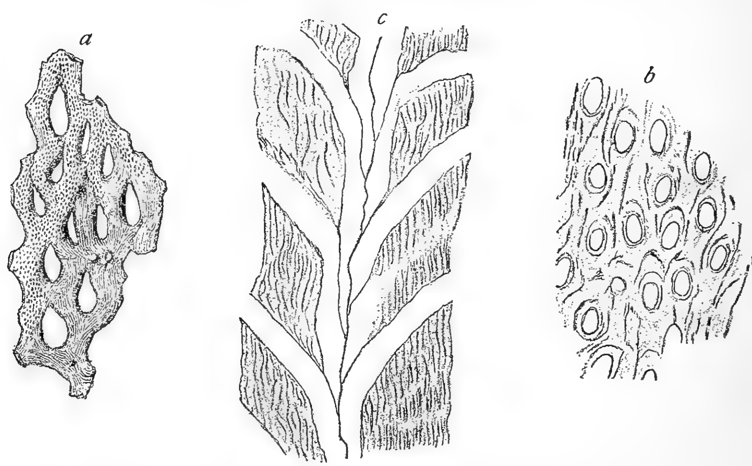

FIG. 51.—GRAPTODICTYA OBLIQUA. *a*, THE TYPE-SPECIMEN, NATURAL SIZE, SHOWING THE STRIATED BASAL PORTION; *b*, TANGENTIAL SECTION, ×20, EXHIBITING THE WIDE, INTERZOŒCIAL SPACES; *c*, VERTICAL SECTION, ×20, WITH THE INTERZOŒCIAL SPACES FILLED BY LAMINATED TISSUE. LOWER PART OF LYCKHOLM LIMESTONE (F1), KERTEL, ISLAND OF DAGO, ESTHONIA.

the zoarium of *G. obliqua* is much coarser, its fenestrules being twice the size of those in *G. proava.* Its zoœcia also are larger, with four in 2 mm., and are directed obliquely to the growing edge; the ornamentation of the surface is likewise coarser. Altogether *G. obliqua* is larger and coarser in every respect than any other species of the genus. Its internal structure, however, is quite similar to that of typical *Graptodictya,* so that there can be little question of its generic placement.

The type-specimen shown in figure 51 *a* lacks the characteristic basal articulating point, but this undoubtedly was present and has only been lost.

Occurrence.—Apparently rare in the lower part of the Lyckholm limestone (F1) at Kurküll, Esthonia.

Holotype.—Cat. No. 57220, U.S.N.M.

British Museum, thin section of type-specimen.

Family STICTOPORELLIDÆ Nickles and Bassler.

This family differs from the Ptilodictyonidæ mainly in that the zoarium is not articulated, but grows upward from, and is continuous with, a spreading base.

Of the seven genera referred to the Stictoporellidæ, only the type genus *Stictoporella* is known at present in the lower Paleozoic rocks of Russia.

Genus STICTOPORELLA Ulrich.

Stictoporella ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, pp. 152, 169; Geol. Surv. Illinois, vol. 8, 1890, p. 394; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 179; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 279.—SIMPSON, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 535.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 46.—CUMINGS, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 756.

Micropora EICHWALD, Bull. Soc. Nat. Moscou, No. 4, 1855, p. 457; Lethæa Rossica, vol. 1, 1860, p. 393.

Not *Micropora* GRAY, List of the specimens of British animals in the collection of the British Museum, pt. 1, Centroniæ or Radiated Animals, 1848, pp. 115, 147.

Zoarium branching, cribrose, or leaflike; zoœcia with the primitive portion tubular, usually long, generally without hemisepta, the inferior one only occasionally present; orifices at the bottom of a wide, sloping vestibule; thick-walled, untabulated mesopores occur between the apertures and line the margins of the zoarium.

Genotype.—*Stictoporella interstincta* Ulrich=*Ptilodictya flexuosa* James. Upper Ordovician (Eden) of the Ohio Valley.

The diagnostic features of this genus, aside from its family characters, are the long tubular primitive portion of the zoœcium and the presence of more or less numerous, untabulated, thick-walled mesopores. Eichwald founded his new genus *Micropora* upon a species which proves upon further investigation to be a *Stictoporella.* However, the name *Micropora* was preoccupied by Gray for a genus of chilostomatous bryozoans, so that *Stictoporella* remains a valid name.

STICTOPORELLA CRIBROSA Ulrich.

Plate 7, fig. 4; text figs. 52, 53.

Stictoporella? cribrosa Ulrich, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 69.

Stictoporella cribrosa Ulrich, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 184, pl. 10, figs. 21–25; pl. 11, figs. 22, 23.—Simpson, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 536, fig. 93.

Zoarium composed of narrow, bifoliate, smooth branches, averaging 2.5 mm. in breadth, inosculating so frequently that a broad expansion perforated by rounded or elliptical fenestrules at rather irregular intervals is the result. Specimens preserving the basal

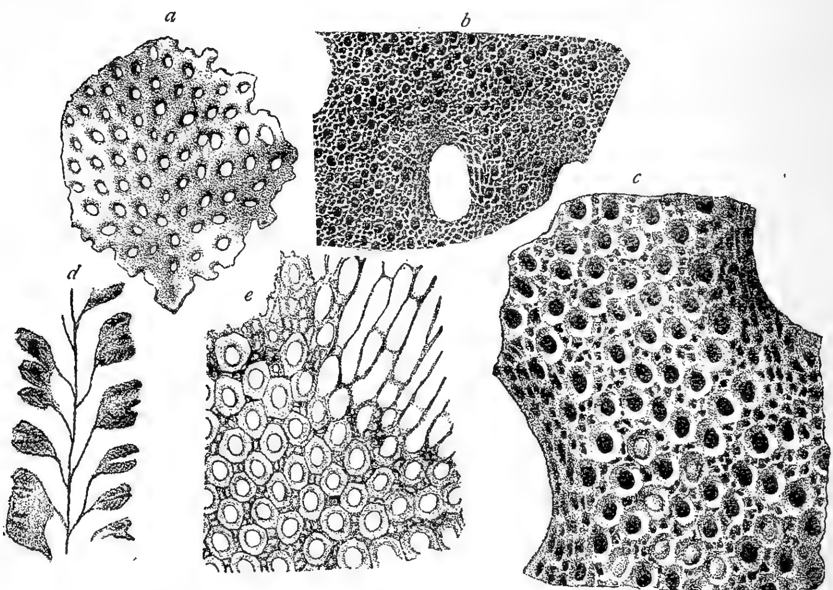

Fig. 52.—Stictoporella cribrosa. *a*, nearly complete zoarium natural size; *b* and *c*, surface of a specimen with numerous mesopores, ×9 and a portion ×18; *d*, vertical section, ×18; *e*, tangential section of an average specimen, ×18. Black River (Decorah) shales, Minneapolis Minnesota. (After Ulrich.)

portion are not common, but show clearly that the zoarial growth is from a small incrusting basal expansion into thin, erect fronds. The largest of the Russian specimens, although still incomplete, is over 70 mm. in its longer diameter. Fronds celluliferous on both sides, as usual in such bifoliate specimens. Fenestrules about 2 mm. in their greatest diameter, although a variation of 1 mm. in each direction from this figure may be observed. This irregularity of the fenestrules is matched by a corresponding variation in the width of the branches, which range from 1.5 mm. to 3 mm., in round numbers. Zoœcial apertures small when compared with other bryozoans, but large for this particular section of the genus, subcircular and set in well-defined, polygonal, sloping areas. The usual aperture is about 0.10 mm. by 0.12 mm., and seven to eight may be counted in 2 mm.; when well preserved, many of the apertures are closed by a convex subcentrally perforated plate. Mesopores small and sometimes few, but often numerous enough to isolate the zoœcia. Along the edges of the zoarial branches around the fenestrules, there is a band of mesopores 0.5 mm. or more in width.

The internal features illustrated in figure 53, prepared from a Russian example, differ from typical species of *Stictoporella cribrosa* only in the scarcity of mesopores and the corresponding greater size of the zoœcia. In tangential sections the polygonal areas are plainly marked out, and the cavity of the zoœcium is seen to be subcircular or ovate and of less diameter than the walls. The mesopores vary in size and shape and are sometimes completely filled by deposits of sclerenchyma.

An examination of numerous specimens from both the American and Russian localities shows that the zoœcium has some variation in size. This is due, as in other bryozoans, to the number of mesopores present. When mesopores are few, the zoœcia are larger, but with numerous mesopores the zoœcia become decreased in size. In each case the number of zoœcia in a given space is the same. Ulrich's illustrations (fig. 52) show the condition in which mesopores are most numerous, while the thin section shown in figure 53 illustrates the opposite condition.

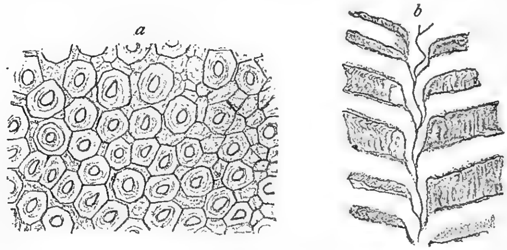

Fig. 53.—Stictoporella cribrosa. *a* and *b*, tangential and vertical sections, ×24, of a well developed Russian example in which mesopores are less abundant than usual. Wassalem beds (D3), Uxnorm, Esthonia.

The occurrence of such highly organized and well-marked species as *Graptodictya proava* (Eichwald) and *Stictoporella cribrosa* Ulrich in both the American and Russian strata without a single variation in their respective specific characters was one of the pleasant surprises of my studies, and to me, at least, was good evidence of the great stratigraphic value of these organisms. Moreover, these species offer so many characters for discrimination that their identification can be made with utmost certainty.

The associated species, *Graptodictya proava* (Eichwald), has a similar cribrose zoarium, but differs in its striated base pointed for articulation. When this base is not present, the absence of mesopores and the smaller, differently shaped zoœcia of the *Graptodictya* are sufficient to distinguish it. *Stictoporella gracilis* (Eichwald) is also a cribrose species, but, as indicated under its description, the dimensions of its zoarium and the shape of the zoœcia are quite different.

Coscinium prœnuntium, new species, likewise has a cribrose zoarium and an attached base, but the zoœcia are rounded and provided with a distinct lunarium. Internally the latter species is, of course, quite different.

Occurrence.—Ulrich's types are from the Rhinidictya bed of the Black River (Decorah) shales, at Minneapolis and St. Paul, Minnesota, but the species is abundant in this as well as the Stictoporella and Ctenodonta beds of the same formation. In Russia specimens are numerous in the Wassalem beds (D3) at Uxnorm and Gut Sack, in Esthonia.

Plesiotype.—Cat. No. 57221, U.S.N.M.

Specimens and thin sections from the Wassalem beds at Uxnorm are in the collections of the British Museum.

STICTOPORELLA GRACILIS (Eichwald).

Plate 7, figs. 1–3; text figs. 54, 55.

Eschara gracilis Eichwald, Schichtensyst. v. Esthland, 1840, p. 205; Urwelt von Russland, pt. 2, p. 43, pl. 1, fig. 4.

Micropora gracilis Eichwald, Lethæa Rossica, vol. 1, 1860, p. 393, pl. 33, fig. 4 *a*, *b*.

The first illustration of this species, published by Eichwald, is hardly sufficient for its accurate identification, but the figures given in his Lethæa Rossica refer undoubtedly to the cribrose bryozoan here referred to the genus *Stictoporella*. This species is represented in the collections before me by fragmentary examples from a number of localities in the government of St. Petersburg, all of them coming from the Glauconite limestone. The most perfect of these examples is shown on plate 7, figure 1, where the zoarium is seen to be of cribrose branches averaging 4 mm. in width and arising from an expanded base. As usual in such forms of growth, the basal expansion and the initial branches are finely striated instead of celluliferous.

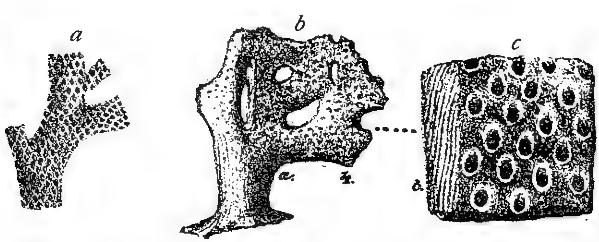

Fig. 54.—Stictoporella gracilis. *a*, Eichwald's original figure (Eschara gracilis); *b* and *c* copies of Eichwald's illustrations of Micropora gracilis; *b*, a zoarium, natural size, and *c*, surface of same, enlarged. "Calcaire à Orthoceratites," Iswoss, government of St. Petersburg.

The zoœcial apertures are rather large for the genus, with four in 2 mm., oval, and more or less oblique, with five to seven rows in the width of a branch. The apertures are separated by longitudinal ridges, while shallow depressions or mesopores occupy the spaces at the distal end of the zoœcia. As shown in figure 3 of plate 7, the margins of the branches are made up of the same finely striated, porous tissue found at the base of the zoarium. The internal structure of the species is shown in figure 55, where the oval zoœcia separated by ridges and occasional mesopore-like spaces of the tangential section, and the long, tubular, primitive zoœcium of the vertical section are the most noteworthy features.

There is no known Russian species with which *Stictoporella gracilis* need be compared. In America its closest ally seems to be *Stictoporella exigua* Ulrich, from the lowest beds of the Trenton limestone at Montreal, Canada. The latter has a quite similar zoœcial structure, but is very different in zoarial growth.

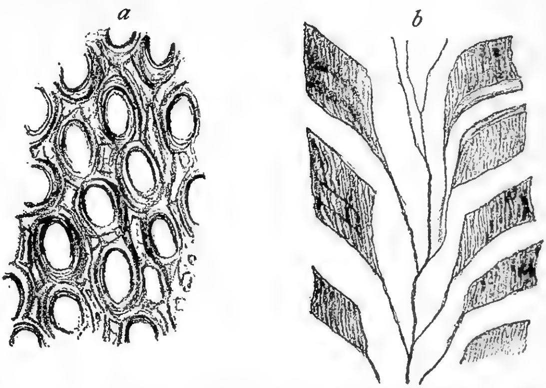

Fig. 55.—Stictoporella gracilis. *a*, tangential section, ×20; *b*, vertical section, ×20. Glauconite limestone (B2), Wassilkowa, government of St. Petersburg.

Occurrence.—Common in the Glauconite limestone (B2) at Wassilkowa, on the Lawa, Oberchowo and Tswos, on the Wolchow, and Gornaja Scheldicha, on Lake Ladoga, government of St. Petersburg.

Plesiotypes.—Cat. No. 57223, U.S.N.M.

British Museum, specimens and thin sections from the Glauconite limestone at Wassilkowa.

Family RHINIDICTYONIDÆ Ulrich.

This prolific family is almost restricted to the Ordovician and includes genera which, in the general shape of the zoarium, seem to be little different from the various preceding Cryptostomata. The zoœcial structure, however, is distinctly different, the most obvious points of difference being the presence of median tubuli between the median laminæ, and between the longitudinal rows of zoœcial tubes. Mesopores are absent, but the interzoœcial spaces are often filled with vesicles.

Genus RHINIDICTYA Ulrich.

Rhinidictya Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 152.—Hall and Simpson, Nat. Hist. New York, Pal., vol. 6, 1887, p. xx.—Ulrich, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 124; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 279.—Simpson, Fourteenth Ann. Rep. State Geol. New York for the year 1894, 1897, p. 605.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 48.—Cumings, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 755.

Stictopora (part) Hall, Nat. Hist. New York, Pal., vol. 1, 1847, p. 73.

Stictopora (not Hall) Ulrich, Geol. Surv. Illinois, vol. 8, 1890, p. 388.

This fine genus is represented in the Russian deposits by two well-marked forms, one from the Wassalem beds, which can not be distinguished from the common Minnesota species *Rhinidictya mutabilis*, and a second closely related species from the Wesenberg limestone, differing mainly in having much larger zoœcia. In America the genus has a rather prolific representation both in species and in specimens. While specimens are not infrequent in the Russian strata mentioned above, the scanty specific development is rather unusual.

Genotype.—*Rhinidictya nicholsoni* Ulrich. Middle Ordovician of the United States and Canada.

RHINIDICTYA MUTABILIS (Ulrich).

Text fig. 56.

Stictopora mutabilis (part) Ulrich, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 66.

Stictopora mutabilis Miller, North Amer. Geol. and Pal., 1889, p. 324, fig. 517.—Ulrich, Geol. Surv. Illinois, vol. 8, 1890, p. 304, figs. 2 *c–h*.

Rhinidictya mutabilis Ulrich, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 125, pl. 6, figs. 1–6, 12, 13; pl. 7, figs. 10–23, 25–28; pl. 8, figs. 1–3.—Whiteaves, Pal. Foss., vol. 3, 1897, p. 240.—Sardeson, Journ. Geol., vol. 9, 1901, p. 155, pl. B, figs. 4–6.

Stictopora mutabilis var. *minor* Ulrich, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1886, p. 67.

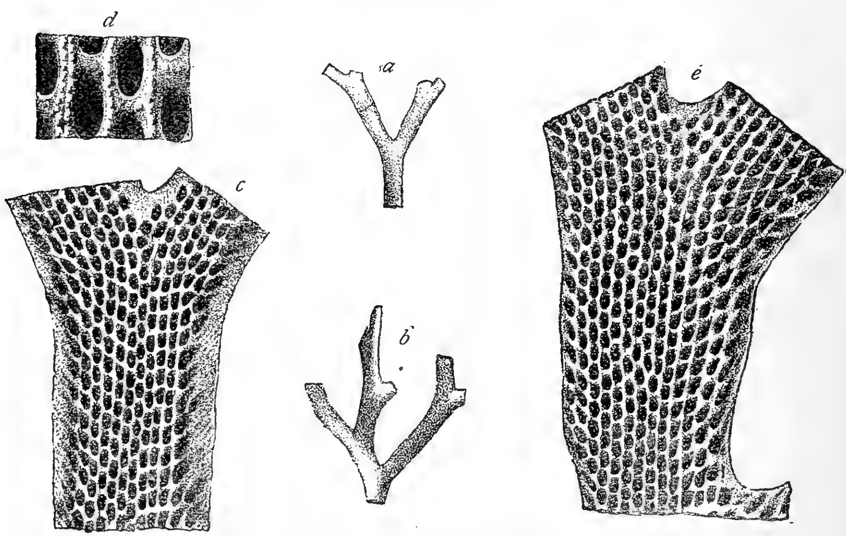

Fig. 56.—Rhinidictya mutabilis. *a*, a young specimen, described as variety minor, natural size; *b*, the usual mature specimen; *c*, surface view, ×9, of a young example; *d*, several apertures of the same, ×35; *e*, surface of original of figure *b*, ×9. Black River (Decorah) shales, Minneapolis, Minnesota. (After Ulrich.)

This is a most abundant bryozoan in the Black River (Decorah) shales of Minnesota and Iowa; in fact, specimens are so numerous that one particular bed has been designated the Rhinidictya bed. The large amount of material studied by Ulrich caused him to recognize in addition to the typical form three varieties, *minor*, *major*, and *senilis*. In his final work upon the subject, variety *minor* was reduced to synonymy under the type form of the species on the grounds that the specimens so designated were only young examples. Curiously enough, most of the specimens found in the Baltic strata are a number of examples from the Wassalem beds at Uxnorm, differing in no appreciable manner from the types of the variety *minor*. It is probable that this is only an accidental coincidence, and that in the course of time specimens of the more mature typical form of the species will be discovered. The surface characters of both the type form of the species and of the young examples designated variety *minor* are illustrated in the accompanying figures. The species is described in considerable detail by Ulrich, but it is believed that the narrow, bifoliate, ribbon-like stipes bearing longitudinal rows of somewhat elongated quadrate zoœcia, with granulose separating ridges, are sufficient to distinguish it from most associated bryozoans.

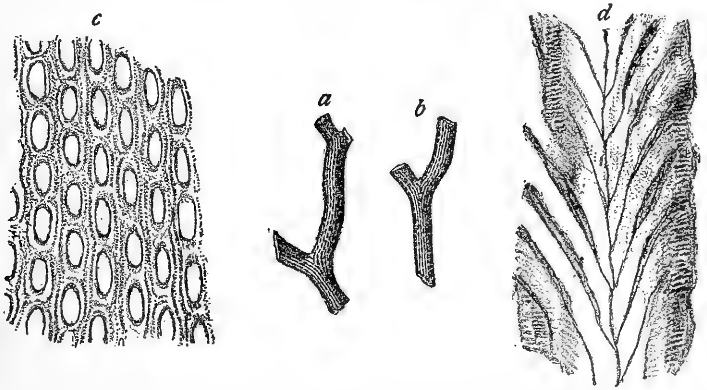

FIG. 57.—RHINIDICTYA EXSERTA. *a* AND *b*, TWO TYPICAL FRAGMENTS, NATURAL SIZE; *c*, TANGENTIAL SECTION, ×20, THROUGH MATURE ZONE OF AN OLD EXAMPLE; *d*, VERTICAL SECTION, ×20, OF THE SAME SPECIMEN. WESENBERG LIMESTONE (E), WESENBERG, ESTHONIA.

The internal structure is very similar to *Rhinidictya exserta*, illustrated above. Comparisons between the two are given on page 134.

Occurrence.—Very abundant in all the divisions of the Black River (Decorah) shales, and in the Fusispira and Nematopora beds of the lower Trenton limestones of Minnesota and Iowa; common in the Wassalem beds (D3) at Uxnorm, Esthonia (Cat. No. 57227, U.S.N.M.)

One specimen (forma *minor*) from the Wassalem beds at Uxnorm in the collections of the British Museum.

RHINIDICTYA EXSERTA (Eichwald).

Text figs. 57, 58.

Eschara exserta EICHWALD, Urwelt Russlands, pt. 2, 1847, pl. 1. fig. 2.

Stictopora exserta EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 392, pl. 26, fig. 11 *a*, *b*.

As shown in figure 58, the two illustrations of *Stictopora exserta* given by Eichwald seem to represent the surface of quite different bryozoans. I am unable to find any form corresponding to figure

58 *a*, but figure 58 *b* in all probability refers to a species of *Rhinidictya* not uncommon in the Wesenberg limestone, for which I shall adopt the name *Rhinidictya exserta*.

The zoarium of *R. exserta* is of narrow, parallel-edged branches, 2½ to 3 mm. in width, dividing dichotomously at intervals of 15 mm. or more. Zoœcia with oblique to nearly direct oblong apertures, five to six in 2 mm., measuring longitudinally, and 11 in the same distance counting transversely. As often noted in this genus, the marginal rows of apertures are usually a little larger than the average and are directed outward. In young examples the zoœcial interspaces are thin and without surface ornament; with age they thicken slightly and exhibit rows of small granules. The latter appear clearly in tangential sections, as indicated in figure 57 *c*.

The internal structure of this species is very similar to that of *R. mutabilis*, which has been so fully described by Ulrich that there is no necessity for repetition. The median tubuli are seen best in transverse sections and are not shown in the accompanying illustrations. The surface characters of the species, although fairly well shown in Eichwald's figure 58 *b*, are perhaps better illustrated in Ulrich's view of *R. mutabilis* in figures 56 *c* and *d*. In spite of this similarity, there need be no difficulty in distinguishing *R. exserta* because its zoœcia are one-fourth to one-third again as large as those of *R. mutabilis*.

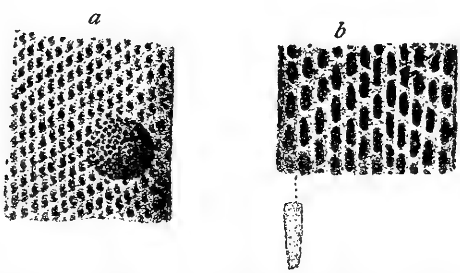

Fig. 58.—Rhinidictya exserta. *a*, Eichwald's original view of this species; *b*, view of his second specimen, upon which the present conception of the species is based.

The bifoliate, narrow, straight edged parallel branches of *R. exserta*, with its oblong zoœcia, are so distinct from associated bryozoans that there is little likelihood of confusing it with any other. In contrast with other bryozoans of the Wesenberg limestone, all of the specimens of the present species that I have seen have weathered out with a distinct white color, a fact which also aids in their identification.

Occurrence.—Apparently common in the Wesenberg limestone (E) at Wesenberg, Esthonia; rare in the Kegel limestone (D2) at Kegel, Esthonia.

Plesiotypes.—Cat. No. 57228, U.S.N.M.

British Museum, one specimen from the Wesenberg limestone at Wesenberg.

Genus PHYLLODICTYA Ulrich.

Phyllodictya Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 153.—Miller, North Amer. Geol. and Pal., 1889, p. 315.—Ulrich, Geol. Surv. Illinois, vol. 8, 1890, p. 390; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, 1893, p. 141; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 280.—Simpson, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 531.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 49.

The members of this genus differ from other Rhinidictyonidæ in having broad, bifoliate zoaria with long zoœcial tubes crossed by complete diaphragms and without hemisepta. Its relations are mainly with *Pachydictya*, but *Phyllodictya* has more or less strongly oblique apertures with the posterior edge raised. Of the two known Russian species, one is identical with an American form, while the second is new.

Genotype.—Phyllodictya frondosa Ulrich. Middle Ordovician (Black River) of the United States and Canada.

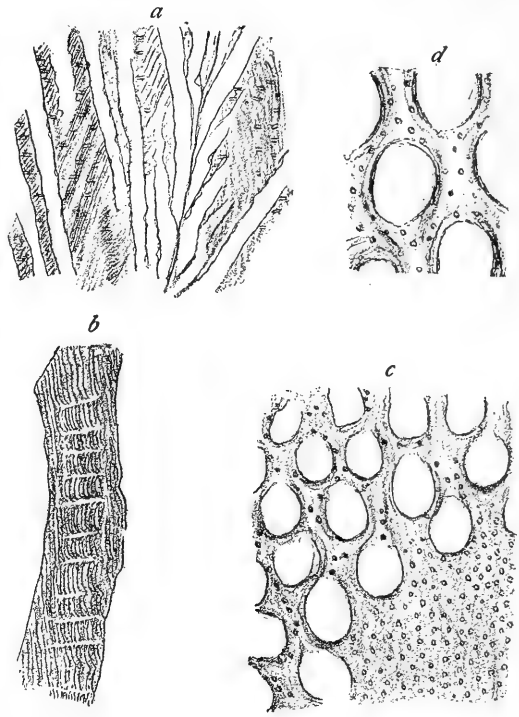

Fig. 59.—Phyllodictya flabellaris. *a*, vertical section, ×20, showing the long, zoœcial tubes; *b*, minute structure of the interzoœcial spaces, ×60; *c*, tangential section, ×20, with portion of a macula and adjoining zoœcia; *d*, several zoœcia of the same section, ×35. Orthoceras limestone (B3), Baltischport, Esthonia.

PHYLLODICTYA FLABELLARIS, new species.

Plate 7, figs. 7, 8; text fig. 59.

This fine new species differs from all other members of the genus in the greater dimensions of both the zoarium and zoœcia. The zoarium is a broad bifoliate expansion of which figure 7 on plate 7 represents only a fragment. The original of this type-specimen must have been at least 40 mm. in height and 60 mm. in width, with a maximum thickness of 4 mm. Another specimen before me has a still greater thickness, so that its other dimensions were probably correspondingly larger. The surface of these zoaria is marked by finely granular solid spots or maculæ at intervals of about 5 mm. The more perfect condition of the surface shows the zoœcia to be arranged in longitudinal series between faintly papillose ridges, but in old examples this arrangement is much obscured. Four zoœcia in 2 mm. measuring longitudinally. Indeed the apertures show the same variation as exhibited in the several illustrations of the following *P. varia*.

Aside from the larger zoœcia the internal structure is also much as in *P. varia*. In vertical section the zoœcial tubes proceed to the surface in a long, gentle curve. Neither diaphragms nor hemisepta have been observed in any of the sections. The zoœcial interspaces are filled with a dense, laminated tissue which, as shown in figure 59, is pierced by numerous tubuli. In tangential sections these tubuli appear as dark spots or pores, numerous in the maculæ, but less common between the zoœcia. The zoœcia in such sections are rounded to elongate oval and drawn out anteriorly with the walls thickened by the interzoœcial deposit of tissue.

Compared with *P. varia*, the only other Russian species of the genus, *P. flabellaris* has larger zoœcia, a broader and thicker zoarium and more conspicuous maculæ. Other bifoliate bryozoans of the Baltic area are too different to require comparison.

Occurrence.—Not uncommon in the Orthoceras limestone (B3) on the island of Rogo, near Baltischport; also at Baltischport, and at Tischer, near Reval, Esthonia.

Cotypes.—Cat. Nos. 57230, 57231, U.S.N.M.

Thin sections of specimens from Baltischport are in the British Museum's collection.

PHYLLODICTYA VARIA Ulrich.

Text fig. 60.

Phyllodictya varia Ulrich, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 144, pl. 14, figs. 1–8.

A second species of *Phyllodictya* in the Middle Ordovician strata of Russia differs conspicuously from the preceding form in having smaller zoœcia and a more delicate zoarium. This particular species was found to agree in all essential respects with the very common Minnesota Ordovician form described by Ulrich as *Phyllodictya varia*. In fact, the similarity is so great that it was thought unnecessary to show any other illustrations than those given by Ulrich. The zoarium is of bifoliate, thin, leaf-like expansions, with sharp, nonporiferous, subparallel edges. Scattered over the celluliferous surfaces at distances of about 4 mm. are solid, finely granostriate maculæ which, in old specimens, as shown in figure 60 *e*, are of considerable size. The normal shape and arrangement of the zoœcia, with their surface ornamentation, is shown in figures 60 *c* and 60 *d*, while the usual views seen in vertical and tangential sections are reproduced in figures 60 *f* and *g*. Measuring longitudinally, five to six apertures may be counted in 2 mm.

Occurrence.—The American types of this species seem to be limited to the Rhinidictya bed of the Black River (Decorah) shales of Minnesota. The Russian examples studied were found in the Wassalem beds (D3) at Uxnorm (Cat. No. 57233, U.S.N.M.).

British Museum, one specimen from the Wassalem beds at Uxnorm.

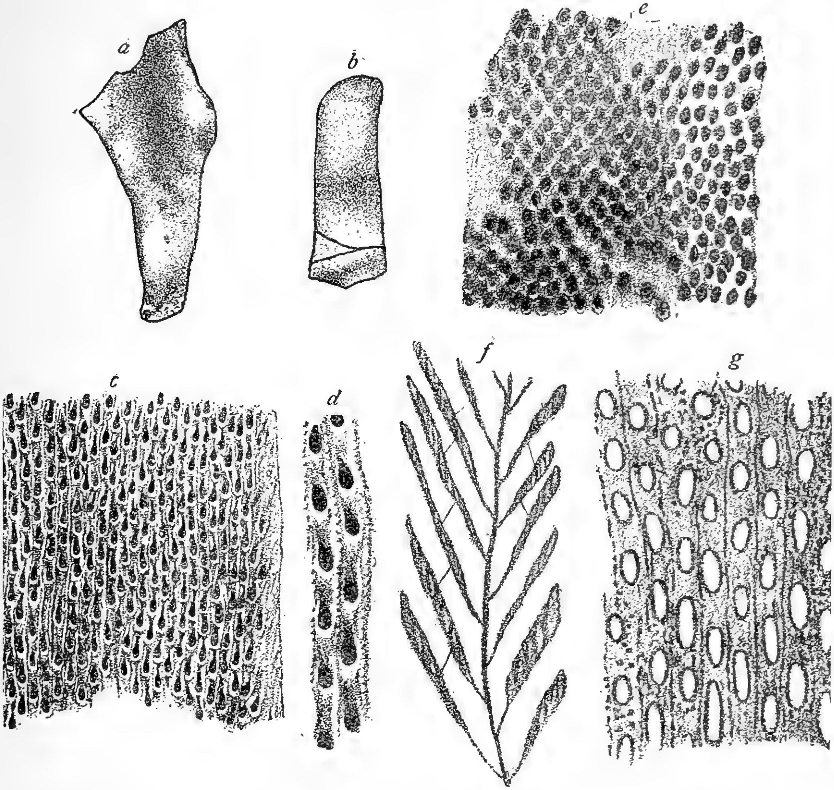

FIG. 60.—PHYLLODICTYA VARIA. *a*, PORTION OF A LARGE ZOARIUM, NATURAL SIZE; *b*, FRAGMENT WITH SUBPARALLEL MARGINS, NATURAL SIZE; *c*, SURFACE OF THE SAME, ×9; *d*, TWO ROWS OF APERTURES, ×18, SHOWING THE PAPILLOSE CHARACTER OF THE RIDGES; *e*, SURFACE OF AN OLD ZOARIUM, ×9, EXHIBITING DISTINCT MACULÆ; *f*, VERTICAL SECTION, ×18; *g*, TANGENTIAL SECTION, ×18. BLACK RIVER (DECORAH) SHALES, MINNEAPOLIS, MINNESOTA. (AFTER ULRICH.)

Genus PACHYDICTYA Ulrich.

Pachydictya ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 152.—FOERSTE, Bull. Sci. Lab. Denison Univ., vol. 2, 1887, p. 162.—MILLER, North Amer. Geol. and Pal., 1889, p. 313.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 390, 522; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 145.—SIMPSON, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 530.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 48.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 57.—HENNIG, Archiv fur Zool., K. Sven. Vet.-Akad. Stockholm, vol. 2, No. 10, 1905, p. 25.—CUMINGS, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 751.

All of the four species of *Pachydictya* found in the Baltic strata prove to belong to that section of the genus in which the zoarium is narrow with subparallel margins and the longitudinal arrangement of the zoœcia predominates. The type species of the genus has a broad, palmate zoarium, but its internal structure is essentially the same as in the narrow, branched forms. The zoœcial apertures in *Pachydictya* are oval and have well-marked, ring-like walls, this character alone being so marked that it serves as a distinction from other genera of the Rhinidictyonidæ.

Genotype.—*Pachydictya robusta* Ulrich. Middle Ordovician (Ottosee) shales of east Tennessee.

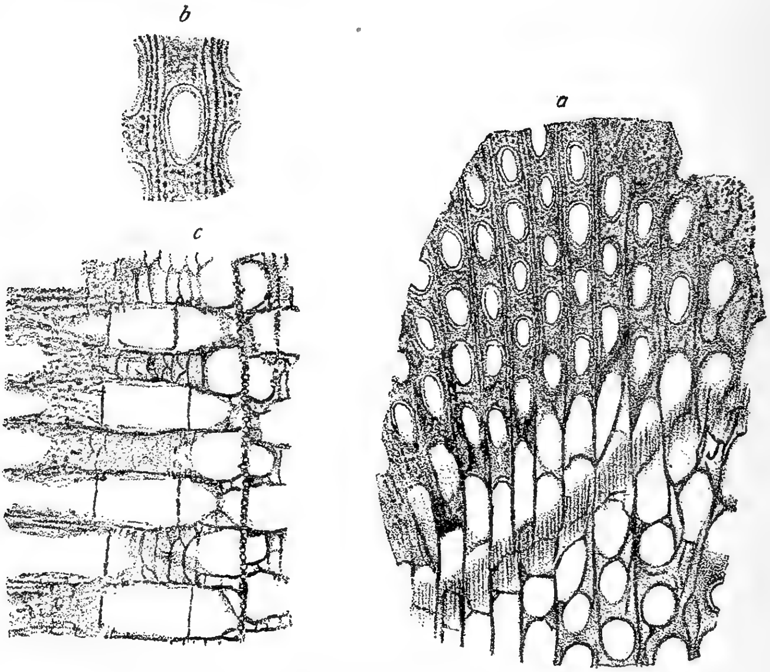

FIG. 61.—PACHYDICTYA ELEGANS.—*a*, TANGENTIAL SECTION, ×18, CUT OBLIQUELY SO AS TO SHOW PARTS OF BOTH SIDES OF THE ZOARIUM. THE UPPER THIRD EXHIBITS THE STRUCTURE OF THE FULLY MATURED ZONE, WHILE A LESS MATURE PORTION IS SHOWN IN THE LOWER PART. THE SHADED AREA WITH SHORT, PARALLEL LINES REPRESENTS THE MEDIAN LAMINA WITH ITS LONGITUDINAL TUBULI; *b*, A SINGLE ZOŒCIUM OF THE SAME SECTION, ×35. CLITAMBONITES BED OF LOWER TRENTON, ST. PAUL, MINNESOTA. *c*, TRANSVERSE SECTION, ×18, PACHYDICTYA FOLIATA, SHOWING THE MEDIAN TUBULI DISTINCTLY. BLACK RIVER (DECORAH) SHALES, ST. PAUL, MINNESOTA. (AFTER ULRICH.)

PACHYDICTYA ELEGANS Ulrich.

Text figs. 61, 62.

Pachydictya elegans ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 154, pl. 8, figs. 18, 19; pl. 9, figs. 8, 9.

Among the several species of *Pachydictya* found in the strata of the Baltic provinces is one represented by a few well-preserved specimens which I am unable to distinguish from the abundant form in the Clitambonites bed of Minnesota described by Ulrich as *P. elegans*. Views of an American and a Russian example are given in figure

62 *a* and *c*, while the surface characters of the former are shown in figure 62 *b*. The zoarium grows from a spreading attached space into narrow, bifoliate branches with thin, sharp, nonporiferous edges. When magnified the celluliferous side in the very regular arrangement of the zoœcia and sculpture of the interspaces presents a highly ornamental appearance. The apertures are elliptical and separated from each other by spaces equal to their shorter diameter. Around each aperture is a well-defined peristome, and between the longitudinal rows of zoœcia a flexuous, thread-like line is developed. These peristomes and longitudinal lines bear a row of minute papillæ, which increase the ornament of the surface. Five to five and one-half zoœcia in 2 mm., measuring lengthwise, and seven rows in 2 mm., counting transversely.

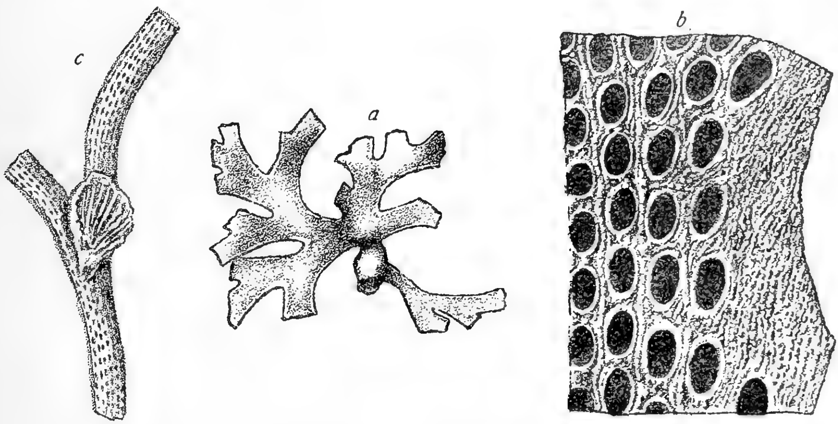

FIG. 62.—PACHYDICTYA ELEGANS. *a*, NEARLY COMPLETE ZOARIUM, NATURAL SIZE, BRANCHING MORE FREQUENTLY THAN USUAL; *b*, ENLARGEMENT OF SURFACE OF SAME, ×18, SHOWING ORNAMENTATION. LOWER PART OF TRENTON LIMESTONE, ST. PAUL, MINNESOTA; *c*, FRAGMENT, ×1.5, WITH YOUNG STREPTELASMA ATTACHED. WESENBERG LIMESTONE WESENBERG, ESTHONIA.

In size of zoœcia and general aspect of the zoarium, *P. elegans* is quite similar to the associated *P. flabellum*. A surface view of the zoœcia enlarged, as shown in figures 62 *b* and 63 *b*, will readily distinguish them, since *P. elegans* has oval cell apertures with a well-marked peristome and highly ornamental interspaces. In thin sections *P. flabellum* shows the regular oval zoœcia of *Pachydictya*, but at the surface they appear to be inclosed in rather regular hexagonal areas formed by the union of the lines in the interspaces. All of the other Baltic species of *Pachydictya* have larger zoœcia.

Occurrence.—Abundant in the Clitambonites bed of the lower Trenton of Minnesota and Iowa. Fairly abundant in the Kuckers shale (C2), Baron Toll's estate, and in the Wesenberg limestone (E) at Wesenberg, Esthonia.

Plesiotype.—Cat. No. 57234, U.S.N.M.

Specimens and thin section from the Wesenberg limestone at Wesenberg in the collections of the British Museum.

PACHYDICTYA FLABELLUM (Leuchtenberg).

Plate 8, fig. 1; text figs. 63, 64.

Eschara flabellum LEUCHTENBERG, Geognosie de Russie, p. 370.
Stictopora flabellum EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 391, pl. 24, fig. 14 *a–c*.

The particular bryozoan that Leuchtenberg had in mind when describing *Eschara flabellum* can probably never be determined, and our knowledge of this species must date from Eichwald's work. Although Eichwald's description leaves much to be desired, his figures agree exactly, so far as they go, with an abundant bryozoan of the Wesenberg limestone belonging to the genus *Pachydictya*. I have figured this species in some detail, and will call attention to the various illustrations in giving its specific characters.

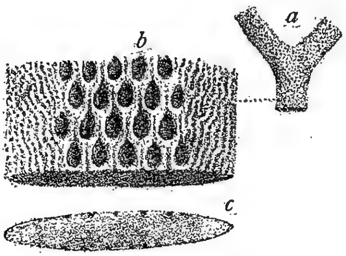

FIG. 63.—PACHYDICTYA FLABELLUM. *a*, FRAGMENT, NATURAL SIZE; *b*, SURFACE OF SAME, ENLARGED, SHOWING THE SOMEWHAT ANGULAR ZOŒCIA AND PORIFEROUS, NONCELLULIFEROUS BORDERS; *c*, TRANSVERSE VIEW OF BRANCH. "CALCAIRE À ORTHOCERATITES," PULKOWA, GOVERNMENT OF ST. PETERSBERG. (COPIED FROM EICHWALD'S FIGURE OF STICTOPORA FLABELLUM.)

As shown in figure 1 of plate 8, the zoarium is of thin, bifoliate, ribbon-like, graceful branches, less than 5 mm. wide, dividing dichotomously at intervals of 15 mm. The margins are acute and usually have a finely striated border. The width of these marginal borders increases with age, as illustrated in Eichwald's view of the surface (fig. 63 *b*). The zoœcial apertures are oval with a poorly developed "ring" or peristome which is usually inconspicuous because the lines of the interzoœcial spaces unite to form a hexagonal area about each aperture. This, as is evident in Eichwald's figure, gives an apparent polygonal outline to the zoœcia, and, moreover, makes the species easy of recognition. Measuring longitudinally, five to six apertures occur in 2 mm.

The internal structure is much as in other species of *Pachydictya* of similar growth. The vertical sections show unusually large vesicles filling the early portions of the interzoœcial spaces, but these are soon replaced by the solid, laminated tissue pierced by the minute tubules. Tangential sections passing near the surface of old examples exhibit oval zoœcia with a narrow peristome, separated by broad, interzoœcial spaces bearing numerous tubules (fig. 64 a). In figure 64 *b* a deeper portion of a tangential section is illustrated with the lower half passing through the vesicular zone. In certain sections, especially of young examples, the vesicles have the appearance of mesopores (fig. 64 *c*).

The only species with which *P. flabellum* may be confused is the equally abundant *P. elegans*. Comparisons between the two are given under the description of the latter.

Occurrence.—Eichwald records the species from Poulkowa. All of the specimens before me come from the Wesenberg limestone (E) at Wesenberg, Esthonia.

Plesiotypes.—Cat. No. 57236, U.S.N.M.

British Museum, specimens and thin sections from Wesenberg limestone, at Wesenberg, Esthonia.

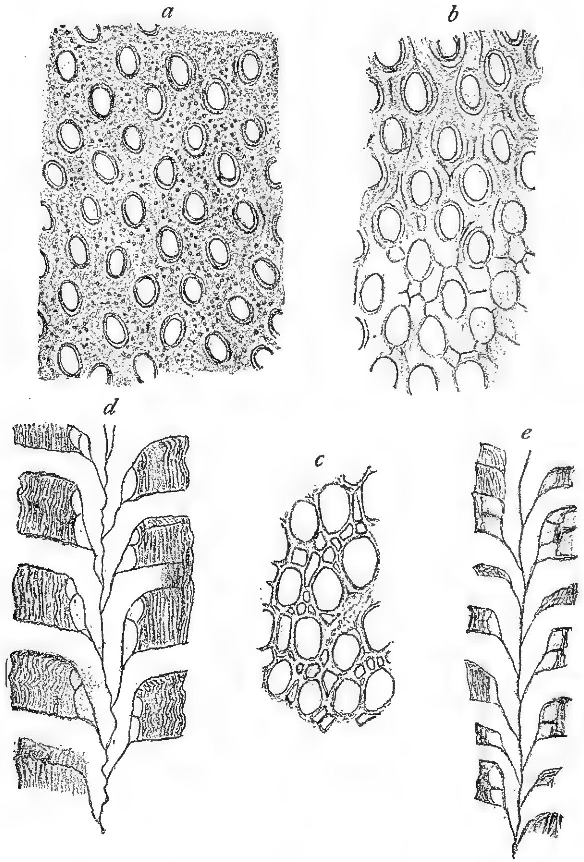

FIG. 64.—PACHYDICTYA FLABELLUM. *a*, TANGENTIAL SECTION, ×20, THROUGH AN OLD PORTION OF THE ZOARIUM; *b*, ANOTHER TANGENTIAL SECTION, ×20, SHOWING THE APPEARANCE IN THE EARLY PORTION OF THE MATURE ZONE; *c*, TANGENTIAL SECTION OF A YOUNG EXAMPLE, ×20, WITH OPEN MESOPORES; *d*, THE USUAL ASPECT OF VERTICAL SECTIONS, ×20; *e*, VERTICAL SECTION, ×20, OF YOUNG SPECIMEN. WESENBERG LIMESTONE (E), WESENBERG, ESTHONIA.

PACHYDICTYA CYCLOSTOMOIDES (Eichwald).

Text figs. 65, 66.

Micropora cyclostomoides EICHWALD, Bull. Soc. Nat. Moscou, No. 4, 1855, p. 459; Lethæa Rossica, vol. 1, 1860, p. 394, pl. 24. fig. 16 *a*, *b*.

Eichwald's figures of *Micropora cyclostomoides* clearly indicate a broad, branching species of *Pachydictya*, with rather large apertures. His types were registered from the "calcaire à Orthoceratites de Wesenberg et d'Erras." This would imply, although not necessarily correctly, that his specimens were derived from the Wesenberg limestone. *Pachydictya elegans*, a species corresponding to his figures of *M. cyclostomoides* in some respects, is present in the Wesenberg limestone, and it is possible that Eichwald had this species before him. However, in view of the uncertainty of accurate identification, I have decided to adopt Eichwald's name, not to replace the American *P. elegans*, but for a common bryozoan in the Kuckers shale and higher formations, differing mainly in having larger zoœcia, a less ornamented surface, and a broader zoarium. If Eichwald's figures can be relied upon, he probably illustrated this large-celled species.

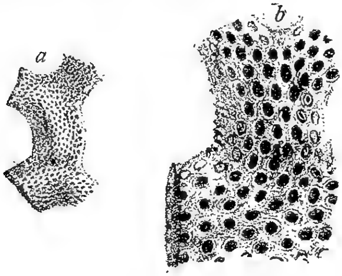

FIG. 65.—PACHYDICTYA CYCLOSTOMOIDES. EICHWALD'S VIEW OF MICROPORA CYCLOSTOMOIDES. *a* AND *b*, FRAGMENT, NATURAL SIZE, AND A PORTION ENLARGED. "CALCAIRE À ORTHOCERATITES" WESENBERG, ESTHONIA.

Pachydictya cyclostomoides, as here identified, forms rather broad, bifoliate branches 5 mm. or more in diameter, frequently and irregularly dividing. The surface is smooth but, unlike the other branching Baltic species of the genus, distinct maculæ are occasionally developed. The zoœcia are large, oval, thick walled, and have a conspicuous peristome; three zoœcia in 2 mm., measuring longitudinally, five rows of apertures in the same distance. The apertures are arranged in rather regular longitudinal series which are most interrupted when a macula is inserted.

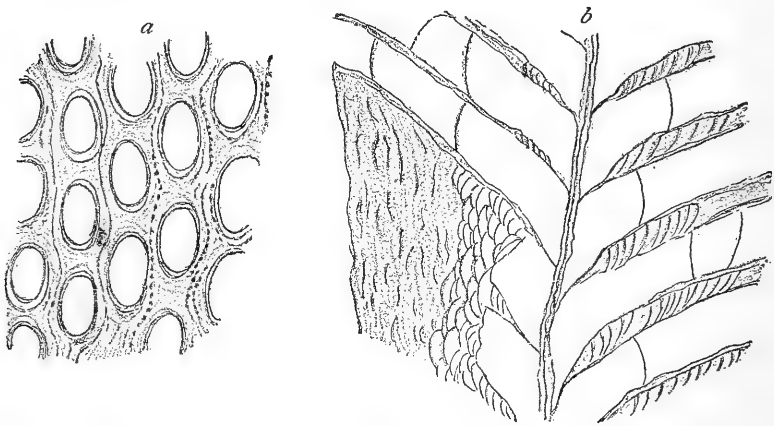

FIG. 66.—PACHYDICTYA CYCLOSTOMOIDES. *a*, TANGENTIAL SECTION, ×20, SHOWING THE LARGE OVAL ZOŒCIA; *b*, VERTICAL SECTION, ×20. JEWE LIMESTONE (D1), ST. MATHIAS, ESTHONIA.

The internal structure is that of a typical *Pachydictya*. In tangential sections the large size of the zoœcia and the wide end spaces separating them are the important features aside from the ring-like walls. Vertical sections show a few diaphragms in the zoœcial tubes and a profuse development of vesicles and laminated tissue in the interzoœcial spaces.

The large oval zoœcia and broad branches with maculæ will distinguish *P. cyclostomoides* from the other Baltic species. Among the American forms none of those with a similar growth has zoœcia of the same size.

Occurrence.—As stated above, Eichwald records the species from Wesenberg and Erras. Specimens which I have identified with it occur abundantly in the Kuckers shale (C2), Baron Toll's estate; in the Jewe limestone (D1), St. Mathias; and in the Kegel limestone (D2) at Kegel, Esthonia. The species is also present in the Chasmops limestone at a locality on the island of Oeland, south of Bödahamn.

Plesiotype.—Cat. No. 57238, U.S.N.M.

Specimens from the Jewe limestone, St. Mathias, Kuckers shale, Baron Toll's estate, and from the Chasmops limestone, island of Oeland, are in the British Museum collections.

PACHYDICTYA BIFURCATA (Hall).

Text figs. 67, 68.

Stictopora bifurcata Hall, Twelfth Ann. Rep. Indiana Geol. Nat. Hist., 1883, p. 267, pl. 13, figs. 3, 4.

Pachydictya bifurcata Foerste, Bull. Sci. Lab. Denison Univ., vol. 2, 1887, p. 163; vol. 3, 1888, pl. 15, fig. 10; Geol. Surv. Ohio, vol. 7, 1895, p. 599, pl. 28, fig. 9.

Stictopora scalpellum Eichwald (not Lonsdale), Lethæa Rossica, vol. 1, 1860, p. 390, pl. 24, fig. 15 *a–c*.

Rhinidictya? Borkholmiensis Wiman, Bull. Geol. Inst. Univ. Upsala, vol. 5, pt. 2, No. 10, 1901, p. 180, pl. 6, figs. 1–7.

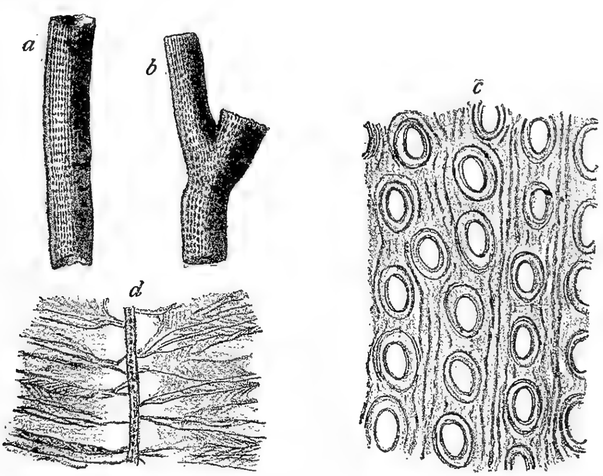

Fig. 67.—Pachydictya bifurcata. *a* and *b*, two fragments, ×1.5; *c*, tangential section, ×20, showing the distinct peristome, thick walls, and wide interspaces; *d*, portion of a transverse section, ×20, with well-marked median tubuli. Lyckholm limestone (F1), Kertel, island of Dago, Esthonia.

The Lyckholm and Borkholm limestones contain numerous examples of a narrow, parallel edged *Pachydictya* which agrees in all of its characters with a common American Clinton species described by

Hall as *Stictopora bifurcata.* A specimen, probably of the same species, was illustrated by Eichwald as *Stictopora scalpellum* (Lonsdale), although this identification on my part is merely a guess, based upon the fact that Eichwald's figured example came from the island of Dago, and evidently represents the old condition of *Pachydictya bifurcata.* At any rate, it is almost certain that Eichwald's *Stictopora scalpellum* does not refer to the Wenlock species described by Lonsdale.

Although closely allied to such species of *Pachydictya* as *P. elegans* and *P. cyclostomoides,* the present form may be distinguished, first, by its regular parallel edged branches, usually 5 mm. in width, divid-

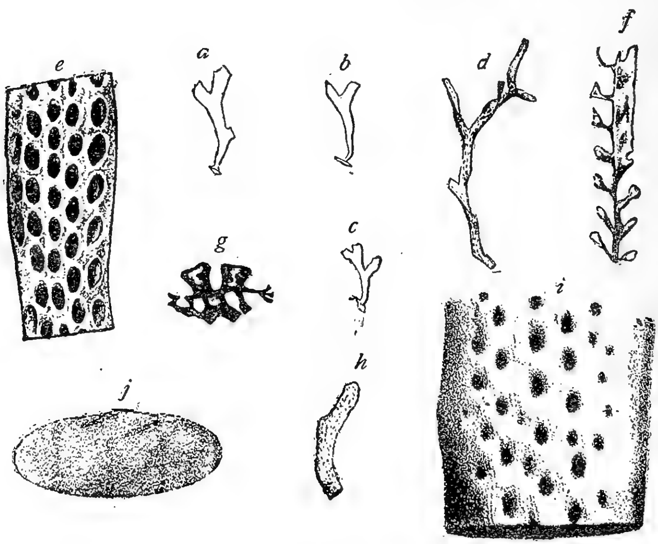

FIG. 68.—PACHYDICTYA BIFURCATA. *a* TO *g*, WIMAN'S FIGURES OF RHINIDICTYA BORKHOLMIENSIS. *a* TO *d*, FOUR FRAGMENTS, NATURAL SIZE; *e*, SURFACE OF FRAGMENT, ×10; *f*, VERTICAL SECTION, ×10; *g*, TRANSVERSE SECTION, ×10. BORKHOLM DRIFT, "ÖJLE MYR, ISLAND OF GOTHLAND; *h* TO *j*, EICHWALD'S FIGURES OF STICTOPORA SCALPELLUM; *h*, FRAGMENT, NATURAL SIZE; *i*, SURFACE ENLARGED; *j*, END VIEW OF SAME. BORKHOLM LIMESTONE, ISLAND OF DAGO.

ing dichotomously at rather long intervals; second, by its large, oval, thick-walled zoœcia, of which there are four to four and one-half in 2 mm., measuring longitudinally; and third, by the broad, granulose interspaces separating the apertures at both their ends and sides. *P. cyclostomoides* has still larger zoœcia and differs further in its broader, more frequently branching zoarium. The other species have smaller zoœcia and a different surface ornament.

Rhinidictya ? borkholmiensis Wiman is in all probability a synonym of the present form. This species is recorded by Wiman as a very common fossil of the drift bowlders at Öjle Myr, on the island of Gothland, and in the Borkholm limestone at Borkholm, Esthonia.

Wiman's figures, here reproduced, represent a species of *Pachydictya* with surface characters identical with *P. bifurcata.* Young specimens of *P. bifurcata* in the collection from the Borkholm limestone at Borkholm have considerable similarity to Wiman's figured examples, and this leads me to believe in the identity of the two species.

Occurrence.—Abundant in the Silurian (Clinton) limestone at Dayton and other localities in Ohio and Indiana. Equally abundant in the Lyckholm limestone (F1) at Kertel, on the island of Dago, and at Lyckholm, Esthonia; in the Borkholm limestone (F2) at Borkholm, Esthonia; Borkholm drift, Öjle Myr, island of Gothland.

Plesiotypes.—Cat. No. 57240, U.S.N.M.

Specimens from the Borkholm limestone, Borkholm, Esthonia, and from the Lyckholm limestone, island of Dago, in the collections of the British Museum.

Family CYSTODICTYONIDÆ Ulrich.

No genus of this family has hitherto been recorded from rocks older than the Middle Devonian, yet a single specimen from the Orthoceras limestone on the island of Rogo possesses all the characters of typical *Coscinium.* The Cystodictyonidæ in all probability are derived from the Rhinidictyonidæ, from which they differ most conspicuously in having a more or less well developed lunarium. It is possible that this appearance of *Coscinium* in the Middle Ordovician represents an early expression of this line of descent and that the characters were still too unstable to survive for any time.

Genus COSCINIUM Keyserling.

Coscinium KEYSERLING, Reise in das Petschora Land, 1846, p. 191.—PROUT, Trans. St. Louis Acad. Sci., vol. 1, 1858, p. 266.—ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 7, 1884, p. 38.—HALL and SIMPSON, Nat. Hist. New York, Pal., vol. 6, 1887, p. xix.—MILLER, North Amer. Geol. and Pal., 1889, p. 298.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 385, 496.—SIMPSON, Fourteenth Ann. Rep. State Geol. New York for the year 1894, 1897, p. 537.—NICKLES and BASSLER, Bull. 173, U. S. Geol Surv., 1900, p. 50.

Coscinium EICHWALD (part), Lethæa Rossica, vol. 1, 1860, p. 397.

Coscinotrypa HALL and SIMPSON, Nat. Hist. New York, Pal., vol. 6, 1887, p. xix.—MILLER, North Amer. Geol. and Pal., 1889, p. 298.—SIMPSON, Fourteenth Ann. Rep. State Geol. New York for the year 1894, 1897, p. 537.

Species of *Coscinium* differ from other genera of the family notably in having a cribrose zoarium. This, in connection with the bifoliate growth, round zoœcia with conspicuous lunaria and solid interspaces, makes the recognition of the genus easy. Five or six species are known from Devonian and Carboniferous rocks.

Genotype.—*Coscinium cyclops* Keyserling. Carboniferous of Russia.

COSCINIUM PRÆNUNTIUM, new species.

Plate 7, figs. 5, 6; text fig. 69.

Zoarium a bifoliate, flabellate, cribrose frond, 30 or more mm. high and the same width, growing from an expanded base attached to foreign bodies. The individual branches are 2 mm. in width and 1 mm. thick. An average fenestrule is broadly oval in outline and is 2 mm. long and 1.5 mm. wide. Base of zoarium and margins of branches noncelluliferous and finely granulose. Apertures subpyriform to trilobate in outline with a distinct lunarium occupying the posterior third or fourth. An average zoœcium is 0.24 mm. long; five in 2 mm., measuring lengthwise. Interzoœcial spaces as wide and often wider than the zoœcia, solid at the surface, granulose or granulostriate.

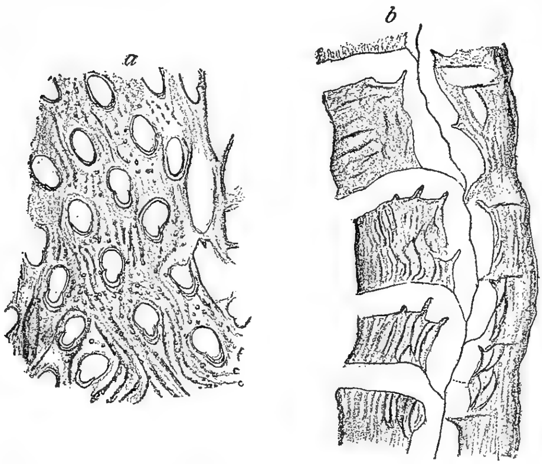

Fig. 69.—Coscinium prænuntium. *a*, tangential section, ×20; *b*, vertical section, ×20. Orthoceras limestone (B3), island of Rogo, Esthonia.

Coscinium prænuntium has a smaller zoarium than the later representatives of the genus. It differs too decidedly from other Ordovician forms to require comparison.

Occurrence.—Rare in the Orthoceras limestone (B3), island of Rogo, Esthonia.

Holotype.—Cat. No. 57243, U.S.N.M.

Specimen and thin sections in the British Museum.

Family ARTHROSTYLIDÆ Ulrich.

Zoarium articulated, consisting of numerous subcylindrical segments, united into small pinnate or bushy colonies, or of continuous, dichotomously divided branches; zoœcia subtubular, more or less oblique, radially arranged about a central axis, and opening on all sides of the segments; or one side may be noncelluliferous and longitudinally striated.

Both the zoœcial and zoarial characters of the Arthrostylidæ are so distinctive that thin sections are seldom necessary for accurate specific determination. It is surprising that of the 12 species of the family identified in Russian strata, 10 are characteristic American forms.

Genus ARTHROSTYLUS Ulrich.

Arthronema (preoccupied) ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, pp. 151, 160.

Arthrostylus ULRICH, American Geologist, vol. 1, 1888, p. 230; Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 188; Geol. Surv. Illinios, vol. 8, 1890, p. 400; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 187; Zittel's Textbook of Paleontology, (Eng. ed.), 1896, p. 280.—SIMPSON, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 527.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 42.—CUMINGS, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 740.

This interesting member of the Arthrostylidæ is represented in the Russian collections by a few individuals which can be referred to the two American Black River species, *A. conjunctus* and *A. obliquus* of Ulrich. These specimens consist of free segments of the zoarium, pointed at one end for articulation with the preceding segment, and with a socket-like hollow at the other end. The complete zoarium in *Arthrostylus* consists of numerous very small subquadrate segments united by terminal articulation and branching dichotomously until a small pinnate or bushy colony is the result; each of these segments has one of its faces longitudinally striated and each of the other faces, of which there are commonly three, bears a linear series of apertures between longitudinal ridges.

Genotype.—*Helopora tenuis* James. Earliest Silurian (Richmond) of the United States.

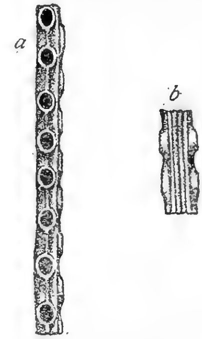

FIG. 70.—ARTHROSTYLUS CONJUNCTUS. *a*, LATERAL VIEW OF THE CENTRAL PORTION OF A SEGMENT, ×18; *b*, SMALL PORTION OF NONCELLULIFEROUS SIDE OF SAME, ×18. BLACK RIVER (DECORAH) SHALES, NEAR FOUNTAIN, MINNESOTA. (AFTER ULRICH.)

ARTHROSTYLUS CONJUNCTUS Ulrich.

Text fig. 70.

Arthrostylus conjunctus ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 189, fig. 14; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 188, pl. 3, figs. 13, 14.—SIMPSON, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 526, figs. 78, 79, 79*a*.

This and the following species of *Arthrostylus* have been briefly but clearly described by Ulrich in his memoir on the Bryozoa of Minnesota, and, as the Russian examples referred to these two species differ in no appreciable way, I have in each case made use of his description.

Original description.—Zoarium jointed; segments very slender, straight, needle-shaped, 3 or 4 mm. long, quadrangular in cross section, 0.25 mm. wide, 0.18 mm. thick, with zoœcial openings on three sides, the fourth being without them, but marked instead with four parallel longitudinal striæ. Zoœcial apertures broad-oval, direct, 0.11 mm. long, 0.09 mm. wide, inclosed by a sharply marked peristome. Peristomes of each row of apertures joined together by a thin ridge, having a length about equal to the larger or outer diameter of the peristomes. Eight zoœcial apertures in each row in 2.5 mm. A thin ridge on each side of the range of apertures of the obverse face of the segment separates it from the lateral rows. Apertures usually arranged alternately in the three rows.

Occurrence.—The American type of the species was obtained in the Phylloporina beds of the Black River (Decorah) shales near Fountain, Minnesota. A single fairly well preserved specimen has been noted in the Wassalem beds (D3) at Uxnorm, Esthonia. (Cat. No. 57244, U.S.N.M.)

ARTHROSTYLUS OBLIQUUS Ulrich.

Text fig. 71.

Arthrostylus obliquus Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 190, figs. 14 *c, d;* Geol. Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 188, pl. 3, figs, 15, 16.

Original description.—Zoarium jointed, segments very slender, needle-shaped, straight or slightly curved, about 4 mm. long, subquadrangular in cross section, 0.2 mm. wide, 0.15 mm. thick, slightly expanding toward the upper extremity. Zoœcia in three rows, occupying as many faces of the segment, the fourth side with three longitudinal striæ, and no zoœcia. Profile of a segment in an obverse or reverse view, wavy on both sides; in a lateral view only on one side.

Zoœcial apertures small, oblique, the posterior margin very prominent, arranged alternately in the three rows, with nine in each, in 2.5 mm. A short ridge from the upper depressed edge of each zoœcial aperture is flanked on each side by the prolonged lateral borders of the aperture. No ridge between the lateral and central row of the zoœcia.

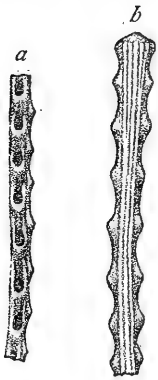

Fig. 71.—Arthrostylus obliquus. *a*, side view of portion of a segment, ×18; *b*, noncelluliferous side, ×18, of the upper portion of a segment. Black River (Decorah) shales, Minneapolis, Minnesota. (After Ulrich.)

The isolated joints of this small but neat bryozoan are so inconspicuous that they are very likely to be overlooked in collections. The species is very similar to the preceding *Arthrostylus conjunctus* Ulrich, but upon close examination may be distinguished by the absence of ridges between the rows of apertures, the prominent lower border, and especially by the oblique zoœcial apertures.

Occurrence.—Ulrich's types of the species were found in the Stictoporella bed of the Black River (Decorah) shales, at Minneapolis, Minnesota, where specimens are rather rare. The species is also of uncommon occurrence in the Echinospherites limestone (C1) at Archangelski, on the Wolchow River, in the government of St. Petersburg (Cat. No. 57245, U.S.N.M.).

Specimens of this species from American localities are in the collections of the British Museum.

Genus HELOPORA Hall.

Helopora HALL, Amer. Journ. Sci., ser. 2, vol. 11, 1851, pp. 388,389; Nat. Hist. New York, Pal., vol. 2, 1852, p. 44.—BILLINGS, Cat. Sil. Foss. Anticosti, 1866, p. 36.—ULRICH, American Geologist, vol. 1, 1888, p. 231; Geol. Surv. Illinois, vol. 8, 1890, pp. 401, 642; Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 191; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 189; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 280.—SIMPSON, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 548.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 42.—HENNIG, Archiv fur Zool., K. Sven. Vet.-Akad. Stockholm, vol. 3, No. 10, 1906, p. 18.

Helopora was founded upon an early Silurian species, *Helopora fragilis* Hall, from the Clinton and Niagara rocks of New York and Canada, and has its best and most typical representation in this time. Unquestionable species of the genus are, however, present in the Middle Ordovician, and the discovery of the following *H. divaricata* Ulrich in the Kuckers shale is an interesting extension of the geographic range of the genus and species.

Helopora differs from *Arthrostylus* in that its segments are generally much larger and bear zoœcial apertures on all sides. The tertiary segments of species of *Arthroclema* have much in common with *Helopora*, and care must be exercised in separating them.

Genotype.—*Helopora fragilis* Hall. Silurian (Clinton) of New York and Canada.

HELOPORA DIVARICATA Ulrich.

Text fig. 72.

Helopora divaricata ULRICH, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 59; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 191, pl. 3, figs. 1–3.

A number of isolated segments of this species have been observed on the thin slabs of limestone in the Kuckers shale. None of these happens to be as large as the American type of the species, and as the zoœcial apertures increase slightly in diameter with the size of the segment itself, the Russian examples naturally have smaller apertures. However, these specimens may be matched in the American collection, so that there can be little doubt regarding the identity of the Russian examples.

The jointed zoarium of *Helopora divaricata* is made up of subcylindrical segments obtuse at both ends, about 7 mm. long and bearing zoœcial apertures, of which there are from six to eight rows, opening on all sides. The diameter of a single segment ranges from 0.5 to 0.9 mm. The apertures number 12 in 5 mm., measuring lengthwise, are comparatively large, oblique, and ovate in shape, and are situated between strong longitudinal ridges. The posterior border of the aperture is thick and prominent, and slopes backward into the aperture next below. This border continues along the sides of the apertures as two diverging ridges, extending to the summit of the longitudinal crests, as shown in the accompanying figure.

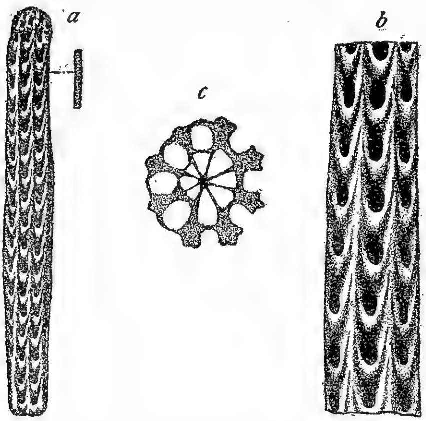

FIG. 72.—HELOPORA DIVARICATA. *a*, FRAGMENT NATURAL SIZE AND ×7; *b*, PORTION OF THE SAME, ×18; *c*, TRANSVERSE SECTION, ×18. BLACK RIVER (DECORAH) SHALE, MINNEAPOLIS, MINNESOTA. (AFTER ULRICH.)

The segments of *H. divaricata* are so much larger than those of the species of *Arthrostylus* that comparisons are not needed. They might, however, be confounded with the tertiary segments of *Arthroclema armatum*. Comparisons of the two species are given in the description of the latter.

Occurrence.—*Helopora divaricata* is not uncommon in the Stictoporella bed of the Black River (Decorah) shales at Minneapolis and other localities in Minnesota, and is equally abundant in the Kuckers shale (C2), Baron Toll's estate, Esthonia (Cat. No. 57246, U.S.N.M.).

British Museum, one specimen from the Kuckers shale, Baron Toll's estate.

Genus ARTHROCLEMA Billings.

Arthroclema BILLINGS, Pal. Foss., vol. 1, 1862, p. 54.—ULRICH, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, vol. 5, 1882, p. 151; American Geologist, vol. 1, 1888, p. 232; Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 192; Geol. Surv. Illinois, vol. 8, 1890, p. 400; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 197; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 281.—SIMPSON, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 546.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 42.

Zoarium of segments celluliferous on all sides as in *Helopora*, but differing in being articulated not only terminally but also laterally in a pinnate manner. The first row of segments and the first set of branches from these are known as the primary and secondary segments and bear articular surfaces on the sides as well as on the ends. The tertiary or last set is articulated only at the end, and the segments of this set must, therefore, have great resemblance to those of *Helopora*. Since the zoœcial structure in each set of segments is practically the same, and all three sets usually occur at the same locality, no especial care is needed in distinguishing them.

Genotype.—*Arthroclema pulchellum* Billings. Middle Ordovician (Trenton) of Canada.

ARTHROCLEMA ARMATUM Ulrich.

Text fig. 73.

Arthroclema armatum ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 194, figs. 19 *a–d* (not *e–h*=*Arthroclema pulchellum* Billings); Geol. Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 201, pl. 2, figs. 8–11, 25, 28–33; pl. 3, fig. 7.—SIMPSON, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 547, fig. 111.—SARDESON, Journ. Geol., vol. 9, 1901, p. 161.

This species is represented in the Russian collections by a few specimens showing no lateral articulations. Had not the American form been so well figured and represented in the collections of the United States National Museum it would have been almost impossible to

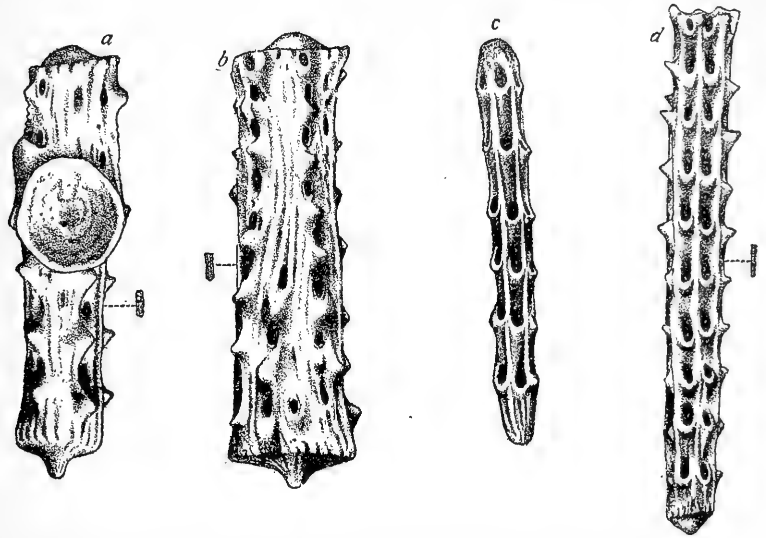

FIG. 73.—ARTHROCLEMA ARMATUM. *a*, LARGE SEGMENT OF THE PRIMARY SERIES, SHOWING A SHARPLY DEFINED, ARTICULATING SOCKET, NATURAL SIZE, AND ×18; *b*, OPPOSITE SIDE OF ANOTHER SEGMENT OF THE PRIMARY SET, ×18; *c*, A SEGMENT OF THE TERTIARY SERIES, ×18; *d*, COMPLETE SEGMENT OF THE SECONDARY SET, ×18. LOWER PART OF THE TRENTON LIMESTONE, CANNON FALLS, MINNESOTA. (AFTER ULRICH.)

have made such a close determination. However, the Russian specimens agree exactly with the tertiary segments of *Arthroclema armatum,* and I have no doubt that in time additional material will prove the correctness of the determination.

These tertiary segments are 2.5 to 3.5 mm. long and 0.3 mm. or less in diameter, five or six sided, with the angles fairly prominent, as shown in figure 73 *c*, which represents the tertiary segment of an American example, quite similar to the corresponding Russian specimens.

The greater strength of the secondary segments, but their evidently close relation to the tertiary ones, is indicated in figure 73 *d*, while the short, compressed, irregularly shaped primary segment, with the striated surface, strong spines, and indistinct zoœcial apertures, is shown in figures 73 *a*, *b*. Figure 73 *a* is especially interesting in illustrating not only the terminal points of attachment but also a large lateral socket.

As noted in a previous description, this species and *Helopora divaricata* are liable to be confused. Comparison of figures 72 and 73 will show differences in zoœcial characters, but the best and surest method of distinction is the discovery of a primary segment of the *Arthroclema* bearing the lateral articulation.

Occurrence.—The isolated segments of this species are abundant in the Nematopora bed of the lower Trenton limestone at Cannon Falls and St. Paul, Minnesota. In Russia the species so far has been observed only in the Glauconite limestone (B2) at Reval, Esthonia (Cat. No. 57247, U.S.N.M.).

Represented in the collections of the British Museum by specimens from American localities.

Genus SCEPTROPORA Ulrich.

Sceptropora Ulrich, American Geologist, vol. 1, 1888, p. 228; Contr. Micro-Pal. Cambro-Sil., pt. 2, 1889, p. 46; Geol. Surv. Illinois, vol. 8, 1890, p. 400; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 281.—Simpson, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 548.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 43.

Sceptropora was founded upon a single species, *S. facula* from the Richmond rocks of Manitoba, Canada, but has since been noted in these strata at many other localities. The discovery of numerous undoubted examples of *S. facula* in the Borkholm limestone is in line with other evidences showing the wide distribution of this Richmond fauna. The generic characters of *Sceptropora* are as follows:

Zoarium of segments which become much expanded in their upper portion and at the top have a socket for the articulation of the next segment; lower portion striated, without apertures; upper part with apertures all around; apertures subovate, in linear series between longitudinal ridges.

Genotype.—*Sceptropora facula* Ulrich. Earliest Silurian (Richmond) of North America and Russia.

Since the publication of the type species of the genus, a second specimen from the Clinton rocks of Canada has been described by Ulrich. The Russian collections now afford a third species, differing decidedly from the genotype but being not far removed in its characters from the Clinton form.

SCEPTROPORA FACULA Ulrich.

Text fig. 74.

Sceptropora facula ULRICH, American Geologist, vol. 1, 1888, p. 228; Contr. Micro-Pal. Cambro-Sil., pt. 2, 1889, p. 46, fig. 2; Geol. Surv. Illinois, vol. 8, 1890, p. 401, fig. 15.—WHITEAVES, Pal. Foss., vol. 3, pt. 2, 1895, p. 117.—SIMPSON, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 549, fig. 116.

Rather numerous specimens of this interesting bryozoan occur scattered through the fossiliferous layers of the Borkholm limestone. Here the species was first identified by a thin section which accidentally cut one of the segments. Further search in the rock awarded well-preserved typical examples. Ulrich's description is copied below:

Segments club-shaped, varying in length from less than 1 mm. to nearly 2 mm.; lower half subcylindrical, about 0.23 mm. in diameter, noncelluliferous, covered with fine, granulose, vertical striæ; lower extremity bulbous, smooth; upper half celluliferous, expanding more or less rapidly, the depressed conical top varying in diameter from 0.7 to 2 mm. The apertures of the zoœcia on the top are subcircular; about 0.09

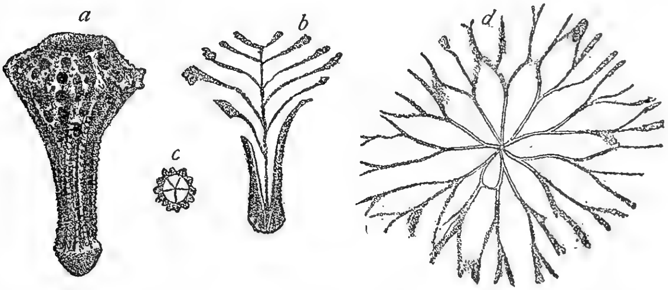

FIG. 74.—SCEPTROPORA FACULA. *a*, SINGLE SEGMENT OF THIS FINE SPECIES, ×18; *b*, VERTICAL SECTION, ×18, THROUGH AN ENTIRE SEGMENT; *c*, TRANSVERSE SECTION, ×18, CUTTING THE LOWER END OF A SEGMENT; *d*, TRANSVERSE SECTION, ×18, THROUGH THE EXPANDED CELLULIFEROUS PORTION. RICHMOND GROUP, STONY MOUNTAIN, MANITOBA. (AFTER ULRICH.)

mm. in diameter and arranged in radial series between raised lines about the large central socket. As the zoarium expands the series increase in number by interpolation. The apertures of the zoœcia on the sides are ovate and a little larger, having an average length of 0.11 mm. Like those on the top, they are arranged between elevated granulose ridges.

None of the arthrostyloid or other Paleozoic bryozoans approaches this species in growth or other characters. The other Russian species of the genus is quite different, as evidenced by a comparison of figures 74 and 75.

Occurrence.—An abundant and highly characteristic fossil of the Richmond group at Stony Mountain, Manitoba, the island of Anticosti, and other Canadian localities, and in the same strata at various localities in the United States, particularly at Wilmington and Savannah, Illinois. Equally abundant in the Borkholm limestone (F2) at Borkholm, Esthonia (Cat. No. 57248, U.S.N.M.).

British Museum, one specimen from the Borkholm limestone at Borkholm, Esthonia.

SCEPTROPORA FRANCISCA, new species.

Text fig. 75.

Zoarium of club-shaped segments bluntly pointed at the proximal end for articulation with the preceding segment. The average individual segment is 4 mm. in length and expands slowly from the basal portion to the distal end which is abruptly rounded and about 2 mm. in diameter. All portions of the segments are cell bearing excepting the extreme base and top, where articulation occurred. The apertures are angular and arranged somewhat irregularly in rows between longitudinal crests formed by the union and greater development of the walls along such lines. Seven zoœcia occur in 2 mm. In some

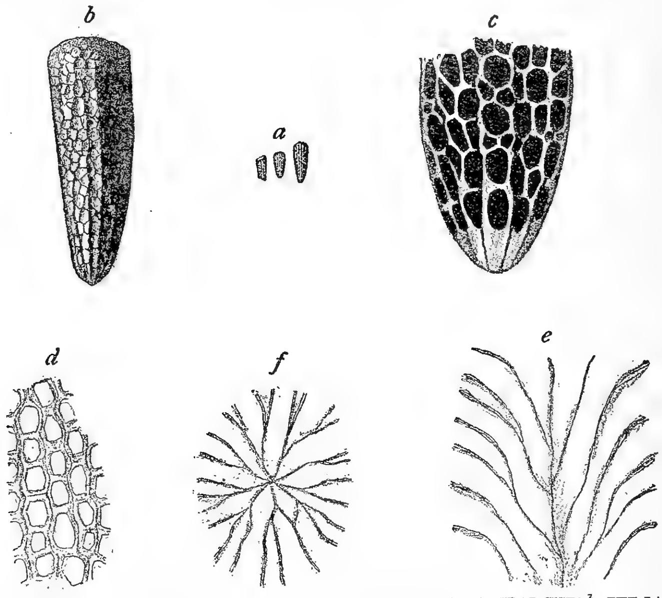

FIG. 75.—SCEPTROPORA FRANCISCA. *a*, GROUP OF THREE SEGMENTS, NATURAL SIZE; *b*, THE LARGEST SEGMENT, ×9; *c*, BASAL PORTION OF THE SAME SPECIMEN, ×20; *d*, TANGENTIAL SECTION, ×20; *e* AND *f*, VERTICAL AND TRANSVERSE SECTIONS, ×20, SHOWING GROWTH OF ZOŒCIA FROM CENTRAL AXIS. WASSALEM-BEDS (D3), UXNORM, ESTHONIA.

specimens certain apertures are small and irregularly angular, giving the appearance of mesopores. These, however, are probably only young zoœcia, for thin sections show no trace of ordinary mesopores.

Aside from the different shape of the segment, vertical sections show little difference from those of the genotype. The zoœcia arise from a distinct central axis marked by a definite line, and proceed to the surface in a gentle curve, the walls as usual becoming thickened in the mature zone. Transverse sections of the two species are identical. In tangential sections the zoœcia are noted to have rather a regular polygonal outline and arrangement in longitudinal rows.

The small, neat segments of *S. francisca* are too distinct from other species of the genus to require comparison. The specific name is in honor of Miss Francisca Wieser, to whom I am indebted for many drawings illustrating this work.

Occurrence.—Not uncommon in the thin limestone layers and in the clays of the Wassalem beds (D3) at Uxnorm, Esthonia.

Cotypes.—Cat. No. 57249, U.S.N.M.

Specimens in the collection of the British Museum.

Genus NEMATOPORA Ulrich.

Nematopora ULRICH, American Geologist, vol. 1, 1888, p. 234; Geol. Surv. Illinois, vol. 8, 1890, pp. 401, 644; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 204; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 281.—SIMPSON, Fourteenth Ann. Rep. State Geol. New York for the year 1894, 1897, p. 553.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 43.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 58.

Numerous specimens of *Nematopora* have been observed in the Russian collections, all of which have proved to belong to species described from North America. The most conspicuous feature of this genus, separating it from the other genera of the Arthrostylidæ, is that the zoarium is continuous and dichotomously branched, with the jointed character either limited to the basal extremity or wanting entirely. The zoœcial characters are evident from the various figures shown on the following pages.

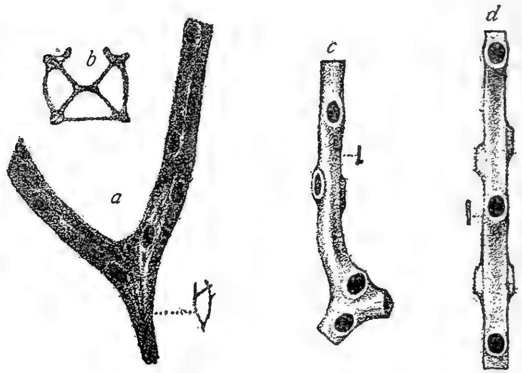

FIG. 76.—NEMATOPORA DELICATULA AND N. CONSUETA. *a*, ZOARIUM NATURAL SIZE AND ×18, OF NEMATOPORA DELICATULA; *b*, TRANSVERSE SECTION OF SAME. GIRARDEAU LIMESTONE DIVISION OF THE RICHMOND GROUP, ALEXANDER COUNTY, ILLINOIS. (AFTER ULRICH.) *c* AND *d*, TWO FRAGMENTS, NATURAL SIZE AND ×18, OF THE TRENTON SPECIMENS REFERRED BY ULRICH TO N. DELICATULA AND HERE RENAMED N. CONSUETA. LOWER PART OF TRENTON LIMESTONE, NEAR CANNON FALLS, MINNESOTA. (AFTER ULRICH.)

Genotype.—*Nematopora ovalis* Ulrich. Middle Ordovician (Trenton) of the United States and Russia.

NEMATOPORA CONSUETA, new name.

Text fig. 76.

Nematopora delicatula ULRICH, Geol. Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 206, pl. 3, figs. 26, 27.

Not *Nematopora delicatula* ULRICH, Geol. Surv. Illinois, vol. 8, 1890, p. 646, pl. 29, figs. 11–11*b*.

The delicate bryozoan for which the above new name is proposed has been confused with a very similar minute species described from rocks at the base of the Cincinnati group in Alexander County, Illinois. These particular strata are now known as the Girardeau limestone and are of Richmond age. The Minnesota specimens identified by Ulrich with *Nematapora delicatula* were found in the Nematopora bed of the lower Trenton. While the specimens in these rather widely separated horizons are quite similar, close comparison reveals sufficient differences to justify their recognition as separate species. The similarity of the two forms is only another example of the close relationship between the Black River, early Trenton, and Richmond faunas, a fact which has been noted at numerous places in this work.

Illustrations of both *Nematopora delicatula* and *N. consueta* are shown in figure 76, and upon comparing them the latter species is found to have apertures slightly larger, more rounded, and a trifle exsert, although a more obvious difference lies in the greater distance between its zoœcial openings.

Occurrence.—The American types of *N. consueta* were found in the Nematopora bed of the lower Trenton near Cannon Falls, Minnesota. In Russia, specimens are not uncommon in the Kuckers shale (C2), Baron Toll's estate, in Esthonia (Cat. No. 57250, U.S.N.M.).

British Museum, one specimen from the Kuckers shale, Baron Toll's estate.

NEMATOPORA OVALIS Ulrich.

Text fig. 77.

Nematopora ovalis Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 197, fig. 21; Geol. Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 204, pl. 3, figs. 24, 25.

Nematopora quadrata Ulrich, Geol. Surv. Illinois, vol. 8, 1890, p. 644, pl. 29, figs 12–12*c*.—Simpson, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 553, figs. 124, 125.

The surface characters of this fine species are so distinct from other forms of *Nematopora* that there should be little difficulty in its identification. Ulrich's diagnosis of the species is concise and applies equally well to the Russian specimens.

Original description.—Zoarium ramose; branches bifurcating at intervals of about 2 mm., 0.3 to 0.4 mm. in diameter, subquadrangular or pentagonal in cross section, each face with a row of zoœcia. Zoœcial apertures direct, very large, oval, nearly 0.3 mm. long by 0.15 mm. wide, inclosed by a sharply defined peristome. A short ridge joins the peristomes of each row of apertures, and longitudinally divides the concave spaces between the ends of the apertures. These spaces are larger in the subquadrate examples than in those having five rows of zoœcia. They also have the thin ridge that bounds each face more distinct from the elevated margins or peristomes of the zoœcial apertures, which, in the pentagonal specimens, to a large extent also form the border of the faces. Longitudinal interspaces generally shorter than the length of the zoœcial apertures; about five of the latter in 2.5 mm.

Occurrence.—The Minnesota types of the species occurred in the Nematopora bed of the early Trenton near Cannon Falls. Specimens from the early Trenton of Trenton Falls, New York, and Montreal, Canada, were described by Ulrich as *Nematopora quadrata*, but fur-

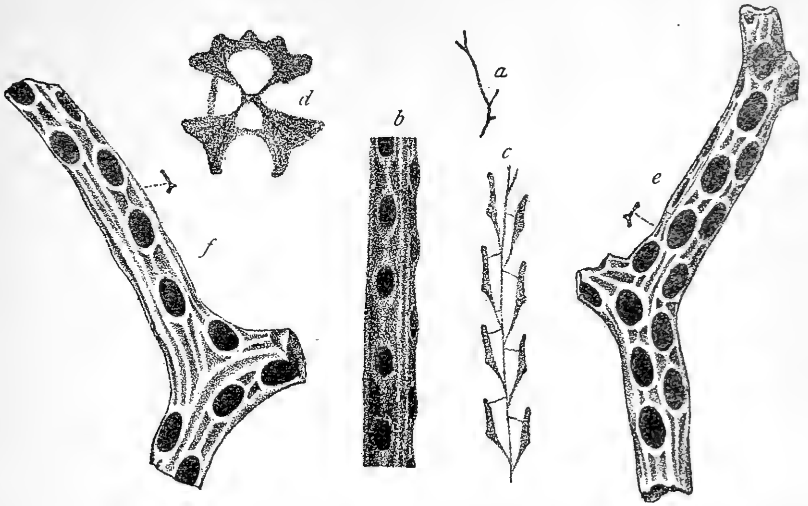

FIG. 77.—NEMATOPORA OVALIS. *a*, ZOARIUM, NATURAL SIZE, OF THE FORM DESCRIBED BY ULRICH AS NEMATOPORA QUADRATA; *b*, PORTION OF THE SAME, ×18; *c*, VERTICAL SECTION, ×18; *d*, TRANSVERSE SECTION, ×50. LOWER PART OF THE TRENTON LIMESTONE, TRENTON FALLS, NEW YORK. *e*, FRAGMENT OF NEMATOPORA OVALIS, NATURAL SIZE, AND ×18, WITH FIVE ROWS OF ZOŒCIA; *f*, ANOTHER FRAGMENT, NATURAL SIZE AND ×18, WITH ONLY FOUR ROWS. LOWER PART OF THE TRENTON, CANNON FALLS, MINNESOTA. (AFTER ULRICH.)

ther research on his part proved their identity with *N. ovalis*. Russian specimens have been found so far only in the Kuckers shale (C2), Baron Toll's estate, Esthonia (Cat. No. 57251, U.S.N.M.).

Represented in the collections of the British Museum by a specimen from the Kuckers shale, Baron Toll's estate.

NEMATOPORA FRAGILIS Ulrich.

Text fig. 78.

Nematopora fragilis ULRICH, Geol. Surv. Illinois, vol. 8, 1890, p. 646, pl. 29, figs. 10–10c.

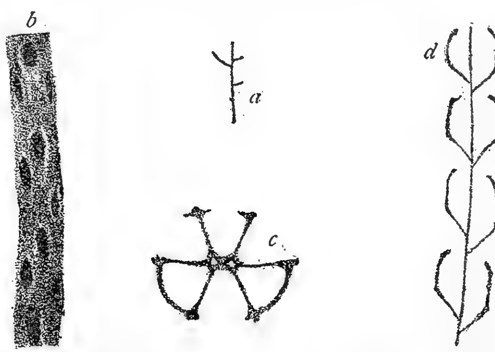

FIG. 78.—NEMATOPORA FRAGILIS. *a*, FRAGMENT, NATURAL SIZE, SHOWING MODE OF BRANCHING; *b*, PORTION OF THE SAME, ×18; *c*, TRANSVERSE SECTION, ×50; *d*, VERTICAL SECTION, ×18. GIRARDEAU LIMESTONE, RICHMOND GROUP, ALEXANDER COUNTY, ILLINOIS. (AFTER ULRICH.)

Zoarium of very slender, dichotomously dividing branches about 0.35 mm. in diameter, with the zoœcia arranged in six longitudinal ranges not separated by a ridge. Seven zoœcia in 4 mm., measuring lengthwise. Apertures ovate, channeled posteriorly with a faint peristome around the sides and front margin, 0.08 mm. wide and 0.16 mm. in length.

Fragments of this characteristic American Richmond species are not uncommon in the collections from the Lyckholm limestone. The delicacy of their branches, as well as the characters noted above, will distinguish these from all associated bryozoans.

Occurrence.—Girardeau limestone division of the Richmond group, Alexander County, Illinois; Lyckholm limestone (F1), Kertel, on the island of Dago, Esthonia (Cat. No. 57252, U.S.N.M.).

British Museum, one specimen from the Lyckholm limestone, Kertel, island of Dago.

NEMATOPORA LINEATA (Billings).

Text fig. 79.

Helopora lineata Billings, Cat. Sil. Foss Anticosti, 1866, p. 36.
Nematopora lineata Ulrich, Geol. Surv. Illinois, vol. 8, 1890, p. 646, pl. 29, figs. 7–7*e*.

Certain thin layers in the lower part of the Anticosti group on the island of Anticosti, Gulf of St. Lawrence, are crowded with fragments of a rather robust species of *Nematopora* described by Billings as *Helopora lineata.* Ulrich has figured the essential external and internal features of the species, referring it to his genus *Nematopora.* Specimens indistinguishable from this *Nematopora* are contained in the solid limestone of the Borkholm formation.

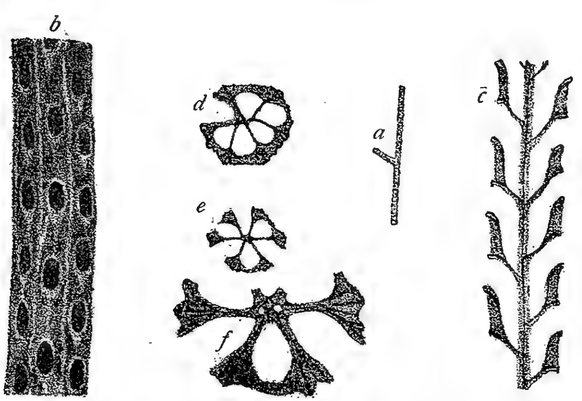

Fig. 79.—Nematopora lineata. *a*, fragment, natural size; *b*, surface of same, ×18; *c*, vertical section, ×18; *d* and *e*, two transverse sections, ×18; *f*, portion of *e*, ×50, showing minute axial canals and wall structure. Richmond division of Anticosti group, island of Anticosti. (After Ulrich.)

Compared with other species of the genus, the branches of *Nematopora lineata* are quite stout, averaging a millimeter in diameter. They are distinctly hexagonal in transverse section on account of the zoœcial arrangement in six rows separated by longitudinal ridges. The lineate appearance given the branch by these ridges is increased by the development of a second ridge, usually connecting the zoœcia. Measuring lengthwise, three and one-half zoœcia occur in 2 mm.

Occurrence.—Common in the Richmond equivalent of the Anticosti group on the island of Anticosti; less abundant in the Borkholm limestone (F2) at Borkholm, Esthonia (Cat. No. 57253, U.S.N.M.). Typical specimens from Anticosti are in the collections of the British Museum.

Genus GLAUCONOME Goldfuss.

Glauconome GOLDFUSS, Petrefacta Germaniæ, 1826, p. 100.—LONSDALE, Murchison's Silurian System, 1839, p. 677.—SHRUBSOLE and VINE, Quart. Journ. Geol. Soc. London, vol. 40, 1884, p. 329.

Penniretepora D'ORBIGNY, Prodr. de Pal., vol. 1, 1850, p. 45.

The Borkholm limestone contains two species of Bryozoa with close relations to *Nematopora* but differing in having one side noncelluliferous. One of these is identical with Billings's *Glauconome strigosa,* from the Anticosti group of Canada, while Wiman has described a second as *Glauconome plumula.* Regarding the standing of the name *Glauconome,* Lonsdale remarks as follows:

Goldfuss has described under the generic name of *Glauconome* five fossils, four of which, according to De Blainville (Man. d'Actinologie, p. 454) and Milne-Edwards (2nd Edit. Lamarck, t. ii, p. 193), belong to the genus *Vincularia,* previously established by De France (Dict. Sc. Nat., tom. lviii, p. 214). The fifth species, common at Dudley, possesses, however, characters essentially different from those of *Vincularia,* and even to those assigned to *Glauconome* by Goldfuss. Instead of the stem being impressed on all sides with rows of cells, it has them over only half the surface, the other half being striated longitudinally. It is probable that the position of the fossil in the matrix prevented that author from detecting the true characters of the coral. For this fossil it has been thought right to retain Goldfuss's name, but a modification in both the generic and specific characters has become necessary. Gen. char.—Stem stony, thin, elongated, oval, branched; cells disposed longitudinally and alternately in rows over one-half the surface, the other half striated longitudinally. Nature of the covering and opening of the cells unknown.

Later work by Vine and Shrubsole led them to suggest that the name *Glauconome* be retained for the *G. disticha* Lonsdale. In 1847 D'Orbigny in his Prodrome de Paleontologie proposed *Penniretepora.* His work on the subject is quoted below:

Penniretepora d'Orb. 1847. Deux rangées de cellules d'un seul côte. Ensemble penniforme, avec une tige et des rameaux libres latéraux.

Lonsdalei d'Orb. 1847. Glauconome disticha, Lonsdale, 1839. In Murch. Silur. Syst., pl. 15, fig. 12d (non Glauconome disticha Gold., 1830), Angleterre, Wenlock-rock.

To sum up, I believe Lonsdale, Vine, and Shrubsole to be correct in recognizing *Glauconome,* for the following reasons. Goldfuss specified no particular type for his genus. Lonsdale was justified, therefore, according to the rules of nomenclature, in adopting *G. disticha,* and in redefining the genus. Although Goldfuss did not figure the noncelluliferous side of *G. disticha,* in fact, did not even recognize it since his specimens were imbedded in the rock, his illustrations and those of Lonsdale are undoubtedly based upon the same species. The new names *Penniretepora* and *Penniretepora lonsdalei* of D'Orbigny are therefore superfluous.

Glauconome, as here recognized, seems to be an undoubted member of the Arthrostylidæ, differing from all other genera of the family in its continuous branching zoarium with the reverse side noncelluliferous. None of the many specimens of *G. disticha* and *G. strigosa* before me shows any evidence of a basal articulation, so that it is probable that the zoarium was attached at the lower end instead of

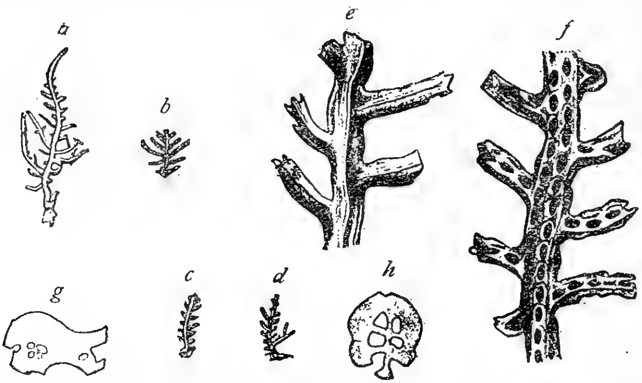

FIG. 80.—GLAUCONOME PLUMULA. *a* TO *d*, FRAGMENTS OF FOUR ZOARIA. *e*, NONCELLULIFEROUS SIDE, ×10; *f*, CELLULIFEROUS FACE, ×10; *g* AND *h*, TWO TRANSVERSE SECTIONS, ×10. BORKHOLM DRIFT, ÖJLE MYR, ISLAND OF GOTHLAND. (AFTER WIMAN.)

jointed. With regard to the distribution of the apertures, *Glauconome* bears the same relation to *Nematopora* that *Arthrostylus* has to *Helopora*.

Genotype.—Glauconome disticha Goldfuss. Silurian of England and Gothland.

GLAUCONOME PLUMULA Wiman.

Text fig. 80.

Glauconome plumula WIMAN, Bull. Geol. Inst. Univ. Upsala, vol. 5, pt. 2, No. 10, 1902, p. 181, pl. 6, figs. 17–24.

This is undoubtedly a typical species of *Glauconome* closely related to the genotype. My material for study consists of a poorly preserved specimen from the Lyckholm limestone, but Wiman's figures clearly indicate the characters and relationship of his species. It need only be compared with *G. disticha* from which it differs, so far as I can judge, only in branching a trifle more regularly and more frequently, and in having slightly smaller zoœcia less regularly arranged. In *G. disticha* the zoœcial apertures are arranged in four regular rows, two on each side of a conspicuous carina. Study of well-preserved specimens of *G. plumula* may show a still closer relationship, in fact possible identity with *G. disticha*.

Occurrence.—Drift, Öjle Myr, island of Gothland; Borkholm limestone (F2), at Borkholm, and Lyckholm limestone (F1), Kertel, on the island of Dago, Esthonia (Cat. No. 57254, U.S.N.M.).

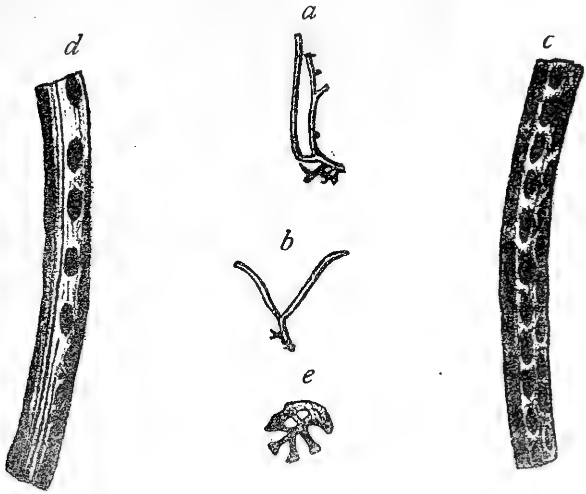

FIG. 81.—GLAUCONOME STRIGOSA. WIMAN'S FIGURES OF THIS SPECIES, DESCRIBED BY HIM AS "SPECIES NO. 1;" *a* AND *b*, TWO FRAGMENTS, NATURAL SIZE; *c*, VIEW, ×10, OF THE CELLULIFEROUS FACE; *d*, SIDE VIEW, ×10, SHOWING THE STRIATED, NONCELLULIFEROUS SIDE AND AN ADJOINING ROW OF ZOŒCIA; *e*, TRANSVERSE SECTION, ×10, ILLUSTRATING THE STRIATED BASAL SIDE AND FOUR ROWS OF ZOŒCIA OPENING ON THE CELLULIFEROUS SIDE. BORKHOLM DRIFT, ÖJLE MYR, ISLAND OF GOTHLAND.

GLAUCONOME STRIGOSA (Billings).

Text fig. 81.

Helopora strigosa BILLINGS, Cat. Sil. Foss. Anticosti, 1886, p. 37.
Nematopora strigosa ULRICH, Geol. Surv. Illinois, vol. 8, 1890, p. 645.
Species No. 1, WIMAN, Bull. Geol. Inst. Univ. Upsala, vol. 5, pt. 2, No. 10, 1902, p. 181, pl. 6, figs. 29–33.

A single well-preserved specimen of *Glauconome* from the Borkholm limestone at Borkholm presents all of the characters seen in the American form described by Billings as *Helopora strigosa.* The American types have not yet been illustrated, but I am basing my identification of the species mainly upon examples in the collection of the United States National Museum which have been compared directly with Billings's described specimen. Wiman's views of his "Species No. 1," herewith reproduced, serve very well for the identification of the species. As seen from them, the zoarium is a narrow, branched stem 0.5 mm. in diameter, with ovate zoœcial apertures arranged in four or five rows, and the remaining portion of the surface noncelluliferous and finely striated. Measuring longitudinally, four zoœcia occur in 2 mm. In cross-section, the zoarium is rounded polygonal in outline, as shown in figure 81 *e*. The zoœcia are about their own length apart longitudinally and the several rows are separated by a poorly developed ridge.

The slender branches with one side noncelluliferous and striated, and the rest of the surface celluliferous, are so distinct from all associated bryozoans that comparisons are unnecessary.

Occurrence.—Abundant in the Richmond division of the Anticosti group on the island of Anticosti, where it is associated with equally numerous specimens of *Nematopora lineata*. Apparently rare in the Borkholm limestone (F2) at Borkholm, Esthonia (Cat. No. 57255, U.S.N.M.), where also it occurs with *Nematopora lineata*. Also in the Borkholm drift, Öjle Myr, island of Gothland.

Family RHABDOMESONTIDÆ Vine.

Species of this family have hitherto not been recorded from strata earlier than the Silurian, so that the occurrence of a new species of *Rhombopora*, and at least one species of a new generic type in the Middle Ordovician, is of considerable interest. The new genus is peculiar in the development of a great number of mesopores, a fact which will cause a slight change in the hitherto published diagnosis of the family.

Genus RHOMBOPORA Meek.

Rhombopora Meek, Pal. Eastern Nebraska, 1872, p. 141.—Etheridge, Ann. and Mag. Nat. Hist., ser. 4, vol. 20, 1877, p. 36.—Vine, Proc. Yorkshire Geol. Polyt. Soc., vol. 8, 1883, p. 105.—Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 7, 1884, p. 26.—Vine, Proc. Yorkshire Geol. and Polyt. Soc., vol. 9, 1885, p. 93.—Foerste, Bull. Sci. Lab. Denison Univ., vol. 2, 1887, p. 71.—Waagen, Mem. Geol. Surv. India, Paleontologia Indica, ser. 13, vol. 1, 1888, p. 963.—Miller, North Amer. Geol. and Pal. 1889, p. 321.—Ulrich, Geol. Surv. Ill., vol. 8, 1890, pp. 402, 647; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 281.—Simpson, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 550.—Grabau, Bull. Buffalo Soc. Nat. Hist., vol. 6, 1899, p. 164.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 43.

In this genus the zoarium consists of solid ramose slender branches with the zoœcial tubes in the vestibular region, thick-walled and with numerous strong acanthopores and smaller spines. The apertures are generally arranged in distinct longitudinal or diagonal lines. The external aperture is oval or circular, and is usually situated at the bottom of a rhombic or hexagonal sloping area.

The following new species is remarkably like the Carboniferous type of the genus, in fact, so far as can be determined from fossil forms, is distinguished only by such minor characters as slight differences in the size and shape of the zoœcia. Still it is believed that this close similarity does not indicate a correspondingly close relationship and that *Rhombopora esthoniæ* is simply an early expression of the general generic type which did not endure.

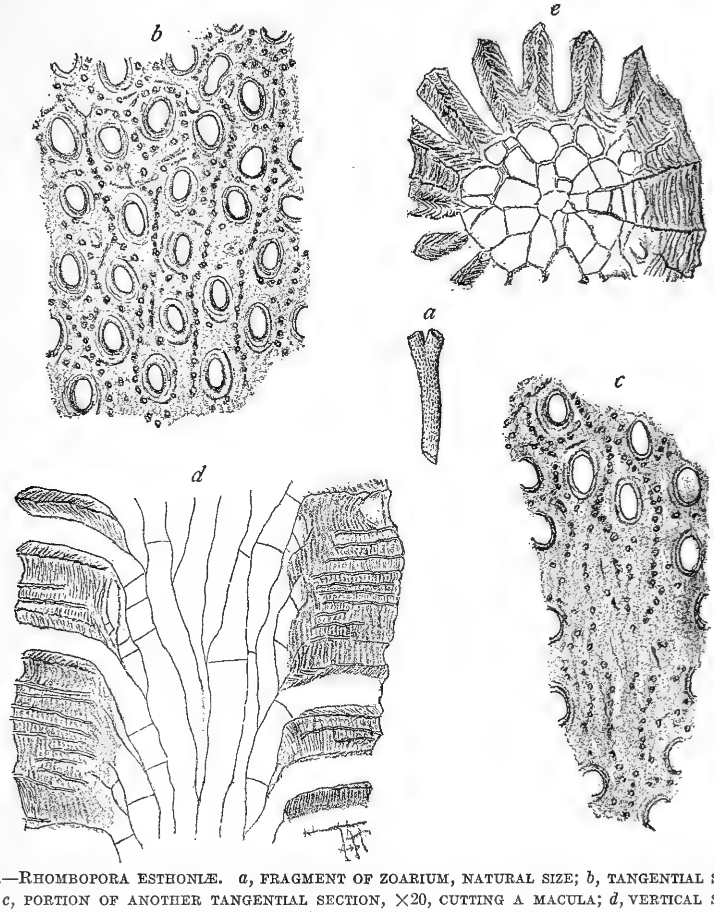

FIG. 82.—RHOMBOPORA ESTHONIÆ. *a*, FRAGMENT OF ZOARIUM, NATURAL SIZE; *b*, TANGENTIAL SECTION, ×20; *c*, PORTION OF ANOTHER TANGENTIAL SECTION, ×20, CUTTING A MACULA; *d*, VERTICAL SECTION, ×20; *e*, TRANSVERSE SECTION, ×20. JEWE LIMESTONE (D1), BARON TOLL'S ESTATE, ESTHONIA.

Genotype.—Rhombopora lepidodendroides Meek. Carboniferous (Upper Pennsylvanian) of the United States.

RHOMBOPORA ESTHONIÆ, new species.

Text fig. 82.

Zoarium a smooth, cylindrical stem, 2 to 3 mm. in diameter, branching dichotomously at intervals of 15 mm. more or less. Zoœcial apertures ovate, averaging 0.20 mm. in length and 0.11 mm. in width, arranged in irregular series, with, however, a tendency to longitudinal rows. Measuring longitudinally, four to five zoœcia in 2 mm., transversely six to seven rows occur in the same distance. Interzoœcial spaces as wide as the apertures and having a carina which carries numerous small spines or acanthopores. Sloping areas about the apertures of variable shape, but usually polygonal with a tendency to hexagonal.

All of the features believed to be seen in thin sections are shown in figure 82 *b* to *e*. Both transverse and vertical sections show that the immature region is composed of thin-walled zoœcia with a few complete diaphragms. In the mature zone the walls thicken greatly and the usual cryptostomatous cell is developed. Tangential sections indicate the oval zoœcia with thick interspaces in which rows of small pores indicate the course of the surface carinæ. The maculæ are composed entirely of such interzoœcial tissue pierced by pores as shown in fig. 82 *c*.

Occurrence.—Somewhat uncommon in the Jewe limestone (D1), Baron Toll's estate, Esthonia.

Holotype.—Cat. No. 57256, U.S.N.M.

One specimen and a thin section of the type are in the collections of the British Museum.

NEMATOTRYPA, new genus.

Zoarium of slender, solid branches composed of long, tubular zoœcia diverging obliquely from a central, thread-like axis. Surface smooth with oval zoœcia arranged in rather regular, longitudinal rows. Interzoœcial space filled by numerous small mesopores open at the surface. Hemisepta and acanthopores or spines as in other members of the family.

Genotype.—*Nematotrypa gracilis,* new species. Middle Ordovician of Russia and Sweden.

The name which has been chosen for this genus has reference to the thread-like central axis from which the zoœcia proceed to open at the surface as so many perforations or apertures. The name will also in part recall *Nemataxis,* another genus of the Rhabdomesontidæ, which is believed to be related. The internal arrangement of the zoœcia is much the same in the two genera, but in *Nemataxis* the interspaces are solid instead of being occupied by open mesopores as in *Nematotrypa.*

The species upon which *Nematotrypa* is based is a very abundant fossil in several of the Middle Ordovician formations of Baltic Russia and Sweden. Fragments from the Lyckholm limestone of the island of Dago, too small for the recognition and description of another form, probably represent another species.

NEMATOTRYPA GRACILIS, new species.

Text fig. 83.

Zoarium, a cylindrical stem varying in diameter from 0.5 to 1.5 mm., occasionally branching dichotomously. Basal portion of zoarium unknown, but probably attached parasitically as in *Rhombopora*. Surface of zoarium smooth but with distinct maculæ of small mesopores at regular intervals. In young specimens the zoœcia are regularly oval and are arranged in distinct longitudinal rows separated by rows of small, elongated mesopores. With age the longitudinal arrangement of both sets of cells becomes less evident and the zoœcial apertures are less regularly oval, while the mesopores

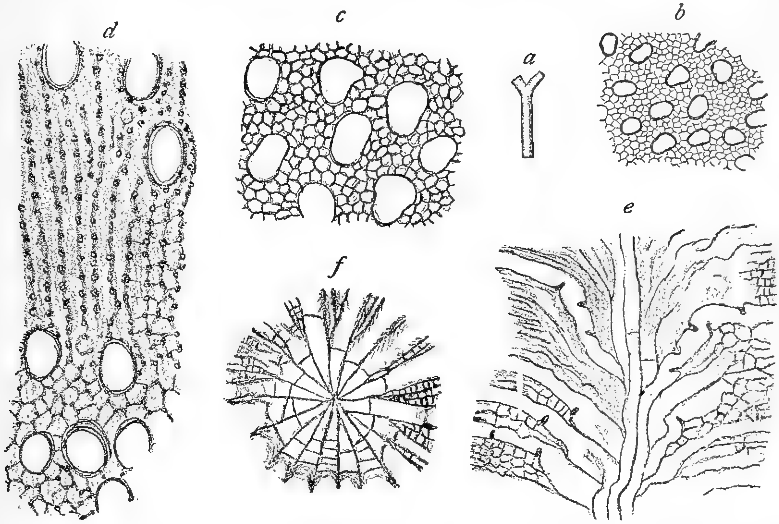

FIG. 83.—NEMATOTRYPA GRACILIS. *a*, FRAGMENT OF ZOARIUM, NATURAL SIZE; *b*, TANGENTIAL SECTION, ×20; *c*, PORTION OF THE SAME, ×40; *d*, TANGENTIAL SECTION, ×50, THROUGH A MACULA AND ADJOINING ZOŒCIA; *e*, VERTICAL SECTION, ×20; *f*, TRANSVERSE SECTION, ×20, SHOWING GROWTH FROM CENTRAL AXIS. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

assume a polygonal shape. The usual zoœcium is 0.16 mm. long and not more than 0.10 mm. wide, with eight or nine in 2 mm., measuring longitudinally. The mesopores are exceptionally small, thin-walled, and in practically every case isolate the zoœcia. In the older zoaria minute granules occur on the cell walls, particularly in the macular areas.

It is difficult to prepare vertical sections showing the characteristic central thread-like axis from which the zoœcial tubes proceed, but transverse sections such as shown in figure 83 *f* exhibit this feature clearly. The noteworthy features of vertical sections are the thin-walled character of the zoœcia in the immature region, the development of an unusual number of small tabulated mesopores in the mature zone, and the occurrence of several distinct sets of inferior and superior hemisepta in the same region of the zoœcia. Views of a tangential section under several magnifications are given in figures 83 *b* and *c*, while in figure 83 *d* the structure of a macular area with its neighboring zoœcia is shown. The latter section was prepared from an old example in which the small pores or granules are well developed. Here also the mesopores forming the macular area have been partially closed by a dense tissue.

Externally *Nematotrypa gracilis* can readily be distinguished from other Ordovician bryozoans by its slender branches of small, oval zoœcia, isolated by exceedingly minute and numerous thin-walled angular mesopores. The internal features are too different to require comment.

Occurrence.—A common fossil of the Kuckers shale (C2), Baron Toll's estate, Esthonia, where the types were found. Other formations and localities are the Jewe limestone (D1), Baron Toll's estate, the Echinospherites limestone (C1), 4 miles east of Reval, and the Chasmops li estone, near Bödahamn, on the island of Oeland.

Cotypes.—Cat. Nos. 57258, U.S.N.M.

Specimens and thin sections from the Kuckers shale, Baron Toll's estate, and from th Chasmops limestone, island of Oeland, are in the British Museum.

Family RHINOPORIDÆ Ulrich.

A single genus and species of this rather unique family is present in the Russian faunas under study. In a former publication [1] I have pointed out the following characters for the family, which may in some respects be considered one of the simplest divisions of the Cryptostomata.

> Zoarium variable in form; zoœcia prone along the basal membrane, simple, oblong, or rhomboidal; vestibules direct, hemisepta wanting or almost so; front of zoœcia below vestibule commonly strengthened with solid or vesicular tissue.

Genus LICHENALIA Hall.

Lichenalia Hall, Amer. Journ. Sci., ser. 2, vol. 11, 1851, p. 401; Nat. Hist. New York, Pal., vol. 2, 1852, p. 171.—Bassler, Bull. 173, U. S. Geol. Surv., 1900, pp. 54, 299; Bull. 292, U. S. Geol. Surv., 1906, p. 60.

In the search for bryozoans in the solid limestones of the Borkholm formation numerous thin, epithecated, subcircular expansions were encountered in a more or less fragmentary state while breaking the rock. These at once recalled the very similar expansions occurring in the Niagaran (Rochester) shales of western New York and designated by Hall as *Lichenalia concentrica*. Upon the preparation of numerous thin sections and a study of microscopic characters this surmise was found to be correct, for no differences of any specific

[1] The Bryozoan Fauna of the Rochester Shales, Bull. 292, U. S. Geol. Surv., 1906, p. 59.

value could be found between these Borkholm specimens and those from the Niagaran in America.

Numerous epithecated bryozoans from various localities have been registered as *Lichenalia concentrica*, because Hall's description and

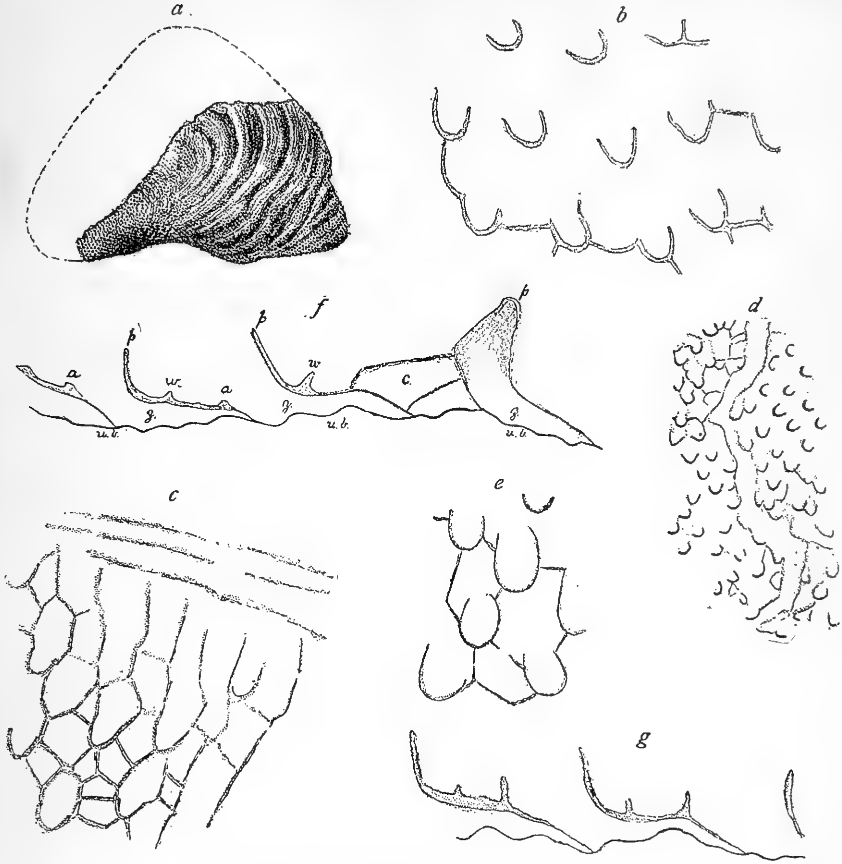

FIG. 84.—LICHENALIA CONCENTRICA. *a*, EPITHECAL SIDE OF A FRAGMENTARY SPECIMEN. BORKHOLM LIMESTONE, BORKHOLM, ESTHONIA; *b*, PORTION OF A TANGENTIAL SECTION, ×20, CUTTING THE HIGH ANTERIOR END OF THE PERISTOME AND A FEW OF THE CONNECTING WALLS; *c*, A TANGENTIAL SECTION, ×20, PASSING THROUGH A LOWER PORTION OF THE ZOARIUM THAN IN *c*. THE LOWER PORTION OF THE FIGURE ILLUSTRATES THE ZOŒCIA AND MESOPORE-LIKE STRUCTURE OF THE MATURE REGION, THE MIDDLE PORTION, THE OBLONG OR RECTANGULAR SHAPE OF THE ZOŒCIA IN THE IMMATURE ZONE, WHILE IN THE UPPER PART OF THE DRAWING ARE SHOWN PORTIONS OF THE CONCENTRIC RINGS OF THE EPITHECA; *d*, A TANGENTIAL SECTION, ×6, PASSING CLOSE TO THE SURFACE OF THE ZOARIUM AND CUTTING ONE OF THE MEANDERING CANALS; *e*, A PORTION OF A TANGENTIAL SECTION, ×20, ILLUSTRATING THE NATURE OF THE WALLS OF THE MESOPORE SPACES; *f*, A VERTICAL SECTION, ×20, ILLUSTRATING THE FOLLOWING CHARACTERS: *z*, THE ZOŒCIA; *c*, ONE OF THE CANALS, COVERED ABOVE; *ub*, UNDULATING BASE OF ZOARIUM; *w*, WALLS FORMING THE MESOPORE-LIKE SPACES; *p*, THE EXTREMELY HIGH POSTERIOR PORTION OF THE PERISTOME; *a*, THE LOW ANTERIOR PORTION OF THE PERISTOME; AND *p'*, A POSTERIOR PORTION OF THE PERISTOME CUT OBLIQUELY; *g*, A MORE DIAGRAMMATIC VERTICAL SECTION, ×20, SHOWING ESPECIALLY THE LOW AND HIGH PORTIONS OF THE PERISTOME AND THE WALLS OF THE INTERZOŒCIAL SPACES. ROCHESTER SHALE, LOCKPORT, NEW YORK. (AFTER BASSLER.)

figures applied only to the basal portion of these subcircular expansions and gave no idea at all of the surface or internal characters. More detailed characters of the genus were not published until 1906,[1]

[1] Bull. 292, U. S. Geol. Surv., 1906.

when I had the opportunity of studying Hall's original types and of determining the generic characters to be as follows: Zoarium a subcircular, unilaminar expansion; zoœcia prostrate; elongate-subrhomboidal, with erect, subtubular vestibules; apertures rounded with peristome much elevated on the posterior side; interspaces depressed; surface traversed by slender, bifurcating ridges which thin sections show to be in reality closed canals.

This peculiar type of structure is represented by a single species, which, however, from its specific peculiarities is easily recognized.

Genotype.—*Lichenalia concentrica* Hall. Silurian of North America and Russia.

LICHENALIA CONCENTRICA Hall.

Text fig. 84.

Lichenalia concentrica Hall, Nat. Hist. New York, Pal., vol. 2, 1852, p. 171, pl. 40E, figs. 5*a–g*.—Bassler, Bull. 292, U. S. Geol. Surv., 1906, p. 61, pl. 22, figs. 1–6; pl. 26, figs. 7–10.

As this is the genotype and only valid species of the genus, the specific characters are as given above. The thin, unilaminate zoaria, large zoœcia (averaging 0.5 mm. in their longer diameter), and the meandering surface canals, are characters making the species easily recognized. None of the Borkholm specimens shows any portion but the epithecated base, because in breaking the limestone this portion, being smooth, parts most readily. These epithecated expansions differ in nowise from the same portion of other explanate bryozoans, so that specimens must be either sectioned or smoothed down and etched to get a view of the internal and surface characters before they can be recognized specifically. Figure 84*a* represents the usual fragmentary specimen characteristic of the Borkholm, while figures 84*b* to *g* illustrate the internal structure of American specimens in some detail. The microscopic structure is so unusual that there is little danger of misidentifying the species.

Occurrence.—A characteristic species of the early Niagaran rocks in America; common in the Borkholm limestone (F2) at Borkholm, Esthonia.

Plesiotype.—Cat. No. 57261, U.S.N.M.

Represented in the collections of the British Museum by specimens from the Borkholm limestone, Borkholm.

Family PHYLLOPORINIDÆ Ulrich.

Zoarium branching; branches free or anastomosing, celluliferous on one side only, the other side striated; zoœcia more or less tubular, often with diaphragms; hemisepta wanting.

Both of the two genera referred to this family are represented in the Russian and Swedish deposits.

Genus CHASMATOPORA Eichwald.

Chasmatopora EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 370.

Phylloporina (Ulrich) FOERSTE, Bull. Sci. Lab. Denison University, vol. 2, 1887, p. 150.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 399, 639; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 208; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 283.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 37.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 48.

Subretepora D'ORBIGNY, Prodr. de Pal., vol. 1, 1850, p. 22.—MILLER, North Amer. Geol. and Pal., 1889, p. 326.

Intricaria HALL, Nat. Hist. New York, Pal., vol. 1, 1847, p. 77.—MILLER and DYER, Contr. Pal., No. 2, 1878, p. 7.

The generic type to which this name was first applied was best described under the name of *Phylloporina* by Ulrich, but it seems to me that the earlier designation *Chasmatopora* has the best right to recognition. The facts in the case are as follows:

In 1860 Eichwald proposed the new genus *Chasmatopora*, giving a fair description for that date, and basing the genus upon a single species, *C. tenella*, which he compared with Hall's *Retepora angulata*, from the Clinton group, of New York. His figure of *C. tenella*, although far from present standards, is sufficient to show that his type-specimen was an angular meshed form closely related to Hall's species. Collections from the Borkholm limestone show numerous examples of such a species, and I have little doubt that this is the form Eichwald had in mind.

D'Orbigny's *Subretepora* was based upon the well-known, widely distributed form *Intricaria reticulata* Hall, but the author of this generic name relied upon Hall's faulty descriptions and figures for his definition. The result was that *Subretepora* was incorrectly defined, and for that reason Ulrich proposed the new name *Phylloporina.*

As pointed out by Ulrich, several distinct types of structure are included in *Phylloporina*. It is therefore probable that with more study both *Phylloporina* and *Chasmatopora* may be recognized.

In *Chasmatopora* the zoarium is of irregularly anastomosing branches with two to eight rows of apertures on one side and the other side noncelluliferous but striated.

Genotype.—*Chasmatopora tenella* Eichwald. Earliest Silurian of Russia.

CHASMATOPORA TENELLA (Eichwald).

Text fig. 85.

Retepora tenella EICHWALD, Schichtensyst. von Esthland, p. 207; Urwelt Russlands, vol. 2, 1842, p. 47, pl. 1, fig. 7.

Chasmatopora tenella EICHWALD, Bull. de la Soc. Nat. Moscou, 1855, No. 4, p. 460; Lethæa Rossica, vol. 1, 1860, p. 371.

Cfr. *Retepora angulata* HALL, Nat. Hist. New York, Pal., vol. 2, 1852, p. 49, pl. 19, figs. 3*a–h*.

As indicated under the generic remarks, *C. tenella* is based upon a very common Borkholm limestone species quite similar to Hall's *Retepora angulata.* This similarity is so great that had the Russian specimens been derived from the American Clinton deposits holding Hall's species they would probably have been identified as the same. However, until a detailed study of all the species of *Chasmatopora* and related genera has been made, I prefer to regard *C. tenella* as distinct, recognizing, as did Eichwald, this great similarity.

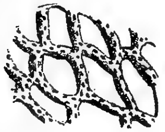

FIG. 85.—CHASMATOPORA TENELLA. CELLULIFEROUS FACE ENLARGED. "CALCAIRE À ORTHOCERATITES," BALTISCHPORT, ESTHONIA. (AFTER EICHWALD.)

The fenestrules of *C. tenella* are quite regularly angular in outline and average 2.5 mm. in length by 1.0 mm. in width. Eichwald's figure (fig. 85) shows this angularity and also indicates the number of zoœcial apertures. The noncelluliferous side is longitudinally striated.

Occurrence.—Eichwald registers this species from the island of Dago, and from Baltischport and Spitham, Esthonia. Specimens are abundant in the Borkholm limestone (F2) at Borkholm, Esthonia (Cat. No. 57263, U.S.N.M.).

The collections of the British Museum contain specimens and thin sections from the Borkholm limestone, Borkholm.

CHASMATOPORA RETICULATA (Hall).

Text fig. 86.

Intricaria? reticulata HALL, Nat. Hist. New York, Pal., vol. 1, 1847, p. 77, pl. 26, figs. 8 *a–c*.

Subretepora reticulata MILLER, North Amer. Geol. and Pal., 1889, p. 326, fig. 524.

Phylloporina reticulata ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 332, 639, pl. 53, figs. 2, 2 *a;* Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 210, pl. 4, figs. 8–15.

A number of specimens indistinguishable from the types of this interesting bryozoan have been found in the Wassalem beds at Uxnorm where they are associated with numerous other American Black River species. The following description and text figure, copied from Ulrich, will serve equally for the recognition of the Russian specimens:

Specimens as seen, consisting of small, flat or undulating, reticulate expansions, being in each case evidently fragments of a depressed, funnel-shaped zoarium, probably not exceeding 5 cm. in diameter. Branches rounded in section, 0.2 to 0.3 mm. in diameter, inosculating at unusually frequent and regular intervals. Fenestrules somewhat elongate, about as wide as the branches, subrhomboidal in shape in the more regularly constructed fragments; their number in a given space is fairly constant, the extremes noticed in 1 cm. being ten and twelve. Reverse of branches convex, finely striated lengthwise.

Obverse strongly convex, with three rather irregular rows of zoœcia, their apertures subcircular, with a distinct peristome, about 0.1 mm. in diameter, eight or nine in 2 mm. Acanthopores abundant, irregularly distributed, rather large, especially so in the earliest forms of the species. Interspaces slightly concave, occasionally faintly pitted and striated.

In tangential sections the zoœcia are rather short, with a row on each side directed obliquely outward, and one series between them. The latter are wedge-shaped, and in deep sections appear as a more or less narrow central space. Diaphragms, one in each tube, have been observed.

Occurrence.—The American specimens are from the Black River and early Trenton, at various localities in New York, Vermont,

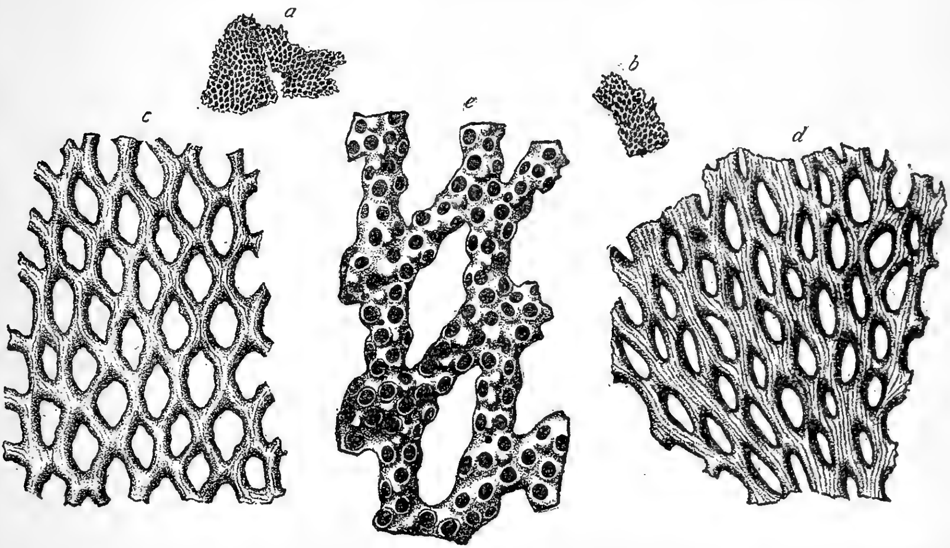

FIG. 86.—CHASMATOPORA RETICULATA. ULRICH'S FIGURES OF PHYLLOPORINA RETICULATA, *a* AND *b*, TWO FRAGMENTS, NATURAL SIZE, EXPOSING THE REVERSE SIDE; *c*, PORTION OF *b*, ×9; *d*, PORTION OF *a*, ×9, SHOWING BROADER BRANCHES; *e*, CELLULIFEROUS SIDE OF A FRAGMENT, ×18. BLACK RIVER (DECORAH) SHALES, MINNEAPOLIS, MINNESOTA.

Minnesota, and Canada. Not uncommon in the Wassalem beds (D3) at Uxnorm, Esthonia (Cat. No. 57262, U.S.N.M.).

Represented in the collections of the British Museum by specimens from American localities.

CHASMATOPORA FURCATA (Eichwald).

Plate 12; text fig. 87.

Polypora furcata EICHWALD, Bull. Soc. Nat. Moscou, No. 1, 1854, p. 89; No. 4, 1855, p. 451; Lethæa Rossica, vol. 1, 1860, p. 378, pl. 23, fig. 11*a*, *b*.

Eichwald's figures of this species show its characters in sufficient detail to cause its recognition easy. Its diagnostic features are, first, the large size of the fenestrules, and, second, the conspicuous grano-lineate ornament of the noncelluliferous side. The other Russian species of the genus are too different to require comparison, but in America certain undescribed Black River forms are closely selated. As shown on plate 12, the zoarium is a flabelliform expantion consisting of slender inosculating branches averaging 0.3 mm. in width. The fenestrules are large and elongate, generally two or three times longer than wide. Measuring lengthwise, four fenestrules occur in 1 centimeter.

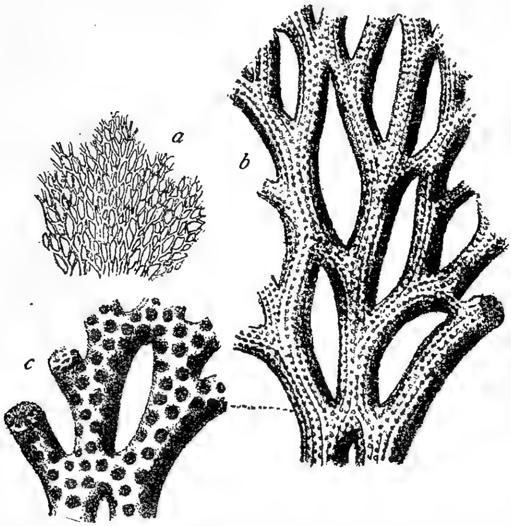

FIG. 87.—CHASMATOPORA FURCATA. EICHWALD'S VIEWS OF POLYPORA FURCATA. *a*, ZOARIUM, NATURAL SIZE; *b*, AN ENLARGEMENT OF THE NONPORIFEROUS SIDE, SHOWING DISTINCT ROWS OF PAPILLÆ; *c*, CELLULIFEROUS FACE ENLARGED. "SCHISTE INFLAMMABLE ARGILEUX," ERRAS, ESTHONIA.

Occurrence.—Eichwald's types were obtained from "le schiste inflammable argileux" at Erras. The species is quite abundant in the Kuckers shale (C2), Baron Toll's estate, near Jewe, Esthonia.

Plesiotype.—Cat. No. 57264, U.S.N.M.

The collections of the British Museum contain specimens and thin sections from the Kuckers shale (C2), Baron Toll's estate.

Genus PSEUDOHORNERA Roemer.

Pseudohornera ROEMER, Leth. geog., Leth Pal., vol. 1, Atlas, 1876, expl. pl. 12.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 49.

Drymotrypa ULRICH, Geol. Surv. Illinois, vol. 8, 1890, p. 309.—MILLER, North. Amer. Geol. and Pal., First Appendix, 1892, p. 684.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 235.

Thamnocella SIMPSON, Fourteenth Ann. Rep. State Geol. New York for 1894, 1897, p. 525.

This genus is best known under the name of *Drymotrypa*, to which practically all of its species have been referred, but *Pseudohornera* must be retained since it, as well as *Drymotrypa*, was founded upon the same species, Hall's *Retepora diffusa*.

The zoarium in *Pseudohornera* is of dichotomously dividing branches celluliferous on one side and longitudinally striated on the reverse. The zoœcia are in several ranges and spring from a thin double plate, beneath which is a number of vesicles; the vestibules expand from the orifice to the angular apertures.

Genotype.—*Retepora diffusa* Hall. Niagaran of New York and Canada.

PSEUDOHORNERA BIFIDA (Eichwald).

Plate 8, fig. 5; plate 12; text figs. 88, 89, 90.

Thamniscus bifidus EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 386, pl. 23, fig. 17 *a*, *b*.

Eichwald's figures of this species, shown in text figure 88, are scarcely enough to make its identification certain, but the fact that he records his type-specimens from Erras, Esthonia, and that he compares the species with Hall's *Retepora* (now *Pseudohornera*) *diff* , led me to regard my conception of the form as correct. From the various figures given here in the text and on the plate, there should be little difficulty in recognizing *Pseudohornera bifida*. Most of the specimens are imbedded in the rock and show only the noncelluliferous side, but one example was found exhibiting the celluliferous surface in a good state of preservation. A view of this is presented on plate 8.

FIG. 88.—PSEUDOHORNERA BIFIDA. EICHWALD'S VIEWS OF THAMNISCUS BIFIDUS. *a* AND *b*, ZOARIUM, NATURAL SIZE, SHOWING THE NONCELLULIFEROUS SIDE, AND PORTION OF THE SAME, ENLARGED. "CALCAIRE À ORTHOCERATITES," ERRAS, ESTHONIA.

The rather regularly bifurcating branches, the fine, grano-lineate ornamentation of the noncelluliferous side and the rather numerous

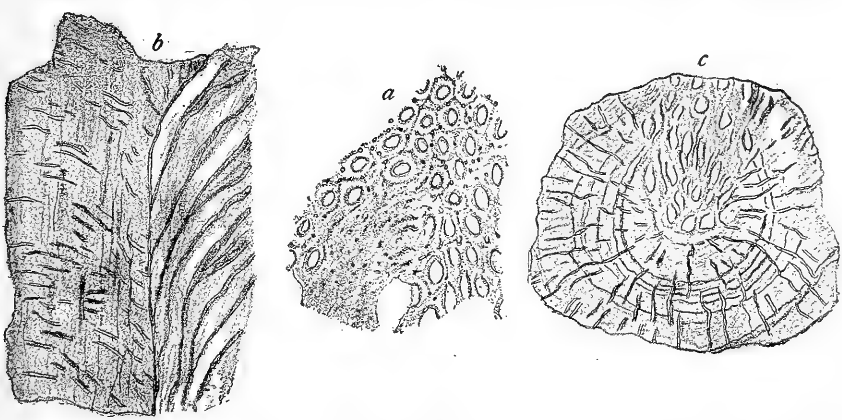

FIG. 89.—PSEUDOHORNERA BIFIDA. *a*, TANGENTIAL SECTION, ×20, OF AN OLD EXAMPLE SHOWING THICK-WALLED, ANGULAR ZOŒCIA; *b*, VERTICAL SECTION, ×20, EXHIBITING THE THICK, SOLID, NONPORIFEROUS SIDE PIERCED BY MINUTE TUBULI, AND THE SHAPE OF THE ZOŒCIA; *c*, TRANSVERSE SECTION, ×20. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

rows of longitudinally arranged zoœcia on the celluliferous face, are characteristic of the species.

Occurrence.—Eichwald records his types from the Ordovician at Erras, Esthonia. Localities represented in the United States National Museum's collection are the Kuckers shale (C2), Baron Toll's estate, near Jewe; the Wassalem beds (D3), at Uxnorm; and the Wesenberg limestone (E) at Wesenberg, Esthonia.

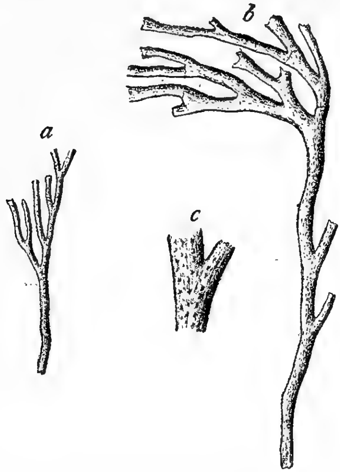

FIG. 90.—PSEUDOHORNERA BIFIDA. *a*, AN ORDINARY SPECIMEN, NATURAL SIZE; *b*, NONCELLULIFEROUS SIDE OF A LARGER, MORE COMPLETE ZOARIUM, ×2; *c*, SURFACE OF SAME, ×4. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

Plesiotypes.—Cat. Nos. 57265, 57266, 57267, U.S.N.M.

Specimens from the Wassalem beds (D3), Uxnorm, and the Kuckers shale (C2), Baron Toll's estate, are in the collection of the British Museum.

PSEUDOHORNERA OROSA (Wiman).

Text g. 91.

Thamniscus orosus WIMAN, Bull. Geol. Inst. Univ. Upsala, vol. 5, pt. 2, 1902, p. 181, pl. 6, figs. 8–11.

This species is known to me only from Wiman's description and figures, the latter being here reproduced. Judging from these, his *Thamniscus orosus* is a typical *Pseudohornera*, differing from other species of the genus in its frequently bifurcating zoarium, in the presence of large oval but few apertures on the celluliferous side, and the distinct crest dividing the noncelluliferous side longitudinally.

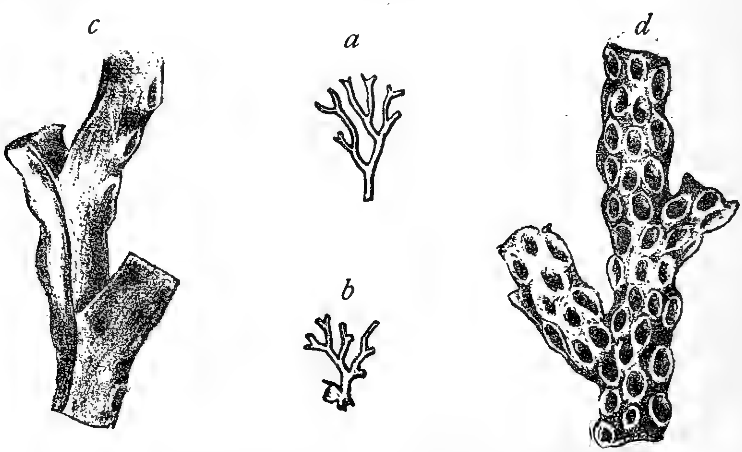

FIG. 91.—PSEUDOHORNERA OROSA. WIMAN'S VIEWS OF HIS SPECIES THAMNISCUS OROSUS; *a* AND *b*, TWO VIEWS, NATURAL SIZE, OF THE MANY-BRANCHED ZOARIUM; *c*, NONCELLULIFEROUS SIDE OF A SPECIMEN, ×10; *d*, CELLULIFEROUS SURFACE, ×10. BORKHOLM DRIFT, ÖJLE MYER, ISLAND OF GOTHLAND.

Occurrence.—Drift of the Borkholm limestone at Öjle Myr, island of Gothland.

Family FENESTELLIDÆ King.

But a single species of this prolific group of post-Ordovician Paleozoic Bryozoa has been recorded from the Russian strata under study. This is a species of the genus *Fenestella* which Eichwald has recorded from the dolomitic limestone at Borkholm. In America the corresponding strata have also afforded a single representative of the same genus.

Genus FENESTELLA Lonsdale.

Fenestella LONSDALE, Murchison's Silurian System, 1839, p. 677.—EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 356.—SHRUBSOLE, Quart. Journ. Geol. Soc. London, vol. 37, 1881, p. 179.—ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 150.—HALL and SIMPSON, Nat. Hist. New York, Pal., vol. 6, 1887, p. xxii.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 395, 534.—POCTA, Syst. Sil. Centre Boheme, vol. 8, pt. 1, 1894, p. 40.—ULRICH, Zittel's Textbook Paleontology (Eng. ed.), 1896, p. 281.—SIMPSON, Fourteenth Ann. Rep. State Geologist of New York, for the year 1894, 1897, p. 500.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, pp. 37, 244.—CONDRA, Nebraska Geol. Surv., vol. 2, pt. 1, 1903, p. 49.—HENNIG, Archiv fur Zool., K. Sven. Vet.-Akad. Stockholm, vol. 3, No. 10, 1906, p. 1.

Fenestrella (error) D'ORBIGNY, Prodr. de Pal., vol. 1, 1850, p. 44.

Actinostroma YOUNG and YOUNG, Quart. Journ. Geol. Soc. London, vol. 30, 1874, p. 681.—VINE, Proc. Yorkshire Geol. Polyt. Soc., vol. 9, 1885, p. 84.

Flabelliporina SIMPSON, Thirteenth Ann. Rep. State Geol. New York for the year 1893, 1895, pp. 703, 724; Forty-seventh Ann. Rep. New York State Mus., 1895, pp. 897, 918; Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 521.

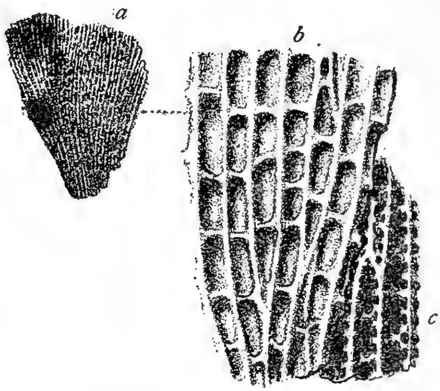

FIG. 92.—FENESTELLA STRIOLATA. *a*, ZOARIUM, NATURAL SIZE; *b*, NONPORIFEROUS SIDE ENLARGED; *c*, SMALL PORTION OF PORIFEROUS SIDE, ENLARGED. EARLY SILURIAN OF BALTIC RUSSIA. (AFTER EICHWALD.)

Zoarium flabellate or funnel shaped, celluliferous on the inner side; branches generally straight, sometimes flexuous, connected at regular intervals by dissepiments; apertures in two rows, separated by a plain or tuberculated median keel.

Genotype.—*Gorgonia antiqua* McCoy. Accepted genotype *F. plebeia* McCoy. Carboniferous of Europe.

FENESTELLA STRIOLATA Eichwald.

Text fig. 92.

Fenestella striolata EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 357, pl. 23, figs. 2*a–c*.

No specimens of this species have come to light in the collections I have studied, but as Eichwald registers the species from Borkholm in rocks most probably of Borkholm age, I have introduced the species as a member of this fauna. As will be seen from the accompanying figure, *F. striolata* is quite a typical *Fenestella,* differing but little from a number of middle Silurian forms which might be mentioned. Indeed, it is possible that Eichwald's figured type was derived from younger rocks than the Borkholm limestone, since he also registers the species from "le calcaire siliceux à Pentameres de Talkhof en Livonie." However this may be, I feel reasonably certain that the genus *Fenestella* in Europe begins in the Lyckholm or Borkholm limestone, and for the present will recognize *F. striolata* as a Borkholm species. As the Borkholm fauna contains so many species in common with the Richmond group of North America, which holds a neat *Fenestella* described by Whitfield as *F. granulosa,* it is possible that *Fenestella striolata* has more relationship with the American form than at present supposed.

Occurrence.—Silurian at Talkhof in Livonia, and at Borkholm, Esthonia.

Order TREPOSTOMATA Ulrich.

Trepostomatous Bryozoa usually form so large a part of the collections from American Ordovician horizons that, in number of specimens at least, species of this order seem to make up the greater part of a fauna. This is equally true for the various Baltic Ordovician formations, indeed, certain limestone layers, such as those in the Wassalem beds (D3), are literally one mass of ramose and other bryozoans. As will be seen from the following pages, a fairly large fauna of Trepostomata has been determined, but I am confident that careful collecting with the Bryozoa particularly in mind will bring to light many more species. The Trepostomata, which include nearly all of the forms classed frequently under the general term "monticuliporoids," have been the occasion of some discussion with reference to their systematic position. Without entering into detail at the present time, I still believe that all of the evidence favors their position in the classification as a well-defined order of Bryozoa rather than an aberrant division of the Anthozoa.

The division Trepostomata was established by Ulrich as a suborder to include the majority of the Paleozoic Bryozoa. The principal peculiarity of the division, now ranked as an order, was the fact that at a certain point in the course of the tubes to the surface they change their character entirely. This change occurs at the beginning of the peripheral or mature zone of the zoarium and consists of the development of mesopores, acanthopores, more numerous diaphragms, opercula, and similar structures of the more mature zooid. In the axial or immature portion of the tubes the walls are simple, thin, and prismatic, with diaphragms few or wanting. The occurrence of clusters of mesopores, or of cells larger than the average, at regular intervals among the zoœcia is another characteristic of the order, although this feature is not confined exclusively to the Trepostomata.

Although under the original definition of the Trepostomata the change in the character of the zoœcial tubes as they pass from the simple immature stage to the more highly organized mature zone was the most distinctive character, it must be remembered that the Paleozoic Ceramoporidæ and Fistuliporidæ and the more recent Cerioporidæ have this same feature. In the latter families other features, particularly their minutely porous wall structure, ally them more closely to the Cyclostomata.

Ulrich and Bassler, in their "Revision of the Paleozoic Bryozoa," [1] have proposed two divisions of the Trepostomata based upon the minute structure of the walls separating adjoining zooids. Of the seven families now recognized under the Trepostomata, four have the calcareous investment of adjoining zoœcia amalgamated together so that one wall can not be distinguished from its neighbor. In the remaining three families the walls retain their duplex character, and when the zoœcia are adjacent their boundaries are marked by a dark, divisional line. This line in all probability represents the fossilized remains of animal matter which filled this space during the life of the organism. Occasionally this narrow, intervening area is occupied by a light-colored tissue, and in this case the outer boundaries of the walls of each zoœcium can be seen. In certain genera of both divisions the amalgamation or the distinct character of the walls is difficult to determine, especially when mesopores are numerous, but if the zoœcia are in actual contact there is little trouble in deciding the position of the particular form under study.

Following is a classification of the Ordovician and early Silurian genera, with the genera common to the American and Baltic deposits marked by an asterisk, and those restricted to the latter by a double asterisk:

Division AMALGAMATA Ulrich and Bassler.

Trepostomata in which the boundaries of adjacent zoœcia are obscured by the more or less complete amalgamation of their walls:

Family MONTICULIPORIDÆ Nicholson (emended Ulrich).

Monticulipora D'Orbigny.
Orbignyella Ulrich and Bassler.
Atactoporella Ulrich.
Peronopora Nicholson.
Homotrypa Ulrich.
Homotrypella Ulrich.
Prasopora Nicholson and Etheridge.
Mesotrypa Ulrich.
Aspidopora Ulrich.

[1] Smithsonian Miscellaneous Collections, vol. 47, 1904, pp. 15–55.

Family HETEROTRYPIDÆ Ulrich.

Heterotrypa Nicholson.
Dekayella Ulrich.
Cyphotrypa Ulrich and Bassler.
Dekayia Edwards and Haime.
Petigopora Ulrich.
Leptotrypa Ulrich.
Atactopora Ulrich.
Stigmatella Ulrich and Bassler.

Family CONSTELLARIIDÆ Ulrich.

Constellaria Dana.
Stellipora Hall.
Nicholsonella Ulrich.
Idiotrypa Ulrich.
Dianulites Eichwald.

Family BATOSTOMELLIDÆ Ulrich.

Bythopora Miller and Dyer.
Eridotrypa Ulrich.
Lioclema Ulrich.
Lioclemella Foerste.
**Orbipora* Eichwald.
**Esthoniopora*, new genus.

Division INTEGRATA Ulrich and Bassler.

Trepostomata in which the boundaries of adjoining zoœcia are sharply defined by a black divisional line:

Family AMPLEXOPORIDÆ Ulrich and Bassler.

Amplexopora Ulrich.
Monotrypella Ulrich.
Rhombotrypa Ulrich and Bassler.
Petalotrypa Ulrich.

Family HALLOPORIDÆ, new name.

Hallopora, new name.
Calloporina Ulrich and Bassler.
Calloporella Ulrich.

Family TREMATOPORIDÆ Ulrich.

Trematopora Hall.
Batostoma Ulrich.
Stromatotrypa Ulrich.
Anaphragma Ulrich and Bassler.
Hemiphragma Ulrich.
**Dittopora* Dybowski.
Diplotrypa Nicholson.
Monotrypa Nicholson.

Division AMALGAMATA Ulrich and Bassler.

Family MONTICULIPORIDÆ Nicholson (emended Ulrich).

The most important characteristic of this family, as emended by Ulrich, is the occurrence of the convex plates known as the cystiphragm. These curved structures are limited to the zoœcial tubes, where they form continuous series lining the walls. In most of the genera the curve is complete, but in *Orbignyella* and *Mesotrypa* the cystiphragms are often so slightly curved that they have the appearance of being merely oblique diaphragms. The use of the cystiphragms is not known, but it is possible that they represent modified ovicells.

The method of zoarial growth in the family varies from incrusting through lamellate, massive, and ramose, to bifoliate, intertwining fronds. It is noteworthy that the massive, free forms of *Prasopora*, the bifoliate forms of *Peronopora*, and the delicate incrusting zoaria of *Atactoporella*, all of which are very abundant in certain faunas of the North American Ordovician, should be entirely absent in the Russian deposits.

Genus MONTICULIPORA D'Orbigny.

Monticulipora D'ORBIGNY, Prodr. de Pal., vol. 1, 1850, p. 25.—MILNE-EDWARDS, Hist. Nat. des Corall., vol. 3, 1860, p. 272.—NICHOLSON, Paleozoic Tabulate Corals, 1879, p. 269; The Genus Monticulipora, 1881, p. 99.—ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, pp. 153, 232.—FOORD, Contr. Micro-Pal. Cambro-Sil., 1883, p. 7.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 370, 407; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 217; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 272.—SIMPSON, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 577.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 28.—ULRICH and BASSLER, Smiths. Misc. Coll., vol. 47, 1904, p. 15.

Peronopora (part) NICHOLSON, The Genus Monticulipora, 1881, p. 215.

Originally this genus was the resting place for a most heterogeneous lot of species, but to-day, through the work of Ulrich, its definite characters, so clearly shown in thin sections, have been so well indicated that there is no longer any excuse for erroneous generic identification. The generic characters are, first, the occurrence of cystiphragms in the zoœcial tubes, both in the axial and peripheral regions, and, second, the peculiarly granulose wall structure pertaining to both zoœcia and mesopores. This combination of characters has been found in species ranging through all the various forms of growth save the bifoliate. The mesopores also, when present, are variable in number. The acanthopores are usually small and numerous, but differ in their microscopic features from those of all the other families of the Trepostomata. The structure of the acanthopores in *Monticulipora* is much like that of the granulose walls, but the distinct central perforation and concentric rings of tissue seen in so many forms are wanting entirely.

Genotype.—Monticulipora mammulata D'Orbigny. Upper Ordovician (Maysville) of the Ohio Basin.

MONTICULIPORA ARBOREA BISPINULATA, new variety.

Text fig. 93.

Cfr. *Monticulipora arborea* ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 220, pl. 20, figs. 1–9, 13, 14.

Zoarium incrusting, both of the type-specimens forming thin expansions less than 20 mm. in diameter upon brachiopods. Surface smooth; maculæ of slightly larger zoœcia at regular intervals but indistinctly visible; zoœcial aperture small, polygonal, nine to ten in 2 mm., with rather thick, minutely granular walls bearing acanthopores of some size, one or two to a zoœcium; mesopores wanting.

The internal characters agree in all respects with typical species of the genus. The minutely granulose walls and distinctly granulose acanthopores, and the absence of mesopores, are well brought out in tangential sections, while vertical sections show the usual cystiphragms forming either a single or double row in each zoœcial tube.

It is possible that more material may show the incrusting expansions upon which the variety is founded to be nothing but the base of ramose zoaria. In this event the varietal name is almost useless,

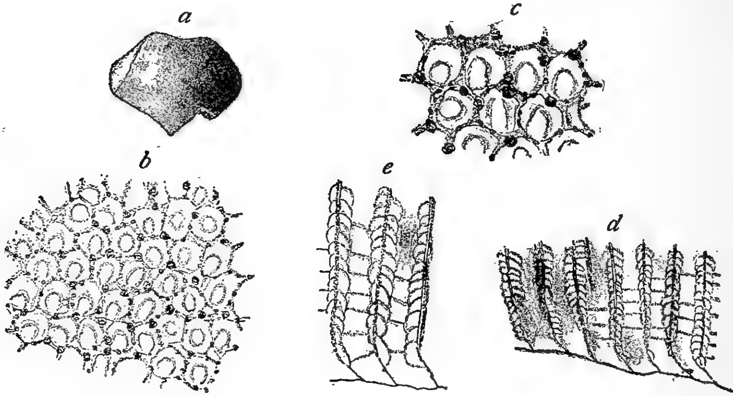

FIG. 93.—MONTICULIPORA ARBOREA BISPINULATA. *a*, ONE OF THE TYPE-SPECIMENS, NATURAL SIZE, INCRUSTING A BRACHIOPOD FRAGMENT; *b* AND *c*, TANGENTIAL SECTION, ×20, AND A PORTION, ×30, SHOWING THE TWO SETS OF GRANULOSE ACANTHOPORES AND THE WALL STRUCTURE; *d* AND *e*, A VERTICAL SECTION, ×20 AND ×30, WITH THE CYSTIPHRAGMS LINING BOTH SIDES OF THE TUBES. WASSALEM BEDS (D3), UXNORM AND GUT SACK, ESTHONIA.

since in practically every other feature the structure is precisely as in *M. arborea* Ulrich. It is true that the granules of the walls in the variety are so large that they have the appearance of acanthopores, thus with the real acanthopores giving the idea of two sets of these structures. Upon this character and the incrusting growth I have distinguished the Russian specimens as a variety.

Occurrence.—*Monticulipora arborea* is a ramose form described by Ulrich from the Clitambonites beds of the Lower Trenton in Minnesota and Iowa. The species reappears in higher beds of the Trenton formation in Kentucky. Variety *bispinulata* is represented by two incomplete specimens from the Wassalem beds (D3) at Uxnorm, near Reval, and at Gut Sack, Esthonia.

Cotypes.—Cat. Nos. 57268, 57269, U.S.N.M.

British Museum, thin section of a type-specimen.

MONTICULIPORA DAGOENSIS, new species.

Text fig. 94.

Zoarium a small, incrusting mass with a smooth, celluliferous surface bearing inconspicuous maculæ. The type-specimen is about a centimeter in diameter and a millimeter thick, and is growing upon a species of *Heliolites.* The surface presents no unusual features unless it is slightly etched with acid and then examined, when moistened, with a hand lens, when distinct acanthopores may be seen at many of the junction angles of the zoœcia. Such a view also shows large and somewhat numerous mesopores as well as the cut edges of the cystiphragms which appear in the zoœcial tubes as circular or semicircular lines. The apertures are small, polygonal, thin-walled, with six in 2 mm., and, on the average, 0.23 mm. in diameter. The

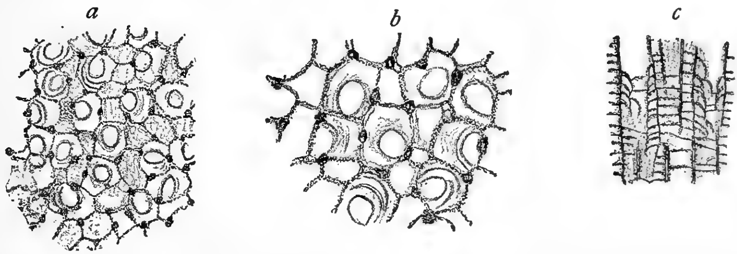

FIG. 94.—MONTICULIPORA DAGOENSIS. *a*, TANGENTIAL SECTION, ×20, ILLUSTRATING THE DISTINCT ACANTHOPORES AND OTHER FEATURES OF THE SPECIES; *b*, PORTION OF SAME, ×35, SHOWING IN ADDITION THE GRANULOSE WALL STRUCTURE; *c*, VERTICAL SECTION, ×20, THROUGH THE MATURE REGION OF THE ZOARIUM, EXHIBITING CLOSELY TABULATED MESOPORES AND ZOŒCIA WITH A DOUBLE ROW OF CYSTIPHRAGMS. LYCKHOLM LIMESTONE (F1), KERTEL, ISLAND OF DAGO.

mesopores are unusually large, sometimes almost equaling the zoœcia from which they can always be distinguished by their lack of cystiphragms. In addition to the structure described, a tangential section brings out the peculiar granulose wall structure characteristic of the genus.

The incrusting growth, small, angular, thin-walled zoœcia, large, numerous mesopores and well marked acanthopores, are characters of the present species which will separate it from all described forms of the genus.

Occurrence.—Rare in the Lyckholm limestone (F1) at Kertel, island of Dago, Baltic Sea.

Holotype.—Cat. No. 57270, U.S.N.M.

British Museum, thin section of the type-specimen.

Genus ORBIGNYELLA Ulrich and Bassler.

Orbignyella ULRICH and BASSLER, Smiths. Misc. Coll., vol. 47, 1904, p. 18.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 26.

This genus was proposed for Monticuliporidæ which differ from *Monticulipora* in wanting its irregularly granulose wall structure, and in having cystiphragms so poorly defined that they appear more like merely curved diaphragms. A third difference noted was in the acanthopores, which, in *Monticulipora*, are imperfectly defined, granulose spots, while in *Orbignyella* they are sharply defined, well-developed structures, as in the Heterotrypidæ.

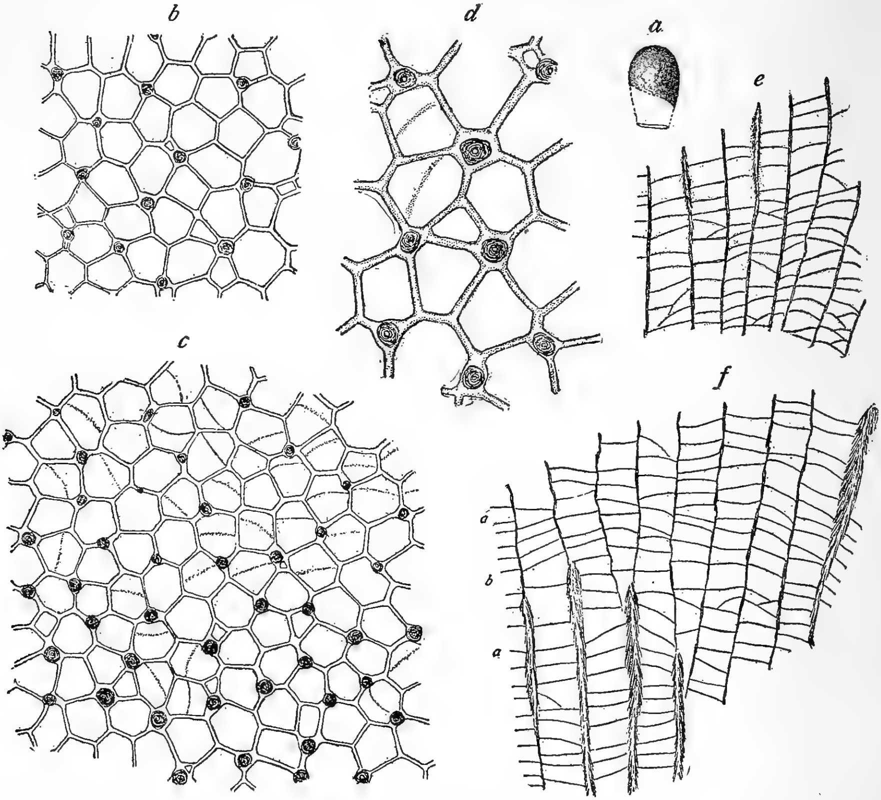

FIG. 95.—ORBIGNYELLA GERMANA. *a*, THE TYPE-SPECIMEN, NATURAL SIZE; *b*, VIEW OF THE USUAL CHARACTERS SEEN IN TANGENTIAL SECTION, ×20; *c*, TANGENTIAL SECTION, ×20, SHOWING DEVELOPMENT OF ACANTHOPORES IN DIFFERENT STAGES OF THE ZOARIUM. THE STRUCTURE OF THE MOST MATURE ZONE IS SHOWN IN THE LOWER HALF OF THE FIGURE; *d*, PORTION OF THE SAME, ×35, SHOWING MINUTE STRUCTURE IN MORE DETAIL; *e*, VERTICAL SECTION, ×20, WITH ACANTHOPORES LITTLE DEVELOPED; *f*, ANOTHER VERTICAL SECTION, ×20, SHOWING THE NUMEROUS DIAPHRAGMS AND STRONG ACANTHOPORES OF THE MATURE REGION (*a*) WITH A SHORT IMMATURE ZONE (*b*). WASSALEM BEDS (D3), UXNORM, ESTHONIA.

Genotype.—Orbignyella sublamellosa Ulrich and Bassler. Middle Ordovician (Stones River) of Tennessee.

ORBIGNYELLA GERMANA, new species.

Text fig. 95.

Cfr. *Monticulipora lamellosa* ULRICH, Geol. Surv. Illinois, vol. 8, 1890, p. 408, pl. 32, figs. 4–4*b*.

Zoarium a globular mass about 10 mm. in diameter and 15 mm. in height; surface smooth, maculæ inconspicuous and distinguishable only by the presence of zoœcia slightly larger than the ordinary.

Zoœcial apertures polygonal, with thin walls, often bearing large acanthopores; six and one-half to seven zoœcia in 2 mm. True mesopores practically absent, the mesopore-like spaces seen in tangential sections probably representing young zoœcia.

The most striking feature of thin sections is the presence of large acanthopores, numbering about one to a zoœcium. These are best shown in tangential sections where they appear as well defined, centrally perforated, circular spots of darker tissue made up of concentric rings. The acanthopores are likewise conspicuous in both vertical and tangential fractures, so that thin sections are not necessary in identifying the species. Vertical sections show rather numerous straight or slightly curved diaphragms, four or five occurring in a tube diameter in the more crowded portions, but two to three being the more usual number.

Apparently the closest ally of the species is the American form *Orbignyella lamellosa* (Ulrich), from the Richmond (Fernvale) shales of Illinois. The latter grows into lamellate expansions with thin-walled zoœcia (eight in 2 mm.), moderately large acanthopores, and straight or curved diaphragms averaging half a tube diameter apart. The different methods of growth, slightly larger zoœcia (six and one-half to seven in 2 mm.), larger acanthopores and more numerous diaphragms of the Russian form are relied upon in founding this new species, although its intimate relationship to *O. lamellosa* is recognized.

Occurrence.—Apparently rare in the Wassalem beds (D3) at Uxnorm, near Reval, Esthonia.

Holotype.—Cat. No. 57271, U.S.N.M.

British Museum, thin section of the type-specimen.

ORBIGNYELLA EXPANSA BALTICA, new variety.

Text fig. 96.

Cfr. *Orbignyella expansa* Bassler, Bull. 292, U. S. Geol. Surv., 1906, p. 26, pl. 10, figs. 5–8.

The specimen upon which this new variety is founded occurs as an incrustation 3 mm. in thickness, upon a *Heliolites*. Its diameter is about 20 mm., so that it is believed with further growth the zoarium might have become a free, lamellate, epithecated expansion. All of the zoœcial characters save one are as in *Orbignyella expansa* from the Niagaran (Rochester) shale of North America. The one exception is the small number of cystiphragms in the specimen under discussion and their comparative abundance in the typical form of the species. The intimate relationship of the species and variety is thus apparent, and the latter represents undoubtedly only an earlier appearance of the species. Making allowance for the possible difference in growth and the variation in development of cystiphragms, the following description of *O. expansa* will serve equally well for the recognition of the variety *baltica*.

Zoarium of lamellate, epithecated expansions composed of one or more layers, each of which is usually several millimeters in thickness. Surface smooth, but exhibiting conspicuous clusters composed of zoœcia attaining a diameter one and one-half times as great as that of the intermacular zoœcia. Zoœcia polygonal, thin walled, four in 2 mm., counting from the center of a macula, or six of the ordinary ones in the same space; when well preserved, showing minute granulations along the walls and small acanthopores usually at the angles. Mesopores wanting. Zoœcial tubes thin walled in the short axial region, slightly thickened in the peripheral, where they contain a rather crowded series of curved diaphragms, three usually occurring in the distance of a tube diameter.

Occurrence.—Rare in the Lyckholm limestone (F1), at Kertel,

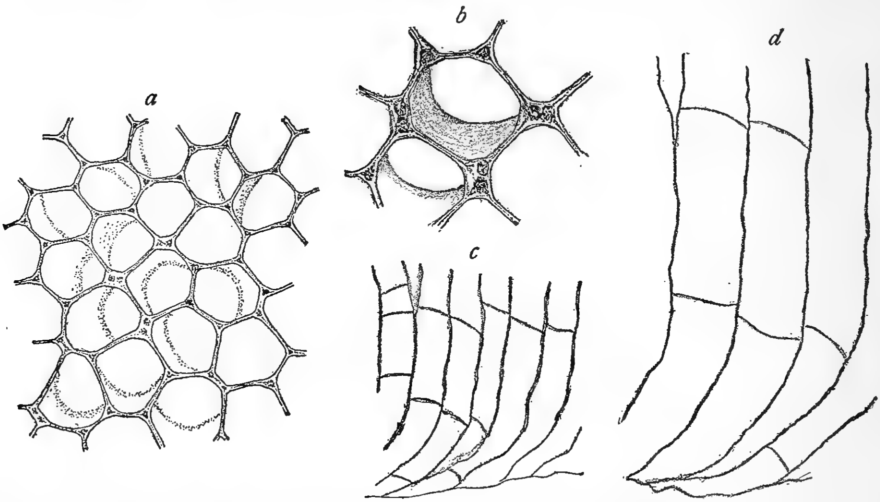

FIG. 96.—ORBIGNYELLA EXPANSA BALTICA. *a*, TANGENTIAL SECTION, ×20, PASSING THROUGH A ZONE OF CURVED DIAPHRAGMS; *b*, SEVERAL ZOŒCIA OF THE SAME, ×35; *c*, VERTICAL SECTION, ×10, THROUGH AN ENTIRE ZOARIAL LAYER; *d*, PORTION OF THE SAME SECTION, ×20. LYCKHOLM LIMESTONE (F1), KERTEL, ISLAND OF DAGO.

island of Dago. The species is not uncommon in the Niagaran (Rochester) shale of New York and Canada.

Holotype.—Cat. No. 57272, U.S.N.M.

British Museum, thin section of the type-specimen.

Genus HOMOTRYPA Ulrich.

Homotrypa ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 240.—FOORD, Contr. Micro-Pal. Cambro-Sil., 1883, p. 9.—MILLER, North Amer. Geol. and Pal., 1889, p. 309.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 370, 409; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 235; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 273.—SIMPSON, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 575.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 29.—BASSLER, Proc. U. S. Nat. Mus., vol. 26, 1903, p. 565.—CUMINGS, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 748.

Numerous typical species of this interesting genus occur in the faunas of late Trenton and of Cincinnatian ages, believed to have been derived from the south Atlantic. The northern Atlantic or Arctic types occur chiefly in the Black River and earliest Trenton formations, and in America are known mainly from deposits in Minnesota and the neighboring States. Of these latter species, *Homotrypa subramosa* Ulrich and *H. similis* Foord are the most abundant and widespread species in America, and their geographic range has now been extended to the Baltic region by the discovery of specimens in several of the Russian formations. Each of these two species is quite unlike the Cincinnatian type of the genus and may be taken as typical of a subgeneric division. Thus, *Homotrypa similis* shows a tendency to variation toward *Eridotrypa*, while the acanthopores and the cystiphragms of *H. subramosa* recall *Monticulipora*.

The zoarium in *Homotrypa* is of ramose or frondescent, smooth or monticulated branches made up of polygonal zoœcia with thin, finely crenulated walls and few diaphragms in the axial region, and thicker walls lined by cystiphragms in the peripheral zone. Mesopores are either absent or are restricted to the maculæ, but acanthopores are generally present. The ramose forms of *Monticulipora* have great similarity to *Homotrypa* externally, but a thin section of the former shows a granulose wall structure very different from the clearer, more distinct walls of *Homotrypa*.

Genotype.—*Homotrypa curvata* Ulrich. Upper Ordovician (Maysville), Ohio Valley.

HOMOTRYPA SIMILIS Foord.

Text figs. 97, 98.

Homotrypa similis FOORD, Contr. Micro-Pal. Cambro-Sil., 1883, p. 10, pl. 2, figs. 2–2*d*.—ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 242, pl. 20, figs. 28–33.

This characteristic American Lower Trenton bryozoan is represented in the Russian Ordovician by numerous specimens from the Wassalem beds (D3) at Uxnorm. Careful comparison show these examples to agree with the American types in all respects save that as a rule the zoaria of the Russian specimens are better developed and have less oblique zoœcia. This latter fact is of slight importance, since the study of the Paleozoic Bryozoa has shown that the greater the development of the mature zone the more directly do the zoœcia open upon the surface. The essential characters of *Homotrypa similis* are as follows:

Zoarium of subcylindrical or compressed branches 4 to 10 mm. in diameter, dividing unequally and often so irregularly as to anastomose. Surface smooth, with distinct, substellate maculæ composed of zoœcia larger than usual surrounding a granulose central space made up of mesopores. Zoœcia oblique in youthful stages, direct and angular in the more mature condition; about eight in 2 mm.

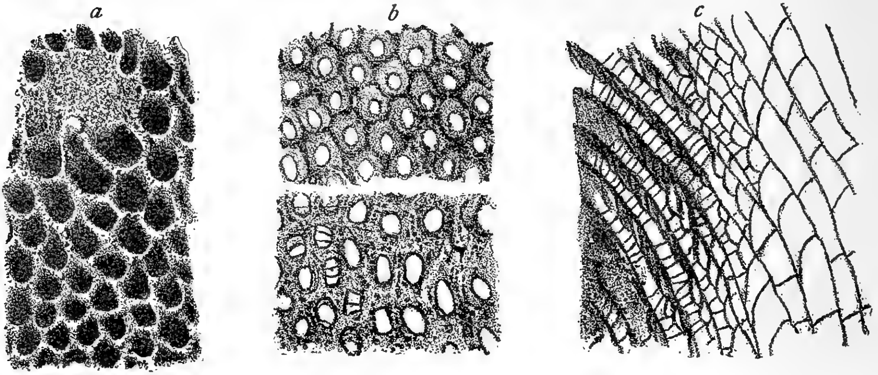

FIG. 97.—HOMOTRYPA SIMILIS. *a*, SURFACE OF A MINNESOTA SPECIMEN, ×18, SHOWING A MACULA AND NEIGHBORING ZOŒCIA; *b*, TWO PORTIONS OF A TANGENTIAL SECTION, ×18, PREPARED FROM AN AUTHENTIC CANADIAN EXAMPLE; *c*, VERTICAL SECTION, ×18, OF THE SAME SPECIMEN, ILLUSTRATING THE CHARACTERISTIC GRADUAL OUTWARD BEND OF THE TUBES AND THE TABULATION. LOWEST BEDS OF THE TRENTON LIMESTONE, OTTAWA, CANADA, AND NEAR TRENTON FALLS, NEW YORK. (AFTER ULRICH.)

Acanthopores inconspicuous at the surface; mesopores absent save in the maculæ.

The views presented in tangential sections of both American and

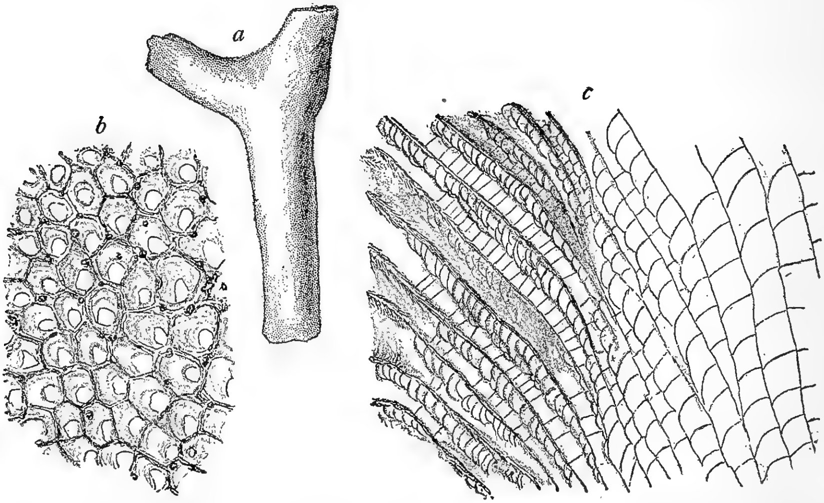

FIG. 98.—HOMOTRYPA SIMILIS. *a*, FRAGMENT OF A BRANCHED ZOARIUM, NATURAL SIZE; *b*, TANGENTIAL SECTION, ×20, ILLUSTRATING THE STRUCTURE CORRESPONDING TO THE UPPER HALF OF FIGURE 97; *b*, *c*, VERTICAL SECTION OF SAME SPECIMEN, ×20, SHOWING IDENTITY WITH THE INTERNAL STRUCTURE OF AMERICAN EXAMPLES. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

Russian specimens are shown in the accompanying illustrations. The marked peculiarities of the species are best seen in vertical sections where the tubes are noted to bend outward very gradually. In the immature region the diaphragms are but slightly curved;

as the mature region is approached these bend more and more until they pass into the usual combination of cystiphragms and diaphragms characteristic of the genus. In the mature region as many as five cystiphragms may occur in a tube diameter, and often a double row of these structures may be noted. In sections of old examples the cystiphragms are observed to be obscured near the surface by a solid filling, which, with the gradually outward bend of the tubes and the crowded cystiphragms and diaphragms, imparts a peculiar aspect to the species and makes it easy of recognition.

Occurrence.—Not uncommon in the Wassalem beds (D3) at Uxnorm, near Reval, Esthonia. In America the species is known from the Clitambonites and Nematopora beds of the Lower Trenton in Minnesota, Iowa, and Wisconsin, and at Ottawa, Canada.

Plesiotype.—Cat. No. 57273, U.S.N.M.

British Museum, specimens and one thin section of the Russian type.

HOMOTRYPA SUBRAMOSA Ulrich.

Text figs. 99, 100.

Homotrypa subramosa ULRICH, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 81; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 239, pl. 19, figs. 21–28; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 273, fig. 451 A–C (not D=*H. separata* Ulrich).

Several irregularly dividing subramose young specimens of *Homotrypa* from the Kuckers shale show all the surface characters of *H. subramosa,* even to the shallow, zoœcial apertures exposing the cystiphragms. This similarity is borne out in the internal structure, which, by comparison of the two sets of figures given here, allowing for difference in the age of the specimens, may be seen to be identical. Ulrich's description of the species is as follows:

Zoarium subramose, frequently though irregularly divided; branches compressed or subcylindrical, their extremities often bulbous. Size of branches varying greatly, the smallest 4 or 5 mm. in diameter, the largest 6 to 9 mm. thick, and as much as 25 mm. wide. Average specimens are about 6 mm. thick and between 8 and 12 mm. wide, with the total height of zoarium rarely exceeding 60 mm. Surface without monticules, nor are the clusters of large cells very conspicuous. Zoœcia with rather thin walls and polygonal, direct apertures; 12 to 14 in 3 mm. Zoœcial apertures shallow, exposing the cystiphragms when in a good state of preservation. These structures leave but a small opening, and when the fossil has suffered a little from attrition (a frequent occurrence in the beds holding the species most abundantly) in which case the true walls are obscured or cut away, the appearance is very deceptive, the apertures seeming to be very small and oblique, and much the greater part of the surface occupied by wall substance. Acanthopores varying in number and size, sometimes as numerous as two to each zoœcium. More commonly the number is little more than half that extreme. In many cases they are large enough to constitute a marked external feature. In others, however, apparently in an equally good state of preservation, they are so small that it is difficult to detect them even with the aid of a good lens.

The distribution of the diaphragms and cystiphragms is sufficiently illustrated in the accompanying figures.

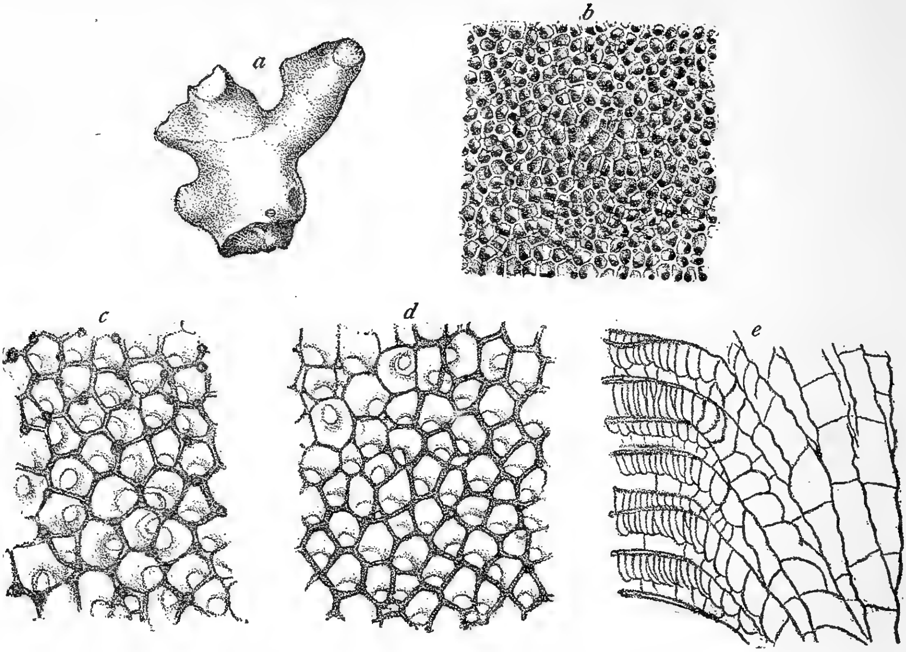

FIG. 99.—HOMOTRYPA SUBRAMOSA. *a*, FRAGMENT OF A ZOARIUM, NATURAL SIZE; *b*, SURFACE OF AN ORDINARY FRAGMENT, ×9, SHOWING THE CYSTIPHRAGMS IN THE ZOŒCIAL APERTURES; *c*, A TANGENTIAL SECTION, ×18, WITH ACANTHOPORES WELL DEVELOPED; *d*, TANGENTIAL SECTION, ×18, WITH ACANTHOPORES LESS CONSPICUOUS; *e*, VERTICAL SECTION OF A TYPICAL EXAMPLE, ×18. PHYLLOPORINA BED OF BLACK RIVER (DECORAH) SHALES, ST. PAUL, AND NEAR CANNON FALLS, MINNESOTA. (AFTER ULRICH.)

The Kuckers examples differ from the typical *H. subramosa* in that the zoarium is somewhat smaller, the walls are thinner, the

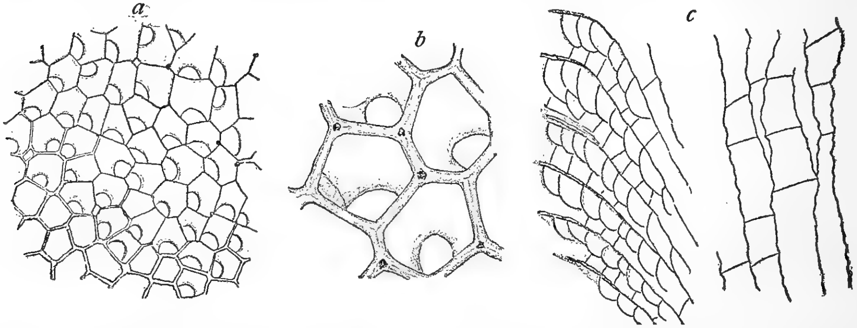

FIG. 100.—HOMOTRYPA SUBRAMOSA. *a*, TANGENTIAL SECTION OF A RUSSIAN SPECIMEN, ×20; *b*, SEVERAL ZOŒCIA OF THE SAME, ×60; *c*, TWO PORTIONS OF A VERTICAL SECTION, PREPARED FROM A YOUNG EXAMPLE, SHOWING THE IMMATURE AND MATURE REGIONS, ×20. KUCKERS SHALE (C2), REVAL, ESTHONIA.

acanthopores less numerous and smaller, and lastly the clusters of larger cells are more conspicuous. All of these same differences pertain to the early Trenton form which Ulrich named *H. insignis*, but later reduced to synonymy. The characters of *H. insignis* are undoubtedly those of young examples of *H. subramosa*.

Occurrence.—The American occurrences are in the Black River and earliest Trenton formations of Minnesota and Iowa. In Russia, the species is not uncommon in the Kuckers shale (C2) at Reval, Esthonia.

Plesiotype.—Cat. No. 57274, U.S.N.M.

A specimen and thin sections from the Kuckers shale, Reval, are in the collections of the British Museum.

Genus HOMOTRYPELLA Ulrich.

Homotrypella ULRICH, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 83.—MILLER, North Amer. Geol. and Pal., 1889, p. 310.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 370, 412; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 228.—SIMPSON, Fourteenth Ann. Rep. State Geologist for the year 1894, 1897, p. 586.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 29.

Three separate sections of this genus are represented in the Black River and earliest Trenton rocks of North America. The first comprises the typical species and consists of stout, ramose branches with direct zoœcia, numerous acanthopores and mesopores, and long mature regions. The second section has short mature regions and oblique apertures, while the third consists of species with a massive zoarium and strong acanthopores, hitherto referred to *Prasopora*. All three sections are represented in the Russian Ordovician by typical American species.

In growth and several other characters *Homotrypella* is quite similar to *Homotrypa*, but it differs conspicuously in the presence of numerous tabulated mesopores.

Genotype.—*Homotrypella instabilis* Ulrich. Middle Ordovician (Black River) of the Mississippi Valley.

HOMOTRYPELLA INSTABILIS Ulrich.

Text figs. 101, 102.

Homotrypella instabilis ULRICH, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 83; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, 1893, p. 229, pl. 18, figs. 9–20.—SIMPSON, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 586, figs. 168, 169.

Specimens which fall within the range of characters presented by this very abundant Black River fossil are frequent in the Kuckers shale. As indicated by the specific name, the species is somewhat variable, yet almost every phase noted in the American specimens has been duplicated in the Russian examples. In figure 101 I have introduced a few of Ulrich's excellent illustrations of the species, but as these show the mature characters more clearly, another set of drawings (fig. 102) to illustrate the young stages, is added. Ulrich has given a good description of the American types which applies equally well to the Russian specimens. His description, slightly changed to agree with the present illustrations, follows:

Zoarium ramose, growth rather irregular; branches rounded, sometimes nodular or lobate, and varying in diameter from 3 to 8 mm.; surface generally without monticules, and when these are present they are low and broad; small maculæ or clusters of mesopores are not infrequently present. Superficial characters of zoœcia and mesopores variable. In some, and these are in most cases well-preserved examples, the zoœcial apertures are irregular both in form and arrangement, with thin walls, partly separated by mesopores numbering one or two to each zoœcium. In these

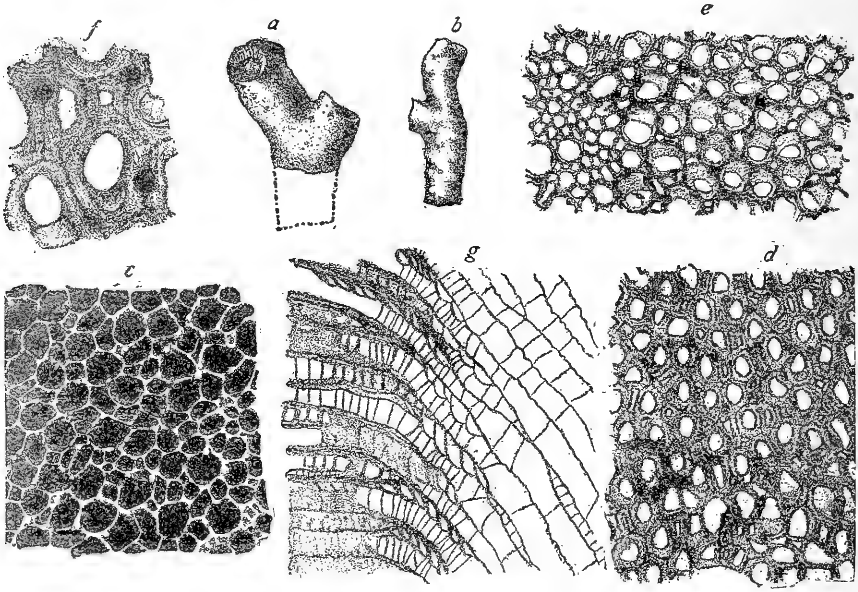

FIG. 101.—HOMOTRYPELLA INSTABILIS. *a* AND *b*, TWO FRAGMENTS, NATURAL SIZE; *c*, SURFACE OF A WELL-PRESERVED EXAMPLE, ×18; *d*, TANGENTIAL SECTION, ×18, PREPARED FROM THE ORIGINAL OF *a*; *e*, ANOTHER TANGENTIAL SECTION, ×18, SHOWING PORTION OF A MACULA AND ZOŒCIA WITH MORE NUMEROUS ACANTHOPORES; *f*, SMALL PORTION OF A TANGENTIAL SECTION, ×50, ILLUSTRATING THE MINUTE STRUCTURE MORE CLEARLY; *g*, VERTICAL SECTION, ×18, WITH THE USUAL DISTRIBUTION OF CYSTIPHRAGMS AND DIAPHRAGMS. RHINIDICTYA BED OF THE BLACK RIVER (DECORAH) SHALES, ST. PAUL AND MINNEAPOLIS, MINNESOTA. (AFTER ULRICH.)

specimens the acanthopores are small yet prominent and sharp, and number from one to three to each zoœcium. The mesopores are always smaller than the zoœcia, but vary occasionally in shape, size, and arrangement. In many other examples both the zoœcia and mesopores are smaller and their walls correspondingly thick, while the acanthopores are blunt and thicker. In most cases a little wearing suffices to obscure the mouths of the mesopores, so that they are readily overlooked. Twelve or thirteen of the zoœcia occur in 3 mm.

Internal characters.—Tangential sections of this species present an unusual variety of appearances. In the majority of sections, providing they are not too deep, the walls of the cells are very thick, with not a sign of cystiphragms in the zoœcial cavities. When a second or peripheral series of cystiphragms has been developed a very different appearance is obtained. Now the walls are thinner, and a cystiphragm, leaving from one-third to one-half of the zoœcial cavity open, is to be seen in each of the zoœcia. In all cases the polygonal lines of contact between the two sets of cells is sharply defined, and the walls of both approximately of equal thickness. The acanthopores are conspicuous features of these sections, but their relative abundance varies somewhat in different examples. In the axial region of vertical sections the walls of the tubes are very thin and finely wavy, and the diaphragms straight and remote, or wanting entirely. As the tubes enter the peripheral region the number of diaphragms is greatly increased, the walls thickened, and cystiphragms, mesopores, and acanthopores developed. The mesopores are distinguished from the zoœcia by their shortness and in having no cystiphragms. The latter structures number from three or four to fifteen in a direct series in each zoœcial tube. In most cases they occur only in the region intervening between the fully matured peripheral and the immature axial region. Beyond them the diaphragms are crowded and essentially horizontal. In the mesopores the diaphragms are often thick and situated about the same distances apart as in the zoœcial tubes, with from fourteen to seventeen in 1 mm. In the axial region of transverse sections the zoœcial tubes are of unequal sizes and of peculiarly irregular shapes.

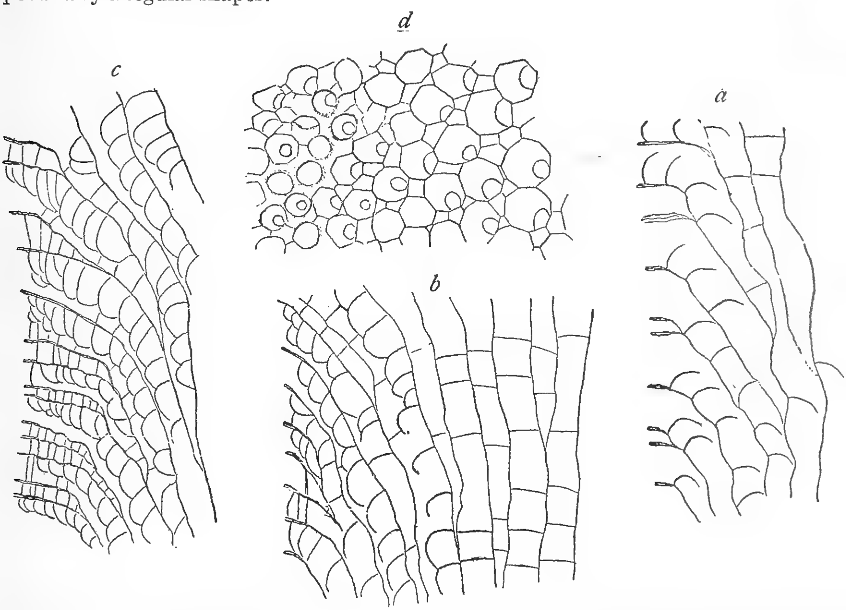

FIG. 102.—HOMOTRYPELLA INSTABILIS. *a*, *b*, AND *c*, VERTICAL SECTIONS, ×20, SHOWING DIFFERENT STAGES IN THE DEVELOPMENT OF THE MATURE ZONE; *d*, TANGENTIAL SECTION, ×20. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

Many of the Russian examples agree with the above description, but a few of them are young examples which have furnished the thin sections illustrated in figure 102. In figure 102 *a*, the vertical section of a stage so youthful that the mature region is scarcely developed, is shown. Distinct cystiphragms are noted in the bend to the mature zone but they are incomplete at their lower end. In figure 102 *b*, a slight advance in the development of cystiphragms may be seen, and a further advanced stage, with the introduction of tabulated mesopores, is illustrated in figure 102 *c*. In all of these vertical sections it is evident that only the earliest cystiphragms are incomplete. Possibly their lower portion consisted of tissue too delicate to show in thin sections. In older zoœcia most of the early cystiphragms have enough tissue added to them to complete the structure. A tangential section of a young example is shown in figure 102 *d*.

The ramose form of growth, numerous tabulated mesopores, and zoœcia lined with cystiphragms, are characters different from all other Russian forms save *Homotrypella cribrosa*. The latter has a more regularly inosculating form of growth, smaller branches, a short mature region, and oblique aperture.

Occurrence.—Abundant in the Rhinidictya bed of the Black River (Decorah) shales at St. Paul, Minneapolis, and other localities in Minnesota. Common in the Kuckers shale (C2), Baron Toll's estate, and at Reval, and in the Echinospherites limestone (C1), 4 miles east of Reval, Esthonia.

Plesiotype.—Cat. No. 57275, U.S.N.M.

British Museum, specimens and thin sections from the Kuckers, Baron Toll's estate.

HOMOTRYPELLA CRIBROSA, new species.

Plate 13, text fig. 103.

Zoarium growing from a thick, small basal expansion into narrow, compressed, rounded branches that inosculate at intervals of 10 mm. or less until there results a broad expansion usually spread in a plane. Branches 2 to 4 mm. in diameter, surface smooth but marked at regular intervals by distinct solid clusters of mesopores. Zoœcial apertures oblique and long drawn out in young stages, direct, polygonal, and thick-walled in old portions of the zoarium; seven to eight zoœcia in 2 mm. Mesopores most abundant in the maculæ but comparatively few elsewhere and usually closed at the surface. Well-defined acanthopores are also few but numerous granules simulating these structures are present in the most mature regions.

Vertical sections of this species are especially interesting. In the immature zone the zoœcial tubes are noticeably constricted whereever a diaphragm is inserted. In the outer portion of this zone large cystiphragms occur and continue until the mature region is reached, where the zoœcial walls thicken, mesopores are introduced, and the cystiphragms decrease in size but are in a crowded series. The diaphragms and cystiphragms of the immature zone average the distance of a tube diameter from each other. Diaphragms are sparsely developed in the mature zone but here three to four cystiphragms occur in the width of a zoœcium. Other features of vertical sections are the gradual bend from the immature to the mature zone, the narrowness of the latter, and the thickening of the walls and closing of the mesopores by layers of tissue as the surface is approached.

Tangential sections taken close to the surface of mature specimens show polygonal thick-walled zoœcia with an occasional closed interspace. True acanthopores are occasionally noted, but smaller granules, as shown in figure 103 *c*, are more common. In this figure about half of the zoœcia show cystiphragms cut by the section.

The smooth branches inosculating so as to form a cribrose zoarium, and the internal features shown in the figure, are sufficient to separate this from similar small-stemmed species. The same species, differing only in having less numerous diaphragms in the immature zone, occurs in the Black River shales of Minnesota.

Occurrence.—Common in the Wassalem beds (D3) at Uxnorm, Esthonia; the same species, or at least a variety, is equally abundant

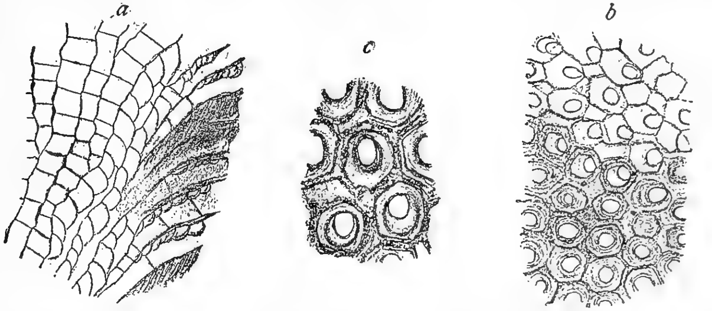

FIG. 103.—HOMOTRYPELLA CRIBROSA. *a*, VERTICAL SECTION, ×20, ILLUSTRATING THE SHORT MATURE ZONE AND TABULATION; *b*, TANGENTIAL SECTION, ×20, SHOWING CHARACTERS OF THE EARLY PART OF THE MATURE ZONE IN THE UPPER HALF AND THE LATER PART IN THE LOWER HALF; *c*, SEVERAL ZOŒCIA OF THE SAME SECTION, ×35. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

in the Black River (Decorah) shales at Fountain and other localities in Minnesota.

Holotype.—Cat. No. 57278, U.S.N.M.

Specimens and thin sections from the Wassalem beds, Uxnorm, are in the collections of the British Museum.

HOMOTRYPELLA HOSPITALIS CRASSA (Ulrich).

Text figs. 104, 105.

Atactoporella crassa ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 225, pl. 15, figs. 18–21.

Cfr. *Monticulipora* (*Prasopora*) *selwynii* var. *hospitalis* NICHOLSON, Genus Monticulipora, 1881, p. 209, fig. 45.

One of the most abundant and characteristic fossils of the Richmond formation in North America is the bryozoan described by Nicholson as *Monticulipora* (*Prasopora*) *selwynii* var. *hospitalis*, later referred by Ulrich as a valid species of *Prasopora*. The small, more or less rounded zoarium, with zoœcia having numerous acanthopores, lined with cystiphragms and separated by closely tabulated mesopores, make this form especially easy of recognition. Detailed collecting in the American Black River and Trenton horizons resulted in the discovery of a species or variety closely related to the Richmond form, and now the study of the Russian Ordovician

Bryozoa has greatly extended the geographical range of this lower form. The occurrence in the Black River-Trenton and in the Richmond strata of a species or variety closely related to a Richmond form, and with apparently no connecting links in the intervening strata, is in line with other faunal similarities of these formations. As shown by further study, this early occurrence of the common Richmond species was described by Ulrich as *Atactoporella crassa*, but it is believed to be more in keeping with the facts to regard it as

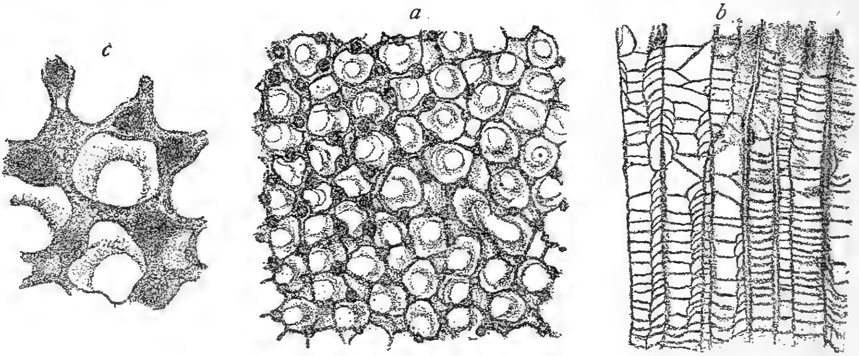

Fig. 104.—Homotrypella hospitalis crassa. Ulrich's views of Atactoporella crassa. *a*, tangential section, ×18, of the Minnesota type; *b*, vertical section of the same, ×18, with the characteristic tabulation of zoœcia and mesopores; *c*, several zoœcia in tangential section, ×50, showing the structure of the most mature zone. Clitambonites bed of the lower Trenton, near Cannon Falls, Minnesota.

a variety of *Prasopora*, now *Homotrypella*, *hospitalis*. The reference of *Prasopora hospitalis* to *Homotrypella* is also believed to be nearer the truth, because this species differs from typical *Homotrypella* only in its massive form of growth. The following description is based upon the Russian specimens.

Zoarium massive, growth beginning upon some foreign object and continuing until a more or less regular, rounded colony results. In the Russian specimen figured, growth has been about a fragment of a brachiopod, almost completely enveloping the shell. Surface marked by moderately elevated, rounded monticules, 3 mm. apart. Under a hand lens the surface is seen to be finely spinulose because of numerous acanthopores. The characteristic features distinguishing this from most associated bryozoans are seen either in thin sections or in fractures moistened and examined under a strong hand lens. In either case the numerous cystiphragms lining the zoœcial walls and the closely tabulated mesopores are evident, while the abundant acanthopores are seen to best advantage in tangential sections. Cystiphragms are found most often lining one side of the zoœcia, but sometimes, as in figure 105 *e*, both sides show them. Ordinarily 30 cystiphragms may be counted in 2 mm., while the mesopores hold approximately the same number of straight diaphragms. In deep tangential sections both the zoœcia and mesopores are thin walled and polygonal, but as the surface is approached, the zoœcial walls thicken at the expense of the mesopores. In the outermost parts of the mature region, calcareous tissue is often developed in the mesopores to such an extent that the latter are obliterated. Eight zoœcia in 2 mm.

Closely compared with typical *Homotrypella hospitalis*, variety *crassa* differs but slightly and apparently only in having more crowded diaphragms and cystiphragms and less developed acantho-

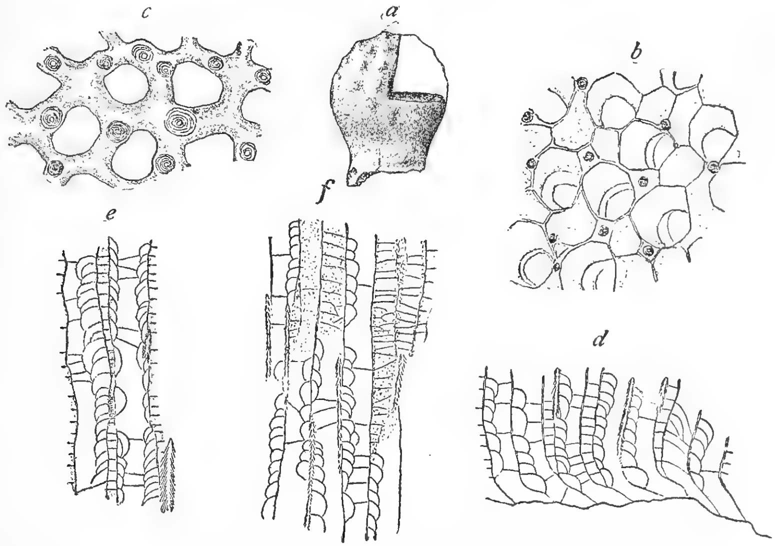

FIG. 105.—HOMOTRYPELLA HOSPITALIS CRASSA. *a*, A RUSSIAN EXAMPLE, NATURAL SIZE; *b*, TANGENTIAL SECTION, ×40, THROUGH THE LESS MATURE PORTION OF A ZOŒCIAL LAYER; *c*, TANGENTIAL SECTION, ×40, THROUGH THE MOST MATURE REGION OF THIS SPECIMEN, WHERE THE MESOPORES ARE OBSCURED BY A DENSE TISSUE; *d*, *e*, AND *f*, THREE VERTICAL SECTIONS, ×20, ILLUSTRATING THE CHARACTERS IN VARIOUS PARTS OF THE ZOARIUM. IN *d* THE YOUNGEST STAGE IS FIGURED WITH THE IMMATURE ZONE, AND THE EARLIEST PART OF THE MATURE REGION DISPLAYED. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

pores. Although even these differences are subject to slight variation, it is believed that a varietal name for the older form is justified.

Occurrence.—The typical form is abundant and characteristic in the Richmond formation at many American localities; the variety *crassa* is known from the Black River shales of Minnesota, Iowa, and elsewhere, and from the lower Trenton rocks, particularly at West Covington, Kentucky. The Russian specimen was found in the Wassalem beds (D3) at Uxnorm, near Reval, Esthonia.

Plesiotype.—Cat. No. 57279, U.S.N.M.

Thin sections of the Russian type are in the collections of the British Museum.

Genus MESOTRYPA Ulrich.

Mesotrypa ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 257.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 30.—BASSLER, Bull 292, U. S. Geol. Surv., 1906, p. 27.—HENNIG, Archiv. fur Zool., vol. 4, No. 21, 1908, p. 29.
Diplotrypa (part) of authors.

Zoarium hemispheric, conical, or discoidal, generally free, with an epitheca on the under surface; zoœcia prismatic or cylindrical, with oblique and sometimes funnel-shaped diaphragms, which are probably modified cystiphragms; zoœcia more or less separated by angular mesopores, which become smaller with age, and are intersected by numerous diaphragms; acanthopores generally present, sometimes of large size.

Genotype.—*Diplotrypa infida* Ulrich. Middle Ordovician (Black River) of Minnesota.

This genus includes several groups of species, all of which agree in having a massive zoarium of zoœcial tubes crossed by curved diaphragms, and of closely tabulated mesopores with rather straight walls. The typical group of the genus includes species with numerous curved diaphragms and strong acanthopores, a combination of characters which has not been found well developed in any of the Russian forms, although two new species are referred to this division. A second generic group, of which the American forms *Mesotrypa discoidea* Ulrich and *M.? rotunda* Ulrich, from the Mohawkian rocks of Minnesota, are typical, is represented by the very similar Russian form *M. discoidea* variety *orientalis*. The latter group, with its few curved diaphragms and absence of acanthopores, suggests alliance with other genera, especially *Diplotrypa*. A third division of the genus is known only from the specimens here described as *M. milleporacea*, new species, and the new variety *parva*, in which the absence of acanthopores and the presence of very numerous and exceptionally small mesopores are the main peculiarities.

MESOTRYPA DISCOIDEA ORIENTALIS, new variety.

Text fig. 106.

Cf. *Mesotrypa discoidea* ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 260, fig. 12.

Zoarium discoid with a flattened, concentrically wrinkled base and a gently convex upper surface; an average example 6 mm. high and 20 mm. in diameter. Upper surface smooth, with maculæ of large zoœcia, inconspicuous, showing plainly only in thin sections. Zoœcial apertures polygonal, usually hexagonal in outline, with mesopores occupying the interspaces left between adjoining zoœcial walls. Acanthopores apparently absent. Walls of both zoœcia and mesopores thin. Seven to eight zoœcia in a distance of 2 mm.

Although in surface characters this form is quite similar to several associated forms, its internal features are striking enough to make its recognition easy. The chief peculiarity seen in vertical fractures or sections is the presence of exceedingly numerous diaphragms in the mesopores and comparatively few of these structures in the zoœcia proper. In the mesopores 20 to 25 diaphragms occur in the space of 1 mm., while in the immature region of the zoœcia only 1

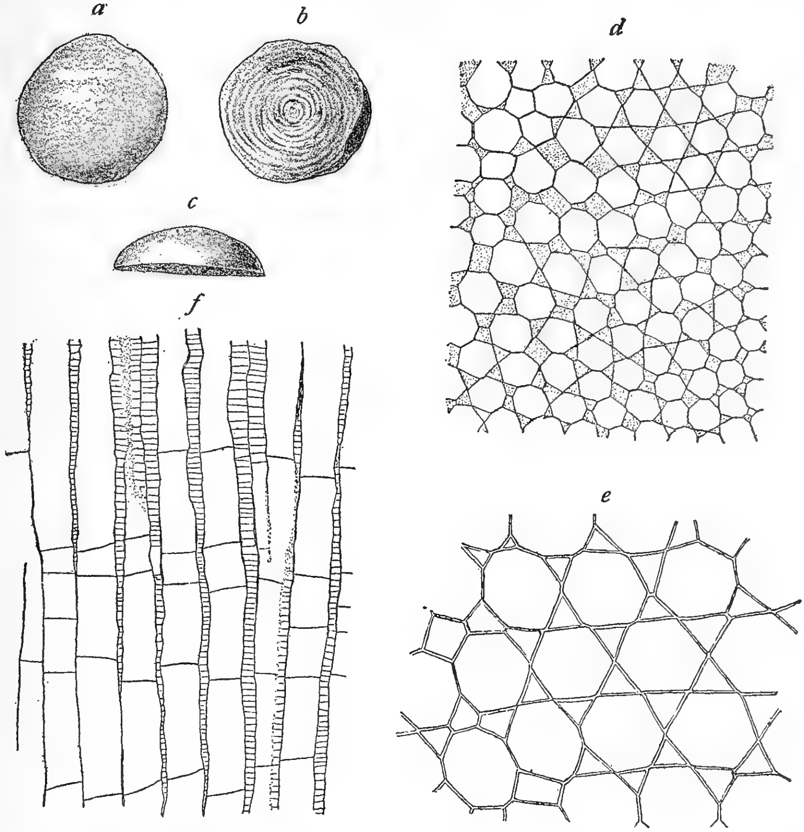

FIG. 106.—MESOTRYPA DISCOIDEA ORIENTALIS. *a, b,* AND *c,* TOP, BASAL, AND SIDE VIEWS OF A ZOARIUM, NATURAL SIZE; *d,* TANGENTIAL SECTION, ×20, WITH THE MESOPORES SHADED; *e,* A PORTION OF THE SAME, ×40, ILLUSTRATING THE SIMPLICITY OF STRUCTURE AND THE TENDENCY OF THE ZOŒCIAL TUBES TO ASSUME A HEXAGONAL OUTLINE; *f,* VERTICAL SECTION, ×20, SHOWING PORTIONS OF TWO IMMATURE ZONES BOUNDING A NARROW MATURE ZONE. JEWE LIMESTONE (D1), BARON TOLL'S ESTATE, ESTHONIA.

may be found in the same distance. The mature region of the zoœcia occasionally have as many as 4 diaphragms, which in all cases are straight or but slightly curved. These are placed on an average of a tube diameter apart.

The Russian specimens are apparently closely related to *Mesotrypa discoidea* Ulrich, from the Nematopora bed of the lower Trenton of Minnesota, with which they agree closely in size of zoœcia and number and tabulation of the mesopores. The two differ mainly in the tabulation of the zoœcia, which, in the Minnesota species, is closer and often exhibits curved diaphragms. A second but minor difference may be noted in the shape of the zoœcia, which in *M. discoidea* are often rounded and in the variety *orientalis* are most often hexagonal. The latter is apparently the European representative of the American species, and the reference of both to *Mesotrypa,* in spite of their numerous straight diaphragms, is believed to be in keeping with the development of the genus. As remarked under the generic discussion, these two forms and the following new species, in addition to *Mesotrypa rotunda* Ulrich, form a small group differing from typical forms of the genus in having straight diaphragms more often than curved. In other respects, namely, the distinctly straight, well-defined walls of both zoœcia and mesopores and the close, compact tabulation of the latter, the generic characters are those of *Mesotrypa.*

Of associated species, *Orbipora distincta* has a similar zoarium but its zoœcia are much larger, acanthopores are numerous, and mesopores are wanting. *Diplotrypa bicornis* often has a similar external aspect, but the difference in tabulation may be seen by comparison of the text figures here given. This latter species likewise has the moniliform mesopores and loose tabulation of *Diplotrypa.*

Occurrence.—Not uncommon in the Jewe limestone (D1), Baron Toll's estate, near Jewe, at St. Mathias, and Paesküll, Esthonia.

Cotypes.—Cat. No. 57280, U.S.N.M.

Specimens and a thin section of the type-specimen are in the collections of the British Museum.

MESOTRYPA EGENA, new species.

Text fig. 107.

The species for which the above new name is proposed is so much like the preceding externally that an examination of its internal structure is necessary for its identification. Both species agree in having a discoid zoarium with a flat, concentrically wrinkled base and a gently convex upper surface. Specimens of *Mesotrypa discoidea orientalis* as a rule exhibit numerous mesopores at the surface, while in *M. egena* mesopores are so few that the zoœcia are polygonal and in contact. The surest method of distinguishing the two, however, is by an examination of the tabulation, as shown in vertical fracture or thin section. In the present species the zoœcial diaphragms are from one to two times their own diameter apart in the immature zone, but so crowded in the mature region that four diaphragms sometimes occur in a distance equal to their own diameter. In these crowded zones the diaphragms are frequently so curved as to resemble cystiphragms. In *M. discoidea orientalis* the diaphragms are a tube diameter distant in the most crowded part and three or four times that distance from each other in the immature region. Still another difference is the presence of small acanthopores in *M. egena,* but these are so inconspicuous that they can be distinguished only in thin sections. The size of the zoœcia and the tabulation of the mesopores is practically the same in both species.

In spite of the great similarity to the preceding species, the present form is believed to be more closely related to the type of the genus, *Mesotrypa infida* (Ulrich), from the Black River shales of Minnesota,

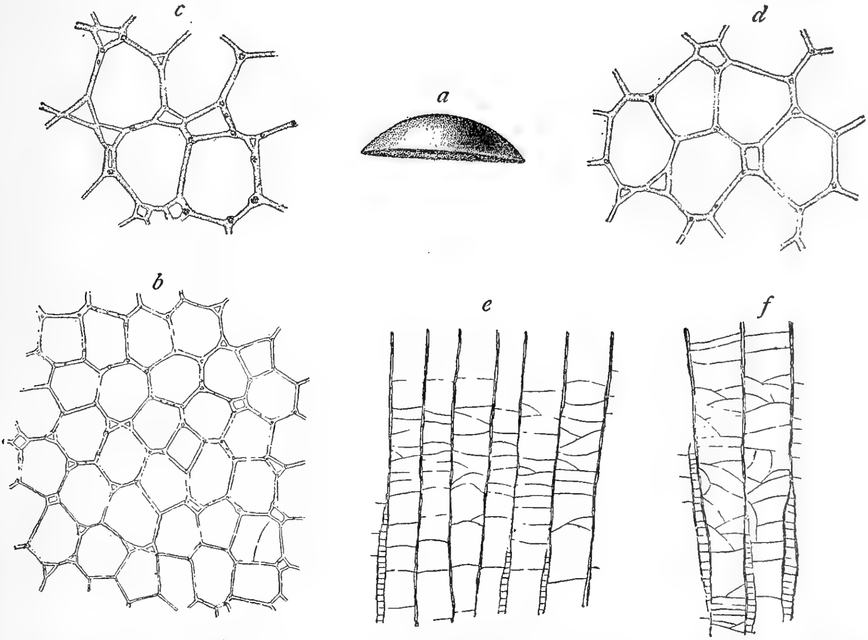

FIG. 107.—MESOTRYPA EGENA. *a,* SIDE VIEW OF TYPE-SPECIMEN, NATURAL SIZE; *b,* TANGENTIAL SECTION THROUGH THE MATURE ZONE, ×20; *c* AND *d,* PORTIONS OF THE SAME, ×35, SHOWING WALL STRUCTURE AND VARIATIONS IN NUMBER OF ACANTHOPORES; *e* AND *f,* TWO PORTIONS OF A VERTICAL SECTION, ×20. KEGEL BEDS (D2), HABBINEM, ESTHONIA.

on account of the presence of small acanthopores and the numerous curved diaphragms. The acanthopores are much stronger and the diaphragms more curved in *M. infida,* but certain portions of its zoarium sometimes exhibit a structure resembling that in *M. egena.* Indeed, the latter may represent merely a poorly developed stage of *M. infida.*

Occurrence.—Rare in the Kegel limestone (D2) at Habbinem, Esthonia.

Holotype.—Cat. No. 57283, U.S.N.M.

Two thin sections of the type-specimen are in the British Museum collections.

MESOTRYPA EXPRESSA, new species

Text fig. 108.

This rather unusual form is particularly interesting in showing to how great an extent mesopores which are abundant in the less mature portions of a colony may be pinched out in the more mature zones. This feature is best seen in vertical sections (fig. 108 *e*), although

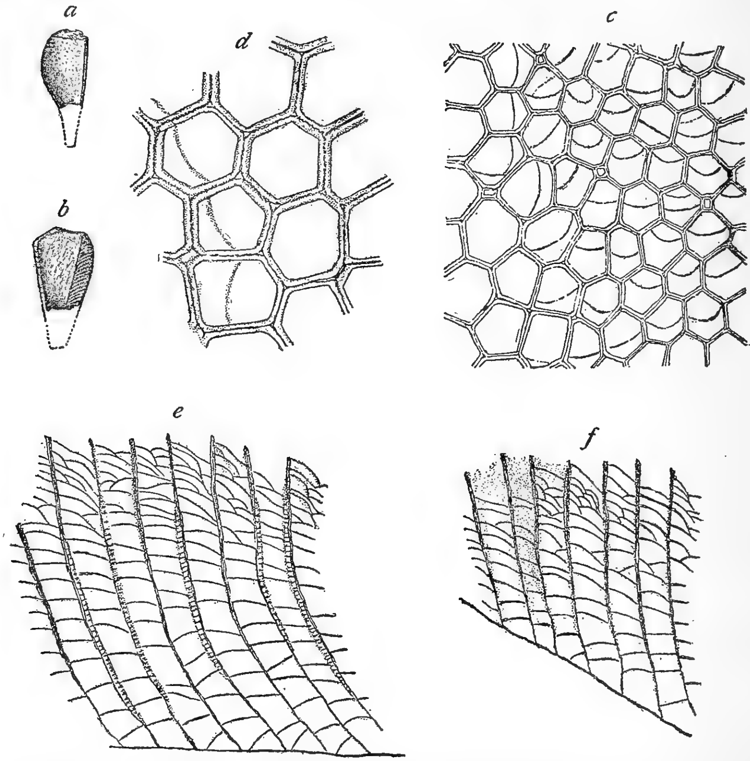

FIG. 108.—MESOTRYPA EXPRESSA. *a*, SIDE VIEW OF THE TYPE-SPECIMEN, GROWING AROUND A HYOLITHES; *b*, VIEW OF THE SAME EXAMPLE FRACTURED LENGTHWISE; *c*, TANGENTIAL SECTION, ×20, THROUGH THE MATURE REGION, ILLUSTRATING THE SCARCITY OF MESOPORES; *d*, A PORTION OF THE SAME, ×35, WITH THE WALL STRUCTURE MORE CLEARLY INDICATED; *e* AND *f*, TWO VERTICAL SECTIONS, ×20, DIFFERING ONLY IN THE DEVELOPMENT OF MESOPORES IN *e*, WHERE THEY DISAPPEAR BEFORE THE SURFACE IS REACHED. KUCKERS SHALE (C2), REVAL, ESTHONIA.

tangential sections prepared from different parts of the zoarium will exhibit the same variation in the number of mesopores. Such a pinching out or disappearance of the mesopores as growth proceeds is a characteristic of the genus as a whole, although it is seldom so well shown as in the present instance.

The three zoaria studied form small, elongate masses incrusting a species of *Hyolithes.* The fractured specimen from which the figured thin sections were prepared is shown in figure 108 *b*, where the layers of zoœcia are seen proceeding from the clay filled body of the shell.

The thin layer of cells is growing upon the flat side of the shell and exhibits a structure that has been noted in all species growing upon *Hyolithes*, namely that no true zoœcia are found here. This portion of the zoarium is made up exclusively of small cells differing from mesopores only in having thicker walls. A discussion of this feature is given on page 47, so that further remarks are unnecessary at this point.

The zoarial surface in *M. expressa* is smooth and without distinct maculæ, although groups of larger zoœcia are present. The apertures are quite regularly hexagonal in outline, with eight in 2 mm. Mesopores practically absent at the surface, acanthopores apparently wanting.

Tangential sections passing through the zoarium near the surface show the great regularity in the shape of the aperture. The cut edges of the curved diaphragms likewise frequently show in such sections as curved lines crossing the apertures. Deeper tangential sections exhibit mesopores and less regular zoœcia.

The chief peculiarity of vertical sections has already been mentioned. The zoœcial tubes are thin walled in the immature region, where closely tabulated, narrow mesopores are developed in some number. As the mature zone is approached, the mesopores become smaller and finally disappear entirely. Here their place is taken by a slight widening of the zoœcia and an increase in the thickness of their walls. Slightly curved diaphragms occur in the immature zone at intervals averaging their own diameter. In the shorter mature zone they are four or five times as numerous and are more curved, in fact they are frequently arranged on top of each other in the manner of true cystiphragms.

There is no described species near enough the present form to make comparison necessary. *Leptotrypa hexagonalis* from the same formation has the same method of growth and similarly shaped apertures, but its internal characters are quite different. A glance at the fractured edge of a zoarium will suffice to distinguish the few horizontal diaphragms of the *Leptotrypa* from the numerous curved structure of the *Mesotrypa*.

Occurrence.—Rare in the Kuckers shale (C2) at Reval, Esthonia.

Holotype.—Cat. No. 57284, U.S.N.M.

British Museum, one specimen and thin sections.

MESOTRYPA MILLEPORACEA, new species.

Text fig. 109.

Zoarium at first incrusting and then becoming a free, lamellate expansion several centimeters wide and averaging 5 mm. in thickness. Celluliferous face smooth, with indistinct maculæ; noncelluliferous side marked with a strongly wrinkled epitheca. Zoœcial apertures rather large, subpolygonal to rounded according to the number of mesopores, thin-walled, five in 2 mm. Mesopores exceptionally small and numerous, the interzoœcial spaces sometimes being filled by three distinct rows of them. Acanthopores wanting.

Vertical sections show erect tubes, in general perpendicular to the basal epitheca, with a very short, inconspicuous immature region. These zoœcia are crossed by numerous, more or less curved dia-

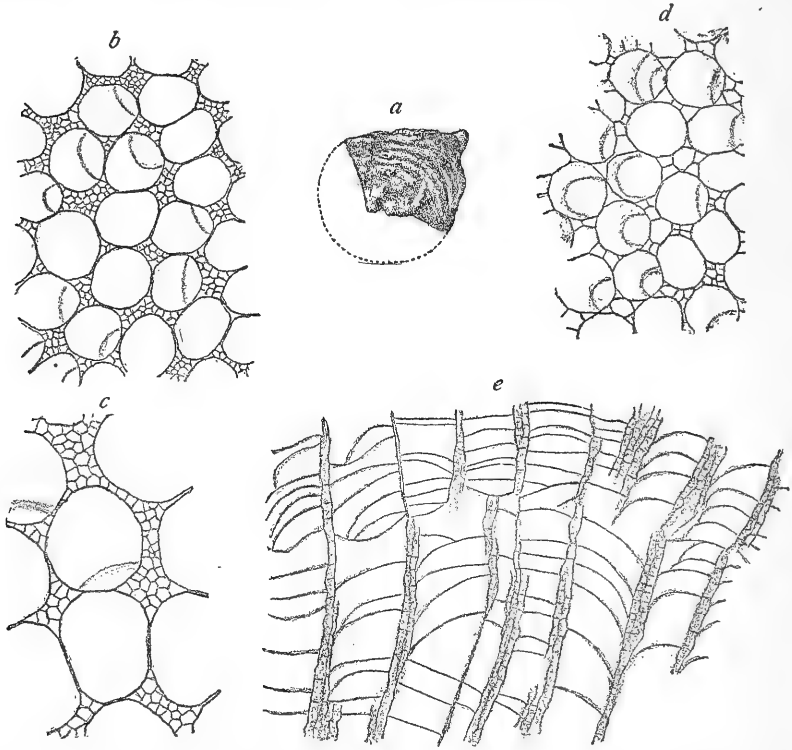

FIG. 109.—MESOTRYPA MILLEPORACEA. *a*, THE EPITHECAL SIDE OF A FRAGMENTARY ZOARIUM, NATURAL SIZE; *b* AND *c*, A TANGENTIAL SECTION, ×20, AND SEVERAL ZOŒCIA, ×35, THROUGH THE REGION IN WHICH THE MESOPORES ARE SMALLEST AND MOST NUMEROUS; *d*, TANGENTIAL SECTION OF THE SAME SPECIMEN, ×20, SHOWING LARGER, LESS NUMEROUS MESOPORES; *e*, VERTICAL SECTION, ×20, PASSING THROUGH PORTIONS OF TWO LAYERS OF ZOŒCIA. CHASMOPS LIMESTONE, SOUTH OF BÖDAHAMN, ISLAND OF OELAND.

phragms with three to five in a tube diameter. A variety of appearances is presented by these diaphragms in such thin sections. Some are straight, others are slightly oblique, while still others are curved as much as in the ordinary cystiphragm. The mesopores are always numerous, but vary in number and size at different stages of growth. In the early portion of the mature region they are seen as single tubes crossed by thin diaphragms at intervals varying from one to two times their own diameter. Their appearance and number at this stage, as shown in tangential sections, is indicated in figure 109 *d*. In the later stages of the mature region their diameter decreases and two or more exceedingly small tubed mesopores occupy the same interzoœcial space. This particular region affords a unique tangential section showing quite large rounded zoœcia and numerous exceptionally small, angular mesopores. This condition is most often presented at the surface of a zoarium and is a distinct aid in the identification of the species. The tangential view, seen in figure 109 *b*, is the usual aspect of the species both at the surface and in sections.

The large zoœcia and the very numerous small mesopores are alone quite striking, but in combination with the oblique diaphragms and lamellate method of growth afford characters unlike any other

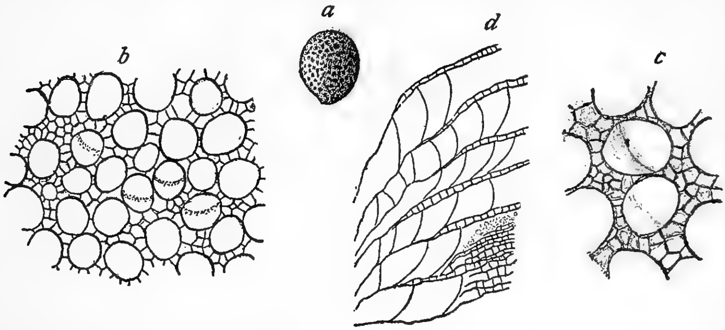

FIG. 110.—MESOTRYPA MILLEPORACEA PARVA. *a*, A ZOARIUM, ×2, SHOWING THE USUAL FORM; *b* AND *c*, A TANGENTIAL SECTION, ×20, WITH SEVERAL ZOŒCIA, ×35; *d*, VERTICAL SECTION, ×20, SHOWING ESSENTIALLY THE SAME STRUCTURE AS IN FIGURE 109 *e*. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

bryozoan save the following variety *parva*, which, as the name indicates, is a smaller form.

Occurrence.—The type-specimen was found by Dr. F. A. Bather in the Chasmops limestone south of Bödahamn, island of Oeland. An example incrusting the epithecated base of *Diplotrypa petropolitana*, from the Jewe limestone (D1), Baron Toll's estate (Cat. No. 57285, U.S.N.M.), differs only in having slightly smaller zoœcia. Other localities are Kuckers shale (C2), Baron Toll's estate (Cat. No. 57286, U.S.N.M.), and Kegel limestone (D2), Kegel, Esthonia (Cat. No. 57287, U.S.N.M.).

The type-specimen and figured thin sections are in the collections of the British Museum.

MESOTRYPA MILLEPORACEA PARVA, new variety.

Text fig. 110.

The internal structure of the specimens distinguished as above is exactly the same as in the typical form of the species, and the differences relied upon in founding the variety are the occurrence, first, of a distinct method of growth and, second, of much smaller zoœcia. Ordinarily such differences, particularly the latter, would be considered of specific importance, but the practical identity of all the other characters in each is believed to show close relationship.

The zoarium of the variety consists of small, globular or ovoid bodies, less than 5 mm. in their greatest diameter, formed by the layers of zoœcia incrusting some foreign object. Eight specimens with this form of growth have been seen. Comparing figures 109 *b* and 110 *b*, the distinctly smaller zoœcia of the variety are plainly evident, as is also the practical identity of the other characters.

Occurrence.—Apparently common in the Kuckers shale (C2), Baron Toll's estate, near Jewe, Esthonia.

Cotypes.—Cat. No. 57288, U.S.N.M.

Specimens and thin sections are in the collections of the British Museum.

Family HETEROTRYPIDÆ Ulrich.

The meager development of this family in the Russian strata seems upon first thought quite unusual, considering the abundant American representation, but a study of the generic distribution offers an explanation for this disparity. Species of *Heterotrypa* are quite abundant in the various Trenton and Cincinnatian formations of North America, but are absent entirely from strata holding the Black River and other Atlantic faunas. They also have not been discovered in European rocks. *Dekayella*, according to present knowledge, has its origin in a Black River species, *D. prænuntia*, common to both continents. In later times, representatives of the genus spread to other faunas so that *Dekayella* lost its value as a strictly Atlantic type. The same is true for *Stigmatella* and *Leptotrypa*, both of which have identical Russian and American representatives in Black River time. *Cyphotrypa* is represented in the Black River by a few species, but its greatest specific development is in faunas of later age, restricted so far as known, to the North American interior seas. *Dekayia*, *Petigopora*, and *Atactopora* are known only in the faunas of late Trenton and Cincinnatian time. With more research into the Russian Heterotrypidæ, it is of course probable that the above notes will require modification, but it is believed that the following fact will remain unchanged, namely that the Baltic forms belong to the generic types identical with those highly characteristic of the American Black River and other North Atlantic faunas.

The Heterotrypidæ are amalgamate Trepostomata differing from the Monticuliporidæ in having straight diaphragms instead of the curved cystiphragms. Clearly defined, frequently large, typical acanthopores are developed in every member of the family. Although the walls of adjoining zoœcia are fused, this double wall persists as a distinct but thin unit which has a clean-cut individuality, as shown in sections. The other two families of the Amalgamata differ from the Heterotrypidæ in just these two respects. Both the Batostomellidæ and the Constellariidæ have diaphragms instead of cystiphragms, thus differing from the Monticuliporidæ, but the first mentioned has thick walls with a number of them so fused together that the individual wall common to adjacent zoœcia is not clearly distinguishable. The Constellariidæ differs from all the Amalgamata families in the nature of its acanthopore, which is small and granular.

Although the family differences mentioned above are few and apparently slight, they are known from the study of a host of species to be fundamental and of as great value as more detailed discriminations founded upon living forms.

Genus DEKAYELLA Ulrich.

Dekayella ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 155; vol. 6, 1883, p. 90.—MILLER, North Amer. Geol. and Pal., 1889, p. 184.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, p. 372; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 269; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 273.—SIMPSON, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 589.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 31.—CUMINGS, American Geologist, vol. 29, 1902, p. 200.—ULRICH and BASSLER, Smiths. Misc. Coll., vol. 47, 1904, pp. 24, 27.

Heterotrypidæ with an erect ramose or frondescent zoarium made up of rather thin-walled zoœcia, usually abundant mesopores, both kinds of tubes crossed by numerous diaphragms; acanthopores in two sets, large and small.

The presence of two sets of acanthopores in *Dekayella* is the only distinction between this genus and *Heterotrypa*, but as this character pertains to a dozen or more species ranging through the middle and upper Ordovician, it is believed to be of generic importance. The two sets of acanthopores are distinctly visible only in the mature zone of the zoarium, so that tangential sections which cut other parts of the specimen will not show this feature.

Genotype.—Dekayella obscura Ulrich. Upper Ordovician (Eden) of the Ohio Valley.

DEKAYELLA PRÆNUNTIA Ulrich.

Text fig. 111.

Dekayella prænuntia ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 270, pl. 23, figs. 32–37.—SIMPSON, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 589, figs. 177–179.

The Wassalem beds at Uxnorm have afforded numerous specimens of a *Dekayella* so similar to the typical *D. prænuntia* Ulrich, and some of its varieties, that I am unable to point out any distinguishing characters. Most of the Russian specimens have the characteristics assigned to *D. prænuntia* var. *simplex* Ulrich, a form in which the mesopores are reduced to a minimum number, the zoœcial apertures are polygonal, thick-walled, and in contact, and the acanthopores are not as well developed as usual. Other examples, however, possess the arrangement of acanthopores and mesopores prevailing in the typical form of the species. The tabulation of the common Russian form is exactly the same as shown in figure 111 *f* of the Minnesota specimen, while tangential sections of both Ulrich's species and varieties can be duplicated in slides prepared from the European examples. The fragment of a zoarium shown in figure 111 *a* will illustrate the growth of the Russian specimens equally well. The characters of *D. prænuntia* are as follows:

Zoarium of subcylindrical, frequently compressed, irregularly dividing branches from 4 to 12 mm. in diameter. Surface without

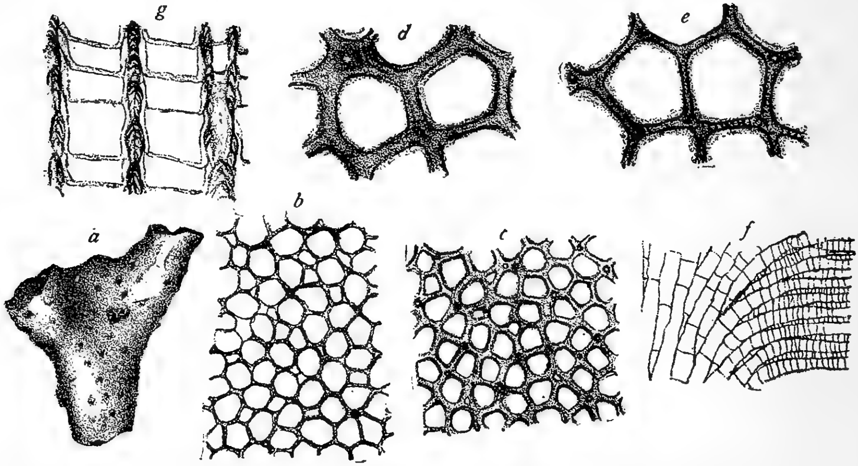

FIG. 111.—DEKAYELLA PRÆNUNTIA AND VARIETIES. *a*, FRAGMENT OF A VARIETY, NATURAL SIZE; *b*, TANGENTIAL SECTION, ×18, OF THE TYPICAL FORM; *c*, TANGENTIAL SECTION, ×18, OF VARIETY SIMPLEX; *d* AND *e*, SMALL PORTIONS OF TWO TANGENTIAL SECTIONS, ×50; *f*, VERTICAL SECTION, ×9, OF SPECIMEN WITH NUMEROUS MESOPORES; *g*, MINUTE STRUCTURE OF WALLS IN SECTIONS, ×50. BLACK RIVER (DECORAH) SHALES, MINNEAPOLIS, MINNESOTA. (AFTER ULRICH.)

monticules but minutely spinulose from the acanthopores which are about half as numerous as the zoœcia. Mesopores averaging one to a zoœcium, irregularly distributed and often segregated into clusters to form the maculæ. Zoœcial apertures angular to rounded according to the number of mesopores, eight to nine in 2 mm.

The characters of the typical form, as seen in tangential sections, are illustrated in figures 111 *b* and *e*, while the vertical section is essentially as shown in figure 111 *f*.

Occurrence.—Not uncommon in the Wassalem beds (D3) at Uxnorm (Cat. No. 57289, U.S.N.M.), and in the Kuckers (C2) at Reval (Cat. No. 57290, U.S.N.M.), Esthonia. The American specimens are abundant in the various divisions of the Black River (Decorah) shales of Minnesota and Iowa.

British Museum, one specimen from the Wassalem beds at Uxnorm.

DEKAYELLA PRÆNUNTIA SIMPLEX Ulrich.

Text fig. 111.

Dekayella prænuntia var. *simplex* Ulrich, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 271, pl. 23, figs. 39–42.

This variety, which, as noted before, is best represented in the Russian collections, may be distinguished from the typical form, first, by the scarcity of mesopores, second, by its rather thick-walled, polygonal zoœcia, and third, by the few and rather poorly developed acanthopores. The two sets of acanthopores characteristic of *Dekayella* are distinguished with difficulty. In vertical sections, aside from the practical absence of mesopores, no differences can be noted between this and the typical form.

Occurrence.—The American types are from the Black River (Decorah) shales, at Minneapolis and St. Paul, Minnesota. Very abundant in the Wassalem beds (D3) at Uxnorm, Esthonia (Cat. No. 57291, U.S.N.M.).

British Museum, specimens and thin sections from Uxnorm.

DEKAYELLA PRÆNUNTIA NÆVIGERA Ulrich.

Dekayella prænuntia var. *nævigera* Ulrich, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 271.

This form is much like the preceding variety *simplex* and differs mainly in having conspicuous groups of maculæ composed of numerous mesopores. Other differences are thinner zoœcial walls and a frequently inosculating form of growth. The Russian specimens are small fragments of zoaria and do not show such frequent branching, but otherwise they are identical with the Minnesota forms.

Occurrence.—Rare in the Wassalem beds (D3) at Uxnorm, Esthonia (Cat. No. 57292, U.S.N.M.). The American form was found in the Black River (Decorah) shales of Minnesota.

British Museum, specimen and thin section from Uxnorm.

Genus LEPTOTRYPA Ulrich.

Leptotrypa Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 6, 1883, p. 158.—Miller, North Amer. Geol. and Pal., 1889, p 311.—Ulrich, Geol. Surv. Illinois, vol. 8, 1890, pp. 377, 455; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 316.—Simpson, Fourteenth Ann. Rep. State Geol. New York for the year 1894, 1897, p. 580.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 31.—Ulrich and Bassler, Smiths. Misc. Coll., vol. 47, 1904, pp. 24, 28.—Cumings, Thirty-second Ann. Rep. Dept. Geol. Nat. Res. Indiana, 1907, p. 749.

Heterotrypidæ with the zoarium of thin, evenly spread, parasitic expansions with thin-walled, polygonal zoœcia, no mesopores, few diaphragms, and very small acanthopores, which are never abundant.

Genotype.—*Leptotrypa minima* Ulrich. Upper Ordovician (Maysville), Ohio Valley.

As understood at the present time, this genus has abundant representatives in the southern Atlantic faunas of Upper Ordovician time, but, with a single exception, no species are known in other Ordovician formations. The exception is the *Leptotrypa hexagonalis* Ulrich, known in America only in the Platteville limestone of Wisconsin and Minnesota, but represented in the Kuckers shale (C2) of Esthonia by numerous specimens.

LEPTOTRYPA HEXAGONALIS Ulrich.

Text figs. 112–114.

Leptotrypa hexagonalis Ulrich, Geol. Surv. Illinois, vol. 8, 1890, p. 455, pl. 36, figs. 6, 6 *a*; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 317.

Original description.—Zoarium forming parasitic expansions less than 1 mm. in thickness, spread upon *Orthoceras* and *Hyolithes*. Surface smooth. Clusters of cell

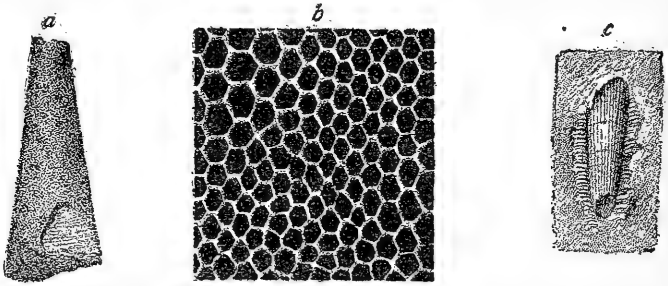

Fig. 112.—Leptotrypa hexagonalis. *a*, the original type of the species, natural size, incrusting a Hyolithes; *b*, surface of the same, ×12. Middle Ordovician (Platteville) limestone, Mineral Point, Wisconsin. (After Ulrich.) *c*, a fragment of limestone with a Hyolithes incrusted by this delicate bryozoan. Kuckers shale (C2), Baron Toll's estate, Esthonia.

apertures of almost twice the usual size are arranged in diagonally intersecting rows; these clusters are about 3 mm. apart, measuring from center to center. Zoœcia regularly hexagonal in shape, sometimes a little elongated, seven, measuring longitudinally, almost nine, diagonally, in 2 mm.; diameter of the smaller 0.2 of the larger 0.35 mm. Acanthopores prominent on the surface when well preserved.

The usual occurrence of this species in America is as a delicate, lace-like expansion upon shells of the pteropod *Hyolithes baconi* Whitfield. The occurrence in the Kuckers shale is identical, even to a great resemblance of the incrusted pteropod to *H. baconi*, although this shell is probably the form described by Eichwald as *Hyolithes striatus*. The internal structure of *Leptotrypa hexagonalis* has never been figured and I am taking this opportunity of presenting thin sections of the type, mainly for comparison with similar sections of the Russian form. Comparison of figures 113 and 114 will show practical identity of structure in the corresponding parts of the sections. The size, shape, and thinness of the cells are especially similar. The Russian specimens, however, exhibit an interesting feature which has not been observed in the American examples. This is the occurrence exclusively of small, thick-walled, closely tabulated mesopore-like cells on the flat side of the *Hyolithes*, and the restriction of the thin-walled, ordinary zoœcia to the curved portions of the shell. A vertical section of this region of small cells is shown in the lower half of figure 114 *c*, and a tangential view in figure 114 *d*. Ordinary

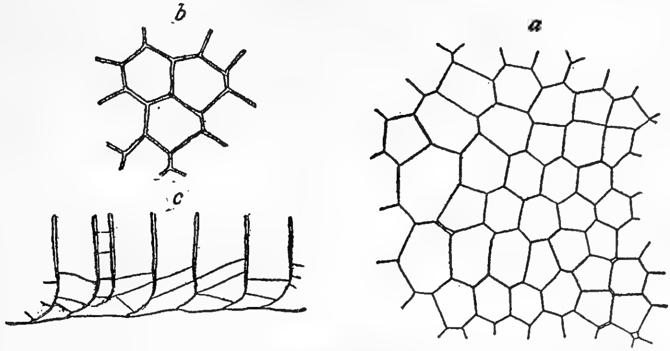

FIG. 113.—LEPTOTRYPA HEXAGONALIS. *a*, TANGENTIAL SECTION OF THE AMERICAN TYPE OF THE SPECIES, ×20; THE LARGER ZOŒCIA FORM PART OF A MACULA, WHILE THE MORE NUMEROUS, SMALLER CELLS ARE OF THE ORDINARY INTERMACULAR KIND; *b*, SEVERAL ZOŒCIA OF THE SAME SECTION, ×30, SHOWING THEIR SIMPLICITY OF STRUCTURE; *c*, VERTICAL SECTION, ×20, EXHIBITING BOTH REGIONS OF THE THIN ZOARIAL LAYER. MIDDLE ORDOVICIAN (PLATTEVILLE) LIMESTONE, MINERAL POINT, WISCONSIN.

zoœcia are wanting entirely in this area which undoubtedly represents similar thickwalled, mesopored areas at the base of the zoarium in such forms as *Diplotrypa bicornis*. The subject of such areas of small cells is discussed on a previous page, where it is suggested

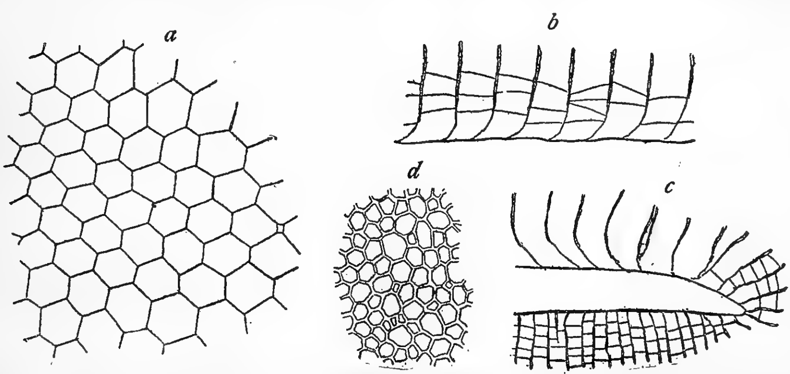

FIG. 114.—LEPTOTRYPA HEXAGONALIS. *a*, TANGENTIAL SECTION, ×20, OF A RUSSIAN EXAMPLE; *b*, VERTICAL SECTION, ×20; *c*, A VERTICAL SECTION, ×20, PASSING THROUGH A LAYER OF ORDINARY ZOŒCIA, AND ALSO CUTTING THE CLOSELY TABULATED, MESOPORE-LIKE TUBES GROWING UPON THE FLAT SIDE OF THE SHELL; *d*, TANGENTIAL SECTION, ×20, THROUGH THE SMALL, THICK-WALLED CELLS. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

that the *Hyolithes* shell frequently or invariably rested upon its flat side in the mud of the sea bottom.

The internal structure is so simple that specific mention of it is hardly necessary. The strong acanthopores spoken of in the original description are extremely shallow and frequently are not present at all.

The delicate parasitic growth and the thin-walled, polygonal, frequently hexagonal, zoœcia are so distinctive of this form that there is little likelihood of confusing it with other species.

Occurrence.—Rather rare in the Platteville limestone of Black River age in Minnesota, Wisconsin, and Illinois. Very common in the Kuckers shale (C2), Baron Toll's estate, near Jewe, Esthonia. The incrusted shells of the latter locality occur mainly in the thin limestone layers, which, where broken, show the *Hyolithes* and the fractured zoarium as shown in figure 112 *c*.

Plesiotypes.—Cat. No. 57293, U.S.N.M.

Specimens and thin section from Kuckers shale, Baron Toll's estate, in the collections of the British Museum.

Genus STIGMATELLA Ulrich and Bassler.

Stigmatella Ulrich and Bassler, Smiths. Misc. Coll., vol. 47, 1904, pp. 24, 33.—Bassler, Bull. 292, U. S. Geol. Surv., 1906, p. 27.—Cumings, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 756.

This genus was established for a group of the Heterotrypidæ differing from other divisions of the family in having the walls of the zoœcial tubes noticeably thickened at periodic intervals, and in developing acanthopores only in these zones of thick walls. This periodic thickening of the zoœcial walls with an accompanying accelerated development of the acanthopores has been found characteristic of a number of Orodovician species which range in growth from the incrusting to irregularly massive and ramose. In all other respects these species are typical Heterotrypidæ. The generic name was selected for the reason that many of the species have unusually distinct maculæ or "spots" composed of mesopores distributed over the zoarium at regular intervals. Thin sections are almost a necessity for the initial determination of a species of *Stigmatella*, although additional specimens of a species can readily be detected after the first example has been sectioned. The areas of thickened walls and numerous acanthopores undoubtedly represent repeated mature zones in the zoarium, for it is here only that mature zoœcial characters can be observed. Mesopores may be few, indeed absent, or numerous. Without sections an incrusting species without mesopores would be confused with a *Leptotrypa* like *L. hexagonalis* figured on page 208, but a single layer of the *Stigmatella* would show several alternately thin and thick walled areas. Comparison with other genera of the Heterotrypidæ might be made, but in every case the distinct zones of *Stigmatella* remain the most diagnostic feature. Another characteristic is the sparse development of diaphragms, in which feature the genus approaches *Dekayia*, although differing in its numerous mesopores. The following species include one with crenulated walls characteristic of the typical members of the genus, and two others conspicuous mainly for their extravagant development of small acanthopores indenting the zoœcial cavity.

Genotype.—Stigmatella crenulata Ulrich and Bassler. Earliest Silurian (Richmond), Ohio Valley.

STIGMATELLA MASSALIS, new species.

Text fig. 115.

Zoarium, a dome-shaped or hemispheric mass, which in the type-specimen is 40 mm. in diameter and 20 mm. high. Surface smooth;

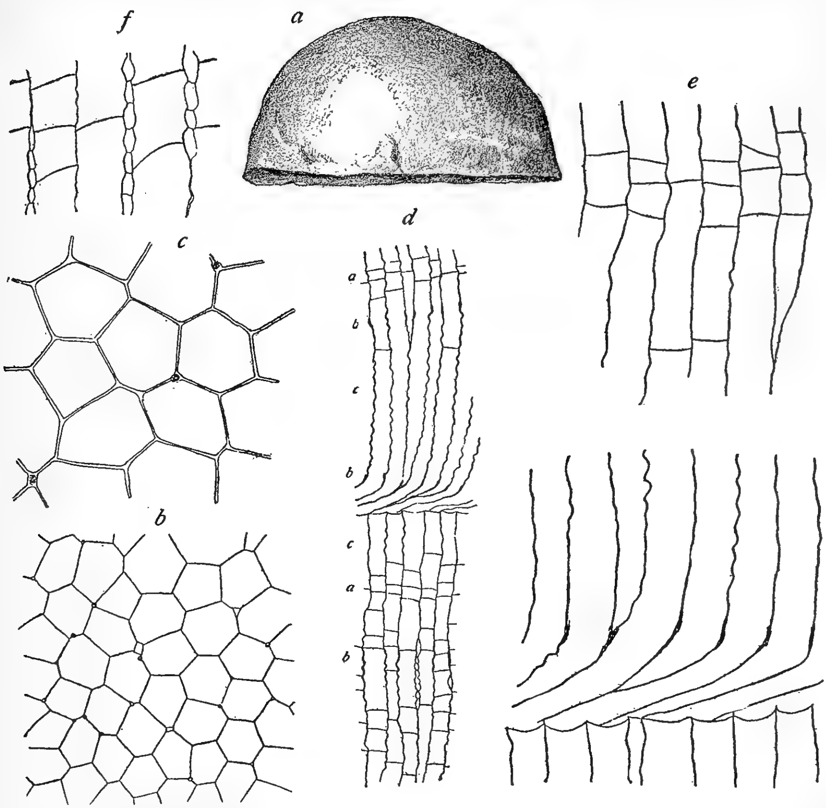

FIG. 115.—STIGMATELLA MASSALIS. *a*, SIDE VIEW OF THE TYPE-SPECIMEN, NATURAL SIZE; *b* AND *c*, TANGENTIAL SECTION, ×20, AND A PORTION OF THE SAME, ×35, PASSING THROUGH THE ZONE IN WHICH ACANTHOPORES ARE DEVELOPED; *d*, VERTICAL SECTION, ×8, PASSING THROUGH TWO LAYERS OF ZOŒCIA; *e*, PORTION OF THE SAME SECTION, ×20; *f*, PART OF VERTICAL SECTION, ×20, THROUGH A MACULA. KEGEL BEDS (D2), HABBINEM, ESTHONIA.

maculæ inconspicuous, composed of zoœcia larger than usual. Zoœcia polygonal, thin-walled, seven in 2 mm.; mesopores almost entirely wanting; restricted to the maculæ when present; acanthopores usually few and inconspicuous at the surface.

The extreme simplicity and thinness of the zoœcial walls, the clear space or white line in the walls separating adjoining zoœcia, and the scarcity of acanthopores are brought out in tangential sections. The tangential section represented in figures 115 *b* and *c* passes through a zone of the zoarium where the acanthopores are best developed. In ordinary tangential sections acanthopores are practically absent. Such sections have few if any characters to distinguish the species from many other Heterotrypidæ. In vertical sections, however, both specific and generic characters are well shown. Figure 115 *d* represents a vertical section passing through two layers of zoœcia and exhibiting several mature (*a*) and immature (*c*) zones, as well as thin zones of accelerated acanthopore development (*b*). Crinkling of the zoarial walls is likewise well shown in this figure and also in figure 115 *e*, which represents the mature region and part of an immature region of a single zoœcial layer. The crenulated zoœcial walls give a beaded aspect to the few mesopores which are occasionally developed in the maculæ (fig. 115 *f*).

While *Stigmatella massalis* agrees in growth with a number of Ordovician species, it can readily be distinguished by its polygonal, small, thin-walled zoœcia, the zonal development of acanthopores, and the crinkling of the walls, as mentioned above.

Occurrence.—Apparently rare in the Kegel beds (D2) at Habbinem, Esthonia.

Holotype.—Cat. No. 57294, U.S.N.M.

A fragment and thin sections of the type-specimen are in the collections of the British Museum.

STIGMATELLA INFLECTA, new species.

Text fig. 116.

This most interesting species is represented by the type and by several additional specimens from the Orthoceras and Echinospherites limestones at localities in the Baltic provinces. All of these examples agree in being rather irregularly rounded masses several centimeters in diameter, such as that shown in figure 116 *a*. The base of the type-specimen, which is of normal growth, is slightly concave and covered with an obscurely marked epitheca. The other examples have had this epithecated side so overgrown by small, thick-walled, mesopore-like cells that it is now obscurely rounded and minutely poriferous. Upper celluliferous side of zoarium smooth and without conspicuous maculæ, although clusters of large zoœcia and more numerous mesopores are present at regular intervals. Zoœcial apertures in the mature stage irregularly petaloid, due to their indentation by numerous small acanthopores. Where an immature stage of the zoarium is presented at the surface, the apertures are polygonal and without acanthopores. The average zoœcium is 0.33 mm. in diameter with four to five in 2 mm. Mesopores are numerous and almost invariably isolate the zoœcia; they are angular, thin-walled, and frequently so large that in the absence of acanthopores the zoœcia and mesopores are often practically indistinguishable. The acanthopores are small but occur in such numbers in the mature zone that they give a minutely spinous or granular aspect to the zoarial surface.

Thin sections show this to be a typical species of *Stigmatella*. Vertical sections exhibit thin, slightly crenulated tubes in the immature

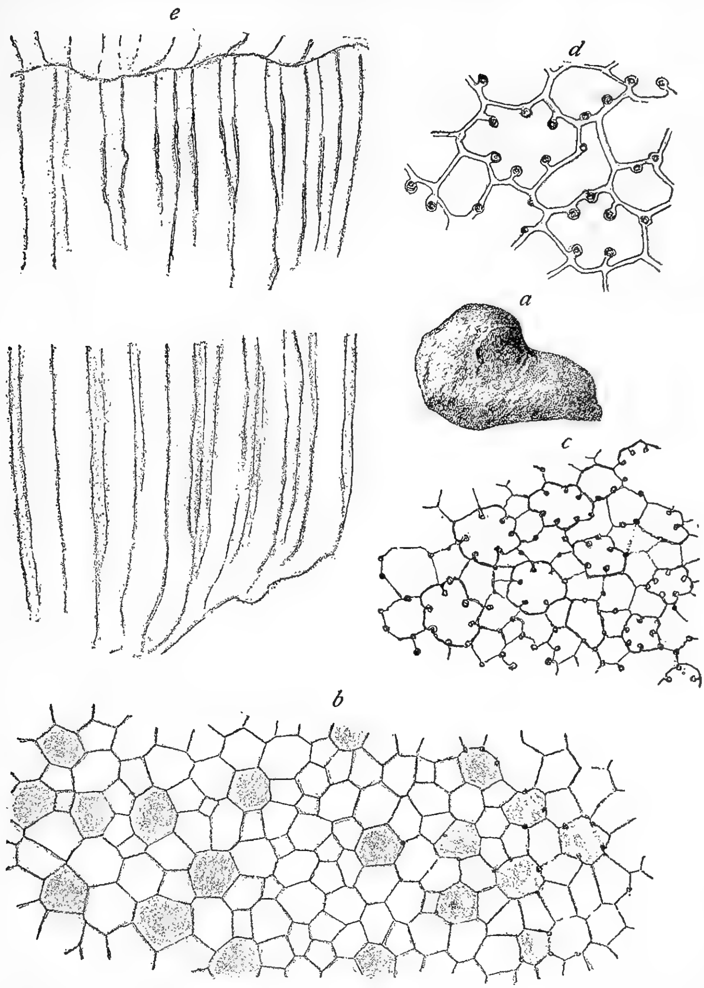

Fig. 116.—Stigmatella inflecta. *a*, side view of the type-specimen, natural size; *b*, tangential section, ×20, with only a small portion cutting the region of acanthopores; *c*, another tangential section, ×20, passing through a well-developed zone of acanthopores; *d*, several zoœcia of the same section, ×40, with the structure of the walls and acanthopores clearly shown; *e*, vertical section, ×20, showing both immature and mature regions. Orthoceras limestone (B3), Port Kunda, Esthonia.

region. These thicken somewhat in the mature zone with the development of numerous acanthopores. The latter region is further distinguished by having an occasional diaphragm in the mesopores. Tangential sections vary in appearance according to the zone which is cut. In figure 116 *b*, the section passes through portions of both the mature and immature zones and shows on the left-hand side the polygonal zoœcia without acanthopores surrounded by mesopores often of so nearly the same size that there is difficulty in separating the two. In the central part of the figure a macula of mesopores occurs, while on the right hand side the initial development of acanthopores at the base of a mature zone is figured. The normal occurrence of the acanthopores in the fully matured zone is illustrated in figures 116 *c* and *d*.

Occurrence.—Rare in the Orthoceras limestone (B3) at Port Kunda, Esthonia, and in the Echinospherites limestone (C1) at Pulkowa and at Archangelski on the Wolchow River, government of St. Petersburg.

Holotype.—Cat. No. 57295, U.S.N.M.

British Museum, two sections of the type-specimen and one specimen from Pulkowa.

STIGMATELLA FOORDII (Nicholson).

Text figs. 117, 118.

Callapora foordii Nicholson, in Nicholson and Lydekker, Man. Pal., vol. 1, 1889, p. 351, fig. 229.

I was fortunate enough to find a single specimen of this interesting organism in the collections from the Kuckers shale, Baron Toll's estate. The species can hardly be said to have been described, and, moreover, Nicholson gave no horizon and locality other than "Ordovician rocks of Esthonia," but his figured thin sections are so distinctive that I have no doubt of the correctness of the present identification. Both his remarks concerning the species and his figures are reproduced below. In the description of his figures, I have also copied Nicholson's wording, although the corresponding terms used in the present paper are inserted in brackets.

> The great majority of the Monticuliporoids exhibit no radial structures in the tubes which could be compared with the "septa" of an ordinary coral. In a few forms, such structures do occur, but it is doubtful if in any such instance we have to deal with structures really developed in mesenteries, and therefore really homologous with the "septa" of the *Zoantharia*. Thus in *Fistulipora* each autopore is provided with two longitudinal folds, situated opposite one another, toward one end of the visceral chamber. Again, in a hitherto undescribed species of *Callopora* each autopore is provided with from two to five radial plications of the wall, which closely resemble the "septa" of *Tetradium*, and give a characteristic floriform appearance to cross sections of the corallites.

As may be readily imagined from the foregoing notes by Nicholson his main object in introducing figures of *Callopora foordii* was to show the occurrence in certain monticuliporoids of radial plications closely resembling the septa of typical corals, and consequently indicating the affinities of *Monticulipora* and its allies with the corals. However, he failed to note that a small acanthopore is present at the end of each fold and that the present species is therefore only an exaggerated case of indentation of the zoœcial cavity by the acanthopore and the wall bearing it. Less pronounced examples of this sort are seen in the preceding *Stigmatella inflecta*, in *Orbipora indenta*, and in many other bryozoans not described in this volume. All gradations may be traced from the extremely developed folds of the present species to very simple indentations caused by the swelling of the zoœcial walls when an acanthopore is inserted; in fact, all such gradations may be seen in a single specimen. Thus, in figure 118 *c*, this portion of a tangential section passes through the basal part of a mature region and shows no acanthopores at all in most of the zoœcial walls, and a few just beginning to indent the cavities of the tubes in the upper third of the figure. Figure 118 *b* exhibits the change from the region of no acanthopores to a zone in which they develop the four-sided *Tetradium* effect illustrated by Nicholson.

The remaining figures, 118 *d* and 118 *e*, show the greatest development of the infolded, acanthopore-bearing, zoœcial wall that has

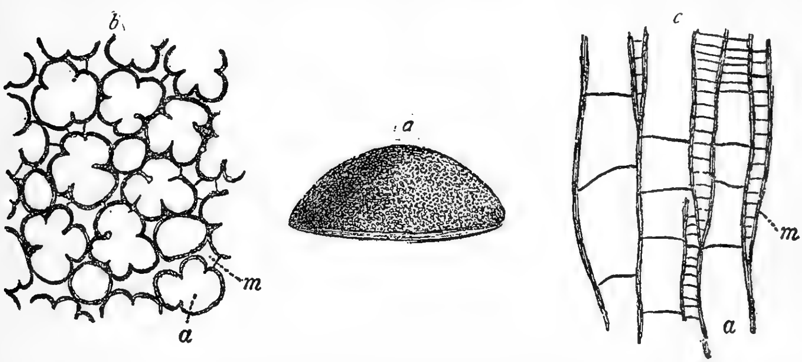

FIG. 117.—STIGMATELLA FOORDII. *a*, A LARGE SPECIMEN OF CALLOPORA FOORDII, OF THE NATURAL SIZE; *b*, TANGENTIAL SECTION OF THE SAME, SHOWING THE PSEUDOSEPTAL FOLDS IN THE AUTOPORES [ZOŒCIA], ENLARGED TWENTY TIMES; *c*, VERTICAL SECTION OF THE SAME, SIMILARLY ENLARGED, *a*, AUTOPORES, *m*, MESOPORES. ORDOVICIAN ROCKS OF ESTHONIA. (AFTER NICNOLSON.)

been observed. In order to show the change most clearly, the zoœcial cavities in figure 118 *b* have been shaded. All of these figures are drawn from the same tangential section which passes somewhat obliquely through the zoarium with the result that one end cuts the immature zone and the rest of the section passes through various phases of the mature region.

As a description of this species has never been given, the following diagnosis is in order:

Zoarium of small, depressed, hemispheric masses seldom over 20 mm. in diameter; basal side flat and covered with a concentrically wrinkled epitheca, celluliferous surface smooth with clusters of larger zoœcia and more numerous mesopores at regular intervals. Zoœcia small, polygonal or petaloid, seven in 2 mm. with an average aperture about 0.28 mm. in diameter. Mesopores angular, thin-walled, and numerous enough to frequently surround the zoœcia. Acanthopores very small, varying from two to eight to a zoœcium and developed at the end of a fold of the wall which in the most mature condition extends far into the zoœcial cavity.

The internal structure as exhibited in tangential sections has been discussed above and the septal folds of Nicholson shown to be the greatly infolded, zoœcial wall bearing an acanthopore. Vertical sections are especially interesting for the reason that they exhibit the diagnostic generic character—the zonal thickening of the walls accompanied by an accelerated development of acanthopores. The characters of such a section, with two successive immature and mature zones, are shown in figure 118 *a*. Nicholson's vertical section

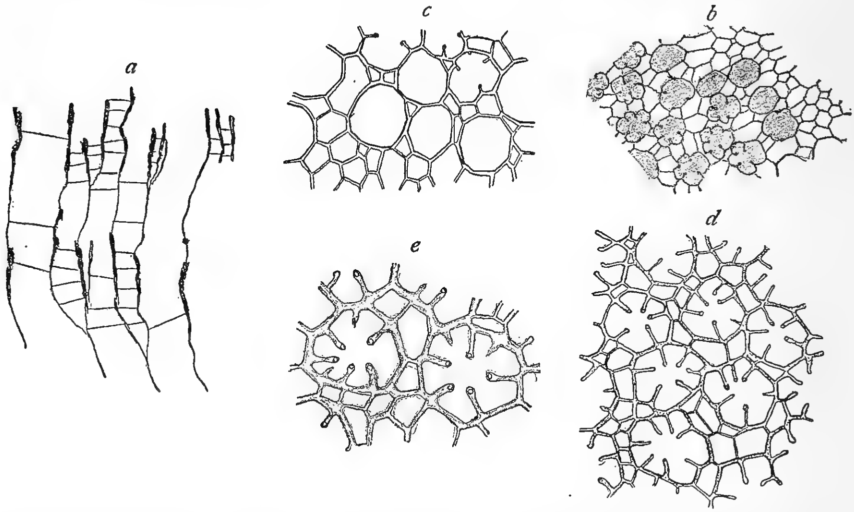

FIG. 118.—STIGMATELLA FOORDII. *a*, VERTICAL SECTION, ×20, PASSING THROUGH TWO LAYERS OF ZOŒCIA; *b*, TANGENTIAL SECTION, ×20, WITH THE ZOŒCIA SHADED; *c*, PORTION OF THE SAME SECTION, ×35, WITH FEW ACANTHOPORES; *d*, ANOTHER PORTION, ×35, SHOWING AN EXTREME DEVELOPMENT OF THE INFOLDED ZOŒCIAL WALL; *e*, SEVERAL ZOŒCIA OF A TANGENTIAL SECTION, ×50, WITH SMALL ACANTHOPORES PLAINLY DEVELOPED AT THE ENDS OF THE INFOLDED WALLS. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

includes only the mature region of a single zone, but the tabulation of both sets of tubes is the same as in the original of figure 117 *a*.

Without careful comparison, the zoœcial characters of the present form seem almost identical with those of *Stigmatella inflecta*, but the zoœcia of the latter are almost twice the diameter of the former. Internally the two species are quite distinct, especially in the tabulation. No American species with which either might be compared is known.

Occurrence.—Rare in the Kuckers shale (C2), Baron Toll's estate, near Jewe, Esthonia.

Plesiotype.—Cat. No. 57298, U.S.N.M.

Section of figured specimen in the collections of the British Museum.

STIGMATELLA CLAVIFORMIS (Ulrich).

Text fig. 119.

Leptotrypa claviformis ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 319, pl. 27, figs. 20, 21.

Among the small, massive bryozoans of the Wassalem beds are rather numerous examples with a club-shaped zoarium which agrees externally with the above common American form. This identification is confirmed by thin sections which show practically no variation in specimens from the two widely separated localities. Figures of the American examples are given below. The following remarks are adapted from Ulrich's description.

Zoarium growing into simple club-shaped forms varying from the smallest figured to one that is 23 mm. long and 1.5 to 2.5 mm. in

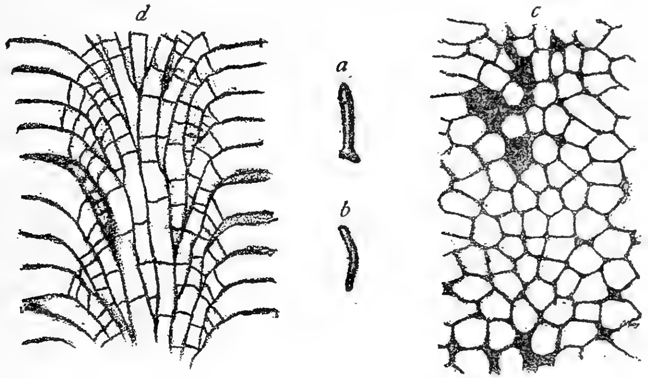

FIG. 119.—STIGMATELLA CLAVIFORMIS. *a* AND *b*, TWO OF THE CLUB-SHAPED ZOARIA, NATURAL SIZE; *c*, VIEW OF ZOŒCIA IN TANGENTIAL SECTION, ×18; *d*, VERTICAL SECTION THROUGH THE MIDDLE OF A ZOARIUM, ×18. BLACK RIVER (DECORAH) SHALES, ST. PAUL, MINNESOTA. (AFTER ULRICH.)

diameter. Zoœcial tubes growing about the axial body very much as in ordinary ramose forms that grow about an imaginary center; diaphragms abundant except in the outer or direct portion; walls thin. Zoœcial apertures subangular, nearly uniform in size, there being no appreciable clusters of large cells; without apparent arrangement, about 14 in 3 mm. What may be mesopores, but more likely are merely young zoœcia, are scattered among the ordinary tubes. At intervals, however, they seem to be more numerous than usual. Many, perhaps the majority, of the angles of junction are thickened and occupied by projecting acanthopores.

Occurrence.—Common in the various divisions of the Black River (Decorah) shales in Minnesota and Iowa; also in the Wassalem beds (D3) at Uxnorm, Esthonia (Cat. No. 57299, U.S.N.M.).

British Museum, one specimen from Uxnorm.

Family CONSTELLARIIDÆ Ulrich.

Until the publication of the English edition of Zittel's Textbook of Paleontology, the members of this family were assigned to the Trematoporidæ, a position which increasing knowledge has shown to be unwarranted. In a general way the wall structure of *Constellaria* and its allies is similar to that obtaining in the other families of the Amalgamata, but other characters are so different that a new family, Constellariidæ, was instituted by Ulrich in the above-mentioned publication. The most obvious characteristic of the family is the usually stellate shape of the maculæ. More important features are the small, hollow spines or granules which occur in place of true acanthopores, and a somewhat granular wall structure occurring in the more mature portion of the zoarium.

The simplest type of Constellariidæ is believed to be expressed in *Dianulites*, which, although it lacks the stellate maculæ, has the characteristic granulose wall structure and the small granules or hollow spines in place of acanthopores. *Dianulites* was at first believed to be restricted to the Baltic Ordovician deposits, but a single large typical species of the genus is now recognized in America. Typical species of *Constellaria*, *Stellipora*, and *Nicholsonella* occur in both America and Russia. The remaining genus of the family, *Idiotrypa*, is known only from early Silurian rocks and has not been noted elsewhere than in North America.

Genus CONSTELLARIA Dana.

Constellaria Dana, Zoophyta, 1846, p. 537.—Nicholson, Pal. Ohio, vol. 2, 1875, p. 214; Pal. Tab. Corals, 1879, p. 292; Genus Monticulipora, 1881, p. 97.—Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 156; vol. 6, 1883, p. 265.—James and James, Journ. Cincinnati Soc. Nat. Hist., vol. 11, 1888, p. 29.—Ulrich, Geol. Surv. Illinois, vol. 8, 1890, pp. 374, 423; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 311; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 276.—J. F. James, Journ. Cincinnati Soc. Nat. Hist., vol. 18, 1896, p. 117.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 34.—Cumings, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 742.

Stellipora Milne-Edwards, Hist. Nat. des Corall, vol. 3, 1860, p. 281.

Stellipora (part) Dybowski, Die Chaetetiden d. Ostbalt. Silur-Form., 1877, p. 42.

The generic characters of this group of Bryozoa have been worked out and described by Ulrich in his various memoirs. The genus is one of the most easily recognized of Ordovician and early Silurian types, mainly on account of the very characteristic star-shaped maculæ. This, although the most obvious feature, is no more important than the erect ramose or frondescent growth and the minute structure of the walls. Nickles and Bassler have briefly defined the genus as follows:

Zoarium growing into erect, flattened branches or fronds from a basal expansion which is attached to foreign bodies; surface with depressed stellate maculæ, the spaces between the rays elevated and occupied by two or three short rows or clusters of closely approximated apertures; mesopores aggregated into maculæ, internally with gradually crowding diaphragms.

Genotype.—Ceriopora constellata (Van Cleve) Dana. Upper Ordovician of the Ohio Valley.

CONSTELLARIA VARIA Ulrich.

Text figs. 120–122.

Constellaria varia Ulrich, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 311, pl. 21, figs. 1–7.

Several well-preserved specimens of a ramose species of *Constellaria* from the Jewe limestone (D1) and Wassalem beds (D3) proved upon

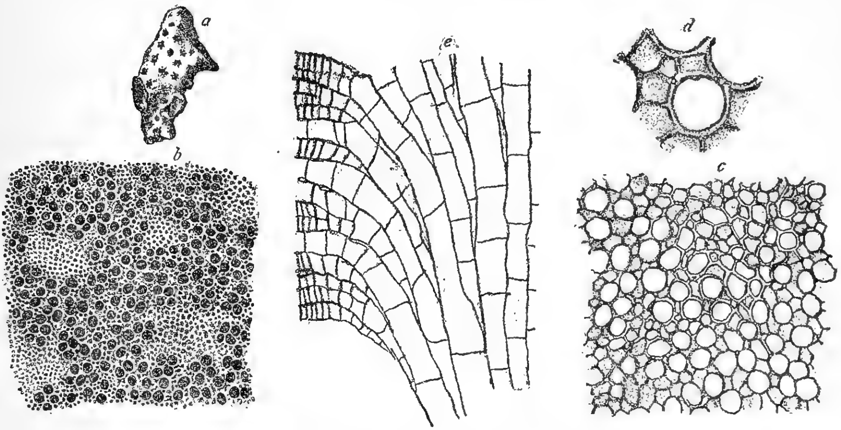

Fig. 120.—Constellaria varia. *a*, fragment of a zoarium, natural size; *b*, surface of a mature specimen, ×9; *c*, tangential section, ×18; *d*, small portion of the same, ×50, with two mural tubuli; *e*, vertical section of average example, ×18. Nematopora bed of Trenton, near Cannon Falls, Minnesota. (After Ulrich.)

careful comparison with the American form to be identical with the well-marked *Constellaria varia* Ulrich from the Lower Trenton strata of Minnesota and other States. Figure 120 represents the external and internal features of the American type and will serve equally well for the identification of the Russian specimens. The internal characters of a well-developed specimen from Uxnorm are shown in figure 121. Comparing this with the corresponding figures of the American form, the tangential sections are seen to be practically identical, while the slight difference in the vertical sections is due solely to the greater development of the mature region in the Russian specimens. The figured vertical section passes through a macula, and thus gives the appearance of a greater development of mesopores. Ulrich's description of the species is quoted below.

Zoarium consisting of one or more irregularly dividing branches arising from a broad basal expansion. Branches usually compressed, generally from 8 to 10 mm. wide, but varying between the extremes of 3 and 15 mm. Maculæ large, irregularly stellate, very slightly depressed or on a level with the general plane of the surface. The small clusters of zoœcial apertures (4 to 10 in each) occupying the angles between the rays may be elevated a little above the level of the maculæ, but as a rule the entire surface may be said to be even. In a few cases, however, the maculæ

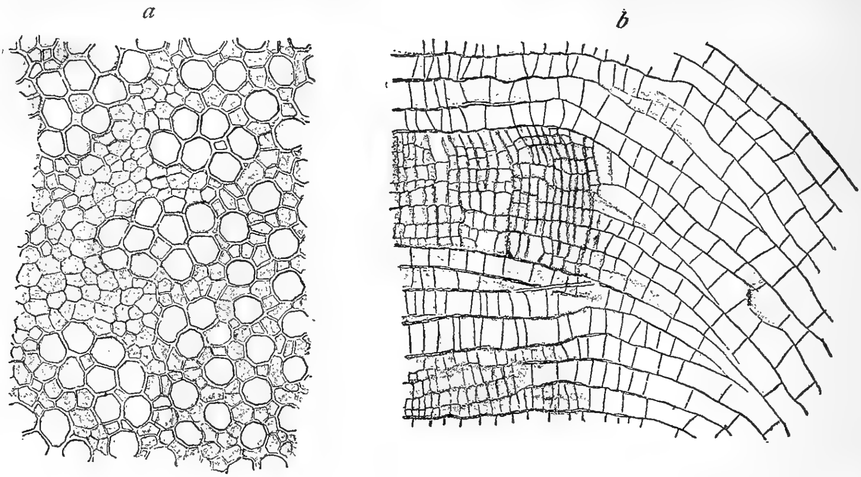

FIG. 121.—CONSTELLARIA VARIA. *a*, TANGENTIAL SECTION, ×20, CUTTING SEVERAL RAYS OF A MACULA; *b*, VERTICAL SECTION, ×20, PASSING THROUGH A MACULA. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

themselves are higher than the spaces separating them. Zoœcial apertures subcircular, inclosed by a very thin rim, and varying considerably in size, though approximately equal on each fragment. Width of interspaces varying correspondingly, so

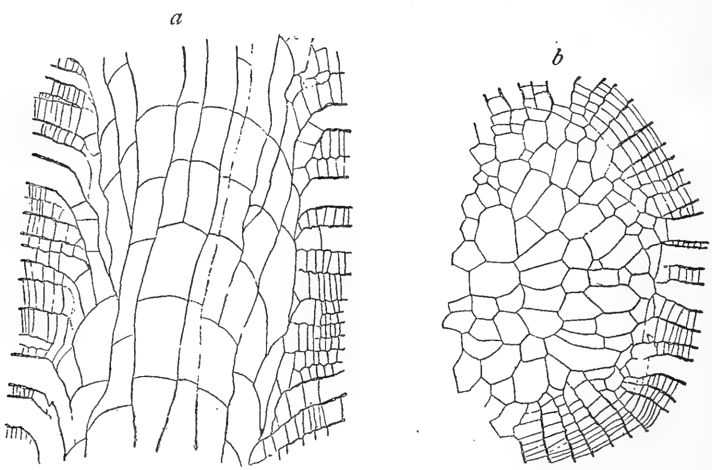

FIG. 122.—CONSTELLARIA VARIA. *a*, VERTICAL SECTION, ×20, OF A SMALL EXAMPLE; *b*, TRANSVERSE SECTION OF THE SAME SPECIMEN, ×20. JEWE LIMESTONE (D1), BARON TOLL'S ESTATE, ESTHONIA.

that about the same number of apertures occur in a given space in all specimens. Ten or 11 occur in 3 mm. in the intermacular spaces, while the diameter of the apertures varies between the extremes of 0.15 and 0.25 mm.

The smooth, ramose zoarium and the well-marked stellate maculæ of *Constellaria varia* are so different from associated forms that no confusion is likely.

Occurrence.—The original types of *Constellaria varia* were found in the Nematopora bed of the Lower Trenton at Cannon Falls, Minnesota. The species is known from the same general horizon at other American localities, notably in Canada and in Tennessee. In the Russian collections from the Wassalem beds (D3), at Uxnorm, near Reval, a fine, practically complete zoarium of this species occurred, while smaller but equally typical specimens were found in the Jewe limestone (D1), Baron Toll's estate, near Jewe, Esthonia.

Plesiotypes.—Cat. Nos. 57300, 57301, U.S.N.M.

British Museum, thin section of a Russian figured specimen.

Genus STELLIPORA Hall.

Stellipora Hall, Nat. Hist. New York, vol. 1, 1847, p. 79.—D'Orbigny, Prodr. de Pal., vol. 1, 1850, p. 22.—Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 155; vol. 6, 1883, p. 263; Geol. Surv. Illinois, vol. 8, 1890, p. 374; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 276.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 34.

Stellipora (part) Dybowski, Die Chaetetiden d. Ostbaltischen Silur-Form., 1877, p. 42.—Miller, North Amer. Geol. and Pal., 1889, p. 203.

Differs from *Constellaria* in its incrusting or free lamellate method of growth and in having the interspaces between the raised zoœcial clusters composed of mesopores alone.

Genotype.—*Stellipora antheloidea* Hall. Middle Ordovician (Trenton) of New York and Canada.

From America but a single species of *Stellipora*, the genotype, has been described, although the collection of the United States National Museum contains several new forms allied to the Russian species. A review of Dybowski's work upon this genus has shown that, while he included *Constellaria* as a synonym, the two species assigned to *Stellipora* are typical members of the latter genus as now restricted. The third species noted below is interesting in that it forms large, isolated, star-like clusters. With the genotype, the several new American forms, and the three species following, *Stellipora* has a fair specific representation.

STELLIPORA REVALENSIS Dybowski.

Plate 4, figs. 8–8*b;* text fig. 123.

Stellipora revalensis Dybowski, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 44, pl. 3, figs. 8*a*, *b*.

Both this and the following species have been described in detail by Dybowski, and I can only verify their reference to *Stellipora* and add a few notes concerning the specific characters. There are no described American forms with which either might be confused. In each species the zoarium is a small, lamellate expansion with a wrinkled epitheca on the basal side, and with prominent star-shaped clusters as the most conspicuous feature of the celluliferous face. In *S. revalensis* these clusters are outlined by polygonal, raised areas composed of mesopores (see pl. 4, fig. 8), but in *S. constellata* these thin ridges are absent, the rays of the maculæ being confluent. The occurrence of such polygonal areas is not restricted to *Stellipora* because species of *Constellaria*, such as *C. polystomella*, and of *Dianulites*, *D. petropolitana* for example, likewise bear them. Numerous specimens of the two latter species have been examined with the result that the polygonal areas are known to be inconstant in their development. Some specimens have them excellently developed, while others show no trace. Still other examples will have a portion of the surface with well marked areas, and another portion without a trace of them.

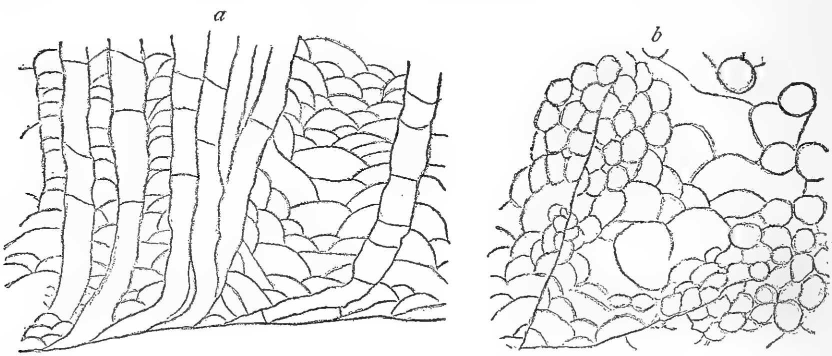

FIG. 123.—STELLIPORA REVALENSIS. *a*, VERTICAL SECTION, ×20; *b*, TANGENTIAL SECTION, ×20, ILLUSTRATING STRUCTURE OF TWO RAYS OF A CLUSTER. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

These thin ridges are composed entirely of mesopores and seem to mark out areas of distinct growth.

In figure 123 the normal internal structure, drawn under the camera lucida, is shown. Figure 123 *a* represents the very short immature zone in which the zoœcia are prostrate, and the mature region of the ordinary zoœcia and a part of a macula. Dybowski's figure of the vertical section is rather diagrammatic and fails to show the cyst-like tabulæ filling the mesopores. The zoœcia proper have straight diaphragms about their own diameter apart in the more crowded portions. Comparing the figure on plate 4 and figure 123, Dybowski's tangential section and the one prepared from specimens in the collection of the United States National Museum are seen to be alike. The small, rounded apertures are the zoœcia, while the large, irregularly shaped openings represent the mesopores.

Further notes upon *Stellipora revalensis* are given under the discussion of the next species.

Occurrence.—Dybowski records his species from zone 1 at Sack, Kuckers, and Reval. The specimens before me come from the

Kuckers shale (C2), Baron Toll's estate, near Jewe, and from Reval, Esthonia.

Plesiotype.—Cat. No. 57302, U.S.N.M.

British Museum, one thin section from the Kuckers shale, Baron Toll's estate.

STELLIPORA CONSTELLATA Dybowski.

Plate 4, figs. 9, 9*a*.

Stellipora constellata DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 48, pl. 3, figs. 9, 9*a*.

I have not encountered this species in the collections studied and must therefore limit my remarks to Dybowski's description and figures. According to that author, the zoarium is lamellate and made up of star-shaped clusters 6 to 8 mm. in diameter and 2 to 3 mm. distant from each other. Each star consists of five to eight elongate, spindle-shaped, rhomboidal elevations arranged radially. The clusters have no polygonal areas segregating them, but are arranged sometimes so closely that the radii become confluent.

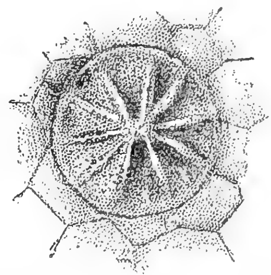

FIG. 124.—STELLIPORA APSENDESOIDES. A ZOARIUM, ×3, ATTACHED TO A SPECIMEN OF ECHINOSPHERITES. ECHINOSPHERITES LIMESTONE (C1), REVAL, ESTHONIA.

Dybowski's illustration of the internal structure is sufficient to show this species to be a typical *Stellipora* and closely related to the preceding *S. revalensis*. Indeed, it is possible that they are identical species, the main difference being the occurrence of thin polygonal raised areas surrounding the maculæ in *S. revalensis*. As remarked before, this occurrence is not always constant in a species and the type of *S. constellata* may have happened to be without them.

Occurrence.—According to Dybowski, the species occurs in his zone 2 at Hohenholm on the island of Dago. If in place, the specimen would probably have come from the Lyckholm limestone (F1)

STELLIPORA APSENDESOIDES, new species.

Text fig. 124.

Zoarium a single, incrusting, rounded cluster of zoœcia and mesopores, 6.5 mm. in diameter and less than a millimeter thick. Surface exhibiting 12 radially arranged, sharply elevated, thin ridges bearing small, subcircular zoœcia, 0.13 mm. in diameter. Depressed areas between the crests occupied by large, angular mesopores which are closed at the surface in mature specimens. In thin sections the usual characters of *Stellipora*, such as shown in *S. revalensis*, are indicated.

Externally the zoarium has quite a resemblance to the Mesozoic genus *Apsendesia*, as suggested in the specific name, but internally the two are quite distinct. The fact that the growth consists of a single cluster or macula will distinguish the species from other *Stelliporas* and also other Russian bryozoans save *Scenellopora socialis* (Eichwald). The zoœcia of the latter are so different in shape and arrangement that no confusion should arise. Of American forms, the one nearest to *S. apsendesoides* is a new species or variety from the Black River shales of Minnesota, having the same method of growth and differing only in its smaller zoarium with fewer and less sharply raised rays.

Occurrence.—Rare in the Echinospherites limestone (C1) at the Red Light House, Reval, Esthonia.

Holotype.—Cat. No. 57304, U.S.N.M.

Genus NICHOLSONELLA Ulrich.

Nicholsonella ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 374, 421; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 313; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 276.—SIMPSON, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 590.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 34.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 37.—CUMINGS, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 751.

Species of *Nicholsonella* are readily recognized in thin sections by the presence of a granular, calcareous deposit in the outer part of the mature zone, filling the interzoœcial spaces and obscuring the walls of the mesopores. The walls of both zoœcia and mesopores are traversed longitudinally by minute tubuli, which, in tangential sections and at the surface appear as granular, acanthopore-like structures. Somewhat similar granular structures are present in *Constellaria* with which *Nicholsonella* is believed to be allied, although the absence of such distinct, star-shaped maculæ in the latter is an easy means of separation. The following well marked species has characters quite different from any known American form of *Nicholsonella* but there seems to be no reason for not referring it to the genus.

Genotype.—*Nicholsonella ponderosa* Ulrich. Middle Ordovician (Black River) of Illinois and Minnesota.

NICHOLSONELLA GIBBOSA, new species.

Plate 11, figs. 1–6; text figs. 125, 126.

Cfr. *Heteropora gibbosa* EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 419, pl. 26, figs. 6 *a*, *b*.

Zoarium of small masses varying in shape from regular hemispheric forms with a flat or slightly concave concentrically wrinkled base, to irregular, elongated or nodulated lumps. The regular hemispheric zoaria occur most often and are usually about 15 mm. in diameter and 6 or 7 mm. high. Continued growth in one direction gives rise to forms several centimeters long and a centimeter or less in diameter, while the irregular nodular masses are the result of either interrupted growth or of accelerated growth in several directions. The zoarial surface in all the various forms of growth is usually smooth, but in rare instances the maculæ are indicated by slightly elevated, dome-shaped areas, 3 mm. apart, measuring from their respective centers. Ordinarily the macular zoœcia and mesopores differ so little from the ordinary forms that the maculæ are indistinguishable at the surface. Zoœcial apertures direct, polygonal to rounded, four in 2 mm., completely isolated by numerous small, angular mesopores. In old examples the walls of both zoœcia and mesopores bear numerous small granules.

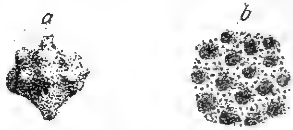

FIG. 125.—NICHOLSONELLA GIBBOSA. EICHWALD'S FIGURES OF HETEROPORA GIBBOSA; *a*, ZOARIUM, NATURAL SIZE; *b*, THE SURFACE ENLARGED. "CALCAIRE À ORTHOCERATITES," PULKOWA, GOVERNMENT OF ST. PETERSBURG.

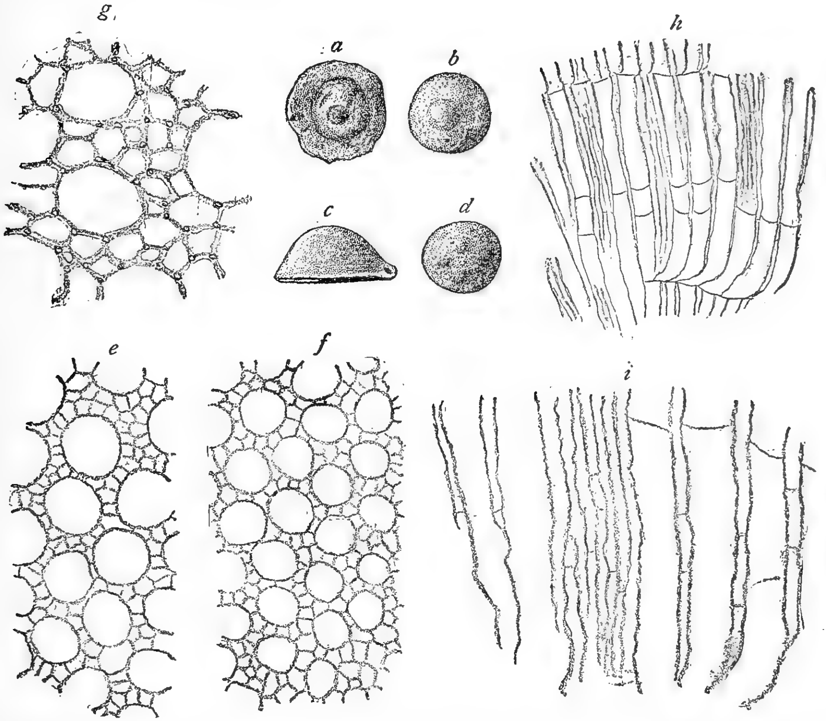

FIG. 126.—NICHOLSONELLA GIBBOSA. *a* AND *b*, TOP VIEWS OF TWO IRREGULAR ZOARIA, NATURAL SIZE; *c*, SIDE VIEW OF A THIRD SPECIMEN OF MORE REGULAR FORM; *d*, AN EXAMPLE WITH LOW MONTICULES, VIEWED FROM ABOVE; *e*, TANGENTIAL SECTION, ×20, THROUGH A MACULA; *f*, PORTION OF THE SAME SECTION, ×20, CUTTING THE ORDINARY ZOŒCIA; *g*, SEVERAL ZOŒCIA, ×40, ILLUSTRATING THE MINUTE STRUCTURE; *h*, VERTICAL SECTION, ×8; *i*, PORTION OF THE SAME SECTION, ×20. GLAUCONITE LIMESTONE (B2), REVAL, ESTHONIA.

As usual in species of the genus, the internal structure of the present form, with regard to clearness of preservation, is in sharp contrast with associated Trepostomata. Numerous thin sections of the best preserved specimens have been prepared, and all agree in the characters here illustrated. In vertical sections the zoœcial walls are thin, slightly crenulated, and only occasionally show as definite sharp lines, usually being represented by a diffuse granular structure. The mesopores differ from the zoœcia only in size and in being possibly more granular in structure. Diaphragms are few in both sets of tubes, the average number in each being represented in the figured vertical sections. Tangential sections show the same indefinite wall structure, and, in addition, exhibit numerous granular structures, possibly representing acanthopores, in the most mature region.

The species described by Eichwald as *Heteropora gibbosa* from the Orthoceras limestone at Pulkowa, appears to be based upon a monticulated zoarium of the present form. Without an examination of Eichwald's type the matter of course can not be settled definitely, but in order to avoid a possible synonym, I have given the form here described the same specific name.

The small, massive zoarium with rather large zoœcia isolated by minute mesopores, and the numerous granules of the surface are external characters which alone will identify the species. Internally the structure is too different from any other form to require comparison.

Occurrence.—Abundant in the Glauconite limestone (B2) at Reval and vicinity, in Esthonia, and at Pawlovsk, Tswos, on the Wolchow River, localities on the Ladoga Canal, and Wassilkowa, government of St. Petersburg; in the Orthoceras limestone (B3), at Pawlovsk, and in the Echinospherites limestone (C1), 4 miles east of Reval, Esthonia.

Cotypes.—Cat. Nos. 57305 to 57313, U.S.N.M.

British Museum, specimens and thin sections from the Glauconite limestone, Reval.

Genus DIANULITES Eichwald.

Dianulites Eichwald, Zool. Spec., vol. 1, 1829, p. 180; Lethæa Rossica, vol. 1, 1860, p. 487.—Dybowski, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 14.—Nicholson, Genus Monticulipora, 1881, pp. 20, 155.—Waagen and Wentzel, Pal. Indica, ser. 13, 1886, p. 874.—Simpson, Fourteenth Ann. Rep. State Geol. New York for the year 1894, 1897, p. 587.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 230.

Hexaporites Pander, Beitr. zur Geogn. d. russ. Reichs., 1830, p. 106, pl. 1, fig. 5; pl. 28, fig. 8.

Although this name has been frequently quoted, the status of the genus is indicated by the following note published by Nickles and Bassler in their Synopsis of American Fossil Bryozoa:[1]

[1] Bull. 173, U. S. Geol. Surv., 1900, p. 231.

This genus as defined by Eichwald is wholly unintelligible and was, until 1877, when Dybowski resurrected and redefined it, not recognized by paleontologists. Dybowski has not helped the matter by his effort, for his arrangement of the species is quite arbitrary, no two forms perhaps being strictly congeneric.

The only observations of any value at all that have been published concerning the generic characters of *Dianulites* are those by Dybowski and by Nicholson. Dybowski retained the genus for those monticuliporoids in which the zoarium was massive or ramose, and consisted of large, thin-walled, tabulated zoœcia in contact with each other on all sides. As expressed in Dybowski's generic synopsis, *Dianulites* would include all forms which have no "coenenchyma" (interstitial cells), but do not possess tabulæ in the tubes, which, in addition, are comparatively large and thin walled. Although this limitation of the genus was a distinct advance upon any previous work, still such generic characters were of so little value that, according to present-day studies, Dybowski assigned representatives of at least four other genera to *Dianulites*. Nicholson, in discussing the subgenus *Diplotrypa*[1] calls attention to a possible identity between *Diplotrypa* and *Dianulites*. However, he rejects the latter name entirely, first, because the generic diagnosis of Eichwald is unrecognizable, and, second, because the genus, as resurrected by Dybowski, is unmistakably not a natural group.

The first species referred by Eichwald to *Dianulites* was either *D. detritus* or *D. fastigiatus*, both of which were described on the same page. Later[2] he distinctly refers to *D. detritus* as the type species and gives good figures of both *D. detritus* and *D. fastigiatus*. The illustrations of these two forms are clearly of the same species, and their identity was recognized by Dybowski, who, however, figures and describes the species as *D. fastigiatus*. As I have not had the opportunity of consulting the original publication, and as Dybowski was probably able to do so, I have accepted the specific name *fastigiatus* for the genotype. Since both names apply to the same form, the matter is of little consequence.

The external features of *Dianulites fastigiatus* are so unique that a study of the internal structure is not necessary to determine the species. Indeed, the merest tyro could identify the species from Eichwald's figures, one of which shows clearly that the zoœcia are completely isolated by mesopores. The occurrence of numerous mesopores is corroborated by thin sections, and yet Dybowski laid stress upon the absence of mesopores, or, in his words, the absence of coenenchyma, as a generic character.

After studying specimens of *Dianulites fastigiatus* from six Russian and Swedish localities, I find that this species, as well as a number of

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[1] Genus Monticulipora, 1881, p. 155.

[2] Lethæa Rossica, vol. 1, 1860, p. 487, pl. 28, figs. 8, 9.

American and European forms, have characters in common which fully justify the recognition of a distinct genus. Although *Dianulites* could not hitherto be regarded as a valid genus, the name is still available, and I propose to retain it with the characters presented by the genotype *D. fastigiatus.*

Generic diagnosis.—Zoarium massive, elongate, bluntly turbinate in the type species, solid and hemispheric in other forms; basal surface covered with an epitheca. As in most other monticuliporoids, maculæ are present, either as groups of larger cells opening on a plane with the other zoœcia, or as clusters of both large and small zoœcia arising into monticules. Zoœcia polygonal, thin-walled, separated by numerous mesopores as in the type species, or with mesopores few and, in some cases, practically absent. Acanthopores absent but numerous small granules may be observed on the zoœcial walls at the surface and in thin tangential sections cutting the oldest part of the peripheral region. Walls of zoœcia amalgamated and showing little structure beyond the granules just mentioned. In fractures the zoœcial tubes break unevenly across or through the walls instead of parting between them as in most associated Trepostomata. This style of rough fracture results in a vitreous or crystalline appearance which has been found most characteristic of this and related genera. Diaphragms always present but varying in number in the different species.

Genotype.—*Dianulites fastigiatus* Eichwald. Middle Ordovician of Russia and Sweden.

Thin sections show a minute structure of the walls that is unlike all other bryozoan genera save *Nicholsonella.* In vertical sections the otherwise structureless walls sometimes present an obscure lineation arranged vertically. Tangential sections show this lineation to be due to minute column-like granulose structures composed of darker calcite. In such a section, a wall with the structure well preserved will, therefore, be made up of alternating light and dark spots. This appearance has been observed in an American species, *Monotrypa* (*?Chaetetes*) *cumulata,* from the Trenton group of Minnesota. Ulrich noted its peculiarity of structure, but believed that it might be due to secondary causes, and therefore hesitated in referring the species to *Chaetetes,* with which genus the column-like structure in the walls seemed to ally it. With only a single species at hand, this hesitancy on his part was only natural, but with numerous examples of the four species here described in addition, and also their great differences in geologic and geographic occurrence, I am convinced that the peculiarities are structural and not due to preservation. Concerning the relation of *Dianulites* to *Chaetetes,* I am at present unable to discuss the subject further than to express the opinion that careful work on the latter genus will show it to be distinct, although possibly allied to the former.

In the above diagnosis I have endeavored to give all of the generic features, although it is recognized that some of these pertain equally well to other genera. The massive zoarium of thin-walled, angular zoœcia, without acanthopores, occurs in a number of totally unrelated genera, but these features, in connection with the peculiar glassy-like internal structure, and the occurrence of numerous small granules or tubular structure in the walls, form a combination of characters duplicated in part in only one other group, namely, the peculiar Ordovician genus *Nicholsonella.* This latter genus has always been regarded as of uncertain affinities because of its unusual internal structure. Its zoaria vary from ramose or flattened branches to free or incrusting expansions externally much like other monticuliporoids. However, the internal characters of species referred here have always seemed so obscure and ill-defined that, until recently, specimens of *Nicholsonella* have been regarded as habitually poorly preserved and invariably unsuited for careful microscopic examination. Like *Dianulites,* its tube walls are thin and in the mature zone, traversed longitudinally by minute tubules which appear at the surface and in tangential sections as granules. Acanthopores are absent, the distribution of tubules and mesopores is the same in the two, but, unlike *Dianulites,* the mesopores in the mature zone of *Nicholsonella* become entirely closed by a perforated calcareous deposit which obscures the characters in this part of the zoarium most effectually.

Compared with *Nicholsonella, Dianulites* differs, therefore, mainly in its prevailingly massive zoarium, more simple zoœcial structure, and in the absence of a calcareous deposit filling the mature portion of the mesopores.

Hexaporites was the name given to a condition of *Dianulites petropolitana* and has no standing. Further remarks upon this name are given under the discussion of that species.

DIANULITES FASTIGIATUS Eichwald.

Plate 2, figs. 1–3; text figs. 127, 128.

Dianulites fastigiatus Eichwald, Zool. Spec., vol. 1, 1829, p. 181; Lethæa Rossica, vol. 1, 1860, p. 488, pl. 28, fig. 9.—Dybowski, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 20, pl. 1, figs. 1–3.

Zoarium a turbinate mass with the lower end rounded or truncated, and the upper end, which alone bears the openings of the zoœcia, flat or slightly concave. The sides and lower portion are covered with an epitheca, which, though sometimes smooth, is more often marked by concentric rings or lines of growth. An average example attains the size shown in figure 127 *a,* but inverted, cone-shaped specimens only a centimeter high have been observed. An entire zoarium is composed of numerous layers of zoœcia arranged so evenly upon each other that there often is no break between the zoœcial tubes of separate growths. Celluliferous surface smooth; maculæ composed of larger zoœcia and more numerous mesopores present at regular intervals but not conspicuous. The shape of the zoarium is well shown by Eichwald's figure here reproduced.

Zoœcia and mesopores often similar in shape and size, each with thin walls and polygonal apertures. The zoœcial apertures, however, are usually more regularly polygonal and slightly larger than the mesopores which frequently are numerous enough to completely isolate neighboring zoœcia. Another distinguishing character between the two at the surface is the frequent occurrence of covers on the mesopores, the last diaphragm in this case serving as a closure. True

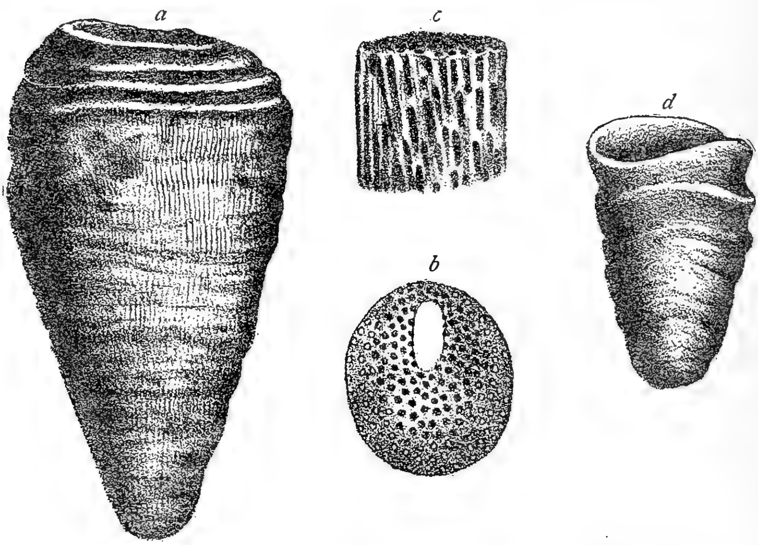


FIG. 127.—DIANULITES FASTIGIATUS. *a*, SIDE VIEW OF A ZOARIUM, SHOWING THE EPITHECA; *b*, TOP OR CELLULIFEROUS SURFACE, ENLARGED; *c*, EDGE VIEW OF A BROKEN FRAGMENT, ENLARGED, ILLUSTRATING THE UNEVEN FRACTURE; *d*, THE TYPE-SPECIMEN OF DIANULITES DETRITUS EICHWALD, NATURAL SIZE. "CALCAIRE À ORTHOCERATITES," REVAL (FIG. *a*), AND PULKOWA (FIG. *d*), BALTIC RUSSIA. (AFTER EICHWALD.)

acanthopores absent, but the granular structure characteristic of the genus is well marked.

The similarity of the zoœcia and mesopores is equally great in thin sections. In vertical sections the wall structure of the two is the same and their diameter is frequently equal. There need be no difficulty in distinguishing the two, however, since diaphragms are practically absent in the zoœcia but occur always in the mesopores at intervals varying from two to five times their own diameter.

The differences between the zoœcia and mesopores at the surface, mentioned above, hold in tangential sections, but here another means of distinguishing them is presented. The zoœcial cavities being practically without diaphragms, are very frequently filled with clay, the dark color of which, in sections, is in contrast with the clear calcite filling the diaphragm-bearing mesopores.

The average zoœcium is 0.35 mm. in diameter, but the large apertures of those in the maculæ attain a size half again as great. Counting the intervening mesopores, three to four zoœcia occur in 2 mm. The minute structure of the walls in both sections has been described under the diagnosis of the genus. The glassy aspect of the material composing the zoarium and the rough fracture of the tubes has also

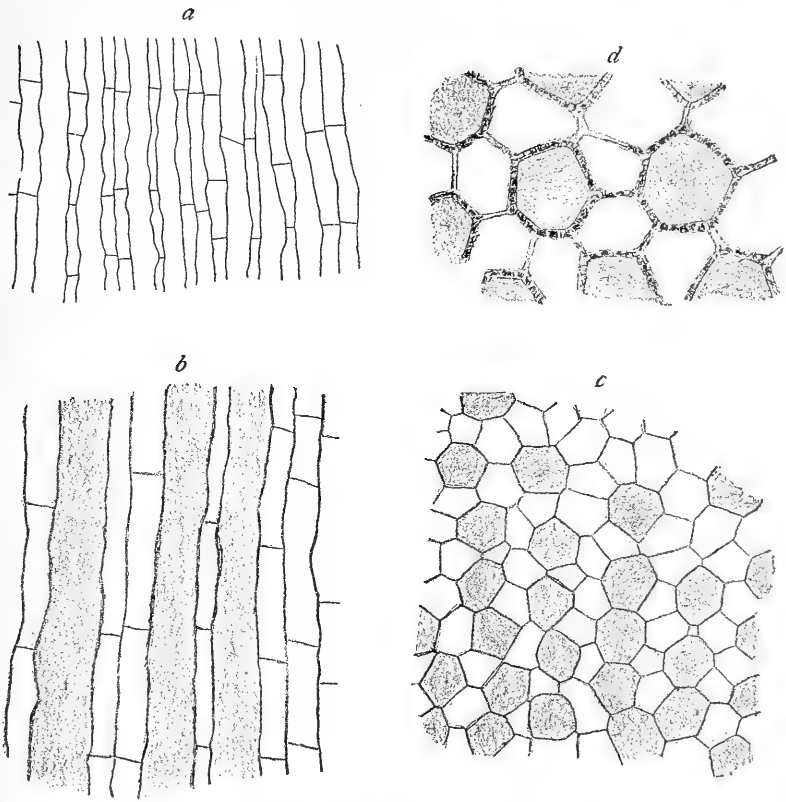


FIG. 128.—DIANULITES FASTIGIATUS. *a*, VERTICAL SECTION, ×9, WITH DIAPHRAGMS IN THE MESOPORES ONLY; *b*, PART OF THE SAME SECTION, ×20, SHOWING THE WALL STRUCTURE; *c*, TANGENTIAL SECTION, ×20, WITH THE ZOŒCIA SHADED TO DISTINGUISH THEM FROM THE MESOPORES; *d*, ANOTHER PART OF THE SAME SECTION, ×40, ILLUSTRATING THE MICROSCOPIC STRUCTURE OF THE WALLS. ECHINOSPHERITES LIMESTONE (C1), DUBOVIKI, ON THE WOLCHOW RIVER, GOVERNMENT OF ST. PETERSBURG.

been noted and is particularly evident in *D. fastigiatus*. The walls of both zoœcia and mesopores are gently undulating.

Dybowski's figures of the internal structure (pl. 2, figs. 1–3), although probably derived in part from thin sections of the species, are misleading in that he considered all of the subequal apertures to be zoœcia. The tabulation shown in figure 3 is undoubtedly taken from a section of another species, but the minute structure of the walls, as indicated in figure 1, is correct.

Compared with other members of the genus, the turbinate shape of the zoarium and the numerous large mesopores are alone sufficient to distinguish the present form. Massive bryozoans of other genera in the Russian Ordovician lack the vitreous substance and rough fracture of *D. fastigiatus*, and therefore will not be confused.

Occurrence.—The specimens in the collections of the United States National Museum were derived from the Echinospherites limestone (C1) at Duboviki, on the Wolchow River, Katlino and Gastilizy, and in the Glauconite limestone (B2) at Pulkowa and Pawlovsk in the government of St. Petersburg, and from the Chasmops limestone, south of Bödahamn, island of Oeland, Sweden. The additional localities, Erras, Reval, and Baltischport, are recorded by Dybowski.

Plesiotypes.—Cat. Nos. 57334 to 57338, U.S.N.M.

Thin sections of the figured specimen from Duboviki, and specimens from the Chasmops limestone, Oeland, are in the collections of the British Museum.

DIANULITES PETROPOLITANA Dybowski.

Plate 2, figs. 4–6*a*; plate 10, figs. 7–11; text figs. 129–132.

Dianulites petropolitana DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 24, pl. 1, figs. 4 and 5.

Hexaporites PANDER, Beitr. zur Geogn. d. russ. Reiches., 1830, p. 106, pl. 1, fig. 5; pl. 28, fig. 8.

Hexaporites fungiformis. LEUCHTENBERG in Eichwald Geognosie de Russ., 1846, p. 370.—EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 478.

Dianulites petropolitanus var. *hexaporites* DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 30, pl. 1, figs. 6, 6*a*.

Monotrypa (*Chætetes?*) *cumulata* ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 307, pl. 27, figs. 26, 27.

The following may be included, at least in part, in the present species:

Millepora hemispherica (part) EICHWALD, Inter ingrica et de trilob. observat., 1825, p. 21.

Favosites petropolitanus PANDER, Beitr. zur Geogn. d. russ. Reiches., 1830, p. 105, pl. 1, figs. 7–11.

Favosites hemisphericum KUTORGA, Beitr. zur Paleontologie und Geogn. Dorpats, 1837, p. 40, pl. 9, fig. 3.

Calamopora fibrosa EICHWALD, Silur. syst. in Ehstl., 1840, p. 197.

Chætetes petropolitanus LONSDALE, in Murchison, Verneuil, and Keyserling, Russia and Ural, vol. 1, 1845, p. 596, pl. A, fig. 10.—KEYSERLING, Reise in d. Petschoraland, 1846, p. 180.—D'ORBIGNY, Prodr. de Pal., vol. 1, 1850, p. 25.—EDWARDS and HAIME, Mon. des Pol. foss., 1852, p. 263.

Monticulipora petropolitana EDWARDS and HAIME, Brit. Foss. Cor., 1854, p. 264.—SCHMIDT, Archiv fur Naturk. Liv., Ehst. u. Kurlands, vol. 2, ser. 1, 1858, p. 228.

Not *Diplotrypa petropolitana* NICHOLSON.

Hemispheric bryozoans from the Paleozoic rocks of many parts of the world have been described and frequently cited in the literature under the specific name of *petropolitana* because of the belief that they were identical with Pander's *Favosites petropolitanus.* To-day the confusion that this has caused is so great that in most cases it is best to disregard such references altogether. In the above list but a single reference to *petropolitana* is of undoubted value, and only the work of those authors who might have included the species here described as *Dianulites petropolitana* is cited. More than a dozen of

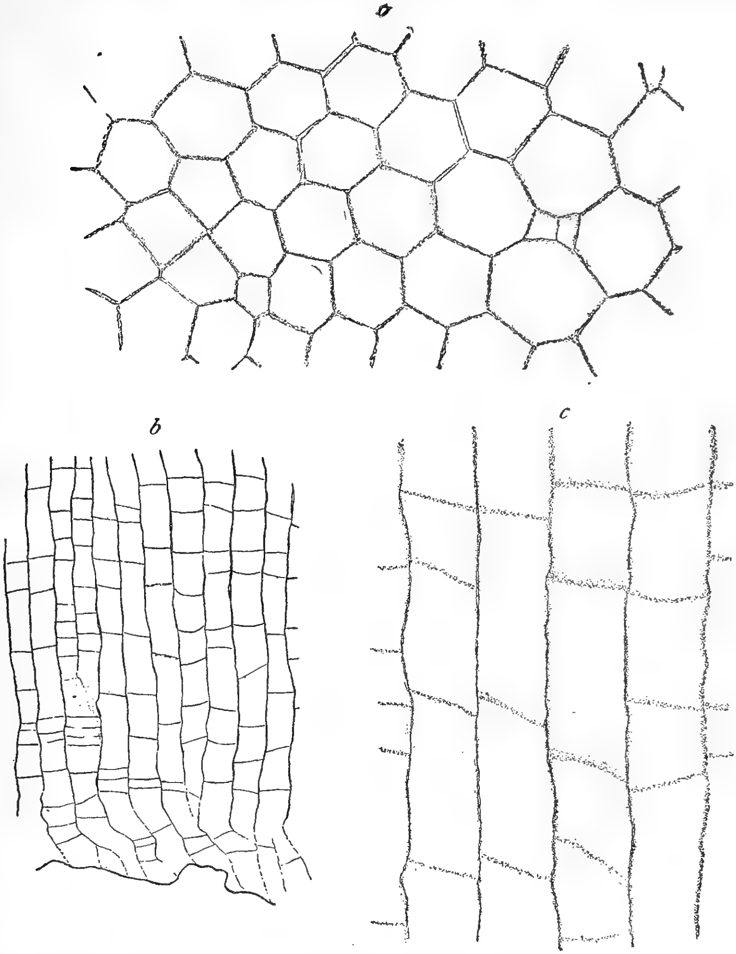


FIG. 129.—DIANULITES PETROPOLITANA. *a*, THE TYPICAL FORM OF THE SPECIES AS SEEN IN TANGENTIAL SECTION, ×20; *b*, VERTICAL SECTION, ×8, SHOWING DISTRIBUTION OF DIAPHRAGMS; *c*, SEVERAL TUBES OF THE SAME, ×20, WITH THE MINUTE STRUCTURE MORE CLEARLY EXHIBITED. GLAUCONITE LIMESTONE (B2), DUBOVIKI, GOVERNMENT OF ST. PETERSBURG.

the Russian Ordovician trepostomatous bryozoans have the zoarial shape of this species, so, without a knowledge of the minute structure, it is obviously impossible to determine which particular one Pander, or any of the other authors except Dybowski, had in mind. Indeed, it is most probable that they included a number of distinct species in their descriptions.

As stated under the discussion of *Diplotrypa*, Nicholson described and illustrated the minute structure of hemispheric specimens from the Chasmops limestone of Sweden as *Diplotrypa petropolitana*, in the belief that they were identical with Pander's *Favosites petropolitanus*. Dybowski's conception of Pander's species, published several years previously, was totally different. In fact, the two are now known to belong not only to different genera but also to distinct families. Since both Nicholson's *Diplotrypa petropolitana* and Dybowski's *Dianulites petropolitana* are sufficiently figured and described to

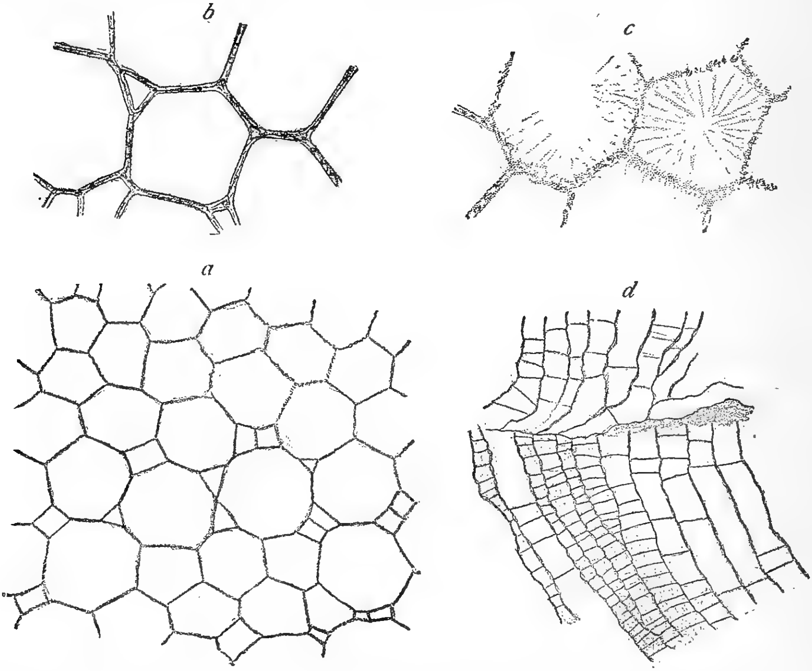


FIG. 130.—DIANULITES PETROPOLITANA. *a*, TANGENTIAL SECTION OF THE FORM "HEXAPORITES," ×20, WITH THE USUAL NUMBER OF MESOPORES; *b*, SMALL PORTION OF THE SAME, ×35, SHOWING GRANULES; *c*, SEVERAL ZOŒCIA OF A TANGENTIAL SECTION, ×35, IN WHICH CRYSTALLIZATION HAS PARTLY DESTROYED THE STRUCTURE; *d*, VERTICAL SECTION, ×8, PASSING THROUGH A MACULA. GLAUCONITE LIMESTONE (B2), TSWOS, ON THE WOLCHOW RIVER, GOVERNMENT OF ST. PETERSBURG.

prevent any doubt regarding them, I have recognized this specific name as a distinct species under each genus, without regard to the fact that each author thought he was redefining Pander's species.

My study of a large collection of Russian and Swedish hemispheric forms, and of Dybowski's description and illustrations, has convinced me that he had in mind a very common massive species with thin-walled, polygonal zoœcia, few mesopores, diaphragms a tube diameter or more apart, and, finally, the wall structure of *Dianulites fastigiatus*. The fact that he regarded Pander's *Hexaporites*, or, as Von Leuchtenberg named it, *Hexaporites fungiformis*, as a variety of *D. petropolitana*, is further evidence to me of the correctness of this identification. Variety *hexaporites*, from its description and illustrations, and from numerous specimens before me, refers, so far as my knowledge goes, to only one bryozoan—a form of *Dianulites petropolitana* in which the maculæ with their surrounding zoœcia form polygonal areas bounded by thin crests or walls of mesopores (see pl. 10, figs. 10, 11). Such an occurrence is not restricted to this genus, since the same polygonal areas are formed on specimens

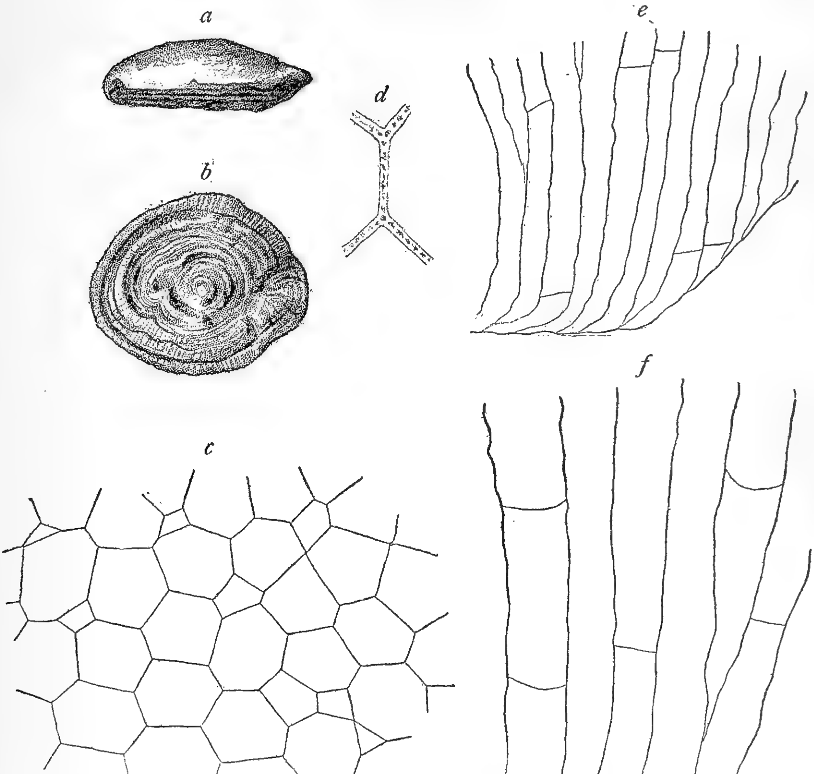


FIG. 131.—DIANULITES PETROPOLITANA. *a* AND *b*, SIDE AND BASAL VIEWS OF THE VARIETY IN THE WESENBERG LIMESTONE; *c* AND *d*, TANGENTIAL SECTION, ×20, AND WALL STRUCTURE OF SAME MUCH ENLARGED, SHOWING IDENTITY WITH THE TYPICAL FORM OF THE SPECIES; *e* AND *f*, VERTICAL SECTION, ×9 AND ×20, WITH FEWER DIAPHRAGMS THAN USUAL. WESENBERG LIMESTONE (E), WESENBERG, ESTHONIA.

of *Stellipora* and *Constellaria*, but the present species is the only *Dianulites* in which they have been observed. As shown in plate 10, figure 11, the same specimen may present the characters of both the species and the so-called variety. The latter is, therefore, placed in synonymy, as is also the name *Hexaporites*, which, moreover, was never described as a generic name.

On account of the complicated history and rather curious variation of *Dianulites petropolitana*, the species has been illustrated in some detail. Comparison of figure 130 with figure 132 shows essentially the same structure in the American form *Monotrypa cumulata*, and its identity with *D. petropolitana* is further evidenced by direct comparison of specimens of the two.

Dianulites petropolitana may be defined briefly as follows:

Zoarium massive, usually hemispheric with a slightly concave, epithecated base, and about 2.5 cm. wide, but ranging from this to large expansions 10 or more cm. across. Some specimens are of irregular shape but almost always show their origin from the usual hemispheric forms. Celluliferous side usually smooth, but sometimes divided into polygonal, usually hexagonal, areas bounded by crest-like elevations formed of mesopores. At the center of these areas is a similarly elevated cluster of mesopores forming the macula. Zoœcia thin-walled, polygonal, averaging four in 2 mm. Mesopores few,

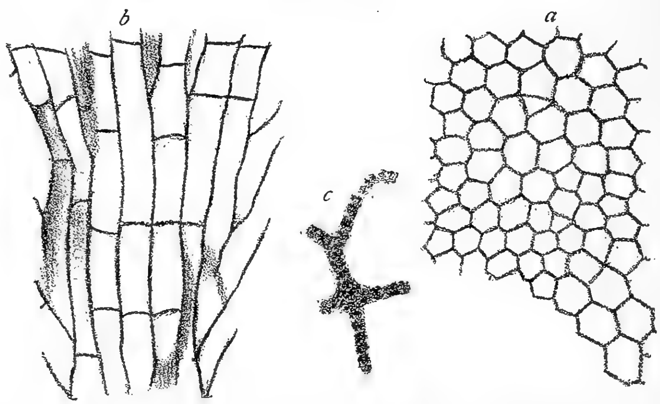


Fig. 132.—Dianulites petropolitana. Ulrich's views of Monotrypa (Chaetetes) cumulata, introduced for comparison. *a* and *c*, tangential section, ×9, and a small portion, ×35, showing wall structure; *b*, vertical section, ×9. Lower part of the Trenton limestone, Goodhue County, Minnesota.

restricted usually to the macula and to the edges of the polygonal areas noted above. Acanthopores absent. Diaphragms placed at irregular intervals in the zoœcial tubes but usually at distances varying between one and two tube diameters. In the mesopores three diaphragms occur in a distance of their own diameter. Walls exhibiting the minute granules seen in the typical species of *Dianulites*.

In figure 129 *a* the usual structure seen in thin sections is illustrated, although it is difficult to give in a drawing a correct impression of the peculiar granular wall structure. In these figures it will be noted that mesopores are almost entirely absent.

Figure 130 represents thin sections of a specimen with more abundant mesopores, in fact, this specimen showed the hexagonal areas of Dybowski's variety *hexaporites*. Aside from the mesopores, the structure is exactly the same as shown in the preceding figure.

Specimens from the Wesenberg limestone differ only in having fewer diaphragms as shown in figure 131. In figure 132, Ulrich's illustrations of the Minnesota species *Monotrypa cumulata* are given for comparison.

Occurrence.—An extremely abundant species in probably all the formations ranging from the Glauconite limestone (B2) to the Wesenberg limestone (E). The collections of the United States National Museum contain specimens from the Glauconite limestone (B2) at Tswos, on the Wolchow River, Duboviki, Gornaja Scheldicha, and Pawlovsk, government of St. Petersburg; from the Orthoceras limestone (B3) at Reval, Malla, and Port Kunda, Esthonia, and Pawlovsk, government of St. Petersburg; from the Echinospherites limestone (C1) at Luggenhusen, Katlino, 4 miles east of Reval, and Duboviki; and from the Wesenberg limestone (E) at Wesenberg. Dybowski mentions a number of other localities, such as Kuckers and Jewe, which have afforded specimens. The American form was found in the Lower Trenton limestone, Goodhue County, Minnesota, and at Ottawa, Canada.

Plesiotypes.—Cat. Nos. 26906, 57339 to 57350, U.S.N.M.

Represented in British Museum by specimens from various localities in Russia and from the island of Oeland.

DIANULITES GRANDIS, new species.

Text fig. 133.

Zoarium massive, regularly hemispheric, consisting of numerous superposed layers of zoœcia. The type-specimen is 6 cm. in diameter and about 3 cm. high. The base as usual in such forms is slightly concave and is covered with a concentrically wrinkled epitheca; upper surface celluliferous and smooth. The zoœcia are large, exceptionally thin-walled, polygonal, with distinct clusters of larger size than the average at intervals of about 6 mm.; two to three zoœcia in 2 mm., one of the average size being 0.8 mm. in diameter, while those forming the maculæ are frequently over a millimeter wide. Mesopores and acanthopores absent. On the best preserved portions of the surface exceptionally small granules may be observed on the zoœcial walls. These appear to better advantage in tangential sections, although even here, on account of the great tenuity of the zoœcial walls, they seldom are as distinctly marked as I have shown them in figure 133 *e*. Vertical sections show thin, slightly crenulated walls with three or more diaphragms in a tube diameter in the mature zone. Figure 133 *d* illustrates the occurrence of several superposed zoœcial layers, each with its short, immature zone and a longer mature portion with numerous diaphragms.

The hemispheric zoarium, thin walls, and exceptionally large zoœcia are sufficient to distinguish this from all similarly growing species. The minutely granulose wall structure determines the generic position, although the granules are seldom clearly exhibited. *Dianulites petropolitana* has a similar zoarium but its zoœcia are a third of a diameter less in size.

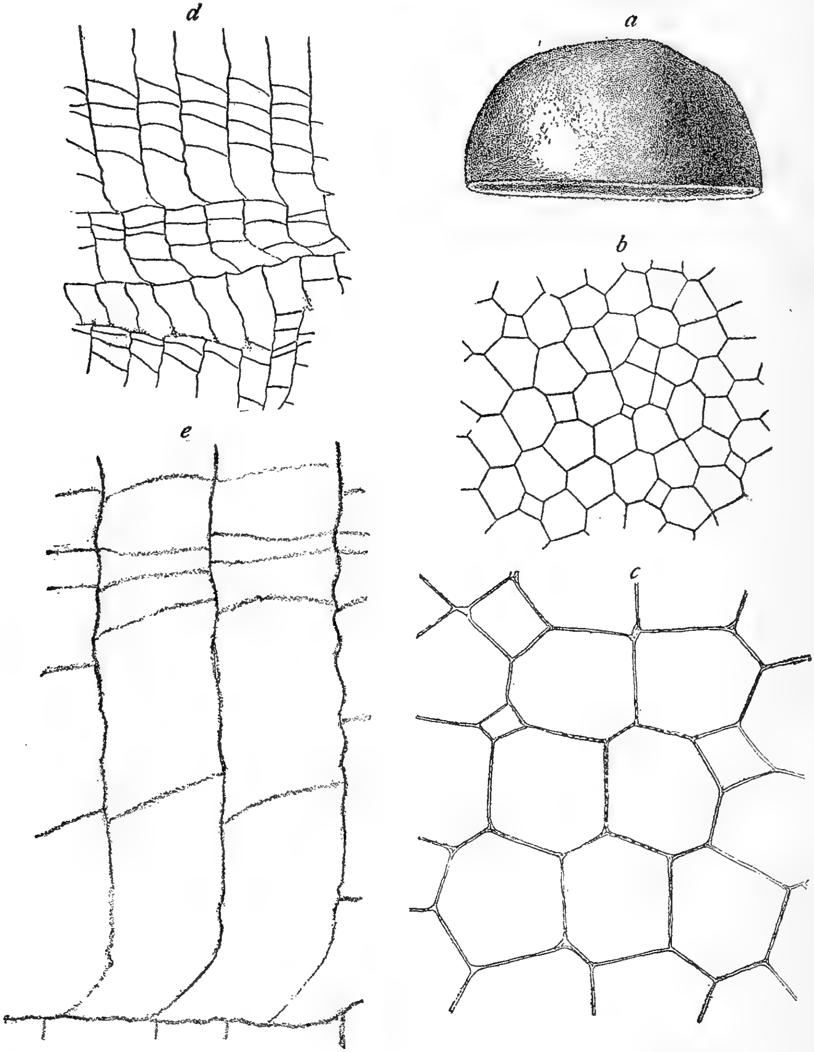


FIG. 133.—DIANULITES GRANDIS. *a*, THE TYPE-SPECIMEN, TWO-THIRDS NATURAL SIZE, IN SIDE VIEW; *b*, VIEW SHOWING SIMPLICITY OF STRUCTURE SEEN IN THE ORDINARY TANGENTIAL SECTION, ×8; *c*, PORTION OF THE SAME, ×20, WITH THE GRANULES PLAINLY EXHIBITED ON THE WALLS OF A FEW ZOŒCIA; *d*, TABULATION IN VERTICAL SECTION, ×8, CUTTING FOUR LAYERS OF ZOŒCIA; *e*, SEVERAL TUBES OF A SINGLE LAYER, ×20, EXHIBITING THE TYPICAL DISTRIBUTION OF DIAPHRAGMS. LYCKHOLM LIMESTONE (F1), PIERSAL, ESTHONIA.

Occurrence.—Apparently rare in the Lyckholm limestone (F1) at Piersal, Esthonia.

Holotype.—Cat. No. 57351, U.S.N.M.

British Museum, thin sections and portion of the type-specimen.

DIANULITES COLLIFERA, new species.

Text fig. 134.

The internal structure of this species is quite similar to that of *Dianulites petropolitana.* Externally there is no difficulty in separating the low hemispheric zoarium of the present form with its nodulated surface (fig. 134 *a* and *b*) from the smooth, dome-shaped

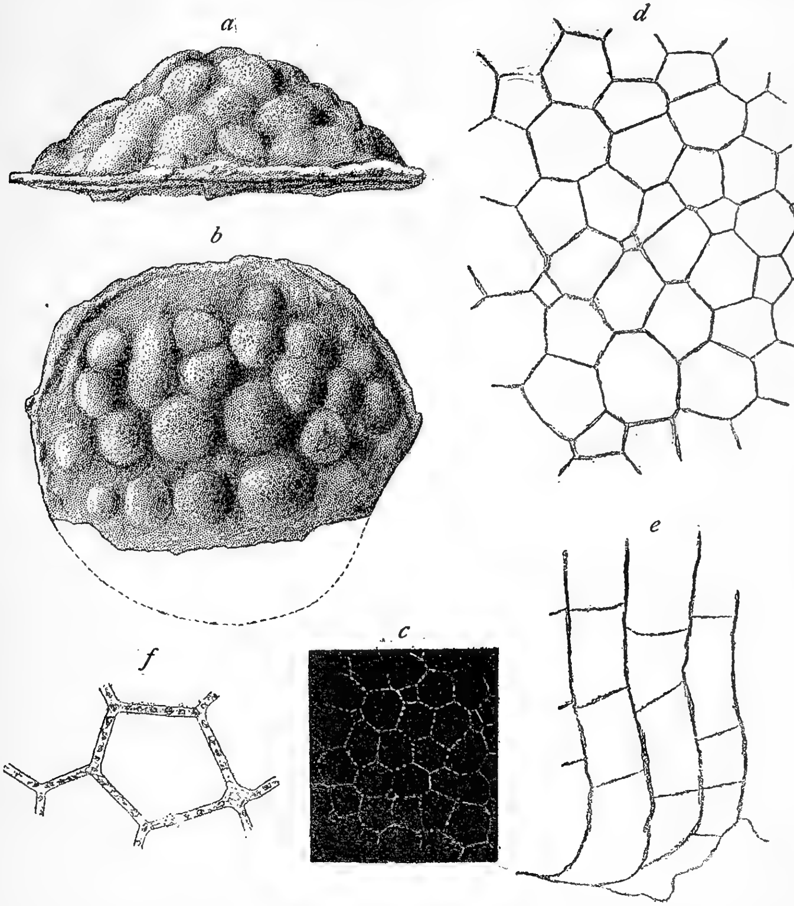


FIG. 134.—DIANULITES COLLIFERA. *a* AND *b*, SIDE AND FRONT VIEWS OF THE TYPE-SPECIMEN, NATURAL SIZE; *c*, SURFACE, ×9, WITH DISTINCT GRANULES ALONG THE WALLS; *d*, THE USUAL ASPECT PRESENTED IN TANGENTIAL SECTIONS, ×20; *e*, VERTICAL SECTION OF SEVERAL TUBES, ×20; *f*, A ZOŒCIUM, ×35, IN A TANGENTIAL SECTION WITH THE CHARACTERISTIC WALL STRUCTURE. LYCKHOLM LIMESTONE (F1), KERTEL, ISLAND OF DAGO.

masses of the former. The zoœcia of *D. collifera* are thin walled, and show the characteristic granules of *Dianulites* exceptionally well, both at the surface and in thin sections. Five zoœcia occur in 3 mm.; mesopores usually few but sometimes numerous enough to average one to a zoœcium. True acanthopores wanting. Tabulæ at intervals varying from one and a half to two tube diameters apart.

The nodulated surface of the zoarium and conspicuous granulated zoœcial walls are the most obvious characters which may be employed in distinguishing this species. The similarity in internal structure to *D. petropolitana* has been mentioned, and it is possible that larger collections will prove the present species to be more closely related than now recognized.

Occurrence.—Apparently rare in the Lyckholm limestone (F1) at Kertel, island of Dago.

Holotype.—Cat. No. 57352, U.S.N.M.

British Museum, thin sections of the type-specimen.

Family BATOSTOMELLIDÆ Ulrich.

In this family the amalgamate nature of the zoœcial walls is most marked, in fact so much so that adjoining walls usually appear as completely fused together. Although the family is well represented in Ordovician strata, species with the most completely amalgamated walls, such as in *Batostomella* and *Stenopora,* are restricted to later Paleozoic rocks. Of the genera discussed in this work, *Bythopora, Lioclemella,* and *Lioclema* are typical Batostomellidæ. Eichwald's *Orbipora* is referred to the family on account of its fused walls, while the new genus *Esthoniopora* is considered as a primitive type of *Stenopora. Eridotrypa,* although probably best placed in the family, is a somewhat aberrant genus having relations with the *H. similis* section of *Homotrypa.*

Genus BYTHOPORA Miller and Dyer.

Bythopora Miller and Dyer, Contr. to Pal., No. 2, 1878, p. 6.—Miller, North Amer. Geol. and Pal., 1889, p. 295.—Ulrich, Geol. Surv. Illinois, vol. 8, 1890, p. 376; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 263; Zittel's Textbook of Paleontology, (Eng. ed.), 1896, p. 277.—Simpson, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 551.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 32.—Grabau, Bull. Buffalo Soc. Nat. Sci., vol. 7, 1901, p. 166.—Bassler, Bull. 292, U. S. Geol. Surv., 1906, p. 29.—Cumings, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 741.—Hennig, Archiv fur Zool., vol. 4, No. 10, 1908, p. 44.

Species of *Bythopora* are uncommon in American Middle Ordovician strata and seem equally scarce in Russia, the following *B. subgracilis* being the only one so far discovered in the rocks of the latter country. The zoarium in *Bythopora* consists of slender branches with small, oblique zoœcial apertures narrowing above. The zoœcial interspaces are generally thick and are channeled. Mesopores and diaphragms are few or wanting and acanthopores are never numerous. At the surface the channeled interspaces and elongate aperture are characteristic.

Genotype.—*Bythopora fruticosa* Miller and Dyer. Upper Ordovician (Maysville) of the Ohio Valley.

BYTHOPORA SUBGRACILIS (Ulrich).

Text figs. 135, 136.

Homotrypella? subgracilis Ulrich, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 230, pl. 26, figs. 10–16.

The author of this species referred it doubtfully to *Homotrypella* because the preservation of the internal structure was such that the cystiphragms were thought to have been destroyed. Better pre-

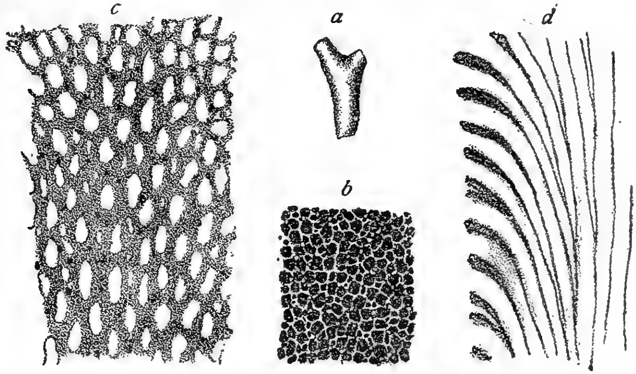


Fig. 135.—Bythopora subgracilis. *a*, an ordinary fragment, natural size; *b*, surface of specimen, ×9; *c*, tangential section of a poorly preserved fragment, ×18; *d*, vertical section, ×18. Rhinidictya bed of Black River (Decorah) shales, St. Paul, Minnesota. (After Ulrich.)

served examples from the type locality have shown that cystiphragms are entirely wanting and that generically the species differs in no way from the other large forms of *Bythopora*. The identification of this species in the Russian strata is based upon several well-preserved specimens, agreeing in all respects with the typical Minnesota examples.

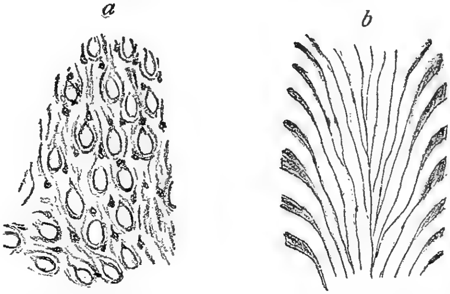


Fig. 136.—Bythopora subgracilis. *a* and *b*, tangential and vertical sections, ×20, of a well-preserved Russian example. Wassalem beds (D3), Uxnorm, Esthonia.

The zoarium of *Bythopora subgracilis* is of small, ramose, subcylindrical, smooth branches 2 to 4 mm. in diameter. The zoœcial apertures are oblique or long drawn out in young examples and more direct in older forms, eight in 2 mm. In the early stages acanthopores are few, but as the apertures become direct numerous small acanthopores are developed. Mesopores are about as numerous as the zoœcia, which they often resemble so closely that it is difficult to distinguish them. Diaphragms are entirely wanting, as shown in the vertical sections figured herewith.

The narrow, smooth zoœcia, usually with long drawn-out zoœcial apertures separated by similarly shaped mesopore spaces and the absence of diaphragms, will serve to distinguish this species from associated small, ramose Trepostomata. The characters of specimens from Minnesota are shown in figure 135, while the identity of the Russian examples is apparent from the internal structure illustrated in figure 136.

Occurrence.—Not uncommon in the Rhinidictya bed of the Black River (Decorah) shales of Minnesota. Less common in the Wassalem beds (D3) at Uxnorm, Esthonia.

Plesiotype.—Cat. No. 57314, U.S.N.M.

Specimens and thin sections from Uxnorm in the collections of the British Museum.

Genus ERIDOTRYPA Ulrich.

Batostomella (part) ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 375, 432.

Eridotrypa ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 264.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 32.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 29.—CUMINGS, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 745.—HENNIG, Archiv fur Zool., vol. 4, No. 21, 1908, p. 36.

Zoarium ramose, branches slender; zoœcia more or less oblique, thick-walled, and intersected by diaphragms, which are most numerous and most closely set in the earlier portion of the short, mature region; mesopores sometimes numerous, sometimes few, with closely set diaphragms; acanthopores small, few, or wanting.

Genotype.—*Eridotrypa mutabilis* Ulrich. Middle Ordovician (Black River) of the Mississippi Valley.

All of the American Black River species of *Eridotrypa* are represented in the several formations of division D, and in the Wesenberg limestone.

ERIDOTRYPA ÆDILIS (Eichwald).

Plate 4, figs. 5, 5a; text figs. 137, 138.

Cladopora ædilis EICHWALD, Bull. Soc. Nat. Moscou, No. 4, 1855, p. 457; Lethæa Rossica, vol. 1, 1860, p. 404, pl. 24, figs. 12, 13.

Monticulipora ædilis DYBOWSKI, Die Chætetiden Ostbaltischen Silur-Formation, 1877, p. 98, pl. 3, figs. 5, 5*a*.

Eridotrypa mutabilis ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 265, pl. 26, figs. 20–32.

The Wesenberg beds of the Russian Baltic provinces contain abundant specimens of the bryozoan well figured by Eichwald as *Cladopora ædilis*. The same species occurs less abundantly in the different divisions of formation D. Upon comparison these specimens are found to be identical with a very common, wide-spread American species, *Eridotrypa mutabilis* Ulrich, occurring in the Black River and lower Trenton strata. Dybowski has given good although somewhat diagrammatic views of the internal structure of Eichwald's species (pl. 4, fig. 5), and these, in connection with the original figures, are sufficient for purposes of identification. As usual in this genus, and as indicated in the name applied to the American form, the surface characters particularly are somewhat variable. This variation is mainly dependent upon age. Thus, in Eichwald's figure (fig. 137), the two fragments are of young zoaria in which the zoœcia are elongate and separated by similarly elongated, shallow mesopore spaces. The other extreme, that of old age, is shown in Ulrich's illustration (fig. 138 *b*). The internal characters are most constant and will serve whenever doubt is raised.

Ulrich has given a detailed description, from which the following notes are derived:

Zoarium of ramose branches 2 to 6 mm. in diameter, the younger examples slender and nearly cylindrical, the old ones more or less

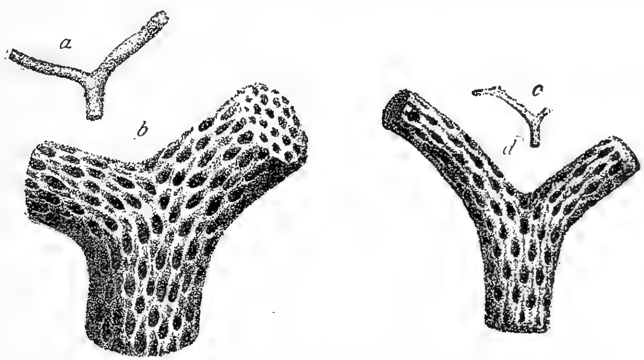


FIG. 137.—ERIDOTRYPA ÆDILIS. COPIES OF EICHWALD'S FIGURES OF CLADOPORA ÆDILIS. *a* AND *c*, TWO FRAGMENTS OF THE NATURAL SIZE; *b* AND *d*, ENLARGEMENTS OF THE SAME SPECIMENS. WESENBERG LIMESTONE (E), WESENBERG, ESTHONIA.

irregular. Zoœcial apertures variable, the changes due chiefly to age, always oblique, the degree decreasing with age; walls thick, generally ridge-shaped, and highest posteriorly, sloping gradually down into the apertures. In young examples, also in old ones on which a new layer of zoœcial tubes was formed, the apertures may be exceedingly oblique and drawn out anteriorly. With age they became gradually more direct. The arrangement of the apertures is always more or less irregular, some of the short rows having six, others seven, and occasionally eight, in 2 mm. Small maculæ, either pitted or irregularly sculptured, commonly present in the older examples. In others the maculæ are represented by clusters of zoœcia which, though a little larger than the average, are distinguished from them chiefly by the greater thickness of the interspaces. The mesopores too are most variable, sometimes appearing to be wanting over large portions of the surface and at other times twice as numerous as the zoœcia. As a rule, however, they are few, appearing at the surface as occasional shallow depressions between the zoœcial apertures. True acanthopores probably wanting, but small knots at the angles of junction may be noticed.

Eridotrypa ædilis may be distinguished from associated ramose bryozoans by its slender, cylindrical, infrequently dividing, smooth branches, with more or less oblique apertures and thick walls or inter-apertural spaces.

Occurrence.—Very abundant in the Wesenberg beds (E) at Wesenberg (Cat. No. 44827, U.S.N.M.). Less common in the Jewe lime-

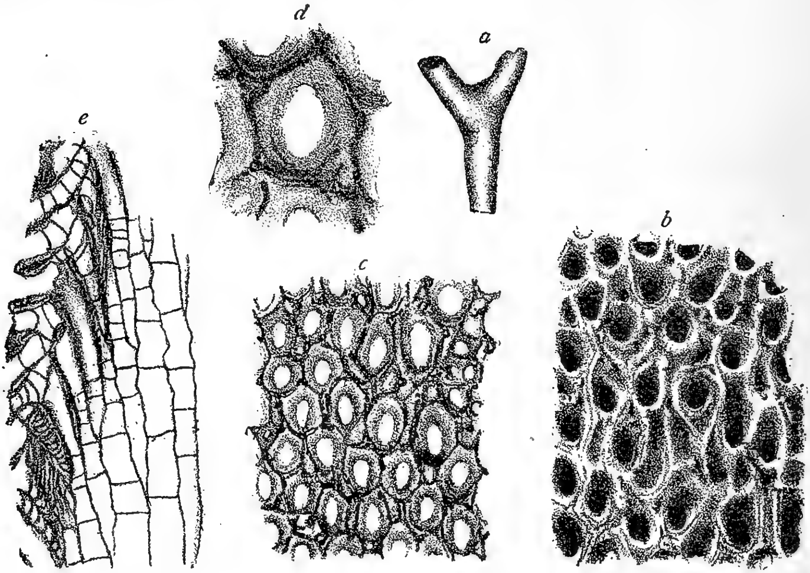


FIG. 138.—ERIDOTRYPA ÆDILIS. COPIES OF ULRICH'S FIGURES OF ERIDOTRYPA MUTABILIS. *a*, SPECIMEN OF AVERAGE SIZE; *b*, SURFACE OF ANOTHER EXAMPLE, ×18, EXHIBITING A MACULA AND NEIGHBORING ZOŒCIA; *c*, TANGENTIAL SECTIONS, ×18, REPRESENTING THE MATURE CONDITION; *d*, A ZOŒCIUM OF THE SAME SECTION, ×50; *e*, VERTICAL SECTION, ×18, OF A MATURE EXAMPLE WITH AN INCRUSTING LAYER OF ZOŒCIA GROWING IN THE OPPOSITE DIRECTION. LOWER PART OF TRENTON LIMESTONE, GOODHUE COUNTY, MINNESOTA.

stone (D1), Baron Toll's estate (Cat. No. 57316, U.S.N.M.); in the Kegel limestone (D2), at Kegel (Cat. No. 57317, U.S.N.M.); and in the Wassalem beds (D3), at Uxnorm, Esthonia (Cat. No. 57315, U.S.N.M.). In America the species is abundant in Black River and Trenton strata at localities too numerous to mention. The specimens figured by Eichwald and Dybowski were derived from the Wesenberg beds at Wesenberg, while Ulrich's type-specimen came from the lower Trenton shales at Cannon Falls, Minnesota.

British Museum, three specimens and one thin section from Russian localities.

ERIDOTRYPA ÆDILIS MINOR (Ulrich).

Text fig. 139.

Eridotrypa mutabilis var. *minor* ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 266, pl. 26, figs. 20, 21, 29, 30.

This varietal name was proposed for specimens differing from the more common form mainly in their internal structure. These differences, quoting from Ulrich, are as follows:

First, the central tubes are unusually large and their walls more wavy than in typical *mutabilis;* second, the tubes altogether seem to have been developed more regularly, and their width in the peripheral region somewhat less; and third, diaphragms are wanting throughout the greater part of the axial region. Under ordinary

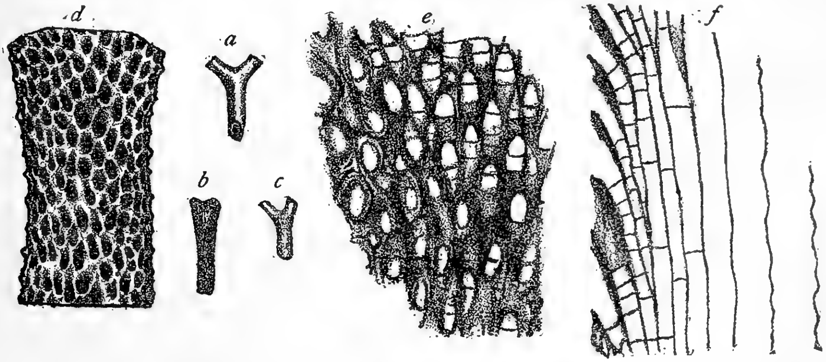


FIG. 139.—ERIDOTRYPA ÆDILIS MINOR. COPIED FROM ULRICH'S FIGURES OF ERIDOTRYPA MUTABILIS MINOR. *a, b,* AND *c,* THREE AVERAGE FRAGMENTS; *d,* SURFACE OF A FRAGMENT, ×9; *e,* TANGENTIAL SECTION, ×18; *f,* VERTICAL SECTION, ×18. LOWER PART OF TRENTON LIMESTONE, NEAR CANNON FALLS, MINNESOTA.

circumstances these differences would be considered as of specific value, but in this instance, knowing the extreme variability of the species, I can not credit them with more than subordinate importance.

Occurrence.—Variety *minor* is known only from the lowest Trenton at Cannon Falls, Minnesota, and from the Wesenberg limestone (E) at Wesenberg (Cat. No. 57318, U.S.N.M.).

British Museum, represented by specimens from American localities.

ERIDOTRYPA EXIGUA Ulrich.

Text fig. 140.

Eridotrypa exigua ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 266, pl. 26, figs. 17, 18.

Original description.—Zoarium small, branches very slender, several hundred fragments varying in diameter from 0.6 to 1.0 mm.; bifurcations apparently remote. Some of the fragments are pointed at the lower end, indicating a free condition of the zoarium, or an articulation like that of *Escharopora.* The eastern form of the species is usually a little stronger than the average of the Minnesota types, the specimens seen from Vermont and New York being mostly 1.0 mm. or a little more in diameter.

Considering the small size of the branches, the zoœcia are large. Their apertures are oblique, but not excessively so, subequal, and arranged in both longitudinal and diagonal series, the former with eight in 3 mm., predominating in the small specimens, and the latter in the larger. At the lower end of each aperture the wall is usually raised into a spine-like prominence. In vertical sections the greater part of the branch is seen to consist of comparatively large and nearly or quite vertical tubes, intersected here and there by a diaphragm. The peripheral region is exceedingly short and abrupt.

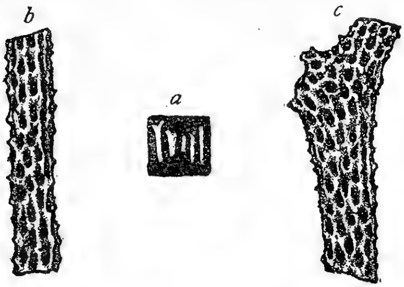


FIG. 140.—ERIDOTRYPA EXIGUA. *a*, GROUP OF FRAGMENTS, NATURAL SIZE; *b* AND *c*, TWO OF THEM, ×9. NEMATOPORA BED OF THE LOWER TRENTON LIMESTONE, NEAR CANNON FALLS, MINNESOTA. (AFTER ULRICH.)

Occurrence.—This neat little species is very abundant in the Nematopora bed of the Lower Trenton at Cannon Falls, Minnesota; it also occurs in the lower part of the Trenton limestone at Trenton Falls, New York, and Chimney Point, Vermont. The species is represented in the Russian collections by a number of examples from the Jewe limestone (D1), Baron Toll's estate, near Jewe (Cat. No. 57219, U.S.N.M.).

British Museum, one specimen from Jewe limestone, Baron Toll's estate.

Genus LIOCLEMA Ulrich.

Leioclema ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, pp. 141, 154.—MILLER, North Amer. Geol. and Pal., 1889, p. 310.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 376, 425.

Lioclema, NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 33.—ULRICH and BASSLER, Smiths. Misc. Coll., vol. 47, 1904, p. 38.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 32.

This genus has its best representation in the Devonian, although a fair number of species is known from both Silurian and Mississippian deposits. Hitherto the oldest known species has been *Lioclema wilmingtonensis* Ulrich, from the earliest Silurian (Richmond) formation of Illinois. The following new species gives a greater antiquity for the genus, although it occurs in the same faunal region as the Richmond form.

The form of growth in *Lioclema* varies from the incrusting through the explanate and solid massive to the ramose. The batostomelloid character of the fused walls is less evident in this genus, particularly in the earlier forms, such as the one described below. The numerous acanthopores inflecting the zoœcia and the isolation of the sparsely tabulated zoœcia by closely tabulated, angular, thin-walled mesopores are other characters which will aid in the recognition of the genus.

Genotype.—*Callopora punctata* Hall. Mississippian (Keokuk and Warsaw) strata of the Mississippi Valley.

LIOCLEMA VETUSTUM, new species.

Text fig. 141.

Zoarium consisting of small, irregular patches, less than 0.5 mm. in thickness, growing upon foreign objects. The type-specimen, from which the figured thin sections were prepared, is incrusting an *Orthoceras*, while the example shown in figure 141 *a*, is growing upon the cystid *Echinospherites*. The surface is conspicuously smooth and shows no distinctly marked clusters of larger zoœcia or mesopores. The zoœcial apertures are quite small and somewhat elongate, averaging 0.3 mm. in their longer diameter, with four to five in 2 mm.; small acanthopores, in number about three to a

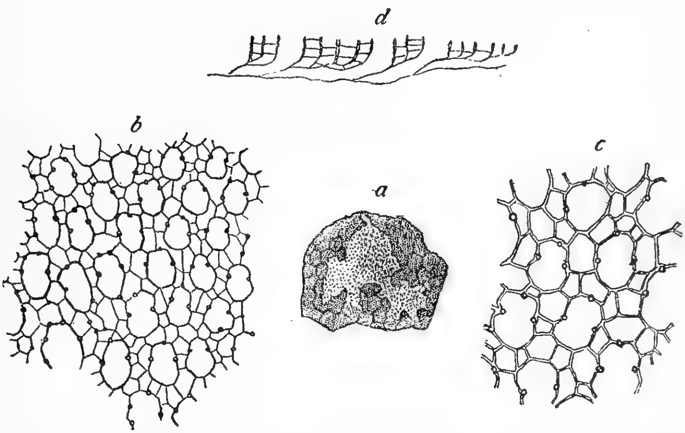


FIG. 141.—LIOCLEMA VETUSTUM. *a*, A ZOARIUM, NATURAL SIZE, INCRUSTING AN ECHINOSPHERITES; *b*, TANGENTIAL SECTION, ×20, SHOWING THE USUAL ARRANGEMENT OF ZOŒCIA AND ACANTHOPORES; *c*, PORTION OF THE SAME, ×35, WITH THE SIMPLICITY OF WALL STRUCTURE MORE EVIDENT; *d*, VERTICAL SECTION, ×20, EXHIBITING TENUITY OF ZOARIUM. KUCKERS SHALE (C2), REVAL AND BARON TOLL'S ESTATE, ESTHONIA.

zoœcium, indent the cavity and cause the petaloid shape of the aperture. Mesopores angular and numerous enough to isolate the zoœcia; walls of both kinds of cells thin.

Vertical sections are difficult to secure on account of the thin zoarium, but all of the structure exhibited in several of these is illustrated in figure 141 *d*. The absence of diaphragms in the zoœcia and their abundance in the numerous mesopores are the most noteworthy features. The appearance in tangential sections is practically the same as in views of the surface.

The delicate incrusting zoarium and the small, petaloid zoœcia, isolated by thin-walled, angular mesopores, are so different from other Ordovician bryozoans that comparisons are unnecessary.

Occurrence.—Apparently not uncommon in the Kuckers shale (C 2), Baron Toll's estate, near Jewe, and in the same rocks at Reval, Esthonia.

Holotype.—Cat. No. 57320, U.S.N.M.

LIOCLEMA SPINEUM, new species.

Text fig. 142.

Zoarium of small, rounded, branching stems, 6 to 7 mm. in diameter. Surface without monticules or conspicuous maculæ, but much roughened by unusually large acanthopores. Zoœcia polygonal, direct, thin-walled, of average size, about 0.4 mm. in diameter, almost always separated from each other by large, angular mesopores. About three zoœcia in 2 mm. The maculæ are discernible, usually

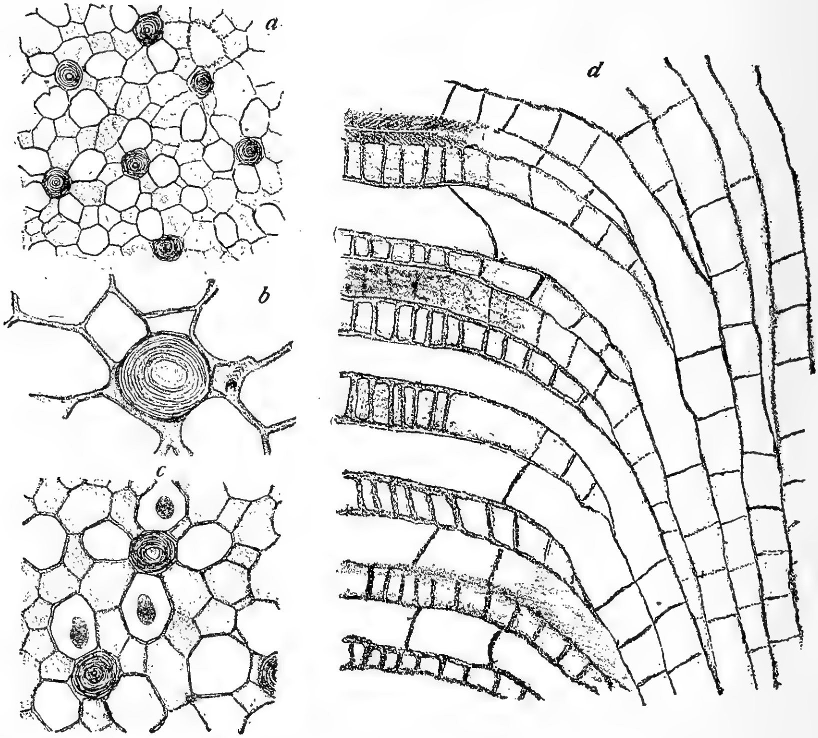


FIG. 142.—LIOCLEMA SPINEUM. *a*, TANGENTIAL SECTION, ×9, SHOWING RELATIONS OF ZOŒCIA, MESOPORES, AND ACANTHOPORES; *b*, THE DETAILED STRUCTURE OF AN ACANTHOPORE, ×40; *c*, PORTION OF A TANGENTIAL SECTION, ×20, WITH THE MESOPORES SHADED; *d*, VERTICAL SECTION, ×20. ORTHOCERAS LIMESTONE (B3), ISLAND OF ROGO, ESTHONIA.

only in thin sections, by the presence of more numerous mesopores and slightly larger zoœcia. Mesopores thin-walled, often larger than the zoœcia but differing from them in having fewer sides. Moreover, the mesopores are frequently closed by the outermost of the numerous diaphragms crossing their tubes. Acanthopores very large and bluntly rounded, often equaling a zoœcium in diameter.

The relative size and arrangement of the zoœcia, mesopores, and acanthopores are well shown in tangential sections. Here the zoœcia are seen to be more regularly polygonal than the mesopores and to have slightly thicker walls. The irregularity in shape and frequent large size of the mesopores is evident in figures 142 *a–c*. The acanthopore is so large that its minute structure is very clear. Sections cutting across the acanthopore show a rounded structure of concentric rings with a central clear space. In vertical sections the concentric rings are seen to be the cut edges of cones of tissue arranged upon each other. Each of these cones has its apex truncated, and, as a result, a tube passes through the midlength of the acanthopore. In tangential section this tube is represented by the central clear space. Diaphragms are rather frequent in the immature zone of the zoœcia but few in the mature region. The mesopores are rather closely tabulated throughout.

The exceptionally large acanthopores will distinguish this from all other ramose bryozoans. *Lioclemella clava* has a somewhat similar zoœcial structure, but has smaller and more numerous acanthopores as well as a different growth habit.

Occurrence.—Not uncommon in the Orthoceras limestone (B3) on the island of Rogo, near Baltischport (Cat. No. 57322, U.S.N.M.); in the Echinospherites limestone (C1), 4 miles east of Reval (Cat. No. 57323, U.S.N.M.); and in the Kuckers shale (C2), Baron Toll's estate, near Jewe (Cat. No. 57324, U.S.N.M.), Esthonia. Rare in the Chasmops limestone, south of Bödahamn, island of Oeland.

Holotype.—Cat. No. 57322, U.S.N.M.

British Museum, thin sections of the type-specimen, and specimens from other localities in Russia.

Genus LIOCLEMELLA Foerste.

Lioclemella Foerste, Geol. Surv. Ohio, vol. 7, 1895, p. 600.—Nickles and Bassler Bull. 173, U. S. Geol. Surv., 1900, p. 33.—Ulrich and Bassler, Smiths. Misc. Coll., vol. 47, 1904, p. 39.—Bassler, Bull. 292, U. S. Geol. Surv., 1906, p. 36.

Species of this genus may be readily recognized by their club-shaped or sparsely divided branches pointed at the distal end for articulation with an attached expanded base. In zoœcial structure the genus is so closely related to *Lioclema* that it is difficult to indicate any distinguishing characters. Species with such a jointed zoarium are not uncommon in the earliest Silurian (Richmond) strata of North America, and continue, although less abundant, into the Silurian. There is little doubt that the following new species is an unequivocal member of the genus.

Genotype.—*Callopora ohioensis* Foerste. Silurian (Clinton) of the Ohio Valley.

LIOCLEMELLA CLAVA, new species.

Text fig. 143.

Zoarium of cylindrical, slightly curved, unbranched club-shaped stems, 6 mm. in diameter and about 60 mm. long, pointed at the lower portion for articulation with an attached, expanded base, and rounded at the distal end where possibly a second articulation occurred. Surface free from monticules but hirsute because of the great number of large acanthopores. Maculæ composed of zoœcia larger than usual are present but quite inconspicuous. About four zoœcia in 2 mm. Zoœcial aperture subangular to rounded, the shape depending upon the number of mesopores which vary in number, but are sometimes so abundant as to isolate the zoœcia.

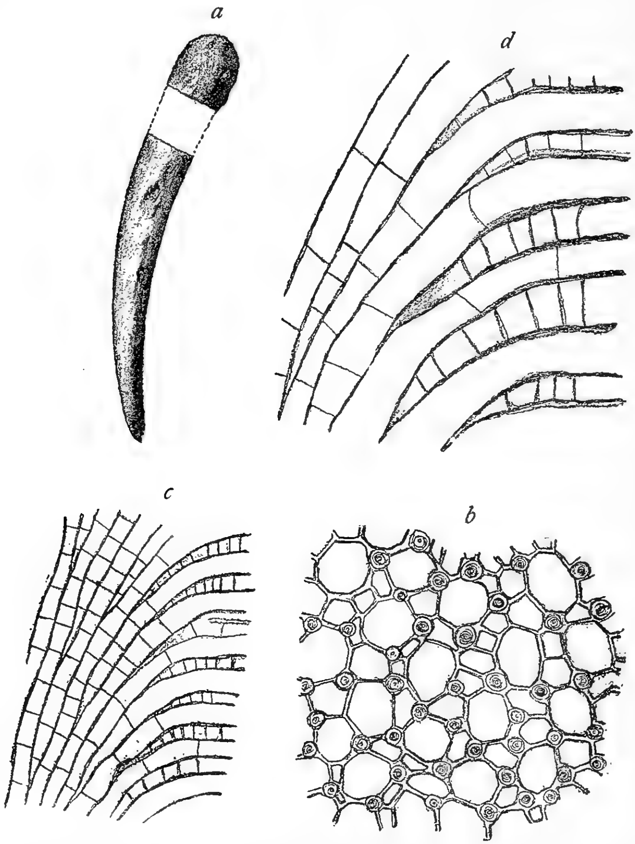


Fig. 143.—Lioclemella clava. *a*, the type-specimen, natural size; *b*, tangential section, ×20, exhibiting the numerous large acanthopores; *c*, vertical section, ×8, illustrating the tabulation; *d*, portion of the same, ×20. Kegel beds (D2), Habbinem, Esthonia.

Acanthopores both large and numerous, appearing at the surface as blunt, perforated spines occupying the junction angles of zoœcia and mesopores.

The most striking feature of tangential sections is the number and size of the acanthopores. These are frequently so large that the place of an ordinary mesopore is occupied by one, and four or five may be noted about a single zoœcium. The material composing an acanthopore is of a lighter color and more granular nature than the solid, dark tissue making up the rest of the zoarium. The walls of adjacent zoœcia and mesopores are obscured by amalgamation, which, in thin sections, gives them the aspect of a solid, indivisible structure. In vertical sections the diaphragms of the zoœcia are noted to average twice their own diameter apart in the immature zone, and to be sometimes entirely wanting in the mature region. In the mesopores, diaphragms are numerous and are usually about their own diameter apart.

The club-shaped zoarium pointed at the base, large zoœcia, and numerous as well as large acanthopores studding the surface, are specific characters which will not allow the present form to be confounded with any associated bryozoan. *Lioclema spineum*, from the Orthoceras limestone, has a somewhat similar zoœcial structure, but here the zoarium is regularly ramose, the zoœcia are larger, and the acanthopores are much stronger.

Occurrence.—Apparently rare in the Jewe limestone (D1), Baron Toll's estate (Cat. No. 57327, U.S.N.M.); in the Kegel beds (D2) at Habbinem (Cat. No. 57325 U.S.N.M.); and in the Wassalem beds (D3) at Uxnorm (Cat. No. 57326 U.S.N.M.), Esthonia.

Holotype.—Cat. No. 57325, U.S.N.M.

British Museum, thin section of specimen from the Jewe limestone, Baron Toll's estate.

Genus ORBIPORA Eichwald.

Orbitulites Eichwald, Zool. Spec., vol. 1, 1829, p. 179.—Milne-Edwards, Hist. Nat. des Corall., vol. 3, 1860, p. 271 (name preoccupied).

Orbipora Eichwald, Bull. Soc. Nat. Moscou, vol. 29, 1856, p. 92; Lethæa Rossica, vol. 1, 1860, p. 484.—Dybowski, Die Chaetetiden der Ostbaltischen Silur-Form., 1877, p. 57.—Nicholson, Genus Monticulipora, 1881, p. 24.—Waagen and Wentzel, Pal. Indica, ser. 13, 1886, pp. 874, 876.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 333.

This generic name has failed of recognition in the more recent work on Paleozoic Bryozoa, and I would not have thought it advisable to resurrect it had not the genotype, *Orbipora distincta,* proved to belong to an apparently unoccupied structural division. A detailed description of both the genus and type species was given by Dybowski in 1877, but neither his work nor that of his predecessors can be considered of much value for present day purposes. Each writer's definition of the genus has proved so different that now the only method of determining the real generic characters is by a reinvestigation of the types or of authentic specimens of the genotype. Dybowski had access to such specimens, but, although his description and figures in connection with those previously published by Eichwald were sufficient to identify the species with some certainty, they gave little information regarding the generic characters. His ideas concerning the genus were such that he referred here two new ramose species, *O. arborescens* and *O. panderi,* the former belonging to a genus still undetermined and the latter an unequivocal *Hemiphragma*. Nicholson, in remarking upon the genus in his volume "The Genus Monticulipora," opposes the resurrection of the name.

Through the kindness of Dr. Mikhailowski, of the University of Dorpat, I have had the opportunity of examining specimens of *Orbipora distincta* studied by Dybowski, who, in turn, as stated before, had access to Eichwald's types. The Dybowski examples are of a well-marked discoid bryozoan easily recognized with sufficient illustrations, and agreeing with a species which I had previously identified from several horizons as a form belonging to a new genus of the Batostomellidæ. Based upon the internal structure, which is well marked in the numerous thin sections studied, this family reference is made with some confidence, although a few features, such as the apparent absence of maculæ, cause final placement of the genus to be still a matter of doubt.

A second species, with the same internal characters, but differing in having a more massive zoariam and smaller zoœcia, is not uncommon in the Orthoceras limestone (B3) at Reval and vicinity, while two well marked forms occur in the lower Asaphus limestone of the island of Oeland.

Based upon these four species, *Orbipora* may be defined as follows:

Zoarium typically discoid, slightly convex above, flat and with a wrinkled epitheca on the underside, or of small, rounded or more or less elongated masses; composed of polygonal, frequently hexagonal, zoœcial tubes in close contact; maculæ apparently absent, if present at all, quite inconspicuous; mesopores wanting, diaphragms extremely few. Acanthopores of considerable size and number, giving a spinous aspect to the surface and frequently indenting the zoœcial walls. Thin sections show that the structure of the walls and acanthopores is consistent with that prevailing in the Batostomellidæ. The walls of adjoining zoœcia are fused together and appear as one amalgamated structure instead of two distinct bands separated by a dark divisional line as in other families. The acanthopores likewise have the clear central structure so well marked in *Lioclema* and *Stenopora*. An exceptionally well preserved specimen from the Chasmops limestone on the island of Oeland shows that the acanthopore has a single row of small pores or granules encircling the inner clear structure. The nature of these pores, as indeed of the acanthopore itself, is unknown, but these different structures certainly had some function.

Aside from its batostomelloid minute structure, the principal generic features of *Orbipora* are its massive growth, absence of mesopores, few diaphragms, and ill-developed maculæ. This generic type is not yet known in American strata.

Genotype.—Orbipora distincta Eichwald. Middle Ordovician of Russia and Sweden.

ORBIPORA DISTINCTA (Eichwald).

Plate 3, figs. 10–10b; text figs. 144–147.

Orbitulites distinctus EICHWALD, Zool. spec., vol. 1, 1829, p. 180.

Favosites hemisphæricus KUTORGA, Beitrag zur Pal. Dorpats, 1835, p. 40, pl. 8, figs. 5 *a–c* (not pl. 9, fig. 3).

Orbipora distincta EICHWALD, Bull. Soc. Nat. Moscou, No. 1, 1856, p. 93; Lethæa Rossica, vol. 1, sect. 1, 1860, p. 484, pl. 28, figs. 6, 7 *a–c*.—DYBOWSKI, Die Chætetiden der Silur-Formation, 1877, p. 60, pl. 2, figs. 10, 10*a*, 10*b*.

Chaetetes hemisphæricus EICHWALD, Lethæa Rossica, vol. 1, sect. 1, 1860, p. 476, pl. 28, fig. 5.

The general characters of this species have been mentioned in the discussion of the genus, but these, as well as the more specific points, are given in the following diagnosis.

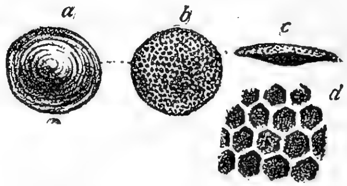


FIG. 144.—ORBIPORA DISTINCTA. *a* AND *b*, BASAL AND CELLULIFEROUS SIDES OF A YOUNG ZOARIUM, NATURAL SIZE, DESCRIBED BY EICHWALD AS CHAETETES HEMISPHERICUS; *c*, SIDE VIEW OF THE SAME SPECIMEN; *d*, CELLULIFEROUS SURFACE ENLARGED. "CALCAIRE À ORTHOCERATITES," PULKOWA, GOVERNMENT OF ST. PETERSBURG. (AFTER EICHWALD.)

Zoarium consisting of a flattened, discoidal mass, sometimes as much as 40 mm. wide and 7 mm. in its greatest height, flat or slightly concave and covered with a wrinkled epitheca on its lower side, slightly convex on the upper or celluliferous surface. Maculæ either absent or differing so little from surrounding areas that they are indistinguishable. The surface is without monticules or elevations of any sort, but is roughened by numerous sharp acan thopores. Zoœcial tubes large, polygonal, usually hexagonal, varying from 0.8 mm. to 1.0 mm. in diameter. Mesopores absent entirely. Acanthopores numerous, as many as 16 surrounding a single zoœcium.

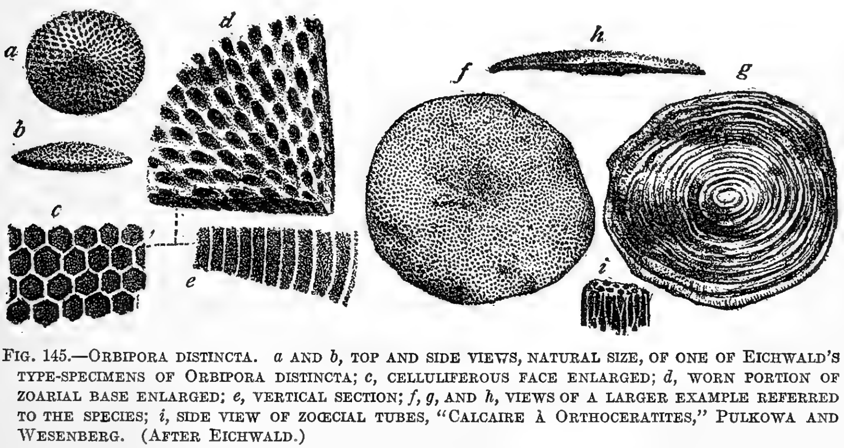


FIG. 145.—ORBIPORA DISTINCTA. *a* AND *b*, TOP AND SIDE VIEWS, NATURAL SIZE, OF ONE OF EICHWALD'S TYPE-SPECIMENS OF ORBIPORA DISTINCTA; *c*, CELLULIFEROUS FACE ENLARGED; *d*, WORN PORTION OF ZOARIAL BASE ENLARGED; *e*, VERTICAL SECTION; *f*, *g*, AND *h*, VIEWS OF A LARGER EXAMPLE REFERRED TO THE SPECIES; *i*, SIDE VIEW OF ZOŒCIAL TUBES, "CALCAIRE À ORTHOCERATITES," PULKOWA AND WESENBERG. (AFTER EICHWALD.)

The internal characters of a well preserved specimen are shown in figures 146 and 147. In tangential section the numerous large acanthopores are particularly noticeable. Here also the rather large central opening or lumen of the acanthopores and the wall structure of adjoining zoœcia are likewise well marked. This structure of the

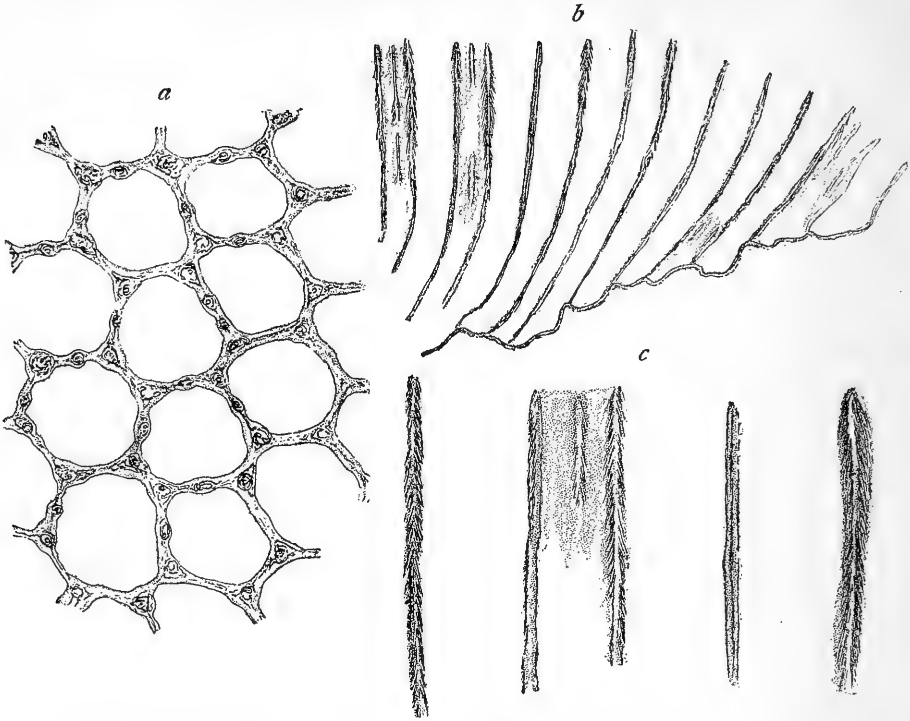


FIG. 146.—ORBIPORA DISTINCTA. *a*, TANGENTIAL SECTION, ×20, ILLUSTRATING THE USUAL STRUCTURES NOTED; *b*, VERTICAL SECTION, ×8, THROUGH A PORTION OF A ZOARIUM; *c*, SMALL PORTION OF THE SAME SECTION, ×20, SHOWING STRUCTURE OF WALLS AND ACANTHOPORES. JEWE LIMESTONE (D1), BARON TOLL'S ESTATE, ESTHONIA.

acanthopores and of the zoœcial walls is essentially the same as in other Batostomellidæ, although the uniform diameter of the zoœcia and absence of maculæ are conspicuous points of difference. The same characters, in addition to the absence of diaphragms, are also well shown in vertical sections.

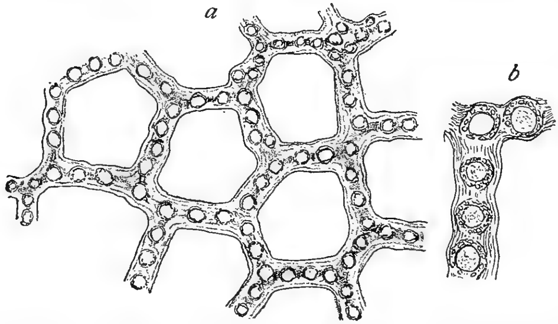


FIG. 147.—ORBIPORA DISTINCTA. *a*, TANGENTIAL SECTION, ×20, IN WHICH THE STRUCTURE IS WELL PRESERVED; *b*, A PORTION OF A ZOŒCIAL WALL, ×35, EXHIBITING THE DETAILED STRUCTURE OF THE ACANTHOPORES. THE LARGE CENTRAL LUMEN AND THE GRANULES OR TUBULES OF THE ACANTHOPORE WALL ARE CLEARLY SHOWN. CHASMOPS LIMESTONE, NEAR BÖDAHAMN, ISLAND OF OELAND.

The discoid zoarium, exceptionally large zoœcia, numerous large acanthopores, and the absence of maculæ and diaphragms, are characters which will cause the present species to be recognized without difficulty.

Occurrence.—Eichwald cites the species from the "calcaire à Orthoceratite," at Pulkowa, Popowa, and Wesenberg. In the collections before me it is present in the Echinospherites limestone (C1) at Reval (Cat. No. 57329, U.S.N.M.); in the Kuckers shale (C2) at Erras (Cat. No. 57330, U.S.N.M.); the Jewe limestone (D1), Baron Toll's estate (Cat. No. 57328, U.S.N.M.), Esthonia; and the Chasmops limestone, south of Bödahamn, Oeland, Baltic Sea.

Plesiotype.—Cat. No. 57328, U.S.N.M.

British Museum, specimens from localities in Esthonia and from the island of Oeland.

ORBIPORA SOLIDA, new species.

Text fig. 148.

Zoarium of dome-shaped, hemispheric or elongated solid masses usually several centimeters in diameter and of corresponding height. The type-specimen, which is one of the largest examples seen, is an elongate oval mass about 40 mm. in diameter and 75 mm. in length. Surface smooth, maculæ as in the type-species being apparently absent. Zoœcia direct, polygonal and of equal size when fully matured. Occasionally a young zoœcium giving the appearance of a mesopore is present, but true mesopores are wanting. Three to four zoœcia occur in 2 mm. Acanthopores numerous and conspicuous at the junction angles of the zoœcia.

The internal structure is essentially the same as in *Orbipora distincta* save that a few scattered diaphragms are occasionally developed. The acanthopores, while not as numerous as in *O. distincta,* are larger and have very distinct central openings.

The more massive zoarium, less abundant acanthopores, and particularly the smaller zoœcia of the present species will readily distinguish it from the related form, *O. distincta.*

Occurrence.—Not uncommon in the Orthoceras limestone (B3) island of Rogo, and at Reval and vicinity.

Holotype.—Cat. No. 57331, U.S.N.M.

British Museum, fragment and thin sections of the type-specimen, and specimens from Reval, Esthonia.

ORBIPORA ACANTHOPHORA, new species.

Text fig. 149.

Zoarium a rounded mass about a centimeter in diameter, with a small, flat basal portion covered with a wrinkled epitheca. Surface without monticules or maculæ, but hirsute on account of numerous large acanthopores arising from the cell walls. Zoœcial apertures irregularly polygonal and much indented by the acanthopores; three to four zoœcia in 2 mm. Mesopores wanting; four to six acanthopores surround an aperture.

In thin sections the amalgamated cell walls and the very large acanthopores composed of a clear, almost structureless tissue are the most noteworthy features of the more minute details. Wherever an acanthopore occurs the walls are greatly thickened, but they are quite thin in the intervening spaces. This alternate thickening and thin-

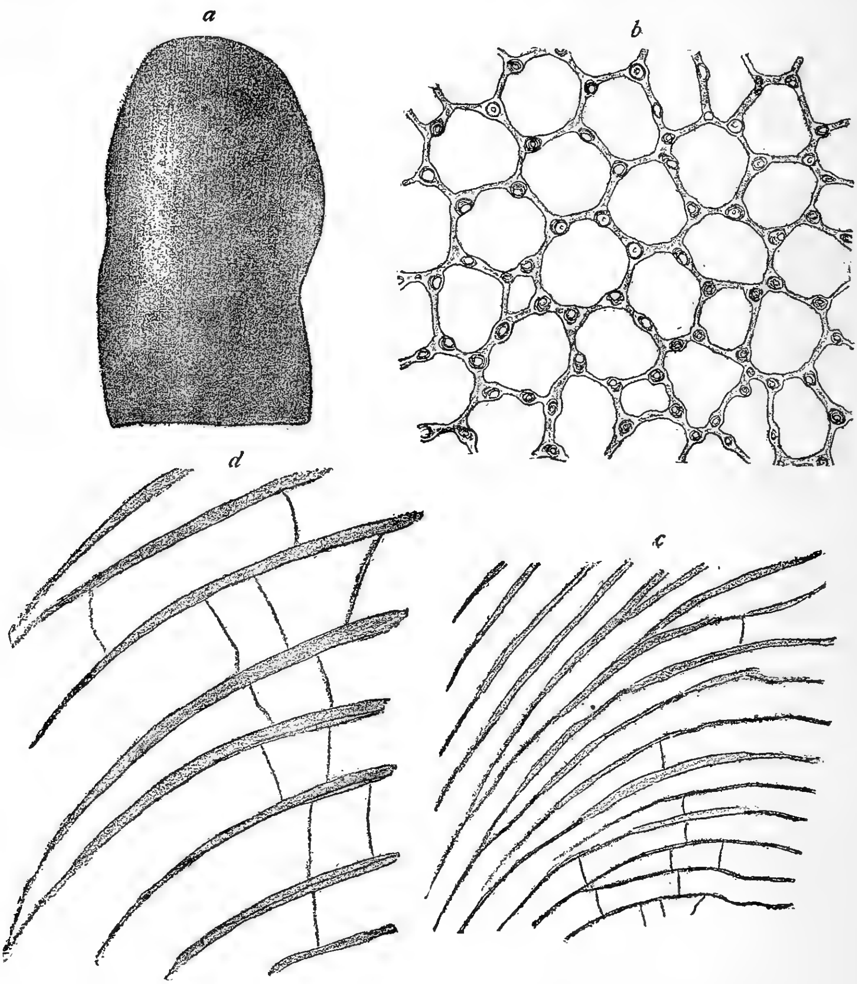


FIG. 148.—ORBIPORA SOLIDA. *a*, SIDE VIEW, NATURAL SIZE, OF THE SOLID, MASSIVE TYPE-SPECIMEN; *b*, TANGENTIAL SECTION, ×20, SHOWING ZOŒCIAL STRUCTURE; *c*, VERTICAL SECTION, ×8, ILLUSTRATING THE USUAL TABULATION; *d*, ANOTHER VERTICAL SECTION, ×20, WITH DIAPHRAGMS MORE REGULARLY PLACED IN THE MATURE ZONE. ORTHOCERAS LIMESTONE (B3), REVAL, ESTHONIA.

ning produces a very irregular aperture with the acanthopore sometimes projecting some distance into the cell cavity. Vertical sections show an occasional diaphragm, although most of the tubes are without them. The minute structure of the walls and acanthopores is exactly the same as in *Orbipora distincta*.

This species is most closely related to *Orbipora solida*, agreeing with it in all characters save the larger size and fewer number of its acanthopores and its much smaller zoarium. A glance at figures 148 and 149 will indicate that in spite of their similar characters, the tangential section of each is quite distinct. The associated *Orbipora*

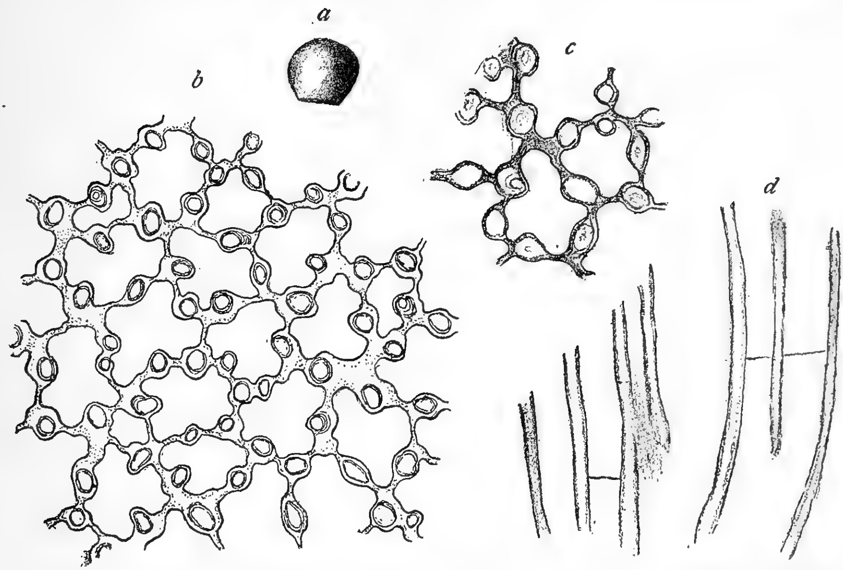


FIG. 149.—ORBIPORA ACANTHOPHORA. *a*, THE TYPE-SPECIMEN, NATURAL SIZE; *b*, TANGENTIAL SECTION, ×20, ILLUSTRATING THE IRREGULAR ZOŒCIA AND NUMEROUS LARGE ACANTHOPORES; *c*, SEVERAL ZOŒCIA OF THE SAME SECTION, ×20, SHADED TO BRING OUT THE CLEAR TISSUE OF THE ACANTHOPORES AND THE AMALGAMATED WALL STRUCTURE MORE PLAINLY; *d*, VERTICAL SECTION, ×20, WITH STRUCTURE OF WALLS AND ACANTHOPORES. LOWER ASAPHUS LIMESTONE, HALLÜDDEN, ISLAND OF OELAND.

indenta has much smaller zoœcia, thinner walls, and smaller acanthopores projecting far into the zoœcial cavity.

Occurrence.—Rare in the lower Asaphus limestone at Hälludden, island of Oeland, Baltic Sea.

The type-specimen and figured thin sections are in the collections of the British Museum.

ORBIPORA INDENTA, new species.

Text fig. 150.

On account of the deep indentation of the zoœcial cavity by numerous small acanthopores, a zoarium of this species often gives the impression of a septate coral like *Tetradium*. Thin sections, however, show that the minute structure is precisely as in the other species here referred to *Orbipora*.

The zoarium of the type-specimen is a small, elongate, dome-shaped mass, 14 mm. in height and 9 mm. wide, with the usual epithecated flattened base. The surface is smooth and without perceptible maculæ; the apertures are irregularly polygonal, five in 2 mm., with thin walls; acanthopores small, four to eight or more surrounding a zoœcium, often occurring at the end of a fold of the wall extending into the zoœcial cavity. The arrangement of the diaphragms, structure of the walls and acanthopores, and other features brought out in sections are shown in the accompanying figures and need not be described.

Although this is an undoubted, indeed, very typical species of the genus, its zoœcial structure has considerable resemblance to such forms as *Stigmatella septatum* and *S. foordii* described on previous

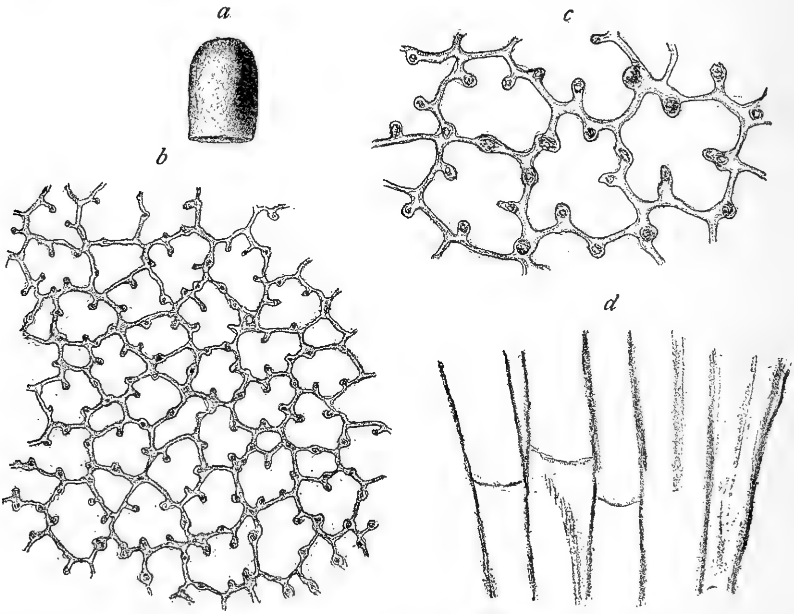


Fig. 150.—Orbipora indenta. *a*, the type zoarium, natural size; *b*, tangential section, ×20, exhibiting the numerous small acanthopores indenting the zoœcial cavity; *c*, portion of the same section, ×35, with the wall and acanthopore structure more clearly shown; *d*, vertical section, ×20. Lower Asaphus limestone, Hallüdden, island of Oeland.

pages. Both of the latter have numerous mesopores so that this feature alone will separate them. Compared with other species of *Orbipora*, *O. indenta* is found to have smaller zoœcia, thinner walls, and more delicate acanthopores. The occurrence of the acanthopores at the end of the infolded wall, giving the indented effect, is likewise quite characteristic.

Occurrence.—Rare in the lower Asaphus limestone at Hälludden, island of Oeland, Baltic Sea, where it is associated with *Orbipora acanthophora.*

The type-specimen and figured thin sections are in the collections of the British Museum.

ESTHONIOPORA, new genus.

The value of the minute wall structure as a reliable character in classification is well exemplified in the group of species for which this new name is proposed. At first the two species now assigned to *Esthoniopora* were regarded as somewhat aberrant forms of *Hemiphragma*, but more detailed investigation of the walls showed that those of adjacent zoœcia were fused together as in the Amalgamata and were not separated by the distinct dark line characteristic of the Integrata. Further study has convinced me that *Esthoniopora* is a member of the Batostomellidæ and not far removed from the late Paleozoic genus *Stenopora*. Indeed, it is possible that the genus is the simplest expression of the stenoporoid type of structure. The arrangement of the diaphragms in *E. communis* is highly suggestive of *Stenopora*, although the beaded walls and the acanthopores of the latter genus are wanting.

Esthoniopora may be defined as follows:

Zoarium massive, hemispheric, with a flat, concentrically wrinkled base; composed of thin-walled, polygonal zoœcia in close contact; walls of great simplicity but clearly amalgamated; acanthopores and mesopores absent; zoœcial tubes with semidiaphragms which, in the type species, are frequently placed opposite each other, and in a second species, are large and curved enough to resemble a cystiphragm.

Genotype.—Esthoniopora communis, new species. Middle Ordovician of Russia and Sweden.

The diagnostic features of *Esthoniopora* are the massive zoarium, polygonal zoœcia with amalgamated walls and semidiaphragms, and the absence of acanthopores and mesopores. All other genera of the Batostomellidæ except *Stenopora* differ so obviously that comparisons are hardly necessary. The relations between *Stenopora* and *Esthoniopora* have been discussed above. The most difficulty will be experienced in separating the species of this new genus from the simple massive types of *Hemiphragma*, and thin sections are necessary to show their distinct wall structure.

In this connection it may be mentioned that both of the species of *Esthoniopora* agree in having their zoœcial tubes filled with coarsely crystalline calcite, which reflects and refracts the light so much that vertical fractures often present an iridescent effect. This character, if it may be so called, is not limited to the present genus, for all of the species of *Calloporina* and *Anaphragma* show the same structure, while other genera show no trace of it. I am thus led to believe that, although this is a purely physical character, it has an organic basis and is thus of value in the discrimination of certain genera and species.

According to present knowledge, species of *Esthoniopora* are unknown in American strata, and in Europe are confined to the Middle Ordovician rocks of Esthonia and the neighboring Baltic Provinces.

ESTHONIOPORA COMMUNIS, new species.

Text figs. 151–155.

Zoarium of regular dome-shaped or hemispheric masses, with a flat, concentrically wrinkled base; growth beginning upon some foreign object, which, in the mature stages, is overgrown or is lost and usually indicated only by the cicatrix of attachment. A well developed zoarium is 30 mm. in its basal diameter and 20 mm. in height, but all sizes from this or even larger, down to masses less than 10 mm. wide, are found. The usual form of zoarium is shown in figure 152 *a*, *b*, but a less usual occurrence is illustrated in figure 155. Here the zoœcia of one portion of a normally growing example have continued growth and have given rise to another normal but attached form.

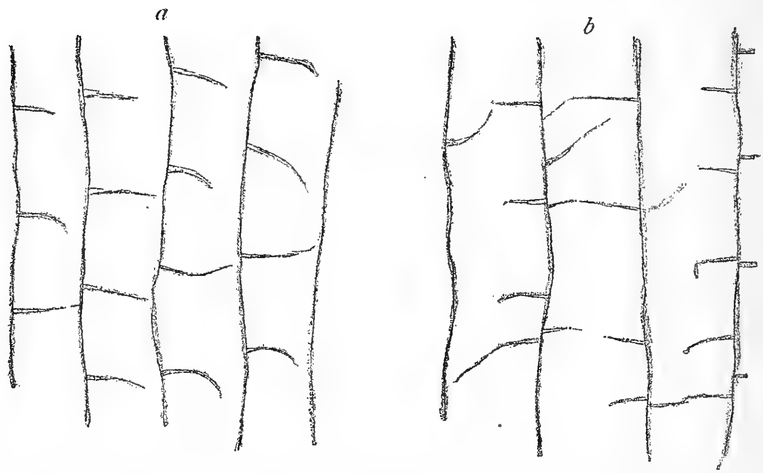


FIG. 151.—ESTHONIOPORA COMMUNIS. *a* AND *b*, TWO VERTICAL SECTIONS, ×20, SHOWING AN IRREGULAR ARRANGEMENT OF THE SEMIDIAPHRAGMS. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

Surface smooth, maculæ 4 to 5 mm. apart, inconspicuous to the unaided eye, and distinguished under a hand lens or in sections by clusters of zoœcia larger than the ordinary. Zoœcia thin-walled, polygonal, usually hexagonal, with three and one-half to four in the space of 2 mm., measuring from the center of a macula. An ordinary intermacular zoœcium is 0.5 mm. in diameter. Mesopores and acanthopores wanting. The bases of some zoaria are covered with small, mesopore-like cells sometimes noticed in other massive bryozoans.

Tangential sections show exceedingly simple zoœcia with the thin walls of those adjacent to each other amalgamated. No trace of acanthopores or mesopores is visible, although small, mesopore-like spaces representing young cells are sometimes present. In vertical sections the presence of semidiaphragms at distances averaging a tube diameter apart is the most important character to be noted. Frequently these semidiaphragms are seen to be placed directly opposite each other in the same tube. In such a case, the structure is exactly the same as the centrally perforated diaphragm of *Stenopora.* At other times the partition extends only partially around the circumference of the cell and appears in sections as a single projecting semidiaphragm.

The typical form of the species is illustrated in figure 152. The regular hemispheric, solid zoarium is made up of a number of distinct

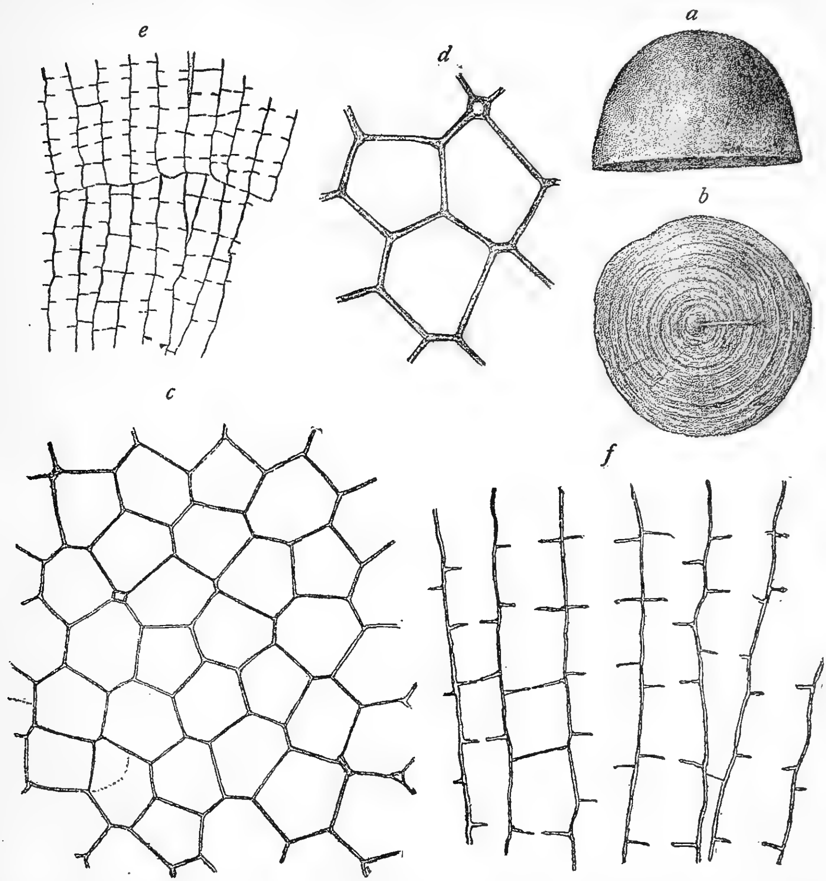


FIG. 152.—ESTHONIOPORA COMMUNIS. *a*, SIDE VIEW OF AN AVERAGE SPECIMEN, NATURAL SIZE; *b*, BASAL VIEW OF SAME SHOWING EPITHECA AND CICATRIX OF ATTACHMENT; *c*, TANGENTIAL SECTION, ×20, OF AVERAGE ZOŒCIA; *d*, SEVERAL ZOŒCIA OF THE SAME SECTION, ×35, ILLUSTRATING SIMPLE, AMALGAMATED WALL STRUCTURE; *e*, VERTICAL SECTION, ×8, THROUGH TWO ZOARIAL LAYERS; *f*, PORTION OF THE SAME SECTION, ×20. JEWE LIMESTONE (D1), BARON TOLL'S ESTATE, ESTHONIA.

zoarial layers, two of which are shown in the vertical section, figure 152 *e*. As usual in such zoaria, the tubes of these individual layers are placed so nearly on top of each other that they form practically one and the same tube throughout the colony.

In figure 154 the zoarium consists of a single layer in which the semidiaphragms are placed opposite each other with considerable regularity. Whenever tabulæ of this sort are cut by the tangential section, they are seen to extend completely around the cavity, or nearly so, as shown in figure 154 *a*.

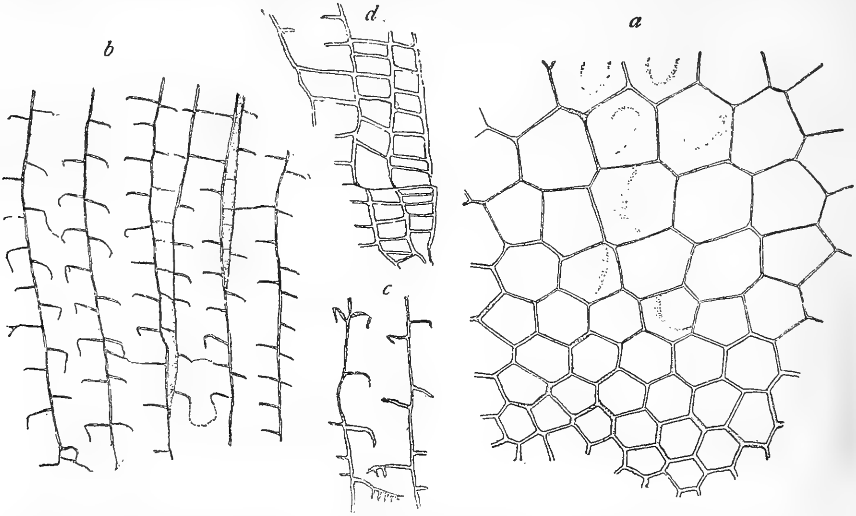


FIG. 153.—ESTHONIOPORA COMMUNIS. *a*, TANGENTIAL SECTION, ×20, SHOWING NORMAL ZOŒCIA IN THE UPPER HALF, AND THE SMALL, THICK-WALLED, MESOPORELIKE CELLS IN THE LOWER PORTION; *b*, VERTICAL SECTION OF THE SAME SPECIMEN, ×20, WITH THE FREE ENDS OF THE DIAPHRAGMS BENT DOWNWARD; *c*, A ZOŒCIAL TUBE OF THE SAME SECTION, ×20, SHOWING FURTHER MODIFICATION OF THE DIAPHRAGMS; *d*, VERTICAL SECTION, ×20, PASSING THROUGH A TRUE ZOŒCIAL TUBE AND THROUGH TWO OF THE SMALLER CELL OPENINGS OF THE BASE. GLAUCONITE LIMESTONE (B2), REVAL, ESTHONIA.

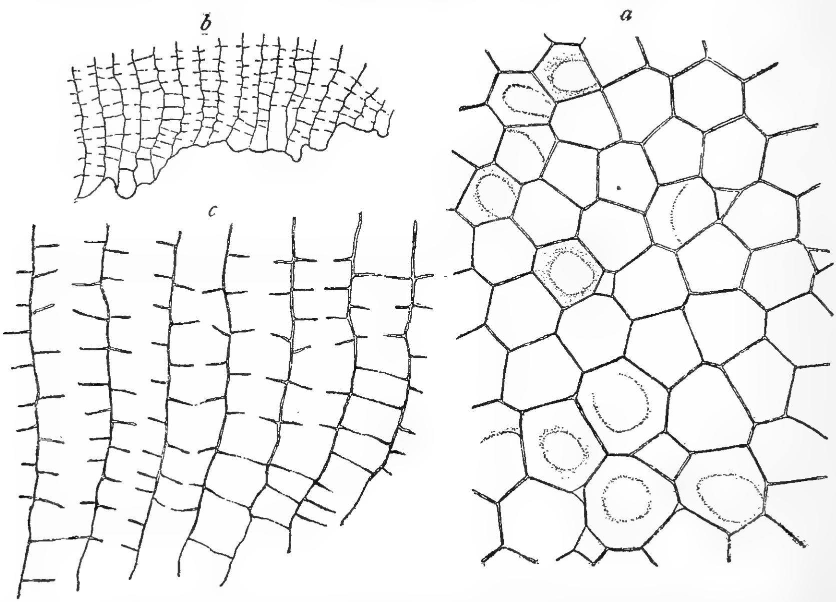


FIG. 154.—ESTHONIOPORA COMMUNIS. *a*, TANGENTIAL SECTION, ×20, CUTTING THE SEMIDIAPHRAGMS IN SOME OF THE TUBES; *b*, VERTICAL SECTION, ×6, THROUGH A SINGLE ZOARIAL LAYER; *c*, A PORTION OF THE SAME, ×20. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

The peculiar form of growth mentioned in the specific diagnosis above is shown in figure 155, while further interesting internal structure is brought out in figures 151 and 153. The latter thin sections were prepared from an example showing the base overgrown with small cells. The tangential section (fig. 153 *a*) passes through this layer of small cells and through the adjoining normal zoœcia. The forms differ from the latter simply in their small size and greater thickness of walls. In vertical sections, however, they show more resemblance to mesopores in being closely tabulated. This is illustrated in figure 153 *d*. Figures 153 *b* and *c* show an occurrence of the diaphragm in which the free ends are either sharply bent downward or have strings of tissue dependent from them. That the latter is sometimes the case is evidenced in figure 153 *c*, where five such projections are noted on the lowest diaphragm.

In growth *Esthoniopora communis* is exactly like *Dianulites petropolitana*, and the size, shape, and general aspect of their zoœcia in surface views are identical. After comparing the figures of their totally different internal structure one is impressed by the necessity either of thin sections or of other means to examine the microscopic characters of fossil Trepostomata. With regard to all other Trepostomata the incomplete diaphragms and amalgamated walls of the present form are the best distinguishing characters. Comparisons with *Esthoniopora curvata* are included under its description.

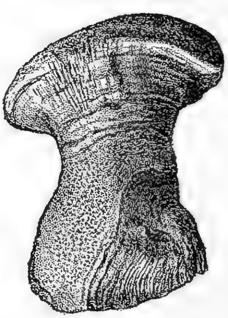


FIG. 155.—ESTHONIOPORA COMMUNIS. AN UNUSUAL FORM OF ZOARIUM, NATURAL SIZE. KUCKERS SHALE (C2), ERRAS, ESTHONIA.

Occurrence.—A common fossil in the Glauconite limestone (B2) at Reval and at Oberchowow, on the river Wolchow; in the Orthoceras limestone (B3) at Port Kunda; in the Echinospherites limestone (C1) at Reval and 4 miles east of Reval, at Katlino, and at Luggenhusen; in the Kuckers shale (C2), Baron Toll's estate, near Jewe, and at Erras; in the Jewe limestone (D1), Baron Toll's estate.

Cotypes.—Cat. Nos. 57357 to 57365, U.S.N.M.

British Museum, specimens and thin sections from various localities in Esthonia.

ESTHONIOPORA CURVATA, new species.

Text fig. 156.

In thin sections this species, with its long, slightly curved, cystiphragmlike, incomplete diaphragms, seems clearly distinct from the preceding *E. communis*, although externally the two are practically identical. A slight increase in the average size of both the macular and intermacular cells is apparent upon close measurement, but this aids little in the discrimination of the two species. However, vertical fractures showing the different style of tabulation will distinguish *E. curvata* at once. The fact that the incomplete diaphragm

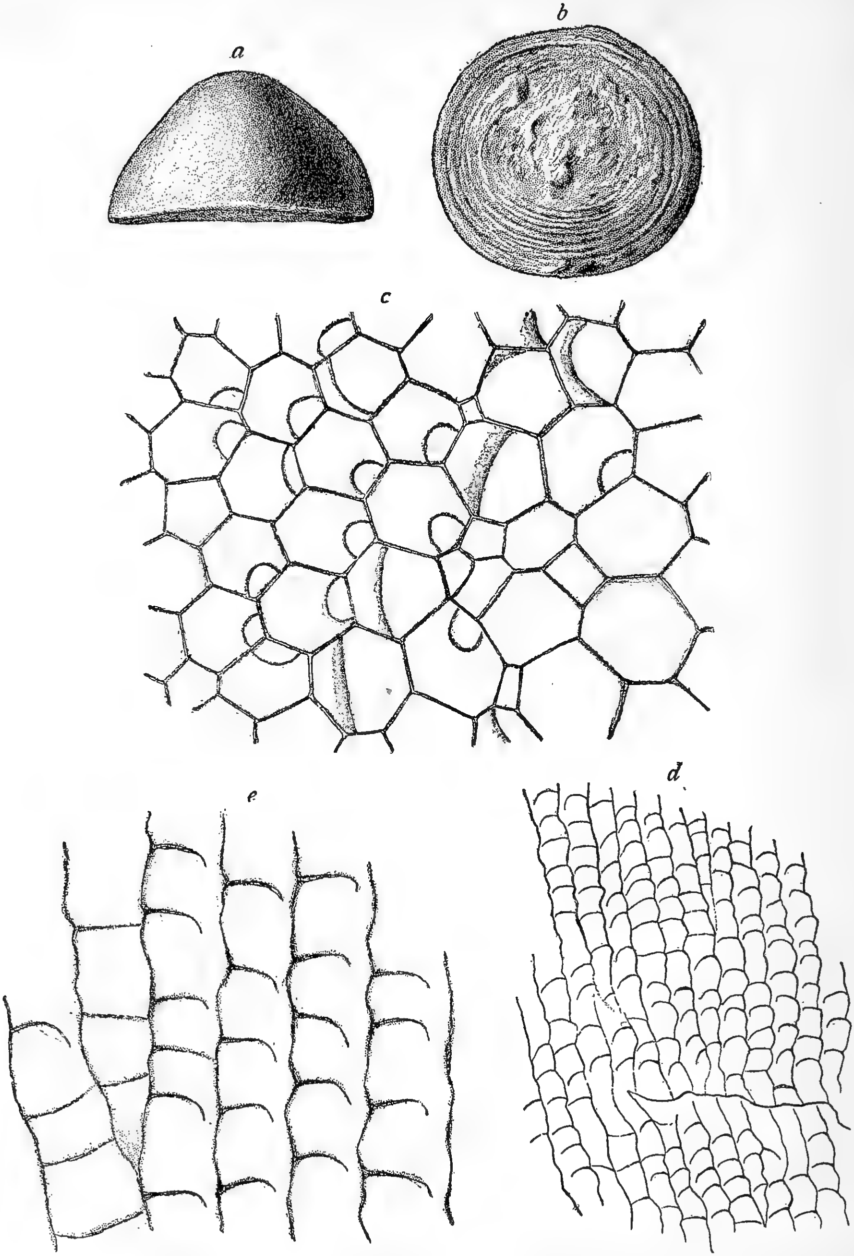


FIG. 156.—ESTHONIOPORA CURVATA. *a* AND *b*, SIDE AND BASAL VIEWS OF A NORMAL EXAMPLE, NATURAL SIZE; *c*, TANGENTIAL SECTION, ×20, SHOWING THE SMALL OPENING LEFT BY THE INCOMPLETE DIAPHRAGM; *d*, VERTICAL SECTION, ×8, THROUGH PORTIONS OF TWO LAYERS, ILLUSTRATING THE CYSTIPHRAGMLIKE INCOMPLETE DIAPHRAGM; *e*, ANOTHER VERTICAL SECTION, ×20. ECHINOSPHERITES LIMESTONE (Ci), DUBOVIKI, GOVERNMENT OF ST. PETERSBURG.

extends almost across the cell cavity is apparent in tangential sections from the small opening left on one side. From the small size of this curved portion it is also evident that the diaphragms extend almost entirely around the zoœcial cavity.

Occurrence.—Not uncommon in the Echinospherites limestone (C1) at Reval and 4 miles east of Reval, in Esthonia, and at Katlino and Duboviki in the government of St. Petersburg; in the Kuckers shale (C2), Baron Toll's estate, near Jewe. The species also occurs in the Chasmops limestone on the island of Oeland, south of Bödahamn. (Cat. Nos. 57366 to 57370).

British Museum, specimens from the island of Oeland.

Division INTEGRATA Ulrich and Bassler.

Family AMPLEXOPORIDÆ Ulrich.

The simplest types of the Integrata are included in this family, which, because of this simplicity as well as the practical absence of mesopores, shows the duplex character of the walls most distinctly. In the Halloporidæ and Trematoporidæ mesopores are almost invariably present, and the black divisional line is then only apparent where the zoœcial walls are in contact.

The Amplexoporidæ include forms of a ramose, massive, or bifoliate growth. The zoœcial tubes are simple, polygonal, with a distinct divisional line. Mesopores are practically wanting, a few abortive cells in the maculæ being their only representatives. Acanthopores are generally abundant, although sometimes wanting.

The type genus of the family, *Amplexopora,* has no known representation in the Ordovician of Russia or in the Black River deposits of America. It is abundantly represented in the upper Trenton and Cincinnatian formations of the Mississippi Valley. *Monotrypella* likewise occurs only in the formations containing faunas of supposed South Atlantic origin. *Rhombotrypa* is found only in the earliest Silurian deposits, where its several species are highly diagnostic fossils. I am convinced that further search will show this genus to be represented in the upper Lyckholm and Borkholm, where species associated with it in America are known.

The discovery of a typical species of *Petalotrypa* in the Middle Ordovician rocks of Russia increases the geologic range of the genus. Hitherto it has been considered typical of the upper part of the Silurian and of the Devonian.

Genus PETALOTRYPA Ulrich.

Petalotrypa Ulrich, Geol. Surv. Illinois, vol. 8, 1890, pp. 377, 453.—Simpson, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 582.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 30.

Amplexoporidæ in which the zoarium forms delicate, bifoliate, thin branches or fronds. The zoœcial structure is essentially as in other genera of the family; that is, the walls of adjoining cells are distinctly marked off from each other by a black divisional line. This dark line is sometimes broken or traversed by areas of the same light-colored tissue making up the wall itself.

Genotype.—*Petalotrypa compressa* Ulrich. Middle Devonian of Illinois and Iowa.

PETALOTRYPA FOLIUM, new species.

Text fig. 157.

Zoarium a delicate, bifoliate expansion about 4 cm. in both height and width and not exceeding a millimeter in thickness. Surface smooth, with clusters of cell apertures, appreciably larger than the average, at intervals of about 3.5 mm. Zoœcial tubes regularly polygonal, opening directly at the surface, seven in 2 mm. Walls of the zoœcia thin and without acanthopores; mesopores either wanting entirely or present only in the maculæ.

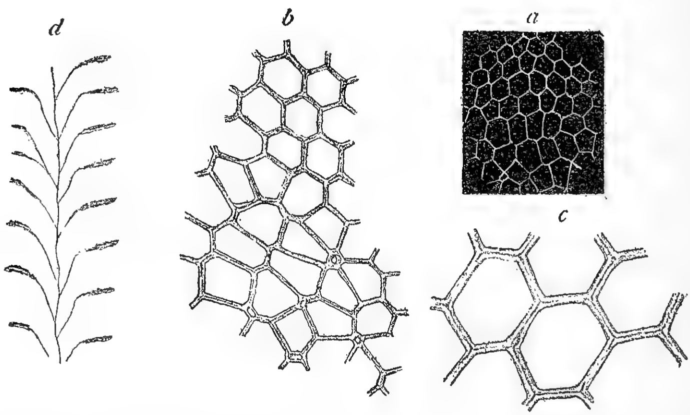


Fig. 157.—Petalotrypa folium. *a*, surface of the type-specimen, ×9, showing a macula in the lower half of figure; *b*, tangential section, ×20; *c*, a few zoœcia of the same, ×40, exhibiting the dark divisional line; *d*, vertical section, ×20, showing bifoliate growth and simplicity of internal structure. Kegel limestone (D2), Habbinem, Esthonia.

In thin sections the zoœcial tubes are seen to arise rather abruptly from each side of the mesial lamina. As the surface is approached their walls thicken slightly and the dark line separating adjoining zoœcia is developed. Vertical sections likewise indicate the absence of diaphragms.

The dark divisional line is especially well shown in tangential sections, which exhibit also the simplicity of zoœcial structure as a whole. In figure 157 *b*, a few mesopores or interspaces are seen to be limited to the macula of larger or more irregularly shaped cells, while the zoœcia proper are smaller and assume a quite hexagonal outline.

The present species agrees in all respects with the Devonian forms upon which the genus was based, indeed, it is quite close to *Petalotrypa* *delicata* Ulrich from the Hamilton group of Iowa and Illinois. Careful comparison shows that the latter has distinctly smaller zoœcia.

Occurrence.—Rare in the Kegel limestone (D2) at Habbinem, Esthonia.

Holotype.—Cat. No. 57371, U.S.N.M.

Family TREMATOPORIDÆ Ulrich.

Zoaria incrusting, ramose or massive. Zoœcial tubes thin and irregular in the axial region, usually constricted where diaphragms are inserted. Walls thickened in the mature region, with a distinct divisional line where the zoœcia are in contact. Acanthopores more or less abundant; mesopores often abundant and of large size, their apertures closed.

Compared with the Halloporidæ this family differs most obviously in having closed mesopores and "beaded" zoœcial tubes caused by the constriction of the walls when a diaphragm is inserted. With the emendation of the Halloporidæ to include a species with a slight development of acanthopores, the most noticeable distinction between the two families—the presence of the structures in one and not in the other—is less marked although still of value. As a rule the Trematoporidæ have a general looseness and slight obscurity of structure quite unlike that of any other family. For example, the walls are not as clear and distinct as in the Amplexoporidæ or Halloporidæ, the acanthopores have a less definite, clear cut structure, and the walls are often undulating. It is difficult to describe this "trematoporoid" structure, although it is usually recognized without difficulty after one has learned it from experience.

The specific and generic representation of the Trematoporidæ is the largest of the Trepostomata. All of the American genera save one are represented, and, with further search, this exception, *Stromatotrypa*, will probably also be found common to both continents. The unusually large specific development of *Hemiphragma* in European strata is an interesting feature brought out by the present studies, and indicates most decidedly the value of the semidiaphrams as a generic character.

Genus TREMATOPORA Hall.

Trematopora HALL, Amer. Journ. Sci., ser. 2, vol. 11, 1851, p. 400; Nat. Hist. New York, Pal., vol. 2, 1852, p. 149.—HALL and SIMPSON, Nat. Hist. New York, Pal. vol. 6, 1887, p. xiv.—MILLER, North Amer. Geol. and Pal., 1889, p. 328.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 373, 418; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 308.—SIMPSON, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 591.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 35.—POCTA, Syst. Sil. du Centre Boheme, vol. 8, pt. 2, 1902, p. 314.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 43.

Not *Trematopora* of Ulrich, 1882; Eichwald, 1860; Dybowski, 1877.

At least 80 species of Paleozoic Bryozoa have been referred to *Trematopora*, from time to time, but few of these are strictly congeneric with the genotype. Ulrich was the first to point out the generic characters and to assign many of this large number of species to more natural positions in the classification.

In his later work, Ulrich has considered the genus as the Silurian representative of *Batostoma*, and has suggested dropping the latter name. The discovery of two new undoubted species of *Trematopora* in the Middle Ordovician of Russia, in addition to the wide-spread *T. primigenia*, and the occurrence of all three in association with typical *Batostoma*, seems sufficient justification for the recognition of both genera.

As indicated in the above synonymy, Dybowski misinterpreted the genus entirely, all of the species referred to it by him proving to be typical forms of his genus *Dittopora*.

Internally the distinctly beaded mesopores, and, externally, the solid zoœcial interspaces and peristomes may be relied upon in distinguishing species of *Trematopora*.

Genotype.—Trematopora tuberculosa Hall. Niagaran strata of the United States and Canada.

TREMATOPORA PRIMIGENIA Ulrich.

Text fig. 158.

Trematopora primigenia Ulrich, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 97.

Trematopora? *primigenia* Ulrich, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 309, pl. 21, figs. 23–40.

This abundant American Black River species is present among the small bryozoans from the Wassalem beds at Uxnorm. Ulrich has given a careful description of the Minnesota specimens which applies equally well to the Russian examples, and it is therefore copied below.

Zoarium loosely bushy, consisting of small slender ramulets, dividing dichotomously at varying intervals; branches cylindrical or compressed, commonly about 2 mm. in diameter, but varying from 1.5 to 4 mm., arising in greater or lesser numbers from a large basal expansion that is thinly spread over some cylindrical body like a crinoid column. Not infrequently the branches inosculate freely. Entire zoaria varying in diameter probably between 20 and 60 mm. Superficial aspect of zoœcia varying with age. In young stages or examples the apertures are more or less oblique, with only the posterior border elevated and the interspaces in a varying degree narrower than the apertures. With age the apertures become somewhat smaller, ovate or subcircular and direct, and the peristome or rim equally elevated all around, while the interspaces were widened till in some examples they are often equal to twice the width of the zoœcial orifices. At the same time the interspaces, which as a rule exhibit no sign of the really very numerous mesopores, are roughened, as are also the peristomes, by the development of acanthopores. These vary greatly in size and number. The arrangement of the zoœcial apertures is only moderately regular, there being here and there spots in which they are of larger size and more widely separated than usual. An average of 12 or 13 in 3 mm., but the number in that distance may vary from 11 to 15.

Internal characters.—In vertical sections the tubes have thin walls, are not entirely vertical, and without diaphragms in the axial region. Near the surface they bend outward rather abruptly when one and sometimes two diaphragms were in most cases thrown across each tube. At the same time an abundant series of mesopores was developed. These are crossed by from two to six diaphragms, the outer ones of which are much thicker and separated by shorter intervals than the inner pair. * * * The walls of the mesopores where two or more occupy an interspace are strongly zigzag, in some instances appearing not unlike vesicular tissue. In tangential sections the zoœcial walls may be thin and occasionally even inflected by the acanthopores, but as a rule they are ring-like, and generally completely separated from each other

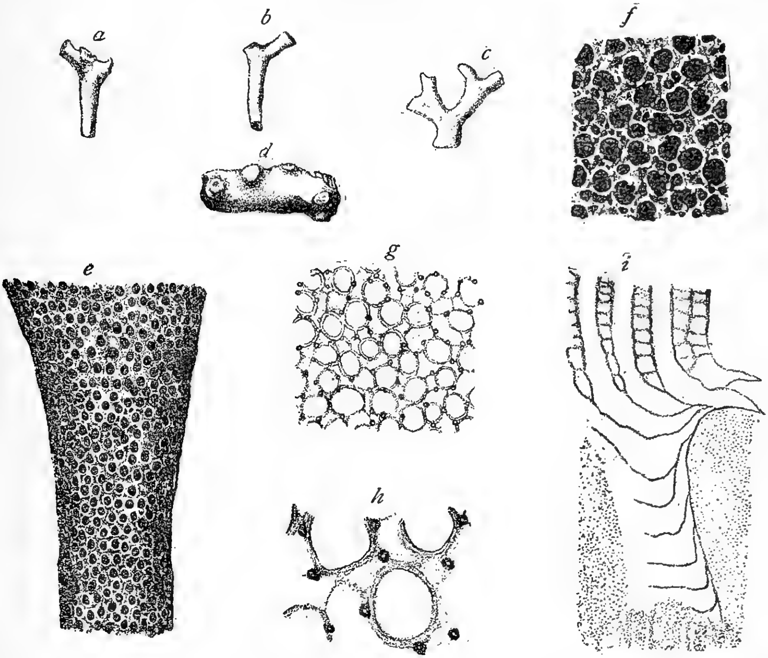


FIG. 158.—TREMATOPORA PRIMIGENIA. *a* TO *c*, THREE FRAGMENTS, NATURAL SIZE; *d*, BASE OF A ZOARIUM, LIFE SIZE; *e*, SURFACE OF A TYPICAL EXAMPLE, ×9, SHOWING THE PERISTOME; *f*, SURFACE OF ANOTHER SPECIMEN, ×18, WITH NUMEROUS ACANTHOPORES AND OPEN MESOPORES; *g*, THE USUAL APPEARANCE IN TANGENTIAL SECTION, ×18; *h*, SEVERAL ZOŒCIA OF THE SAME SECTION, ×50; *i*, VERTICAL SECTION, ×18, THROUGH A BASAL EXPANSION ATTACHED TO A CRINOID COLUMN. BLACK RIVER (DECORAH) SHALE, MINNEAPOLIS, MINNESOTA. (AFTER ULRICH.)

by a series of unequal and irregularly shaped mesopores. The acanthopores are distinct, nearly uniform in size, usually attached to the outer side of the zoœcial walls, and number from one to three or four to each zoœcium.

Occurrence.—Common in the Rhinidictya bed of the Black River (Decorah) shale at various localities in Minnesota. Apparently rare in the Wassalem beds (D3) at Uxnorm, Esthonia (Cat. No. 57372, U.S.N.M.).

Specimens from American localities are in the collections of the British Museum.

TREMATOPORA KUCKERSIANA, new species.

Text fig. 159.

Free examples of this fine new form have not been seen, the species being founded upon specimens embedded in the solid limestone. These, however, are well preserved and show the following characters:

Zoarium of cylindrical branches 5 mm. in diameter, dividing infrequently. Surface smooth, with the usual maculæ of large zoœcia and wider interspaces. Zoœcial apertures rounded to oval, with a well-marked peristome. Six to seven zoœcia in 2 mm., measuring from the center of a macula. Acanthopores few. Mesopores numerous, usually isolating the zoœcia, but not visible at the surface where their place is taken by tissue forming the solid interzoœcial spaces characteristic of the genus.

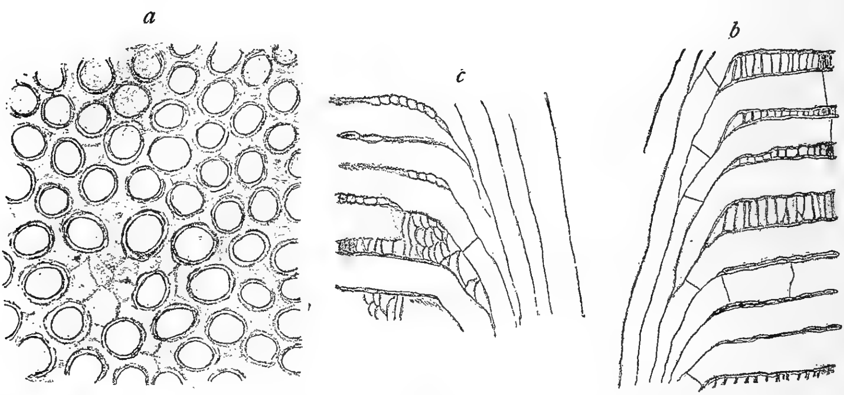


FIG. 159.—TREMATOPORA KUCKERSIANA. *a*, TANGENTIAL SECTION, ×20, SHOWING OVAL ZOŒCIA AND DISTINCT PERISTOMES; *b*, VERTICAL SECTION, ×20; *c*, ANOTHER VERTICAL SECTION, ×20, SHOWING THE BEADED MESOPORES WITH CYSTLIKE DIAPHRAGMS. KUCKERS SHALE (C2), REVAL, ESTHONIA.

Vertical sections show the usual beaded mesopores with numerous diaphragms, which, when unusually crowded, give a cystose structure to the interzoœcial spaces. As the surface is approached the mesopores become filled with a laminated tissue, which, in tangential or surface views, appears as solid interspaces. The zoœcia have thin walls and no diaphragms in the immature region and slightly thickened walls with only an occasional diaphragm in the mature zone. The beaded mesopores, with their crowded, often cyst-like diaphragms, and their outer filling of tissue, form the most important feature of such sections.

Tangential sections through the outermost part of the zoarium show oval to circular zoœcia with distinct peristomes separated by solid tissue, through which the outlines of the mesopores are sometimes faintly visible. Deeper sections exhibit the mesopores more clearly, but show less distinct peristomes.

The large, rounded zoœcia, distinct peristomes, solid interspaces, and cylindrical branches are characters which will readily distinguish this species. Certain species of *Hallopora* have a similar zoarium and general aspect, but their mesopores are never closed at the surface.

Occurrence.—Rare in the Kuckers shale (C2) at Reval, and in the Jewe limestone (D1), Baron Toll's estate, in Esthonia.

Holotype.—Cat. No. 57373, U.S.N.M.

British Museum, thin sections of the type-specimen.

TREMATOPORA CYSTATA, new species.

Plate 11, fig. 25; text fig. 160.

Numerous well-preserved examples of this typical little *Trematopora* are in the collections before me, and all agree in the internal and external features shown on plate 11, figure 25, and text figure 160.

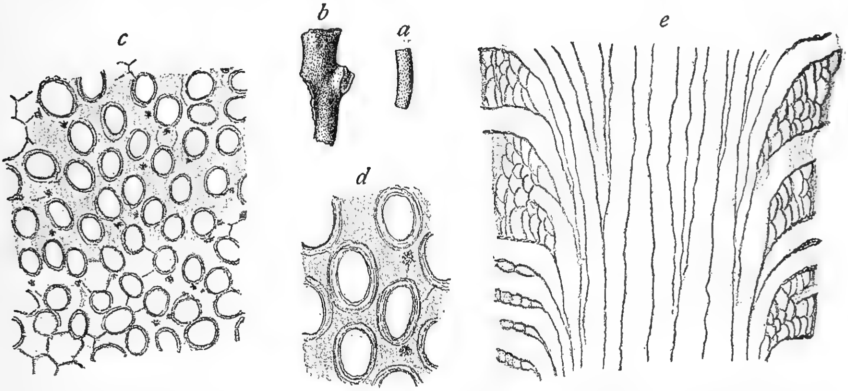


Fig. 160.—Trematopora cystata. *a* and *b*, two fragments, natural size; *c*, tangential section, ×20, showing oval zoœcia, distinct peristomes and small acanthopores; *d*, several zoœcia, ×40; *e*, vertical section of a branch, showing the usual appearance, ×20. Kuckers shale (C2), Reval, Esthonia.

The zoarium is of small, cylindrical stems, 2 to 3 mm. in diameter, which branch frequently and irregularly. The surface is smooth, but has distinct maculæ of larger zoœcia and wider interspaces, as shown in figure 25 of plate 11. Acanthopores are rather numerous, although not as abundant as in *Trematopora primigenia*. Vertical sections show the most decided features of internal structure, the presence of abundant cyst-like structures filling the mesopores. Near the surface these are obscured or replaced by a dense, laminated tissue. Six to seven zoœcia occur in 2 mm.

Trematopora cystata is closely related to *T. primigenia*, but differs in having large zoœcia, less abundant acanthopores, and especially in the numerous crowded, cyst-like diaphragms filling the mesopores. *Trematopora kuckersiana* has larger zoœcia, fewer acanthopores, and a more robust zoarium.

Occurrence.—Abundant in the Kuckers shale (C2) at Reval; less common in the Kegel limestone (D2) at Kegel, Esthonia; rare in the limestone with *Trinucleus seticornis* near Hulterstad Church, island of Oeland.

Cotypes.—Cat. No. 57375, U.S.N.M.

British Museum, specimens from Reval, Esthonia, and from the island of Oeland.

Genus BATOSTOMA Ulrich.

Batostoma Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 154.—Foord, Contr. Micro-Pal. Cambro-Sil., 1883, p. 17.—Miller, North Amer. Geol. and Pal., 1889, p. 294.—Ulrich, Geol. Surv. Illinois, vol. 8, 1890, pp. 379, 459; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 288; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 275.—Simpson, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 588.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 35.—Cumings, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 740.

This genus is most prolific both in species and specimens, but seems to be limited to Ordovician strata and to the Richmond formation of the earliest Silurian. In America no less than a dozen species have been described from the Middle Ordovician alone, and a number of new forms are known. Four of these same forms occur in the Russian deposits with a few new species. The essential characters of the genus are embodied in the following description:

Zoarium irregularly ramose, branches arising from a large basal expansion; zoœcia with walls that are thin in the immature region, much thickened and in sections appearing ring-like (but seldom in contact) in mature region; diaphragms present; mesopores numerous or few, irregular in size or shape; acanthopores usually of large size and abundant, sometimes few.

Genotype.—*Monticulipora* (*Heterotrypa*) *implicata* Nicholson. Upper Ordovician (Eden) of the Ohio Valley.

BATOSTOMA MAGNOPORA Ulrich.

Text figs. 161, 162.

Batostoma magnopora Ulrich, Geol. and Nat Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 261, pl. 25, figs. 12–15.

Original description.—This is given by Ulrich as follows:

Zoarium ramose; branches large, subcylindrical, 8 to 15 mm. wide; surface elevated at irregular intervals into low monticules, the latter broad and occupied by zoœcia a little larger than the average. Zoœcia unusually large, about eight in 3 mm., their apertures polygonal, the walls thin, with one or two small acanthopores to each zoœcium rising generally from the wall at some point between the angles of junction. Many of the latter are occupied by small mesopores, but these are to be regarded as comparatively very few and at all times difficult to distinguish externally.

Internal characters.—In tangential sections the tubes are polygonal and have rather thin walls, in which the line of contact between adjoining tubes is distinctly preserved. Mesopores few, small, chiefly at the angles of junction. Acanthopores small, incon-

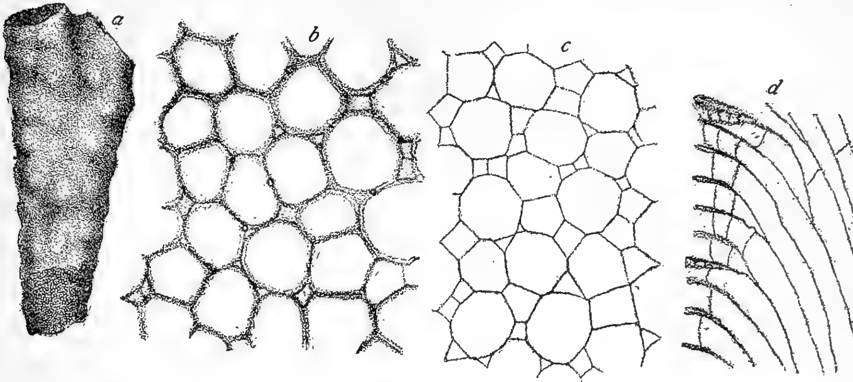


FIG. 161.—BATOSTOMA MAGNOPORA. *a*, SMALL SPECIMEN OF NATURAL SIZE; *b*, TANGENTIAL SECTION, ×18; *c*, PART OF AXIAL REGION IN TRANSVERSE SECTION, ×18; *d*, VERTICAL SECTION OF ZOARIUM WITH A NARROW MATURE ZONE, ×9. BLACK RIVER (DECORAH) SHALE, MINNEAPOLIS AND ST. PAUL, MINNESOTA. (AFTER ULRICH.)

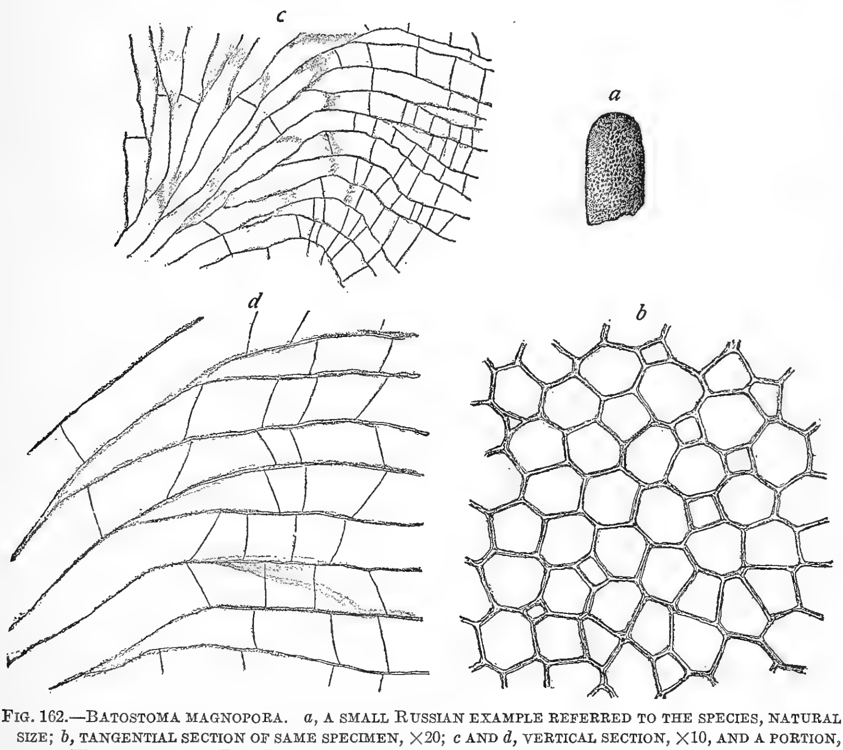


FIG. 162.—BATOSTOMA MAGNOPORA. *a*, A SMALL RUSSIAN EXAMPLE REFERRED TO THE SPECIES, NATURAL SIZE; *b*, TANGENTIAL SECTION OF SAME SPECIMEN, ×20; *c* AND *d*, VERTICAL SECTION, ×10, AND A PORTION, ×20. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

spicuous. In vertical sections the tubes proceed toward the surface in a very gentle curve until they enter the unusually narrow peripheral region, where the curve is sufficiently accelerated to enable them to open at the surface with nearly direct apertures. Diaphragms are very remote or wanting in the axial region, and not numerous even in the peripheral portion. Here each tube presents from one to five, separated by intervals of from one-half to one tube diameter. In the mesopores, which appear to be very short, the diaphragms are much closer, with three or four in 0.5 mm. In the central part of transverse sections the tubes are conspicuously divided into a large and small set, both having very thin walls.

Occurrence.—The American types are from the Rhinidictya bed of the Black River (Decorah) shales of Minnesota. In Russia the species is known only from the Wassalem beds (D3) at Uxnorm, Esthonia.

Plesiotype.—Cat. No. 57377, U.S.N.M.

Thin sections of the Russian type are in the collections of the British Museum.

BATOSTOMA FERTILE Ulrich.

Text fig. 163.

Batostoma fertilis Ulrich, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 92.

Batostoma fertile Ulrich, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 290, pl. 25, figs. 1-11; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 275, fig. 459 B.

Original description.—Ulrich thus describes this species:

Zoarium attaining a large size, 50 to 100 mm. in height, consisting of strong, irregularly thickened, more or less compressed branches that divide without regularity; thickness of branches 5 to 25 mm., width 8 to 30 mm. Zoœcial apertures varying according to the size and number of the mesopores and the thickness of the walls, from polygonal to circular. In some specimens and portions of others mesopores are exceedingly few and the zoœcial walls thin and generally in contact at all sides; in the majority of examples mesopores are moderately abundant and the walls thicker, but the zoœcial apertures are still polygonal or at any rate most of them subangular. From this, the typical form, we can trace the variations by small degrees into a form which, for the sake of reference, may be designated as var. *circulare*. In this the zoœcial apertures are almost perfectly circular, inclosed by a raised rim or peristome, and largely separated from each other by depressed interspaces. * * * Interspaces occupied by mesopores varying considerably in size and shape. Their mouths are commonly closed by a calcareous plate in which a variously situated rounded opening may be observed. When the preservation is unusually favorable the surface of the plate is studded with very minute papillæ representing the terminations of exceedingly small foramina. Acanthopores between one and two to each zoœcium, but very small and only in rare instances distinguishable at the surface. At intervals of 3 or 4 mm. occur clusters of zoœcia a little larger than the average, and in the center of these usually small substellate maculæ. Between eight and nine of the average zoœcia in 3 mm.

Internal characters: In vertical sections the tubes have thin and somewhat irregularly fluctuating walls in the axial region. Their course to the surface is gently curved throughout, and as they near the same their walls are appreciably thickened, while mesopores, whose number varies greatly in different specimens, are abruptly developed. The mesopores may be constricted at the points where they are intersected by the diaphragms. The latter are often thickened circumferentially, and vary somewhat in the number occurring in a given space, seven and eleven in 1 mm. being the extremes so far noticed. In the axial region diaphragms are very far apart or are wanting entirely, but in the peripheral portion the average distance between them is about equal to half their diameter. Specimens more than 12 mm. thick consist of two or more layers of tubes.

In the above description Ulrich has embodied all of the essential features of the species. The Russian examples referred here are so similar externally and internally that there can be little doubt of the correctness of their reference to *Batostoma fertile.*

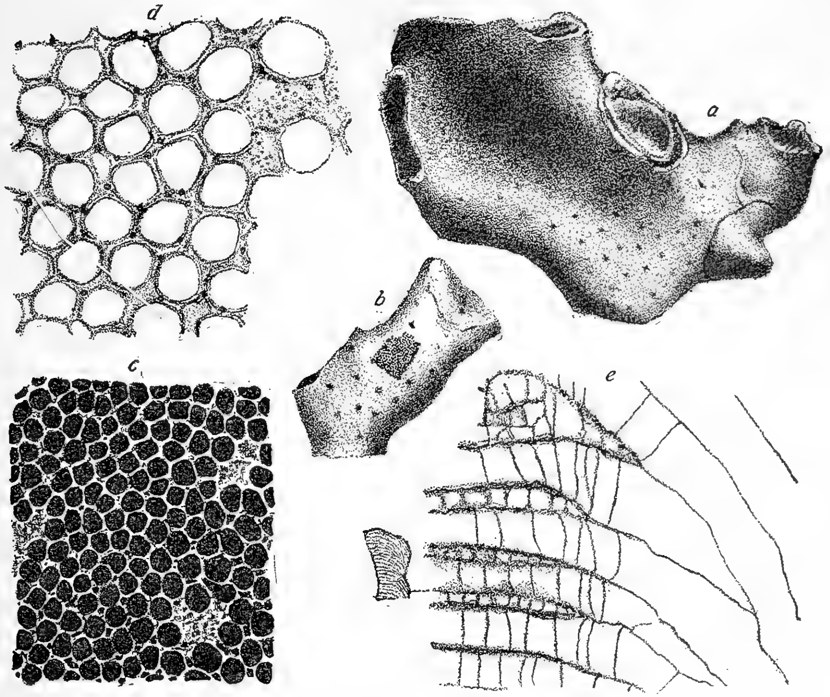


FIG. 163.—BATOSTOMA FERTILE. *a* AND *b*, A LARGE AND A SMALL SPECIMEN, NATURAL SIZE; *c*, SURFACE OF THE LARGER SPECIMEN, ×9; *d*, TANGENTIAL SECTION OF THE SAME EXAMPLE, ×18; *e*, VERTICAL SECTION, NATURAL SIZE, AND A PORTION, ×18. BLACK RIVER (DECORAH) SHALES, MINNEAPOLIS, MINNESOTA. (AFTER ULRICH.)

Occurrence.—Common in the Stictoporella bed of the Black River (Decorah) shales of Minnesota; rare in the Echinospherites limestone (C1) near Reval, Esthonia (Cat. No. 57378, U.S.N.M.).

American specimens of the species are in the collections of the British Museum.

BATOSTOMA FERTILE CIRCULARE Ulrich.

Text fig. 164.

Batostoma fertile var. *circulare* ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 291, pl. 25, figs. 8, 9; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 275, fig. 459 B.

The distinctive feature of this variety is pointed out in the above description, and illustrated in the accompanying figure, although often the peristomes are thicker and more distinctly separated from each other than is shown in the figure. Both species and variety are found associated in American strata and likewise in the Russian.

Occurrence.—Abundant in the Stictoporella bed of the Black River (Decorah) shale in Minnesota; rare in the Echinospherites limestone (C1), near Reval, Esthonia (Cat. No. 57379, U.S.N.M.).

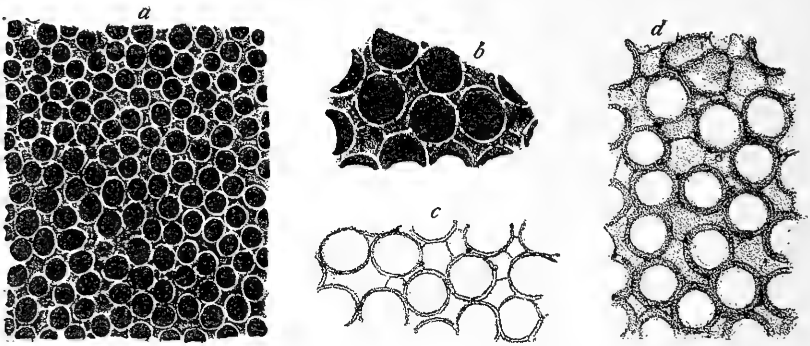


FIG. 164.—BATOSTOMA FERTILE CIRCULARE. *a* AND *b*, SURFACE OF A TYPICAL EXAMPLE, ×9, WITH A PORTION, ×18; *c* AND *d*, TWO TANGENTIAL SECTIONS, ×18, FROM DIFFERENT PARTS OF THE MATURE ZONE. BLACK RIVER (DECORAH) SHALES, MINNEAPOLIS, MINNESOTA. (AFTER ULRICH.)

American specimens of the species are in the collections of the British Museum.

BATOSTOMA MICKWITZI, new species.

Plate 10, figs. 3–6; text fig. 165.

This striking bryozoan may be easily recognized by its unusually robust branches, very large polygonal zoœcia and few mesopores. In size of zoarium the species is approached by no other of the known Paleozoic ramose bryozoans, while such unusually large zoœcia are found in but few branching species. The small fragment figured on plate 10 averages 25 mm. in diameter, but the more complete zoarium illustrated has branches 40 mm. in diameter, increasing to 70 mm. just before a bifurcation. This latter specimen, and another showing the basal portion clearly, indicate that the complete zoarium consisted of a stout, slightly spreading basal portion arising into a short, cylindrical stem, which, after a growth of 60 mm. or more, divided dichotomously. After a growth for a similar distance, each of these divisions branches in the same way, but after this second branching, zoarial growth seems to have stopped. An entire zoarium was therefore probably seldom over 150 mm. in height.

Surface of a zoarium smooth, maculæ scarcely distinguishable with the naked eye, but under a hand lens they are seen to be composed of the usual large zoœcia and more numerous mesopores. Zoœcia angular, unusually large, four to four and one-half in 2 mm.; an ordinary zoœcium averages 0.5 mm. in diameter, while the largest zoœcia of the maculæ are one-half again as large. Zoœcial walls thin; acanthopores apparently seldom developed, probably represented by knot-like structures in the cell angles; mesopores few, generally entirely absent in the intermacular areas and occurring only sparingly in the maculæ.

In vertical sections the tubes in the immature zone have thin, somewhat flexuous walls and are crossed by very few diaphragms.

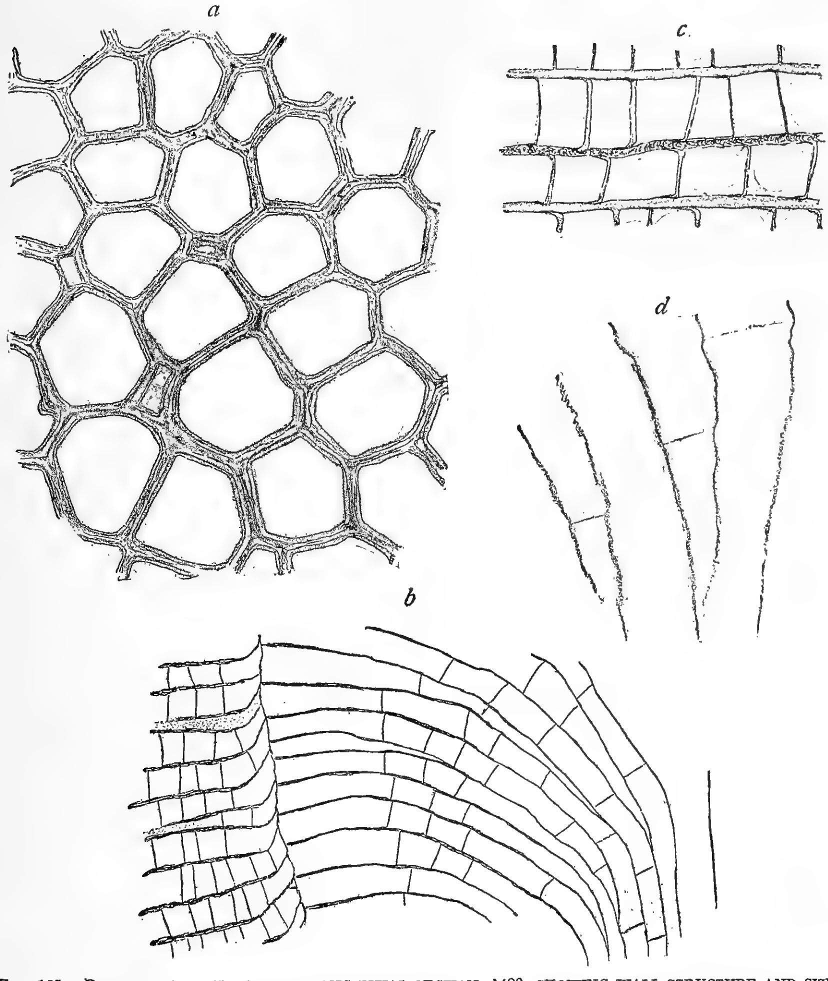


FIG. 165.—BATOSTOMA MICKWITZI. *a*, TANGENTIAL SECTION, ×20, SHOWING WALL STRUCTURE AND SIZE OF ZOŒCIA, RANGING FROM THE LARGE ONES OF THE MACULA TO THE SMALLER ORDINARY ONES; *b*, VERTICAL SECTION, ×8, THROUGH BOTH REGIONS AND WITH A SECOND GROWTH OF ZOŒCIA; *c*, SEVERAL TUBES OF THE MATURE ZONE, ×20, IN VERTICAL SECTION; *d*, VERTICAL SECTION, ×20, SHOWING STRUCTURE OF WALLS IN THE IMMATURE ZONE. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

The curve to the surface is gentle and the mature region is distinguished principally by the more abundant diaphragms and slightly thicker walls. In the most crowded portion of the tubes three diaphragms occur in their own diameter, but one to two in this distance is more often the rule.

In the size of its zoœcia alone this species is so decidedly different from other ramose Trepostomata that comparisons are unnecessary. The specific name is in honor of the late Dr. August von Mickwitz, who collected the type-specimens.

Occurrence.—Common in the Wassalem beds (D3) at Uxnorm, Esthonia.

Cotypes.—Cat. No. 57380, U.S.N.M.

Thin sections of the type-specimens and two specimens from the type locality are in the collections of the British Museum.

BATOSTOMA WINCHELLI (Ulrich).

Text fig. 166.

Amplexopora winchelli Ulrich, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 91.

Batostoma winchelli Ulrich, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 295, pl. 26, figs. 33–37; pl. 27, figs. 1–6.—Simpson, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 588, fig. 174.

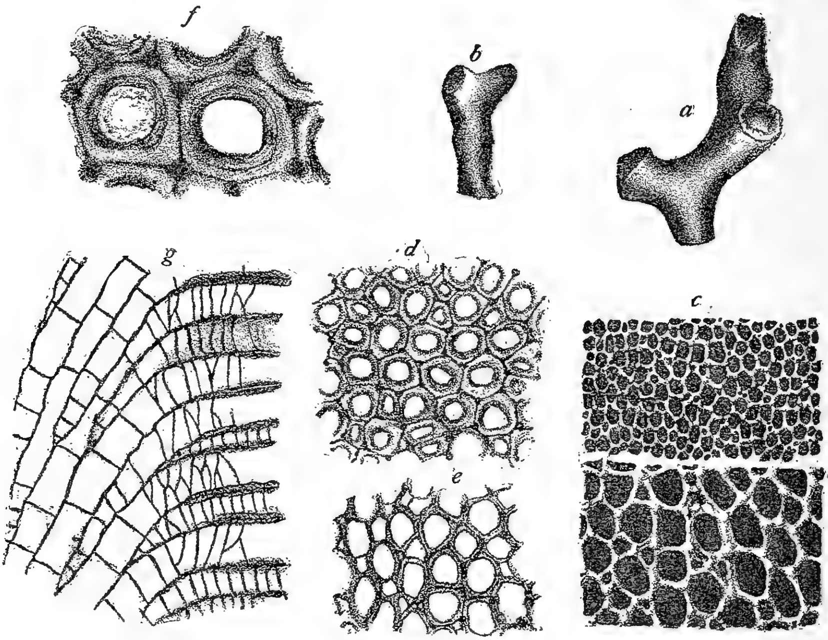


Fig. 166.—Batostoma winchelli. *a* and *b*, two fragments of natural size; *c*, surface of *a*, ×9 and ×18; *d*, tangential section, ×18, showing character of a mature example; *e*, small portion of a tangential section of a young specimen, ×18; *f*, several zoœcia of figure *d*, ×50; *g*, vertical section, ×18, of an ordinary specimen. Black River (Decorah) shale, St. Paul, Minnesota. (After Ulrich.)

The Russian specimens referred to this abundant American species show external and internal features so similar to those figured below that the illustrations of the American form will serve for both. The following are the essential characters of the species:

Zoarium of irregularly ramose, subcylindrical, smooth branches, usually 5 to 7 mm. in diameter. Zoœcial apertures subangular, somewhat irregularly arranged, seven to eight in 2 mm., with moderately thick walls, ridge shaped when perfect, and with acanthopores at the angles of junction. Mesopores few and irregularly developed.

The internal structure is well illustrated in the accompanying figure, which is copied from Ulrich. The zoœcia are smaller than in any of the other species of the genus, and this, in addition to their shape, will aid in identification.

Occurrence.—Common in the Rhinidictya bed of the Black River (Decorah) shales of Minnesota; apparently rare in the Jewe beds (D1) at Paesküll (Cat. No. 57381, U.S.N.M.), and in the Wesenberg limestone (E) at Wesenberg, Esthonia (Cat. No. 57382, U.S.N.M.)

British Museum, specimen and thin section from Paesküll, Esthonia.

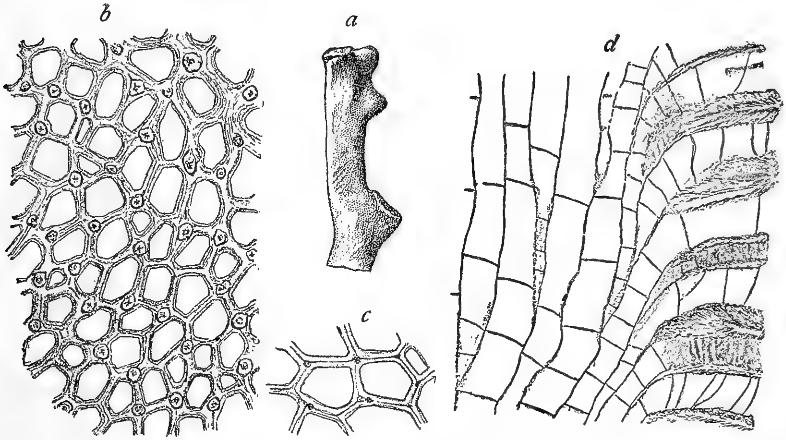


FIG. 167.—BATOSTOMA WINCHELLI SPINULOSUM. *a*, A RUSSIAN EXAMPLE, NATURAL SIZE; *b*, TANGENTIAL SECTION, ×20, SHOWING THICK WALLS AND FEWER LARGER ACANTHOPORES THAN USUAL; *c*, SEVERAL ZOŒCIA OF ANOTHER TANGENTIAL SECTION OF THE SAME SPECIMEN, ×20, EXHIBITING THE NORMAL DEVELOPMENT OF ACANTHOPORES NOTED IN AMERICAN EXAMPLES; *d*, VERTICAL SECTION, ×20. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

BATOSTOMA WINCHELLI SPINULOSUM Ulrich.

Text figs. 167, 168.

Batostoma winchelli var. *spinulosum* ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 296, pl. 27, figs. 7, 8; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 275, fig. 459 C.

In the typical form of this species the acanthopores are small or only of medium size, and are numerous enough to occupy nearly all the junction angles. The present variety was distinguished by Ulrich to include those specimens having the same general zoarial and zoœcial characters except that the acanthopores are much stronger and the zoœcia are a trifle larger. Tangential sections prepared from American specimens are shown in figure 168 for comparison with the Russian specimens referred to the variety. The thin sections of the particular specimen illustrated in figure 167 show unusually large and few acanthopores, but other sections of the same example show them of the more usual size and number.

Occurrence.—Common in the Black River (Decorah) shales of Minnesota; apparently rare in the Wassalem bed (D3) at Uxnorm, Esthonia.

Plesiotype.—Cat. No. 57383, U.S.N.M.

Thin sections of the Russian example are in the collections of the British Museum.

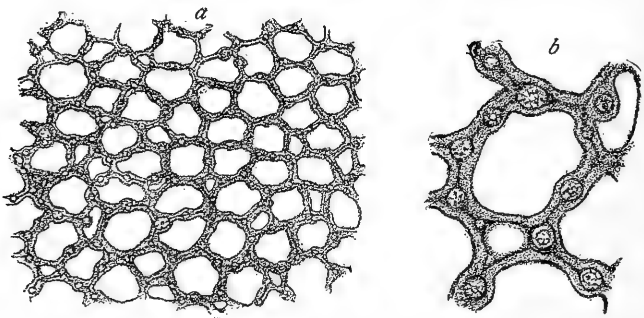


FIG. 168.—BATOSTOMA WINCHELLI SPINULOSUM. *a* AND *b*, TANGENTIAL SECTION, ×18, AND A SINGLE ZOŒCIUM, ×50, WITH NUMEROUS ACANTHOPORES. BLACK RIVER (DECORAH) SHALES, ST. PAUL, MINNESOTA. (AFTER ULRICH.)

BATOSTOMA GRANULOSUM, new species.

Text fig. 169.

Only two examples of this form are known to me, but its large zoœcia and numerous large acanthopores, in addition to its internal structure, form a combination of characters so different from other species of *Batostoma* that I do not hesitate to describe it as new. The example on which the description is based is a cylindrical stem 8 mm. in diameter, most of which has been used in making the thin sections studied. Its surface is free from monticules but granulose because of the numerous acanthopores. Zoœcia thick-walled, irregularly polygonal with occasional mesopores. Acanthopores large and numerous, eight usually surrounding a zoœcium. Three and one-half to four zoœcia in 2 mm. Maculæ of larger zoœcia and more abundant mesopores a conspicuous feature of the surface and of thin sections.

The internal structure is that of a typical *Batostoma*. In the vertical section figured the mature region is short and little developed, but the beaded mesopores and usual wall structure of the genus are apparent. Tangential sections bring out the numerous large acanthopores very plainly and show in addition rather few mesopores.

Altogether the numerous large acanthopores will distinguish this from other species of the genus which have equally large zoœcia. A very similar, undescribed, or possibly the same species, is present in the Black River rocks of America.

Occurrence.—Rare in the Jewe limestone (D1), Baron Toll's estate, near Jewe, Esthonia, and in the Itfer limestone (C3), north of Wesenberg, Esthonia.

Holotype.—Cat. No. 57384, U.S.N.M.

British Museum, thin sections of the type-specimen, and a specimen from the Itfer limestone, north of Wesenberg.

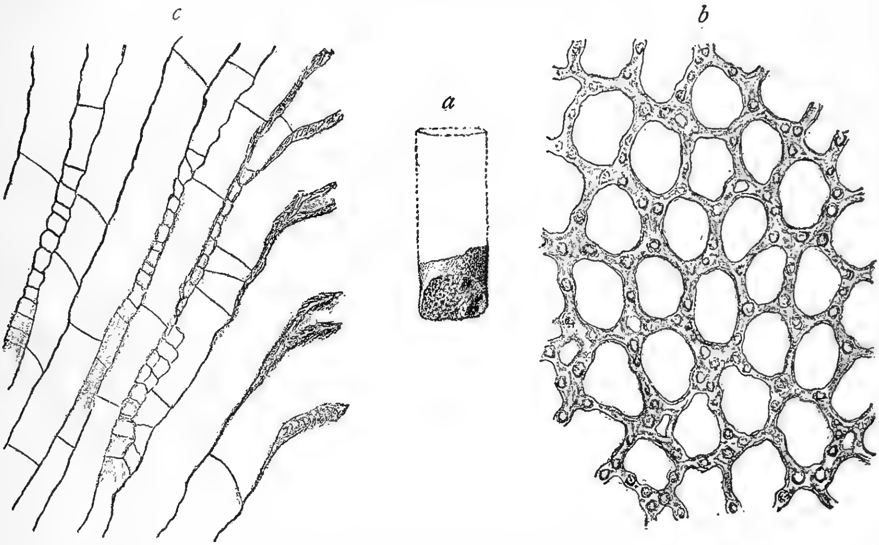


FIG. 169.—BATOSTOMA GRANULOSUM. *a*, THE SECTIONED TYPE-SPECIMEN, NATURAL SIZE; *b*, TANGENTIAL SECTION OF MATURE ZONE, ×20, SHOWING NUMEROUS GRANULE-LIKE ACANTHOPORES; *c*, VERTICAL SECTION, ×20, WITH THE MATURE ZONE ONLY A LITTLE DEVELOPED. JEWE LIMESTONE (D1), BARON TOLL'S ESTATE, ESTHONIA.

Genus HEMIPHRAGMA Ulrich.

Batostoma (part) ULRICH, Geol. Surv. Illinois, vol. 8, 1890, p. 379.

Hemiphragma ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 299; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 275.—SIMPSON, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 592.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, p. 35.

The genus *Hemiphragma* was established by Ulrich to include four American species apparently closely related to *Batostoma*, but differing in having incomplete instead of complete diaphragms in their mature region. A ramose form, *Batostoma irrasum* Ulrich, occurring in the Middle Ordovician strata of Minnesota and Iowa, was selected as the genotype, and its style of growth was regarded as a generic characteristic. Since that time a fifth ramose species, *Monticulipora whitfieldi* James, from the Eden division of the Cincinnatian rocks, has been assigned to the genus, and at least four undescribed branching forms have been discovered. In addition to this four American species with the same structural features of incomplete diaphragms, but with a massive form of growth, are awaiting description. The genus *Hemiphragma* is therefore represented in America by no less than thirteen species. The occurrence of ten species in the Middle Ordovician of Russia and Sweden, seven of which are new, is an interesting addition to our knowledge of the genus, and, as noted before, emphasizes the value of incomplete diaphragms as a generic feature.

Genotype.—Batostoma irrasum Ulrich. Middle Ordovician (Black River) of Minnesota and Iowa.

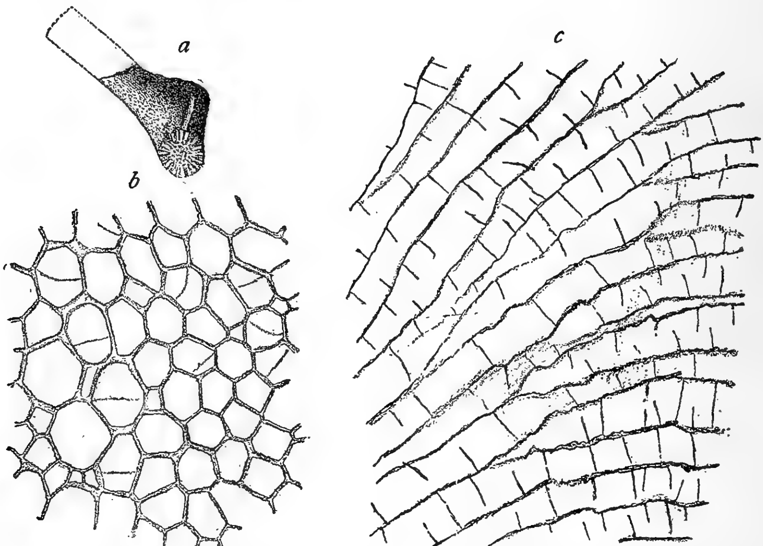


FIG. 170.—HEMIPHRAGMA TENUIMURALE. *a*, THE RUSSIAN EXAMPLE SECTIONED, NATURAL SIZE; *b*, VIEW OF TANGENTIAL SECTION THROUGH THE OLDEST PART OF THE MATURE ZONE; *c*, VERTICAL SECTION, ×20. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

HEMIPHRAGMA TENUIMURALE Ulrich.

Text figs. 170, 171.

Hemiphragma tenuimurale ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 301, pl. 24, figs. 20–23.

The following remarks, although based on the Russian specimens of this species, apply also to the American types.

Zoarium of small, irregularly dividing branches, 6 to 10 mm. in diameter; surface smooth with inconspicuous maculæ of zoœcia larger than usual; zoœcial tubes polygonal, thin-walled; five to six zoœcia in 2 mm.; mesopores few, restricted almost entirely to the maculæ; no acanthopores observed.

The most important internal features are shown in vertical sections where the thin, irregularly fluctuating walls and the rather numerous incomplete diaphragms, with as many as three in a tube diameter in the mature zone, are the most important points to be noted. The zoœcial walls in the mature zone are but slightly thickened, differing in this respect from nearly all other ramose species of *Hemiphragma*. The particular thin section figured shows incomplete diaphragms at distances ranging from one to two tube diameters in a portion of the immature region.

In general zoarial and zoœcial characters these Russian examples are practically identical with the abundant American form from the Clitambonites and Nematopora beds of the Lower Trenton in Minnesota. Indeed, the only difference noted at all was the occurrence of

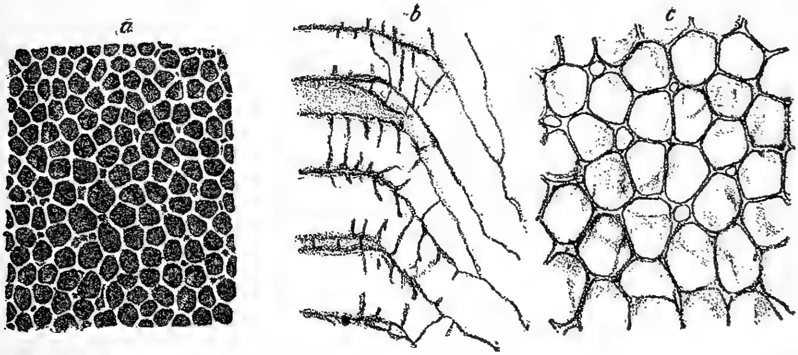


FIG. 171.—HEMIPHRAGMA TENUIMURALE. ULRICH'S VIEWS OF THE MINNESOTA TYPES. *a*, SURFACE OF SPECIMEN SHOWING THE SEMIDIAPHRAGMS IN THE ZOŒCIAL CAVITIES, ×9; *b*, VERTICAL SECTION, ×18; *c*, TANGENTIAL SECTION, ×18, SHOWING THE FULLY MATURED CONDITION. LOWER BEDS OF THE TRENTON LIMESTONE, NEAR CANNON FALLS, MINNESOTA.

a few incomplete diaphragms in the immature zone of the Baltic specimens. Such an occurrence is known in old examples, particularly at the base of a zoarium, and it is evident that the particular sections figured were obtained from such specimens.

The ramose habit of growth, thin-walled, polygonal zoœcia, few mesopores, and especially the numerous incomplete diaphragms of the mature region, are characters which will distinguish *H. tenuimurale* from associated forms. Comparison of figures 170 and 171 will show the practical identity of internal structure in the Russian and American specimens.

Occurrence.—Common in the Clitambonites and Nematopora beds of the Lower Trenton at various localities in Minnesota and Iowa. Rare in the Wassalem bed (D3) at Uxnorm, near Reval, Esthonia.

Plesiotype.—Cat. No. 57416, U.S.N.M.

British Museum, a thin section of the Russian type.

HEMIPHRAGMA IRRASUM (Ulrich).

Text figs. 172, 173.

Batostoma irrasa ULRICH, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 94.

Hemiphragma irrasum ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 299, pl. 24, figs. 5–19; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 275, fig. 460.—SIMPSON, Fourteenth Ann. Rep. State Geologist of New York for the Year 1894, 1897, p. 592, figs. 190–193.

This very abundant American Black River species is represented in the Russian collection by a large zoarium which, as a comparison of figures 172 and 173 will show, has a structure practically identical

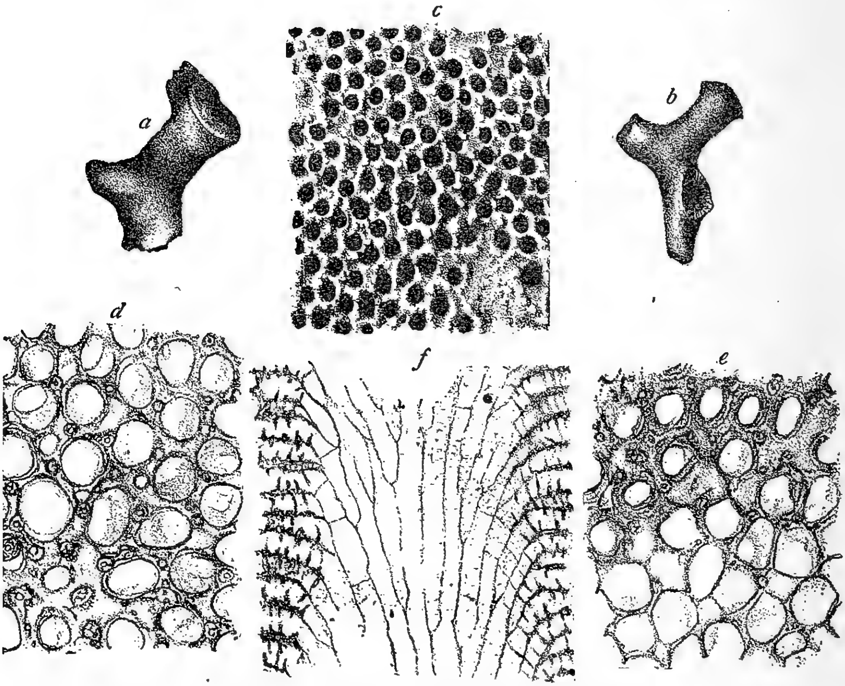


FIG. 172.—HEMIPHRAGMA IRRASUM. *f*, VIEWS OF THE MINNESOTA TYPES, AFTER ULRICH. *a* AND *b*, TWO FRAGMENTS, NATURAL SIZE, SHOWING DIFFERENCE IN SIZE AND BRANCHING; *c*, SURFACE OF AN AVERAGE EXAMPLE, ×9; *d* AND *e*, TANGENTIAL SECTIONS, ×18, EXHIBITING RANGE OF STRUCTURE NOTED IN VARIOUS PARTS OF THE ZOARIUM; *f*, VERTICAL SECTION OF BRANCH, ×9. BLACK RIVER (DECORAH) SHALES, MINNEAPOLIS, MINNESOTA.

with that of Ulrich's types. In fact, this specimen differs only in the greater size of its branches, a difference due entirely to age. Ulrich has given the following description of *Hemiphragma irrasum:*

Zoarium consisting of small, subcylindrical, frequently and rather irregularly dividing branches, commonly 5 or 6 mm. in diameter, but varying from 4 to 8 mm., the latter extreme probably only when an extra layer of tubes has grown over the original branch. Monticules wanting, but under fully matured conditions the surface is abundantly spinulose. Zoœcia with subangular apertures and thin walls when young, and with smaller, subcircular or oval apertures and more or less thick walls in fully matured examples; arrangement of apertures rather regular in rows about small solid spots, in the immediate vicinity of which the zoœcia may be of larger size than elsewhere; seven to nine in 3 mm. Interspaces apparently solid and generally with shallow irregular depressions in most specimens, but in very young stages a variable number of irregular mesopores may be recognized. Acanthopores numerous, two or more to each zoœcium, situated in the angles of junction and interspaces, and increasing in size with age. They are large and a conspicuous external feature of well-preserved mature examples.

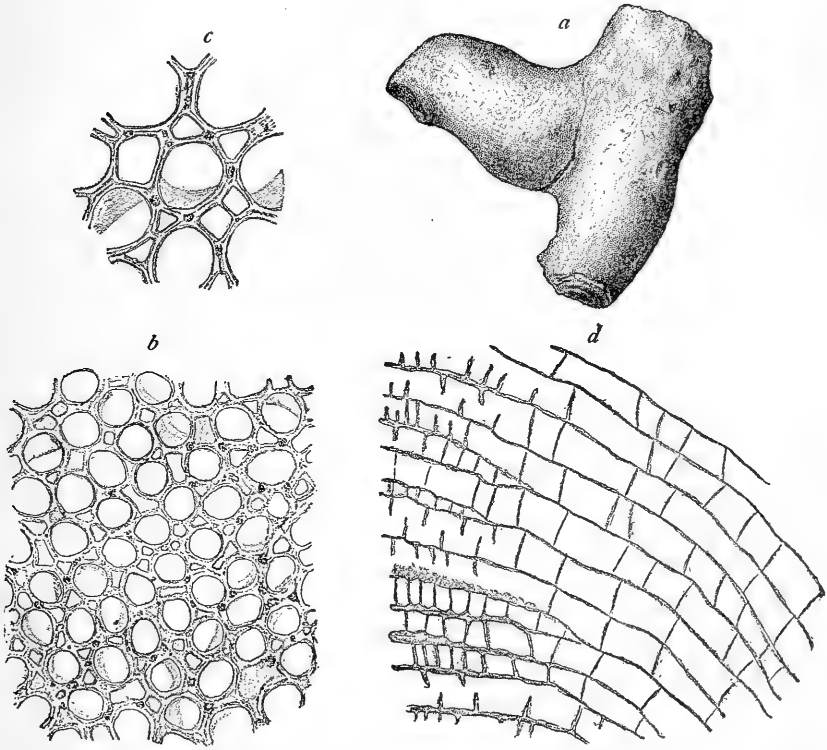


FIG. 173.—HEMIPHRAGMA IRRASUM. *a*, VIEW, NATURAL SIZE, OF THE LARGE, IRREGULARLY BRANCHING BASAL PORTION OF A ZOARIUM; *b*, TANGENTIAL SECTION OF THE SAME SPECIMEN, ×20; *c*, SEVERAL ZOŒCIA, ×35, ILLUSTRATING THE MINUTE WALL STRUCTURE; *d* VERTICAL SECTION, ×20, PASSING THROUGH BOTH REGIONS. ORTHOCERAS LIMESTONE (B3), BALTISCHPORT, ESTHONIA.

Internal characters.—In the axial region of vertical sections the tubes have thin and irregularly fluctuating walls and few or no diaphragms. The latter are complete here and the proximal end of the tube expands to full size with unusual rapidity. In the peripheral region, which is narrow and abruptly distinguished from the axial, the walls are more or less thickened, and the tubes intersected by semidiaphragms, about four in 0.5 mm. I have satisfied myself that all the transverse partitions in this outer part of the zoœcial tubes are really incomplete. That many may appear entire in sections is only because their inner edge happens to be vertical instead of horizontal. Mesopores are difficult to make out in these sections, being short and usually filled, in part at least, with solid tissue. Tangential sections require no description, all the essential characters being shown in the figures.

Occurrence.—In America, common in most of the subdivisions of the Black River (Decorah) shales in Minnesota and Iowa and in the Clitambonites bed of the Lower Trenton of the same states. Apparently rare in Russia, the only known specimen being from the Orthoceras limestone (B3), near Baltischport, Esthonia.

Plesiotype.—Cat. No. 57417, U.S.N.M.

British Museum, thin section of the Russian type.

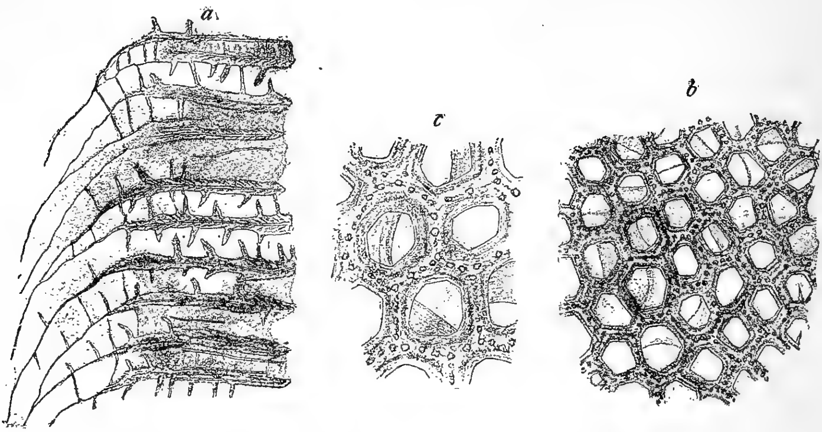


FIG. 174.—HEMIPHRAGMA PANDERI. *a*, VERTICAL SECTION, ×20, SHOWING THE LARGE, THICK SEMI-DIAPHRAGMS; *b*, THE USUAL VIEW SEEN IN TANGENTIAL SECTION, ×20; *c*, PORTION OF SAME, ×40, SHOWING STRUCTURE OF WALLS AND ACANTHOPORES. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

HEMIPHRAGMA PANDERI (Dybowski).

Plate 3, figs. 9–9*c;* text fig. 174.

Orbipora panderi DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 66, pl. 2, figs. 9–9*c*.

Cfr. *Hemiphragma ottawaense* (FOORD), Contr. Micro-Pal. Cambro-Sil., 1883, p. 18, pl. 2, figs. 1–1*f*.

Dybowski has given sufficient illustrations of this fine species (see pl. 3, figs. 9–9*c*) to make its identification easy, and the additional figures here presented are introduced to exhibit features of internal structure not shown by the author of the species. As Dybowski's figures show, the species is an undoubted typical *Hemiphragma*, and to one acquainted with American forms its resemblance to *Hemiphragma ottawaense* (Foord), from the lowest Trenton of Canada, is very striking. This resemblance is most marked in the surface features of the zoarium and in the internal structure seen in vertical sections. Tangential sections show, however, that the Russian species has more angular zoœcia, more numerous and more regularly arranged acanthopores, and fewer mesopores or closed interspaces. Thus, while the two are closely related, and possibly one is only a variety of the other, an examination of the magnified surface will distinguish them. The characters of *Hemiphragma panderi* are as follows:

Zoarium of stout, cylindrical, rather infrequently dividing branches, averaging 10 mm. in diameter. Surface smooth, with conspicuous maculæ composed of thick-walled mesopores and zoœcia larger than usual or of aggregations of mesopores completely filled with a dense tissue. The latter arrangement in the maculæ forms the spots well shown in Dybowski's figure. These maculæ are either level with the surface or are slightly sunk beneath the plane of the ordinary zoœcia. Zoœcial apertures subangular, thick walled, and exhibiting numerous blunt acanthopores on the walls and on the closed mesopores forming the maculæ. Six zoœcia in 2 mm. Mesopores few, seldom more than one to a zoœcium, and usually closed at the surface. Acanthopores of medium size, but so numerous that 20 to 24 sometimes surround a zoœcium.

The internal structure is so distinct that a description, in addition to the figures, is hardly necessary. Vertical sections show characteristic incomplete diaphragms very distinctly. In this species cross partitions of any kind are absent in the immature zone, and semidiaphragms are first inserted in the bend to the mature region. In the latter region proper they are well developed both in size and number. The especial features of tangential sections are the angular, thick-walled zoœcia, the numerous acanthopores, and the scarcity of mesopores.

Occurrence.—Common in the Kuckers beds (C2) and apparently rare in the Jewe limestone (D1), Baron Toll's estate, Esthonia.

Plesiotype.—Cat. No. 57418, U.S.N.M.

British Museum, specimens and thin sections from the Kuckers (C2), Baron Toll's estate.

HEMIPHRAGMA GLABRUM, new species.

Plate 10, fig. 1; text fig. 175.

Zoarium ramose, of smooth, slender, cylindrical, frequently dividing branches, 3 to 4 mm. in diameter. Maculæ composed of thick-walled mesopores, a conspicuous feature of the surface under the hand lens but less noticeable to the unaided eye. Zoœcial apertures subangular, thick-walled, frequently separated by mesopores with walls of equal thickness. About seven zoœcia in 2 mm. Acanthopores very inconspicuous or wanting.

In the axial region of vertical sections the zoœcial tubes have strongly crenulated or fluctuating walls, and are not crossed by partitions save an occasional semidiaphragm developed usually in the bend to the mature zone. The zoœcial walls become thicker and less crenulated in the mature region where the thickness is again increased by the deposition of solid tissue along their sides. Here diaphragms are more numerous and nearly always appear to be complete. In the mesopores diaphragms occur at intervals of one-half their diameter apart. Frequently the mesopores become filled with solid tissue to such an extent that they are indistinguishable in sections and form solid interspaces at the surface.

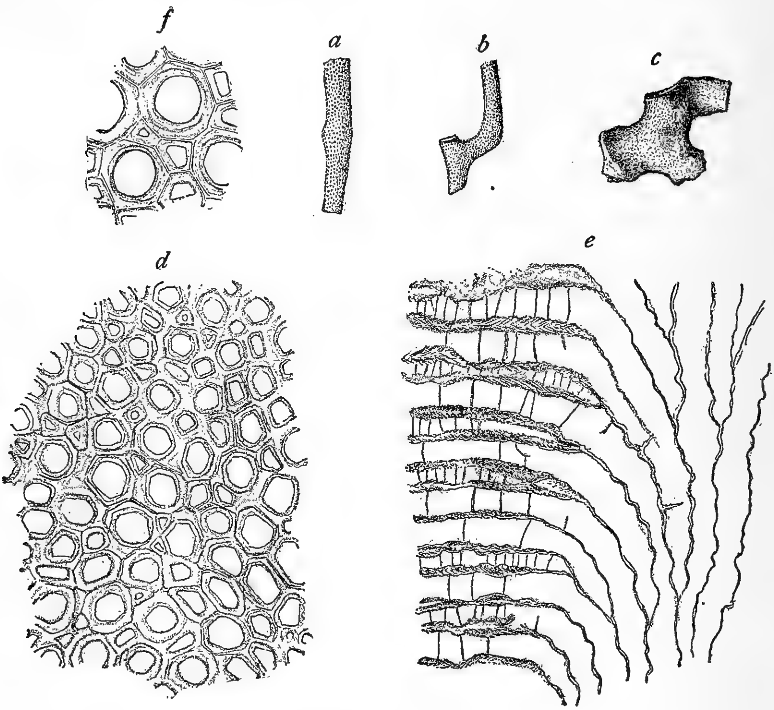


Fig. 175.—Hemiphragma glabrum. *a* and *b*, two fragments, natural size; *c*, basal portion of a zoarium, natural size; *d*, tangential section, ×20, exhibiting thick-walled, angular zoœcia and mesopores; *e*, vertical section, ×20, showing fewer semidiaphragms than usual; *f*, several zoœcia of a tangential section, ×35, illustrating wall structure. Wassalem beds (D3) Uxnorm, Esthonia.

The internal structure of numerous specimens of this well-marked species has been studied and the usual characters are illustrated in figure 175. In figure 175 *e* the semidiaphragms are not as numerous as in other vertical sections while the complete diaphragms are more abundant. It is probable that most of the latter are in reality incomplete and only appear complete because of the way they are cut by the section.

Externally the slender, branching, smooth stems with thick-walled zoœcia and mesopores, and internally the strongly crenulated walls of the immature region, and the occurrence of semidiaphragms are characters which will aid in separating the present species from associated ramose bryozoans. The thick-walled subangular zoœcia and mesopores, practical absence of acanthopores, and the few semidiaphragms will separate it from other species of the genus.

Occurrence.—Not uncommon in the Wassalem beds (D3) at Uxnorm, Esthonia.

Cotypes.—Cat. No. 57420, U.S.N.M.

British Museum, one specimen and one thin section.

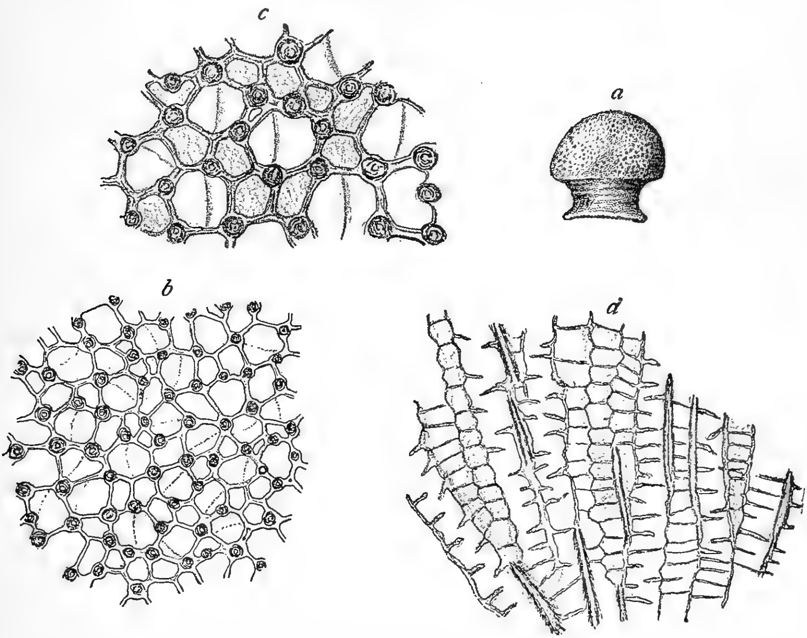


Fig. 176.—Hemiphragma pygmæum. *a*, side view of a typical specimen, ×2; *b*, an ordinary tangential section, ×20, showing the conspicuously large, numerous acanthopores; *c*, portion of the same, ×35, with more detailed structure of the acanthopores and walls; *d*, vertical section, ×20, with characteristic tabulation. Chasmops limestone, south of Bödahamn, island of Oeland.

HEMIPHRAGMA PYGMÆUM, new species.

Text fig. 176.

In the collection made by Dr. Bather from the Chasmops limestone, near Bödahamn, Oeland, are several specimens of a small, massive *Hemiphragma*, which proved upon study to have some very striking internal characters. The zoarium of the specimens observed is of small pedunculate masses about 8 mm. in height and the same measurement in their greatest width. The general shape of the zoarium, as well as the smooth surface of one of the types, is shown in figure 176 *a*. Maculæ are observed with difficulty at the surface, the most striking feature here being rather small, polygonal to rounded zoœcia, numerous angular mesopores, and many large conspicuous acanthopores. The latter form the most noticeable character in thin sections, where, in the tangential especially, they are so large that the place of an ordinary mesopore is often occupied by one. Four acanthopores usually surround a zoœcium, although six or seven sometimes occur. Mesopores are likewise numerous and so large that in tangential sections they are often distinguished from the true zoœcia with difficulty. In vertical sections the difference in tabulation will of course readily distinguish the two. The walls of both zoœcia and mesopores are quite thick for such a form of growth, in fact, with the exception of size of zoarium, *H. pygmæum* is an exceptionally well developed species. The tabulation of zoœcia and mesopores is shown in figure 176 *d*, while an idea of the relative size, arrangement, and number of mesopores as well as the structure of walls and acanthopores may be had from figures 176 *b*. and *c*.

None of the other species of *Hemiphragma* has such well developed acanthopores, and this character alone will serve to distinguish the species.

Occurrence.—Apparently rare in the Chasmops limestone near Bödahamn, island of Oeland, Sweden.

The figured type and thin sections are in the collection of the British Museum.

HEMIPHRAGMA MULTIPORATUM, new species.

Text fig. 177.

Although but a few examples of this species have been seen, its characters are so distinct from all other species of the genus that no difficulty should arise in distinguishing it. The zoarium in the type-specimen is a flattened, hemispheric mass, which, before thin sections were cut from it, was 20 mm. in diameter and about 7 mm. high. As usual in zoaria of this shape, the base is slightly concave with a concentrically wrinkled epitheca. The celluliferous surface is smooth but shows distinct maculæ composed entirely of mesopores, at intervals of 4 mm., measuring from center to center. The zoœcial apertures are thin-walled, polygonal, and are completely isolated by one to three rows of angular mesopores. About four zoœcia occur in 2 mm., although the diameter of a single zoœcium averages 0.30 mm. Acanthopores are absent entirely, but mesopores are exceedingly abundant. In the maculæ seven rows of mesopores may be counted, but in the intermacular spaces one or two rows usually separate neighboring zoœcia.

Excepting the numerous mesopores, the internal structure is quite similar to other massive forms of the genus. The mesopores are closely tabulated with straight partitions, while the zoœcia have the usual semidiaphragm projecting from either wall and averaging two in a tube diameter in the crowded portions. The very numerous mesopores, however, form the most striking feature of both vertical and tangential sections. Another characteristic of the mesopores is their comparatively straight walls which are in contrast with those of other species of the genus.

The hemispheric growth, great abundance of mesopores, large, distinct maculæ, absence of acanthopores, and the distinct tabulation of both zoœcia and mesopores, form a combination of characters which amply distinguish the present form.

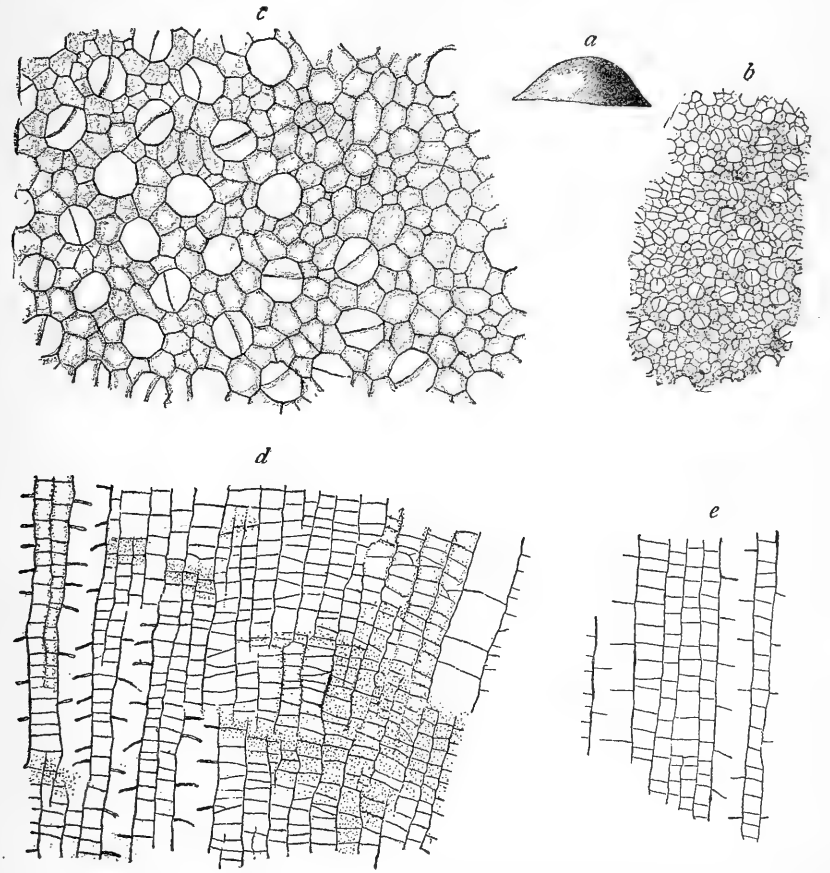


FIG. 177.—HEMIPHRAGMA MULTIPORATUM. *a*, SIDE VIEW OF THE TYPE-SPECIMEN BEFORE SECTIONING; *b*, TANGENTIAL SECTION, ×8, SHOWING A MACULA IN THE LOWER PART OF THE FIGURE; *c*, PORTION OF THE SAME, ×20, WITH THE MESOPORES SHADED TO DISTINGUISH THEM FROM THE ZOŒCIA; *d*, VERTICAL SECTION, ×20, INCLUDING A MACULA; *e*, A PART OF THE SAME SECTION, ×20, SHOWING THE DIFFERENCE IN TABULATION BETWEEN ZOŒCIA AND MESOPORES. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

Occurrence.—Rare in the Kuckers shale (C2), Baron Toll's estate, Esthonia, and in the Echinospherites limestone (C1), at Duboviki, on the Wolchow River, government of St. Petersburg.

Holotype.—Cat. No. 57421, U.S.N.M.

British Museum, thin section of specimen from the Kuckers shale, Baron Toll's estate.

HEMIPHRAGMA SUBSPHERICUM, new species.

Plate 10, fig. 2; text figs. 178, 179.

Zoarium massive, quite variable in shape, but usually of irregular subspherical masses, several centimeters in diameter. Young examples are often uniformly rounded, but in older examples, where the growth is less regular, the zoarium is somewhat irregular, and

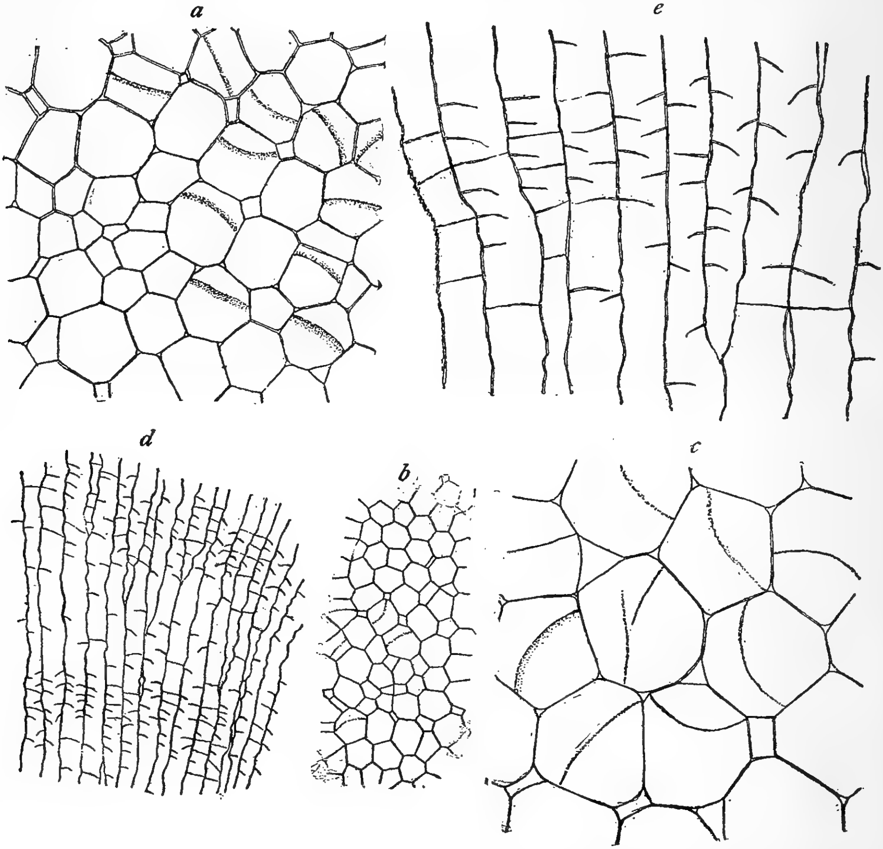


FIG. 178.—HEMIPHRAGMA SUBSPHERICUM. *a* AND *b*, TWO PORTIONS OF A TANGENTIAL SECTION, ×20 AND ×8, IN EACH CASE CUTTING A MACULA; *c*, ZOŒCIA OF THE SAME SECTION, ×40, ILLUSTRATING THE EXTREMELY THIN SIMPLE WALLS; *d*, VERTICAL SECTION, ×8, PASSING THROUGH SEVERAL SUCCESSIVE IMMATURE AND MATURE REGIONS; *e*, PART OF THE SAME SECTION, ×20, SHOWING WALLS AND SEMIDIAPHRAGMS MORE CLEARLY. WESENBERG LIMESTONE (E), WESENBERG, ESTHONIA.

may attain a diameter of 5 or 6 cm. The zoarial surface is smooth, but clusters of large zoœcia forming the maculæ occur at intervals of 5 mm. and are visible to the unaided eye. Zoœcial apertures direct, thin-walled, angular, and in contact, five in 2 mm. Mesopores few, often entirely wanting; acanthopores absent.

In vertical sections of a large specimen the zoarium is seen to be made of a number of zoœcial layers, each of which shows an immature region where the walls are thin, and semidiaphragms are far apart, and a mature zone conspicuous for its crowded partitions and slightly thicker walls. Two such layers are shown in the accompanying illustration (fig. 178 *d*), while a more magnified view of a mature zone and part of an immature zone is shown in figure 178 *c*. The occurrence of incomplete diaphragms throughout the zoœcial tubes and the practical absence of small, beaded tubes with straight partitions may be seen in such sections. The arrangement and abundance of the semidiaphragms is about the same in this species as in the other massive forms, *H. rotundatum* and *H. pygmæum*, but an especial

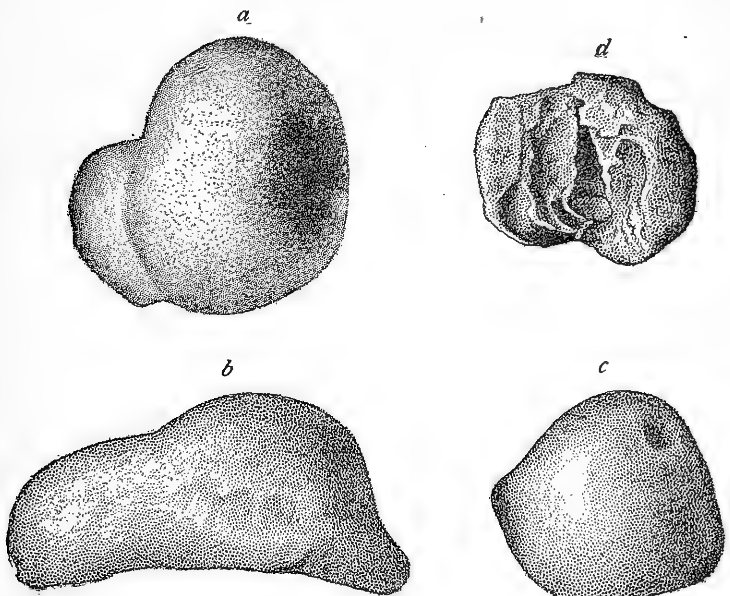


FIG. 179.—HEMIPHRAGMA SUBSPHERICUM. FOUR VIEWS OF ZOARIA, NATURAL SIZE. *a*, SIDE VIEW OF A SPECIMEN COMPOSED OF TWO ROUNDED ZOARIA GROWING TOGETHER; *b*, SIDE VIEW OF A LONGER, MORE FLATTENED SPECIMEN; *c*, A ROUNDED, SOMEWHAT IRREGULAR EXAMPLE; *d*, BASAL VIEW OF SPECIMEN, SHOWING CICATRIX OF GASTROPOD UPON WHICH GROWTH COMMENCED. WESENBERG LIMESTONE (E), WESENBERG, ESTHONIA.

point of difference is the crenulation of the tubes in *H. subsphericum*. This latter feature is likewise shown in vertical fractures of the zoarium.

Tangential sections bring out the extreme simplicity and thinness of the zoœcial walls and the absence of acanthopores. Mesopore-like spaces are present in such sections, but these are usually young zoœcia. At the surface of the zoarium such spaces are practically wanting, the zoœcia being regularly polygonal and in contact on all sides. The semidiaphragms, which in vertical sections are noted to frequently curve slightly downward, are seen in tangential sections where they appear as a more or less curved line crossing the zoœcium.

The massive zoarium, extremely thin-walled polygonal zoœcia, absence of acanthopores, few mesopores, crenulated zoœcial tube and numerous semidiaphragms of *H. subsphericum* should suffice to distinguish it from associated as well as other massive bryozoans. Externally *Monotrypa jewensis* is quite similar, but the vertical fracture of *H. subsphericum* showing semidiaphragms will distinguish them. A globose *Hemiphragma* in the lowest Trenton strata of the United States is closely related to the form under discussion, but as it remains undescribed, comparisons are unnecessary.

Occurrence.—Abundant in the Wesenberg limestone (E) at Wesenberg, Esthonia, and vicinity.

Cotypes.—Cat. No. 57423, U.S.N.M.

Specimens and thin sections in the collection of the British Museum.

HEMIPHRAGMA ROTUNDATUM, new species.

Text fig. 180.

The type-specimen of this species is a rounded, subpyriform mass, about 20 mm. long and 14 mm. in diameter, with a smooth, celluliferous surface and inconspicuous maculæ. The zoœcial apertures are direct, angular, thin-walled, and exhibit sharp acanthopores of medium size at many of their junction angles. Five to six occur in 2 mm. The mesopores are angular, usually small and few, seldom

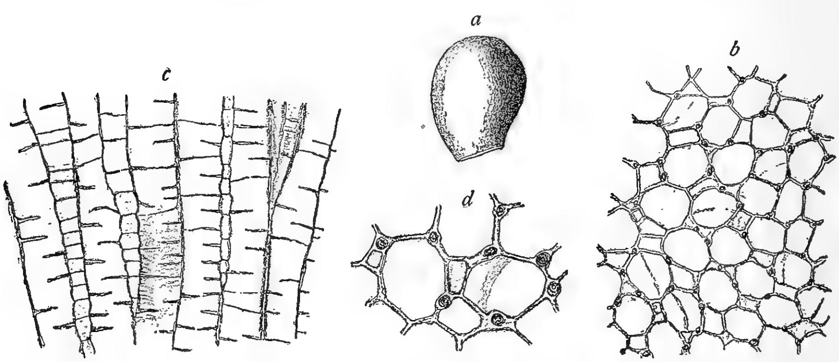


FIG. 180.—HEMIPHRAGMA ROTUNDATUM. *a*, SIDE VIEW OF THE TYPE-SPECIMEN, NATURAL SIZE; *b*, TANGENTIAL SECTION OF THE TYPE, ×20; *c*, A VERTICAL SECTION, ×20, ILLUSTRATING THE TABULATION OF BOTH ZOŒCIA AND MESOPORES; *d*, A FEW ZOŒCIA, ×35. ORTHOCERAS LIMESTONE (B3), ISLAND OF ROGO, ESTHONIA.

numerous enough to isolate the zoœcia. Under a hand lens maculæ composed of larger zoœcia and more numerous mesopores may be observed at regular intervals. The zoœcial apertures, when likewise magnified, often exhibit the semidiaphragms at or near the surface as a partition extending half way across the opening.

Vertical sections exhibit two features in particular. First the zoœcial tubes are occupied by semidiaphragms, as noted above, these appearing in thin sections as incomplete partitions projecting from either side of the tube half way across the cavity. Occasionally a complete diaphragm seems to be present, but this is merely an incomplete one cut parallel to its edge instead of across it. These partitions are placed at a rather uniform distance of half a tube diameter apart in the more crowded or mature zone. The second noticeable feature of vertical sections is the occurrence of well-marked mesopores crossed by normal, entire partitions at intervals of their own diameter. These mesopores are regularly beaded tubes as long as their diameter is less than that of the ordinary zoœcia, but as soon as the size of the latter is reached, their walls become straight and semidiaphragms are introduced, showing that the mesopores have been replaced by zoœcia.

In vertical sections the present species is quite similar to *Hemiphragma pygmæum* from the Chasmops limestone of the island of Oeland. Tangential sections show that the latter has considerably smaller zoœcia, thicker walls, and much stronger acanthopores. Again, the zoarium of *H. pygmæum*, although subglobular in shape, is of small, pedunculate masses. Another massive species in the Baltic Ordovician is the *H. subsphericum* from the Wesenberg formation, but its large, thin-walled, angular zoœcia, with few mesopores are quite distinct from those of both the above forms, although again the vertical section is somewhat similar.

Occurrence.—Rare in the Orthoceras limestone (B3), island of Rogo, near Baltischport, Esthonia. The species also occurrs in the Echinospherites limestone (C1) at Reval. Specimens are also known from the Kuckers shale (C2) at Reval, and from Baron Toll's estate, Esthonia.

Holotype.—Cat. No. 57424, U.S.N.M.

Thin sections of a specimen from the Orthoceras limestone, island of Rogo, are in the collections of the British Museum.

HEMIPHRAGMA MACULATUM, new species.

Text fig. 181.

Zoarium of small, slender, cylindrical branches 2.5 mm. in diameter on an average. Surface without elevations but conspicuously marked by large, distinct maculæ 2.5 mm. apart, measuring from center to center. These maculæ, which are composed entirely of small mesopores, are frequently several millimeters in diameter, and as they are slightly depressed and are arranged alternately the branches are irregularly constricted along a spirally ascending line. Zoœcia polygonal, six in 2 mm., with rather thick walls. Mesopores angular, numerous but exceptionally small. Acanthopores absent.

Figure 181 *b* and *c* shows the usual view in tangential sections. The unusually small mesopores, the thickness of the walls in both kinds of cells, and the absence of acanthopores, are most characteristic. In vertical sections the walls in the immature zone are seen to be thin and crenulated. An occasional incomplete diaphragm occurs here as well as in the mature zone, although they are scarce in the latter region. The mesopores when not obscured by the dense tissue of the interzoœcial spaces are distinctly beaded and have diaphragms about their own diameter apart.

Externally the narrow, cylindrical branches, polygonal thick-

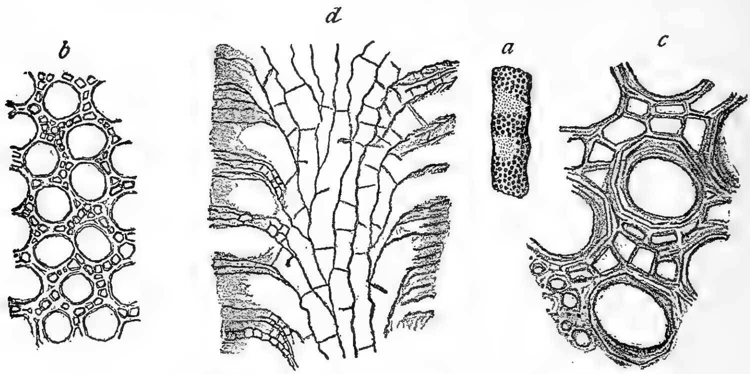


FIG. 181.—HEMIPHRAGMA MACULATUM. *a*, A FRAGMENT, ×2, EXHIBITING PORTIONS OF TWO MACULÆ; *b*, TANGENTIAL SECTION, ×20, THROUGH THE INTERMACULAR ZOŒCIA; *c*, SEVERAL ZOŒCIA OF THE SAME SECTION, ×40; *d*, VERTICAL SECTION, ×20, THROUGH THE ENTIRE WIDTH OF A BRANCH. KUCKERS SHALE (C2), REVAL, ESTHONIA.

walled zoœcia with numerous very minute angular mesopores, will readily serve for the identification of *H. maculatum*. The incomplete diaphragm, crenulated walls, and small mesopores are especially characteristic of thin sections.

Occurrence.—Not uncommon in the Kuckers shale (C2) at Reval, and Baron Toll's estate, Esthonia.

Holotype.—Cat. No. 57428, U.S.N.M.

British Museum, thin section of the type-specimen.

HEMIPHRAGMA BATHERI, new species.

Text fig. 182.

The zoarium of this well-marked species is of small, frequently branching, cylindrical stems averaging 2 mm. in diameter. The surface is smooth and presents no conspicuous maculæ, as in the preceding species, although clusters of larger zoœcia and more numerous mesopores are present as usual. Zoœcia polygonal, thick-walled, with solid interzoœcial spaces; five to six zoœcia in 2 mm. Acanthopores small, sometimes numerous at the surface where they occur along the crest of the zoœcial wall. Mesopores few, averaging about one to a zoœcium, usually filled by the dense tissue forming the solid interzoœcial spaces. Through this tissue the outlines of the mesopores are visible in thin sections.

The internal structure is simple, although very characteristic for the genus. In tangential sections the angular zoœcia and mesopores with their thick walls bearing rather small acanthopores are to be noted. Vertical sections show thick, well developed, incomplete diaphragms in the mature region, with thin, flexuous walls and no diaphragms in the immature zone.

Excepting *Hemiphragma maculatum*, this species differs from all others of the genus in its very slender, ramose zoarium. The internal structure is somewhat similar to that in *H. panderi*, but the latter has a stouter zoarium with smaller zoœcia, fewer mesopores, and more numerous acanthopores. The specific name is in honor of Dr. F. A. Bather, who collected the type-specimens.

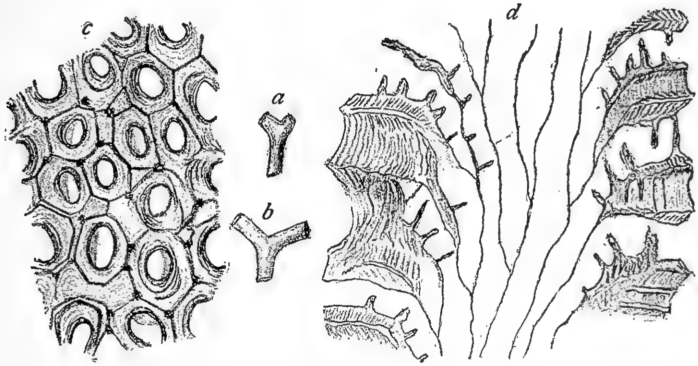


FIG. 182.—HEMIPHRAGMA BATHERI. *a* AND *b*, TWO FRAGMENTS, NATURAL SIZE; *c*, A TANGENTIAL SECTION, ×20, SHOWING THE CHARACTERISTIC, THICK-WALLED, POLYGONAL ZOŒCIA; *d*, VERTICAL SECTION OF A BRANCH, ×20, EXHIBITING CHARACTERISTIC TABULATION. CHASMOPS LIMESTONE, SOUTH OF BÖDAHAMN, ISLAND OF OELAND.

Occurrence.—Not uncommon in the Chasmops limestone, south of Bödahamn, island of Oeland.

The figured types and sections are in the collections of the British Museum.

Genus ANAPHRAGMA Ulrich and Bassler.

Anaphragma ULRICH and BASSLER, Smiths. Misc. Coll., vol. 47, 1904, p. 49.

This genus was established for a species agreeing in all respects with *Batostoma* Ulrich, save that the zoœcial tubes and mesopores were practically free of diaphragms, and that the walls in the immature region were strongly crinkled. Up to this time but a single species was known, *Anaphragma mirabile* from the Fernvale limestone of the Richmond group in Illinois and Wisconsin.

Genotype.—*Anaphragma mirabile* Ulrich and Bassler. Early Silurian (Richmond) of Illinois, Wisconsin, and Esthonia.

ANAPHRAGMA MIRABILE Ulrich and Bassler.

Text fig. 183.

Anaphragma mirabile Ulrich and Bassler, Smiths. Misc. Coll., vol. 47, 1904, p. 49, pl. 13, figs. 9–11.

The discovery of this unusual type in the Russian deposits is a most interesting example of the wide geographic range of the Bryozoa, and of their consequent value in detailed correlation. After a most critical

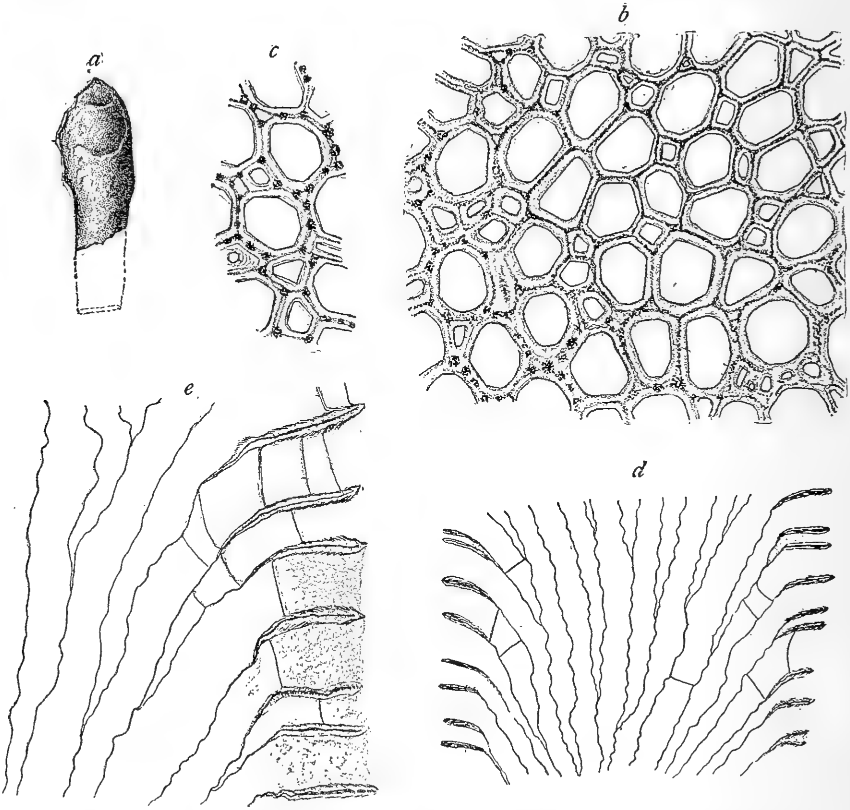


Fig. 183.—Anaphragma mirabile. *a*, view of an irregularly growing branch, natural size; *b*, tangential section, ×20; *c*, several zoœcia of another part of this section, ×20, showing numerous acanthopores; *d*, a vertical section, ×9, through the entire width of the branch; *e*, portion of the same section, ×20, showing the structure in more detail. Lyckholm limestone (F1), Hohenholm, island of Dago.

comparison of numerous thin sections of both American and Russian specimens of the species, I am unable to point out any differences between them. The figured vertical sections of the type showed no diaphragms in the zoœcial tubes, but a restudy of the species in connection with the present work brought out the fact that an occasional diaphragm may occur, its place usually being at the bend from the immature to the mature region. The most marked example of such an occurrence is shown in the vertical sections, figures 183 *d* and *e*.

Other sections, even from the same specimen, show no diaphragms at all. This has required a slight emendation in the original diagnosis of the genus.

The zoarium of *Anaphragma mirabile* is of smooth, strong, subcylindrical branches, 8 to 10 or more millimeters in diameter, dividing rather frequently. Maculæ not a conspicuous feature; distinguished only by the size of their zoœcia, which are somewhat larger than the average. Zoœcial apertures angular to subangular, with rather thick walls, five to six zoœcia in 2 mm.; mesopores small and comparatively few in number; acanthopores small and seldom well shown at the surface, although when observed they show the usual apical perforation.

In vertical sections the striking feature is the almost complete absence of diaphragms in both the zoœcia and mesopores. In the axial region the walls are thin and wavy, the crenulations being long and not so frequent as in species of *Calloporina*, a somewhat similar genus of the Halloporidæ. With the inception of the mature region, the walls become greatly thickened and considerable laminated tissue is developed upon the inner sides. Tangential sections show the zoœcial walls to be of considerable thickness and to have the characteristic structure of *Batostoma*. The acanthopores are seen to be small, few in number, and situated at the junction angles.

The rather large angular zoœcia, thick walls, and few mesopores, and, more satisfactorily, the crenulated tubes with their practical absence of diaphragms, distinguish this species from otherwise similar associated forms.

In the thin sections shown in figure 183 *b* and *c*, the acanthopores and the dark line separating adjoining zoœcia are especially well developed.

Occurrence.—The species is a characteristic fossil of the Fernvale limestone division of the Richmond group in the Mississippi Valley, the type-locality being Wilmington, Illinois. The Russian examples of the species were found in the upper part of the Lyckholm limestone (F1) at Kertel, and at Hohenholm on the island of Dago.

Plesiotype.—Cat. No. 57385, U.S.N.M.

Represented in the collections of the British Museum by American specimens.

ANAPHRAGMA MIRABILE COGNATA, new variety.

Text fig. 184.

Zoarium ramose with branches subcylindrical, frequently dividing, and 6 to 8 or more millimeters in diameter; maculæ not a conspicuous feature of the surface, which is smooth. Zoœcial apertures polygonal with rather thick walls. Five zoœcia in 2 mm. Mesopores few and small, acanthopores small and sometimes numerous but not conspicuous at the surface.

The most marked character seen in vertical sections or in longitudinal fractures is the great crinkling of the zoœcial walls in the immature region and the almost entire absence of diaphragms in this and the mature regions. In the latter the zoœcial walls thicken greatly, the crenulation is less marked or disappears entirely, and acanthopores are developed. Mesopores, which occur only in the mature region, are distinguished with difficulty on account of their similarity to the ordinary zoœcia. The thick walls, small acantho-

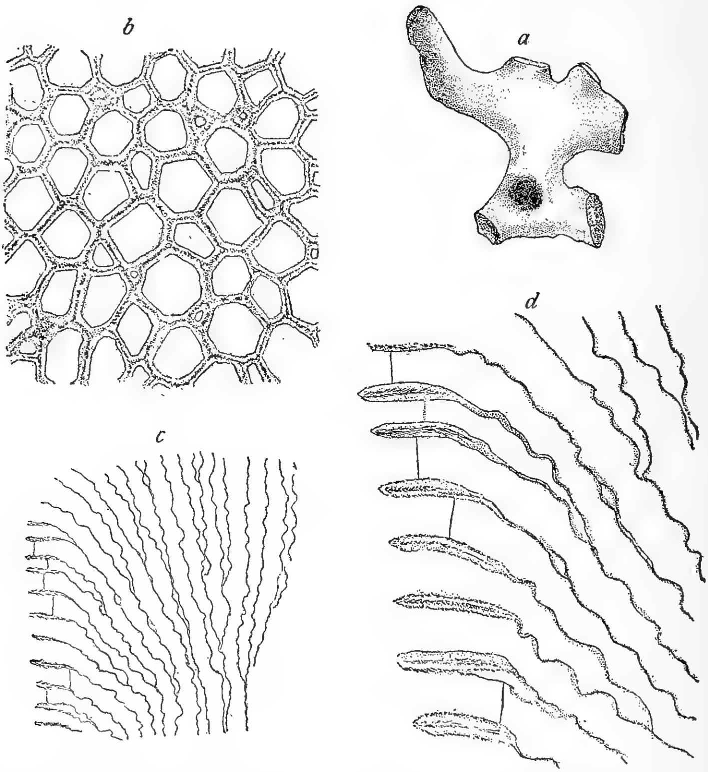


FIG. 184.—ANAPHRAGMA MIRABILE COGNATA. *a*, VIEW OF FRAGMENT, NATURAL SIZE; *b*, TANGENTIAL SECTION, ×20, WITH WALL STRUCTURE PLAINLY MARKED; *c* AND *d*, VERTICAL SECTION, ×8, AND A PORTION, ×20. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

pores, and the black line separating adjoining zoœcia, are well shown in tangential sections.

The present species differs so much from associated ramose bryozoans in the practical absence of diaphragms and the strong, crenulated walls, that comparisons are unnecessary. Critically compared with *Anaphragma mirabile,* however, it is found to agree in growth, thickness of zoœcial walls, and in most of the internal characters, differing only in that the walls are more crenulated and that the zoœcia are a trifle smaller. These differences are possibly of specific importance in so simple a form, but the Middle Ordovician form is undoubtedly the progenitor of the early Silurian genotype, and the purposes of classification may, perhaps, be best furthered by considering it as only a variety.

Occurrence.—Found in the Wassalem beds (D3) at Uxnorm and Gut Sack, and in the Wesenberg limestone (E) at Wesenberg, Esthonia.

Holotype.—Cat. No. 57387, U.S.N.M.

Fragment and thin sections of the type-specimen in the collections of the British Museum.

Genus DITTOPORA Dybowski.

Dittopora Dybowski, Die Chaetetiden der Ostbalt. Silur-Formation, 1877, p. 84.—Nicholson, Genus Monticulipora, 1881, p. 234.—Roemer, Lethæa geognostica, pt. 1, Leth. Pal., 1883, p. 479.

Trematopora Dybowski, Die Chaetetiden der Ostbalt. Silur-Formation, 1877, p. 69.

This generic name was proposed for certain monticuliporoids in which, according to Dybowski, the corallites were of two kinds, one being cylindrical and separated by a reticulate coenenchyma, and the other consisting of prismatic tubes in close contact. These two kinds of corallites, according to the same author, may be arranged in alternating rows or may be confined to particular parts of the colony. Wandröhrchen (acanthopores) and tabulæ are present. In the genotype, *D. clavæformis* Dybowski, in which the colony is club-shaped, the prismatic corallites are restricted to the basal portion, while the cylindrical kind of corallites occur in the upper portion of the stem. In a second species, *D. annulata* (Eichwald), the two kinds of corallites are arranged in alternating, transversely elongated zones.

Both of these species are well represented in the collections before me, and from a study of them, I must conclude that Dybowski's generic characters are valueless—indeed the same features are found in many diverse genera. The cylindrical corallites separated by a reticulate coenenchyma are simply the ordinary zoœcia with intervening, closely tabulated mesopores. The prismatic tubes in close contact are thick-walled mesopores which, in *D. clavæformis* are extremely abundant at the base of the zoarium, and in *D. annulata* form the ring-like maculæ. Thin sections of the two species mentioned, and of the very abundant *Trematopora colliculata* Eichwald, indicate that these European forms constitute a natural group closely related on one hand to *Trematopora* and on the other to *Hemiphragma*. It is, therefore, deemed advisable to retain the name *Dittopora* for this group of species, with the following amended definition.

Zoarium ramose, growing from an expanded base into more or less branching stems. Zoœcial structure as in the Trematoporidæ, quite similar to *Hemiphragma* but differing in having the incomplete diaphragms practically limited to the bend from the immature to the mature zone. Elsewhere the diaphragms are complete. Mesopores numerous, moniliform, with tabulæ at their constricted portions. Acanthopores developed in two fairly well marked sets, the first consisting of a pair of large acanthopores situated one on each side of a zoœcium, and the second of numerous smaller ones distributed indiscriminately along the walls of both zoœcia and mesopores.

The diagnostic generic distinctions of *Dittopora,* in addition to the general family characters, are believed to be, first the restriction of incomplete diaphragms to the earliest part of the mature zone, and, second, the occurrence of two distinct sets of acanthopores. The internal structure of the genotype, as shown in figure 185, is identical with that of *D. annulata,* and is equally well developed in Eichwald's *Trematopora colliculata,* which Dybowski considered a typical species of *Trematopora.*

Genotype.—Dittopora clavæformis Dybowski. Middle Ordovician of Esthonia.

DITTOPORA CLAVÆFORMIS Dybowski.

Plate 3, figs. 7–7 *b*; plate 11, figs. 18–24; text fig. 185.

Dittopora clavæformis Dybowski, Die Chaetetiden Ostbaltischen Silur-Formation, 1877, p. 85, pl. 2, figs. 7–7*b*.—Nicholson, The Genus Monticulipora, 1881, p. 235, fig. 50.

The shape of the zoarium in this interesting species is so distinct from most other Ordovician bryozoans that the species is easily identified. Dybowski has given a good description of both the external and internal features, the latter, however, based upon his interpretation of the generic characters. As shown in Dybowski's figures on plate 3, the zoarium is of small, club-shaped stems, often with a slightly expanded base. Growth commences upon a foreign object, such as the brachiopod shell (pl. 11, fig. 24), and continues until a colony 10 to 20 mm. high results. With age the basal part of the zoarium becomes covered with elongate, thick-walled mesopores similar to those found in the basal portions of many other bryozoans. Surface of zoarium usually smooth, but occasionally the maculæ are so strongly developed that they encircle the branch, and being slightly depressed, give the annulated effect seen in figure 22 of plate 11. Zoarial growth usually stops with the formation of a single club-shaped mass, but occasionally a second similarly shaped zoarium arises from the upper portion of the first. Rarely the initial zoarium bifurcates (see pl. 11, fig. 23).

Zoœcia small, elongate-oval in young specimens but angular, thick-walled in the more mature condition. Mesopores numerous, closed at the surface. Acanthopores in the usual two sets, but in old examples there is little difference in their respective size and they are so numerous that a granulose appearance is imparted to the zoarial surface. An ordinary zoœcium is 0.33 mm. in diameter with five in 2 mm.

The important features of thin sections have been indicated in the remarks on the genus. A tangential section of a young example is shown in figure 185 *a*, mainly to exhibit the two sets of acanthopores, the larger set in this case being located about the zoœcia in pairs, and the smaller in the walls of the mesopores forming a macula. Tangential sections of an older example show numerous acanthopores of more equal size.

Vertical sections show the usual close tabulation in the mesopores,

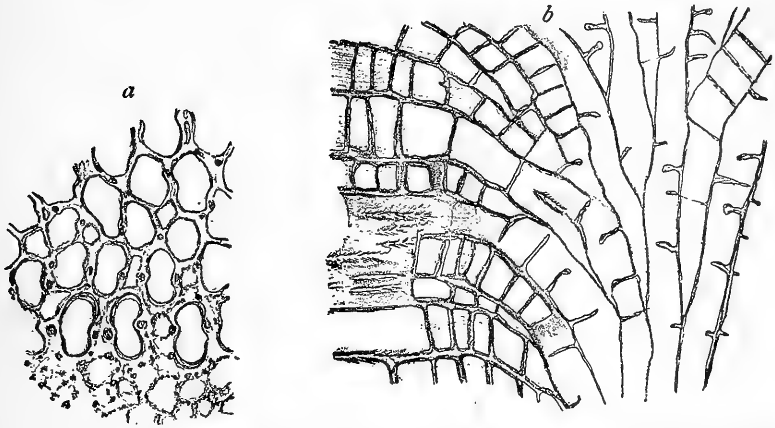


FIG. 185.—DITTOPORA CLAVÆFORMIS. *a*, TANGENTIAL SECTION, ×20, OF A YOUNG EXAMPLE SHOWING TWO SETS OF ACANTHOPORES AND SHAPE OF ZOŒCIA DISTINCTLY; *b*, VERTICAL SECTION OF THE SAME SPECIMEN, ×20, ILLUSTRATING DISTRIBUTION OF SEMIDIAPHRAGMS. GLAUCONITE LIMESTONE (B2), REVAL, ESTHONIA.

but the zoœcial tubes have well-marked semidiaphragms in both the immature and mature regions. The outer region of the mesopores is usually filled with a dense tissue through which the acanthopores penetrate.

The only bryozoan with a similar method of growth is the *Stigmatella claviformis* (Ulrich) from the Wassalem beds, but its zoœcial structure is so different that comparisons are unnecessary. The associated *Dittopora annulata* has a similar internal structure, but its growth is strictly ramose.

Occurrence.—Common in the Glauconite limestone (B2) at Pulkowa, Wassilkowa, Tswos, and other localities in the government of St. Petersburg; in the same formation at Reval and at Strietburg, in Esthonia.

Plesiotypes.—Cat. Nos. 57390 to 57396, U.S.N.M.

British Museum, specimens from Reval, Esthonia.

DITTOPORA ANNULATA (Eichwald).

Plate 3, fig. 5; plate 11, figs. 16, 17; text figs. 186, 187.

Chætetes annulatus EICHWALD, Lethæa Rossica, vol. 1, sect. 1, 1860, p. 480, pl. 28, figs. 2*a*–2*c*, 3*a*–3*d*.

Dittopora annulata DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 86, pl. 2, fig. 5.—NICHOLSON, The Genus Monticulipora, 1881, p. 234, fig. 49.

Zoarium of small, ramose, frequently dividing branches 3 to 6 mm. in diameter. Surface finely spinulose on account of the numerous small acanthopores; maculæ of thick-walled mesopores usually closed at the surface, and encircling the branch, giving the characteristic annulated appearance. In the early portion of the mature region the usual pair of larger acanthopores, one on each side of a

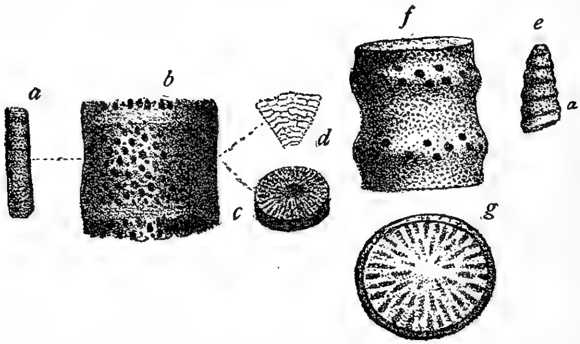


FIG. 186.—DITTOPORA ANNULATA. COPY OF EICHWALD'S ILLUSTRATIONS OF CHÆTETES ANNULATUS. *a*, FRAGMENT OF A NORMAL MATURE ZOARIUM, NATURAL SIZE; *b*, SMALL PORTION OF THE SAME MAGNIFIED TO SHOW THE ARRANGEMENT OF THE RING-LIKE MACULÆ AND THE DISTRIBUTION OF ZOŒCIA AND MESOPORES; *c*, END VIEW OF A FRAGMENT ENLARGED; *d*, VIEW OF CELLS IN SECTION; *e* AND *f*, FRAGMENT OF AN OLD EXAMPLE AND A PORTION ENLARGED. HERE THE ZOŒCIA ARE ALMOST ENTIRELY OBLITERATED BY THE EXTENSIVE DEVELOPMENT OF MESOPORE-LIKE CELLS; *g*, END VIEW OF BRANCH, MAGNIFIED. "CALCAIRE À ORTHOCERATITES," PULKOWA AND POPOWKA, GOVERNMENT OF ST. PETERSBURG.

zoœcium, is present, but numerous smaller acanthopores develop in the later portions of the same zone and become so nearly equal in size that the distinction between the two sets is lost. The tangential sections shown in figure 187 *a* and *b* are through this older portion of the mature region. Dybowski's figure (pl. 3, fig. 5) represents the larger set more distinctly, and also shows the hour-glass shape imparted to the zoœcia by the indentations of the walls whenever a pair is well developed. Vertical sections show essentially the same structure as in *D. clavæformis*. Semidiaphragms are fewer in *D. annulata* and occur mainly in the bend to the mature zone.

While it is recognized that *D. clavæformis* and *D. annulata* are closely related, the ramose habit of growth of the latter is the most obvious difference. The ring-like maculæ are not of specific importance, because they are equally well developed in all of the other species of *Dittopora*.

Occurrence.—A common fossil in the Glauconite limestone (B2) at Popowka, Tswos, Wassilkowa, Oberchow, Grenaja Sheldacha, and other localities in the government of St. Petersburg. Less abundant in the Orthoceras limestone (B3) on the island of Rogo, near Bal-

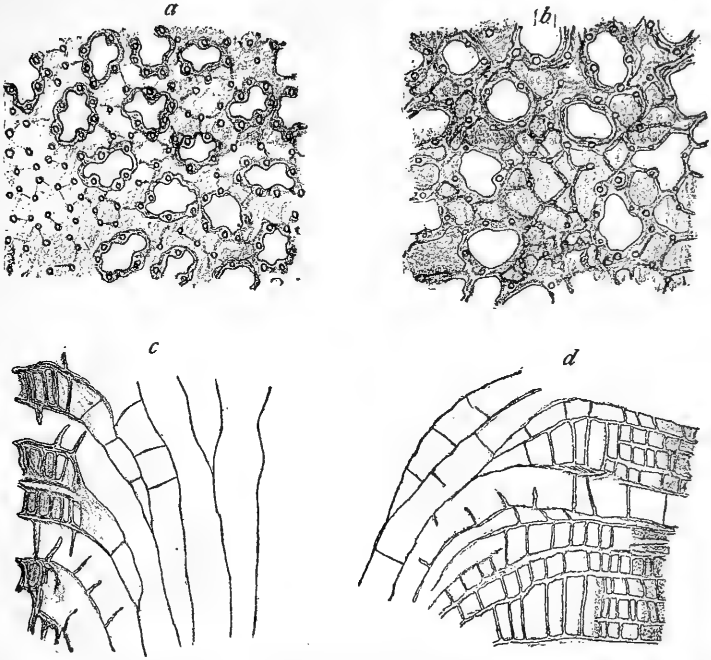


FIG. 187.—DITTOPORA ANNULATA. *a*, TANGENTIAL SECTION OF A MATURE EXAMPLE, ×20, PASSING THROUGH THE OUTER DEPOSIT OF INTERZOŒCIAL TISSUE IN WHICH THE MESOPORES ARE BARELY VISIBLE; *b*, ANOTHER TANGENTIAL SECTION, ×20, CUTTING A MACULA AT A LOWER LEVEL AND EXHIBITING THE MESOPORES; *c*, VERTICAL SECTION, ×20, OF A YOUNG EXAMPLE, SHOWING THE OCCURRENCE OF SEMIDIAPHRAGMS IN THE BEND FROM THE IMMATURE TO THE MATURE REGION; *d*, SIMILAR SECTION OF AN OLDER SPECIMEN, ×20, WITH THE MESOPORES WELL DEVELOPED AND THEIR OUTER PORTIONS FILLED BY TISSUE. GLAUCONITE LIMESTONE (B2), WASSILKOWA, GOVERNMENT OF ST. PETERSBURG.

tischport, Esthonia. Rare in the Echinospherites limestone (C1), 4 miles east of Reval.

Plesiotypes.—Cat. Nos. 57397 to 57402, U.S.N.M.

British Museum, specimens and thin sections from the Glauconite limestone, Tswos.

DITTOPORA COLLICULATA (Eichwald).

Plate 3, figs. 1–4c, 6; plate 11, figs. 7–15; text figs. 188–190.

Trematopora colliculata EICHWALD, Bull. Soc. Nat. Moscou, No. 1, 1856, p. 96.—SCHMIDT, Archiv. fur d. Nat. Liv-, Ehst- und Kurlands, vol. 2, ser. 1, 1858, p. 228.—EICHWALD, Lethæa Rossica, vol. 1, sect. 1, 1860, p. 494, pl. 27, figs. 14*a–c*.—DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 72, pl. 2, figs. 4–4*c*.—NICHOLSON, The Genus Monticulipora, 1881, p. 233, fig. 48.

Trematopora cingulata DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 78, pl. 2, figs. 1, 1*b*.

Trematopora cingulata var. *nodosa* DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 80, pl. 2, fig. 1*a*.

Trematopora variabilis DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 81, pl. 2, figs. 2, 2*a*.

Trematopora variabilis var. *complanata* DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 83, pl. 2, figs. 3, 3*a*.

Trematopora pustulifera DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 80, pl. 2, fig. 6.

Dybowski has given a lengthy, detailed description of Eichwald's *Trematopora colliculata,* and more or less extended descriptions of the species and varieties listed above as synonyms. On account of the marked external peculiarities, elongate-oval zoœcia with closed interzoœcial spaces, Eichwald's illustrations (fig. 188) are sufficient for the identification of his species; moreover, Dybowski has figured the internal structure fairly well (see pl. 3, figs. 4–4 *b*). I have examined over 400 specimens with this same internal structure. Of these a small percentage have their maculæ raised into rounded monticules, as figured by Eichwald, a large number have their monticules transversely elongated, while, finally, in the largest number of specimens the maculæ are not raised at all, but are so elongated that they form an encircling ring about the zoarial branch. Such variation is not unusual in species of *Batostoma* and other genera of the Trematoporidæ, although it is especially well developed in the present form.

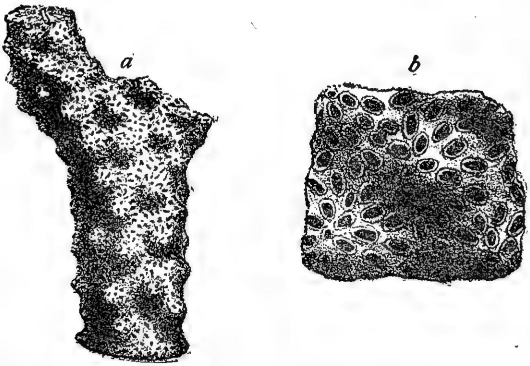


FIG. 188.—DITTOPORA COLLICULATA. EICHWALD'S FIGURES OF TREMATOPORA COLLICULATA. *a* AND *b*, FRAGMENT OF ZOARIUM, NATURAL SIZE, AND SURFACE OF SAME, ENLARGED. "CALCAIRE À ORTHOCERATITES," REVAL, ESTHONIA.

Numerous thin sections of these several forms have been prepared and the internal structure in each found to be identical. Moreover, there are all degrees of gradation in the extent and elevation of the maculæ, so that little question can be raised as to the specific identity of the forms here considered as synonyms. Comparing Dybowski's figures, we find that in *Trematopora cingulata* (pl. 3, figs. 1, 1*b*) the maculæ do not rise above the general surface and are so elongated transversely as to form encircling rings. *T. cingulata* var. *nodosa* (pl. 3, fig. 1*a*) differs only in having these ring-like maculæ slightly elevated. In *T. variabilis* (pl. 3, figs. 2, 2*a*) the maculæ, although transversely elongate, are arranged somewhat irregularly and the acanthopores are more numerous. *T. variabilis* var. *complanata* (pl. 3, figs. 3, 3*a*) has the same zoœcial structure and differs only in the very irregularly shaped monticules. Dybowski's tangential sections (pl. 3, figs. 1*b*, 2*a*, 3*a*, 4*a*, and 4*c*) are sufficient in themselves to show the identity of his various species, but the only illustration of *T. pustulifera* (pl. 3, fig. 6) shows apparently a somewhat different internal structure. Examination of Dybowski's type-specimen,

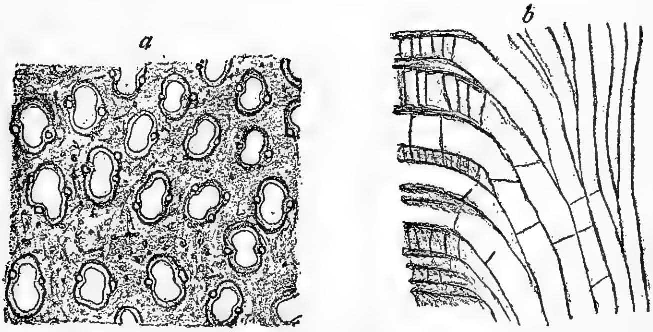


Fig. 189.—Dittopora colliculata. *a*, tangential section of a young example, ×20, showing the characteristic shape of zoœcia and the larger set of acanthopores; *b*, vertical section of the same specimen, ×20. Wassalem beds (D3), Uxnorm, Esthonia.

kindly loaned by Doctor Mikhailowski, proves *T. pustulifera* to be only a form of this same abundant *Dittopora*, with numerous well-developed acanthopores and a zoarium without conspicuous maculæ. To show this identity, a figure of a tangential section prepared from the type is introduced (fig. 190 *b*). Considering the numerous new species of Trepostomata in the Russian Ordovician, it is odd that this particular form should have received so many names. The following description is believed to cover the essential characters of the species.

Zoarium growing from a rounded or somewhat pointed base into straight, cylindrical, rather infrequently dividing branches, varying from 3 mm. to 10 mm. or more in diameter. Surface with more or less elongated solid maculæ composed of closed mesopores bordered by a row of zoœcia slightly larger than the rest. Maculæ often transversely elongated to such an extent that frequently several coalesce and form a continuous uncelluliferous band about the branch.

The maculæ may be on a plane with the surface or may rise as rounded or elongated monticules. These various developments of the maculæ are shown in Dybowski's figures and also on plate 11.

Zoœcia oval with a well-marked peristome, four in 2 mm. measuring lengthwise, and shaped like the figure 8 because of a constriction in the mid-length caused by the indentation of the walls by a pair of large acanthopores (fig. 189 *a*). In some forms this regular arrangement is somewhat obscured by the introduction of several additional equally large acanthopores less regularly placed. These large acanthopores are ring-form with a conspicuous central open space or lumen, and are in marked contrast with the second set of acanthopores, which consists of numerous smaller, more granular strucures irregularly placed on the mesopore walls. The arrangement and relative size of these two sets are illustrated in figure 189 *a*.

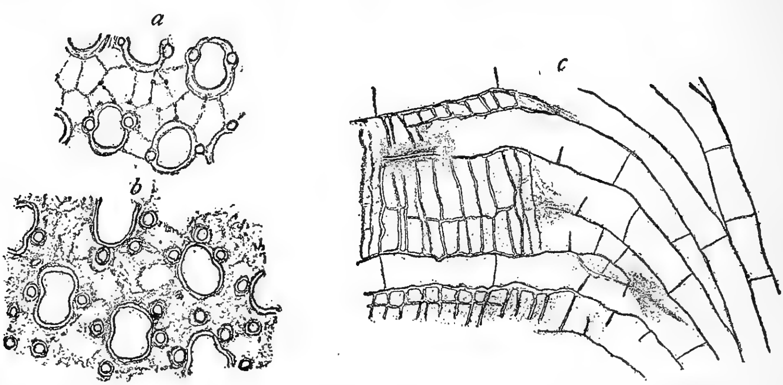


FIG. 190.—DITTOPORA COLLICULATA. *a*, SMALL PORTION OF A TANGENTIAL SECTION, ×20, WITH THE WALLS OF THE MESOPORES VISIBLE. THE LARGE AND SMALL SET OF ACANTHOPORES ARE CLEARLY DEVELOPED; *b*, ANOTHER TANGENTIAL SECTION, ×20, WITH THE MESOPORES AND SMALL ACANTHOPORES OBLITERATED BY THE INTERZOŒCIAL TISSUE. THIS THIN SECTION WAS PREPARED FROM A SPECIMEN IDENTIFIED BY DYBOWSKI AS TREMATOPORA PUSTULIFERA; *c*, VERTICAL SECTION, ×20, SHOWING THE OCCURRENCE OF SEMIDIAPHRAGMS ONLY IN THE BEND TO THE MATURE ZONE. WASSALEM BEDS (D3). UXNORM AND WASSALEM, ESTHONIA.

Mesopores closed at the surface, and so numerous as to isolate the zoœcia.

The important features shown in tangential sections are the oval, frequently constricted zoœcia with thick, ring-like walls, the large acanthopores with well defined central space, and the smaller, more granular acanthopores irregularly placed in the inter-zoœcial spaces. Such sections prepared from near the surface of well developed specimens show only a dense tissue penetrated by the smaller acanthopores in the interzoœcial spaces (fig. 190 *b*), but in deeper sections (fig. 190 *a*), the outlines of the mesopores are visible.

On account of the thickness of the mature zone, it is difficult to prepare vertical sections showing the full length of the zoœcial tubes. This difficulty was experienced by Dybowski, as is evidenced by his figured vertical section (pl. 3, fig. 4*b*) of the type form of the species. In order to show all of the characters seen in such sections, I have introduced figures of sections prepared from a young zoarium and a portion of a section of an old example (figs. 189 *b* and 190 *c*). The arrangement of diaphragms is essentially the same in both. In the immature zone the diaphragms are complete and are at distances of two or more tube diameters from each other. In the bend from the immature to the mature zone, a few semidiaphragms are developed, while in the mature zone proper a few scattered complete diaphragms may be seen. The tabulation and wall structures of the mesopores is as usual in members of this family. In the earlier stages the walls are moniliform and diaphragms are inserted regularly; later the diaphragms become more numerous and in addition are thickened and appear irregularly placed because of the deposition of layers of tissue upon them. In old examples this tissue is so abundant at the surface that the interzoœcial spaces are closed entirely. The closely tabulated mesopores with this deposit of tissue gave rise to Dybowski's idea of a "coenenchyma" separating the corallites or ordinary zoœcia.

In its specific character *Dittopora colliculata* is approached by no described species. The large, oval, constricted zoœcia, conspicuous acanthopores, closed interzoœcial spaces with a zoarium of cylindrical stems, made it easy of recognition without considering the marked internal characters.

Occurrence.—Very abundant in the Wassalem beds (D3) at Uxnorm, Gut Sack, and Wassalem, Esthonia. Rare in the Wesenberg limestone (E) at Wesenberg; in the Kuckers shale (C2), Baron Toll's estate, and in the lowest part of the Lyckholm limestone (F1) at Kertel and Hohenholm, island of Dago. Several specimens were collected by Doctor Bather in the Chasmops limestone, south of Bödahamn, island of Oeland.

Plesiotypes.—Cat. Nos. 57403 to 57409, U.S.N.M.

Specimens and thin sections from the Wassalem beds at Uxnorm, and from the Chasmops limestone, island of Oeland, are in the collections of the British Museum.

Genus MONOTRYPA Nicholson.

Monotrypa Nicholson, Paleozoic Tabulate Corals, 1879, p. 293; Genus Monticulipora, 1881, pp. 102, 168.—Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 153.—Hall and Simpson, Nat. Hist. New York, Paleontology, vol. 6, 1887, p. xiii.—Ulrich, Geol. Surv. Illinois, vol. 8, 1890, p. 379; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 303; Zittel's Textbook of Paleontology (Eng. ed.), 1897, p. 275.—Simpson, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 581.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 36.—Bassler, Bull. 292, U. S. Geol. Surv., 1906, p. 46.—Hennig, Archiv. fur Zool., vol. 4, No. 10, 1908, p. 46.

Ptychonema Hall and Simpson, Nat. Hist. New York, Pal., vol. 6, 1887, pp. xiv, 14.—Simpson, Fourteenth Ann. Rep. State Geologist of New York for the year 1894, 1897, p. 583.

In *Monotrypa* the simplest structure of the Trematoporidæ is present. The zoarium is massive and composed of simple, thin-walled, polygonal zoœcia in contact, both mesopores and acanthopores being absent. Internally the wall structure is as in other trematoporoid genera, even to the crinkling so often noted in the family. The only species so far found in the Russian collections seems to be closely allied to the genotype.

Genotype.—*Chætetes undulatus* Nicholson. Middle Ordovician of Canada.

MONOTRYPA JEWENSIS, new species.

Text fig. 191.

Cfr. *Monotrypa undulata* Nicholson, Paleozoic Tabulate Corals, 1879, p. 321, pl. 14, figs. 3–3*b*, 4, 4*a*.

Zoarium of rounded, hemispherical, or depressed spherical masses 10 to 15 mm. in diameter and also in height. Celluliferous surface smooth, with thin-walled, polygonal zoœcial apertures, four to five in 2 mm. Clusters of zoœcia larger than usual present at regular intervals but inconspicuous. Occasionally small, angular mesopore-like openings are scattered among the ordinary apertures, but these represent young zoœcia.

The important features of vertical sections are the crenulations of the zoœcial walls and the practical absence of diaphragms both in the immature and mature zones. Occasionally a single diaphragm is inserted in the outer portion of the mature zone as represented in figure 191 *c*. Tangential sections show the extreme simplicity of structure of the thin-walled, angular zoœcia.

The massive habit of growth, thin-walled polygonal zoœcia, crenulated walls, and practical absence of diaphragms are characters which will distinguish this species from all associated forms and cause it to be recognized without difficulty. A vertical fracture is of course necessary to determine the more important characters.

Upon comparison with American forms, *Monotrypa jewensis* is found to be closely related to the type of the genus, *M. undulata*, from the lower Trenton strata of Canada. The latter is not as well known as it should be, but, judging from Nicholson's description and figures, *M. undulata* has slightly smaller zoœcia and more abundant diaphragms.

Occurrence.—Not uncommon in the Jewe limestone (D1), Baron Toll's estate, and in the Kegel limestone (D2), at Kegel, Esthonia.

Holotype.—Cat. No. 57410, U.S.N.M.

British Museum, specimen and thin sections from the Jewe limestone, Baron Toll's estate.

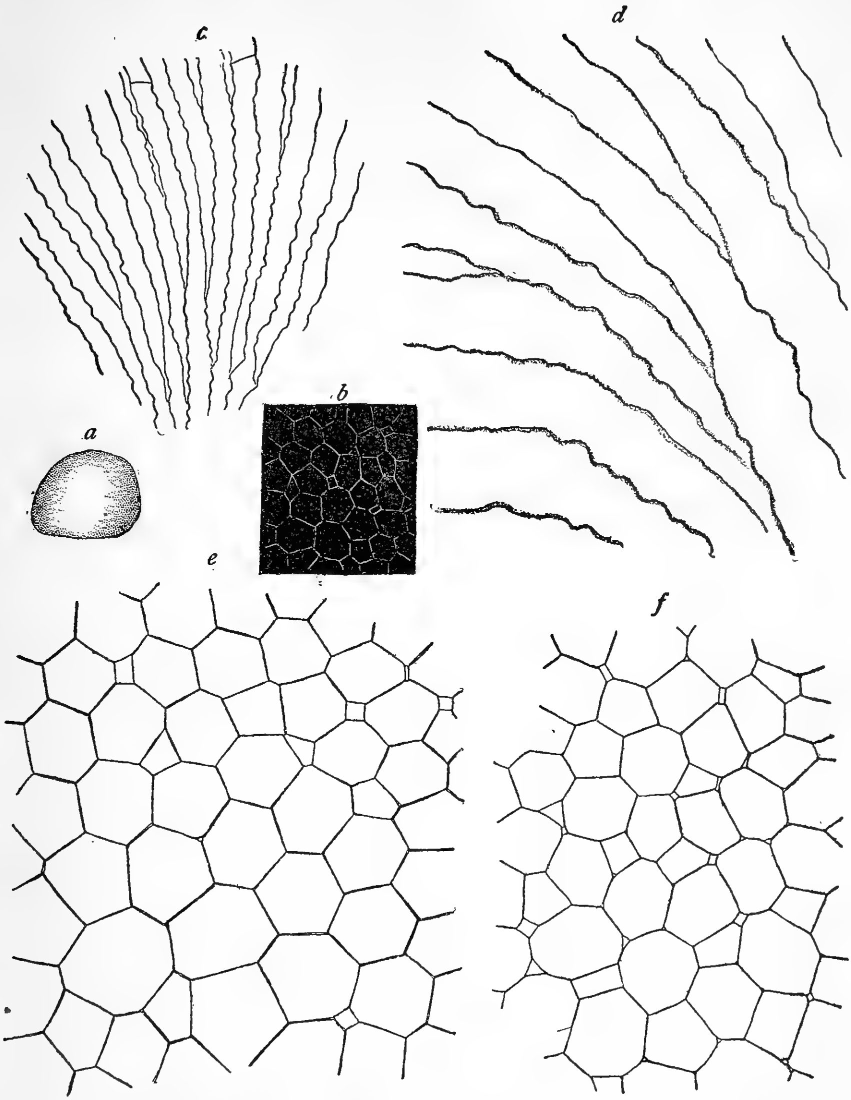


FIG. 191.—MONOTRYPA JEWENSIS. *a*, PROFILE VIEW OF A SMALL ZOARIUM, NATURAL SIZE; *b*, SURFACE OF THE SAME SPECIMEN, ×10; *c*, VERTICAL SECTION, ×8, ILLUSTRATING THE CRINKLED WALLS AND FEW DIAPHRAGMS; *d*, PORTION OF THE SAME SECTION, ×20; *e*, TANGENTIAL SECTION, ×20, CUTTING A MACULA; *f*, ANOTHER TANGENTIAL SECTION, ×20, WITH NUMEROUS YOUNG ZOŒCIA RESEMBLING MESOPORES. JEWE LIMESTONE (D1), BARON TOLL'S ESTATE, ESTHONIA.

Genus DIPLOTRYPA Nicholson.

Diplotrypa Nicholson, Pal. Tabulate Corals, 1879, p. 292; Genus Monticulipora, 1881, pp. 101, 155.—Ulrich, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 153; Geol. Surv. Illinois, vol. 8, 1890, pp. 378, 457; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 285; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 275.—Nickles and Bassler, Bull. 173, U. S. Geol. Surv., 1900, p. 36.—Bassler, Bull. 292, U. S. Geol. Surv., 1906, p. 47.

Callopora (part) Dybowski (not Hall), Die Chaetetiden d. Ostbaltischen Silur-Formation, 1877, p. 106.

This division of the Trepostomata was instituted by Nicholson as a subgenus under *Monticulipora,* with Pander's *Favosites petropolitanus* as the type. Just which particular species of the many hemispheric bryozoans Pander had in mind is impossible to tell without an examination of his type-specimen; indeed, it is not unlikely that this author himself confused several species. Subsequently, other writers described and figured presumably the same species, but in almost every case their diagnoses and illustrations are insufficient for the recognition of the species. The result of this frequently imperfect work was that many species in Europe as well as in America have been identified as *Favosites* or *Chætetes petropolitanus,* based merely upon method of growth. Indeed, there has been no name so frequently cited where it is very probable that almost every citation refers to a different form.

In his Paleozoic Tabulate Corals, Nicholson described and illustrated the internal characters of hemispheric specimens from the Chasmops limestone of Ostrogothia, Sweden, basing his new subgenus *Diplotrypa* upon these examples which he identified as *Favosites petropolitanus* Pander. Two years previously Dybowski had resurrected Eichwald's imperfectly defined genus *Dianulites,* and had adequately described and illustrated certain Russian hemispheric bryozoans as *Dianulites petropolitanus* (Pander). The internal structure of these two forms, identified as the same species, is totally different, and the identification of Pander's species is still uncertain. It happens, however, that the form identified by Nicholson as Pander's species is very abundant throughout the Russian Middle Ordovician, and likewise that Dybowski's *Dianulites petropolitanus* (Pander) is associated with the Swedish *Diplotrypa petropolitana* in the latter country; moreover, they are generically distinct. The way is thus open to clear this complicated mixture of species and genera by recognizing Nicholson's identification as *Diplotrypa petropolitana* Nicholson, and regarding Dybowski's conception of the species as a valid form of *Dianulites.*

The genus *Diplotrypa* comprises species with massive or discoid free zoaria, composed of comparatively large zoœcial tubes with thin, prismatic walls. Mesopores are always present, although they vary in number and size. The diaphragms are horizontal and more or less abundant in both zoœcia and mesopores; acanthopores wanting.

In other words, the genus is like *Monotrypa* save that mesopores are present.

Genotype.—Diplotrypa petropolitana Nicholson. Middle Ordovician of Baltic Russia and Sweden.

DIPLOTRYPA PETROPOLITANA (Nicholson).

Text figs. 192–195.

Monticulipora (*Diplotrypa*) *petropolitana* NICHOLSON, Pal. Tab. Corals, 1879, p. 313, pl. 13, figs. 3–3 *c*; The Genus Monticulipora, 1881, p. 156, text fig. 30.

The following may also be included, at least in part, in the present species:

Millepora hemispherica (part) EICHWALD, Inter ingrica et de trilob. observat., 1825, p. 21.

Favosites petropolitanus PANDER, Beitr. zur Geogn. d. russ. Reiches., 1830, p. 105, pl. 1, figs. 7–11.

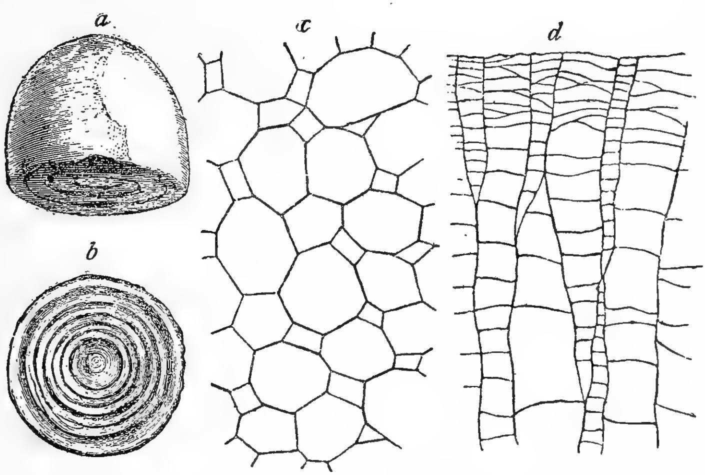


FIG. 192.—DIPLOTRYPA PETROPOLITANA. NICHOLSON'S ILLUSTRATIONS OF MONTICULIPORA (DIPLOTRYPA) PETROPOLITANA, INTRODUCED FOR COMPARISON. *a*, PROFILE VIEW OF AN AVERAGE SPECIMEN, NATURAL SIZE; *b*, BASAL VIEW OF SAME SHOWING WRINKLED EPITHECA; *c*, TANGENTIAL SECTION, ×20; *d*, VERTICAL SECTION THROUGH AN IMMATURE AND A MATURE ZONE, ×20. MIDDLE ORDOVICIAN (CHASMOPS) LIMESTONE, OSTROGOTHIA, SWEDEN.

Favosites hemisphericum KUTORGA, Beitr. zur Paleontologie und Geogn. Dorpats, 1837, p. 40, pl. 9, fig. 3.

Calamopora fibrosa EICHWALD, Silur. syst. in Ehstl., 1840, p. 197.

Chætetes petropolitanus LONSDALE, in Murchison, Verneuil, and Keyserling, Russia and Ural, vol. 1, 1845, p. 596, pl. A, fig. 10.—KEYSERLING, Reise in d. Petschoraland, 1846, p. 180.—D'ORBIGNY, Prodr. de Pal., vol. 1, 1850, p. 25.—EDWARDS and HAIME, Mon. des Pol. foss., 1852, p. 263.

Monticulipora petropolitana EDWARDS and HAIME, Brit. Foss. Cor., 1854, p. 264.—SCHMIDT, Archiv fur Naturk. Liv.-, Ehst- u. Kurlands, vol. 2, ser. 1, 1858, p. 228.

Not *Dianulites petropolitanus* DYBOWSKI and other authors.

Zoarium massive, discoid when young but with age becoming hemispheric to spheroidal; base circular, often concave and covered with a concentrically wrinkled epitheca. Average specimens are several centimeters in diameter, but examples as wide as 15 cm. occur. Upper surface celluliferous, smooth; maculæ inconspicuous, composed of more numerous mesopores and of zoœcia larger than elsewhere. Zoœcial apertures polygonal, averaging 0.50 mm. in diameter, with three in 2 mm.; walls thin. Mesopores variable in size and shape, and rather numerous.

The shape of the zoarium and the internal characters of the Swedish specimens studied by Nicholson are shown in figure 192, while thin

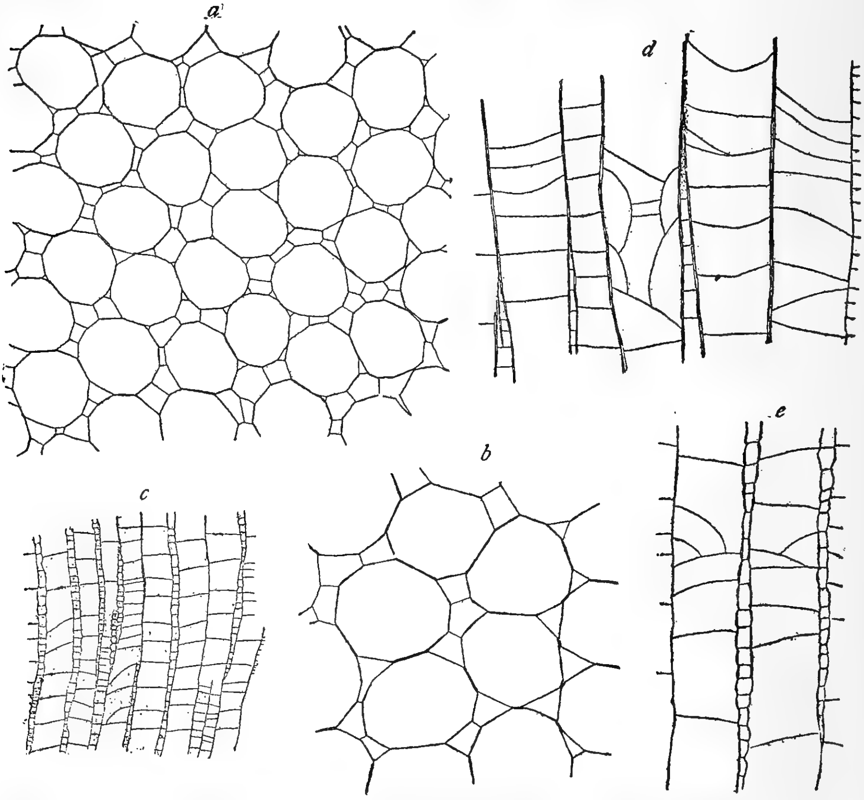


FIG. 193.—DIPLOTRYPA PETROPOLITANA. *a*, TANGENTIAL SECTION, ×20, SHOWING NUMEROUS MESOPORES; *b*, A PORTION OF THE SAME, ×35, ILLUSTRATING SIMPLICITY OF WALLS; *c*, VERTICAL SECTION, ×8, WITH USUAL ARRANGEMENT OF DIAPHRAGMS; *d* AND *e*, PORTIONS OF A VERTICAL SECTION, ×20, WITH A FEW CURVED DIAPHRAGMS. KEGEL BEDS (D2), KEGEL, ESTHONIA.

sections of Russian examples are illustrated in the following figures. In tangential sections the absence of acanthopores, the tenuity and simple character of the walls, and the polygonal shape of both zoœcia and mesopores are most noticeable. The most important specific character is seen in vertical sections or in vertical fractures showing the tabulation. In the mesopores the diaphragms average a tube diameter apart, thus, in comparison with the zoœcial tubes giving a crowded effect. The same average holds for the zoœcia proper, although the distribution of diaphragms is not so regular. In the immature zone these structures are horizontal and are placed from two to a single tube diameter apart. The mature zones are recognized almost solely by the crowding of the diaphragms, three or four of which occur in the space of one diameter. Here, too, they are often curved; indeed, in some tubes a few cystiphragms are introduced. This crowding and the curved diaphragms are well shown in the mature zone of Nicholson's vertical section (fig. 192 *d*), while an occurrence of cystiphragms is illustrated in figure 193 *d*. The usual

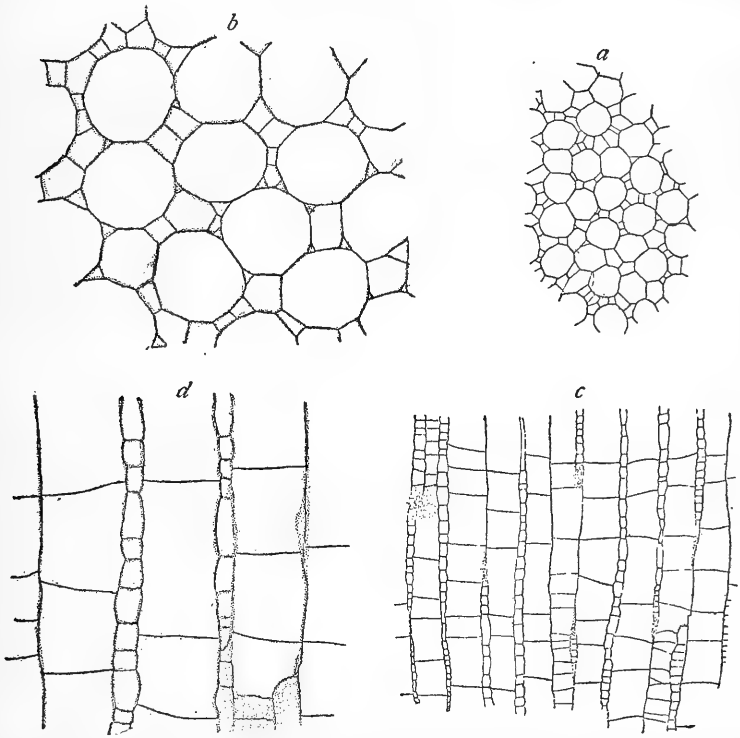


FIG. 194.—DIPLOTRYPA PETROPOLITANA. *a*, SMALL PORTION OF A TANGENTIAL SECTION, ×8; *b*, PARTS OF SAME SECTION, ×20; *c*, VERTICAL SECTION, ×8, WITH TWO MATURE ZONES BOUNDING AN IMMATURE REGION; *d*, PORTION OF SAME, ×20, SHOWING THE BEADED WALLS AND ALSO TWO MESOPORES REPLACED BY A ZOŒCIUM. LYCKHOLM LIMESTONE (F1), KERTEL, ISLAND OF DAGO, ESTHONIA.

distribution of diaphragms for the species is shown in figure 194, where another peculiarity of the species as well as the genus is illustrated, namely, the change of a mesopore into a zoœcium.

As pointed out by Ulrich,[1] *Diplotrypa petropolitana* is closely allied to *D. westoni* Ulrich from the Trenton formation of Manitoba, Canada, but the few diaphragms of the latter will distinguish it. The large zoœcia and rather crowded tabulation distinguish *D. petropolitana* from all described members of the genus. Compared with associated

[1] Contr. Micro-Pal. Cambro-Sil., pt. 2, 1889, p. 30.

massive species with complete diaphragms, *Hallopora dybowskii* is very similar in many respects, but its zoœcial tubes contain so few diaphragms that they often appear to be wanting. The other species have noticeably smaller zoœcia as well as other differences, while associated hemispheric forms of other genera have very distinct internal characters.

Occurrence.—Nicholson's type-specimens of *Diplotrypa petropolitana* were collected in the Ordovician (Chasmops) limestone in Ostrogothia, Sweden. Typical specimens from the same limestone at Räbeck,

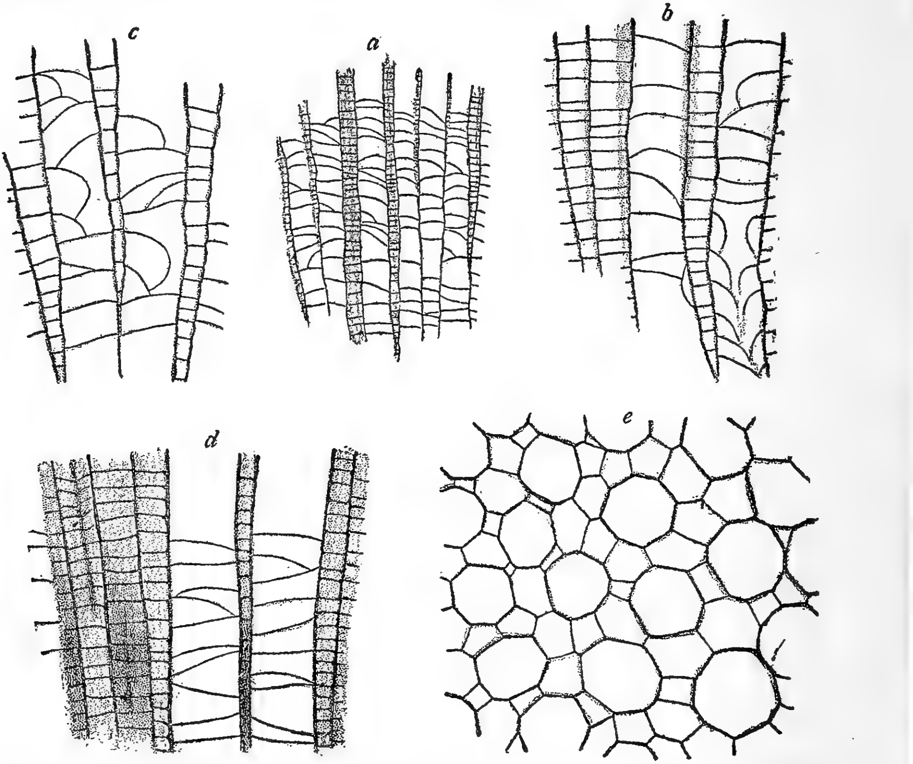


FIG. 195.—DIPLOTRYPA PETROPOLITANA. *a*, VERTICAL SECTION, ×8, OF A SPECIMEN SHOWING NUMEROUS CURVED DIAPHRAGMS; *b*, PORTION OF THE SAME SECTION, ×20, WITH FUNNEL-SHAPED DIAPHRAGMS IN ONE OF THE ZOŒCIAL TUBES; *c*, ANOTHER PORTION, ×20, SHOWING A FEW CYSTIPHRAGM-LIKE STRUCTURES; *d*, VERTICAL SECTION, ×20, THROUGH A MACULA; *e*, A TANGENTIAL SECTION, ×20, SHOWING THE USUAL ARRANGEMENT AND SHAPE OF ZOŒCIA AND MESOPORES. LYCKHOLM LIMESTONE (F1), KERTEL, ISLAND OF DAGO, ESTHONIA.

island of Oeland, are in the collections of the United States National Museum and the British Museum.

In Russia the species occurs in all the strata ranging from the Glauconite limestone (B2) to the lower part of the Lyckholm (F1). The more important localities represented by specimens in the collections of the United States National Museum are: Glauconite limestone (B2), Echinospherites limestone (C1), and Kuckers shale (C2), Reval, Esthonia; Kuckers shale (C2), Erras, and Baron Toll's estate, Esthonia; Jewe limestone (D1), St. Mathias, Baron Toll's estate, and Paesküll, Esthonia; Kegel limestone (D2) Kegel, Esthonia; Wassalem beds (D3), Uxnorm, Esthonia; Wesenberg limestone (E), Wesenberg, Esthonia; Lyckholm limestone (F1), Lyckholm and Lechts, Esthonia, and Hohenholm, Kertel, Paope, and Keilo, island of Dago.

Plesiotypes.—Cat. Nos. 57430 to 57449, U.S.N.M.

British Museum, specimens and thin sections from various localities in Russia, and the island of Oeland.

DIPLOTRYPA BICORNIS (Eichwald).

Plate 5, figs. 3–3*d*; text figs. 196–198.

Dianulites bicornis EICHWALD, Zool. spec., vol. 1, 1832, p. 181, pl. 2, fig. 15.

Chætetes heterosolen KEYSERLING, Beobachtungen auf einer Reise in das Petschora-Land, 1846, p. 181, fig. *a*, *b*.—EDWARDS and HAIME, Monogr. des polyp. foss., 1852, p. 273.

Monticulipora heterosolen SCHMIDT, Archiv. fur Naturk. Liv-, Ehst- und Kurlands, vol. 2, ser. 1, 1858, p. 228.—MILNE-EDWARDS, Hist. nat. des Cor., vol. 3, 1860, p. 274.

Ceriopora bicornis EICHWALD, Lethæa Rossica, vol. 1, sec. 1, 1860, p. 413, pl. 25, fig. 3.

Callopora heterosolen DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 119, pl. 4, figs. 3*a–d*.

Cfr. *Diplotrypa limitaris* ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 286, fig. 18.

Commencing in the Glauconite limestone and continuing through the Wassalem beds is a species of *Diplotrypa* equally as abundant as the associated *D. petropolitana* and *Hallopora? dybowskii*. This species was first described by Eichwald as *Dianulites bicornis*, his illustrations being presented below as figure 196. Dybowski gave a full description and numerous figures of the species, but adopted Keyserling's specific name *heterosolen*, for the reason that the term *bicornis* was applicable to only a particular form of growth. Although this is true, the rules of nomenclature demand the use of the earlier name adopted above.

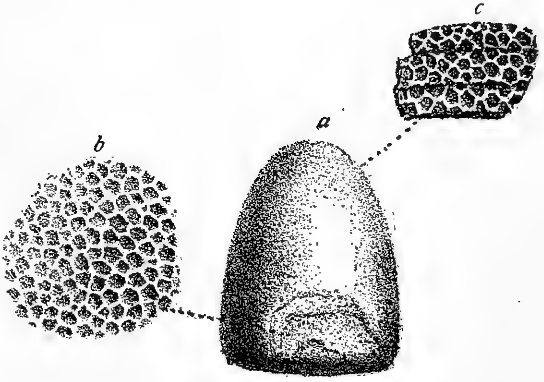


FIG. 196.—DIPLOTRYPA BICORNIS. *a*, AN EXAMPLE OF THE USUAL FORM, NATURAL SIZE; *b* AND *c*, TWO VIEWS OF THE SURFACE, ENLARGED. COPIED FROM EICHWALD'S FIGURES OF CERIOPORA BICORNIS. "CALCAIRE À ORTHOCERATITES," PULKOWA, GOVERNMENT OF ST. PETERSBURG.

Although extremely variable in form, the zoarium of *Diplotrypa bicornis* is massive and more or less hemispheric. Young specimens are regularly hemispheric in shape with a wrinkled epithecated base often preserving the impression of the object upon which growth started. Continued unequal development in certain parts of such regularly formed zoaria result in the irregular masses figured by Dybowski (pl. 5, fig. 3). An irregular mass with two conspicuous horn-like projections was selected as the type of *Dianulites bicornis* by Eichwald. In some cases two normally shaped zoaria may be joined, the base of the younger adhering to the top of the older specimens, or, again, curious double forms may occur by continued growth

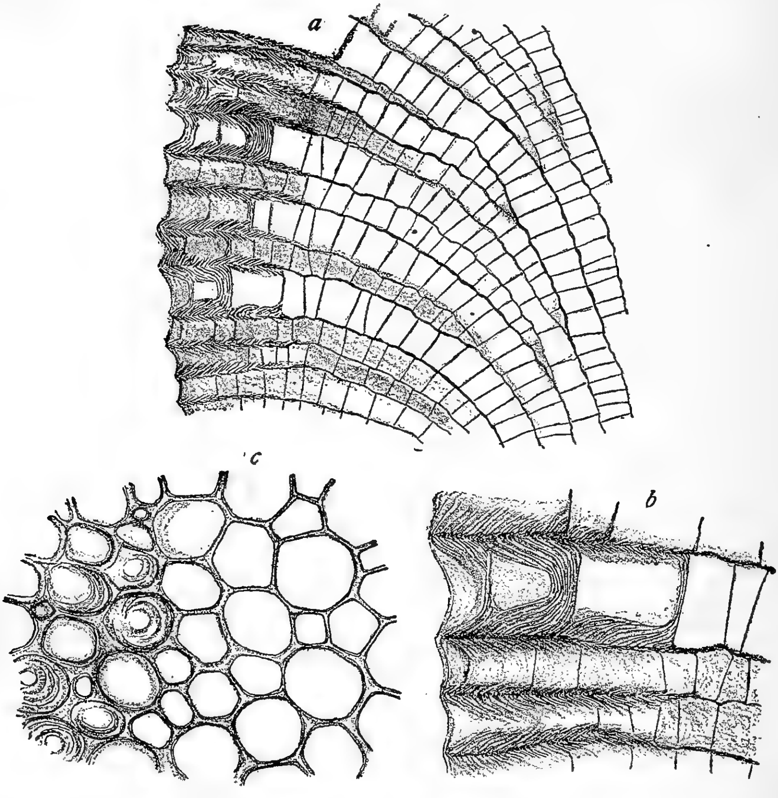


FIG. 197.—DIPLOTRYPA BICORNIS. *a*, VERTICAL SECTION THROUGH THE BASAL PART OF A ZOARIUM, ×20, SHOWING THE OUTER PORTION OF THE MATURE REGION OBSCURED BY DEPOSITS OF TISSUE; *b*, SMALL PORTION OF THE SAME SECTION ENLARGED TO EXHIBIT DEPOSITION OF TISSUE MORE CLEARLY; *c*, A TANGENTIAL SECTION, ×20, PASSING FROM THE REGION OF NORMAL ZOŒCIA AND MESOPORES INTO THE AREA OF APERTURES WITH GREATLY THICKENED WALLS. THE ORDINARY INTERNAL STRUCTURE OF THIS SPECIES IS SHOWN IN FIG. 198, DRAWN FROM THIN SECTIONS PREPARED FROM THE SAME SPECIMEN GIVING THE STRUCTURE FIGURED ABOVE. JEWE LIMESTONE (D1), BARON TOLL'S ESTATE, ESTHONIA.

of certain zoœcia of a lower zoarium into a second more or less regular example. Celluliferous surface usually smooth, but in a few examples the maculæ have been observed to form low rounded monticules.

Zoœcial tubes polygonal, five to six in 2 mm. Mesopores of variable size and number, most numerous in the maculæ where they isolate the zoœcia. Walls of both zoœcia and mesopores thin in the immature zone and in the mature region of the younger stage of a colony. The oldest portion of a zoarium the base and the edge of the celluliferous surface, exhibits a dense, solid surface to the unaided eye, but when magnified, this region is seen to be made up of minute, thick-walled, round to hexagonal cells of a uniform diameter. In

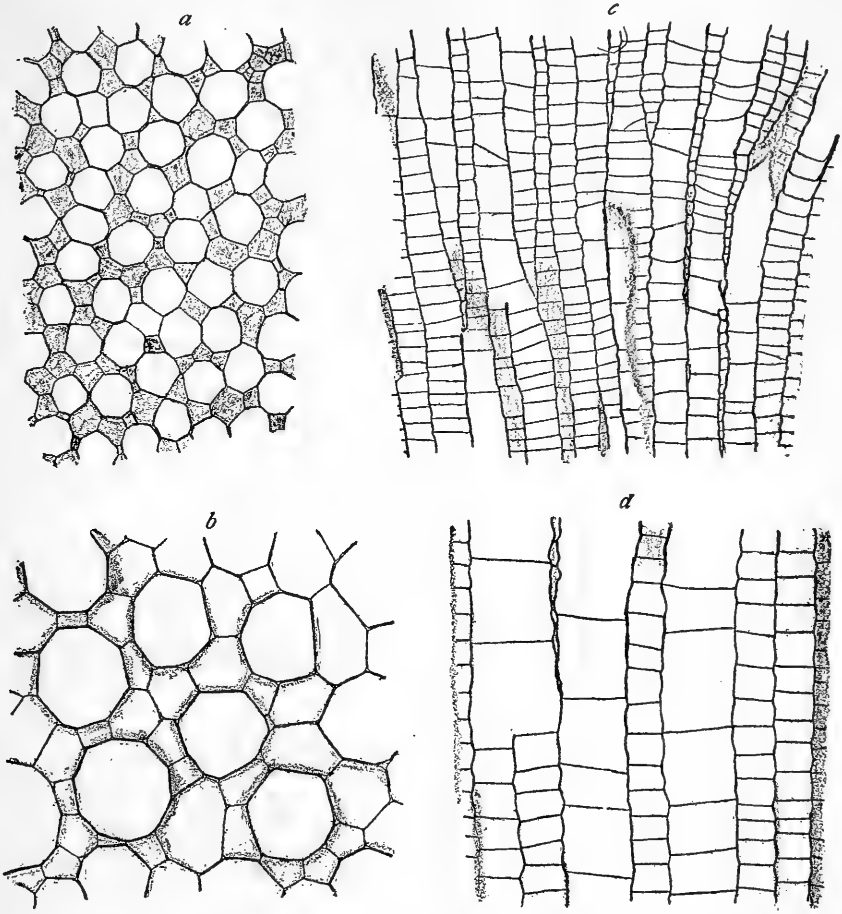


FIG. 198.—DIPLOTRYPA BICORNIS. *a*, TANGENTIAL SECTION, ×20, SHOWING THE SHAPE, SIZE, AND ARRANGEMENT OF ZOŒCIA AND MESOPORES IN THE MATURE ZONE. THE MESOPORES ARE SHADED FOR CONVENIENCE OF RECOGNITION; *b*, PART OF THE SAME SECTION, ×40; *c*, VERTICAL SECTION, ×20, SHOWING THE REGULAR AND CLOSE ARRANGEMENT OF TABULÆ IN THE MESOPORES AND THEIR IRREGULAR DISTRIBUTION IN THE ZOŒCIA; *d*, VERTICAL SECTION, ×40, ILLUSTRATING THE NORMAL DISTRIBUTION OF DIAPHRAGMS IN THE TWO KINDS OF TUBES. HERE ONE OF THE ZOŒCIA REPLACES TWO MESOPORES. THIN SECTIONS OF THE BASAL PART OF THIS SAME ZOARIUM ARE SHOWN IN FIG. 197. JEWE LIMESTONE (D1), BARON TOLL'S ESTATE, ESTHONIA.

tangential sections through this and the adjacent normal celluliferous area, the zoœcial walls are seen to become so thickened by the deposit of a dense tissue that the diameter of the orifice is the same as that of the mesopores. The same thickening of the walls is well exhibited in vertical sections where the mesopores also are noted to be invested with a similar but thinner deposit of the same tissue. Small or young zoœcia naturally show little of this thickening, but in the usual examples, the dense, solid basal portion may be considered as a character of value in the identification of the species.

The internal characters seen in tangential sections have been mentioned. Aside from their smaller size and the thickening noted above, the zoœcial tubes are quite similar to those of other *Diplotrypas*. In vertical sections, aside from the usual, somewhat beaded walls, the marked characteristic in all good species of the genus is the abundant development of diaphragms in the zoœcial tubes. In the immature zone these are seldom farther apart than the diameter of two tubes, while in the crowded portions of the mature region, two and sometimes three occur in the width of a zoœcium. Altogether the diaphragms are more uniformly distributed in both regions than in other species of the genus. In the mesopores these partitions maintain their usual distribution of about their own diameter apart.

In size of zoœcia and distribution of diaphragms, *Diplotrypa bicornis* agrees well with the American *D. limitaris*, described by Ulrich from the Nematopora bed of the Trenton in Minnesota. The few mesopores of the Minnesota species will serve to separate the two, although it is probable that *D. limitaris* is the American representative of the common Russian form.

Diplotrypa bicornis is an excellent species of the genus and may be distinguished from associated forms by the comparatively small size of its zoœcia and the abundant development of diaphragms. *D. petropolitana*, *D. hennigi*, and *D. moniliformis* have noticeably larger zoœcia. Difficulty may be experienced in separating certain specimens of *D. hexagonalis*. Here, however, the zoœcia, although quite similar in size, have few diaphragms, while the mesopores are much more closely tabulated.

Occurrence.—Abundant in most of the divisions ranging from the Glauconite limestone to the Wassalem beds. The specimens illustrated are from the Jewe limestone (D1), Baron Toll's estate. Among other localities are: Glauconite limestone (B2), Reval; Echinospherites limestone (C1), at Reval, 4 miles east of Reval, and at Duboviki; and in the Kuckers shale (C2), Baron Toll's estate and Erras; and in the Chasmops limestone, south of Bödahamn, island of Oeland.

Plesiotypes.—Cat. Nos. 57450 to 57458.

British Museum, thin sections of figured type, and specimens from various localities in Russia and island of Oeland.

DIPLOTRYPA MONILIFORMIS, new species.

Text fig. 199.

Cfr. *Diplotrypa neglecta* ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 287, fig. 19.

The species for which the above new name is proposed is closely related to the form described by Ulrich from the Nematopora bed of

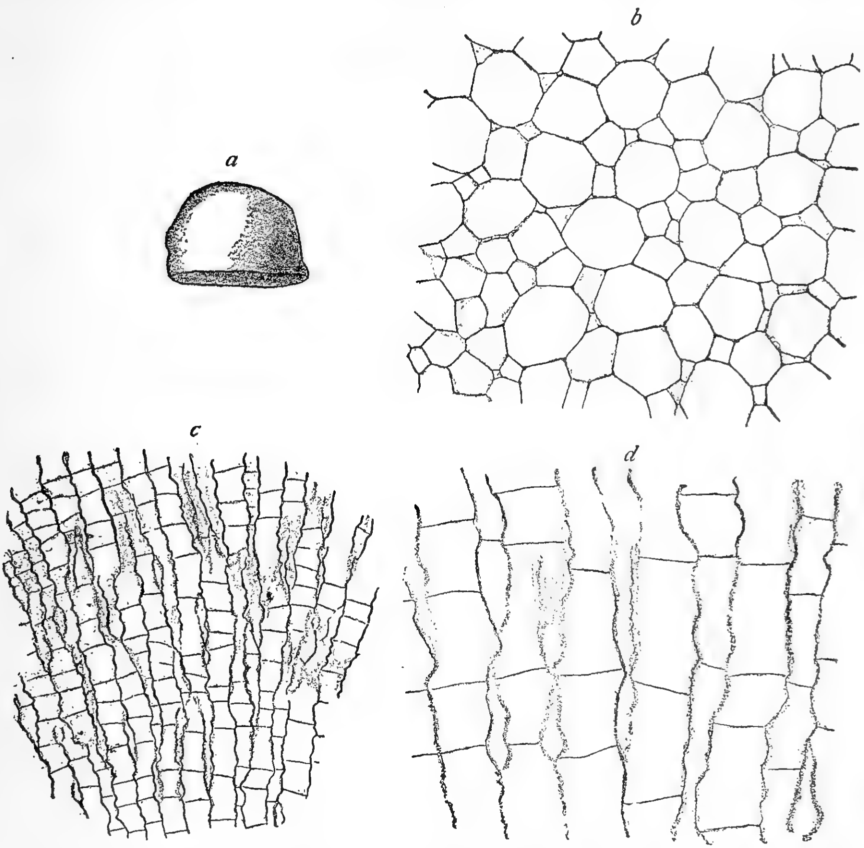


FIG. 199.—DIPLOTRYPA MONILIFORMIS. *a*, SIDE VIEW OF A ZOARIUM, NATURAL SIZE; *b*, TANGENTIAL SECTION, ×20, EXHIBITING MESOPORES MORE NUMEROUS THAN USUAL; *c*, VERTICAL SECTION, ×8, PASSING THROUGH SEVERAL SUCCESSIVE MATURE AND IMMATURE REGIONS, ILLUSTRATING THE VERY IRREGULAR CRENULATED WALLS AND THE SIMILAR TABULATION OF BOTH SETS OF TUBES; *d*, PORTION OF THE SAME SECTION, ×20, SHOWING WALL STRUCTURE MORE CLEARLY. JEWE LIMESTONE (D1), BARON TOLL'S ESTATE, ESTHONIA.

the Trenton formation at Hader, Minnesota, as *Diplotrypa neglecta*. Each agrees in having irregularly arranged polygonal zoœcia with rather few mesopores, variable in size and distribution, and often distinguished from the zoœcia with difficulty. The aspect in vertical section is likewise very similar, although the irregularity of the walls is more marked in the Russian species, which may be defined as follows:

Zoarium a dome-shaped or hemispheric mass about 20 mm. wide and 12 mm. high. Surface smooth, maculæ inconspicuous, and distinguished mainly by the presence of more numerous mesopores. Zoœcia polygonal, irregularly arranged, three to four in a space of 2 mm. Mesopores of irregular sizes and shapes and seldom completely isolating the zoœcia. Walls of both zoœcia and mesopores thin.

In vertical sections the very irregular zoœcial walls are the most striking feature, and this peculiarity alone will aid considerably in the identification of the species. The difference in tabulation between zoœcia and mesopores is often so slight that the latter can only be recognized by their smaller size. In many cases the mesopores abruptly cease and their places are taken by zoœcia of normal size.

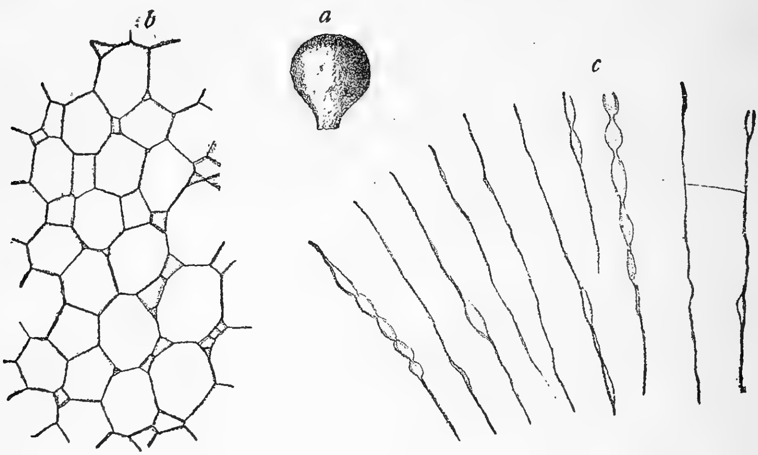


FIG. 200.—DIPLOTRYPA HENNIGI. *a*, SIDE VIEW OF A ZOARIUM, NATURAL SIZE; *b*, TANGENTIAL SECTION, ×20; *c*, VERTICAL SECTION, ×20, SHOWING THE ZOŒCIAL WALLS BUT SLIGHTLY UNDULATING ALTHOUGH THE MESOPORES ARE STRONGLY BEADED. KUCKERS SHALE (C2), BARON TOLL'S ESTATE, ESTHONIA.

Compared with other hemispheric bryozoans, the polygonal zoœcia and mesopores, with their crinkled walls and the uniform distribution of diaphragms, are diagnostic of *Diplotrypa moniliformis*.

Occurrence.—Apparently rare in the Jewe limestone (D1), Baron Toll's estate, near Jewe, Esthonia.

Holotype.—Cat. No. 57413, U.S.N.M.

Thin sections of the type-specimen are in the collections of the British Museum.

DIPLOTRYPA HENNIGI, new species.

Text fig. 200.

Externally this species has much resemblance to the associated *Monotrypa jewensis*, but close examination will show that its zoœcia are smaller, and that the small polygonal apertures scattered among the ordinary large openings are in reality true mesopores and not young zoœcia. A vertical fracture or thin section brings out more obvious differences, as a comparison of figures 191 and 200 will indicate. Most important of these differences are the strongly beaded mesopores and the straight zoœcial walls of *D. hennigi* in contrast with the strongly crinkled walls and absence of mesopores in the *Monotrypa*. The zoarium of *Diplotrypa hennigi* is of smooth, rounded masses composed of thin walled, polygonal zoœcia with occasional small, angular mesopores. Six of the ordinary zoœcia in 2 mm. Acanthopores wanting. The specific characters are best shown in vertical sections, where the slightly undulated zoœcial walls, the decided beading of the mesopores, and the paucity of diaphragms in the zoœcia proper are most diagnostic.

The specific name is in honor of Dr. Anders Hennig, of Lund, Sweden, in appreciation of his work upon the Silurian Bryozoa of the island of Gothland.

Occurrence.—Apparently rare in the Kuckers shale (C2), Baron Toll's estate, near Reval, Esthonia.

Holotype.—Cat. No. 57414, U.S.N.M.

Thin sections of the type-specimen are in the collections of the British Museum.

DIPLOTRYPA WESTONI Ulrich.

Text fig. 201.

Diplotrypa westoni Ulrich, Contr. Micro-Pal. Cambro-Sil., Pt. 2, 1889, p. 30, pl. 8, figs. 4–4*b*; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 274, fig. 457.—Whiteaves, Pal. Foss., vol. 3, pt. 3, 1897, p. 163.

Several specimens of *Diplotrypa* from the Chasmops limestone of Sweden were at first assigned by me to a new species, but upon close comparison I find that the differences between them and the type of *Diplotrypa westoni* are too slight even for varietal distinction. The characters of the Swedish examples are shown in the accompanying figures. The size of the zoœcium, number of mesopores, and distribution of diaphragms in both sets of tubes is practically the same. Indeed, the only difference that I can point out between Ulrich's figures and my own is the slightly greater number of mesopores in the latter, a distinction removed by other specimens.

Diplotrypa westoni need only be compared with *D. petropolitana*, but the more abundant diaphragms of the latter easily separate the two, although other differences can be seen by comparing their respective figures. The distinctive characters of *D. westoni* are best exhibited in vertical sections. Here the sparse tabulation of the zoœcia is most evident, but a second striking feature is the angularity of the beading formed by the walls of the mesopores. In most species of this genus the walls are gently undulated, but in this form the undulations are so sharp that they are in reality angular.

Occurrence.—Rare in rocks supposed to be of Lower Trenton age on Big Island, Lake Winnipeg, Canada. Apparently common in the Chasmops limestone at Nittsjo Rätvik, Dalarne, Sweden, and south of Bödahamn, island of Oeland.

Plesiotype.—Cat. No. 57415, U.S.N.M.

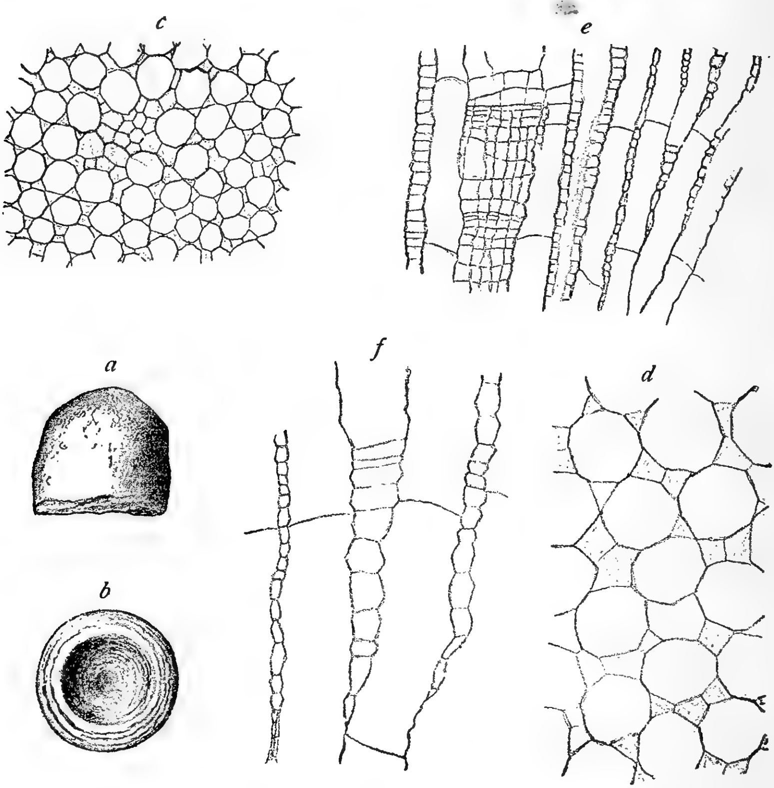


FIG. 201.—DIPLOTRYPA WESTONI. *a* AND *b*, SIDE AND BASAL VIEWS OF A ZOARIUM, NATURAL SIZE; *c*, TANGENTIAL SECTION, ×8, THROUGH A MACULA AND ADJOINING ZOŒCIA; *d*, PORTION OF THE SAME SECTION, ×20; *e*, VERTICAL SECTION, ×8, CUTTING A MACULA; *f*, SEVERAL TUBES OF THE SAME, ×20, ILLUSTRATING THE ANGULARLY BEADED MESOPORES, THE REPLACEMENT OF A MESOPORE BY A ZOŒCIUM, AND THE TABULATION OF BOTH SETS OF TUBES. MIDDLE ORDOVICIAN (CHASMOPS) LIMESTONE, NITTSJO RÄTVIK, DALARNE, SWEDEN.

British Museum, specimens from the island of Oeland and thin sections of the figured specimen.

Family HALLOPORIDÆ, new name.

This new name in place of Calloporidæ becomes necessary through the substitution of *Hallopora* for the preoccupied *Callopora*. The family includes those integrate trepostomatous bryozoans in which the zoœcial tubes are thin-walled and attain their full size slowly, but chiefly in which acanthopores are absent. Diaphragms are closely arranged in the tapering proximal end, are few or wanting in the rest of the immature region, and become crowded in the mature zone. The earliest part of the zoœcial tubes thus has the characters of mesopores. *Hallopora*, the type genus, is numerously represented both in individuals and species throughout the Ordovician, Silurian, and earliest Devonian.

Genus HALLOPORA, new name.

Callopora HALL, Amer. Journ. Sci., ser. 2, vol. 11, 1851, p. 400; Nat. Hist. New York, Pal., vol. 2, 1852, p. 144.—NICHOLSON, Pal. Province Ontario, 1874, p. 61; Geol. Mag., new ser., vol. 1, 1874, p. 13.—ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, pp. 154, 251.—FOERSTE, Bull. Sci. Lab. Denison University, vol. 2, 1887, p. 172.—HALL and SIMPSON, Nat. Hist. New York, Pal., vol. 6, 1887, p. xv.—MILLER, North Amer. Geol. and Pal., 1889, p. 295.—ULRICH, Geol. Surv. Illinois, vol. 8, 1890, pp. 372, 416; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, 1893, p. 275; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 275.—SIMPSON, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, p. 588.—NICKLES and BASSLER, Bull. 173, U. S. Geol. Surv., 1900, pp. 36, 186.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 40.—CUMINGS, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 741.—HENNIG, Archiv fur Zool., vol. 4, No. 10, 1908, p. 48.

Monticulipora (section 1) DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Form., 1877, p. 89.

Not *Callopora* GRAY, NORMAN, and LEVINSEN.

Unfortunate as it may seem to the paleontologist, the well-known generic name *Callopora* Hall must, according to the rules of nomenclature, be replaced by another term. Nickles and Bassler recognized the facts, and in their Synopsis of American Fossil Bryozoa published the following:

In 1848 Gray (Proc. Zool. Soc. London, Appendix, 1848, and List of British Animals in the collection of the British Museum, 1848, pp. 109, 146) proposed the generic term *Callopora* for a single species, the *Flustra lineata* of Linnæus, but the term failed to gain acceptance, and the species *lineata* is now considered to be a *Membranipora*. As *Callopora* Hall has become deeply engrafted into literature, it seems undesirable under the circumstances to replace it by a new name.

However, Gray gave a description of his genus, poor as it may be considered from the standpoint of to-day, and the important point of his work is that he selected a type species. *Callopora* must, therefore, stand based upon this species, even though more recent work should prove it to be a *Membranipora*. Such excellent authorities in the study of recent Bryozoa as Levinsen and Norman have worked out the details of Gray's *Callopora lineata* and consider the genus a valid one.

In view of the above, I propose the name *Hallopora* in honor of the distinguished paleontologist James Hall, to replace his Paleozoic genus *Callopora*. This new name seems most appropriate in commemoration in a small way of Professor Hall's work upon fossil Bryozoa, and particularly upon this generic group.

The zoaria of *Hallopora* are almost always solid ramose and bushy. In the perfect state the apertures are closed by perforated, ornamental covers which, as growth proceeds, form the diaphragms of succeeding layers.

Genotype.—*Callopora elegantula* Hall. Early Silurian of America and Europe.

HALLOPORA MULTITABULATA (Ulrich).

Text fig. 202.

Monotrypella multitabulata ULRICH, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 100.

Callopora multitabulata ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 280, pl. 23, figs. 11, 12, 16, 17, 24–26, 30, 31; Zittel's Textbook of Paleontology (Eng. ed.), 1896, p. 274, fig. 456 C, D.—SARDESON, Journ. Geol., vol. 9, 1901, p. 9, pl. A, figs. 5–6*d*.—RUEDEMANN, Bull. 49, New York State Mus., 1901 [1902], p. 13.—NICKLES, Kentucky Geol. Surv., Bull. 5, 1905, p. 42, pl. 1, fig. 2.—BASSLER, Proc. U. S. Nat. Mus., vol. 30, 1906, p. 22, pl. 1, figs. 5–7.

Several specimens in the collections from the Wassalem beds at Uxnorm are externally and internally so similar to examples of *Hallopora multitabulata* from the Black River and lowest Trenton rocks of Minnesota that were the two lots mixed they could not be sepa-

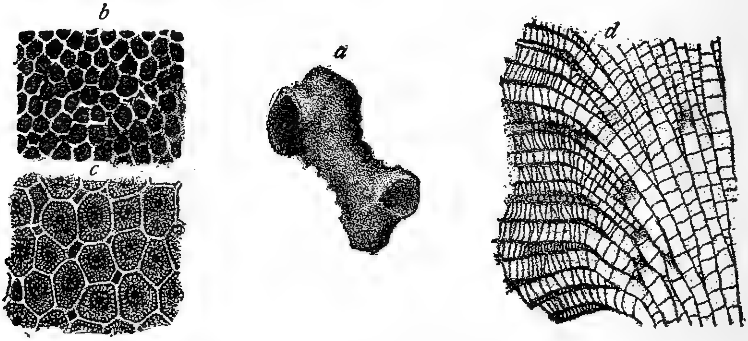


FIG. 202.—HALLOPORA MULTITABULATA. *a*, VIEW OF TYPICAL SPECIMEN, NATURAL SIZE; *b*, SURFACE OF THE SAME, ×9; *c*, SURFACE OF A FINELY PRESERVED EXAMPLE, ×18, SHOWING THE ORNAMENTED, ZOŒCIAL COVERS; *d*, VERTICAL SECTION, ×9, EXHIBITING THE CHARACTERISTIC CROWDED TABULATION. BLACK RIVER (DECORAH) SHALES, ST. PAUL, MINNESOTA. (AFTER ULRICH.)

rated. One of the Russian specimens is almost an exact duplicate of the American specimen shown in figure 202 *a*, while the internal structure shown in the vertical section, figure 202 *d*, is repeated in the thin sections of the foreign form.

The zoarium of *Hallopora multitabulata* is of more or less irregularly divided subcylindrical branches with rather strongly elevated monticules. The zoœcia at the surface are angular, thin-walled, and in close contact, about eight in 2 mm. The apertures of the zoœcia are often closed with ornamental opercula, as shown in figure 202 *c*. Mesopores are few. The most marked internal feature is the crowded tabulation shown in figure 202 *d*. In the immature zone the diaphragms are seldom more than their own diameter apart and frequently more closely spaced. In the mature zone six or seven diaphragms may frequently be counted in the space of a tube diameter. The few mesopores present are equally crowded.

Occurrence.—Abundant in the Black River and Lower Trenton strata of Minnesota, Iowa, Kentucky, and Tennessee. Less common in the Wassalem beds (D3) at Uxnorm, Esthonia (Cat. No. 57459, U.S.N.M.).

Represented in the British Museum by a specimen and thin section from Uxnorm.

HALLOPORA GOODHUENSIS (Ulrich).

Text figs. 203, 204.

Callopora goodhuensis Ulrich, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 282, pl. 23, figs. 9, 10, 21, 29.

This bryozoan is closely related to *Hallopora multitabulata* (Ulrich), but differs in that the surface is without monticules, the average size of the branches is less, the zoœcia are smaller, especially at the center of transverse sections, and their apertures are subangular and slightly smaller. The internal structure is very similar, the most marked

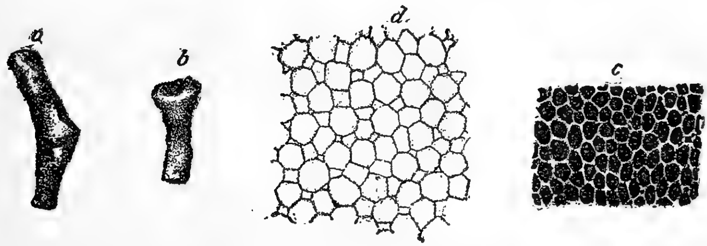


Fig. 203.—Hallopora goodhuensis. *a* and *b*, two fragments of natural size; *c*, surface of a specimen, ×9; *d*, axial region of a transverse section, ×18. Clitambonites bed of the lower Trenton limestone, near Cannon Falls, Minnesota. (After Ulrich.)

difference being that the mature region is narrower. The internal structure of a well developed Russian example is shown in figure 204.

Occurrence.—Abundant in the Clitambonites bed of the Lower Trenton at St. Paul and other localities in Minnesota; not uncommon in the Wassalem beds (D3) at Uxnorm, and in the Wesenberg limestone (E) at Wesenberg, Esthonia.

Plesiotypes.—Cat. Nos. 57460, 57461, U.S.N.M.

British Museum, specimens and thin sections from Uxnorm.

HALLOPORA WESENBERGIANA (Dybowski).

Plate 4, fig. 2–2*h;* text fig. 205.

Monticulipora wesenbergiana DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 95, pl. 3, figs. 2*a–h*.

Dybowski records this as a very abundant species at Wesenberg and gives a lengthy description and numerous figures of its charac-

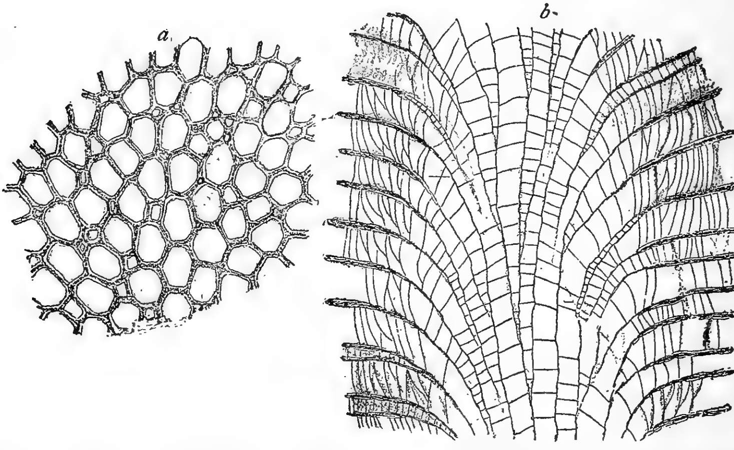


FIG. 204.—HALLOPORA GOODHUENSIS. *a*, TANGENTIAL SECTION, ×20, OF A SMALL BUT WELL DEVELOPED RUSSIAN SPECIMEN; *b*, VERTICAL SECTION OF THE SAME SPECIMEN, ×20. WASSALEM BEDS (D3), UXNORM, ESTHONIA.

ters. He fails to illustrate the tabulation, a most important character in the discrimination of such species, but I have no doubt that the common *Hallopora* of the Wesenberg limestone, whose internal characters are shown in figure 205 is Dybowski's *Monticulipora wesenbergiana.*

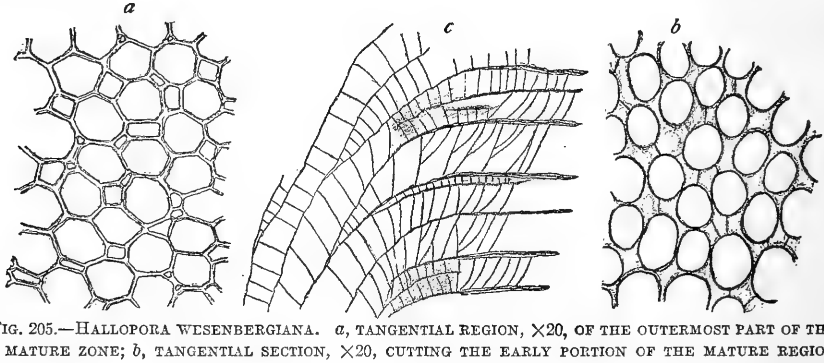


FIG. 205.—HALLOPORA WESENBERGIANA. *a*, TANGENTIAL REGION, ×20, OF THE OUTERMOST PART OF THE MATURE ZONE; *b*, TANGENTIAL SECTION, ×20, CUTTING THE EARLY PORTION OF THE MATURE REGION WHERE MESOPORES ARE BEST DEVELOPED; *c*, VERTICAL SECTION, ×20, SHOWING CHARACTERISTIC TABULATION. WESENBERG LIMESTONE, WESENBERG, ESTHONIA.

As shown in Dybowski's figure, the branches frequently and irregularly divide and average 5 mm. in diameter. Their surface is smooth, but maculæ of larger zoœcia and more numerous mesopores are frequently plainly evident to the unaided eye. The apertures are usually large, angular, thin-walled, with few mesopores, but in young specimens particularly mesopores are more numerous and sometimes completely isolate the zoœcia. Six zoœcia in 2 mm.

The internal characters are essentially the same as in *H. multitabulata.* The vertical section figured shows the average distribution of diaphragms, but in other examples the peripheral zone is broader and contains more numerous diaphragms. Here also it is to be observed that the mesopores are most common in the early part of the peripheral zone and pinch out before the surface is reached. This causes the variation to be observed in tangential sections. Such a section passing through the early part of this outer region shows, as seen in figure 205 *b*, rounded zoœcia more or less separated by mesopores. The zoœcia in a section taken just below the surface are angular, partly in contact, and mesopores are comparatively few.

Comparing *H. wesenbergiana* with *H. multitabulata,* its closest ally, it is found that the latter has smaller zoœcia (eight in 2 mm.), a tuberculated surface, and a more regular zoarium. The associated *H. goodhuensis* is also quite similar, but differs in having a small, more regularly branching zoarium, with smaller zoœcia and more regularly dividing branches. Indeed, these three species have so much in common that it requires close discrimination to separate them.

Occurrence.—Extremely abundant in the Wesenberg limestone (E) at Wesenberg and other localities in Esthonia; less common in the Wassalem beds (D3) at Uxnorm. The same species, or at least a closely related variety, occurs rarely in the Orthoceras limestone (B3) at Reval.

Plesiotype.—Cat. No. 57462, U.S.N.M.

Specimens and thin sections from the Wesenberg limestone at Wesenberg, are in the collections of the British Museum.

HALLOPORA SPLENDENS, new species.

Text fig. 206.

Cfr. *Callopora ampla* ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 281, pl. 23, figs. 13–15, 18–20, 22, 23, 27, 28.

Zoarium of irregularly divided, stout, subcylindrical branches averaging 10 mm. in diameter. Surface smooth, maculæ inconspicuous, 3 mm. distant from each other and made up of zoœcia slightly larger than the average. Zoœcia direct, angular, with rather thick walls for the genus, 5 in 2 mm. Zoœcial aperture often preserving ornamented opercula. Mesopores almost entirely absent at the surface but visible in vertical sections in the bend from the immature to the mature region. Ornamented opercula or closures are preserved on a few of the specimens.

In tangential sections the zoœcia are polygonal and in contact with each other, usually on all sides. The walls are comparatively thick, and show the original boundary line between the zoœcia as a well defined dark line. Mesopores are few and limited almost entirely to the maculæ.

Vertical sections are particularly interesting in showing the distribution of diaphragms and mesopores. As shown in figure 206 *e*, the latter originate in the bend from the immature to the mature zones, but frequently cease before the surface is reached. In some

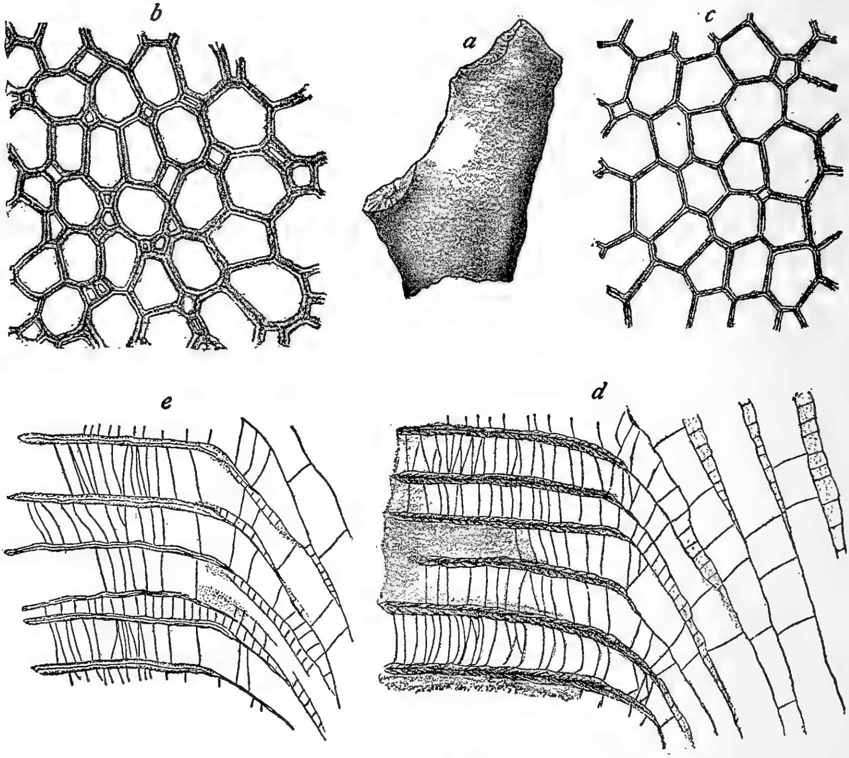


FIG. 206.—HALLOPORA SPLENDENS. *a*, FRAGMENTARY SPECIMEN, NATURAL SIZE; *b*, TANGENTIAL SECTION, ×20, CUTTING THE MOST MATURE PORTION OF THE ZOARIUM; *c*, USUAL ASPECT OF TANGENTIAL SECTIONS, ×20; *d*, VERTICAL SECTION, ×20, WITH PRACTICALLY NO MESOPORES; *e*, ANOTHER VERTICAL SECTION, ×20, ILLUSTRATING OCCURRENCE OF MESOPORES. JEWE LIMESTONE (D1), BARON TOLL'S ESTATE, ESTHONIA.

cases (see fig. 206 *d*) mesopores are practically absent, even in this restricted zone. As usual the diaphragms are closely arranged in the mesopores. In the zoœcia proper diaphragms are equally abundant as in the mesopores, in the earliest stages when the tubes are scarcely wider than the mesopores. After the zoœcia have attained their normal size, diaphragms are from one to three diameters distant from each other in the immature zone, but crowded in the mature region where 8 to 10 mm. may sometimes be counted in the length of one diameter.

Hallopora splendens is a fine example of that section of the genus typified by the American form *H. ampla* (Ulrich) in which diaphragms are exceedingly abundant in the mature zone and mesopores are correspondingly rare. Indeed, the species under discussion is closely related to *H. ampla,* differing especially in its more robust growth, larger and more direct zoœcia, and wider mature zone. *H. ampla* has six to seven zoœcia in 2 mm., its mature zone is usually quite narrow, and the zoœcia as a result are somewhat obliquely directed at the surface. *H. splendens* has five zoœcia in 2 mm., a wide, well-developed mature zone, and rather thick walled, direct zoœcia.

The associated form, *Hallopora tolli,* new species, has equally large zoœcia, but here mesopores are numerous and diaphragms are almost entirely wanting in the zoœcial tubes.

Occurrence.—Not uncommon in the Jewe limestone (D1), Baron Toll's estate, and at St. Mathias, Esthonia.

Holotype.—Cat. No. 57466, U.S.N.M.

Specimens and thin sections in the collections of the British Museum.

HALLOPORA DUMALIS (Ulrich).

Text fig. 207.

Callopora dumalis ULRICH, Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 282, pl. 23, figs. 1–8.

Several examples of a small, frequently branching *Hallopora* from the Kuckers shale possess the characters of the American species *H. dumalis,* illustrated in figure 207. The zoarium consists of num-

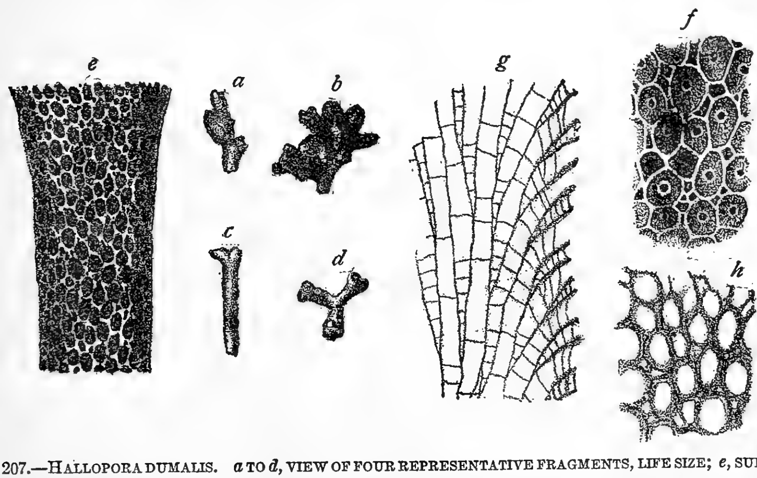


FIG. 207.—HALLOPORA DUMALIS. *a* TO *d*, VIEW OF FOUR REPRESENTATIVE FRAGMENTS, LIFE SIZE; *e*, SURFACE OF THE SLENDER SPECIMEN, ×9; *f*, SURFACE OF ANOTHER SPECIMEN, ×18, WITH ZOŒCIAL CLOSURES PRESERVED; *g*, VERTICAL SECTION, ×18; *h*, TANGENTIAL SECTION, ×18. PHYLLOPORINA BED OF BLACK RIVER (DECORAH) SHALES, ST. PAUL, MINNESOTA. (AFTER ULRICH.)

erous small branches averaging 1.5 mm. in diameter, inosculating to form a bushy mass. Fragments of a zoarium are shown in figures 207 *a* to *d*. The surface of these branches is smooth, with the zoœcial apertures in young examples more or less oblique, ovate, and separated by numerous mesopores. With age, the apertures become more direct and angular, with less numerous mesopores, as illustrated in figure 207 *e*. Seven to eight zoœcia in 2 mm. The American specimens occasionally show apertures with closures marked by faint lines radiating from a small central perforation. The internal characters are sufficiently illustrated in figure 207 *g* and *h* to require no description.

Occurrence.—Common in the Phylloporina bed of the Black River (Decorah) shales, and in the Clitambonites bed of the lowest Trenton at St. Paul and Cannon Falls, Minnesota. Apparently rare in the Kuckers shale (C2) at Reval, Esthonia (Cat. No. 57468, U.S.N.M.).

Represented in the collections of the British Museum by specimens from American localities.

HALLOPORA UNDULATA (Ulrich).

Text fig. 208.

Callopora undulata Ulrich, Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minnesota, 1886, p. 95; Geol. Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 279, pl. 22, figs. 24–31.

The slender, ramose branches with rather large rounded monticules and the internal structure shown in figure 208, are sufficient to separate this neat little *Hallopora* from other species of the genus. The

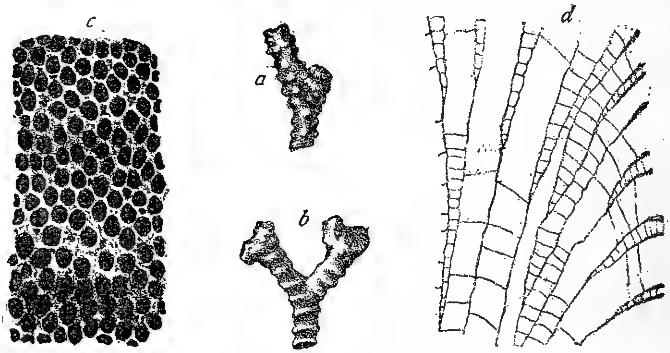


Fig. 208.—Hallopora undulata. *a* and *b*, typical specimens of the natural size; *c*, surface of original of figure *b*, ×9; *d*, vertical section, ×18. Black River (Decorah) shales, St. Paul, Minnesota. (After Ulrich.)

Russian examples referred to the species differ only in having a slightly less robust zoarium, a difference which would undoubtedly be eliminated with larger collections.

Ulrich's description is quoted below:

Zoarium ramose, branches slender, averaging about 2.5 or 3 mm. in diameter, dividing dichotomously at intervals of 10 mm. or more. Surface with rather large, rounded monticules, that usually coalesce laterally, forming transverse ridges, or more or less complete annulations, 5 in 10 mm. In some fragments and portions of others the monticules are separate, while in a few they are nearly obsolete. Zoœcia with moderately thin walls, subangular or ovate apertures, of nearly equal size over all portions of the surface; 10 or 11 in 3 mm. Mesopores comparatively few, small, not readily distinguished externally, their mouths usually closed. Zoœcial covers not observed.

Occurrence.—Common in the Black River (Decorah) shales at Minneapolis and St. Paul, Minnesota, and in the Wassalem beds (D3) at Uxnorm, Esthonia (Cat. No. 57469, U.S.N.M.).

British Museum, specimen and thin section from Uxnorm.

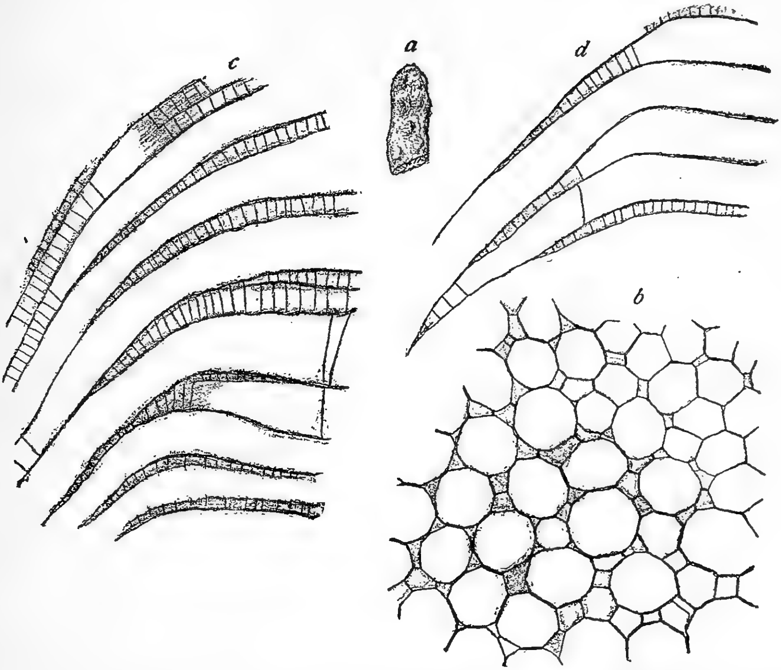


Fig. 209.—Hallopora tolli. *a*, small fragment, natural size; *b*, tangential section, ×20, showing large, thin-walled-zoœcia with numerous mesopores; *c* and *d*, two portions of a vertical section, ×20, exhibiting tabulation. Kuckers shale (C2), Reval, Esthonia, and Jewe limestone (D1), Baron Toll's estate.

HALLOPORA TOLLI, new species.

Text fig. 209.

This well marked species forms smooth, cylindrical branches 6 to 8 mm. in diameter, very much like *H. wesenbergiana*, but differing conspicuously in having much larger zoœcia. Internally the two are quite distinct, as a glance at the figures, especially of vertical sections, will show. In tangential section, *H. tolli* exhibits its polygonal to rounded, thin-walled zoœcia, four in 2 mm., with a fair number of small, angular mesopores. In the maculæ the mesopores are occasionally numerous enough to isolate the zoœcia, but elsewhere they are seldom so abundant.

Besides the large zoœcia and numerous mesopores, the tabulation is quite distinctive for this species. In the zoœcia proper, three or four diaphragms are inserted in the earliest portion of a tube; then they are practically absent until the close of the mature zone, when a few mesopores are occasionally found. The mesopores, as in other species of the genus, are closely tabulated throughout.

While the present species is quite different from associated bryozoans, it is closely related to a new species occurring in the lowest Trenton strata at Belleville, Canada. Indeed, the two agree in all respects save the occurrence of more numerous mesopores in the Russian form.

Occurrence.—Rare in the Jewe limestone (D1), Baron Toll's estate, Kuckers shale (C2), Reval, and in the Kegel limestone (D2), Kegel, Esthonia.

Cotypes.—Cat. Nos. 57470 to 57472, U.S.N.M.

HALLOPORA ELEGANTULA (Hall).

Text fig. 210.

Callopora elegantula HALL, Nat. Hist. New York, Pal., vol. 2, 1852, p. 144, pl. 40, figs. 1*a–m*.—ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 250, pl. 11, figs. 6–6*b*.—SIMPSON, Fourteenth Ann. Rep. State Geologist New York for the year 1894, 1897, pl. 18, figs. 1–7.—BASSLER, Bull. 292, U. S. Geol. Surv., 1906, p. 41, pl. 17, figs. 11–15; pl. 26, fig. 12.

Callopora nana NICHOLSON, Ann. and Mag. Nat. Hist., ser. 5, vol. 13, 1884, p. 120.

In breaking up limestone from the Borkholm formation, several fragments of a large celled *Hallopora* were found, which, upon study with thin sections, proved to be identical with the wide spread early Silurian species *H. elegantula.* This species has been described and figured on several occasions, so that I need only point out its diagnostic features.

The zoarium is of smooth branching stems 3 to 5 mm. in diameter, with large, rounded, thin-walled zoœcial apertures, four to five in 2 mm., separated by a variable number of mesopores. The apertures are frequently closed by ornamental covers, as shown in figure 210 *f*. The characteristic tabulation of both zoœcia and mesopores is illustrated in figures 210 *d* and *e*, while an ordinary tangential section through the mature zone is shown in figure 210 *c*. That the perforated closures become the tabulæ of succeeding zoœcia is evident from figure 210 *a*.

The smooth stems and the large, rounded apertures with numerous mesopores in addition to the internal generic characters, will readily serve to distinguish this species.

Occurrence.—Abundant in almost all of the early Silurian strata of North America. Hall's types came from the Niagaran (Rochester) shale of New York. In Europe the species is known from the Wenlock shales of England and in the equivalent strata on the island of

Gothland, where the name *Callopora nana* has been applied to it by Nicholson. The Russian specimens were derived from the Lyckholm limestone (F1), Kertel, island of Dago (Cat. No. 57474, U.S.N.M.),

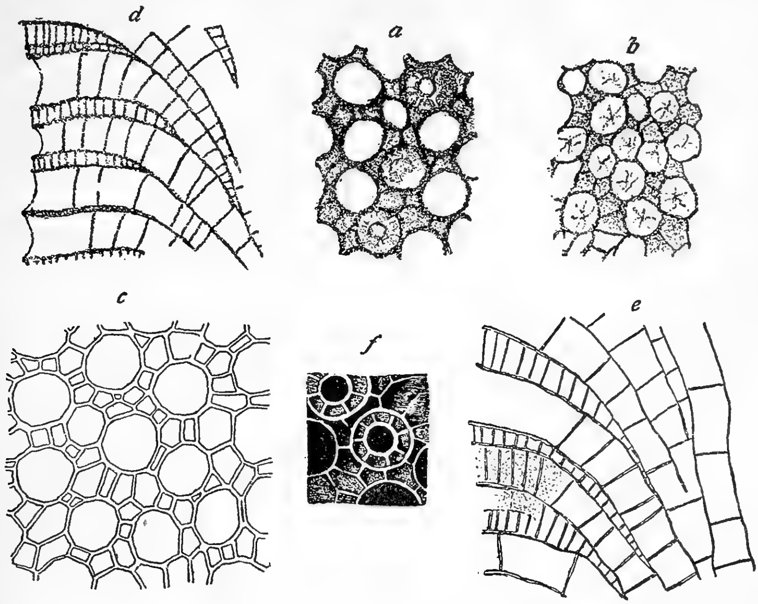


FIG. 210.—HALLOPORA ELEGANTULA. *a*, TANGENTIAL SECTION, ×18, WITH THREE OF THE ZOŒCIA SHOWING OPERCULA; *b*, TRANSVERSE SECTION, ×18, ILLUSTRATING THE SHAPE OF THE ZOŒCIA AND MESOPORES IN THE IMMATURE REGION; *c*, TANGENTIAL SECTION, ×20, THROUGH THE MATURE ZONE; *d* AND *e*, TWO VERTICAL SECTIONS, ×18 AND ×20, SHOWING SLIGHT DIFFERENCES; *f*, SURFACE VIEW OF SEVERAL ZOŒCIA, ×20, SHOWING PERFORATED CLOSURES. NIAGARAN (ROCHESTER SHALE), LOCKPORT, NEW YORK.

and the Borkholm limestone (F2), at Borkholm, Esthonia (Cat. No. 57475, U.S.N.M.).

Specimens from American localities in the British Museum.

HALLOPORA ? DYBOWSKII, new species.

Plate 5, figs. 1–1*l*; text figs. 211, 212.

Callopora nummiformis DYBOWSKI (part), Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 109, pl. 4, figs. 1*a*–*l* (part).—NICHOLSON, Man. of Paleontology, 1889, p. 348.

Not *Callopora nummiformis* HALL, Nat. Hist. New York, Pal., vol. 2, 1852, p. 148, pl. 40, figs. 5, 5*a*.

Associated with *Diplotrypa petropolitana* in the Russian and Swedish Middle Ordovician formations is a hemispheric bryozoan so similar in almost all respects that an examination of a vertical section or fracture is necessary to distinguish it. This new species is quite as abundant as its associate and the most conspicuous difference, without the examination of thin sections, is in its sparing development of diaphragms. Under the name of *Callopora nummiformis*

Hall, Dybowski figured a vertical section (see pl. 5, fig. 1 *l*), which is undoubtedly of this form. His tangential section (figs. 1–1 *e*) may also be from specimens of the same species. His figures 1 *f* to 1 *h*, however, are undoubtedly based upon thin sections of *Prasopora simulatrix* Ulrich, an abundant hemispheric bryozoan in the Trenton strata of America. Dybowski erroneously identified these several species with *Callopora nummiformis* Hall, a small, discoid bryozoan from the Silurian rocks of New York and Indiana. The latter species, which belongs to *Mesotrypa*, a genus of the Monticuliporidæ, has been figured by the present writer,[1] and comparison will show the error of Dybowski's identification.

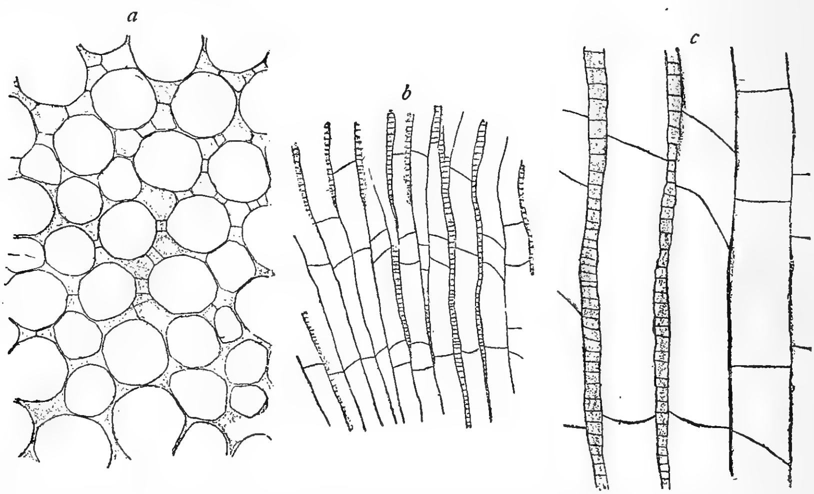


FIG. 211.—HALLOPORA ? DYBOWSKII. *a*, TANGENTIAL SECTION, ×20, WITH ZOŒCIA LESS ANGULAR THAN USUAL; *b*, VERTICAL SECTION, ×8, SHOWING CURVED DIAPHRAGMS; *c*, SEVERAL TUBES OF THE SAME, ×20. WESENBERG LIMESTONE (E), WESENBERG, ESTHONIA.

So far as the zoarial characters go, the description of *Diplotrypa petropolitana* will apply to the present form in every respect, and even the internal structure is somewhat similar. Tangential sections of the two species are almost identical. Slight differences exist, but these can not be described as permanent because of the variation in each in shape of zoœcia and number of mesopores. In vertical sections the widely separated diaphragms, three to ten tube diameters apart, in the zoœcial tubes of *H.? dybowskii*, are in marked contrast with the numerous diaphragms of the similar species. That this is a constant difference was shown by a study of over one hundred specimens of both species, each specimen falling into its particular place, with no intermediate forms. Continuing the comparison with *D. petropolitana* it is found that *H.? dybowskii* does not possess the beaded walls characteristic of *Diplotrypa*. Moreover, as in other

[1] Bull. 292, U. S. Geol. Surv., 1906, pl. 10, figs. 1, 2.

species of *Hallopora*, its diaphragms have at one time served as closures for the zoœcia, as shown in Dybowski's figure 1 *i* of plate 5. The presence of these ornamental, centrally perforated closures, the rounded zoœcia and closely tabulated mesopores with straight walls, and the absence of acanthopores, cause me to place the species in the genus *Hallopora*. The growth is not in accord with this genus, nor does the tabulation of zoœcia strictly agree, so, for this reason, I am questioning the generic identification.

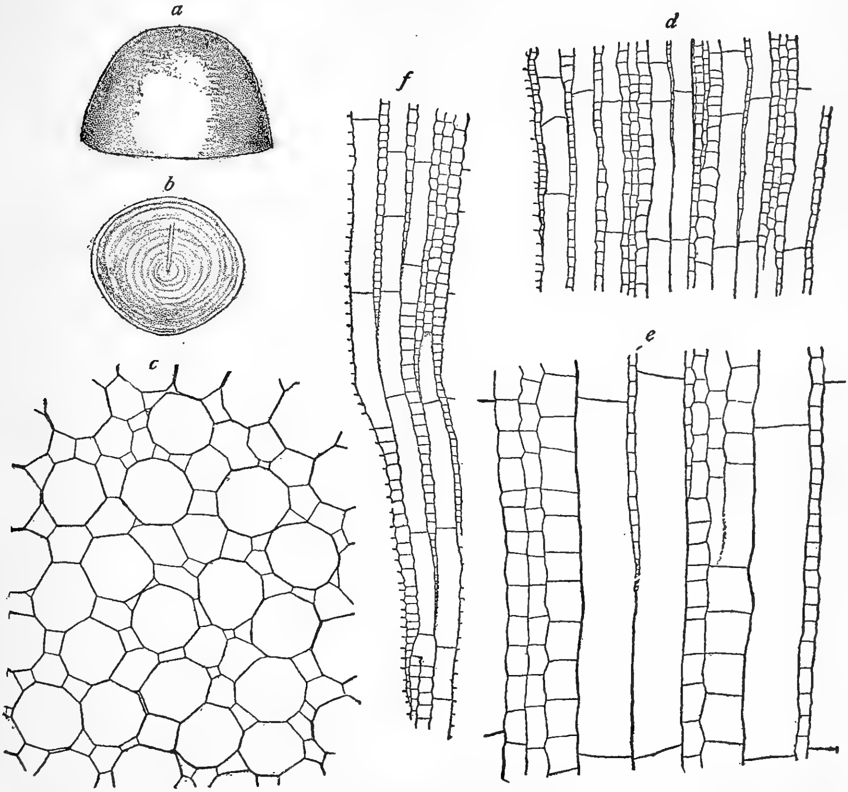


FIG. 212.—HALLOPORA ? DYBOWSKII. *a*, SIDE VIEW OF A SMALL EXAMPLE, NATURAL SIZE; *b*, BASAL VIEW SHOWING WRINKLED EPITHECA AND CICATRIX OF ATTACHMENT; *c*, AN AVERAGE TANGENTIAL SECTION, ×20; *d*, VERTICAL SECTION, ×8, SHOWING THE NORMAL FEATURES OF THE SPECIES; *e*, PORTION OF THE SAME, ×20; *f*, A LONG VERTICAL SECTION, ×8, EXHIBITING THE DISTRIBUTION OF DIAPHRAGMS. TWO OF THE ZOŒCIAL TUBES REPLACE MESOPORES. JEWE LIMESTONE (D1), BARON TOLL'S ESTATE, ESTHONIA.

By examining a moistened longitudinal fracture with a hand lens no difficulty will be experienced in separating associated hemispheric bryozoans from this species. The specific name is in honor of the excellent pioneer work of Dr. Dybowski upon Paleozoic Bryozoa.

Occurrence.—Abundant at various localities in Esthonia in formations ranging from the Echinospherites limestone (C1) to the Wesenberg (E). The particular localities represented in the collection of the U. S. National Museum are Reval and Gastilizy, in the Echinospherites limestone (C1), Baron Toll's estate, in the Kuckers shale (C2) and Jewe limestone (D1), and at Wesenberg, in the Wesenberg limestone (E). The species also occurs in the Chasmops limestone on the island of Oeland, Sweden.

Cotypes.—Cat. Nos. 57473, 57476 to 57480, U.S.N.M.

A fragment of the sectioned type and two thin sections from the Jewe limestone, Baron Toll's estate, and specimens from the Chasmops limestone, island of Oeland, are in the collections of the British Museum.

HALLOPORA? TENUISPINOSA, new species.

Text fig. 213.

This interesting species, in manner of growth and tabulation has much in common with other species of *Hallopora*, but differs from all the described forms in the development of rather numerous shallow acanthopores. These are plainly visible at the surface of well preserved specimens, but they are seen in thin sections only when the outermost part of the peripheral zone is cut.

The zoarium of this species is of dwarfed stems seldom branching more than once. The specimen shown in figure 213 is a typical example of a complete zoarium. The surface is smooth and presents no well-marked maculæ, although groups of slightly larger zoœcia can be discovered upon close observation. The zoœcial apertures are thin walled and vary from a rounded to polygonal shape, according to the number of intervening mesopores. In the mature condition, three to five small, sharp acanthopores project from each zoœcial wall. Four and one-half to five zoœcia in 2 mm.

In vertical sections the tabulation of both sets of tubes is seen to be essentially the same as in the usual species of *Hallopora*. In the zoœcial tubes, diaphragms are abundant in the earliest part of the immature zone, and are then wanting almost entirely throughout the rest of the tubes. In the mesopores, the cross partitions average their own diameter apart. Their place is almost always marked by a constriction of the walls, producing the beaded effect most conspicuous in *Diplotrypa*.

Tangential sections show thin-walled, rounded to polygonal zoœcia with numerous mesopores. Occasionally two zoœcia are in contact and then exhibit the dark divisional line of the Integrata. The exceptional feature of such sections is the occurrence of small acanthopores, which, however, are seldom as numerous as at the surface itself. These acanthopores are very shallow and, as a rule, are included in thin sections only accidentally.

This species is referred to *Hallopora* because of its general zoarial and zoœcial structure. The acanthopores and beaded mesopores are features indicative of the Trematoporidæ, but until more species are known, I prefer to classify the present form as a doubtful *Hallopora*.

Occurrence.—Common in the Wesenberg limestone (E) at Wesenberg, Esthonia. Less common in the Kegel limestone (D2) at Kegel, Esthonia.

Holotype.—Cat. No. 57481, U.S.N.M.

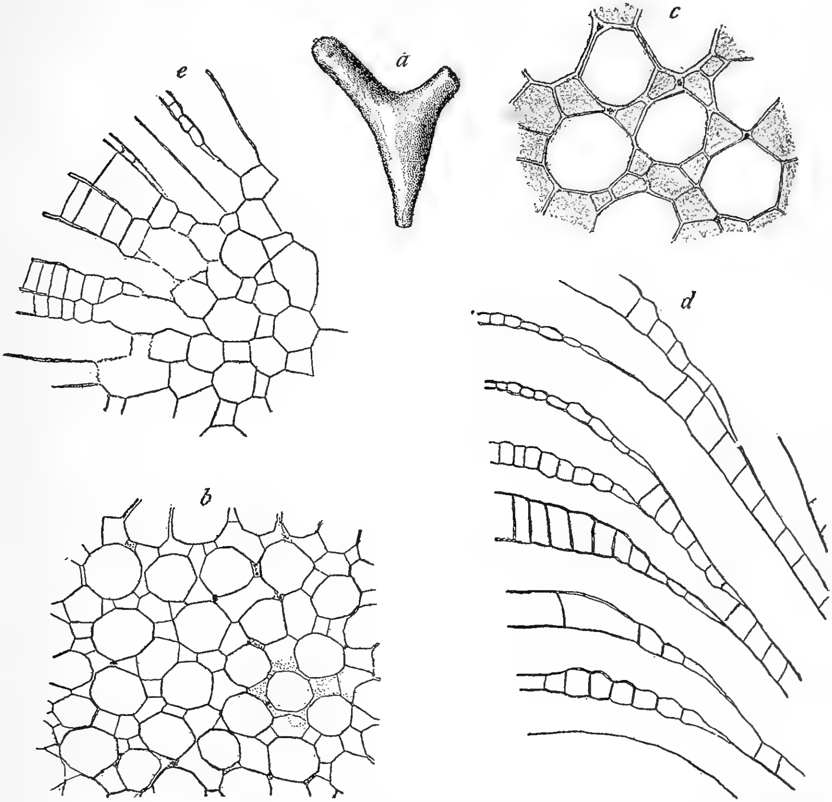


Fig. 213.—Hallopora ? tenuispinosa. *a*, an ordinary fragment, natural size; *b*, tangential section, ×20, showing a few small acanthopores; *c*, portion of the same, ×35, with the structure of zoœcia and acanthopores more clearly exhibited; *d*, vertical section, ×20, with characteristic tabulation; *e*, portion of a transverse section, ×20. Wesenberg limestone (E), Wesenberg, Esthonia.

A thin section of the type-specimen is in the collections of the British Museum.

UNDETERMINED GENERA AND SPECIES.

Although I have attempted to identify all of the Russian Ordovician forms previously described, it happens that there are still quite a number so poorly defined and figured that I at least am able to do nothing with them. In all of these cases, so far as I am aware, the original types are either lost or are not distinguished. Should some future student be able to discover these types, and from their study give a clear idea of the forms, unrecognizable at present, the generic and specific names, according to the rules of nomenclature, will date from his work, and should synonyms of species herein described be discovered, the standing of the latter will not be invalidated. For the sake of convenience, these unrecognizable genera and species are discussed in alphabetical order. In the following notes reference is also made to genera and species from the Russian Ordovician deposits incorrectly placed in the Bryozoa, or worth mentioning for other reasons.

Genus ARCHEOPORA Eichwald.

Archeopora Eichwald, Lethæa Rossica, vol. 1, 1860, p. 405.

The eight species described under this genus by Eichwald range in time from the Ordovician to the Carboniferous, and undoubtedly embrace a number of generic types. No type species is mentioned, and the first species, *Archeopora lamella* may be accepted as the genotype. The generic character, according to Eichwald, is that the bryozoan consists of a single incrusting, calcareous layer, made up of circular cells [zoœcia] isolated from each other by minute pores [mesopores]. Such a zoarium and arrangement of zoœcia and mesopores occurs in a number of genera, and, without further data, the genus is unrecognizable.

ARCHEOPORA LAMELLA Eichwald.

Text fig. 214.

Archeopora lamella Eichwald, Lethæa Rossica, vol. 1, 1860, p. 405, pl. 24, figs. 17, 18.

The description of this species contains no characters of any value other than that the zoarium is incrusting with the cells rounded and separated from each other by minute pores. Eichwald's figures are

Fig. 214.—Archeopora lamella. Eichwald's views of his type-specimens, one (*a* and *b*, natural size and enlarged) showing mesopores, and the second (*c* and *d*) apparently with solid interzoœcial spaces.

here reproduced, but without knowing the particular horizon and locality of the originals, and the amount of magnification, none of which is given, one can hardly even make a guess as to the species.

It is also most likely that a number of forms was grouped under this name, since the occurrence of the species is given as the Ordovician limestone, in the vicinity of Zarskoje, Wesenberg, and Erras, and the Silurian strata on the island of Oesel and at Kamenetz Podolsk.

ARCHEOPORA ANGULOSA Eichwald.

Text fig. 215.

Archeopora angulosa Eichwald, Lethæa Rossica, vol. 1, 1860 p. 410, pl. 26, fig. 2.

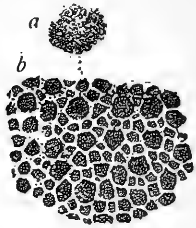


Fig. 215.—Archeopora angulosa. *a* and *b*, the incrusting type-specimen, natural size and enlarged, showing angular zoœcia and open mesopores. (After Eichwald.)

This species forms thin, incrusting expansions upon *Echinospherites* in the Ordovician limestone at Pulkowa and at Wesenberg, the figured specimen being from the latter locality. Both the zoœcia and mesopores, as indicated in figure 215, are angular, differing in that respect from *A. lamella*. I am unacquainted with an incrusting form of this sort from either Pulkowa or Wesenberg, but even were such specimens before me, more specific characters than are given by Eichwald would be necessary before an identification of any value could be made.

ARCHEOPORA PUNCTATA Eichwald.

Text fig. 216.

Archeopora punctata Eichwald, Lethæa Rossica, vol. 1, 1860, p. 406, pl. 24, fig. 19.

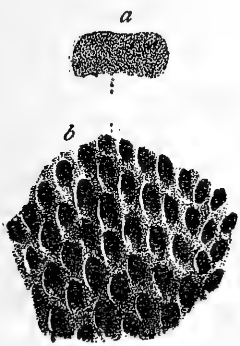


Fig. 216.—Archeopora punctata. *a* and *b*, the type-specimen, natural size and enlarged. Ordovician limestone, Dolgaja River, government of St. Petersburg. (After Eichwald.)

The description of this species includes more details than that of any other of the various Ordovician forms referred to the genus, and it is possible that the new species, *Favositella punctata*, described in this volume, is based upon the same form. For this reason I have selected the same name for the supposed new species of *Favositella* and have indicated its possible identity with *Archeopora punctata* in the synonymy. Eichwald describes *Archeopora punctata* as a thin, rounded, lamellar expansion, with thick-walled, oval cells radiately arranged. One end of the cell is higher than the other [lunarium], and ten rows of cells occur in the space of a line. Eichwald's figure also bears a resemblance to those of the *Favositella*, but in spite of these several facts one can not be certain of the identity of *A. punctata* until the type or authentic specimens are restudied.

Occurrence.—Archeopora punctata was recorded from the Ordovician (Orthoceratite) limestone along the Dolgaja River, Gdow district, government of St. Petersburg. *Favositella punctata* is common at Uxnorm, Esthonia, in the Wassalem beds (D3).

ARCHEOPORA RADIANS Eichwald.

Text fig. 217.

Archeopora radians Eichwald, Lethæa Rossica, vol. 1, 1860, p. 408, pl. 24, fig. 20.

The figures of this species indicate without the slightest doubt that it is founded upon the basal side of some parasitic bryozoan. As many forms would present the same or a quite similar appearance from this side, it is obviously impossible to recognize the particular one Eichwald figured. The species must, therefore, be classed as unrecognizable.

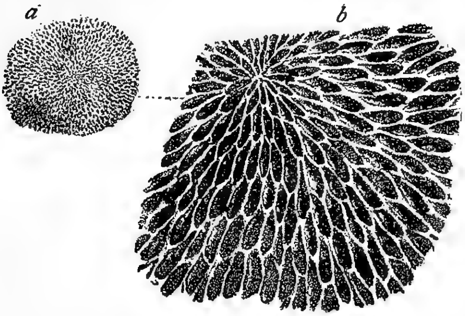


Fig. 217.—Archeopora radians. *a* and *b*, the type-specimen, natural size and enlarged. (After Eichwald.)

Occurrence.—Ordovician limestone, near Pulkowa and Wesenberg.

CALAMOPORA ALVEOLARIS Goldfuss.

Calamopora alveolaris Goldfuss, Petref. Germ., vol. 1, 1826, p. 77, pl. 26, fig. 1.—Eichwald, Lethæa Rossica, vol. 1, 1860, p. 466.

Russian specimens from various horizons and localities have been identified as above by Eichwald with this species, which, as figured by Goldfuss, is a typical *Favosites*. The Ordovician specimens so referred have certainly little in common with the latter form.

CALAMOPORA FIBROSA Goldfuss.

Calamopora fibrosa var. *tuberosa ramosa* Goldfuss, Petref. Germ., vol. 1, 1826, p. 82, pl. 28, fig. 3.

Calamopora fibrosa Eichwald, Lethæa Rossica, vol. 1, 1860, p. 469.

Under this name Eichwald described one or more of the numerous massive Russian bryozoans, but which can not be determined. Goldfuss's species is likewise so figured and described that it can not be recognized.

Eichwald records the species from both Ordovician and Silurian localities of Baltic Russia.

CALAMOPORA POLYMORPHA Goldfuss.

Calamopora polymorpha Goldfuss, Petref. Germ., vol. 1, 1826, p. 79, pl. 27, figs. 2–5.—Eichwald, Lethæa Rossica, vol. 1, 1860, p. 466.

The Ordovician specimen so identified can not be recognized from Eichwald's description, but are certainly very different from the Devonian fossils figured by Goldfuss under this name.

Occurrence.—Identified in Russian Ordovician at Pulkowa, Erras, and Wesenberg, as well as in later horizons at various localities.

CALAMOPORA RETICULATA Eichwald.

Text fig. 218.

Calamopora reticulata EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 469, pl. 23, figs. 6 *a*, *b*.

The Ordovician specimen figured by Eichwald under the above name is probably a well-preserved fragment of *Hemiphragma panderi* (Dybowski). This identification can not of course be made positively without a study of the figured example, but the ramose zoarium, shape of zoœcia, absence of mesopores, and especially the arrangement of the numerous acanthopores recall the *Hemiphragma.*

CALLOPORA LIGNIFORMIS Dybowski.

Plate 5, fig. 5, 5 *a*.

Callopora ligniformis DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Form., 1877, p. 116, pl. 4, figs. 5, 5 *a*.

According to Dybowski, the zoarium of this species is of cylindrical, solid, ramose, smooth branches, with an internal structure much like his *Callopora nummiformis.* I have not come across specimens with these characteristics and can not place the species.

Occurrence.—Probably in the Wassalem beds (D3), Wassalem and Erras, Esthonia.

FIG. 218.—CALAMOPORA RETICULATA. *a* AND *b*, ZOARIUM NATURAL SIZE AND SURFACE ENLARGED. (AFTER EICHWALD.)

CALLOPORA PIRIFORMIS (Eichwald).

Plate 5, figs. 6, 6*a*, 6*b*.

Dianulites piriformis EICHWALD, Zool. spec., vol. 1, 1832, p. 181, pl. 2, figs. 1, 2.

Chætetes piriformis EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 478.

Callopora piriformis DYBOWSKI, Die Chaetetiden der Ostbaltischen Silur-Form., 1877, p. 117, pl. 4, fig. 6 *a*, *b*.

Although this species seems to have been fairly well figured by Eichwald and later by Dybowski, I am unable from either their descriptions or figures to place it definitely. Dybowski mentions the great resemblance of its internal structure to that of his *Callopora nummiformis* (=*Hallopora ? dybowskii*), but his figures, although bearing out his remarks in part, show an almost complete absence of diaphragms in the zoœcial tubes. At any rate, *Dianulites piriformis* must be regarded as one of the undetermined species.

Occurrence.—Formation B, Pulkowa, government of St. Petersburg.

DIANULITES APICULATUS (Eichwald).

Plate 2, figs. 7, 8; text fig. 219.

Millepora apiculata Eichwald, Inter ingrica, 1825, p. 21.
Orbitulites apiculatus Eichwald, Zool. spec., vol. 1, 1829, p. 150, pl. 2, fig. 3.
Chætetes apiculatus Eichwald, Lethæa Rossica, vol. 1, 1860, p. 479, pl. 28, figs. 1 *a–d*.
Dianulites apiculatus Dybowski, Die Chaetetiden der Ostbaltischen Silur-Form., 1877, p. 32, pl. 1, figs. 7, 8.

Eichwald's figures and description of *Chætetes apiculatus* are of practically no value in distinguishing it from the numerous other massive Russian bryozoans. Dybowski's treatment of the species is but little better. My guess regarding the species is that it is founded upon small examples of *Dianulites petropolitana,* or some other massive bryozoan with the base covered by a layer of the smaller, thick-walled, closely tabulated mesopore-like cells.

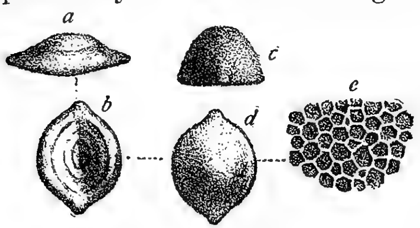


Fig. 219.—Dianulites apiculatus. *a* to *d*, four views of Eichwald's type of Chætetes apiculatus; *e*, celluliferous surface enlarged. (After Eichwald.)

Occurrence.—Dybowski cites Erras, Duboviki, Pulkowa, and Popowa as localities.

DIANULITES HAYDENII Dybowski.

Plate 2, figs. 11–11*b*.

Dianulites haydenii Dybowski, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 37, pl. 1, figs. 11 *a–b*.

Although Dybowski gives a detailed description and figures the internal structure of this species, he shows no characters which enable me to recognize what particular form he had in mind. Without a restudy of the type-specimens, if they are available, I fear that *Dianulites haydenii* can not be recognized.

Occurrence.—Middle Ordovician, Wesenberg and Wassalem.

DIANULITES SULCATUS Dybowski.

Plate 2, figs. 12–12*b*.

Dianulites sulcatus Dybowski, Die Chaetetiden der Ostbaltischen Silur-Formation, 1877, p. 38, pl. 1, fig. 12*a*, *b*.

The figures of this species are clearly of some *Homotrypa* or *Homotrypella,* but for lack of specimens from the type locality, I am unable to decide the relationship of the form. If the zoarial growth shown by Dybowski is constant, this alone should help in identifying the species.

Occurrence.—Probably Lyckholm limestone, Kertel, island of Dago.

ESCHARIPORA RECTA Eichwald.

Escharipora recta EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 435, pl. 27, figs. 8*a–c*.
Not *Escharopora recta* HALL.

The species referred by Eichwald to Hall's *Escharopora recta*, a well known bryozoan from the Trenton formation of New York, has no relationship to this or any other bryozoan, but is allied to *Receptaculites* and *Ischadites*. The latter alliances were recognized by Eichwald, since he placed his description of *Escharipora recta* next to those of *Ischadites*. His error was in the identification of his species, and not in its classification.

Occurrence.—Eichwald cites the species as from the "Calcaire à Orthoceratites," island of Dago.

Genus MICROPORA Eichwald.

Micropora EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 393.

The status of this genus has been indicated on page 127. *Micropora gracilis* Eichwald, the first species, proves to be a valid species of *Stictoporella*, and the generic name *Micropora* might have been retained instead of *Stictoporella* had it not been employed by Gray previously for another generic type of bryozoans.

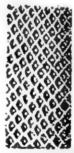


FIG. 220.—MICROPORA RHOMBICA. FRAGMENT OF ZOARIUM, ENLARGED. ORDOVICIAN, REVAL, ESTHONIA. (AFTER EICHWALD.)

MICROPORA RHOMBICA (Eichwald).

Text fig. 220.

Eschara rhombica EICHWALD, Urwelt Russlands, vol. 2, 1847, p. 43, pl. 1, fig. 3.
Micropora rhombica EICHWALD, Bull. Soc. Nat. des Moscou, 1855, p. 458; Lethæa Rossica, vol. 1, 1860, p. 395.

Eichwald's description of this species is of little value for accurate determination, but the original of his figure, reproduced here, is in all probability a species of *Escharopora*. *E. subrecta* is the only Russian species of the genus so far noted, and it is possible that *Micropora rhombica* refers to the same form. Should Eichwald's type be discovered and found to be the same as *Escharopora subrecta*, this would not affect the synonymy, since *Micropora rhombica* can not be considered as sufficiently described and figured to be recognized.

Occurrence.—"Calcaire à Orthoceratites de Reval."

Genus MYRIOLITHES Eichwald.

Myriolithes EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 450.

Although this genus was described as a member of the tabulate corals, it is probable that the type-species, *M. fastigiatus* is a ramose monticuliporoid bryozoan. Neither Eichwald's figure nor description is sufficient to determine the matter, and until his type-specimens are restudied, the genus can not be considered valid. The other three species referred to *Myriolithes* by Eichwald are from Carboniferous strata and undoubtedly belong to a genus distinct from the Ordovician type.

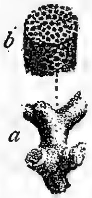


FIG. 221.—MYRIOLITHES FASTIGIATUS. *a*, THE TYPE-SPECIMEN, NATURAL SIZE AND SLIGHTLY ENLARGED. ORDOVICIAN, PULKOWA, GOVERNMENT OF ST. PETERSBURG. (AFTER EICHWALD.)

MYRIOLITHES FASTIGIATUS (Eichwald).

Text fig. 221.

Millepora fastigiata EICHWALD, Observat. de Trilobit., 1825, p. 21.
Myriapora fastigiata EICHWALD, Bull. Soc. Nat. Moscou, 1856, p. 88.
Myriolithes fastigiatus EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 450, pl. 26, fig. 13*a*, *b*.

The facts concerning this species are noted above. The species can not be recognized from either the description or figure.

Occurrence.—"Calcaire à Orthoceratites de Poulkowa."

MONTICULIPORA OVULUM Eichwald.

Monticulipora ovulum EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 492, pl. 25, figs. 8*a–d*.

Although this is registered as a *Monticulipora* by Eichwald, his figured specimen is undoubtedly a coral like *Heliolites* and not a bryozoan.

ORBIPORA FUNGIFORMIS Eichwald.

Text fig. 222.

Orbipora fungiformis EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 485, pl. 28, fig. 4*a*, *b*, *c*.

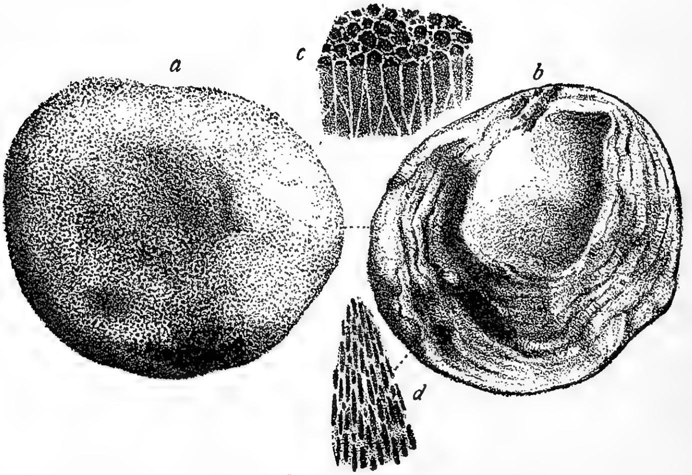


FIG. 222.—ORBIPORA FUNGIFORMIS. *a* AND *b*, CELLULIFEROUS AND EPITHECATED SIDES OF THE TYPE-SPECIMEN; *c*, CELLULIFEROUS SURFACE ENLARGED; *d*, BASAL SIDE, ENLARGED. HOHENHOLM, ISLAND OF DAGO. (AFTER EICHWALD.)

Eichwald's description and figures are the only ones of any value that have ever been published regarding this species. As shown by the figure here introduced, little can be said about the species except that it is a massive bryozoan, apparently. Before the species can be considered valid, the internal structure of the type must be described and figured.

Occurrence.—Hohenholm, island of Dago, probably in the Lyckholm limestone.

Genus PTEROPORA Eichwald.

Pteropora EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 395.

According to Eichwald, this genus is related to *Ichthyorachis* McCoy, but differs in having a celluliferous tissue connecting the lateral branches. It is in this very character that the genus is peculiar and unlike any other fenestellid or similar bryozoan. Eichwald possessed only a single specimen of each of his species, and as these were attached to the rock he did not determine the nature of the opposite face. None of the specimens in the various collections I have studied has shown the characters ascribed to *Pteropora*.

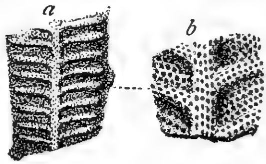


FIG. 223.—PTEROPORA PENNULA. *a* AND *b*, EICHWALD'S VIEWS OF THE TYPE-SPECIMEN, NATURAL SIZE AND ENLARGED. ORDOVICIAN, SPITHAM, ESTHONIA.

PTEROPORA PENNULA Eichwald.

Text fig. 223.

Pteropora pennula EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 396, pl. 23, figs. 15*a*, *b*.

As remarked above, I have been unable to identify this species, and, in accordance with my plan of including identified species only in the main body of this paper, this and the following form must remain uncertain.

Occurrence.—"Calcaire à Ortheratites," Spitham, Esthonia.

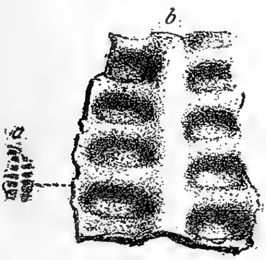


FIG. 224.—PTEROPORA EXILIS. *a* AND *b*, ZOARIUM NATURAL SIZE, ENLARGED. ORDOVICIAN, ERRAS, ESTHONIA. (AFTER EICHWALD.)

PTEROPORA EXILIS Eichwald.

Text fig. 224.

Pteropora exilis EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 397.

All that is known of this species is shown in the accompanying figure.

Occurrence.—"Calcaire à Orthoceratites," Erras, Esthonia.

PTILOPORA DISTICHA Goldfuss.

Glauconome disticha GOLDFUSS, Petref. Germ., vol. 1, 1827, p. 217, pl. 64, fig. 15.
Ptilopora disticha EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 383.

Under the above name Eichwald identified a species supposed to be the same as the widespread Silurian form now known as *Pennirete-*

pora disticha. Eichwald's specimens were recorded from the inflammable, argillaceous shale (Kuckers, C2), near Erras. I have not seen this form and the identification is probably incorrect.

Genus RHABDINOPORA Eichwald.

Rhabdinopora EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 368.

This genus was described as belonging to the Bryozoa, an error which is now well known since its genotype, *Rhabdinopora flabelliformis* is the widespread form best known as *Dictyonema flabelliformis*. In our list of foreign genera, Nickles and myself[1] included *Rhabdinopora* among the Bryozoa with the comment "seems to be a fenestellid with one row of cells to the branch; this is a type unknown to us, unless it be a case of defective observation." The present allusion to *Rhabdinopora* is to correct the error of its reference to the Bryozoa.

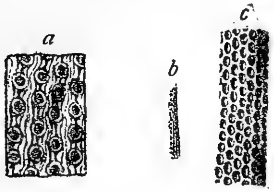


FIG. 225.—STICTOPORA SCALPELLIFORMIS. *a*, EICHWALD'S FIGURE OF THE SURFACE ENLARGED; *b* AND *c*, EICHWALD'S ORIGINAL FIGURE OF THE SAME SPECIES.

STICTOPORA SCALPELLIFORMIS (Eichwald).

Text fig. 225.

Eschara scalpelliformis EICHWALD, Urwelt Russlands, vol. 2, pl. 1, fig. 1; Lethæa Rossica, vol. 1, 1860, p. 391, pl. 33, fig. 3*a*, 3*b*.

The two type-specimens of this species as shown by the accompanying figures, are undoubtedly different. I have not encountered any specimen which might be identified with either one of the types. Without an actual restudy of these types, the species can not be considered as valid.

Occurrence.—"Calcaire à Orthoceratite," Reval and Erras.

VINCULARIA MEGASTOMA Eichwald.

Text fig. 226.

Vincularia megastoma EICHWALD, Lethæa Rossica, vol. 1, 1860, p. 402, pl. 24, fig. 9.

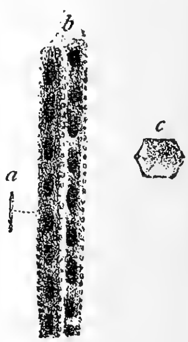


FIG. 226.—VINCULARIA MEGASTOMA. *a* AND *b*, TYPE-SPECIMEN, ×1 AND ENLARGED; *c*, CROSS-SECTION OF SAME. (AFTER EICHWALD.)

This species is registered from several post-Ordovician localities and from the middle Ordovician at Wesenberg. If the figured type came from Wesenberg, and is correctly illustrated, the species is undoubtedly a *Nematopora* closely allied to *N. granosa* Ulrich[2] from the lowest Trenton beds at Cannon Falls, Minnesota. The collections from the Wesenberg limestone have afforded no specimens of this kind, and until the type locality of *V. megastoma* is known, the species can not be identified with certainty.

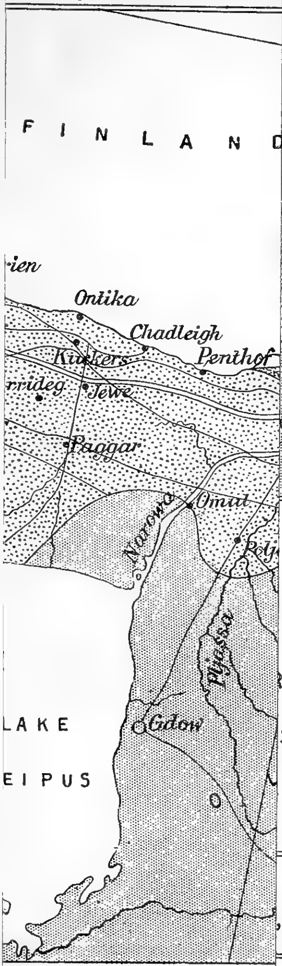
[1] Synopsis of American Fossil Bryozoa, Bull. 173, U. S. Geol. Surv., 1900, p. 57.

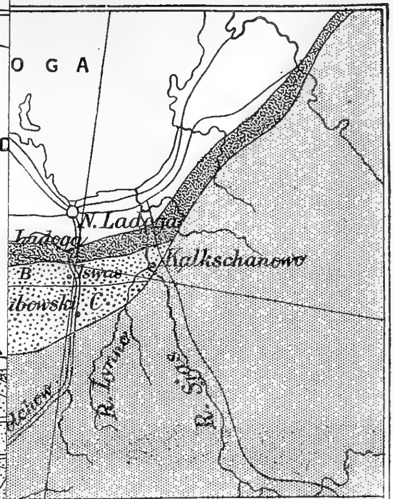
[2] Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 196, fig. 20; Geol. and Nat. Hist. Surv. Minnesota, vol. 3, pt. 1, 1893, p. 205, pl. 3, figs. 17-20.

EXPLANATION OF PLATES.

PLATE 1.

Geologic map of the Russian Baltic Provinces (after von Schmidt).





(AND CAMBRIAN)

ROVINCES OF RUSSIA

STHONIA, LIVONIA

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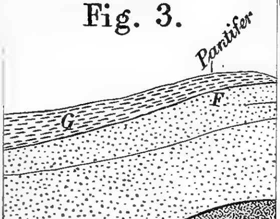
G-K

Fig. 3.



HONIA ON THE GULF OF F
LOGICAL MAP OF ESTHONIA,

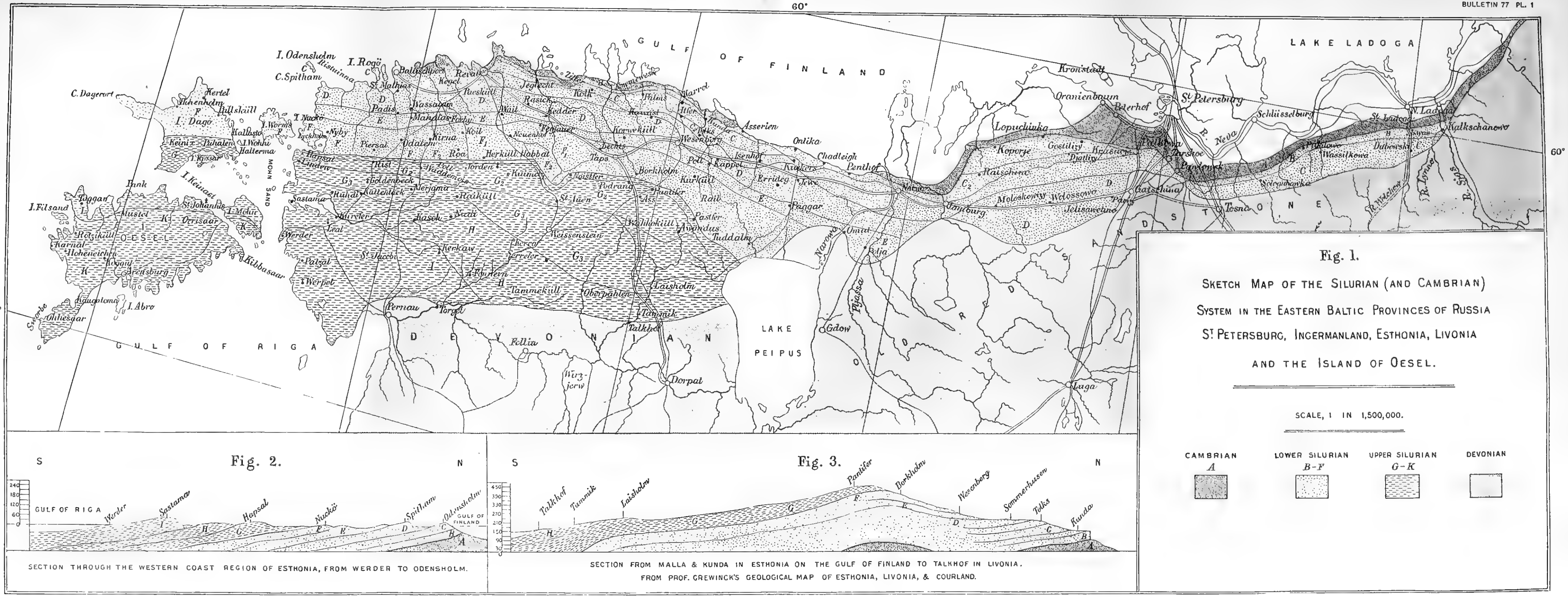


Fig. 2. SECTION THROUGH THE WESTERN COAST REGION OF ESTHONIA, FROM WERDER TO ODENSHOLM.

Fig. 3. SECTION FROM MALLA & KUNDA IN ESTHONIA ON THE GULF OF FINLAND TO TALKHOF IN LIVONIA. FROM PROF. GREWINCK'S GEOLOGICAL MAP OF ESTHONIA, LIVONIA, & COURLAND.

PLATE 2.

[After Dybowski.]

This and the three following plates, copied from Dybowski, are about two-thirds of the size as published by him. In the descriptions of these plates the generic and specific names are as given by Dybowski, while the horizon and locality were obtained from his descriptions. Notes by the present writer are enclosed in brackets.

Dianulites fastigiatus Eichwald.

Fig. 1. Transverse section through middle portion of zoarium.
2. Tangential section near surface of colony.
3. Vertical section.
Zone 1 [B], Reval, Pulkowa, etc.

Dianulites petropolitanus Pander, sp.

4. Tangential section.
5. Vertical section.
Zones 1 and 2 [B], various localities.

Dianulites petropolitanus var. *hexaporites* Pander.

6. Side view of zoarium, ×2/3.
6*a*. Surface of zoarium, ×2/3.
Zone 1 [B], Reval, Pulkowa, Popowka.

Dianulites apiculatus Eichwald.

7. Tangential section cutting the basal zone of small cells.
8. Vertical section.
Zone 1 [B], Pulkowa, Popowka, etc.

Dianulites rhombicus (Nicholson).

9. Tangential section of zoarium.
Zone 2 [E], Wesenberg.

Dianulites elegantulus (Fr. Schmidt).

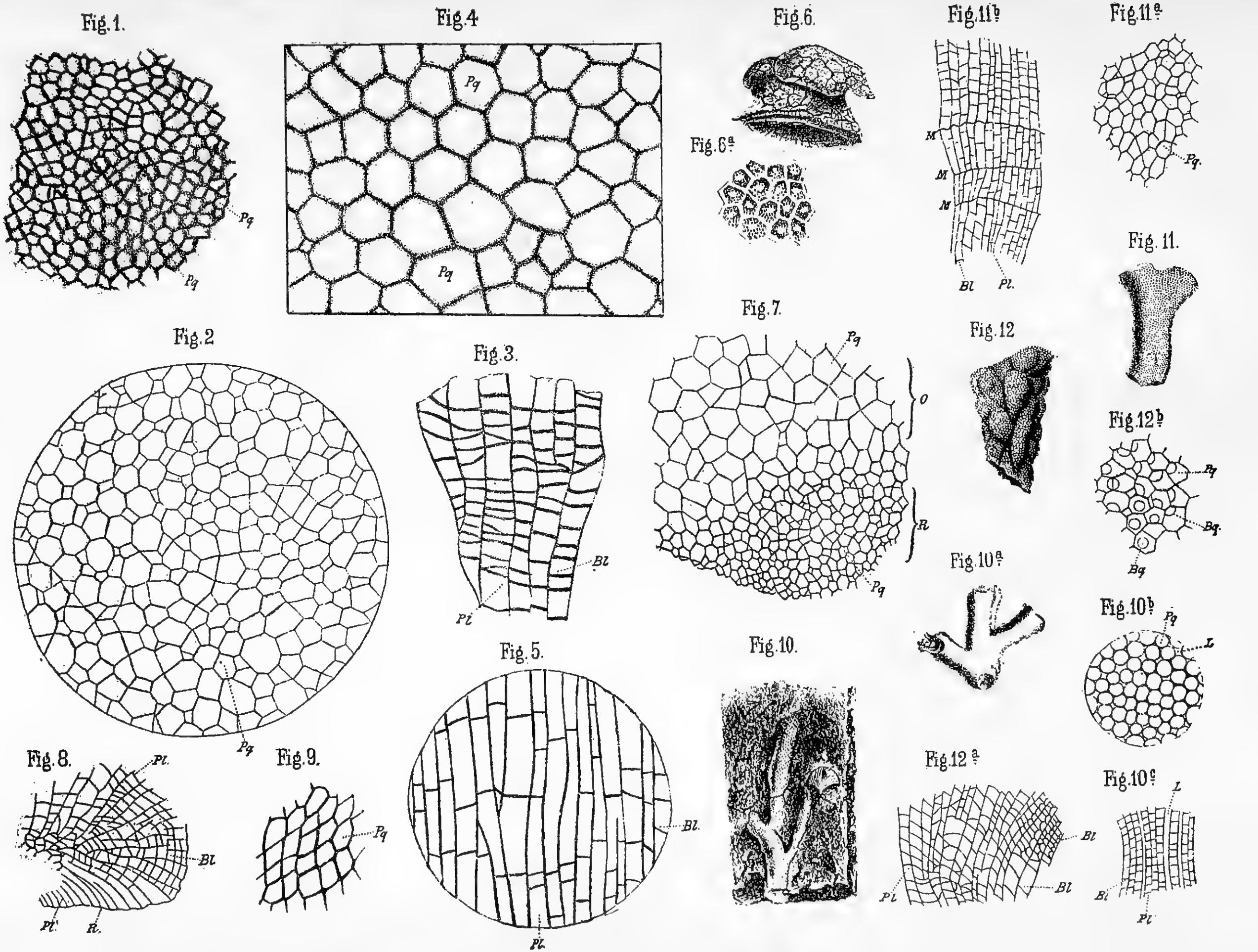
10, 10*a*. Two fragments of zoaria.
10*b*. Tangential section.
10*c*. Vertical section.
Zone 8 [Silurian], Ohhesare-pank and Kattripank.

Dianulites haydenii, new species.

11. Side view of fragment, ×2/3.
11*a*. Tangential section through mature zone.
11*b*. Vertical section.
Zone 2 [E], Wesenberg.

Dianulites sulcatus, new species.

12. Fragment of zoarium, ×2/3.
12*a*. Vertical section.
12*b*. Tangential section.
Zone 2 [D], Kertel, island of Dago.



Early Paleozoic Bryozoa of the Baltic Provinces.

Plate 3.

[After Dybowski.]

Trematopora cingulata, new species.

Fig. 1. Fragment of zoarium, natural size.

1*b*. Tangential section.

Zone 1 [C], Kuckers, Sack.

Trematopora cingulata var. *nodosa*, new variety.

1*a*. Fragment, ×2/3.

Zone 2 [D], Wait.

Trematopora variabilis, new species.

2. Portion of zoarium, about natural size.

2*a*. Tangential section.

Zone 2 [D], Wassalem.

Trematopora variabilis var. *complanata*, new variety.

3. Fragment of a zoarium, ×2/3.

3*a*. Tangential section.

Zone 2 [D], Wassalem.

Trematopora colliculata Eichwald.

4. Transverse section.

4*a*. Tangential section.

4*b*. Vertical section.

4*c*. Tangential section showing arrangement of zoœcia, acanthopores, and mesopores.

Zone 2 [D], Worms, etc.

Dittopora anulata Eichwald, sp.

5. Tangential section.

Zone 1 [B], Popowa.

Trematopora pustulifera, new species.

6. Tangential section.

Zone 2 [D], Wassalem.

Dittopora clavæformis, new species.

7. Three zoaria, ×2/3.

7*a*. Vertical section.

7*b*. Tangential section.

Zone 1 [B], Pulkowa.

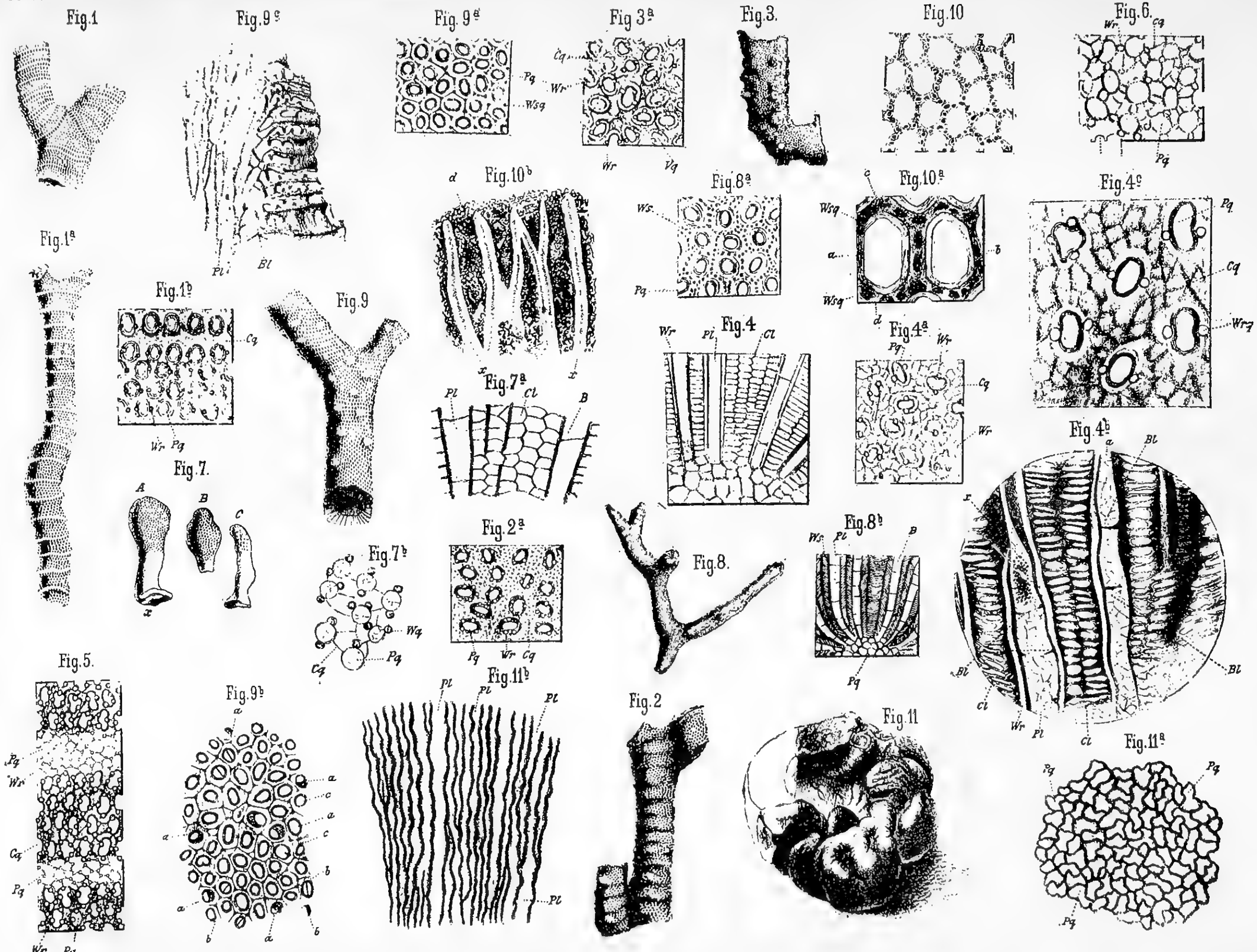
Orbipora arborescens, new species.

8. Zoarium, ×2/3.

8*a*. Tangential section.

8*b*. Transverse section of branch.

Zone 8 [Silurian], Lode.



Early Paleozoic Bryozoa of the Baltic Provinces.

Orbipora panderi, new species.

9. Fragment of zoarium, ×2/3.
9*c*. Vertical section.
9*a* and *b*. Tangential sections.
Zone 1 [C], Kuckers.

Orbipora distincta Eichwald.

10. Tangential section.
10*a*. Enlarged portion of same.
10*b*. Vertical section.
Zone 1 [C], Erras, Reval, etc.

Solenopora spongioides, new species [not a bryozoan].

11. View of organism, ×2/3.
11a. Tangential section, greatly enlarged.
11*b*. Vertical section.
Zone 3 [E], Herküll.

Plate 4.

[After Dybowski.]

Monticulipora rugosa Edwards and Haime.

Fig. 1. Tangential section introduced for comparison.
Upper Ordovician [Maysville], Cincinnati, Ohio.

Monticulipora wesenbergiana, new species.

2. Fragment of zoarium, natural size (Wesenberg).
2*a*. Another fragment, ×2/3 (Wait).
2*b*. Base of zoarium attached to foreign body, ×1 (Wesenberg).
2*c*, *d*, *e*. Different views of another basal part of a zoarium.
2*f*. Tangential section.
2*g*. Tangential section through the basal part of a zoarium.
2*h*. Another tangential section.
Zone 2 [E], Wesenberg and Wait.

Monticulipora, sp.

3. Tangential section.
3*a*. Same, more enlarged.
Zone 2 [D], Wassalem.

Trachypora porosa, new species [not a bryozoan].

4. Fragment of a colony, ×3.
4*a*. Surface, enlarged.
Zone 8 [Silurian], Kaugatomo-pank, Ohhesare-pank.

Monticulipora ædilis Eichwald, sp.

5. Tangential section of a mature specimen.
5*a*. Vertical section.
Zone 2 [E], Wesenberg.

Labechia conferta Lonsdale, sp. [not a bryozoan].

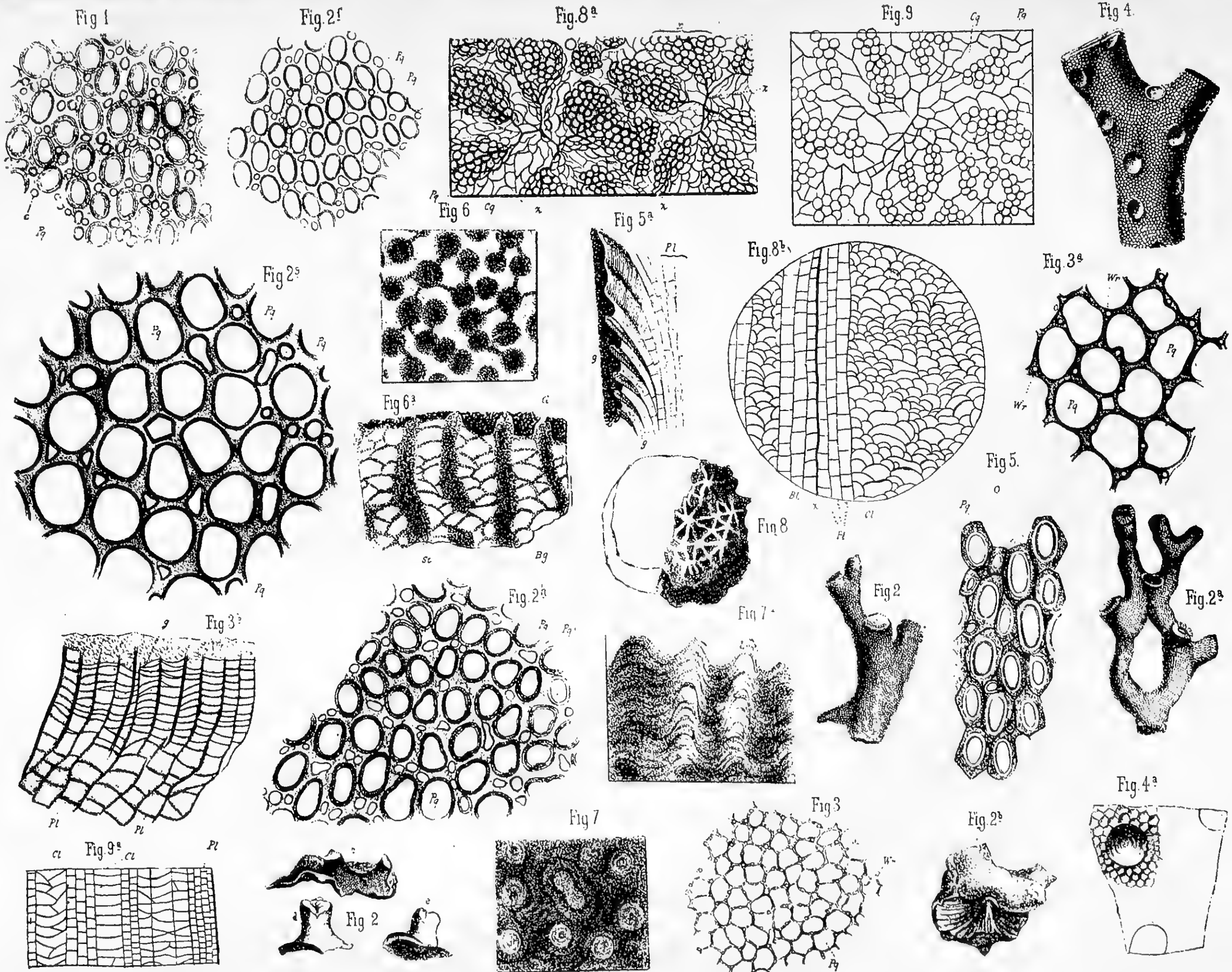
6*a*. Tangential and vertical sections.
Silurian, Dudley, England.
7*a*. Tangential and vertical sections of Russian example.
Silurian, Hoheneichen.

Stellipora revalensis, new species.

8. Portion of a zoarium, ×2/3.
8*a*. Tangential section.
8*b*. Vertical section.
Zone 1 [C], Reval.

Stellipora constellata, new species.

9. Tangential section.
9*a*. Vertical section.
Zone 2 [?F], Hohenholm.



EARLY PALEOZOIC BRYOZOA OF THE BALTIC PROVINCES.

Plate 5.

[After Dybowski.]

Callopora nummiformis Hall.

Fig. 1 *a*, *b*. Three tangential sections (Kuckers).

1*c*. A tangential section showing more angular zoœcia (Reval).

1*d*, *e*. Two tangential sections (Wesenberg).

1*f*, 1*g*, 1*h*. Two tangential and a vertical section of a *Prasopora* from Cincinnati, incorrectly referred here.

1*i*. Surface of a zoarium showing covers to apertures (Wesenberg).

1*k*. Surface showing monticules.

1*l*. Vertical section showing characteristic tabulation of zoœcia and mesopores (Kuckers).

Zones 1 and 2, various localities.

Heliolites dubia Fr. Schmidt [not a bryozoan].

2 *a*. Tangential and vertical sections.

Silurian, Hapsal.

Callopora heterosolen Keyserling.

3. Outlines of variously shaped zoaria (Reval, Erras, Kuckers, and Baltischport).

3*a*. Vertical section through the upper part of a zoarium.

3*b*. Vertical section through the basal part of a zoarium.

3*c* and *d*. Tangential sections through the upper and basal parts of the zoarium, respectively.

Zone 1 [B–D], various localities.

Callopora maculata, new species.

4. Fragment of a zoarium, natural size.

4*a*. Vertical section.

4*b*. Tangential section.

Zone 8 [Silurian], Ohhesare-pank.

Callopora ligniformis, new species.

5. Tangential section.

5*a*. Vertical section.

Zone 2 [D], Wassalem.

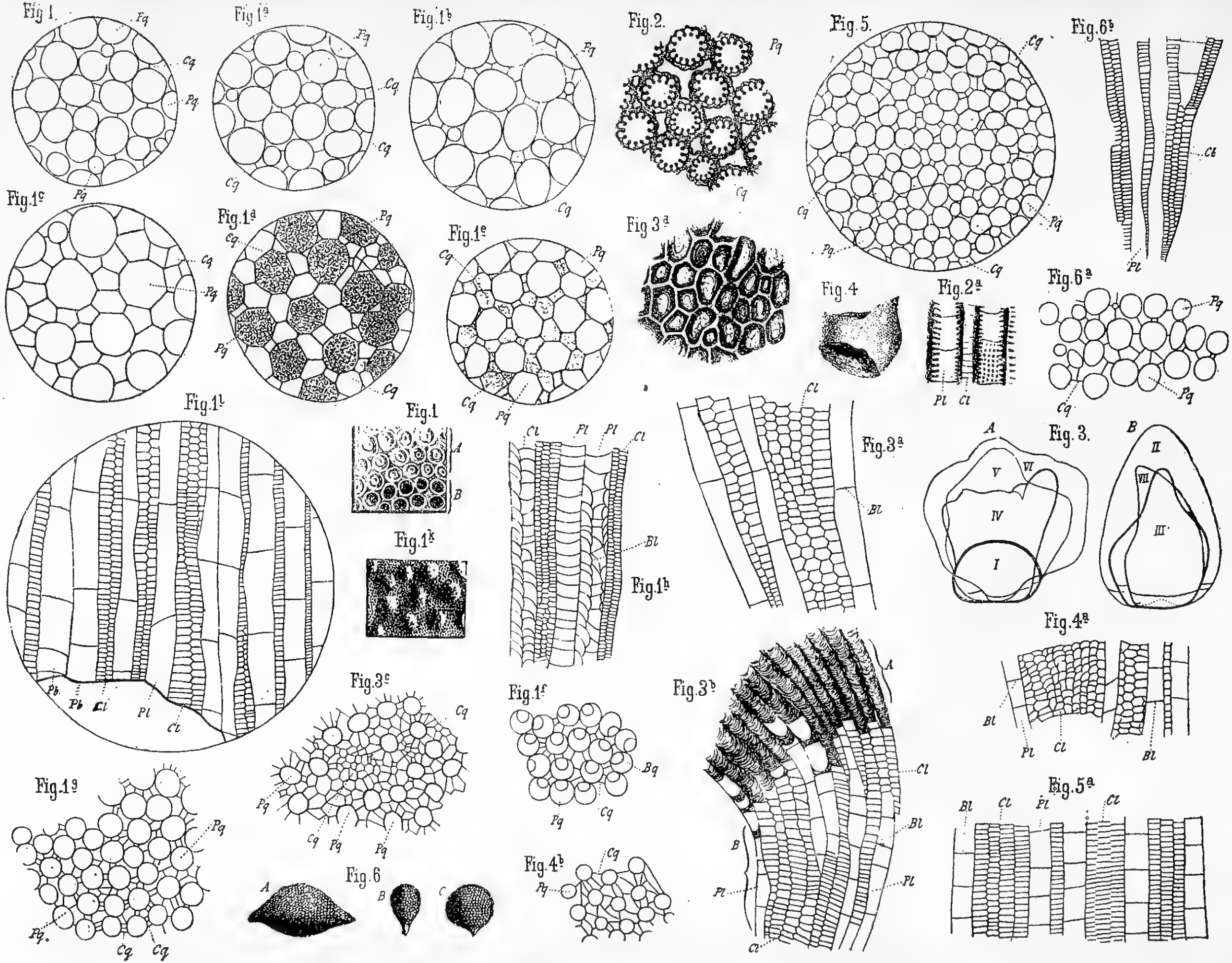
Callopora piriformis Eichwald sp.

6. Three zoaria, ×2/3.

6*a*. Tangential section.

6*b*. Vertical section.

Zone 1 [B], Pulkowa.



EARLY PALEOZOIC BRYOZOA OF THE BALTIC PROVINCES.

Plate 6.

Corynotrypa schucherti Bassler.

Fig. 1. The type-specimen, ×3, incrusting a species of *Streptelasma*.
Wesenberg limestone (E), Wesenberg, Esthonia.

Ceramopora intercellata, new species.

2. Surface of the type example, ×18, showing portion of a macula of mesopores and the adjoining zoœcia.
Lyckholm limestone (F1), Hohenholm, island of Dago.

Ceramopora invenusta, new species.

3. Surface of the type, ×9, partially obscured by clay, exhibiting the irregular zoœcia and numerous granules.
Wesenberg limestone (E), Wesenberg, Esthonia.

Anolotichia revalensis, new species.

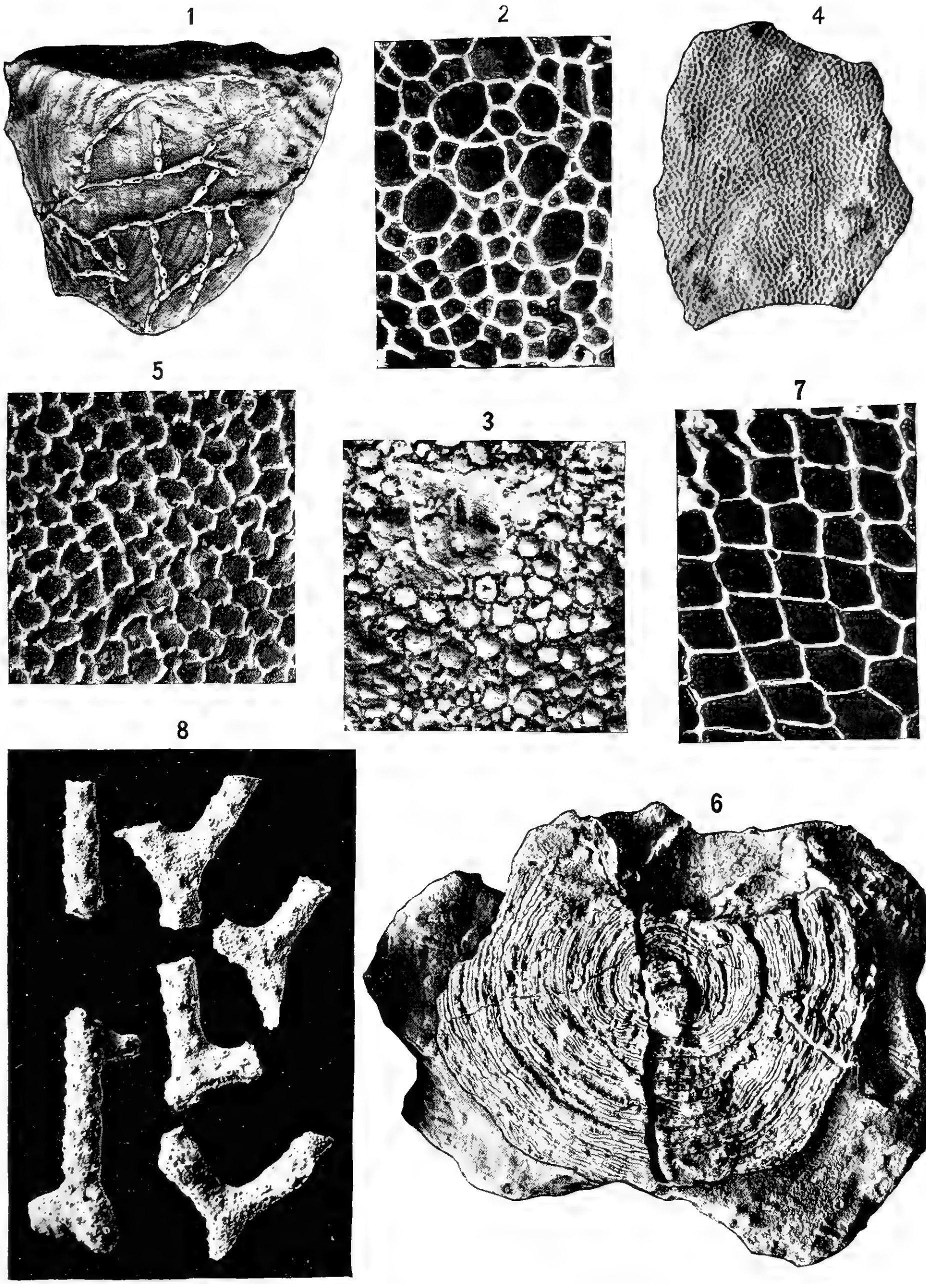
4. Celluliferous side of a thin, flat expansion, ×1.5, with groups of larger zoœcia indistinctly shown.
5. Surface of the same example, ×9, showing the angular zoœcia, few mesopores, and crescentic lunarium.
Orthoceras limestone (B3), Reval, Esthonia.

Anolotichia rhombica, new species.

6. A zoarium attached to a rock fragment, ×1.5, showing the concentrically wrinkled epitheca.
7. Celluliferous surface of the same specimen, ×18, illustrating the rhomb-shaped zoœcial apertures.
Wesenberg limestone (E), Wesenberg, Esthonia.

Mitoclema boreale, new species.

8. Six fragments, ×6.
Wesenberg limestone (E), Wesenberg, Esthonia.



EARLY PALEOZOIC BRYOZOA OF THE BALTIC PROVINCES.

Plate 7.

Stictoporella gracilis (Eichwald).

Figs. 1, 2. Two zoaria, natural size, showing the expanded, attached base and the cribrose branches.

3. Surface of original of fig. 1, ×12.
Glauconite limestone (B2), Wassilkowa, government of St. Petersburg.

Stictoporella cribrosa Ulrich.

4. Fragment of a zoarium, ×1.5, preserving the expanded, attached base.
Wassalem beds (D3), Uxnorm, Esthonia.

Coscinium prænuntium, new species.

5. A rather complete zoarium, natural size, showing the cribrose branches and attached basal portion.
6. Surface of the same, ×12, exhibiting the prominent lunaria and the papillose interzoœcial spaces.
Orthoceras limestone (B3), island of Rogo, Esthonia.

Phyllodictya flabellaris, new species.

7. The incomplete, flabellate type-specimen, natural size.
8. Surface of same, ×12, showing a solid macula and adjoining zoœcia.
Orthoceras limestone (B3), island of Rogo, Esthonia.

Spatiopora lineata incepta Ulrich.

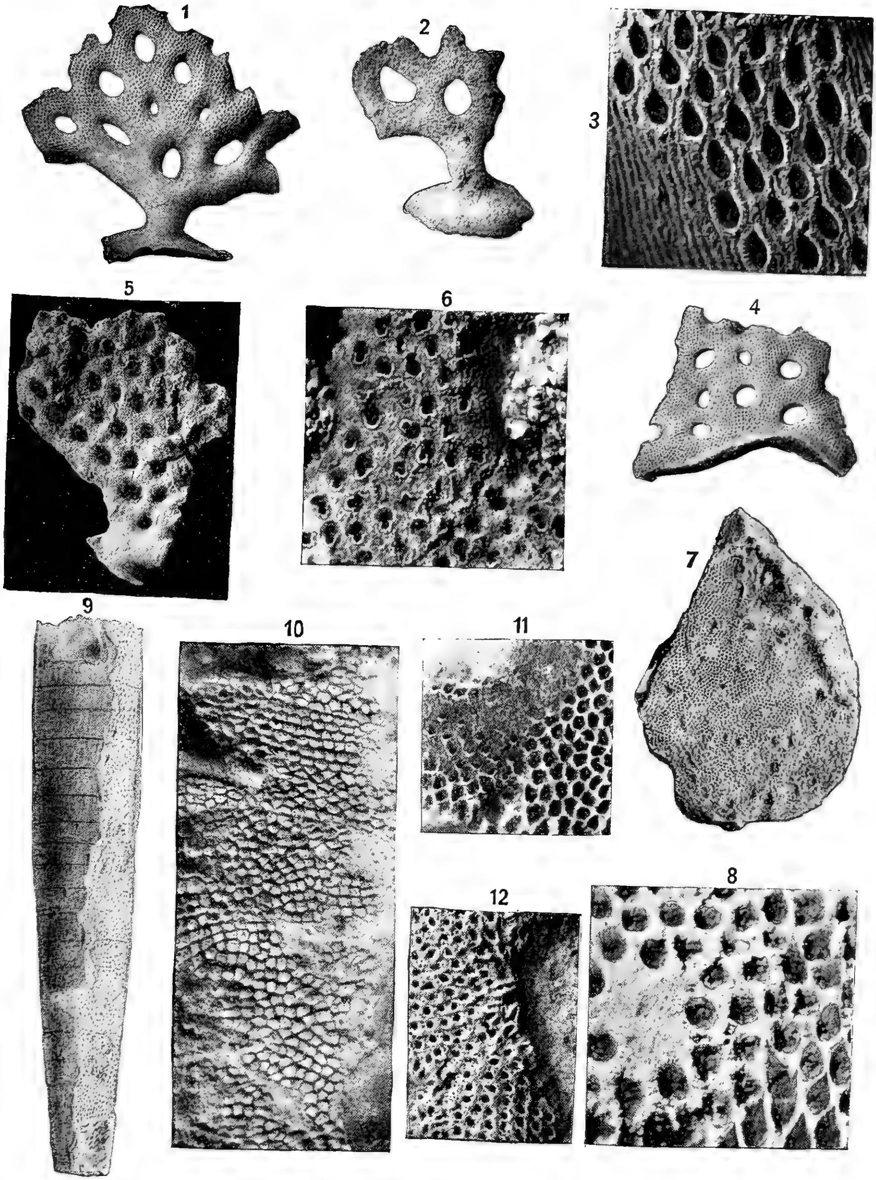
9. Life-size view of the Russian specimen referred to this variety.
10. View of the surface of the same, ×4.
Wesenberg limestone (E), Wesenberg, Esthonia.

Anolotichia impolita Ulrich.

11. Surface of a Russian example of this species, ×4.
Kuckers shale (C2), Baron Toll's estate, Esthonia.

Coeloclema crassimurale, new species.

12. Surface of a basal expansion, ×4, referred to this species.
Jewe limestone (D1), Baron Toll's estate, Esthonia.



EARLY PALEOZOIC BRYOZOA OF THE BALTIC PROVINCES.

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Plate 8.

Pachydictya flabellum (Leuchtenberg).

Fig. 1. A nearly complete zoarium, ×1.5.
Wesenberg limestone (E), Wesenberg, Esthonia.

Graptodictya proava (Eichwald).

2. Surface of portion of a branch, ×18, showing striated noncelluliferous border and several adjoining rows of zoœcia.
Wassalem beds (D3), Uxnorm, Esthonia.

Graptodictya bonnemai, new species.

3. Magnified view, ×18, of branch.
Kuckers shale (C2), Baron Toll's estate, Esthonia.

Graptodictya obliqua, new species.

4. Surface of the type-specimen, ×8.
Lower part of Lyckholm limestone (F1), Kerküll, Esthonia.

Pseudohornera bifida (Eichwald.)

5. Celluliferous side of portion of a zoarium, ×6.
Kuckers shale (C2), Baron Toll's estate, Esthonia.

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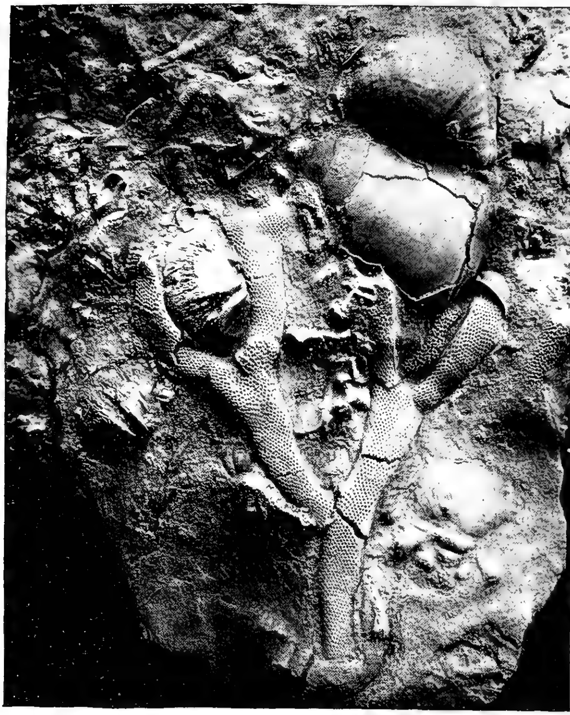

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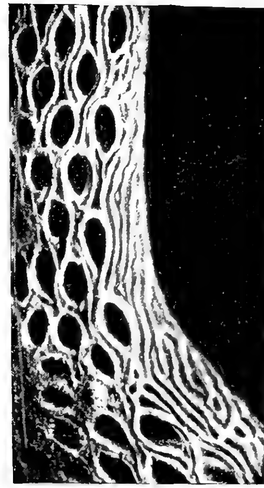

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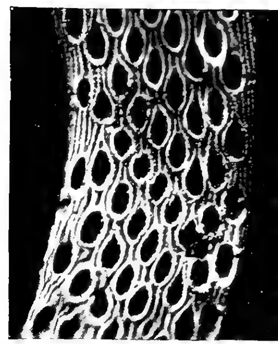

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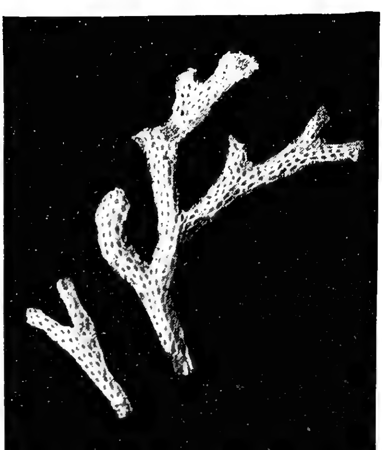

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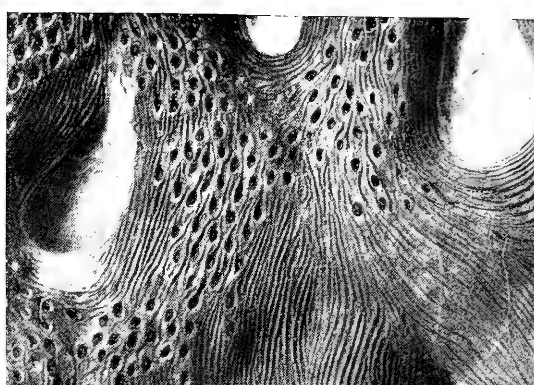

EARLY PALEOZOIC BRYOZOA OF THE BALTIC PROVINCES.

PLATE 9.

Graptodictya proava (Eichwald).

Fig. 1. Nearly complete zoarium, ×1.5.

2. Fragment, ×2, showing the striated base pointed for articulation.
3. View, natural size, of an old, average example.
4. Surface, ×5, of another fragment.
5. Fragment of a rock, ×2, containing a solid, ramose bryozoan, to which is attached the cuplike, attached basal expansion of this species.

   Wassalem beds (D3), Uxnorm, Esthonia.
6. View, natural size, of the American example of this species described by Sardeson as *Stictoporella cribrosa*.

   Lower part of Trenton limestone, Kenyon, Minnesota.

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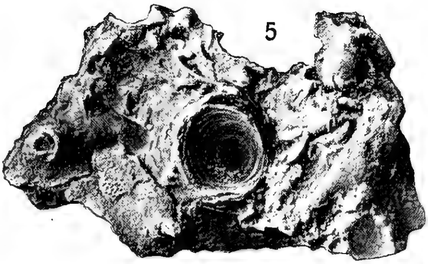

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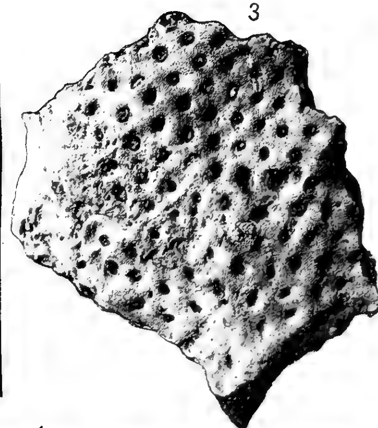

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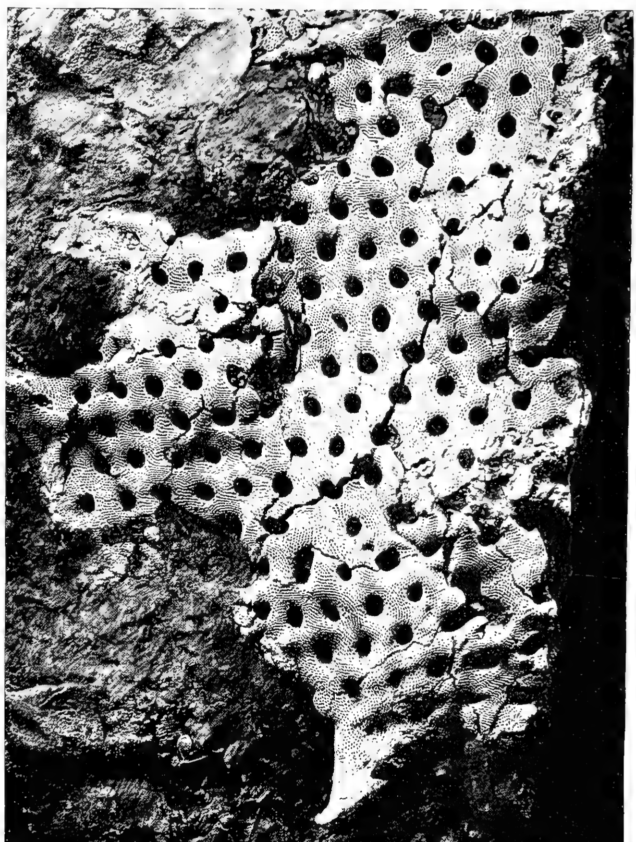

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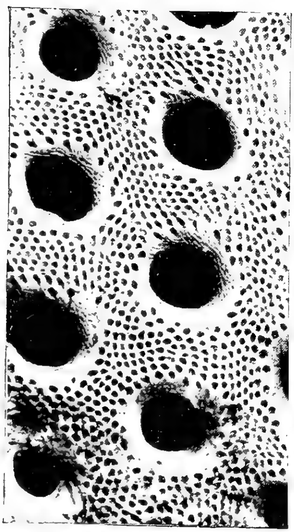


EARLY PALEOZOIC BRYOZOA OF THE BALTIC PROVINCES

Plate 10.

Hemiphragma glabrum, new species.

Fig. 1. Nearly complete zoarium, natural size.
Wassalem beds (D3), Uxnorm, Esthonia.

Hemiphragma subsphericum, new species.

2. Surface, ×8, of one of the specimens of text fig. 179, showing the thin-walled apertures with semidiaphragms exposed.
Wesenberg limestone (E), Wesenberg, Esthonia.

Batostoma mickwitzi, new species.

3. Nearly complete zoarium, one-half natural size.
4. A complete, unbranched, small zoarium, two-thirds natural size.
5. Branching fragment, two-thirds natural size.
6. Surface of original of preceding, ×8.
Wassalem beds (D3), Uxnorm, Esthonia.

Dianulites petropolitana Dybowski.

7. Surface, ×8, of the typical form of the species.
Orthoceras limestone (B3), Reval, Esthonia.
8. Epithecated, basal side of a specimen of the form *hexaporites*, natural size.
9. Celluliferous face of a specimen of the same form, slightly enlarged, in which the hexagonal outline is produced by covered mesopores opening on a plane with the ordinary zoœcia.
10. Surface of the same specimen still further enlarged.
Glauconite limestone (B2), Tswos, on the Wolchow River, government of St. Petersburg.
11. Surface of a specimen, natural size, showing hexagonal areas present in one portion and absent in the rest of the figure.
Glauconite limestone (B2), Granaja Scheldicha, government of St. Petersburg.

PLATE 12.

Surface of a fragment of Kuckers shale, magnified two and a quarter diameters. The numerous, ribbon-like fronds are of *Graptodictya bonnemai*, the reticulate specimens are of *Chasmatopora furcata*, while the large, dichotomously branching example shows the noncelluliferous face of *Pseudohornera bifida*. Other species represented on this fragment are the delicate *Nematopora consueta* and *Protocrisina ulrichi*.

Kuckers shale (C2), Baron Toll's estate, near Jewe, Esthonia.

Plate 11.

Nicholsonella gibbosa (Eichwald).

Figs. 1–5. Five zoœcia of various sizes and shapes, × 1.5.
6. Surface of the original of fig. 1, × 18.
Glauconite limestone (B2), Wassilkowa, government of St. Petersburg.

Dittopora colliculata (Eichwald).

7–10. Four small examples, natural size, with distinctly elevated maculæ.
11–14. Four specimens of the usual size and surface features.
15. A nearly smooth example, natural size.
Wassalem beds (D3), Uxnorm, Esthonia.

Dittopora annulata (Eichwald).

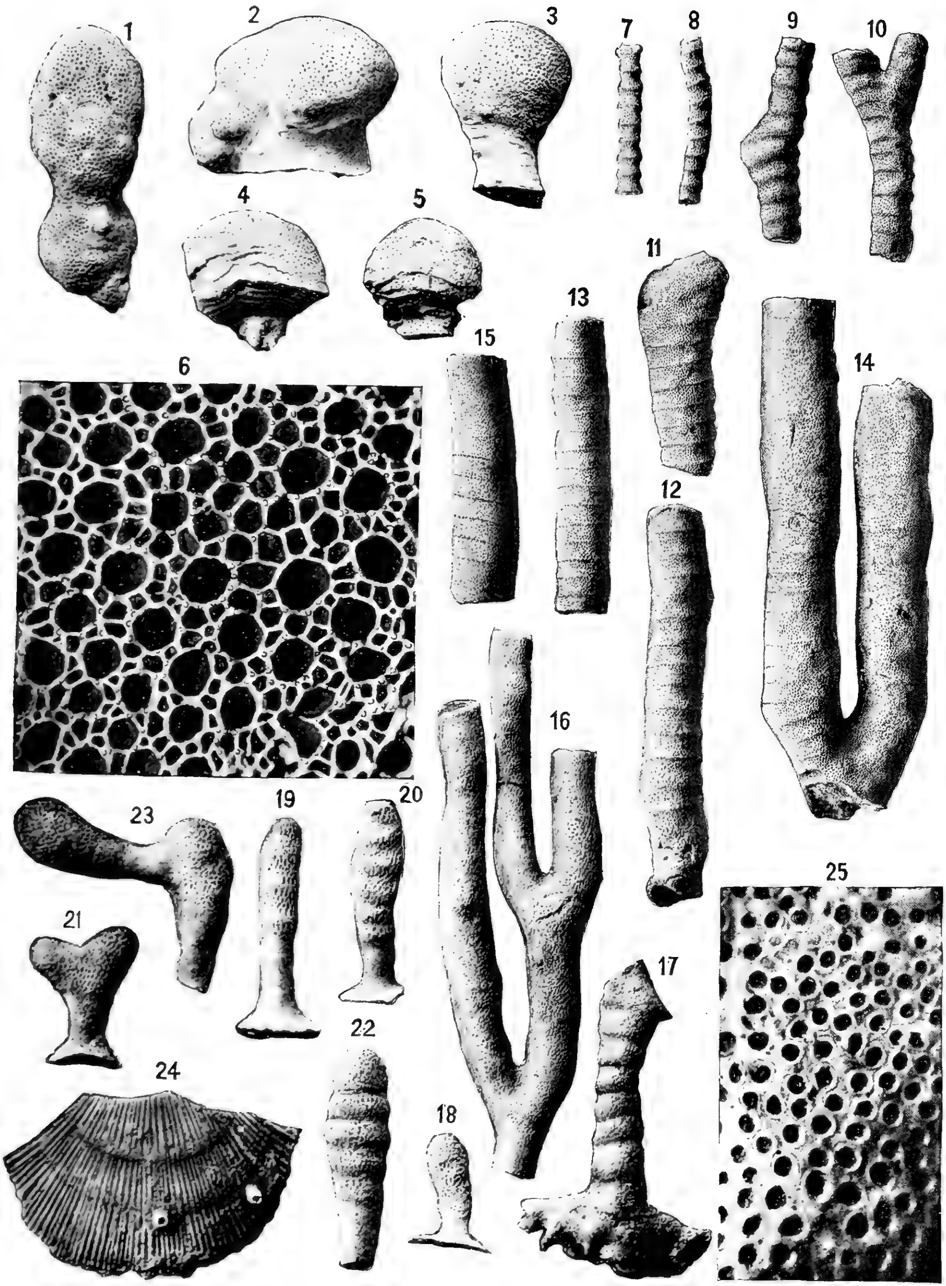
16. Portion of a zoarium, × 1.5, with indistinct maculæ.
Orthoceras limestone (B3), island of Rogo, Esthonia.
17. An example, ×1.5, preserving the parasitic basal portion, and showing distinct ring-like maculæ.
Glauconite limestone (B2), Tswos, on the Wolchow River, government of St. Petersburg.

Dittopora clavæformis (Dybowski).

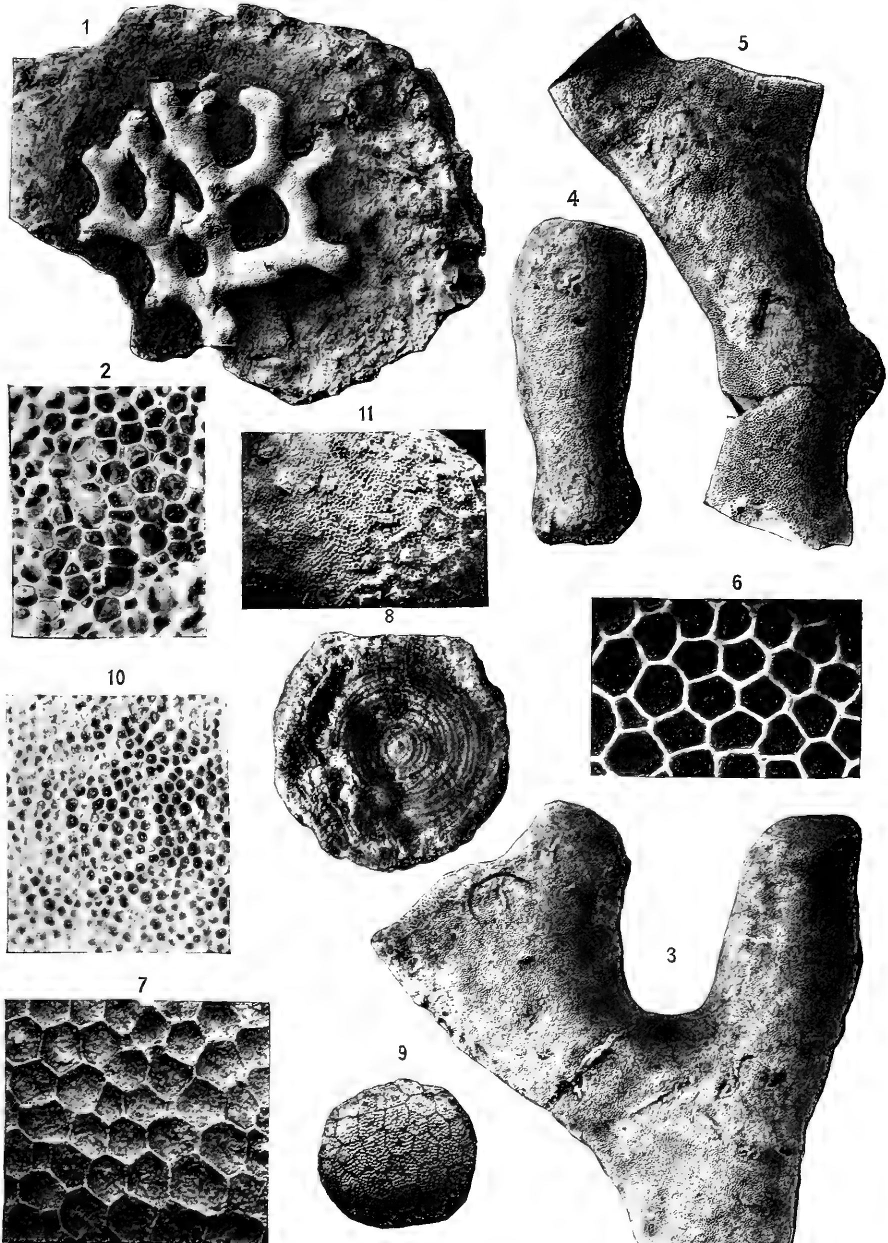
18–23. A group of specimens, ×2, exhibiting various forms of growth.
24. Fragment of a brachiopod, ×1.5, with the basal portions of two examples attached.
Glauconite limestone (B2), Tswos and other localities, government of St. Petersburg.

Trematopora cystata, new species.

25. Surface of a well-preserved example, ×15.
Kuckers shale (C2), Reval, Esthonia.



EARLY PALEOZOIC BRYOZOA OF THE BALTIC PROVINCES.



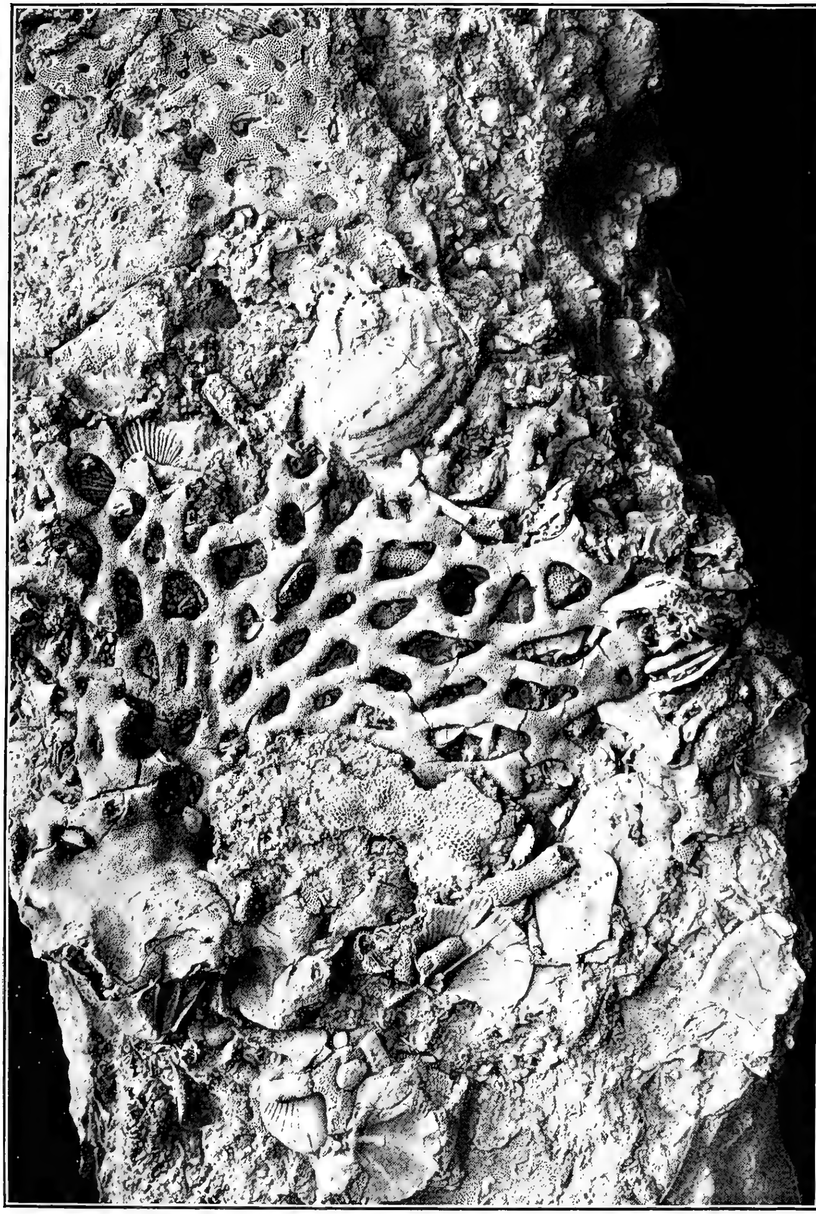
EARLY PALEOZOIC BRYOZOA OF THE BALTIC PROVINCES.

Early Paleozoic Bryozoa of the Baltic Provinces.

PLATE 13.

Surface of a slab of limestone from the Wassalem beds, illustrating the abundance of fossils in this formation. The large, reticulate specimen with a solid, spreading base, in the middle portion of the plate, is of the abundant *Homotrypella cribrosa,* the ribbon-like, cribrose frond in the upper part of the plate represents *Graptodictya proava;* a fragment of *Favositella? punctata* lies just below the center of the plate. Most of the slender, ramose specimens are young examples of *Dittopora colliculata.*

Wassalem beds (D3), Uxnorm, near Reval, Esthonia.



Early Paleozoic Bryozoa of the Baltic Provinces.

INDEX.

(Synonyms are in *italics*.)

	Page.
abrupta, Corynotrypa	65
acanthophora, Orbipora	255
Acanthopores	48
Acknowledgments	2, 3
Actinostroma	175
ædilis, Cladopora	242
ædilis, Eridotrypa	242
minor, Eridotrypa	245
ædilis, Monticulipora	242
alveolaris, Calamopora	342
Amalgamata	177, 178
American and Baltic Ordovician Bryozoa, Summary of	32
ampla, Callopora	329
Amplexopora	178
Amplexopora winchelli	278
Amplexoporidæ	178, 265
Anaphragma	178, 297
mirabile	298
cognata	299
angulata, Retepora	169
angulosa, Archeopora	341
annulata, Dittopora	304
annulatus, Chætetes	304
Anolotichia	91
brevipora	94
impolita	97
ponderosa	91
revalensis	95
rhombica	92
sacculus	98
antheloidea, Stellipora	221
Anthozoa, List of	19
antiqua, Gorgonia	175
apiculata, Millepora	344
apiculatus, Chætetes	344
apiculatus, Dianulites	344
apiculatus, Orbitulites	344
apsendesoides, Stellipora	223
arachnoidea, Aulopora	60
arachnoidea, Stomatopora	60
arborea bispinulata, Monticulipora	179
Monticulipora	179
Archeopora	340
angulosa	341
lamella	340
punctata	105, 341
radians	342
Arctic America, Ordovician and Early Silurian strata of	32
armatum, Arthroclema	151
Arthroclema	150
armatum	151
pulchellum	150
Arthronema	147
Arthropora	119
simplex	120
Arthrostylidæ	146
Arthrostylus	147
obliquus	148
aspera, Spatiopora	106
Aspidopora	177
Atactopora	178
Atactoporella	177
Atactoporella crassa	193
Aulopora	59
arachnoidea	60
Aulopora sp	68
Baltic and American Ordovician and Early Silurian Bryozoa, Summary of	18
Baltic area, Paleontology of	19
Baltic Ordovician and Early Silurian Bryozoa, Table showing range of	50
Baltic Sea area, General Geology of	4
Baltic Sea area, Map of	5
Baltic Sea area, preservation of fossils in	4
barberi, Corynotrypa	63
batheri, Hemiphragma	296
Batostoma	178, 272
Batostoma	281
Batostoma fertile	274
circulare	275
granulosum	280
Batostoma irrasa	284
Batostoma magnopora	272
mickwitzi	276
winchelli	278
spinulosum	279
Batostomellidæ	178, 240
bicornis, Ceriopora	317
Dianulites	317
bicornis, Diplotrypa	317
bifida, Pseudohornera	173
bifida, Thamniscus	173
bifurcata, Pachydictya	143
bifurcata, Stictopora	143
Black River group	27
Blue clay and associated strata	10
bonnemai, Graptodictya	122
boreale, Mitoclema	69
Borkholm Bryozoa, List of	17
limestone, F 2	16
Borkholmiensis, Rhinidictya?	143
Brachiopoda, List of	20
brevipora, Anolotichia	94
Bryozoa in Cambrian strata	10
Bryozoan faunas, American Black River and Trenton	27

	Page.
Bythopora	178, 240
fruticosa	240
subgracilis	241
Bythotrypa	100
Calamopora alveolaris	342
Calamopora fibrosa	232, 313
Calamopora fibrosa	342
Calamopora fibrosa tuberosa ramosa	342
Calamopora polymorpha	342
reticulata	343
Callopora	312, 325
Callopora ampla	329
dumalis	331
elegantula	326, 334
foordii	214
goodhuensis	327
heterosolen	317
Callopora ligniformis	343
Callopora multitabulata	326
nana	334
nummiformis	335
Callopora piriformis	343
punctata	246
Callopora undulata	332
Calloporella	178
Calloporina	178
Cambrian and Ordovician formations in Russia, Table of	6
Cambrian and Ordovician strata, Table of	7, 8
Cambrian-Early Silurian strata of Baltic Russia, Composite section of	9
Cambrian strata, blue clay and associated rocks, A 1	10
Bryozoa in	10
description of	8
Ungulite sandstone, A 2	10
Cephalopoda, List of	21
Ceramopora	76
imbricata	76
intercellata	79
invenusta	78
Ceramopora socialis	108
Ceramopora spongiosa	77
Ceramoporella	81
distincta	81
granulosa minor	81
uxnormensis	82
Ceramoporidæ	74
Ceriopora bicornis	317
Ceriopora constellata	219
Chætetes annulatus	304
apiculatus	344
hemisphæricus	253
heterosolen	317
petropolitanus	232, 313
piriformis	343
Chætetes rhombicus	92
Chasmatopora	169
furcata	171
reticulata	170
teuella	169
Cheilotrypa	111
Chilotrypa	111
hispida	111
immatura	111
cinctosum, Mitoclema	69
cingulata nodosa, Trematopora	306
cingulata, Trematopora	306
Cladopora ædilis	242
Clathropora flabellata	123
clavæformis, Dittopora	302
clava, Lioclemella	249
claviformis, Leptotrypa	217
claviformis, Stigmatella	217
Clitambonites bed, Bryozoa of	31
Cœloclema	83
crassimurale	84
laciniatus	85
Cœnites laciniatus	85
colliculata, Dittopora	306
colliculata, Trematopora	306
collifera, Dianulites	239
communis, Esthoniopora	259, 260
Composite geologic section, Ordovician of northeastern Iowa and southeastern Minnesota	25
Composite section, Cambrian-Early-Silurian strata of Baltic Russia	9
compressa, Petalotrypa	266
concentrica, Lichenalia	168
conjunctus, Arthrostylus	147
Constellaria	178, 218
varia	219
Constellariidæ	178, 218
constellata, Ceriopora	219
Stellipora	223
consueta, Nematopora	155
Correlations, stratigraphic	36
Corynotrypa	61
abrupta	65
barberi	63
delicatula	61
dissimilis	68
inflata	64
schucherti	67
Coscinium	145
cyclops	145
prænuntium	146
Coscinium proavium	123
proavus	123
Coscinotrypa	145
crassimurale, Cœloclema	84
crenulata, Stigmatella	211
Crepipora	85
Crepipora impolita	97
Crepipora incrassata	89
lunatifera	88
schmidti	87
simulans	86
cribrosa, Homotrypella	192
cribrosa, Stictoporella	123
cribrosa, Stictoporella	128
Crisinella œilensis	73
Cryptostomata	112
Ctenodonta bed, Bryozoa of	29
Ctenostomata	54
cumulata, Monotrypa (Chaetetes)	232
curvata, Esthoniopora	263
Homotrypa	185
cyclops, Coscinium	145
Cyclostomata	58
cyclostomoides, Micropora	141
cyclostomoides, Pachydictya	141
Cyphotrypa	178

	Page.
cystata, Trematopora	271
Cystodictyonidæ	145
dagoensis, Monticulipora	181
Dekayella	178, 205
obscura	205
prænuntia	205
nævigera	207
simplex	207
Dekayia	178
delicatula, Corynotrypa	61
delicatula, Hippothoa	61
Nematopora	155
Stomatopora	61
tenuissima, Stomatopora	61
Diamesopora	83
Diamesopora vaupeli	83
Dianulites	178, 226
apiculatus	344
bicornis	317
Dianulites collifera	239
fastigiatus	228, 229
grandis	237
haydeni	344
petropolitana	232
petropolitanus	313
Dianulites petropolitanus var. *hexaporites*	232
piriformis	343
rhombicum	92
Dianulites sulcatus	344
Diastoporidæ	59
dichotoma, Stomatopora	59
Dictyonema beds, A 3	11
Didymopora	109
diffusa, Retepora	172
Diplotrypa	178, 312
Diplotrypa	196
Diplotrypa bicornis	317
hennigi	322
infida	196
limitaris	317
moniliformis	321
neglecta	321
petropolitana	232, 313
westoni	323
discoidalis, Favositella	103
discoidea, Mesotrypa	196
orientalis, Mesotrypa	196
dissimilis, Corynotrypa	68
dissimilis, Stomatopora	68
disticha, Glauconome	160
disticha, Glauconome	347
disticha, Ptilopora	347
distincta, Ceramoporella	81
Orbipora	252, 253
distinctus, Orbitulites	253
Dittopora	178, 301
annulata	304
clavæformis	302
colliculata	306
divaricata, Helopora	149
Drymotrypa	172
dumalis, Callopora	331
dumalis, Hallopora	331
Dybowskia	109
Dybowskiella	109
dybowskii, Hallopora?	335

	Page.
Early Paleozoic Bryozoa, collections of	3
distribution of	3, 4
Early Silurian strata, description of	11
Echinodermata, List of	19
Echinospherites limestone, C 1	13
egena, Mesotrypa	198
elegans, Pachydictya	138
elegantula, Callopora	334
elegantula, Hallopora	334
ensiformis, Phænopora	118
Entalophoridæ	69
Eopaleozoic deposits, Correlation table of	38
Eridotrypa	178, 242
ædilis	242
minor	245
exigua	245
Eridotrypa mutabilis	242
var. *minor*	245
Eschara exserta	133
flabellum	140
gracilis	130
rhombica	345
Eschara scalpelliformis	348
Escharipora recta	345
Escharopora	113
Escharopora	115
recta	115
subrecta	116
Esthoniopora	178, 259
communis	259, 260
curvata	263
exigua, Eridotrypa	245
Protocrisina	72, 73
exilis, Pteropora	347
expansa baltica, Orbignyella	183
Orbignyella	183
Ptilodictya	114
explanata, Phænopora	118
expressa, Mesotrypa	200
exserta, Eschara	133
exserta, Favositella	102
Rhinidictya	133
exserta, Stictopora	133
facula, Sceptropora	152, 153
fastigiata, Millepora	346
Myriapora	346
fastigiatus, Dianulites	228, 229
Myriolithes	346
Faunas, Russian Ordovician, Lists of	19
Favositella	100
discoidalis	103
exserta	102
interpuncta	101
? punctata	105
Favosites hemisphæricus	253
hemisphericum	232, 313
petropolitanus	232, 313
Fenestella	175
striolata	175
Fenestellidæ	175
Fenestrella	175
fertile, Batostoma	274
fertile circulare, Batostoma	275
fibrosa, Calamopora	232, 313
fibrosa, Calamopora	342
fibrosa tuberosa ramosa, Calamopora	342

	Page.
Fistulipora	109
primæva	109
Fistuliporella	109
Fistuliporidæ	108
flabellaris, Phyllodictya	135
flabellata, Clathropora	123
flabellata, Ptilodictya	114
flabellata, Stictoporella	123
Flabelliporina	175
flabellum, Eschara	140
flabellum, Pachydictya	140
flabellum, Stictopora	140
flexuosa, Ptilodictya	127
Flustra lanceolata	113
folium, Petalotrypa	266
foordii, Callopora	214
foordii, Stigmatella	214
fragilis, Helopora	149
Nematopora	157
francisca, Sceptropora	154
frondosa, Phyllodictya	135
fruticosa, Bythopora	240
fungiformis, Hexaporites	232
fungiformis, Orbipora	346
furcata, Chasmatopora	171
furcata, Polypora	171
Fusispira and Nematopora beds, Bryozoa of	31
Gastropoda, List of	21
germana, Orbignyella	182
gibbosa, Heteropora	224
Nicholsonella	224
glabrum, Hemiphragma	287
gladiola, Ptilodictya	114
Glauconite limestone, B 2	12
sandstone, B 1	11
Glauconome	159
disticha	160
Glauconome disticha	347
Glauconome plumula	160
strigosa	161
goodhuensis, Callopora	327
goodhuensis, Hallopora	327
Gorgonia antiqua	175
Gorgonia proavus	123
gracilis, Eschara	130
Micropora	130
gracilis, Nematotrypa	164, 165
grandis, Dianulites	237
granulosa minor, Ceramoporella	81
granulosum, Batostoma	280
Graptodictya	121
bonnemai	122
obliqua	126
perelegans	121, 122
proava	123
Hallopora	178, 325
dumalis	331
Hallopora? dybowskii	335
elegantula	334
goodhuensis	327
multitabulata	326
splendens	329
Hallopora? tenuispinosa	338
tolli	333
undulata	332
wesenbergiana	328

	Page.
Halloporidae	178, 324
haydeni, Dianulites	344
Helopora	149
divaricata	149
fragilis	149
Helopora lineata	158
strigosa	161
Helopora tenuis	147
Hemiphragma	178, 281
batheri	296
glabrum	287
rrasum	284
maculatum	295
multiporatum	290
ottawaense	286
panderi	286
pygmæum	289
rotundatum	294
subsphericum	292
tenuimurale	282
hemisphæricus, Chætetes	253
Favosites	253
hemispherica, Millepora	232, 313
hemisphericum, Favosites	232, 313
hennigi, Diplotrypa	322
Heterodictya	113
Heteronema	57
priscum	10, 57
Heteropora gibbosa	224
heterosolen, Callopora	317
Chætetes	317
Monticulipora	317
Heterotrypa	178
Heterotrypidæ	204
hexagonalis, Leptotrypa	208
Hexaporites	226, 232
fungiformis	232
Hippothoa delicatula	61
inflata	64
hispida, Chilotrypa	111
Homotrypa	177, 184
curvata	185
similis	185
subramosa	187
Homotrypella	177, 189
cribrosa	192
hospitalis crassa	193
instabilis	189
Homotrypella? subgracilis	241
hospitalis crassa, Homotrypella	193
Idiotrypa	178
Idmoneidæ	71
imbricata, Ceramopora	76
immatura, Chilotrypa	111
implicata, Monticulipora (Heterotrypa)	272
impolita, Anolotichia	97
impolita, Crepipora	97
incrassata, Crepipora	89
indenta, Orbipora	257
infida, Diplotrypa	196
inflata, Corynotrypa	64
inflata, Hippothoa	64
Stomatopora	64
inflecta, Stigmatella	212
instabilis, Homotrypella	189
Integrata	178, 265

	Page.
intercellata, Ceramoporella	79
interpuncta, Favositella	101
Interspace	47
interstincta, Stictoporella	127
Intricaria	169
Intricaria? reticulata	170
invenusta, Ceramopora	78
irrasa, Batostoma	284
irrasum, Hemiphragma	284
Itfer beds, C 3	15
Jewe limestone, D 1	15
jewensis, Monotrypa	310
Kegel beds, D 2	15
kuckersiana, Trematopora	270
Kuckers shale, C 2	14
laciniatus, Cœloclema	85
laciniatus, Cœnites	85
Lake Nipissing, Ontario, Islands of, Black River fossils from	33
lamella, Archeopora	340
lamellosa, Monticulipora	182
lanceolata, Flustra	113
lanceolata, Ptilodictya	114
Leioclema	246
Leptotrypa	178, 207
Leptotrypa claviformis	217
Leptotrypa hexagonalis	208
minima	207
Lichenalia	166
concentrica	168
ligniformis, Callopora	343
limitaris, Diplotrypa	317
lineata, Helopora	158
lineata incepta, Spatiopora	107
Nematopora	158
Lioclema	178, 246
spineum	248
vetustum	247
Lioclemella	178, 249
clava	249
Lunarium	48
lunatifera, Crepipora	88
Lyckholm limestone, F 1	16
Maculæ	47
maculatum, Hemiphragma	295
magnopora, Batostoma	272
mammulata, Monticulipora	179
Map of Baltic Sea area	5
massalis, Stigmatella	211
megastoma, Vincularia	348
Mesopores	47
Mesotrypa	177, 196
discoidea	196
orientalis	196
egena	198
expressa	200
milleporacea	201
parva	203
mickwitzi, Batostoma	276
Micropora	127, 345
cyclostomoides	141
gracilis	130
rhombica	116, 345
Millepora apiculata	344
fastigiata	346
hemispherica	232, 313
milleporacea, Mesotrypa	201
milleporacea-parva, Mesotrypa	203
minima, Leptotrypa	207
minor, Stomatopora	68
mirabile, Anaphragma	297, 298
Mitoclema	69
boreale	69
cinctosum	69
Mitoclema? mundulum	70
moniliformis, Diplotrypa	321
Monotrypa	178, 309
Monotrypa (Chaetetes?) cumulata	232
Monotrypa jewensis	310
undulata	310
Monotrypella	178
Monotrypella multitabulata	326
Monticulipora	177, 179, 325
Montic ipora ædilis	242
Monticulipora arborea	179
bispinulata	179
dagoensis	181
Monticulipora (Diplotrypa) petropolitana	313
heterosolen	317
Monticulipora (Heterotrypa) implicata	272
lamellosa	182
mammulata	179
ovulum	346
Monticulipora petropolitana	232, 313
Monticulipora (Prasopora) selwynii var. hospitalis	193
Monticulipora wesenbergiana	328
Monticuliporidæ	177, 178
multiporatum, Hemiphragma	290
multitabulata, Callopora	326
multitabulata, Hallopora	326
multitabulata, Monotrypella	326
mundulum, Mitoclema?	70
mutabilis, Eridotrypa	242
mutabilis var. *minor, Eridotrypa*	245
mutabilis var. *minor, Stictopora*	132
mutabilis, Rhinidictya	132
mutabilis, Stictopora	132
Myriapora fastigiata	346
Myriolithes	345
fastigiatus	346
nana, Callopora	334
neglecta, Diplotrypa	321
Nematopora	155
consueta	155
Nematopora delicatula	155
Nematopora fragilis	157
lineata	158
ovalis	155, 156
Nematopora quadrata	156
strigosa	161
Nematotrypa	164
gracilis	164, 165
Nicholsonella	178, 224
gibbosa	224
ponderosa	224
nicholsoni, Rhinidictya	132
North Polar region, Map of	40
North Polar seas, Bathymetric chart of	44
nummiformis, Callopora	335
obliqua, Graptodictya	126
obliquus, Arthrostylus	148

	Page.
obscura, Dekayella	205
oeilensis, Crisinella	73
Oldest known Bryozoa	3, 10
Orbignyella	177, 181
expansa	183
baltica	183
germana	182
sublamellosa	182
Orbipora	178, 251
acanthophora	255
distincta	252, 253
fungiformis	346
indenta	257
Orbipora panderi	286
Orbipora solida	255
Orbitulites	251
apiculatus	344
distinctus	253
Ordovician formations, Upper Mississippi Valley	25
Ordovician of northeastern Iowa and southeastern Minnesota, Composite geologic section of	25
Ordovician strata, description of	11
Dictyonema beds, A 3	11
Echinospherites limestone, C 1	13
Glauconite limestone, B 2.	12
Glauconite sandstone, B 5.	11
Itfer beds, C 3	15
Jewe limestone, D 1	15
Kegel beds, D 2	15
Kuckers shale, C 2	14
Lyckholm limestone, F 1	16
Wassalem beds, D 3	15
Wesenberg limestone, E	16
orosa, Pseudohornera	174
orosus, Thamniscus	174
Orthoceras limestone, B 3	13
Ostracoda, List of	22
ottawaense, Hemiphragma	286
ovalis, Nematopora	155, 156
ovulum, Monticulipora	346
Pachydictya	137
bifurcata	143
cyclostomoides	141
elegans	138
flabellum	140
robusta	138
Paleogeographic map, Generalized	43
panderi, Hemiphragma	286
panderi, Orbipora	286
Pelecypoda, List of	21
Penniretepora	159
pennula, Pteropora	347
perelegans, Graptodictya	121, 122
Peronopora	177
pertenuis, Rhopalonaria	61
Petalotrypa	178, 265
compressa	266
folium	266
Petigopora	178
petropolitana, Dianulites	232
Diplotrypa	232, 313
petropolitana (Diplotrypa) Monticulipora	313
Monticulipora	232, 313
petropolitanus, Chætetes	232, 313
petropolitanus, Dianulites	313
petropolitanus, Favosites	232, 313
petropolitanus, var. hexaporites, Dianulites	232
Phaenopora	118
Phaenopora cf. ensiformis	118
Phaenopora explanata	118
Phyllodictya	135
flabellaris	135
frondosa	135
varia	136
Phylloporina	169
Phylloporina and Fucoid beds, Bryozoa of	30
Phylloporina reticulata	170
Phylloporinidæ	168
piriformis, Callopora	343
Chætetes	343
piriformis, Dianulites	343
Platteville limestone in Minnesota, Bryozoa of	28
plumula, Glauconome	160
polymorpha, Calamopora	342
Polypora furcata	171
ponderosa, Anolotichia	91
Nicholsonella	224
prænuntia, Dekayella	205
nævigera, Dekayella	207
simplex, Dekayella	207
prænuntium, Coscinium	146
Prasopora	177
primæva, Fistulipora	109
primigenia, Trematopora	268
priscum, Heteronema	10, 57
proava, Graptodictya	123
proavium, Coscinium	123
proavus, Coscinium	123
Gorgonia	123
Protocrisina	71
exigua	72, 73
ulrichi	73
proutana, Stomatopora	61
Pseudohornera	172
bifida	173
orosa	174
Pteropoda, List of	21
Pteropora	347
exilis	347
pennula	347
Ptilodictya	113
expansa	114
flabellata	114
flexuosa	127
gladiola	114
Ptilodictya lanceolata	114
Ptilodictya subrecta	116
Ptilodictyonidæ	113
Ptilopora disticha	347
Ptychonema	309
Publications, List of	48
pulchellum, Arthroclema	150
punctata, Archeopora	105, 341
Callopora	246
Favositella	105
pustulifera, Trematopora	306
pygmæum, Hemiphragma	289
quadrata, Nematopora	156

Page.
radians, Archeopora 342
radiata, Scenellopora 107
recta, Escharipora 345
Escharopora 115
recta, Stomatopora 68
repens, Vinella 55
Retepora angulata 169
diffusa 172
Retepora tenella 169
reticulata, Calamopora 343
Chasmatopora 170
reticulata, Intricaria? 170
Phylloporina 170
Subretepora 170
revalensis, Anolotichia 95
Stellipora 221
Rhabdinopora 348
Rhabdomesontidæ 162
Rhinidictya 131
Rhinidictya bed, Bryozoa of 29
Rhinidictya? Borkholmiensis 143
Rhinidictya exserta 133
mutabilis 132
nicholsoni 132
Rhinidictyonidæ 131
Rhinoporidæ 166
rhombica, Anolotichia 92
rhombica, Eschara 345
rhombica, Micropora 116, 345
rhombicum, Dianulites 92
rhombicus, Chætetes 92
Rhombopora 162
esthoniæ 163
lepidodendroides 163
Rhombotrypa 178
Rhopalonaria pertenuis 61
Richmond group, equivalents of 2
robusta, Pachydictya 138
rotundatum, Hemiphragma 294
sacculus, Anolotichia 98
scalpelliformis, Eschara 348
scalpelliformis, Stictopora 348
scalpellum, Stictopora 143
Scenellopora 107
radiata 107
socialis 108
Sceptropora 152
facula 152, 153
francisca 154
schmidti, Crepipora 87
schucherti, Corynotrypa 67
selwynii var. hospitalis, Monticulipora (Prasopora) 193
shafferi, Stictopora (Ptilodictya) 119
Silurian strata, Borkholm limestone 16
Lyckholm limestone 16
similis, Homotrypa 185
simplex, Arthropora 120
simulans, Crepipora 86
socialis, Ceramopora 108
socialis, Scenellopora 108
solida, Orbipora 255
Spatiopora 106
aspera 106
lineata incepta 107
spineum, Lioclema 248
Page.
splendens, Hallopora 329
spongiosa, Ceramopora 77
Stellipora 178, 221
Stellipora 218
Stellipora antheloidea 221
apsendesoides 223
constellata 223
revalensis 221
Stictopora 131
Stictopora bifurcata 143
exserta 133
flabellum 140
mutabilis 132
var. minor 132
Stictopora (Ptilodictya) shafferi 119
scalpelliformis 348
Stictopora scalpellum 143
Stictoporella 127
Stictoporella bed, Bryozoa of 28
Stictoporella cribrosa 123
Stictoporella cribrosa 128
Stictoporella flabellata 123
Stictoporella gracilis 130
interstincta 127
Stictoporellidæ 127
Stigmatella 178, 210
claviformis 217
crenulata 211
foordii 214
inflecta 212
massalis 211
Stomatopora 209
Stomatopora 61
Stomatopora arachnoidea 60
Stomatopora delicatula tenuissima 61
Stomatopora dichotoma 59
Stomatopora dissimilis 68
inflata 64
minor 68
proutana 61
recta 68
tenuissima 61
Stones River Group 26
strigosa, Glauconome 161
strigosa, Helopora 161
Nematopora 161
striolata, Fenestella 175
Stromatotrypa 178
subgracilis, Bythopora 241
subgracilis, Homotrypella? 241
sublamellosa, Orbignyella 182
subramosa, Homotrypa 187
subrecta, Escharopora 116
subrecta, Ptilodictya 116
Subretepora 169
reticulata 170
subsphericum, Hemiphragma 292
sulcatus, Dianulites 344
tenella, Chasmatopora 169
tenella, Retepora 169
tenuimurale, Hemiphragma 282
tenuis, Helopora 147
tenuispinosa, Hallopora 338
tenuissima, Stomatopora 61
Thamniscus bifida 173
orosus 174

	Page.
Thamnocella	172
tolli, Hallopora	333
Trematopora	178, 267
Trematopora	301
cingulata	306
nodosa	306
colliculata	306
Trematopora cystata	271
kuckersiana	270
primigenia	268
Trematopora pustulifera	306
Trematopora tuberculosa	268
Trematopora variabilis	306
complanata	306
Trematoporidæ	178, 267
Trepostomata	176
Trilobita, List of	23
tuberculosa, Trematopora	268
ulrichi, Protocrisina	73
undulata, Callopora	332
undulata, Hallopora	332
undulata, Monotrypa	310
Ungulite sandstone, A 2	10
Upper Mississippi Valley, Ordovician formations of	25
uxnormensis, Ceramoporella	82
varia, Constellaria	219
Phyllodictya	136
variabilis complanata, Trematopora	306
Trematopora	306
vaupeli, Diamesopora	83
Vesicular tissue	48
vetustum, Lioclema	247
Vincularia megastoma	343
Vinella	55
repens	55
Vinellidæ	55
Wassalem beds, D 3	15
wesenbergiana, Hallopora	328
wesenbergiana, Monticulipora	328
Wesenberg limestone, E	16
winchelli, Amplexopora	278
winchelli, Batostoma	278
spinulosum, Batostoma	279
Zoarium	46
Zoœcium	46